

Research Paper

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 farming experience, income level and extension visits significantly influenced soyabean output positively at the 5% level. However, distance from home to farm and educational level had an inverse 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

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 Europe from China where it originated, the crop has become important world-wide as a primary source of vegetable oil and protein (Ajao et al., 2012; Sinclair and Backman, 1989; Hymowitz, 1970). 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 (Mpeperekı et al., 1996). 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 Ogundipe and Osho (1990) and Osho et al. (1994) 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 result in land degradation because farmers can no longer apply traditional fertility regeneration techniques like fallowing on their limited landholdings (Shiferaw et al., 2002). 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 (Serraj et al., 2004). According to Sanchez (2002), 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. Sanchez et al. (1998) 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 (CIAT, 2006). 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 (Adler, 2008). In the light of this, efforts are being made by the *N2 Africa project* to promote biological nitrogen fixation through the use of inoculum in Ghana and some African countries. In Ghana, the project provided inoculum to some Soyabean farmers in the three northern regions of Ghana 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 2.1).

Table 2.1: 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 Ordinary Least Squares (OLS) estimation procedure was used to estimate a Cobb-Douglas Soyabean production function. The empirical model was specified as:

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

Where:

Ln = Natural logarithm

Y = Quantity of soyabean harvested (kg)

X₁ = Years of formal education

X₂ = Experience in soyabean farming (years)

X₃ = Annual income (GHC)

- 113 X_4 = Distance from home to farm (km)
 114 X_5 = Number of extension visits last season
 115 X_6 = Member of Farmer Association (Yes = 1; No = 0)
 116 X_7 = Credit access (Yes = 1; No = 0)
 117 X_8 = Use of inoculum last season (Yes = 1; No = 0)
 118 μ = Error term
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120 A binary logistic regression model was used to examine the factors that determine farmers'
 121 willingness to pay for inoculum in Soyabean production.
 122 Mathematically, logit probability is represented by:

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

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 126 *Where:*

127 $Z_i = \beta X_i$; β a vector of unknown coefficients; X_i a vector of factors/characteristics of the i^{th}
 128 farmers; $\Phi(\beta X_i)$ is the probability that the i^{th} factor will affect farmer's willingness to pay for
 129 inoculum.
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131 The probability that a given factor affects farmer's decision to pay for inoculum is the area
 132 under the standard normal curve between $-\infty$ and βX_i . The larger the value of βX_i , the more
 133 important the factor is in affecting farmer's decision-making. The change in $\Phi(\beta X_i)$ relative to
 134 the change in X_i is given by:
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$$\frac{\delta \phi(\beta x_i)}{\delta x_{ij}} = \left[\frac{\delta \phi}{\delta z_i} \right] \left[\frac{\delta z_i}{\delta x_{ij}} \right] = f(z_i) \beta_j$$

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

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 150 *Where:*

151 P_i = Probability that a farmer is willing to adopt and pay for inoculum
 152 β_0 = Constant
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154 $\sum_{ij=1}^{nk} \beta X_{ij}$ = vector of all the explanatory variables
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 158 β_i = Parameters/coefficients of the explanatory variables, and

159 ε_i = Random/disturbance term.

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161 The following explanatory variables were included in the model:

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

163 X_2 = Years of formal education

164 X_3 = Distance from home to farm (km)

165 X_4 = Household size

166 X_5 = Experience in soyabean production (years)

167 X_6 = Extension visits last year

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

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

170 X_9 = Degree of commercialization (proportion of output sold)

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172 The maximum likelihood estimation procedure was used to obtain the model estimates.

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204 **3. RESULTS AND DISCUSSION**

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206 **Characteristics of respondents**

207 Table 3.1 summarizes the characteristics of respondents. Majority of respondents were
 208 males who were married and of northern Ghana extraction. Less than 30% of the farmers
 209 interviewed belonged to farmer organizations. Majority of respondents appeared to have
 210 food security challenges at the household level as only 28% were able to feed their
 211 households throughout the year.

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Table 3.1 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

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Source: Field survey, 2013.

Table 3.2 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 3.2: 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
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.

Soyabean Production

Figure 3.1 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.

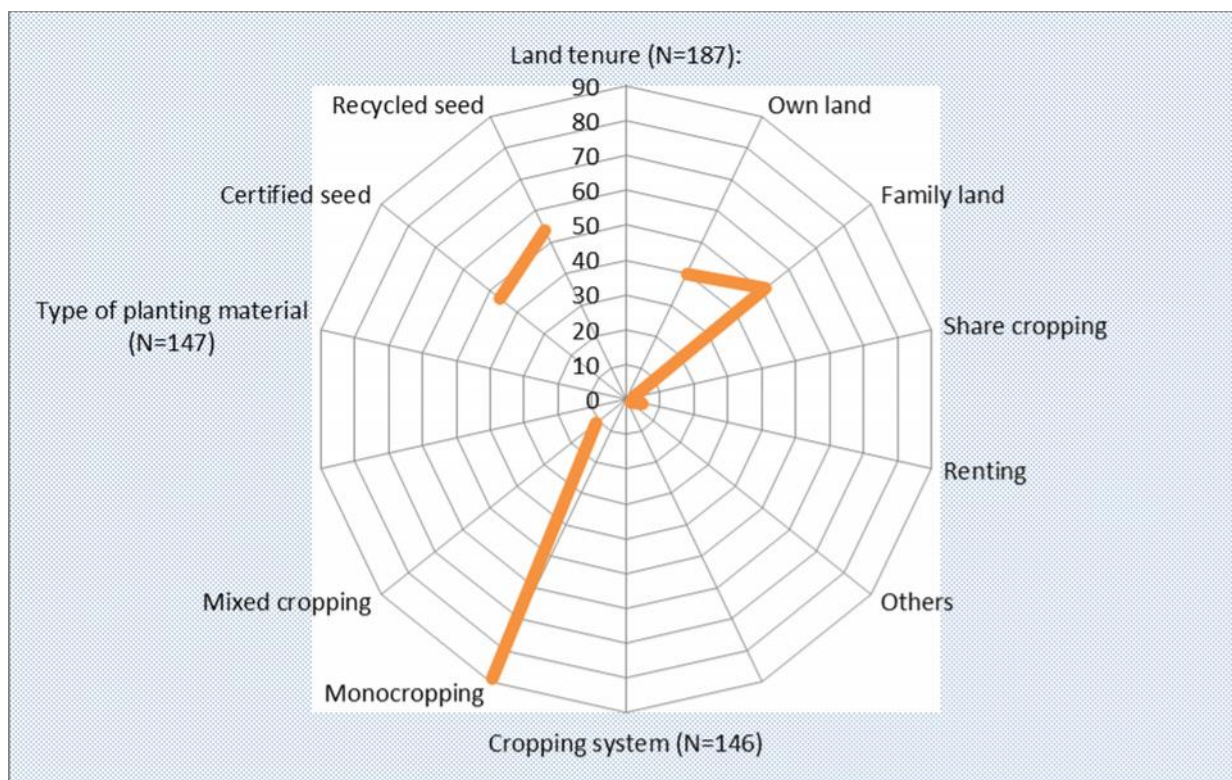


Figure 3.1: Land tenure, planting material type and cropping system used in Soyabean production

Source: Generated from Field data, 2013.

Average yield of soyabean was estimated at 271Kg per acre. Whereas acreage cultivated, total output and percentage of output sold were found to differ significantly across the four study districts with differences in yield of Soyabean across these districts were statistically insignificant at the 10% level (Table 3.3). 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 3.4).

268 **Table 3.3: 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)

269 Source: Generated from Field Data, 2013.

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272 **Table 3.4: 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)

273 Source: Generated from Field Data, 2013.

Factors influencing Soyabean production

Table 3.5 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 63% of the variations in the output of soyabean in the study area. The statistically significant factors were years of formal education, farming experience, extension contact, distance to farm and annual income of the farmer. Whereas farming experience, extension contact and income level had a positive effect on soyabean production; educational level and distance to farm were found to have a negative effect on production, *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 3.5: Regression estimates for factors influencing Soyabean production

Variables	Coefficients	t	Prob.
(Constant)	-14.035**	-2.538	0.028
Ln_ Years of formal education	-0.634***	-3.728	0.003
Ln_ Farming experience	0.745***	4.504	0.001
Use of inoculum (Yes=1; No=0)	0.287	1.458	0.173
Membership of Farmer Association (Yes=1; No=0)	0.091	0.481	0.640
Access to credit (Yes=1; No=0)	0.237	1.310	0.217
Ln_ Extension visits	0.336*	1.820	0.096
Ln_ Annual Income	0.392*	1.976	0.074
Ln_ Distance to farm	-0.337*	-2.130	0.057

F=4.996 (df:19; sig.@0.008); R Square =0.784; Adjusted R Square =0.627 (Std. Error of the estimate =0.98851)

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

Dependent Variable: Ln_ Soyabean output (Kg)

Farmers' willingness to pay for inoculum use

Table 3.6 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.

304 **Table 3.6: 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 inoculum:</i>		
Yes	151	80.3
No	37	19.7

305 Source: Field survey, 2013.

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309 Table 3.7 provides the empirical estimates obtained from the willingness to pay logit model.
310 The Chi-square figure of 51.72 was significant at the 1% level, indicating that the
311 independent variables in the model significantly affect the outcome variable (i.e. willingness
312 to pay for inoculum). Farmers' willingness to pay for inoculum was found to be positively
313 influenced by experience in soyabean production, access to credit, percentage of produce
314 sold and awareness about inoculum at the 5% significance level. Male farmers were found to
315 be more willing to pay for inoculum than female farmers, and distance from home to farm
316 was found to be negatively related to farmers' willingness to pay for inoculum, *ceteris*
317 *paribus*.

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342 **Table 3.7: 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 Soyabean 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				

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

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347 **4. CONCLUSION**

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

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359

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 361 Africa is a project that is aimed at putting Nitrogen fixation to work for smallholder farmers in
 362 eight African countries including Ghana, and it is being funded by Bill and Miranda Gates
 363 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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