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Assessment of Agro-input Dealers' Willingness to Invest in Legume Inoculants in Northern Ghana

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Authors' contributions

This work was jointly carried out by all the authors. Author EM designed the study, performed the statistical analysis, and wrote the first draft of the manuscript. Author BDKA streamlined the analyses of the study and made editorial comments. Author SSJB reviewed literature and streamlined the analysis and author FK reviewed literature. All authors read and approved the final manuscript.

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ABSTRACT

In recent past, efforts in sub-Saharan Africa (SSA) including Ghana have stressed on increasing legume productivity and associated benefits to rural livelihoods. However, technologies such as legume inoculants that enhance legume productivity are associated with constraints such as quality assurance and proper storage conditions. This study assessed agro-input dealers' willingness to invest in legume inoculants using cross-sectional data of 200 agro-input dealers sampled across Guinea Savanna agro-ecology of Ghana. Investment decision is modeled as a two stage process using the Double Hurdle approach. The results indicate that different set of factors influence investment decision and intensity of investment separately. However, economically active household members, inoculants training, and agro-ecology influence both investment decisions. Capacity building of agro-input dealers on inoculants handling coupled with favourable policy environment in the Guinea Savanna agro-ecology will lead to an increase in the intensity of investment in legume inoculants.

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Keywords: Agro-input dealers; willingness; legume inoculants; double hurdle model; Ghana.

ACRONYMNS AND ABBREVIATIONS

AGRA : Alliance for a Green Revolution in Africa
CSIR : Council for Scientific and Industrial Research
DL : Double Hurdle
NGOs : Non-Governmental Organizations
SARI : Savanna Agricultural Research Institute
SHP : Soil Health Project
SSA : Sub-Saharan Africa
UK : United Kingdom

1. INTRODUCTION

Agricultural production in most parts of sub-Saharan Africa (SSA) is dominated by smallholder farming systems of low productivity. Valuable natural resource for most African countries such as agricultural land is becoming scarce due to degradation by both natural and anthropogenic factors [1] Soil degradation has led to loss of soil fertility in major areas in northern Ghana and consequently a decline in crop yields. Low soil fertility has also been identified as a major contributor to the low yields recorded by the agricultural sector [2]. This constitutes serious threats to food production and food security. Major cereals such as maize and rice have received increasing use of fertilizer which accounts for major increases in agricultural productivity. However, grain legumes such as groundnut, cowpea and soybean have remained unfertilized by farmers resulting in very low yields.

Grain legumes are key source of nitrogen-rich edible seeds, providing a wide variety of high-protein products and constituting the major source of dietary protein in the diets of the poor in most parts of sub-Saharan Africa. Largely grown as subsistence food crops, they are predominantly crops grown by women and used within the family with an annual per capita consumption of about 9 kg and providing 88 kcal/capita/day. Legumes such as groundnut and soybean are also major sources of edible oil and other industrial by-products. In northern Ghana, legumes are mostly grown in rotations with cereals or included as minor intercrops in fields of cereals and other staple crops and sometimes in alley cropping. This is because smallholder farmers operate under diverse socio-ecological constraints that limit the productivity of legumes and farmers' ability to scale up the integration of legumes into their farming systems.

The main source of nitrogen for these legumes is biological nitrogen (N_2)-fixation which does not benefit only the legumes but succeeding crops (mainly cereals) as well. The low nitrogen in the native soils of northern Ghana can therefore be supplemented with biologically-fixed nitrogen. A symbiotic rhizobium-legume association is required for this N-fixation. This symbiotic association can be exploited in agriculture if legumes are grown in soils having sufficient amounts of effective indigenous rhizobia strains. The number and effectiveness of indigenous rhizobia in soil have a direct influence on the amount of nitrogen fixed [3].

Groundnut and cowpea are said to be promiscuous, nodulating with many strains of rhizobia that are present in the soil. However, not all nodulation-inducing rhizobia are efficient in N fixation. The main concern is how to obtain legumes to contribute to the productivity of maize and other food crops associated with them. The most effective way to exploit the legume-rhizobia symbiotic association in agriculture is through production and use of inoculants [4] and increasing the land area under legumes cultivation. The production of inoculants involves identification and selection of effective strains specific to a legume crop, growing the bacteria in a laboratory and mixing it with a carrier for inoculating the seeds of the selected crop. This is undoubtedly the most economically-viable and environmentally-friendly option now in terms of supplying nitrogen to the legume crops.

Past efforts in sub-Saharan Africa including Ghana have stressed on increasing legume productivity and associated benefits to rural livelihoods. Current production of inoculants in SSA is limited to a few private/public organizations and it's far below the potential demand for this product. In Ghana, the soybean

inoculants which have been introduced to northern Ghana by the N_2Africa project and the AGRA-sponsored Soil Health Project on inoculants production, distribution and utilization is imported from LegumeFix (UK) and Nodumax (IITA, Ibadan, Nigeria) and MEA (Nairobi, Kenya). Continuous reliance on these supply chains is not sustainable. As a result, more public-private partnerships will need to be established to trigger initial investment in inoculants production and/or supply. However, the few private/public organizations in SSA that have been involved in limited production have identified specific constraints related to supply chains, notable of which are quality assurance and proper storage conditions. Furthermore, lack of peat deposits or other suitable materials in Africa limits accessibility to highest quality carriers, and the technical skills and capacity for investment in industrial microbiology are limiting attraction to investment. Difficulties in identifying, as well as ensuring, ready markets may contribute to these constraints. Nonetheless, the initiation and growth of an inoculant industry parallel to expanding legume production is seen as necessary and inevitable if the latter is to succeed.

In response to these constraints, AGRA (Alliance for a Green Revolution in Africa) signed an agreement with the Savanna Agricultural Research Institute (SARI) of the Council for Scientific and Industrial Research (CSIR) to implement the AGRA's Soil Health Project on "Enhancing Soil Health in northern Ghana: Inoculants Production, Distribution and Utilization through Public-Private Partnership" with one of its objective being increasing the adoption and use of legume inoculants by smallholder farmers in northern Ghana. As part of the promotion of the legume inoculants, the role of the private sector has been highlighted to ensure up-take of the technology and up-scale to a larger number of farm households in northern Ghana. The ultimate aim of this partnership is to create business opportunities for the private sector as well as create employment for the youth. In order to assess the readiness of the private sector to take up the technology, it is very important to do an initial willingness assessment on the part of the private sector that will inform investment decision. Based on this backdrop, the present study was designed to generate relevant information on the private sector willingness to invest in the legume inoculants using the Double Hurdle approach.

2. METHODOLOGY

2.1 Theoretical Framework

The rational expectation theory assumes that an individual chooses a production mix that maximizes profit [5,6]. However, this assumption can be considered as a narrow perspective of describing an individual's willingness to invest in a technology. Agro-input dealers' investment decision in legume inoculants is modeled as a dichotomous choice involving two mutually exclusive alternatives based on differences in socio-economic characteristics among willing and non-willing agro-input dealers [7]. A technology is worth investing in if the expected utility derived from investment is higher than the expected utility from non-investment. Assuming U_{wi} is the expected utility derived from investment in legume inoculants by the *ith* agro-input dealer and U_{zi} is the expected utility from non-investment in legume inoculants by the *ith* agro-input dealer. According to [8], the observed choice between the two reveals which one provides the greater utility. An individual decides to invest if the expected utility derived from investment (U_{wi}) exceeds that from non-investment (U_{zi}) such that the difference (y_i^*) between the two states is given as:

$$y_i^* = U_{wi} - U_{zi} = x_i\beta + \varepsilon_i > 0 \quad (1)$$

However, the two utilities are unobservable thus can be expressed as a function of observable components in the latent variable model below:

$$y_i^* = x_i\beta + \varepsilon_i > 0 \; where \; y_i = \begin{cases} 1 \; if \; y_i^* > 0 \\ 0 \; otherwise \end{cases} \quad (2)$$

Where y_i is the binary willingness decision variable of investment in legume inoculants (P = 1) and non-investment (P = 0); x is a vector of explanatory variables; and ε_i is the random error term.

Following from [8], the Probit model is specified as:

$$Prob(y_i = 1|x_i) = \int_{-\infty}^{x'\beta} \emptyset(t)dt = \Phi(x_i'\beta) \quad (3)$$

Where $\emptyset(.)$ and $\Phi(.)$ correspond respectively to the density function and the cumulative distribution function of the normal distribution.

It is also hypothesized that willingness to invest and the intensity of investment can be jointly or separately made. The Tobit model is used when

the two decisions are jointly made [9]. However, it is also possible that decision on investment and intensity of investment may be made separately which justifies the use of the Double Hurdle (DL) model and the Heckman Sample Selection model [10]. Both Heckman and the Double Hurdle estimation methods, treat investment as a two-step decision process which is independently determined unlike the Tobit model where both decision to invest and the intensity of investment are jointly determined. The Double Hurdle and Heckman's model both adopt the Probit model to determine the investment decision of agro-input dealers at the first stage but the Double Hurdle uses a truncated model to determine the extent of investment. The Heckman's method assumes that the factors that determine willingness to invest are different from those that influence the intensity of investment.

In the Double Hurdle model, two separate stochastic processes determining the willingness to invest using the Probit model and the intensity of investment using truncated regression model. The two separate investment decision equations can be expressed as:

$$Y = Prob(Y|Y^* > 0) = m\alpha + \varepsilon \quad (4)$$

$$Z = E(Z|Z^* > 0) = x\beta + \mu \quad (5)$$

Where Y represent the investment decision state, Y^* the latent investment state, Z is the amount willing to invest in the legume inoculants technology, Z^* the latent intensity state and conditional to the investment decision, m and α vectors of independent variables and coefficients respectively for the investment decision, x and β vectors of independent variables and coefficients respectively for the intensity of investment and ε and μ are the error terms.

In order to justify the use of the Double Hurdle, a restriction test was carried out using the log likelihood values obtained from a separate estimation of Tobit, Probit and Truncated regression models [11]. The following likelihood ratio statistic was computed using the formula below:

$$\lambda = 2(LL_{Probit} + LL_{Truncreg} - LL_{Tobit}) \quad (6)$$

The test statistic has a chi-square distribution with degrees of freedom equal to the number of independent variables (including the intercept). The Tobit model is rejected in favour of the Double Hurdle model if λ exceeds the appropriate chi-square critical value [12]. Table 1B shows the list of explanatory variables and their *a priori* expectations.

2.2 Sampling and Data Collection

Selection of the agro-input dealers followed a multi-stage sampling technique. The districts with high representation of agro-input dealers were purposively selected followed by a random selection of the agro-input dealers. In all, 200 agro-input dealers were selected across the three Northern Regions.

The study relied basically on primary data. The data for this study was obtained from a survey of agro-input dealers in northern Ghana between April and May, 2015. A semi-structured questionnaire was used to capture socio-demography, knowledge of legume inoculants, investment decision, and general business practices of agro-input dealers in northern Ghana.

3. RESULTS AND DISCUSSION

3.1 Descriptive Characteristics of Agro-input Dealers

Table 1 shows the socio-demography of the agro-input dealers based on regional disaggregation. The results show that the average age of the sampled agro-input dealers is 39 years indicating the youthfulness of the agro-input dealers in northern Ghana (Table 1). Normally people in such age bracket are energetic, innovative and adventurous which are essential in the operation of agro-business. Investment in legume inoculants can be high for people in such age group since they have more time to test technology and make decisive choices concerning inoculants sales. Comparatively, agro-input dealers in the Upper West Region are relatively older than those in the other regions. [13] also observed a mean age of 39 years among sampled agro-input dealers in Kenya. The average number of household members across the three regions is eight. Households in northern Ghana are often noted for relatively high numbers of household members. A typical household in the sampled areas consists of four educated and three economically active members (Table 1). Both categories of household members contribute immensely to the economic well-being of the

household. On the average, agro-input dealer businesses in the study area are relatively old. Based on the sample, it can be inferred that agro-input dealers in Upper West have been in existence for quite a long time relative to those operating in the Northern and Upper East Regions. The results contradicts the findings of [13,14] who independently recorded mean age of seed trading businesses in Eastern Kenya to be 5.5 years and 60 percent of agro-dealers having been in operation for 5 years or less in Machakos and Uasin Gishu respectively.

In terms of education, about 36 percent of the agro-input dealers have attained Junior High School (JHS) education followed by 26 percent with no formal education and 19 percent with primary education (Table 1). Based on regional disaggregation, more agro-input dealers in the Upper East Region have attained tertiary education relative to those in the other regions. Education is expected to positively influence an individual's ability to source and interpret information concerning chemical handling, and usage. The sampled agro-input dealers are primarily engaged in both farming and trading. Majority (58%) of the respondents in the Upper West Region are traders relative to those in the Northern and Upper East Regions. In terms of nativity, 81 percent of the agro-input dealers are natives which give them unlimited access to communal resources (Table 1). Membership of an association provides opportunity for knowledge sharing, access to credit, and timely information for effective planning. The results show that 44 percent and 40 percent of the sampled agro-input dealers belong to farmer associations and agro-input dealers associations respectively.

The result elucidates that 79 percent of agro-input dealers have knowledge about legume inoculants and use which is almost similar across the three regions (Table 2). Agro-input dealers obtain information on inoculants from different sources such as NGOs, research institutions, other agro input dealers, and some lead farmers. Research institutions served as the major source of information on legume inoculants. However, the situation varies in the Upper East Region where NGOs served as the main source of information on inoculants (Table 2). Extensive interaction between NGOs and input dealers in Upper East accounted for variation in the results. Most of these NGOs engaged in development programmes are able to reach out to more

Table 1. Socio-economic characteristics of agro-input dealers

Variable	Region			Overall
	Northern	Upper east	Upper west	
Age	37	40	43	39
Household size	9	8	8	8
Educated household members	3	4	4	4
Economically active household members	3	3	3	3
Trading experience	13	14	18	15
Level of education				
• None	36	12	19	26
• Primary	21	20	14	19
• JHS	31	37	42	36
• SHS	9	14	17	13
• Tertiary	1	14	6	6
• Technical/Vocational	1	2	0	1
Main occupation				
• Farming	53	59	39	51
• Public service	1	2	4	2
• Trading	44	39	58	46
• Artisanship	2	0	0	1
Nativity	82	74	85	81
Membership of association	43	49	37	43
Type of association				
• Farmer based organization	40	58	37	44
• Traders association	26	2	11	16
• Agro-input dealers association	35	38	53	40

community with extension information received from research institutions. In northern Ghana, about 76 percent of agro-input dealers are willing to invest in legume inoculants business. Interestingly, all the sampled agro-input dealers in the Upper East Region are willing to engage in the sale of inoculants to farmers whilst 80 percent and 50 percent of those in Northern and Upper West Regions respectively are commercialize legume inoculants (Table 2).

Most (76%) of the sampled agro-input dealers in northern Ghana have benefited from training on the use and storage of legume inoculants. Agro-input dealers in Northern Region have been the most beneficiary of these trainings probably due to the presence of research institutions and numerous NGOs working with smallholder farmers and input dealers in the region (Table 2). Training on inoculants technology was conducted by different organizations. Specifically, 73, 94 and 63 percent of inoculants trainings in the Northern, Upper East and Upper West Regions respectively were conducted by research institutions. However the Upper West Region recorded the highest number of trainings (38%) organized by an NGO (Table 2).

The results also show that farmers who have come into contact with the sampled agro-input dealers are willing to use the inoculants on their legumes. The primary target customers of the agro-input dealers are individual farmers followed by farmer-based organizations (FBOs) and other agro-input dealers. Inoculants technology can be disseminated successfully with active participation of the private sector such as agro-input dealers. It is observed that 78 percent of the sampled agro-input dealers are willing to expand their business to accommodate the sale of legume inoculants (Table 2).

Fig. 1 shows the proportions of farmers that inoculate soybean, cowpea and groundnut in in northern Ghana. According to the agro-input dealers, farmers usually purchase inoculants for use on the different leguminous crops. The study specifically revealed that about 70 percent, 55 percent and 50 percent of farmers in Northern, Upper East and Upper West Regions respectively inoculate soybean. Following the soybean is groundnut and with cowpea inoculation not a popular practice among majority of the farmers per the agro-input dealers' assertion. The result has implication for targeting

Table 2. Knowledge, source and training in legume inoculants technology

Variable	Region			Overall
	Northern	Upper east	Upper west	
Knowledge of inoculants technology (%)	79	71	73	76
Source of information (%)				
• NGO	36	37	30	35
• Research institution	54	0	67	60
• Farmer based organization	1	0	0	1
• Extension	0	0	3	1
• Radio	1	0	0	1
• Other farmers	3	0	0	1
• Agro-input dealers	5	0	0	3
Willingness to invest in legume inoculants (%)	80	100	50	76
Inoculants training (%)	75	73	64	72
Training organizers (%)				
• NGO	22	6	38	22
• Research institution	73	94	63	75
• Other agro-input dealer	5	0	0	3
Farmers willingness to buy legume inoculants	96	91	100	96
Target customers of agro-input dealers				
• Individual farmers	88	86	84	87
• FBOs	7	9	16	10
• NGOs	2	0	0	1
• Agro-input dealers	4	5	0	3
Business expansion plan	79	81	72	78

of customers as well as education of farmers on the benefits of legume inoculation. Sensitization and education of farmers on the use of inoculants is likely to stimulate increase in adoption and subsequent increase in supply on the part of agro-input dealers.

3.2 Descriptive Characteristics of Agro-Input Dealers by Investment Status

Table 3 shows the means of agro-input dealers' characteristics by investment status. The results show that 47 percent of the agro-input dealers are willing to invest in legume inoculants. Agro-input dealers who are willing to invest in legume inoculants are significantly distinguishable in terms of awareness of legume inoculants and access to loans. Input dealers who are willing to invest in legume inoculants have relatively higher level of awareness about legume inoculants relative to the non-willing agro-input dealers. The results emphasize the importance of awareness creation in the adoption and investment decision process. The categories of agro-input dealers who are unwilling to invest in legume inoculants have relatively higher access to agricultural loan. The result therefore implies that access to loan does not necessarily guarantee investment in legume inoculants but improves the business capacity of agro-input dealers. However, access to the legume inoculants may be a limiting factor even when credit is available.

3.3 Factors Influencing Willingness and Intensity of Investment in Legume Inoculants

This study adopted the Double Hurdle over the Heckman sample selection approach based on the Heckman results in the appendix (Table 1B). The rho value of -0.061 indicates that there is negative correlation between the error terms of the investment decision equation and intensity of investment equation. The Wald test indicates the correlation is not significant thus using Heckman's technique will be misleading (Table 1B).The probability and intensity of agro-input dealers' willingness to invest in legume inoculants was estimated using the Double Hurdle approach. The Double Hurdle was best suited for the data based on the restriction test. Test statistics of Tobit model and Double Hurdle model are shown in Table 4. The Tobit model was rejected in favour of the Double Hurdle model since the computed lambda (λ) from the likelihood ratios exceeded the critical chi-square (chi2) value. The results confirm the superiority of the Double Hurdle specification over the Tobit model. It can therefore be concluded that decision on willingness to invest and intensity of

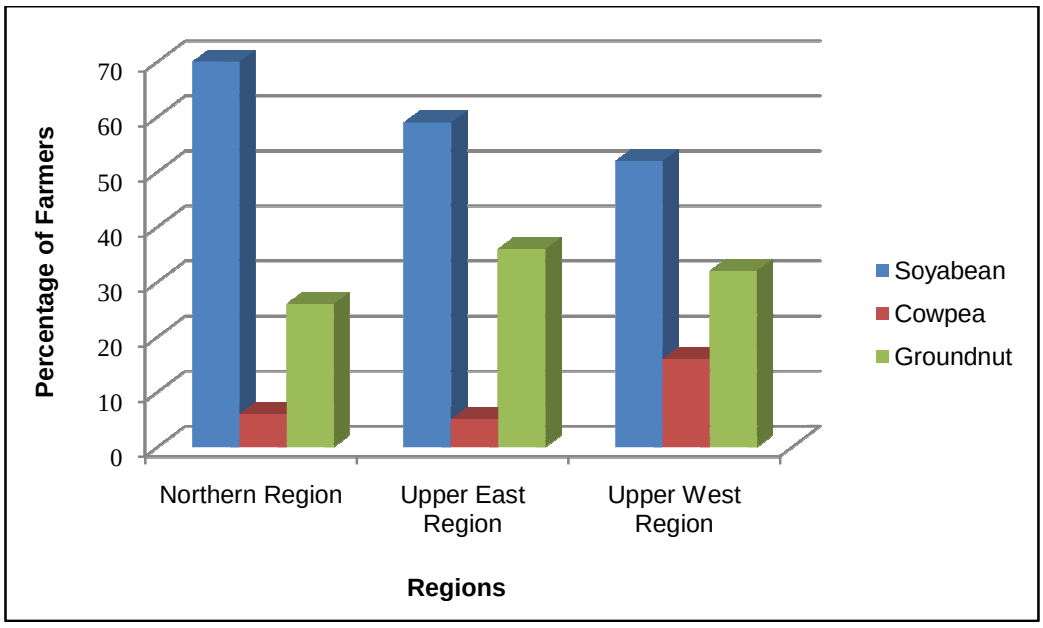

Fig. 1. Farmers' choice of legume inoculation in Northern Ghana

investment are made separately. Willingness to invest and intensity of investment are determined by different set of factors however; economically active household members, inoculants training, and agro-ecology influenced both decisions.

Awareness of inoculants, age, economically active household members, participation in inoculants training, and agro-ecology significantly determine willingness to invest in legume inoculants. However, intensity of investment is significantly determined by economically active and educated household members, inoculants training, agro-ecology, access to financial institutions and main occupation of agro-input dealer (Table 4).

Awareness of inoculants is a necessary condition for investment in the legume inoculants business. For agro-input dealers who are aware of legume inoculants, the probability of investing in it is 44 percent higher than those who are unaware of the legume inoculants. Awareness of an existing technology empowers an individual to make an informed decision about an innovation or technology. Knowledge about a technology influences perception, expectation and adoption decision [15]. However, awareness of legume inoculant does not influence the extent to which agro-input dealers are willing to invest in the commercialization of the technology. Continuous education on the use and benefits of the technology will enhance investment decision. Intensive business capacity building of agro-input dealers will eventually increase interest and investments in the technology.

Willingness to invest in legume inoculants is significantly influenced positively by age of agro-input dealer. A unit increase in the age of the agro-input dealer leads to a marginal change in the probability of an agro-input dealer to invest in legume inoculants (Table 4). The result suggests that older agro-input dealers are more willing to invest in inoculants technology. Usually, it is expected that younger entrepreneurs are more risk-loving compared to relatively older entrepreneurs. Relatively older agro-input dealers may have expressed willingness due to the information received regarding the legume inoculant against the backdrop that farmers use less or no fertilizer on legumes. However, age of agro-input dealer was insignificant in the determination of intensity of investment decision. Targeting of potential traders of the legume inoculant must include both young and old coupled with intensive education and technical guidance to increase decision on the extent of legume inoculant investment in Ghana.

The number of economically active household members positively and significantly influences willingness and intensity of investment in legume inoculants. A unit increase in the number of economically active household members results in 8 percent and 1 percent increase in willingness and intensity of investment in legume inoculants respectively. Usually, economically active members contribute to household income that can enhance intensity of investment in legume inoculants. In the absence of credit, an agro-input dealer may depend on the household members who are economically active to

Table 3. Agro-input Dealers' characteristics per investment status

Variables	Willing to invest (N=64)	Non-willing to invest (N=136)	Probability
Age	39(8.391)	39(9.461)	0.717
Sex	0 .877(0.331)	0.904(0.295)	0.554
Marital status	0.922(0.270)	0.926(0.263)	0.909
Education	0.753(0.434)	0.733(0.444)	0.758
Trading experience	14(7.587)	15(8.553)	0.304
Household size	9(3.387)	8(3.634)	0.485
Educated household members	4(2.331)	4(2.188)	0 .237
Economically active household members	3(1.279)	3(1.369)	0.297
Membership of association	0.415(0.497)	0.434(0.497)	0.806
Awareness of inoculants	0.954 (0.211)	0.659(0.476)	0.000***
Access to agricultural loan	0.053 (0.229)	0.289(0.456)	0.031**
Access to financial institution	0.046(0.211)	0.015(0.121)	0.182
Nativity	0.815(0 .391)	0.933(1.526)	0.539
Amount willing to invest	0.059(0.155)	0.038(0.115)	0.299

Notes: Standard deviations are in parentheses. The t-statistics was used for two groups mean comparison
**** p < 0.01, ** p < 0.05*

Table 4. Factors influencing legume inoculants investment decision

Variables	Double hurdle				Tobit	
	Probit		Truncated			
	Marginal effect	Std. error	Marginal effect	Std. error	Marginal effect	Std. error
Awareness of inoculants	0.443***	0.050	0.027	0.018		
Age	0.011*	0.007				
Marital status					0.307	0.189
Membership of FBO	-0.085	0.072				
Economically active persons	0.075**	0.030	0.011*	0.006	-0.071*	0.039
Educated household members			-0.007*	0.004	0.048**	0.024
Inoculants training	-0.460***	0.060	0.030*	0.017	1.194***	0.099
Agro-ecology	0.147**	0.075	0.033**	0.014	0.071	0.090
Household members in trading business	-0.047	0.042				
Trading experience	-0.010	0.007	0.001	0.001	0.003	0.006
Access to financial institution			0.360***	0.052		
Trading in inputs as primary occupation			0.029**	0.014	0.234***	0.088
Nativity					-0.107	0.103
LR chi2(8)	80.19				155.32	
Wald chi2(9)			106.29			
Prob>chi2	0.000		0.000		0.000	
Pseudo R2	0.3248				0.371	
Log likelihood	-83.366		180.216		-131.615	
Likelihood ratio test statistics (λ)			263.934***			

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$

support in the business. Alternatively, economically active members may also not depend on the agro-input dealers thus leading to further investment of profit in the business.

The number of educated household members significantly affects the intensity of investment in legume inoculants negatively. The intensity of investment decreases marginally for a unit increase in the number of educated household members. The plausible reason is that, education increases an individual's ability to make an independent decision as well as reducing the possibility of engaging in agricultural activities. Agriculture has been perceived to be a vocation for the uneducated despite recent effort to correct that perception. This has led to increase in non-agricultural job opportunities at the expense of agriculture. Lack of investment in agriculture on the part of government has further worsened the situation. The implication of this finding is that there must be conscious effort by government and its development partners to encourage educated members of society into agriculture coupled with sufficient financial and technical support.

Training of agro-input dealers negatively influences willingness to invest in legume inoculants but significantly increases the intensity of investment in the technology. A unit increase in the number of trainings in the legume inoculants technology reduces the willingness to invest in the technology by 46 percent but increase the intensity of investment by 3 percent (Table 4). Training of agro-input dealers on the use and storage of inoculants does not guarantee willingness to invest in the technology. It is also possible that agro-input dealers may not immediately appreciate the benefits of training which tends to influence their willingness to invest in the sale of legume inoculants. However, subsequent training on the use and benefits of legume inoculants is expected to reinforce their existing knowledge and later influence their intensity of investment in the legume inoculants.

Agro-ecology is observed to significantly increase both willingness and intensity of investment in legume inoculants by 15 percent and 8 percent respectively (Table 4). The agro-ecological zone determines the profitability of investment in technologies [16]. Agro-input dealers in the Guinea Savanna agro-ecological zone are well positioned in terms of investment in legume inoculants due to the importance of leguminous crops in the zone. The Guinea Savannah agro-ecology contributes largely to the national area cropped to legumes [17]. Increase in cultivation of leguminous crops in the Guinea Savannah agro-ecology may be complemented by an increase in soil fertility enhancing technologies such as the use of inoculants. The use of inoculants is far less expensive than other soil fertility enhancing technologies thus stimulating willingness of farmers' adoption and subsequently leads to an increase in the intensity of investment on the part of the input dealers.

Agro-input dealers who have access to financial institutions are 36 percent more willing to intensively invest in legume inoculants as compared to those without access to financial institutions (Table 4). Access to financial institutions increases the probability of accessing funds for investment in legume inoculants. Agriculture in Ghana has been perceived to be more risky due to high dependence on rainfall hence reducing financial institutions commitment to invest in the sector. However, the trend is gradually changing especially when development partners are working closely with financial institutions to advance credit for the agricultural players. Currently, projects such as the Alliance for a Green Revolution in Africa (AGRA) Soil Health Project, and Agricultural Value Chain and Mentorship Project (AVCMP) in the northern Ghana provided financial support for input dealers to service farmers' needs. The implication of the result is that in the promotion of the legume inoculants among agro-input dealers, conscious efforts must be made to link them to financial institutions.

Finally, trading in farm inputs as a primary occupation increases an individuals' intensity of investment decision in legume inoculants. Per the result, an individual who trades in inputs as a primary occupation is more willing to intensify investment in legume inoculants by 3 percent relative to those engaged in other primary occupations (Table 4). The potential benefits associated with the sale of legume inoculants will be much more appreciated by an agro-input dealer relative to those involved in other occupations. Agricultural development projects in northern Ghana that promotes the use of inoculants among smallholder farmers must target agro-input dealers who primarily trade in farm inputs.

4. CONCLUSION

This paper assessed the factors influencing agro-input dealers' willingness and intensity of investment in legume inoculants in northern Ghana. The results show that agro-input dealers are exposed to legume inoculants use and economic benefits by research institutions and NGOs. Willingness to invest in legume inoculants is relatively high among agro-input dealers. Determinants of willingness to invest in the technology is significantly influenced by awareness of inoculants, age of agro-input dealer, economically active household members, participation in trainings on inoculants, and agro-ecology whereas intensity of investment is determined by economically active and educated household members, training on inoculants, agro-ecology, access to financial institutions and primary occupation of agro-input dealers. It is established that economically active household members, inoculants training, and agro-ecology influence both investment decisions. There is the need to continuously sensitize and train agro-input dealers on the use and benefits of legume inoculants in order to influence investment decisions. Secondly, facilitation of linkages between financial institutions and agro-input dealers by research and NGOs must be encouraged and strengthened in order to sustain these decisions. Finally, in the promotion of the legume inoculants, conscious effort must be made to target individuals who primarily trade in farm inputs to enhance investment decision and visibility of the product among smallholder farmers.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table 1A. Heckman selection model estimates of investment decision

Heckman selection model — Number of obs = 197
(regression model with sample selection) — Censored obs = 134
Uncensored obs = 63

Wald chi2(8) = 46.63
Log likelihood = -25.68758 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
invest						
sex	.076966	.0417206	1.84	0.065	-.0048049	.1587368
mainoccup	.0566501	.0292317	1.94	0.053	-.0006429	.1139431
eduhhmem	-.0107387	.0075196	-1.43	0.153	-.0254768	.0039995
econactive	.0096741	.0140129	0.69	0.490	-.0177907	.0371388
financialink	.0730228	.077153	0.95	0.344	-.0781943	.2242399
agcolgy	.007553	.028563	0.26	0.791	-.0484294	.0635354
inocuknwdge	.018227	.0807271	0.23	0.821	-.1399951	.1764492
inocutrain	.1616202	.0584508	2.77	0.006	.0470588	.2761817
_cons	-.0756848	.1188526	-0.64	0.524	-.3086316	.1572619
willingness						
inocuknwdge	2.256698	.3624857	6.23	0.000	1.546239	2.967156
age	.034551	.020816	1.66	0.097	-.0062476	.0753497
massociation	-.28891	.2524347	-1.14	0.252	-.783673	.2058529
econactive	.2341996	.0968452	2.42	0.016	.0443865	.4240127
inocutrain	-1.782303	.2830802	-6.30	0.000	-2.33713	-1.227476
agcolgy	.4671727	.2426534	1.93	0.054	-.0084192	.9427646
busihlphhmem	-.142325	.1390318	-1.02	0.306	-.4148222	.1301723
farmexp	-.0320221	.0221099	-1.45	0.148	-.0753567	.0113126
_cons	-3.161345	.7515625	-4.21	0.000	-4.634381	-1.68831
/athrho	-.0612281	.3658255	-0.17	0.867	-.7782329	.6557767
/lnsigma	-2.333211	.0901255	-25.89	0.000	-2.509854	-2.156569
rho	-.0611517	.3644575			-.6516913	.5755459
sigma	.0969838	.0087407			.0812801	.1157215
lambda	-.0059307	.0354317			-.0753756	.0635141

LR test of indep. eqns. (rho = 0): chi2(1) = 0.03 Prob > chi2 = 0.8696

Table 1B. List of explanatory variables and a priori expectation

Variable	Description	A priori
Age	Age of agro-input dealer measured in years	+/-
Sex	1 if agro-input dealer is a male and 0 otherwise	+/-
Marital status	1 if agro-input dealer is married and 0 otherwise	+
Education	Number of years of formal education	+
Trading experience	Number of years of trading experience	+
Household size	Total number of household size	+/-
Economically active household members	Proportion of household members that are economically active	+
Educated household members	Proportion of household members that are educated	+/-
Household members in trading business	The number of household members that assist directly in the agro-input business	+
Membership of association	1 if agro-input dealer belongs to an association and 0 otherwise	+
Agro-ecology	1 if agro-input dealer resides in Guinea Savanna agro-ecology and 0 otherwise	+/-
Inoculants training	Number of trainings received on inoculants handling	+
Awareness of inoculants	1 if agro-input dealer is aware of inoculants and 0 otherwise	+
Access to financial institution	1 if agro-input dealer has access to financial institutions and 0 otherwise	+
Trading in inputs as primary occupation	1 if agro-input dealer primarily trades in inputs sales and 0 otherwise	+/-
Nativity	1 if agro-input dealer is a native and 0 otherwise	+/-

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