Original Research Article

WILLINGNESS TO PAY FOR BIOFERTILIZERS AMONG GRAIN LEGUME FARMERS IN NORTHERN GHANA

Abstract

Background: The call for use of improved Soil Fertility Management (SFM) technologies is a prerequisite to increase in agricultural productivity among farmers. This study assessed farmers' willingness to pay for selected financially rewarding biofertilizer technology packages for legume production in northern Ghana. A simple random sampling technique was used to elicit responses from a sample of 400 grain legume farmers randomly selected from Northern and Upper West Regions of Ghana. The double bounded dichotomous choice (DBDC) format was employed and determinants of farmers WTP evaluated using the maximum likelihood estimation approach.

Results: The results showed that about 60%, 25% and 46% of soya, cowpea and groundnuts farmers respectively were willing to pay for the selected biofertilizers (Biofix, BR3267 and Legumefix respectively) at not exceeding GHC 14.00, GHC 28.00 and GHC 20.00 per 0.2kg of the respective biofertilizers. Legume farmers in Northern Region were however willing to pay higher for the three biofertilizer technologies as compared to their counterparts in Upper West Region. For 0.2 kg each of Biofix, BR3267 and Legumefix, farmers in Northern Region were willing to pay approximately GHC 17.00, GHC 12.00 and GHC 23.00 respectively whereas those in Upper West Region were willing to pay GHC 14.00, GHC 9.00 and GHC 11.00 for the same quantity of each biofertilizer technology package respectively. The study also identified farming experience, FBO membership, awareness and use of biofertilizers as significant determinants of farmers' willingness to pay for Biofertilizers

Conclusion: Comparatively, the mean price farmers are willing to pay for these three technologies is below ex-factory price, hence subsidizing the cost of production of these biofertilizers in the initial stages will be relevant for improving farmers WTP. Sustained awareness creation through periodic education and sensitization by using FBOs as leverage points is also highly recommended to improve farmers' understanding of the concept of biofertilizer use.

Keywords: Willingness to Pay (WTP), Biofertilizers, Grain Legume, Soil Fertility Management.

1. Introduction

The important role grain legumes play in the Ghanaian economy cannot be understated. Despite their immense contribution to household income, food security, and general livelihoods, the incidence of low crop productivity continues to be a challenge facing grain legume farmers in Ghana. Soils in SSA (including Ghana) are usually low in nitrogen and phosphorous (the most limiting plant nutrients) and this gives rise to low yields. These low yields are particularly pronounced in grain legumes where yields have been reported to be below the achievable rate (0.7 ton/ha as against 3 tons/ha), thereby presenting a wide yield gap (Mutegi and Zingore, 2014).

Low cost and sustainable solutions compatible with the socioeconomic conditions of smallholder farmers are therefore needed to solve these soil fertility problems leading to poor yields of grain legumes. A recognized approach by soil scientists and agronomists to dealing with soil health and fertility problems of smallholder farmers is the introduction of cost effective and yield rewarding soil fertility management technologies such as biofertilizers, organic fertilizers and an integrated approach [i.e. Integrated Soil Fertility Management(ISFM)]. Adoption of biofertilizers in soil fertility management is gaining prominence due to recent interest in sustainable agriculture. Biofertilizers are preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants to take up nutrients by their interactions in the rhizosphere when applied through seed or soil (Niño et al, 2012; Vessey, 2003). Their presence accelerates microbial processes that make soil nutrients readily available and easily assimilated by crops. Biofertilizers are considered to be an important component of integrated soil nutrient management, as they are cost effective and renewable source of plant nutrients that can supplement nutrients from other source (e.g. chemical fertilizers) in sustainable agricultural production systems.

Despite the expected positive impact of biofertilizer adoption on yield and the environment, farmers' decision and willingness to invest in biofertilizers will be conditioned by several factors. For instance, the level of awareness about biofertilizers, farmers' socio-economic situation such as educational level and income, access to extension services and agro-input shops as well as farm size and farming experience, are expected to affect their perceptions about biofertilizers and their willingness to pay for them. Currently, there is limited empirical information on farmers' willingness to pay for biofertilizers and the key factors that determine how much they are willing to pay for a unit of these biofertilizers in Ghana. Therefore, the purpose of this paper was to evaluate farmers' willingness to pay for biofertilizers and examine the key determinants of willingness to pay among grain legume farmers in northern Ghana.

The main objectives addressed in the paper were to estimate farmers' mean willingness to pay for selected biofertilizers; and examine the key determinants of farmers' willingness to pay for biofertilizers

Results of the study are expected to guide stakeholders in formulating strategies to promote the demand for and use of biofertilizers among grain legume farmers in Ghana when the products are made readily available on the market.

2. Biofertilizers in Soil Fertility Management and Determinants of Willingness to Pay (WTP)

As a form of organic/biological product, biofertilizers are said to be comprised of specific microorganisms in concentrated forms which, when applied to seed or soil, colonize plant roots thus promoting growth through increase in supply of primary nutrients to the host plant (Chen, 2006; Gaur, 2010; Gupta and Sen, 2013). They have been recognized as microbial inoculants artificially multiplied to improve soil fertility and crop productivity and have been internationally accepted as efficient and economical alternatives to mineral-N fertilizer due to the need for less capital input associated with their use (Hafeez *et al,*. 2002; Howladar & Rady, 2013 ; Mazid & Khan 2014). As low cost, renewable sources of plant nutrients, biofertilizers are said to be the answer to the inherently nutrient-deficient sub-Saharan agrarian soils that are mostly Nitrogen and Phosphorus deficient; and this boils down to their ability to generate these essential nutrients through their biological activity in the rhizosphere (Schachtman *et al*,. 1998; Muraleedharan *et al,*. 2010). While some studies view biofertilizers as potential supplements/complements to chemical fertilizers, meaning they cannot act as standalone in plant nutrient management (Rai, 2006; Raghuwanshi, 2012), other studies identify them as safe alternatives or substitutes to mineral fertilizers (Deepali and Gangwar, 2010; Prasanna *et al*,. 2011; Aziz *et al*,. 2012; Youssef & Eissa, 2014).

Reports from previous studies (e.g. Waddington *et al*,. 2004; Mapfumo, 2011) reveal that, using the biofertilizer technology for grain legumes to induce Biological Nitrogen Fixation (BNF) does not only benefit legume production, but it also benefits subsequent cereal crops planted in rotation on the same fields. Biofertilizers can therefore be said to have a long-term effect on maintaining soil fertility as well as ensuring sustainable agriculture through the buildup of soil nitrogen and other essential microbial organisms for use by other non-leguminous crops. Notwithstanding their role as a financially efficient approach in addressing soil fertility concerns, demand for biofertilizers (inoculants) in SSA has been rather minimal (Kannaiyan, 1993).

3. Study Area, Materials and Methods

Study Area

The study was conducted in the Upper West and Northern Regions of Ghana. These regions where selected mainly because they have been trial sites in Ghana for soil fertility management projects such as *N2 Africa* and IITA COMPRO II projects which focused on biological nitrogen fixation and ISFM technologies for legume production respectively. These two regions are also part of the 'breadbasket' regions of Ghana where grain legume production (soybean, cowpea and groundnut) is also predominant. Table 1 provides production statistics of the major grain legumes produced in two target regions.

Table 1: Production statistics on Major Grain Legumes in the study regions

Legumes	**Northern Region**		**Upper West Region**	
	Area (Ha)	***Production (Mt)***	***Area (Ha)***	***Production (Mt)***
Soybean	60,431	126,656	15,630	17,736
Groundnut	130,352	224,476	132,605	162,265
Cowpea	62,544	124,720	75,956	84,996

Source: Statistics, Research and Info. Directorate (SRID), MoFA, (2012)

Socio-economic data was obtained through a field survey of grain legume farmers in the target regions. Data on general characteristics of households, grain legume production activities, input usage and farmers' willingness to pay decisions were elicited from farmers. A combination of both purposive and simple random sampling methods was used in drawing samples at various levels. Two districts were selected purposively from both Northern Region (*Karaga* and *Savelugu* districts) and Upper West Region (*Wa West* and *Nadowli* districts) due to previous SFM project activities in these districts. Five (5) communities were randomly selected from each district and 20 legume farmers were randomly selected from each of the communities based on a prepared list. Hence, a total sample size of 400 grain legume farmers was selected for the study. Structured questionnaire was employed to conduct personal interviews. To elicit relevant information to assess farmers' willingness to pay, a choice card consisting of relevant information on selected biofertilizers was designed and presented to farmers

Analytical Framework for Willingness to Pay

Three main biofertilizers were presented to farmers. These included *Biofix*, *BR3267* and *Legumefix* for soya, cowpea and groundnut production respectively. Farmers' willingness to pay for these biofertilizers was evaluated by employing the contingent valuation approach which has been recognized as one of the best means of valuing goods which are not already on the markets (Randall *et al.,* 1974; Donfouet and Makaudze, 2011). Farmers were presented with hypothetical scenarios dependent on simulated values. Among the existing approaches of evaluating WTP using contingent evaluation, the 'Double-Bounded Dichotomous Choice Format' was used. The double bounded dichotomous choice format presents follow-up questions that provide more effective binary responses than the single bounded method. Adding a follow-up bid substantially improves statistical information provided by the data (Hanemann, et al,. 1991).

Double-bounded dichotomous choice format, presents respondents with a follow-up bid offer after an initial first bid is introduced. Respondents are asked if they would accept or reject the first bid (Bi) and based on their answer, a second bid which may be higher (B_{iu} if yes to first bid) or lower (B_{id} if no to first bid) is presented. This format therefore has four possible outcomes: "*yes:yes, yes:no, no:yes and no:no*" as shown in Table 3. Farmers' refusal to pay for the individual biofertilizers at the initial prices as well as their associated lower bids represented a *No:No* response; their refusal but however acceptance of the lower bid represented a *No:Yes* response; their acceptance of the proposed first bid but rejection of the associated higher bid denoted a *Yes:No* response and their acceptance of both first and higher bids denoted a *Yes:Yes* response.

Table 2 provides a summary of Bids generated for the double-bounded choice format for the three biofertilizers.

Table 2: Proposed Bid Prices (GHC) for the Selected Biofertilizers

Biofertilizer	Bid 1	Higher Bid	Lower Bid
Biofix	28.00	56.00	14.00
BR3267	55.00	110.00	28.00
Legumefix	40.00	80.00	20.00

Source: Generated from IITA figures

Table 3 below presents the definition and measurements of bid levels and their expected responses.

Table 3: Description of variables used in Generating Bids

Variable	Description	Measurement of Values

Bid 1	Initial amount (bid) in GHC	1 if yes and 0 otherwise
Bid h	Higher amount (bid) in GHC	1 if yes and 0 otherwise
Bid l	Lower amount (bid) in GHC	1 if yes and 0 otherwise
Nn	Rejection of initial and lower bid	1 if *no,no* to WTP questions
Ny	Rejection of initial but acceptance of lower bid	1 if *no,yes* to WTP questions
Yn	Acceptance of initial bid but rejection of a higher bid	1 if *yes,no* to WTP questions
Yy	Acceptance of both initial and higher bid	1 if *yes,yes* to WTP questions
DepVar	Dependent variable as (=1 if nn=1, =2 if ny=1, =3 if yn=1 and =4 if yy=1)	
	Response to Bid 1	1 if DepVar = 3 or 4
	Response to Bid 2	1 if DepVar = 2 or 4

Source: Authors Compilation, 2016.

The Log-likelihood function for the responses, following Hanemann *et al*., (1991) is given as;

$$\ln L^D(\theta)=\sum_{i=1}^{N}\left\{d_i^{yy}\ln\pi^{yy}\left(B_iB_i^u\right)+d_i^{yn}\ln\pi^{yn}\left(B_iB_i^u\right)+d_i^{ny}\ln\pi^{ny}\left(B_iB_i^u\right)+d_i^{nn}\ln\pi^{nn}\left(B_iB_i^u\right)\right\}$$

Where:

$\mathbf{B_i}$=1st bid (if response is yes)

$\mathbf{B_i^u}$ = 2nd bid (if response is yes)

$\mathbf{B}_i^{\mathbf{d}}$ = 2nd bid (if response is no)

$\mathbf{d}_i^{yy}$, $\mathbf{d}_i^{yn}$, $\mathbf{d}_i^{ny}$, $\mathbf{d}_i^{nn}$ denote responses to "yes:yes, yes:no, no:yes and no:no" respectively

$\boldsymbol{\pi}^{yy}$, $\boldsymbol{\pi}^{yn}$, $\boldsymbol{\pi}^{ny}$, $\boldsymbol{\pi}^{nn}$ represent probability of obtaining a "yes:yes, yes:no, no:yes, and no:no" respectively.

To estimate the double bound model, the following information is necessary;

Let t^1 and t^2 represent the 1st and 2nd bids respectively.

- An individual farmer rejecting both initial and lower bid implies $0<WTP < t^2$.
- If an individual farmer rejecting initial bid but accepting the lower bid, then $t^2 > t^1$ implying $t^2 \leq WTP \leq t^1$
- If an individual farmer accepting the initial bid but rejecting the higher bid, then $t^2 > t^1$ implying $t^1 \leq WTP < t^2$
- An individual farmer accepting both initial and higher bids implies $t^2 \leq WTP < \infty$

We define Y_i^1 and Y_i^2 as dichotomous variables representing responses to the first and second questions; and under the assumptions that;

$WTP_i(z_{i,}\mu_i) = z_i{}'\beta + \mu_i$ and $\mu_i \sim N(0,\sigma^2)$

Therefore, the probability of each of the four scenarios above occurring is given as;

1. $Y_i^1=1$ and $Y_i^2=0$

$$\Pr(\text{y,n}) = \Pr(t^1 \le WTP < t^2)$$

$$= \Pr(t^1 \le z_i'\beta + \mu_i < t^2)$$

$$= \Pr\left(\frac{t^1 - z_i'\beta}{\sigma} \le \frac{\mu_i}{\sigma} < \frac{t^2 - z_i'\beta}{\sigma}\right)$$

$$= \Phi\left(\frac{t^2 - z_i'\beta}{\sigma}\right) - \Phi\left(\frac{t^1 - z_i'\beta}{\sigma}\right)$$

Hence using symmetry of the normal distribution, we have

$$\Pr(\text{y,n}) = \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)$$

2. $Y_i^1=1$ and $Y_i^2=1$

$$\Pr(\text{y,y}) = \Pr(WTP > t^1, WTP \ge t^2)$$

$$= \Pr(z_i'\beta + \mu_i > t^1, z_i'\beta + \mu_i \ge t^2)$$

By symmetry, we have;

$$\Pr(y,y) = \Phi\left(z_i{}' \frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)$$

3. $Y_i^1=0$ and $Y_i^2=1$

$$\Pr(n,y) = \Pr\left(t^2 \le WTP < t^1\right)$$

$$= \Pr\left(t^2 \le z_i'\beta + \mu_i < t^1\right)$$

$$= \Pr\left(\frac{t^2 - z_i'\beta}{\sigma} \le \frac{\mu_i}{\sigma} < \frac{t^1 - z_i'\beta}{\sigma}\right)$$

$$= \Phi\left(\frac{t^1 - z_i'\beta}{\sigma}\right) - \Phi\left(\frac{t^2 - z_i'\beta}{\sigma}\right)$$

$$\Pr(n,y) = \Phi\left(z_i{}' \frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) - \Phi\left(z_i{}' \frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right)$$

4. $Y_i^1=0$ and $Y_i^2= 0$

$$\Pr(n,n) = \Pr\left(WTP < t^1, WTP < t^2\right)$$

$$=\Pr(z_i'\beta+\mu_i<t^1, z_i'\beta+\mu_i<t^2)$$

$$=\Pr(z_i'\beta+\mu_i<t^2)$$

$$=\Phi\left(\frac{t^2-z_i'\beta}{\sigma}\right)$$

$$\Pr(n,n) \quad =1-\Phi\left(z_i'\frac{\beta}{\sigma}-\frac{t^2}{\sigma}\right)$$

Farmers' willingness to pay for the selected biofertilizers for their legume production after generating the relevant variables above was hence specified as:

$$WTP_i=\beta_o+B_1GEN-\beta_2AGE+\beta_3YEDU+\beta_4YEXP-\beta_5TFL+\beta_6FBO-\beta_7DisEXT-\beta_8DisAgro+$$

$$\beta_9AmtC+\beta_{10}FInc-\beta_{11}OffINC+\beta_{12}awBIO+\beta_{13}useBIO+\varepsilon \text{...........(1)}$$

Where;

- WTP_i represents farmers' willingness to pay for the selected ith biofertilizer (i.e. either *Biofix, Legumefix* or *BR3267*)
- ε denotes the error term.

The maximum likelihood approach which is an estimation procedure for obtaining estimates for β and σ by constructing a log-likelihood function was used to estimate the WTP equations. This procedure generates the choice probabilities by maximizing the log-likelihood function for the four discrete outcomes (Hanemann et al., 1991 and McClusky et al., 2003)

Determinants of Willingness to Pay

A number of factors have been identified in literature to influence farmers' WTP for improved agricultural technologies (e.g. Adesina and Baidu-Forson, 1995; Ulimwengu and Sanyal, 2011; Chiputwa *et al.,* 2011; Baffoe-Asare *et al*., 2013). A study by Zakaria *et al.* (2014) identified factors such as gender, age, education, farm size, access to credit, FBO membership among others as likely determinants of farmers' willingness to pay for agricultural technologies in general. In a study to assess farmers' WTP for improved soil conservation practices in Ethiopia, Kasaye (2015) identified gender, education level, income and livestock ownership of household head as statistically significant determinants of WTP. A joint estimation of farmers WTP for agricultural services by Ulimwengu and Sanyal (2011) in Uganda classified farmers with access to information and extension services as less willing to pay for information service. Distance was also found to impede farmers WTP while agricultural income and land ownership significantly influenced farmers WTP for agricultural information services.

Table 4 provides a description of the variables used in the WTP model.

Table 4: Description of variables used in WTP Analysis

Variable	Description	Values	*Apriori* Expectations
Individual Characteristics			
GEN	Categorical variable representing the gender of respondent	1 if male and 0 otherwise	+
AGE	Age of respondent in years	Continuous variable (count)	+/-
YEDU	Number of years of formal education of respondent	Continuous variable (count)	+
YEXP	Number of years of farming experience	Continuous variable (count)	+
Farm Level Characteristics			
TFL	Total farmland in acres allocated to legume crops	Continuous variable (count	+/-
Institutional Characteristics			
FBO	Membership of a farmer based organization	1 if yes and 0 otherwise	+
AmtC	Amount of credit used during the 2015 cropping season	Continuous variable (count) 1 if yes and 0 otherwise	+
FInc	Farm income as a major source of household income		
DisExt	Distance to nearest agric extension office in km	Continuous variable (count)	-
Offinc	Farmer's participation in off	1 if yes and 0 otherwise	+/-

	farm income generating activities		
DisAgro	Distance to nearest agro input shop in km	Continuous variable (count)	-
Technology Awareness and Use			
awBIO	Awareness of the use of biofertilizers for legume production	1 if yes and 0 otherwise	+
useBIO	The previous use of biofertilizer for legume production	1 if yes and 0 otherwise	+

A key aspect of contingent valuation is the determination of the mean WTP. The 'doubleb' command of the maximum likelihood function in STATA was employed to directly estimate the mean WTP for each of the three biofertilizers.

4. Results and Discussion

Willingness to Pay for Biofertilizers

Following the presentation of the three biofertilizers to farmers, a bidding game was conducted to determine farmers' WTP for each of the technologies based on the figures presented in Table 2 above. Proportion of farmers who responded to different bid figures are presented in Table 5 and Figure 1 below. Less than 10% of farmers in the pooled sample were willing to pay for the recommended biofertilizers at their respective initial bid prices. However, when the initial bids/prices were reduced by 50%, about 50% of legume farmers were willing to pay for *Biofix*, 40% were willing to pay for *Legumefix* and some 20% were willing to pay for *BR3267*. Farmer's willingness to pay for *BR3267* was generally lower for all its proposed bid prices as compared to *Biofix* and *Legumefix*. This could be attributed to its high cost relative to the other biofertilizers. Generally, majority of farmers are willing to pay for biofertilizers, but at prices below their current ex-factory prices (used as initial bid prices). This could result from their inadequate knowledge about biofertilizers and their use in legume production since it is still a novel technology to farmers in Ghana. Also farmers in the study area are generally smallholder farmers who are considered "poor" and mostly resource and credit constrained.

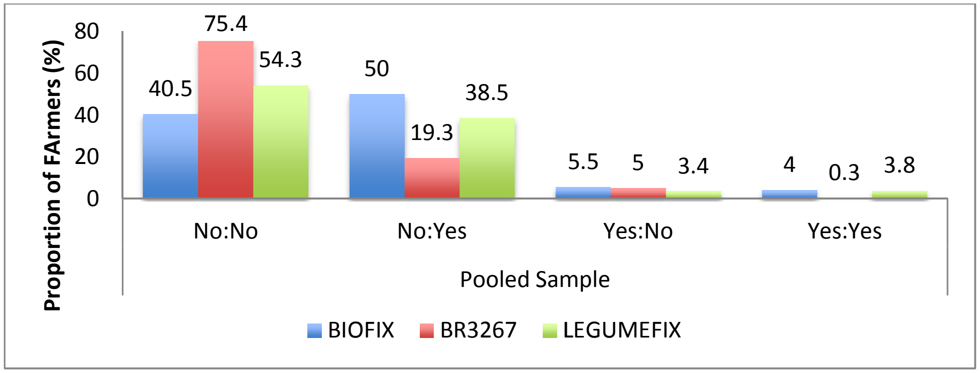
Table 5: Farmers Willingness to Pay for Bid Prices (Pooled Sample)

Biofertilizers	Bid 1	High Bid	Low Bid
Biofix	37(9.3)	16(4.0)	200(50)
BR3267	21(5.3)	1(0.3)	78(19.5)
Legumefix	28(7.0)	15(3.8)	158(39.5)

Source: Generated from Field Survey Data, 2016.

From Figure 1, it can be deduced that about 60%, 25% and 46% of farmers were willing to pay for *Biofix*, *BR3267* and *Legumefix* respectively at the lower bids of GHC 14.00, GHC 28.00 and GHC 20.00 proposed for 0.2kg of each sachet of the biofertilizers.

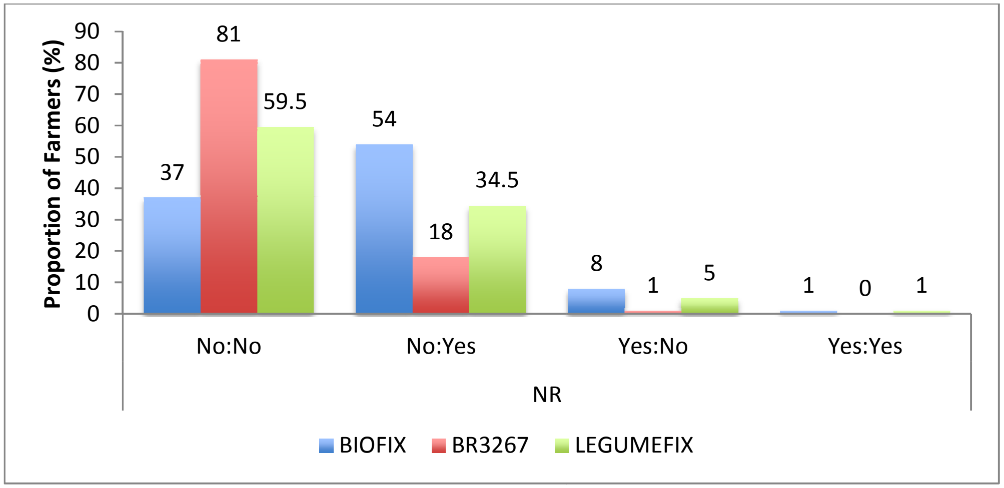
Figure 1: Responses to Proposed Biofertilizer Bid Prices



Source: Generated from Field Survey Data, 2016.

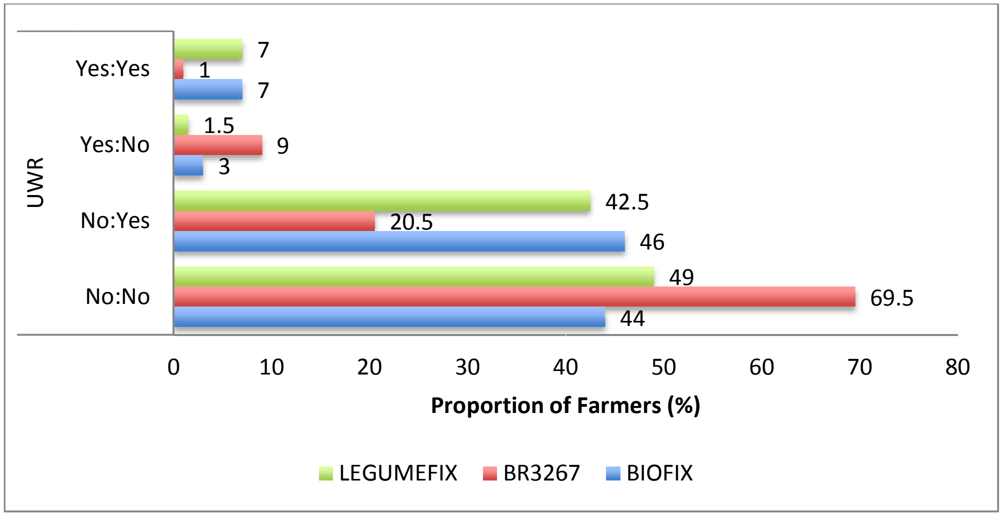
On regional basis as presented in Figures 2*a*&*b*, the highest response rate of 54% WTP was recorded at the lower bid of *Biofix* in the Northern Region. About 46% of farmers were willing to pay for *Biofix* in UWR at the same lower bid price. *Legumefix* was second to *Biofix* in both regions in terms of farmers' willingness to pay responses; about 35% and 43% of farmers were willing to pay for its use at the proposed lower bid of GHC 20.00. All grain legume farmers in Northern Region rejected the higher bid of *BR3267* (GHC 110.00) and less than 2% accepted it in UWR.

Figure 2*a*: Responses to Proposed Biofertilizer Bid Prices for farmers in NR



Source: Generated from Field Survey Data, 2016.

Figure 2*b*: Responses to Proposed Biofertilizer Bid Prices in UWR



Source: Generated from Field Survey Data, 2016

Determinants of willingness to pay for biofertilizers

Table 6 presents a summary description of variables used in the willingness to pay (WTP) model estimation for the selected biofertilizer technologies (*Biofix*, *BR3267* and *Legumefix*).

Table 6: Summary Statistics of Variables Used in Willingness to Pay Model

	BIOFIX	**BR3267**	**LEGUMEFIX**
Variables	Mean (SD)	Mean (SD)	Mean (SD)
Bid 1	28.00(0.0)	55.00(0.0)	40.00(0.0)
Bid 2	17.89(12.2)	32.31(18.3)	24.20(15.3)
WTP 1 (response 1)	0.09(0.3)	0.05(0.2)	0.07(0.3)
WTP 2 (response 2)	0.54(0.50)	0.20(0.4)	0.43(0.50)

GEN (1=male)	0.64(0.50)
AGE (years)	41.67(13.9)
YEDU (years)	2.43(4.40)
YEXP (years)	20.02(12.6)
TFLC (acres)	3.82(3.4)
FBO (1=yes)	0.83(0.4)
DisEXT (km)	13.77(7.5)
DisAgro (km)	8.66(7.1)
CRDTamt (GHC)	55.80(112.1)
OFFact (1=yes)	0.53(0.5)
BIOAW (1=yes)	0.34(0.5)
BIOU (1=yes)	0.04(0.2)

Note: (SD) donates Standard Deviation

Source: Generated from Field Survey Data, 2016.

Results of the maximum likelihood estimation of farmers' willingness to pay for selected biofertilizer technologies in the different locations (NR and UWR) are presented in Table 7. The coefficients of the male-gender variable and years of formal education were positive and statistically significant in the *Legumefix* model for NR. This suggests that males are more willing to pay for *Legumefix*; thereby supporting the widely known assertion that males are economically more endowed than females and will therefore be more capable of paying for improved agricultural technologies, all things being equal. Hence although females have been identified to be more involved in the cultivation of grain legumes (CGIAR, 2016), when it comes to paying for improved SFM technologies in line with their cultivation, their male counterparts are more financially capable to afford these technologies as noted by CGIAR (2013). Also educated farmers are more willing to pay for this biofertilizer and this could be explained by the advantages of awareness and knowledge that comes with higher education, ceteris paribus.

Table 7: Maximum Likelihood Estimations of Determinants of Willingness to Pay Across the two Locations

Categories	Variables	Northern Region			Upper West Region			Pooled Sample		
		BIOFIX	BR3267	LEGUMEFIX	BIOFIX	BR3267	LEGUMEFIX	BIOFIX	BR3267	LEGUMEFIX
HOUSEHOLD CHARACTERISTICS	CONSTANT	13.36 (3.64)	2.64 (0.26)	19.01 (2.94)	8.26 (12.24)	-21.98 (-0.83)	7.65 (0.42)	14.35 (18.24)	-16.23 (-0.92)	9.54 (0.86)
	AGE	-0.09 (-0.93)	-0.13 (-0.56)	-0.15 (-0.84)	-0.081 (-0.36)	-0.18 (-0.38)	-0.13 (-0.38)	-0.08 (-0.74)	-0.19 (-0.71)	-0.19 (-1.14)
	GEN	2.83 (1.25)	-3.45 (-0.65)	12.31*** (2.97)	0.42 (0.11)	4.52 (0.56)	-0.78 (-0.13)	1.25 (0.62)	-2.78 (-0.56)	7.05** (2.16)
	YEDU	-0.15 (-0.66)	0.37 (0.73)	0.70* (1.88)	-0.10 (-0.27)	0.03 (0.03)	-0.24 (-0.40)	0.03 (0.15)	0.65 (1.29)	0.06 (0.19)
FARM LEVEL CHARACTERISTICS	*YEXP*	0.20* (1.65)	0.60** (2.07)	0.00 (0.00)	0.42* (1.17)	0.73 (1.43)	0.24 (0.61)	0.31** (2.59)	0.87*** (2.84)	0.15 (0.77)
	TFLC	0.44* (1.89)	-0.46 (-0.91)	2.68 (0.63)	0.53 (0.78)	-0.74 (-0.50)	0.16 (0.14)	0.63** (2.27)	-1.37 (-1.97)	0.08 (0.20)
	FarmInc	-	-	-	6.56 (0.85)	15.11 (0.83)	0.39 (0.03)	4.75 (0.82)	9.57 (0.66)	6.10 (0.65)
INSTITUTIONAL CHARACTERISTICS	*FBO*	5.77*** (3.53)	8.76** (2.05)	0.07 (0.03)	6.02** (1.96)	11.33* (1.71)	1.61 (0.32)	6.07*** (3.60)	9.37** (2.21)	0.35 (0.13)
	DisEXT	0.08 (0.64)	0.08 (0.31)	0.13 (0.62)	0.04 (0.16)	0.15 (0.26)	0.13 (0.32)	0.79 (0.65)	0.28 (0.94)	0.35 (1.72)
	DisAgro	-0.05 (-0.36)	0.19 (0.59)	-0.28 (-1.15)	-0.38* (-1.68)	0.19 (0.40)	-0.45 (-1.28)	-0.10* (-0.49)	0.08 (0.27)	-0.21 (-1.61)
	CRDTamt	0.00 (0.17)	0.00 (0.12)	0.00 (0.27)	0.03* (1.88)	0.00 (0.07)	0.01 (0.38)	0.01 (1.07)	0.04 (2.07)	0.01 (1.00)
	OFFact	0.89 (0.56)	0.16 (0.04)	-2.68 (-0.94)	-0.14 (-0.04)	-3.56 (-0.48)	5.33 (0.94)	2.02 (1.18)	6.22 (1.49)	0.17 (0.06)
TECHNOLOGY AWARENESS AND USE	*BIOAW*	0.58 (0.25)	8.16 (1.30)	5.64* (1.40)	7.01** (2.21)	3.00 (0.44)	4.78 (0.93)	3.25** (1.69)	0.93 (0.20)	5.05* (1.83)
	BIOU	4.08 (0.63)	29.24** (2.12)	0.10 (0.01)	3.77 (1.60)	15.11 (0.83)	6.40 (0.62)	2.89 (0.68)	23.64** (2.56)	7.02 (1.02)
Loglikelihood		-187.34	-95.18	-201.51	-236.50	-156.87	-208.36	-445.68	-259.39	-425.78
$Wald\ chi^2$(13)		25.75**	12.85	26.65***	26.24**	12.02	5.16	42.32***	30.07***	21.68*

Note: ***, **, * denote significance at 1, 5 and 10% respectively; z-values are in parenthesis. *Source: Authors Compilation, 2016*

Experience in farming had a positive and statistically significant correlation with farmers willing to pay for Biofix and BR3267 in NR and only Biofix in UWR suggesting farmers with more years in farming are more likely to pay for the use of biofertilizers. This conforms with studies by Edemeades *et al*,. (2008) and Uganda and Onumadu and Osahon (2014) who concluded that farmers with more years in farming are more positively inclined to adopting and paying for improved technologies they assume to increase their crop productivity. FBO membership also showed a positive and statistically significant relationship with farmers' willing to pay for Biofix and BR3267 in both locations. This is expected since FBOs serve as units where farmers share information and gain insights into issues pertaining their production activities. This finding corresponds with that of Chiputwa *et al*,. (2011) and Baffoe-Asare *et al*,. (2013

Amount of credit borrowed for legume production during the 2015-cropping season was generally positive for all the WTP parameters in the different locations but only statistically significant for Biofix in UWR. This presupposes that farmers who have access to credit in UWR are more likely and willing to pay for Biofix.

Biofertilizer awareness and use were positive and statistically significant determinants of farmers' willingness to pay for Biofix in UWR and BR3267 in NR. With regards to the fact that technology awareness reduces performance uncertainties (Caswell *et al.,* 2001; Bonabana- Wabbi 2002), this finding implies that farmer's awareness of the Biofix technology makes them more informed about its potential, therefore increasing their willingness to pay for its use.

Mean WTP for Selected SFM Technologies

As shown in Table 8 for the two locations (NR and UWR) and pooled sample, the mean WTP for Biofix was about GHC17.00 in NR and GHC 14.00 in UWR. For BR3267 farmers were willing to pay GHC 12.00 per 0.2 kg in NR as against GHC 9.00 in UWR. For Legumefix approximately GHC 23.00 in NR and GHC 11.00 in UWR were the average amounts farmers were willing to pay for 0.2 kg of the fertilize. Though the mean prices deviate considerably from the initial prices proposed (GHC 28.00 for Biofix, GHC 55.00 for BR3267 and GHC 40.00 for Legumefix), comparatively farmers in NR were more willing to pay higher for the biofertilizer technology than their counterparts in UWR.

Table 8: Mean WTP for 0.2 kg of Selected SFM Technologies (GHC)

SFM Technology	NR	UWR	Pooled Sample
Biofix	16.59	14.43	15.68
BR3267	11.64	8.73	9.62
Legumefix	23.04	11.20	19.00

Source: Generated for Field Data, 2016.

5. Conclusion and Recommendation

The main objective of the study was to evaluate farmers' willingness to pay for selected biofertilizers for legume production and to assess the possible determinants of farmers' willingness to pay for each of them. The double bounded dichotomous choice format of the contingent evaluation method was employed and the determinants of farmers WTP evaluated using the maximum likelihood approach. The study revealed that about 60%, 25% and 46% of farmers were willing to pay for *Biofix*, *BR3267* and *Legumefix* respectively when the bid price was not greater than GHC 14.00, GHC 28.00 and GHC 20.00 per 0.2 kg sachet of the respective biofertilizers. Generally, legume farmers in Northern Region were willing to pay higher for the three biofertilizer packages as compared to their counterparts in Upper West Region. For 0.2 kg each of *Biofix, BR3267* and *Legumefix*, farmers in Northern Region were willing to pay approximately GHC 17.00, GHC 12.00 and GHC 23.00 respectively. However, those in Upper West Region were willing to pay only GHC 14.00, GHC 9.00 and GHC 11.00 for the same quantity of the respective biofertilizers. The study has also shown that farming experience, FBO membership, awareness and previous use of biofertilizers are the significant factors that influence farmers' willingness to pay for biofertilizers. The study concludes that the prospects for the sale of biofertilizers on the Ghanaian market for grain legume farmers are bright. However, the mean amounts they are willing to pay for these biofertilizers are far lower than their ex-factory prices. This could be as a result of the low level of awareness about biofertilizers and the the benefits associated with their use in grain legume production.

Based on the findings from the study the following recommendations are made:

There is need for government to strengthen district agricultural extension services delivery to ensure awareness creation about biofertilizers through periodic education and sensitization of farmers. This will increase both potential and actual demand for these biofertilizers.

Since the average prices farmers are WTP are way below the ex-factory prices, the government of Ghana through the Ministry of Agriculture should expand the current fertilizer subsidy programme to cover biofertilizers as a means of encouraging adoption by farmers. This could be used as a short term (two years) measure for farmers to experience the benefits associated with the use of biofertilizers.

Ethics approval and consent to participate

Ethics approval was primarily given by the Ministry of Food and Agriculture District Directorates of the selected research districts and communities. A formal consent statement was also read out to each participant (farmer) and their approval given before any research procedures carried out.

References

Adesina AA and Baidu-Forson J (1995). Farmers' Perceptions and Adoption of New Agricultural Technology: *Evidence from Analysis in Burkina Faso and Guinea, West Africa. J. Agric. Econ*. 13:1-9

Aziz, Z. F. A., Saud, H. M., Rahim, K. A. and Ahmed, O. H. (2012). Variable responses on early development of shallot (*Allium ascalonicum*) and mustard (*Brassica juncea*) plants to *Bacillus cereus* inoculation. Malaysian Journal of Microbiology, 8:47-50.

Baffoe-Asare, R., Danquah, J. A., & Annor-Frimpong, F. (2013). Socioeconomic Factors Influencing Adoption of Codapec and Cocoa High-tech Technologies among Small Holder Farmers in Central Region of Ghana. *American Journal of Experimental Agriculture*, *3*(2), 277–292.

Bonabana-Wabbi J. (2002). Assessing Factors Affecting Adoption of Agricultural Technologies: The Case ofIntegrated Pest Management (IPM) in Kumi District, Msc. Thesis Eastern Uganda

Caswell, M., Fuglie, K., Ingram, C., Jans, S., and Kascak, C. (2001). Adoption of Agricultural Production Practices. Report No. 792, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture.

CGIAR. (2013). Research Program on Grain Legumes: Gender Strategy. Leveraging legumes to combat poverty, gunger, malnutrition and environmental degradation. Brochure_GL_October, 2013

CGIAR. (2016). Gender Research. Grain Legumes Newsletter

Chiputwa, B., Langyintuo, A. S., & Wall, P. (2011). Adoption of Conservation Agriculture Technologies by Smallholder Farmers in the Shamva District of Zimbabwe: A Tobit application.

Chen, J.-H. (2006). the Combined Use of Chemical and Organic Fertilizers and/or Biofertilizer for Crop Growth and Soil Fertility. *International Workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use*.

Deepali and Gangwar (2010). Biofertilizers: An Ecofriendly Way to Replace Chemical Fertilizers.

Donfouet H.P.P. and Makauddze E.M. (2011). The Economic Value of the Willingness to Pay for a Community-Based Prepayment Scheme in Rural Cameroon. Research Paper No.3.

Edmeades, S., Phaneuf, D. J., Smale, M., and Renkow, M. (2008). Modelling the Crop Variety Demand of Semi-Subsistence Households: Bananas in Uganda. Journal of Agricultural Economics, 2 (59): 329–349.

Gaur V (2010). Biofertilizer – Necessity for Sustainability. J. Adv. Dev. 1:7-8.

Gupta, A. & Sen, S. (2013), Role of Biofertilisers and Biopesticides for Sustainable Agriculture, scholar.google.com.

Hafeez FY, Hameed S, Zaidi AH, Malik KA. (2002). Biofertilizers for Sustainable Agriculture. In: Techniques for Sustainable Agriculture, 67-73. ISBN, NIAB, Faisalabad, Pakistan

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation. *American Journal of Agricultural Economics*, *73*(4), 1255–1263.

Howladar, S. M., & Rady, M. M. (2013). Effect of Bio-Nitrogen as a Partial Alternative to Mineral-Nitrogen Fertiliser on Growth , Nitrate and Nitrite Contents , and Yield Quality in Brassica, *7*(7), 283–288

Kannaiyan S. (1993) Nitrogen Contribution by Azolla to Rice Crop, Proc.Indian Natl. Sci. Acad. Part B Biol. Sci. 59, 309–314.

Kasaye, B. (2015). Farmers “ Willingness to Pay for Improved Soil Conservation Practices on Communal Lands in Ethiopia (Case Study In Kuyu Woreda

Mapfumo, P. (2011), “Comparative Analysis of the Current and Potential Role of Legumes in Integrated Soil Fertility Management in Southern Africa”, http://www.researchgate.net

Mazid, M., & Khan, T. A. (2014). Future of Bio-fertilizers in Indian Agriculture: An Overview. *International Journal of Agricultural and Food Research*, *3*(3), 10–23.

McCluskey, J.J., Ouchi, H., Grimsrud, K.M., & Wahl, T.I. (2003). Consumer response to genetically modified food products in Japan. *Agricultural and Resource Economics Review*, *32*, 222-231.

Muraleedharan.H, Seshadri. S and Perumal. K. (2010). Biofertiliser (Phosphobacteria), Shri Murrugapa Chettiar Research Centre.

Mutegi, B. J., Zingore, S., Program, S. S. A., Division, S. A., & Compound, I. (2014). Closing yield gaps in sub-Saharan Africa through Integrated Soil Fertility Management, (1), 1–3.

Onumadu, F. N., & Osahon, E. E. (2014). Socio-Economic Determinants of Adoption Of Improved Rice Technology By Farmers In Ayamelum Local Government Area Of Anambra. *International Journal of Scientific & Technology Research*, *3*(1), 308–314.

Prasanna, A., Deepa, V., Balakrishna Murthy, P., Deecaraman, M., Sridhar, R. and Dhandapani, P. (2011). Insoluble phosphate Solubilization by Bacterial Strains Isolated from Rice Rhizosphere Soils from Southern India. International Journal of Soil Science, 6:134-141.

Raghuwanshi. R. (2012), Opportunities and Challenges to Sustainable Agriculture in India, NEBIO, Vol.3, No.2, pp. 78-86.

Rai, M. K. (2006). *Handbook Of Microbial Biofertilizers*

Randall, Alan, Barry C.I, and Clyde E (1974). "Bidding Games for Valuation of Aesthetic Environmental Improvements." Journal of Environmental Economics and Management. Vol.1, No.2:132-149.

Schachtman, D.P., Reid, R.J., and Ayling, S.M. (1998). Phosphorus Uptake by Plants: From Soil to Cell. Plant Physiology 116: 447-453.

Ulimwengu, J., & Sanyal, P. (2011). Joint Estimation of Farmers' Stated Willingness to Pay for Agricultural Services. *International Food Policy Research Institute Discussion Paper 01070.*

Vessey J.K. (2003). *Plant Growth Promoting Rhizobacteria as Bio-fertilizers*: Plant Soil, 255: 571-586

Waddington, S., Sakala, D., Mekuria, M. (2004). "Progress in Lifting Soil Fertility in Southern Africa", In Proceedings of the 4th International Crop Science Congress, Held 26 Sep – 1 Oct 2014, Bisbane, Australia

Youssef, M. M. A., & Eissa, M. F. M. (2014). Biofertilizers and their Role in Management of Plant Parasitic Nematodes. A review. *Journal of Biotechnology and Pharmaceutical Research*, *5*(1), 1–6.

Zakaria, H., Abujaja, A. M., Adam, H., & Nabila, A. Y. (2014). Factors affecting Farmers Willingness to Pay for Improved Irrigation Service: A case study of Bontanga Irrigation Scheme in Northern Ghana, *2*(1), 68–76.