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EFFECT OF FARMERS' ADOPTION OF SOYBEAN INOCULANTS ON OUTPUT IN THE EAST GONJA DISTRICT IN THE NORTHERN REGION, GHANA

BY

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DECLARATION

CANDIDATE'S DECLARATION

"I NASIRU ADAM, declare that references contained in published works which have all been duly cited and acknowledge, this work is the result of my own innovative research and it has not been submitted, either in part or whole for another degree elsewhere"

Signature …………… Date …………………….

SUPERVISORS'S DECLARATION

I, Hudu Zakaria, hereby certify that the preparation and presentation of this thesis were supervised in accordance with the guidelines for preparation and submission of thesis laid down by the School of Research and Graduate Studies, University for development Studies, Tamale

Supervisor Signature……………………

Date………………………

Hudu Zakaria

(Supervisor)

DEDICATION

To Allah be the Glory

I didcate this work to the entire family of Alhaji Yari especially Wedad, Maisha and Abdul Hamid Yari

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ABSTRACT

The primary objective of this study was to identify the factors that influence adoption of soybean inoculant and its effect on productivity of farmers in the East Gonja District. The study adopted a multi-stage sampling approach, with the first stage involved random sampling of 10 communities in the district. In the second-stage, stratified random sampling techniques were employed in which soybean farmers in the selected communities were stratified into adopters and non-adopter. Finally, simple random sampling technique was then employed to sample 150 adopters and 150 non-adopters. In total, 300 respondents were sampled for the study. Through personal interviews, key informant interviews and observations, data were collected from the sampled 300 farmers and three extension field officers. Descriptive and inferential statistics were employed in analysing the data gathered. Tobit and ordinary least squares (OLS) regression models were used to understand adoption and its performance. The finding shows that farmers' age and sex, are significant and negatively related to adoption, while household size and perceptions of inoculant with regards to cost, environmental friendliness are significant positively related to adoption. The studies also revealed that rhizobium inoculant use and weedicide use were significant determinants of soybean productive among soybean farmers in the East Gonja District of Northern Region. Poor accessibility and problem of storage of inoculants as well as complexity of soybean inoculant use were the constraints farmers faced in the use of soybean inoculant. The study recommends that ministry of food and agriculture and other stakeholders in the soybean industry should ensure that rhizobium inoculant would be made readily available to Agro inputs dealers' shops for easy accessibility by farmers.

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ABBREVIATION AND ACRONYM

BNF	Biological Nitrogen Fixation
EGD	East Gonja District
FAO	Food and Agricultural Organization
FAOSTAT	Food and Agricultural Organization of United Nation
GSS	Ghana Statistical Service
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
MDGs	Millennium Development Goals
MiDA	Millennium Development Authority
MOFA	Ministry of Food and Agriculture
NGO	Non-Governmental Organisation
SARI	Savannah Agricultural Research Institute
SEND	Social Enterprise Development of West Africa
SSA	Sub-Saharan African
TAM	Theory Acceptance Model
TPB	Theory of Planned Behaviour
USAID	United State Agency For International Development

CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Poor soil fertility is a major challenge in achieving food security and rural development in Sub-Saharan Africa (Sanginga and Woomer, 2009). Nutrient exhaustion, is a key factor in low soil fertility when nutrients removed through crop off-take and other loses are not adequately replaced. This phenomenon is widespread across sub-Saharan Africa countries (Onwonga and Freyer, 2006). Nitrogen is the most affected because of its high uptake, vulnerability to leaching, losses in gaseous form and through crop harvest. The use of chemical fertilizers to improve the problem of low soil fertility is limited by high cost of inputs leading to very low usage per unit area. Moreover, smallholders fail to use the recommended rates of inorganic fertilizers (Onwonga and Freyer, 2006).

Nitrogen and phosphorus are the two major nutrients that largely limit plant growth in smallholder farms in Sub-Saharan Africa. According to Hungria and Kaschuk, (2014), leguminous plants need high amount of nitrogen (N) for grain yield, but it is difficult for smallholder farmers with limited resources to supply the needed high N quantities. Most low income farmers tend to plant legumes without any major external input thus obtaining low yields. Under such conditions, legumes depend on biological nitrogen fixation through symbiosis with rhizobia to partially or fully meet their N requirement (Hungria and Kaschuk, 2014). Though, most of the original rhizobia cannot meet all the N requirements of legumes even when promiscuous soybeans are planted (Sanginga et al., 1996).

Rhizobial inoculation of legumes is a common and widespread practice in other parts of the world (Albaredaetal, 2009). However, in Africa, particularly Ghana, the practice is relatively new to farmers.

There have been conflicting reports of the performance of inoculants in many African countries due to the differences in types and quality of strains used in this inoculant. However, few studies in Ghana have attempted to demonstrate the effect of legume inoculation and its economic importance in farmers' field. Dogbe et al. (2013) studied the effect of *Rhizobium* inoculation and its economic importance on farmers 'field in Northern Ghana. Their study demonstrated significant increase in grain yield at the sites studied. They, therefore, concluded that there are greater economic benefits in using *Rhizobium* inoculants. Thus, the introduction of local or exotic strains that are proven highly competitive and effective could potentially increase grain legume production.

Among the factors for selecting *Rhizobium* strains, effectiveness is of major importance. In recent times, there have been interventions by various non-Governmental Organizations (NGOs) to increase the yield of soybean for smallholder farmers through rhizobia inoculation. The importance of soybean (Glycine max L) is key, a crop with multiple uses as a source of nutrients in human diet such as protein, vitamins and oil for the, a source of livestock and aquaculture feed, and industrial or commercial biofuel (Raghuvanshi and Bisht, 2010). Nutritionally, the crop contains 30% cholesterol free oil, 40% protein and essential vitamins for effective body nourishment (Mokhtar, et al., 2011). Its production is a very prominent source of income and source of livelihoods for many households (Mbanya, 2011). The crop is not widely grown in Ghana (Akramov and Malek, 2012). In Ghana, the crop is mainly produced under rain-fed conditions on small farms, averagely 3 acres (IFPRI, 2007).

National estimates show that the crop is principally produced in the northern regions, especially the eastern corridor of the Northern Region (Dogbe, 2013). SRID (2012) reported that soybean production in the northern regions alone account for about 77% of the national production.

As of the year 2010, the average yield of soybean was estimated to be up to 0.8 metric tons per hectare. But the potential achievable yield for soybean is pegged at 4.5 metric tons per hectare under the best agricultural practices in Ghana (MiDA, 2010). Thus the national achieved yield is less than 30% of its achievable yields and only 7% of favorable land allocated is to soybeans (Masuda and Goldsmith, 2009; Hartman et al., 2011).

Globally, in 2010, the demand for soybean is estimated to be up to 300 million tons which exceeds the current production level of 40 million tons (FAO, 2010). Soybean is usually rotated with cereals such as maize, millet, sorghum because of its ability to improve soil nutrients (IFPRI, 2012). The crop depends highly on soil macro-and-micronutrients such as Sulphate, Triple Superphospate and potassium.

The National Variety Release and Technical Committee under the MoFA approved three soybean genotypes released by Savannah Agricultural Research Institute (SARI) with a call on farmers in Northern Ghana to purchase the seeds to help improve their yields (MoFA, 2013). The three seeds are; afaya, songda and Janguma among other crops (rice and maize) is noted to receive potential government investment in order to address the problems of food insecurity, rising food prices and import bills by enhancing the competitiveness of its production (IFPRI, 2012). In the absence of the nutrients, its fails to produce the maximum yields.

Low soil fertility, poor varieties, poor climatic conditions, limited utilization of rhizobia inoculants and low application of chemical or organic fertilizer mitigate against its yields (FAO, 2010; Dogbe, 1998; Woomer *et al*., 2012).

Soybean has a unique ability to fix atmospheric nitrogen through symbiotic association with root nodule bacteria and could be used to improve the yields of legumes in sub-Saharan Africa, since current yields are only a small fraction of their potential (Abaidoo et al., 2013).

It is capable of fixing between 44 and 300 kg of nitrogen per hectare which makes a significant nitrogen contribution to intercropped and rotated cereal crops. It is less susceptibility to resist pests and diseases and can stay longer in storage (Ugwu and Ugwu, 2010). It also has broader leaf biomass which translates into soil fertility benefit to other crops. But, one key ingredient that it needs for proper and effective nodulation is nitrogen. However, this is a limiting factor hindering the growth and nodulation of soybean in northern region because of poor soil fertility. Researchers have reported that Biological Nitrogen Fixation (BNF) serves as a potential alternative to inorganic nitrogen-fertilizer in agriculture, which is environmental friendly and cost effective (Bala, 2011).

Inoculating legumes with rhizobia has been used to achieve substantial increases in legume nodulation, grain and biomass yield, nitrogen fixation and post-crop soil nitrate levels over this period. It is renowned that, most soybean farmers rely on chemical fertilizers as nutrient supplements with the aim of improving the crop yields (Asante, 1999). Artificial rhizobia inoculant for soybean is an organic source of nutrient which aids in nodulation. But it is not widely known especially in sub-Saharan Africa. For example, less than 1% of farmers use inoculants in sub-Saharan African (Karanja et al., 2000).

This study therefore focuses on identifying factors which influences farmers' use of rhizobia inoculants for soybean and its effect output in East Gonja district.

1.2 Problem Statement

Soybean is the major cash crop widely cultivated in northern Ghana and some parts of central and Volta regions where the crop is well adapted, (Abaidoo, Ewusi, and Asei, 2015). Because of the economic potential of soybean and the fact that these regions are the poorest regions in Ghana (GSS, 2015) soybean cultivation has long been promoted among smallholder farmers, especially women, as a means of eluviation poverty in these areas (Akramov and Malek, 2012; Avea, et al, 2016 and MiDA, 2010). Government and some Non-Governmental Organizations (NGOs) and have been implementing programmes and activities aimed at promoting soybean cultivation and marketing. Some of these programmes ranges from dissemination of improved seeds and innovative technologies in soybean production, financial support and subsidies to soybean value chain development and market facilitations (Avea et al, 2016, Dogbe et al, 2013; MiDA, 2010 & Mbanya, 2011).

Despite these efforts, yield gaps and production inefficiencies still exist among smallholder farmers. Available statistics indicate that yields of soybean in Ghana are low compared to the potential ones (Akramov and Malek, 2012; Avea et al. 2016; MiDA, 2010). According to estimates by Millennium Development Authority (MiDA), which is also cited in Akramove et, al, (2012) and Avea et al, (2016), the 2010 yield of soybean was 0.8 t/ha against an achievable yield of 2 t/ha and a potential yield of 4.5 t/ha. Also IFPRI reported in 2013 that average yield of soybean in 2012 was 0.9 t/ha against an achievable yield of 1.6 t/ha and a potential one of 4 t/ha.

Decreasing soil fertility coupled with low external supply of nitrogen and phosphorus, which are the major nutrient for plant growth, use of low yielding seeds, erratic rainfall pattern, limited utilization of rhizobium inoculants and inappropriate agronomic practices have been largely responsible for the low than potential yield of soybean in Ghana (Dogbe et al, 2013 Hungria and Kaschuk, 2014 and Woomer *et al*., 2012).

However, the increasing cost of chemical fertilizers within the past decades had led to the inability of most of the farmers to optimize their use, and thus exacerbating the low nitrogen problem in the soils of the Guinea savanna zone of Ghana (Frimpong, 2016). In this regard, changing elemental atmospheric nitrogen to organic forms by Biological Nitrogen Fixation (BNF) both by symbiotic and asymbiotic microorganisms in the soil had drawn much attention (Solomon et al., 2012). Since the discovery of BNF in the late 19th century, research works have been reported on its potentiality as an alternative to inorganic nitrogen fertilizer in agriculture (Bala, 2011; N'cho et al, 2013). This knowledge soon led to the practice of inoculation with early adoption achieved by transferring soil from field or soil to seed before planting. However, this was quickly replaced by the use of pure cultures on agar slants, and later as broths (Bala, 2011). Adoption of soybean rhizobium inoculants is useful to farmers especially in northern regions where the fertility of soils are poor. It is believed that most soils lack nitrogen, and soybean is highly affected leading to low yields (Dogbe et al. 2013).

This problem necessitates conscious efforts, to create awareness of soybean rhizobia inoculant among farmers. *Rhizobium* inoculants enrich soils deficient of nitrogen and enhance nodulation of soybean. They include both nitrogen-fixers and phosphate-solubilizers which enhances the availability of nitrogen and phosphate in the soil. Also, majority of the high-yielding varieties of soybean requires enough nitrogen and phosphate for high productivity. It is evident that, the farmers utilization of soybean rhizobia inoculants is limited (Bala et al. 2011).

As a result the use of *Rhizobium* inoculant is widely being promoted among soybean farmers in the Savannah Ecological Zone (Avea et al, 2016 and Dogbe et al, 2013). In Ghana, the utilization of the inoculant is highly stimulated by donor agencies such as IITA, N2-Africa and USAID (Woomer et al., 2013). In East Gonja district NGOs like SEND Ghana, Green earth revolution, are widely promoting the use of inoculant among the smallholder soybean farmers. In-spite of these persistent efforts, adoption of soybean inoculants among farmers in the District is still low and not encouraging. However, the researcher's search have not found any empirical study which have assessed factors affecting the adoption of soybean inoculant in the District and constraints affecting farmers' adoption. Such information would have been useful to policy makers and implementers of soybean productivity improvement programmes in their effort to promote the cultivation of soybean as a strategic crop for poverty reduction.

In response to this apparent lack of information, this study sought to analyse factors affecting adoption of soybean inoculant and its effect on productivity of soybean farmers in the East Gonja District of Northern region.

1.3 Research Question

The following questions were formulated to guide the study.

1.3.1 Main Research Question

Main research question is what factors influence adoption of soybean inoculant and how does the adoption affect productivity of soybean farmers in the East Gonja District?

1.3.2 Specific Research Question

1. What do soybean farmers in the East Gonja District know about soybean inoculants?

2. What perceptions do soybean farmers in the East Gonja District hold towards soybean inoculants?

3. What factors determines farmers' adoption of soybean inoculants among soybean farmers in the East Gonja District?

4. What is the effect of farmers' adoption of soybean inoculants on productivity among soybean farmers in the East Gonja District?

5. What are the constraints limiting soybean inoculant's use among soybean farmers in the East Gonja District?

1.4 Objectives of the Study

1.4.1 Main research objectives

The main objective of the study is to identify the factors that influence adoption of soybean inoculant and its effect on productivity of farmers in the East Gonja District.

1.4.2 Specific research objectives

Specifically, the study sought to:

1. Examine the knowledge of soybean farmers on soybean inoculants among soybean farmers in the East Gonja

2. Analyse farmers' perceptions towards soybean inoculants among soybean farmers in the East Gonja District.

3. Assess the determinants of soybean inoculants adoption among soybean farmers in the East Gonja.

4. Analyze the effect of soybean inoculants adoption on productivity among soybean farmers in the East Gonja.

5. Analyse the constraints to soybean inoculants use among soybean farmers in the East Gonja District.

1.5 Justification of the Study

Knowing farmers' adoption of Soybean inoculants is an important step in providing market information to potential investors who want to develop the Soybean industry. Adoption of soybean inoculant can be a gauge for alternative source of soil nutrients which can help government and other stakeholders to cut down huge expenditure on inorganic fertilizers in Ghana. As such information generated in this study comes as handy to policy makers and stakeholder in the soybean industry. The research also adds to the body of existing literature on soybean and adoption of soybean inoculants among farmers.

1.6 Operation Definition of Terms

Rhizobium Inoculant: This is an artificial nitrogen fixing bacteria, with the qualities of enhancing soil fertility and improving yields of soybeans.

Productivity: It is the expected output (yield) soybeans obtained per the unit of input (inoculant, weedicide, labour etc.) used on the farm.

Adoption: Adoption is the continuous usage of the inoculant technology by farmers after two years of its introduction in the study area.

1.7 Organization of the studies

The thesis is organized into five chapters. Chapter one deals with the introduction of the study. It focuses on the background of the study, problem statement of the research, objectives and questions of the study, the justification of the study and conceptual framework use for the study.

Chapter two reviews and discusses literature relevant to the topic to establish a theoretical approach for the research. The areas of literature considered very important to the study and provides enough evidence for analytical discussion to support the study.

Chapter three focuses on, instruments used to collect needed information for this study, it also presents research design, sampling procedure, data collection and analysis.

Chapter four presents results and discussions of findings of the research within the context of the study objectives.

Chapter five, the last chapter focuses on conclusion, implications and recommendations base on the findings of the research.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews related research which are relevant to this study. The chapter is divided into two parts. In the first part, the theoretical frameworks and conceptual framework that guide the study are discussed. Then in the second part of the chapter, related studies are reviewed.

2.1 Adoption Theories

This section presents theoretical review of adoption theories. They are Diffusion of Innovation Theory, Theory of Planned Behaviour (TPB) and Technology Acceptance Model (TAM).

2.1.1 Diffusion of Innovation Theory

According to Rogers, there are four critical elements in the analysis of the diffusion of innovations; the innovation, communication channels, social system and time. An innovation, according to Rogers is "an idea, practice that is perceived as new by an individual or unit of adoption". In Rogers, (1995) many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely recognized by potential adopters, and that the innovation will therefore diffuse quickly. Most innovations, in fact, diffuse at an inadequately slow rate." Diffusion is seen as "the process by which an innovation is communicated through certain channels over time among members of a social system". A technological innovation usually has two components: a hardware aspect (the tool, product) and a software aspect (how to use the hardware).

For good reasons studies of diffusion of innovations have often addressed individual innovations, in practice innovations often come in packages clusters and are interrelated and interdependent (Torbon, 2011). The characteristics of innovations explain their rate of adoption. Five of such characteristics of importance are discerned:

1) The relative advantage reflects how the innovation is subjectively perceived superior to the previous idea;

2) Compatibility reflects how the innovation is perceived “consistent with the existing values, past experiences, and needs of potential adopters”;

3) Complexity reflects the perceived difficulty to understand and use the innovation;

4) Trialability is “the degree to which an innovation may be experimented with on a limited basis”

5) Observability reflects how the results of an innovation are visible to others. An innovation can further be changed or modified by a user, (Rogers, 2003).

Communication, through channels, provides information to a social system with the purpose to influence the knowledge and assessment of the innovation. Mass media is often more effective in creating awareness of an innovation, while personal contacts are more effective in forming an opinion about a new idea, (Rogers, 2003). Such interpersonal communication is facilitated if senders of information are optimally similar to the receiver in certain attributes. More education and participation in a farmer association can both improve one’s access to information on a new technique and help a farmer deal with changes required by new technologies (Feder et al. 1985, Rogers 1995).

Finally, rate of adoption is the relative speed with which an innovation is adopted by members of a social system. The social system with its interrelated units shares an interest in finding solutions to a common goal, so as to improve their agricultural productivity to enhance livelihoods. Such a system has a social and communication structure that facilitates or hinders the diffusion of innovations in the system. Norms, being part of the social system, are the established behavior patterns for system members. Often opinion leaders play a crucial role in influencing system members.

Change agents may have the explicit role to influence members in a certain direction. Both opinion leaders and change agents are central actors in diffusion of innovations (Torbon, 2011). This theory is relevant to this studies because, it access how information on soybean inoculant is disseminated to farmers within the study area.

2.1.2 Theory of Planned Behavior (TPB)

The predictability of the Theory of Reasoned Action (TRA) is strong across studies; it becomes problematic if the behavior under study is not under full volitional control. Sheppard et al. (1988) noted two problems of the theory. First, one must differentiate the difference between behaviors from intention. This could be problematic because a variety of factors in addition to one's intentions determine how the behavior is performed. Second, there is no provision in the model for considering whether the possibility of failing to perform is due to one's behavior or due to one's intentions. To deal with these problems, Ajzen (1985) extended the Theory of Reasoned Action by including another construct called perceived behavioral control, which predicts behavioral intentions and behavior.

The extended model is called the Theory of Planned Behavior (TPB). Considering, TRA and TPB have many similarities. In both theories, Behavioral Intention is a main factor in the prediction of actual behavior.

Both theories assume that human beings are basically rational and make systematic use of information available to them when making decisions. By considering control-related factors, TRA assumes that the behavior being studied is under total volitional control of the performer (Madden et al., 1992).

But, TPB expands the boundary conditions of TRA to more goal-directed actions. Attitude toward Behaviour is defined as "a person's general feeling of favorableness or unfavorableness for that behavior" (Ajzen and Fishbein, 1980).

Subjective Norm is defined as an individual's perception that most people who are important to a person think the individual should or should not perform the behavior in question, (Ajzen and Fishbein, 1980). Attitude toward behavior is a function of the product of one's salient beliefs that performing the behavior will lead to certain outcomes, and an evaluation of the outcomes, that is, ranking of the desirability of the outcome.

The main difference between these two theories is that the TPB has added Perceived Behavioral Control as the determinant of Behavioral Intention, as well as control beliefs that affect the perceived behavioral control. Though it may be difficult to assess actual control before behavior, TPB asserts that it is possible to measure Perceived Behavioral Control - "people's perception of the ease or difficulty in performing the behavior of interest" (Ajzen, 1991). Perceived Behavioral Control is a function of control beliefs and perceived facilitation.

Control belief is the perception of the presence or absence of necessary resources and opportunities desired to carry out the behavior. Perceived facilitation is one’s assessment of the importance of the resources required to an achieved the outcomes (Ajzen and Madden, 1986).

Perceived Behavioral Control is included as an external variable that has both a direct effect on actual behavior and an indirect effect on actual behavior through intentions. The indirect effect is based on the assumption that Perceived Behavioral Control has motivational implications for behavioral intentions.

When people believe that they have little control over performing the behavior because of a lack of required resources and opportunities, then their intentions to perform the behavior may be low even if they have favorable attitudes or the subjective norms concerning performance of the behavior. Bandura (1977) has provided empirical evidence that people's behavior is strongly influenced by the confidence they have in their ability to perform the behavior. The structural link from Perceived Behavioral Control to Behaviour Intention reflects the motivational influence of control on actual behavior through intentions.

The direct path from Perceived Behavioral Control to actual behavior is assumed to reflect the actual control an individual has over performing the behavior. Ajzen (1985) offers the following rationale for this direct path. First, if intention is held constant, the effort needed to perform the behavior is likely to increase with Perceived Behavioral Control. For example, if two people have equally strong intentions to learn how to apply rhizobia inoculant, and if both try to do so, the person who is confident that he or she can master this activity is more likely to apply than a person who doubts his or her ability.

Second, Perceived Behavioral Control often serves as a substitute for actual control, and insofar as perceived control is a realistic estimate of actual control, Perceived Behavioral Control should help to predict actual behavior. This theory is relevant to this studies because, it established how various social factors such as Subjective Norm, Perceived Behavioral Control and Attitudes of soybean inoculant will influence individual farmers' decision to adopt soybeans inoculant in the study area.

2.1.3 Technology Acceptance Model

The technology acceptance model (TAM) is developed based on the theory of reasoned action. It was originally specified by Davis, (1986) and later refined by Davis, Bagozzi and Warshaw in 1989 (Davis, *et al.,* 1989). TAM replaces behavioral attitude and subjective norm factors of the TRA with two technology acceptance measures.

Which are perceived ease of use and the perceived usefulness of technology; these two measures have clearly differentiated the TAM from the TRA, though the TAM remains strongly influenced by behavioral elements due to its origin. TAM models explain how an individual accepts or rejects and uses the technology.

An individual‘s attitude toward use of technology is basically determined by two attributes, thus perceived ease of use and perceived usefulness. These two factors are affected by external variables (Davis, *et al.,* 1989). Perceived ease of use is defined by "the degree to which an individual believes that using a particular technology will be more comfortable with it" (Davis 1986). Perceived ease of use has a causal and significant effect on the perceived usefulness, which is explained by "the degree to which an individual believes that using a particular technology would enhance his or her needs" (Davis 1986).

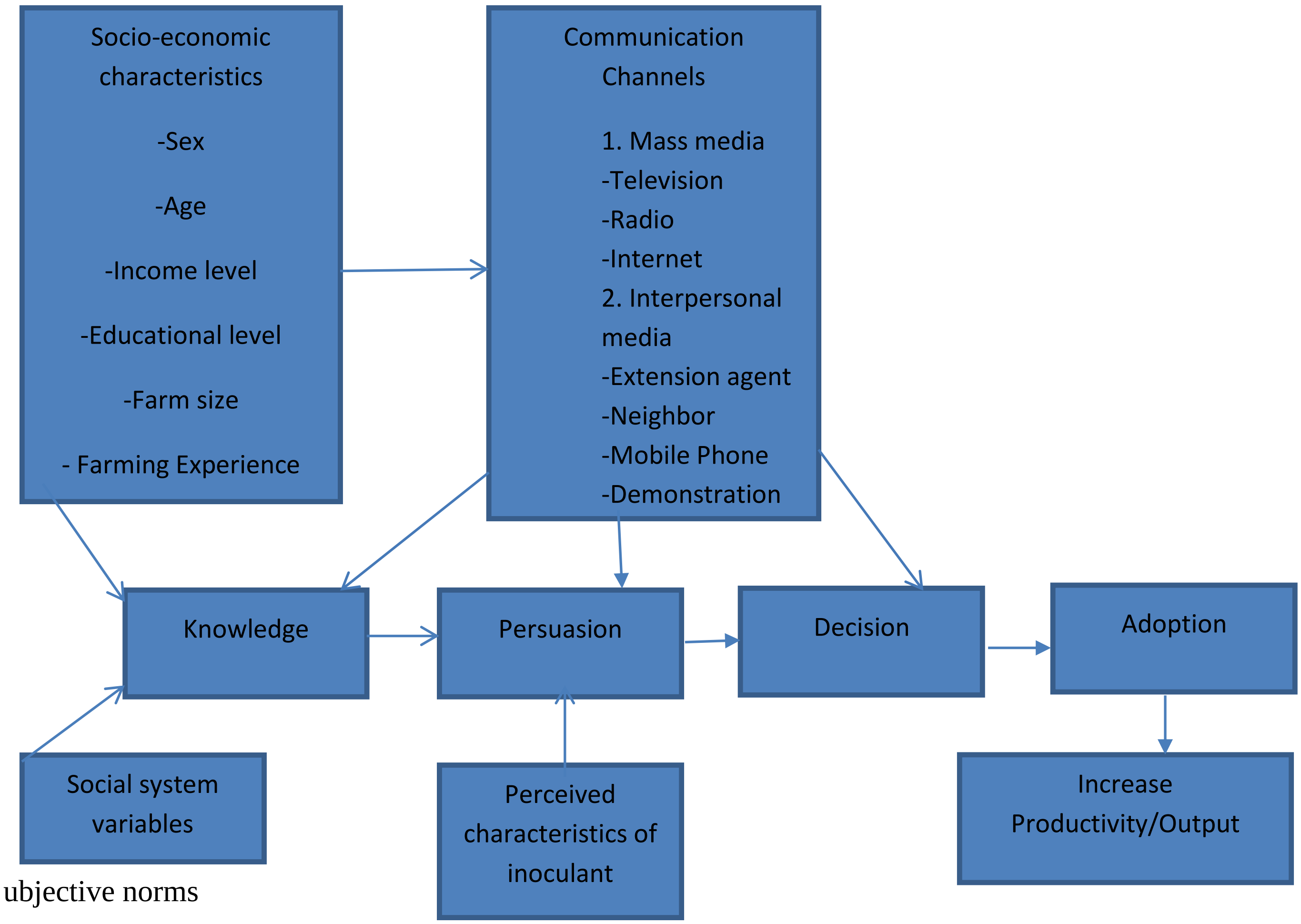
TAM assumes that when an individual has formed the intention to act, he/she will be free to act. However, several factors, such as social or environmental limitations, may affect whether or not the individual will act (Bagozzi 2007).

Decision-making on the use of improved technologies by farmers is a complex process. Several authors (Feder, Just, and Zilberman 1985; Doss, 2006; Everett, 2003 and Eelko, and Maryse, 2009) have proposed a theoretical model where in the technology-adoption process; an individual passes through the stages of knowledge, persuasion, decision, implementation (adoption) and confirmation (post-adoption assessment). Information is necessary at various stages to reduce uncertainty about the usefulness of the innovation. The decision stages result in adoption or rejection of the idea. This theory is relevant to this studies because, it examined how the attributes of soybean inoculant will influence individual farmers' decision to adopt soybeans inoculant in the study area. These are attributes perceived usefulness of soybeans inoculant and perceived ease of usage of soybeans inoculant for farming activities.

2.1.4 Conceptual Framework

The framework presents a theoretical view of the researchers 'scope of study. The components of the conceptual framework are as follows: Socio-economic characteristics (Sex, Age, Educational level, Farm size, Income level and Farming experience), Perceived characteristics of inoculant (Gives higher yields, Environmental friendly, Easy to apply, Affordability and Farmers knowledge of inoculant), Communication channels (1. Mass media: Television, Radio and Internet -2. Interpersonal media: Extension agent, Neighbor, Mobile Phone and Demonstration) and Social system variable (Household head, Opinion leader and Social norms), with other determining factors: Knowledge, Persuasion, Decision, Adoption and Rejection. The various components are linked together by arrows to show how these components influence each other.

Figure 2.0 shows a diagrammatic representation of the conceptual framework and the influence these components might have on adoption or rejection of rhizobia inoculant. From figure 2.0, the researcher proposes that, the socio-economic characteristics will influence the use of communication channels among farmers. The use of these communication channels will lead to increase awareness or knowledge of farmers on rhizobia inoculant. From the knowledge stage, farmers will then decide whether to adopt or reject. However, adoption or rejection of the technology will depend on the perceived characteristics of rhizobia inoculant. When an individual farmer adopt the soybean inoculant, it is expected to improve soybean productivity or output of soybean.



ubjective norms

)pinion leaders

ocial norms

-Farmers knowledge of inoculant

-Environmental friendly

-Higher yields

-Easy to apply

-Affordability

Figure 2.0 Conceptual Framework for the Study

Source: Modify from Roger, 2003 (Author, 2017)

2.2 Background of Inoculant

In Bashan (1998), the history of inoculation with beneficial bacteria can be traced back for centuries. By the end of the 19th century, the practice of mixing "naturally inoculated" soil with seeds became a recommended technique of legume inoculation in the USA (Smith, 1992). For almost 100 years, *Rhizobium* inoculants have been produced around the world (Bashan, 1998). Some legumes, such as soybean *(Glycine max)* in Brazil, are not fertilized with nitrogen, but are only inoculated. Soybean inoculation has made a major agricultural impact in the USA, Brazil, and Argentina (Bashan, 1998).

In countries such as Australia, North America, Eastern Europe, Egypt, Israel, South Africa, New Zealand, and, to a lesser extent, Southeast Asia have used inoculation on other legumes. Though, the large majority of less developed countries in Asia, Africa, and Central and South America, inoculant technology has had little impact on crop productivity (Bala et al., 2011). Fertilizers, especially nitrogen and phosphates, are one of the most important inputs used in the global agricultural industry.

Inoculants used as either substitute or complement to the use of commercial or noncommercial fertilizers have the potential to increase productivity and profitability of legume crops, enhance food production, support social progress in many under-developed countries, and moderate environmental effects of use of commercial inorganic fertilizers in agriculture.

For almost 100 years, *Rhizobium* inoculants have been produced around the world, primarily by small companies. Some legumes, like the soybean *(Glycine max* (Merr.)L.) in Brazil, are not fertilized with nitrogen, but are only inoculated (Döbereiner, lecture in: VI *Azospirillum* conference, Sárvár. Two major breakthroughs in plant inoculation technology occurred in the late 1970s: (i) *Azospirillum* was found to enhance non-legume plant growth (Döbereiner and Day, 1976), by directly affecting plant metabolism (Bashan & Holguin, 1997), and (ii) biocontrol agents, mainly of the *Pseudomonas fluorescens* and *P. putida* groups, began to be intensively investigated (Défago et al. 1992; Kloepper and Schroth, 1981; Glick, 1995: Glick and Bashan, 1997).

For some time now, several other bacterial genera, such as *Bacillus*, *Flavobacterium*, *Acetobacter*, and several *Azospirillum*- related microorganisms have also been evaluated (Kloepper, 1994; Tang, 1994; Tang and Yang, 1997). A major role of inoculant formulation is to provide a more suitable microenvironment to prevent the rapid decline of introduced bacteria in the soil. Inoculants have to be designed to provide a dependable source of beneficial bacteria that survive in the soil and become available to the plant. Developing countries practice mainly low-input agriculture in which fertilizers, pesticides, and agro-technical machinery are scarce. The financial resources of the individual farmer in a family' farm system are small and the availability of bank loans is extremely limited. Naturally, this type of farming does not have the resources to invest in improved agricultural techniques. Artificial inoculation, in particular, requires an infrastructure to store and transport biological products in large quantities into rural areas, and this infrastructure is not available in most developing countries (Bashan, 1998).

In most developing countries, even the wealthier growers lack adequate knowledge of modern agricultural techniques. Unfortunately, the growers' formal agricultural education is poor. Most growers tend to practice traditional methods or copy methods from more developed countries without being aware of the deficiencies of such practices in their own particular region or without knowing the "cost" to the environment.

In most cases, fertilizers are too expensive or the crop's value does not justify the expense In places where fertilizers are available, over fertilization is common (Bashan et al., 1992), and this practice may contaminate deep water reservoirs, produce major health hazards to the future population, and disrupt the local environment (Turrent-Fernández, 1994).

2.2.1 Inoculants come in four basic dispersal forms

(i) Powders. This form is used as a seed coating before planting. The smaller the particle size, the better the inoculant will adhere to the seeds. Standard sizes vary from 0.075 to 0.25 mm, and the amount of inoculant used is around 200 to 300 g/ha. These inoculants are the most common in developed (Smith, 1997) and developing countries (Tang and Yang, 1997).

(ii) Slurries. This inoculant is based on powder-type inoculants suspended in liquid (usually water). The suspension is directly applied to the furrow or alternatively, the seeds are dipped just prior to sowing.

(iii) Granulars. These inoculants are applied directly to the furrow together with the seeds. Size ranges are from 0.35 to 1.18 mm. Rhizobia inoculant is used at a rate of 5 to 30 Kg/ha.

These inoculants are popular and have been successfully commercialized since 1975 (Tang, 1994; Tang and Yang, 1997).

Bead-like forms are synthetic variations of granular forms. These can be in macro sizes (1 to 3 mm in diameter) used as granules form, or in micro size (100 to 200 mm) used as a powder for seed coating. These inoculants are a new, as yet unproven, possibility in inoculation technology, and their features will be described later in detail.

(iv) Liquids. These inoculants use broth cultures or liquid formulations, mainly in water, but also in mineral or organic oils.

The seeds are either dipped into the inoculant before sowing, or an applicator evenly sprays the liquid inoculant on the seeds. After drying, the seeds are sown. This method ensures even coverage of the seeds without interference with the seed monitoring system of the planters or inoculum loss when dried (Smith, 1995). These inoculants are currently popular in the USA, Canada, Argentina, and Brazil, mainly for soybeans, but also for lentils, peas, and peanuts (Smith, 1995,).

For bio control agents of leaf diseases, the inoculant can be diluted in water and sprayed for better coverage of the leaves (Daayf et al., 1995). Alternatively, the suspension can be sprayed directly into the furrow or on the seeds before sowing. The in-furrow inoculant provides a larger amount of bacteria to the plant than seed inoculation. In rhizobia, this improves plant nodulation (Smith, 1995).

2.2.2 Types of Inoculation

In Hegde, (1992), there are two methods of inoculation; seed inoculation and soil inoculation. The latter is done by delivering the inoculant directly into the sowing furrow with the seeds (Gault, 1982). Seed inoculation is the most popular method worldwide, as long as the farmer is willing to take the extra step of mixing the inoculant with the seeds immediately before sowing.

The less common method, soil inoculation, is now being used successfully for rhizobia inoculation, but has several disadvantages which limit its future for the application of Azospirillum, which survives poorly in many soils (Bashan et al. 1995).

For inoculation of soybeans, the major inoculated crop, changing management practices (conservation tillage and narrow rows) also limit the use of the granular form (Smith, 1995).

Microbial inoculants can be applied during three possible phases: (i) at the seed processing plant as a seed coating, months before the actual sowing, (ii) "on site", as a seed application just before sowing, or by inoculant delivery directly onto the seeds in the furrow, and (iii) after seedlings emerge (Bashan, 1986).

However, the most popular method to date with peat based inoculants is the "on site" method, primarily because of lower costs. However, Fages (1992) revealed, some main drawbacks for "on-site" seed inoculation: (i) additional work is required during sowing, which is time restricted, (ii) the seed germination rate may decrease if some seeds are damaged during the mixing step with the inoculant, (iii) since the bacteria in the inoculant are alive, they may be subjected to UV irradiation which can reduce their population during the field mixing operation, and (iv) the bacterial population may be reduced when the wet inoculant is attached to the chemically coated seeds.

Soil inoculation is an alternative to seed inoculation. It is more convenient for the farmer than seed inoculation, but is sometimes not as effective. It is also more expensive because more inoculant is required. Soil inoculation can be done either with peat-based granules or with micro-granulated forms of inert materials; sand, calcium carbonate or marble powder. These materials are mixed with the inoculum in the factory or can be mixed with the seeds by the farmer prior to sowing. The technique uses a specific granular applicator which makes use of insecticide applicators farmers already know.

2.2.3 Optimal Characteristic of a Carrier for Inoculants

The carrier is the delivery vehicle of live microorganisms from the factory to the field; however, no universal carrier or formulation is presently available for the release of microorganisms into soil (Trevors et al., 1992). The carrier is the major portion (by volume or weight) of the inoculant. The materials of which the carrier is composed and the type of formulation vary. The carrier can be slurry or a powder.

A good carrier should have one essential characteristic: the capacity to deliver the right number of *viable* cells in good physiological condition at the right time (Bashan, 1986c, 1991; Fages, 1990, 1992; Smith, 1992; Trevors et al. 1992). Additional desirable characteristics for a good inoculant should be as follows:

(i) Chemical and physical characteristics. The inoculants should be nearly sterile or easily sterilized, and as chemically and physically uniform as possible.

They should also be of consistent quality, high water-holding capacity (for wet carriers) and suitable for as many bacterial species and strains as possible.

(ii) Manufacturing qualities. The inoculant should be easily manufactured and mixed by existing industry, it should allow for the addition of nutrients, have an easily adjustable pH, and be made of a reasonably priced raw material in adequate supply

(iii) Farm handling qualities. A good inoculant allows for ease of handling (a major concern for the farmer), provides rapid and controlled release of bacteria into the soil, and can be applied with standard agro technical machinery.

(iv) Environmental characteristics. The inoculant should be nontoxic, biodegradable and nonpolluting, and should minimize environmental risks such as the dispersal of cells to the atmosphere or to the ground water.

(v) Storage qualities. The inoculant should have sufficient shelf life (one or two years at room temperature is often necessary for successful integration into the agricultural distribution system in some countries).

Naturally, no single carrier can have all these qualities, but a good one should have as many as possible. A "super-inoculant" such as the one described above is theoretically possible.

For bacteria with poor survival in the soil, like Azospirillum sp. (Bashan et al., 1995), these formulations are largely useless since they do not provide a protective environment for the bacteria. Furthermore, in some plant species, these formulations should be applied several days after sowing at seedling germination, causing extra work and cost for the farmer. The microbial inoculant is not merely a suitable carrier containing the bacteria. Other materials might be involved in the final formulation.

For example: an Azospirillum lipoferum inoculant for corn, developed in France, was based on 1% alginate containing the bacterial cells and 99% inert calcium carbonate "diluent", which allowed for the right bacterial concentration, because the alginate contained too many cells of Azospirillum for optimal inoculation (Anonymous, 1995). Apparently this alginate formulation was never commercialized, perhaps due to its high cost, and A. lipoferum was commercialized in a sterile peat inoculant instead (Anonymous, 1996). The use of each type of inoculant depends upon market availability, cost, and the needs of a particular crop under specific environmental conditions. For example, the granular form is better than powder inoculants for rhizobia, under stressful planting conditions, but since more is required, it is costlier (Smith, 1992).

2.2.4 Rationale for Using Rhizobium Inoculants in Legume Production

Biological nitrogen fixation is a natural process whereby atmospheric nitrogen is reduced to ammonia. In legume, this system operates in the root nodules formed by the nitrogen fixing Rhizobium spp. In most natural ecosystems, heavy losses of nitrogen occur due to crop uptake, leaching, erosion, denitrification etc. However, significant replenishment of nitrogen occurs in most soils mainly due to biological nitrogen fixation (Hardarson et al. 1987).

Nitrogen provided in this form is not only cheap but also does not impart other undesirable aspects such as pollution hazards due to heavy use of inorganic nitrogen fertilizers. In addition, inoculation of seeds, plants and soil with Rhizobium is even simpler than applying correct doses of inorganic nitrogen fertilizers such as urea or ammonium phosphate. Rhizobia bacteria are among the most useful soil microorganisms for crop production. They form symbiotic relation with legume plants in root nodules and fix atmospheric nitrogen which becomes the source of nitrogen for the plant.

In order to get maximum benefit from the relation, inoculation with live effective rhizobial cell is needed and the environmental conditions such as soil temperature and acidity must not be detrimental to their survival. When biological nitrogen fixation is successful, leaf chlorophyll content of the legume plant increases due to the presence of high available nitrogen derived from the process (Furseth, et al. (2012). It is evident that AMF plays a great role in supplying plant phosphorus. Therefore, agricultural systems that involve AMF are the most sustainable and most reliable because of the beneficial effect of AMF on nutrient use efficiency.

Many researchers while assessing the effect of dual inoculation have reported no effect of rhizobial performance on AMF, with AMF having a great effect on nodulation and nitrogen fixation (Xavier et al., 2004). However, the adoption of rhizobial inoculation on indigenous AMF is very limited. Rhizobia inoculant is a formulation of both carrier and rhizobia. Many carriers have been tested and used for good quality rhizobia inoculants but how effectively this has been adopted has not been extensively established.

2.3 Origin and Distribution of Soybeans

Soybean is native to Eastern Asia, mainly China, Korea and Japan, from where it spread to Europe and America and other parts of the world in the 18th century (Ngeze, 1993). Evidence in Chinese history indicates its existence more than 5,000 year ago, being used as food and a component of drugs (Norman et al., 1995). Some researchers have suggested Australia and Eastern Africa as other possible centres of origin of the genus *Glycine* (Addo-Quaye et al., 1993). It is widely grown on large scale in both the temperate and tropical regions such as China, Thailand, Indonesia, Brazil, the USA and Japan; where it has become a major agricultural crop and a significant export commodity (Evans, 1996).

Soybean was first introduced to Africa in the early 19th century, through Southern Africa (Ngeze, 1993) and is now widespread across the continent (Wikipedia, 2009). However, Shurtleff and Aoyagi (2007) have stated that, it might have been introduced at an earlier date in East Africa, since that region had long traded with the Chinese. The same report indicates that soybean has been under cultivation in Tanzania in 1907 and Malawi in 1909. In Ghana, the Portuguese missionaries were the first to introduce the soybean in 1909. This early introduction did not flourish because of the temperate origin of the crop (Mercer-Quarshie and Nsowah, 1975). However, serious attempts to establish the production of the crop in Ghana started in the early 1970s.

This was as a result of collaborative breeding efforts of Ghana's Ministry of Food and Agriculture (MoFA) and the International Institute of Tropical Agriculture (IITA) (Tweneboah, 2000).

2.4 The economic importance of soybean production

Soybean (Glycine max L) is key a crop with multiple uses as a source of nutrients in human diet such as protein, vitamins and oil for the, a source of livestock and aquaculture feed, and industrial or commercial biofuel (Raghuvanshi & Bisht, 2010).

Nutritionally, the crop contains 30% cholesterol free oil, 40% protein and essential vitamins for effective body nourishment (Mokhtar, *et al*., 2011). Its production is a very prominent source of income and livelihoods for many households (Mbanya, 2011). The crop is not widely grown in Ghana (Akramov and Malek, 2012). In Ghana, the crop is mainly produced under rain-fed conditions on small farms, averagely 3 acres (IFPRI, 2007).

National estimates show that the crop is principally produced in the northern regions, especially the eastern corridor of the Northern Region (Dogbe, 2013). SRID (2012) reported that soybean production in the northern regions alone account for about 77% of the national production.

As of the year 2010, the average yield of soybean was estimated to be up to 0.8 metric tons per hectare. But the potential achievable yield for soybean is pegged at 4.5 metric tons per hectare under the best agricultural practices in Ghana (MiDA, 2010). So it is able to achieve less than 30% of its achievable yields and only 7% of favorable land allocated is to soybeans (Masuda and Goldsmith, 2009; Hartman et al., 2011).

Globally, in 2010, the demand for soybean is estimated to be up to 300 million tons which exceeds the current production level of 40 million tons (FAO, 2010).

Soybean is usually rotated with cereals such as maize, millet, sorghum because of its ability to improve soil nutrients (IFPRI, 2012). The crop depends highly on soil macro-and-micronutrients such as Sulphate, Triple Superphospate and potassium. The National Variety Release and Technical Committee under the MoFA approved three soybean genotypes released by SARI with a call on farmers in Northern Ghana to purchase the seeds to help improve their yields (MoFA, 2013).

The three seeds are; afaya, songda and Janguma among other crops (rice and maize) is noted to receive potential government investment in order to address the problems of food insecurity, rising food prices and import bills by enhancing the competitiveness of its production (IFPRI, 2012).

Soybean has a unique ability to fix atmospheric nitrogen through symbiotic association with root nodule bacteria and could be used to improve the yields of legumes in sub-Saharan Africa, since current yields are only a small fraction of their potential (Abaidoo et al., 2013).

Soybean is capable of fixing between 44 and 300 kg of nitrogen per hectare which makes a significant nitrogen contribution to intercropped and rotated cereal crops. It is less susceptibility to resist pests and diseases and can stay longer in storage (Ugwu and Ugwu, 2010).

It also has broader leaf biomass which translates into soil fertility benefit to other crops. But, one key ingredient that it needs for proper and effective nodulation is nitrogen. However, this is a limiting factor hindering the growth and nodulation of soybean in northern region because of poor soil fertility. Researches have reported that Biological Nitrogen Fixation (BNF) serves as a potential alternative to inorganic nitrogn-fertilizer in agriculture , which is environmental friendly and cost effective (Bala, 2011).

2.5 Adoption of Agricultural Innovation

According to Feder et al (1985), note adoption of technological innovations in agriculture has met a considerable attention among policy makers because the majority of the population of under developed countries obtains its livelihood from agricultural production and because new technology apparently offers opportunity to increase production as well as income. While the finding of low levels of technology adoption is well accepted, some studies attempt to explain the slow rate of adoption of modern agricultural technology in Ghana and other Sub-Saharan African (SSA) countries. The introduction of many new technologies has encountered with partial success as measured by observed rates of adoption.

The orthodox knowledge is that constraints to the rapid adoption of innovations involves factors like lack of credit, limited access to information, aversion to risk, inadequate farm size, inadequate incentives associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labor shortages (thus preventing timeliness of operations), chaotic supply of complementary inputs (like seed, chemicals, and water), and inappropriate transportation infrastructure (Feder et al., 1985).

In most cases, agricultural technologies are introduced in packages that include several components, an example is the high-yielding varieties (HYV), fertilizers, and corresponding land preparation practices. While the components of a package may complement each other, some of them can be adopted independently. Therefore, farmers may face several distinct technological options (Mann, 1998).

In 1985, Feber used an analytical framework for investigating adoption processes at the farm level should include a farmer's decision-making model determining the extent and intensity of use of the new technology at each point throughout the adoption process and a set of equations of motion describing the time pattern of parameters which affect the decisions of the farmer.

These changes in parameters are the result of dynamic processes such as learning through information gathering, learning by doing, or accumulation of resources. According to Uaiene et al. (2009) the literature on agricultural technology adoption is vast and somewhat difficult to summarize compactly.

Traditionally, economic analysis of agricultural technology adoption has focused on imperfect information, risk, uncertainty, institutional constraints, human capital, input availability, and infrastructure as potential explanations for adoption decisions (Foster & Rosenzweig 1996; and Kohli & Singh 1997).

A study conducted by Floyd *et al*. (1999) to understand the adoption and associated impact of technologies in the Western hills of Nepal, analyzed seven factors hypothesized to influence adoption. Those factors are agro-ecological zone, extension input level, access, food self-sufficiency, ethnic group, sex of respondent and sex of household-head. Some of these factors are socio-demographic factors.

Tenge *et al*. (2013) in their study of examining the options to increase adoption of lowland rice and legume technologies in Morogoro, Tanzania, pointed eleven factors that could influence the adoption of different crops. Those factors are high yield, drought tolerant, early maturity, late maturity, disease tolerant, good taste, high prices, market availability, improve soil fertility and not attractive to birds.

Agwu (2004) in the study of factors influencing adoption of improved cowpea production technologies study in Nigeria selected six factors that could influence the adoption. Those factors were age, family size, educational qualification, membership of farmer organization, farm size and farmer experience.

Bonabana-Wabbi (2002) in the study assessing factors affecting adoption of agricultural technologies in Kumi District, Eastern Uganda, classified factors that influence adoption into three categories. The factors were grouped into economic factors under which there was farm size, cost of technology, level of expected benefits and off-farm hours.

The second category with social factors under which there are age, education and gender. The third category with institutional factors contains; information and extension contact or service. Similar studies had classified also the factors that influence adoption of the technology in three categories. This is the case of FAO (2001) in the study to understand the support of transfer, adoption and dissemination of labour saving technologies in Masaka and Wakiso. The three categories are socio-cultural factors, economic factors and institutional arrangements and policy issues. Studies by FAO (2001), Bonabana-Wabbi (2002) and Alemitu (2011) agreed that institutional factors especially the extension services are most important to increase or to decrease the degree of adoption. However, many developing countries do not have efficient extension systems and in some instances they are nonexistent altogether services to support the adoption of improved technology.

Ownership of large tracts of land can facilitate experimentation with new agricultural technologies, and also determine the pace of willingness as large land owners are more likely to be the early adopters (de Janvry et al, 2011).

Moreover, the limited availability of land may shoot the use of organic fertilizers in a poor resource setting (Pingali etal, 1987). Furthermore, the quality of land may be a major factor in deciding the use of key inputs such as chemical fertilizers, or using improved crop varieties due to expected higher returns (Carletto et al, 2007). In countries, with entrenched overlapping and relatively unsecure property land rights (Deininger and Ayalew Ali, 2008), availability of land alone may not spur agricultural technology adoption. The main determinant of continuous willingness to adopt is the profitability of agricultural enterprises. The changing prices for agricultural products are shown to be a key factor in agricultural technology adoption (Kijima et al, 2011).

Primarily attracted by higher product prices, farmers can abandon the technologies if the expected benefits from adoption are lower than the prevailing costs. The changing profitability of agricultural enterprises also introduces the time dimension as a driver of adoption households may adopt technologies for some but not all periods. Another reason, which drives agricultural technology adoption, is peer effects or learning from other farmers.

According to Oster and Thorton (2009), in any technology adoption process, peer effects work in three major ways: (1) individuals profit from acting like friends/neighbours; (2) individuals gain knowledge of the benefits of the technology from their friends; and (3) individuals learn about how to use a new approach from peers. With regard to agricultural technology adoption, peer effects can lead to economies of scale by lowering transportation costs but can also lead to increased competition and land prices, which can spur dis-adoption (Carletto et al, 2007). Indeed, some studies, for example Conley and Udry (2010) in Ghana, showed that learning by doing influenced technical change in pineapple cultivation.

A study conducted by Muzari, et al., (2012) in Sub-Saharan Africa on the impacts of technology adoption by smallholder farmers, found out that the factors affecting technology adoption were assets, income, institutions, vulnerability, awareness, labour, and innovativeness by smallholder farmers. They also established that technologies that require few assets, have a lower risk premium, and are less expensive have a higher chance of being adopted by smallholder farmers.

However, evidence from empirical studies on Africa confirm that farmers in Sub-Saharan Africa (SSA) face a host of constraints, ranging from infrastructure, incentives, and liquidity, which hinders adoption and retention of agricultural technology (Kijima et al, 2011; Marenya and Barrett, 2009 and Jayne et al, 2003).

The cost of technology is a major constraint to technology adoption, the removal of subsidies on prices of seed and fertilizers since the 1990s due to the World Bank-sponsored structural adjustment programs in sub-Saharan Africa has worsened this constraint (Nkonya *et al*., 1996). However, the relevance of input subsidies was seen by African leaders at the 2006 'Abuja Declaration on Fertilizer for the African green Revolution'.

In this African Ministers of Agriculture committed to substantially raise the very low rates of fertilizer use across the continent with measures to reduce costs of fertilizer acquisition and supply, improve smallholder access by scaling up private sector and other supply networks, provide targeted fertilizer subsidies and invest in infrastructure, supplier finance and complementary seed and soil services, and improve trade flows (Africa Fertilizer Summit, 2006).

Subsidies induce farmers to adopt the use of agricultural inputs, which are more costly to procure than the benefits they provide. Inputs subsidies boost demand and encourage input suppliers to expand their presence to remote areas thus increase agricultural productivity, DANIDA (2011).

Agricultural input subsidies are useful instrument for promoting greater equality by targeting subsidies specifically at the poorest smallholders. Conventional arguments for subsidies in agricultural development have focused on the promotion of increased agricultural productivity through the adoption of new technologies (Ellis, 1992). Morris et al. (2007) describe ten features of smart subsidies: 'promoting fertilizer as part of a wider strategy', 'favouring market based solutions' in input supply, 'promoting competition' in input supply, 'paying attention to demand', 'insisting on economic efficiency', 'empowering farmers', 'involving an exit strategy', 'pursuing regional integration', 'ensuring sustainability', and 'promoting pro-poor economic growth'

Several studies have emphases on the importance of agricultural subsidies. Dorward et al (2004) in a studies on green revolution experience in Asia argue that sustained input subsidies were a major part of successful Green Revolution packages, making a critical contribution to thickening and thus 'kick starting markets' first within staple food supply chains and then in the wider rural economy.

Djurfeldt et al (2005) also argue that input subsidies were a critical element within green revolution policies, drawing on detailed policies studies across a range of Asian countries. Fan et al (2007) further provided empirical evidence on the contribution of input subsidies to growth and poverty reduction in India in the early stages of the green revolution but not later.

A study by Kohli and Singh (1997), on analysis of the adoption of high yielding varieties (HYV) in India, revealed that inputs played a major role in the rapid adoption of HYVs in the Punjab.

They claimed that the effort made by the Punjab government to make the technological innovations and their complementary inputs more easily and cheaply available through subsidies allowed the technology to diffuse faster than in the rest of India.

Butzer et al (2002), study on the decision to adopt HYVs in India. They establish that, since HYVs require higher levels of fertilizer and irrigation to realize their yield potential, their introduction corresponded with a large jump in the demand for fertilizer and irrigated land.

Another study by McGuirk and Mundlak (1991) on the transformation of Punjab agriculture during the Green Revolution and find that, the short period of transition from the use of traditional varieties to the adoption of HYVs was largely determined by the availability of irrigation facilities and fertilizer. This result partially stems from the fact that, as mentioned before, to fully utilize the yield potential of HYVs, it is necessary to apply considerably larger doses of fertilizer and water per unit of land.

A study conducted by SEND-GHANA in 2015, on the introduction of nation-wide fertilizer subsidy programme covering three types of inorganic fertilizer (Sulphate of Ammonia, Urea, and Compound fertilizer). The programme was a rapid intervention to help increase food production at the peak of the global financial, food and energy crisis that was adversely affecting poor countries.

The goal was to help farmers increase fertilizer application for increased crop production. The target was to increase the country's fertilizer application rate to at least 50 kilogrammes (Kg) per hectare (ha) as recommended in the Medium Term Agricultural Sector Investment Programme (METASIP) of the Ministry of Food and Agriculture (MOFA).

The study revealed that the introduction of the fertilizer subsidies increased the usage of the fertilizer by farmers leading to higher yields. The quantity of subsidized fertilizer (except for 2012) rose steadily by 317% from 43,176mt in 2008 to 180,000mt in 2013, (SEND-GHANA, 2015). The Africa Union Fertilizer Summit held in 2006 in Abuja, Nigeria, stressed that fertilizer subsidies will directly lead to increase fertilizer usage among farmers in SSA (Morris et al. 2007). The relevance of input subsidies was seen by African leaders at the 2006 'Abuja Declaration on Fertilizer for the African green Revolution'. In this African Ministers of Agriculture committed to substantially raise the very low rates of fertiliser use across the continent with measures to reduce costs of fertiliser acquisition and supply; improve smallholder access by scaling up private sector and other supply networks; provide targeted fertilizer subsidies and invest in infrastructure, supplier finance and complementary seed and soil services; and improve trade flows (Africa Fertilizer Summit, 2006). Subsidies may induce farmers to adopt the use of inputs and thereby increase agricultural productivity.

Subsidies merely encourage the adoption of inputs, which are more costly to procure than the benefits they provide. Input subsidies could boost demand and encourage input suppliers to expand their presence to remote areas, DANIDA (2011).

Agricultural input subsidies can be a useful instrument for promoting greater equality by targeting subsidies specifically at the poorest smallholders. Conventional arguments for subsidies in agricultural development have focused on the promotion of increased agricultural productivity through the adoption of new technologies (Ellis, 1992).

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Dorward et al (2004) in a review of green revolution experience in Asia argue that sustained (but not indefinite) input subsidies were a major part of successful Green Revolution packages, making a critical contribution to thickening and thus 'kick starting markets' first within staple food supply chains and then in the wider rural economy. Djurfeldt et al (2005) also argue that input subsidies were a critical element within green revolution policies, drawing on detailed policies reviews across a range of Asian countries. Fan et al (2007) provide empirical evidence on the contribution of input subsidies to growth and poverty reduction in India in the early stages of the green revolution but not later.

Furthermore, free agricultural training and extension programmes can be an incentive to promote adoption agricultural technologies, such as training on use of improved seeds, application of fertility and other technologies (Nkonya*et al.*, 2004). Information acquisition on market access about a new technology is also an incentive for farmers to adopt. Information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time (Caswell *et al*., 2001). Exposure to information about new technologies as such significantly affects farmers' willingness to adopt agricultural.

2.6 Factors That Influence Farmers' Adoption of Agricultural technologies

Human Capital is the quality of labour available or ability to command labour for adoption of improved agricultural innovation. These variables are comprised of individual or community characteristics such as age, education, sex, household size, and their relationship to technology adoption is one of potential.

Age is a central factor that influences the probability of adoption of new technologies because it is said to be a primary latent characteristic in adoption decisions. Though, there is contention on the direction of the effect of age on adoption. However, studies show that there is no concrete evidence of the influence of age on agricultural innovation adoption. Conroy (2005) found out that frequent contact with the nature and command of age on farmer's contribution to new technology is indecisive. Younger farmers are likely to take up new technology than older farmers being that they are of higher schooling and have more contact to innovations. On the other hand, it may be that older farmers may have extra resource that makes it more likely for them to try new technologies. In studies on adoption of rice in Guinea, age was either not significant or was negatively related to adoption (Adesiina and Baidu-Forson, 1995).

Moreover, since adoption pay-offs occur over a long period of time, while costs occur in the earlier phases, age (time) of the farmer can have a profound effect on technology adoption. However, Dogbe (2006) argued that though older people have experience and resources, their receptivity to new ideas and technologies typically decreases with age.

Due to the inconsistency of findings between age and adoption, Nkonya and Norman (2003) concluded that the effect of age on adoption tended to be location and technology specific. Age can generate or erode confidence in new technology.

In adoption literature, there are studies that have looked into acceptance of technologies or potential adoption and adoption of technologies. Potential adoption studies focuses on the evaluation and trial processes after the initial diffusion, awareness and interest stages of the adoption process (Everett, 2003). Potential adopters, according to Everett (2003), are socially integrated with a large degree of opinion leadership in their social systems.

Farmers' educational background is a potential factor in determining the readiness to accept and properly use of an innovation (Amir, 2006). The relationship between farmers' education and attitude towards adoption is an empirical question as it provides the farmer with necessary skills to enhance adoption of improved agricultural technology. Adoption of inoculant technology involves technical applicability and a farmer with high level of education on how to handle the technology.

Accessibility to information on agricultural innovation has often been directly associated with the factors of literacy as well as poverty. According to Sheba (1997) exposure to education permits an individual to control the rate of message input and develop the ability to store and retrieve information for later use.

Most studies suggested that education increases awareness and prepares people for innovative changes. For instance, Cotlear (1990) finds for his sample of households in three regions in the Peruvian Sierra that education plays a greater role for early adopters, who use education to decrease the costs of obtaining new information and learning to apply new techniques, than for late adopters, who may simply copy their neighbours' behaviour. Weir and Knight (2000) state that to some extent that educated farmers are more likely to be willing to take risks with new technology and more likely to be adopters of successful innovations, there are possibilities for positive external returns to schooling in this context. Returns to education are greater the more the opportunities for adoption of technical innovation. However the authors contend that the applied literature on the effect of education on innovation in developing countries is limited (Weir and Knight, 2000).

Another study by Pramanik et al (2001) argues that majority of farmers at grassroots are uneducated, and therefore stressed the need to recognize the fact that they can be very efficient in some recommended agricultural innovations, if properly presented to them. Some other findings also dwell on the relationship between variables such as education, Social status, age, income, use of the media, farm size and adoption. Additionally, Voh found, for instance, that education had a significant association with adoption of innovation among some farmers from Northern Nigeria (Voh, 1982). Finally, in a study conducted in Anambra and Imo States of Nigeria, found a positive correlation between level of education and response to innovation campaigns (Emenyeonu, 1987). Crook et al. (2011) when studying a Meta-analysis relationship between human capital and firm performance found that human capital is positively correlated with innovators or early adopters. That is, farmers with higher levels of education adopt new technologies more rapidly than farmers with lower education; and laggards are associated both with lower education.

Gender is one of the most important factors influencing adoption of improved innovation technology. Over field and Fleming (2001) studying coffee production in Papua New Guinea show insignificant effects of gender on adoption. Another studies on the "effort in improving women's working skills does not appear warranted as their technical efficiency is estimated to be equivalent to that of males". Since adoption of a practice is guided by the utility expected from it, the effort put into adopting it is reflective of this anticipated utility.

It might then be expected that the relative roles women and men play in both 'effort' and 'adoption' are similar, hence suggesting that males and females adopt practices equally.

Household size is another important component of agricultural technology. A study in land management uses household size as a determinant. An improved land management practice requires labour input from households. Kimaro *et al.* (2013) observed that a family with larger number of members is more likely to try and continue using a potential profitable technology. The socio-economic characteristics of the sampled respondents are income, land and income generating activities influence adoption of improved practices in both directions. Farmers with higher income are more likely to be adopters of new practices than farmers with low income. High income also has a positive influence on the initial stages of trial of innovations as wealth allows the farmers to invest a relatively small proportion of their income to venture into an uncertain enterprise (Amir and Pannel, 1999). Shivley (1999) found that high income was positively correlated with adoption of hedgerows in the Philippines.

However, availability of off-farm income found to have a positive and significant influence the adoption decision of the farmers on crossbred dairy cows in the central highlands of Ethiopia (Berhan, 2002). In agricultural related venture, the notion that technological innovations are perceived to be more risky than traditional practices has received considerable support in the literature. Many researchers argue that the perception of increased risk inhibits adoption (Feder *et al.*, 1985). When an innovation first appears potential users are generally uncertain of its effectiveness and tend to view its use as experiment show that uncertainty declines with learning and experience thus induce more risk-averse farmers to adopt an innovation, provided it is profitable (Schaffnit-chatterjee, 2010).

Innovators and early adopters are believed to be more inclined to take risk than are "early" and "late majority farmers". Late adopters and Laggards are likely to be even more risk averse. Moreover, all technology adoption decisions carry with them some mixture of subjective risk such as human tendencies to assume more uncertainty in outcomes from unfamiliar techniques and objective risks resulting from variations in climate, diseases, and the timely access to critical inputs. The observed patterns of technology adoption are typically influenced by the farmers' individual risk preferences and their ability to bear the risk of a new and uncertain endeavor.

Farm size is among of the factors measured when modelling adoption processes. Land as a factor of production and storage of wealth is the most important asset influencing adoption (Shively, 1999). Farm size does not always have the same effect on adoption; rather, the effects of farm size vary depending on the typology, characteristics of technology being introduced, and the institutional setting of the local community. The relationship between farm size and adoption depends on factors such as fixed adoption costs, risk preferences, human capital, credit constraints, labour requirement and tenure arrangements (Feder *et al.*, 1985).

A study by Umar et al. (2009) found no significant relationship between income and adoption, a possible inference from the finding is that respondents with high income because of their potential privileged position to acquire production inputs will be more willing to adopt new technologies and accept higher risk than a low income respondents. However, empirical research shows that farm size a proxy of income is a significant factor determining adoption. This is because farm size can affect and in turn be affected by the other factors influencing adoption. The effect of farm size on adoption could be positive, negative or neutral (Doss and Morris, 2001).

Fixed costs are often a primary barrier to adoption; therefore, spreading fixed costs over a larger farm may be one explanation for the observed positive association between farm size and propensity to adopt. Feder *et al.*, (1985), further noted factors that influence whether farmers adopt technologies has been the focus of past adoption studies and have been crucial for the development of techniques for studying adoption.

Farmers with larger farms are more likely to adopt new technologies because they can spread the costs over a wide range of outputs than it is possible for small-scale farmers. In a studies by Nzully (2007) found that farmers with large farms were able to adopt rain water harvesting technologies in their farms than those with small farms.

This was possible because farmers were able to take risks of experiment with the new technology. Use of one of the intercropping techniques or using fallow areas would not affect the cereal crops. On the other hand intensification of agriculture related activities, such as use of modern soil fertility management techniques, encourages adoption.

This implies that the development and use by farmers of high yielding crop varieties and intensive crop management practices can significantly enhance adoption of forage/browse legumes by releasing land for forage production (Gebremedhin et al ., 2003).

However, these studies fail to adequately answer the questions of factors such as institutions and markets affect the use and adoption of new technologies. This study sought to address this gap in determination of technology use.

A study by Forson (1995), on modern sorghum and rice varietal characteristics showed that farmer perceptions of technology characteristics significantly affect adoption decisions of those new agricultural technologies.

Mather et al., (2003) examined the adoption of disease resistant bean varieties in Honduras. Hintze et al., (2003) examined the factors, including varietal characteristics, affecting the low levels of adoption of improved maize varieties in Honduras. Ransom *et al.,* (2003) examined the adoption of maize varieties in the hills of Nepa.

2.7 Farmers Knowledge on Agricultural Technologies Adoption

A study conducted by Crowder, (2008) revealed that knowledge was very important for promoting use and adoption of innovative technological discoveries for increased efficiency and productivity. This implies knowledge needs to be reinforced in the farmer for increased use and adoption of productive recommendations. Crowder (2008) reported that field days and demonstrations of cover cropping on working farmers were effective in reducing the knowledge gap and increasing use of the practice. There is the need to provide strong evidence on the benefits of the improved production recommendations through field days and demonstrations in order to increase farmers knowledge and use of the practice. This means knowledge gained through field days and demonstrations motivates farmers to use and adopt the recommended practices.

According to Crowder (2008), knowledge was not the only factor observed to affect use and adoption of improved practices. Eelko et al., (2009) investigated the differences between companies with regard to their knowledge, perceived potential value, implementation and satisfaction with commerce. The study involved 127 companies and found that there are higher scores for companies at the advanced level and significant negative interaction effects between adoption level and adoption intention. Due to the magnitude of these effects, the interaction effects tended to cancel out the additional effect of adoption intention for companies at the advanced level.

2.8 Farmers' Perceptions towards Agricultural Technologies Adoption

Loevinsohn et al. (2013), recounted that, farmers' decisions about whether and how to adopt new technology are conditioned by the dynamic interaction between characteristics of the technology itself and the range of conditions and circumstances. According to Nabifo (2003), farmer's perception of a technology is a key determinant in the decision to use. If farmers" perceptions are that the technology is not profitable, there will be low investment in the technology, the likelihood to usage would be high. For instance, perception studies on soil fertility improvement technologies have focused on both whether farmers view it as a problem or not and based on specific attributes and benefits of a technology. In the studies that are based on farmer perceptions of soil fertility, farmers who view soil fertility as a problem have higher acceptance and adoption of a technology. As in the case inoculant technology farmers with notion that using inoculant would reduce cost of farming are more likely to adopt (Nabifo, 2003),

In addition, farmers' perception that technology development and the subsequent benefits, require a lot of time to realize, can reduce their interest in the new technology because of farmers' advanced age, and the possibility of not living long enough to enjoy it (Caswell et al., 2001). Additionally, elderly farmers often have different goals other than income maximization, in which case, they will not be expected to adopt an income-enhancing technology. Shepard et al., (1997), stated that limitations for the adoption potential of hedgerow intercropping involved inappropriate targeting, where the farmers" priority problem is not low soil fertility.

Farmer participation was being enhanced by the provision of incentives such as fertilizers, improved crop material and limited monitoring of labour requirement, crop and economic performance.

In studies that focus on specific attributes and benefits of a technology, it has been shown that, the attributes are perceived differently by farmers depending on factors such as socioeconomic and asset endowment. The grass fallows in Rwanda are found in farms that are less than a hectare of land, thus dispelling the notion that extensive land sizes are required for the fallow technology. He indicates that short term improved woody fallows on the other hand are used by farmers for fuel wood, N-fixation, the prevention of weeds and energy sources for soil micro-organisms.

Farouque and Hiroyuki (2007) in a study aimed at determining farmers‟ perception of Integrated Soil Fertility (ISF) and Nutrient Management (NM) for sustainable crop production found that the landless, marginal and small farmers had a low level of awareness when compared to medium and large farm holders and thus affected their perception. The study found that a significant proportion (78%) had either a low or a very low level of perception while 22% had a medium to high level of perception. They indicate that individual farmers had a low perception of preparation of farm yard manure and the role of organic matter as well as the beneficial aspect of ISF and NM for sustainable crop production.

Among the characteristics of farmers; education level, farming experience, farm size and communication exposure influenced farmers positively while family size and fertilizer use negatively influenced farmers‟ perception of ISF and NM.

Bruening et al., (1992) in their study on farmers" perception about usefulness of informational and organizational sources found that those farmers who had more than a high school education perceived water pollution, manure mismanagement, and nutrient mismanagement as more serious environmental issues than those farmers who had not completed high school.

Ahmed et al., (2004) in their investigation into the perceived farm management and marketing educational needs of farm operations in Jordan found that higher perception ratings were observed for those who utilized more sources of information and preferred group extension. Duncan (2004) when investigating knowledge and perceptions of Virginia secondary agriculture educators toward the agricultural technology program reported that the educators either agreed or strongly agreed that the agricultural training program will contribute to students" success in the agriculture industry and that the program offers a valuable educational experience for students.

Adesina and Baidu-Forson (1995) showed that farmer perceptions of technology characteristics significantly affects adoption decisions of new agricultural technologies. They suggested further research to include farmer subjective perceptions of the characteristics of new agricultural technologies.

However, Ajayi (2007) indicates that technical characteristics are important but not exclusive conditions for farmers" acceptability and adoption of good agricultural technologies. He further points out that there is relatively little information and systematic feedback regarding farmers" perception and knowledge of technologies.

2.9 Constraints to Agricultural technologies use

Doss, (2004) reported that there were three reasons that constrained farmers use and adoption of improved technologies or recommendations. The first was simply that farmers were not aware of the technologies as well as the related costs and benefits.

The second reason was the timing of the technological support which was usually wrong and inappropriate. The third reason was that technologies were not profitable or beneficial.

Doss (2004) also reported that institutional factors such as policy affected access and availability of inputs, markets, credit facilities to support use of technologies. A study in Nigeria revealed that household marital status affected access to the production resources because the married households had greater decision-making power and capability to use innovations (Odebode, 2008). This indicates that the diversity in socio and economic characteristics based on marital status reflects on the capability of the farming household towards use of agricultural innovations.

This is probably because the burden associated with agricultural production activities are likely to be shared and lessened where there is husband and wife working together. Hence, the finding from the study shows that agricultural services should not always generalize the kind of support given to different types of households. Another study, Lllewellyn et al (2006) also found that the use of the practices was reduced because the extension agents could not reach the farmers on time due to poor transport and other technical problems they faced.

Sanginga et al (1999) reported that labour availability limited the size of land a household could cultivate and also reduced use of improved soybean technologies by resource poor farmers. The problem of labour availability adversely affected the timeliness of critical operations and adoption of agricultural technology.

Farmers in Ghana generally face a number of production constraints. Dogbe, (2013) observed that a major constraint to agricultural development in the Northern Region of Ghana is farmers' inability to access credit. Al-Hassan, Sarpong and Mensah-Bonsu (2006) reported poor access to guaranteed input and output markets as major problems confronting farmers on adoption of agricultural technologies.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents a brief socioeconomic profile of the study area. It provides the methodological procedures used to gather, analyze and present the data. It specifically highlights the research design which entails the sources and type of data, the data collection approach and instruments used, the sampling procedure adopted as well as the analytical tools (descriptive and econometric models) employed in getting the results of the study.

3.1 The Study Area

The study was carried out in the East Gonja district of the Northern Region. The population of East Gonja District, according to the 2010 Population and Housing Census, is 135,450 representing 5.5 percent of the region's total population. About 72.6% of the population are engaged in agriculture out of the 72% economically active population aged 15 years and above**.** The East Gonja District was created by a legislative instrument (LI 1938) in 2007. The District is located at the South-eastern section of the Northern Region of Ghana.

The district lies within Latitude 8^{o}N and 9.29 ^{o}N and, Longitude 0.29E and 1.26^{o}W. It shares boundaries with the Mion District and the Tamale Metropolitan Assembly to the North, Central Gonja District to the West, Nanumba-North, Nanumba-South and Kpandai Districts to the East, and the Brong-Ahafo Region to the South. The total land area of the district is 8,340.10 square kilometres, occupying about 11.95 percent of the landmass of the Northern Region, it is the largest district in the country, (GSS, 2014).

The East Gonja District lies in the Tropical Continental climatic zone. Temperatures are fairly high ranging between 29ºC and 40ºC. Maximum temperature is usually recorded in April, towards the end of the dry season with minimum temperatures recorded from December to January, during the Harmattan period.

The area experiences a single raining season (May to October) and a long dry season (November to March/April). Average annual rainfall varies between 1,112.7 mm and 1,734.6mm, (GSS, 2014).

The natural vegetation in the district is the Guinea Savannah Woodland. However, there are few grooves, which have been preserved over the years. The tree cover is relatively dense, compared to the rest of the Northern Region. However, intensive harvesting of trees for fuel wood and charcoal burning, and also activities of the Fulani herdsmen are fast reducing the tree cover, especially in areas close to the Tamale Metropolitan District, (GSS, 2014).

The district has a number of large water bodies that flow throughout the district. These include the Volta Lake and the Dakar River both of which run across the district. A number of streams, dugouts, valleys, hills and mountains are also found at various locations in the district, as part of the natural environment. The confluence of the Volta and some of its major tributaries including the White Volta and the Dakar River are found in the district, (GSS, 2014).

The soils in the district can be classified into two major types. These are: Alluvial soils generally classified under Glysols are found around the Volta Lake, particularly in the drawn-down zone of the Volta Lake during the dry season. The soils along the Lake are medium textured and moderately well drained in parts. The soil is potentially fertile and is suitable for a variety of crops especially vegetables and rice, thus making agricultural an attractive venture for the natives, (GSS, 2014).

Figure 3.1 Map of East Gonja District

Source: (Ghana Districts, 2014)

3.2 Research Design

Descriptive survey with mixed method design was employed in carrying this study. Descriptive research is a most basic type of enquiry that aims to observe (gather information on) certain phenomena, often at a single point in time using cross-sectional survey to examine a situation by describing important factors such as demographic and socio-economic, behaviours, attitudes, experiences, and knowledge (Kelley, Clark, Brown and Sitzia , 2003). The main focus of this study is to assess the adoption of soybean inoculant and its effect on output, as such descriptive survey design was considered appropriate in achieving the study's objective. As defined by Cooper and Schindler, (2001) descriptive survey design discover and measure cause and effect relationships among variables. As such descriptive survey design was adopted to guide the contact of the study.

However, both qualitative and quantitative approaches of gathering data were employed to holistically explore factors affecting soybean farmers' adoption of inoculant and its effect on soybean yield. Mixed methods, which provide systematic way of gathering and analysing qualitative and quantitative data (Creswell, 2010) was adopted in gathering, understanding and analysing data on farmers' adoption of soybean inoculant. The use of different methods is referred to as triangulation or multiple strategies is a method that is used to overcome the problems associated with researches that rely on only one theory, single method and single data set (Mikkelsen, 1995).

3.3 Population

Population is the total collection of elements about which we wish to make inferences (Cooper and Schindler, 2001). The target population for this study comprises of all the 600 registered soybeans farmers in the East Gonja district. The list of 600 soybean farmers were provided by the district department of agriculture as soybean farmers they been working with under various soybean improvement projects. NGOs such as SEND Ghana, Green earth revolution, are widely promoting the use of inoculant among the smallholder soybean farmers in the district as part of the district's soybean productivity improvement project. These farmers were targeted because they have been introduced to soybean inoculant use by the Ministry of Food and Agriculture (MOFA) in collaboration with Savannah Agricultural Research Institute (SARI) for a decade. In addition, these farmers been trained on the use of soybean inoculant and have been linked with soybean inoculant supplier under SEND GHANA Soybean Project which have been running in the District since 2013.

3.4 Sample Size and Sampling Procedure

Choosing the appropriate sample depend on the kind of data analysis the researcher plan on. The accuracy of the sample depends largely on the researchers' purpose and the populations' characteristics (Neuman, 2003). In general the population of the study was made up of soybean farmers in the East Gonja district. Specifically, the study considered soybean farmers who have been introduced to soybean inoculant use and are aware of its supply arrangement put in place by the SEND GHANA soybean project. In all there 600 registered soybean farmers who aware of soybean inoculant and its supply arrangement. As they constitute the sampling frame for this study. Cochran's (1977) sample size determination formula was then applied in calculating the sample size. Applying Cochran (1977), sample size (n) computation formula as:

$$n = \frac{N}{1+Ne^2} \quad \text{……………………………………………………………(1)}$$

Where n = sample size

N = target population of soybean farmers

e = marginal error (5%)

Thus N = 600

$$n = \frac{600}{1 + 600(0.05)^2} = 240$$

Adjusting for correction factor and unforeseen circumstance, the target sampled size was increased by 25% to 300 soybean farmers.

3.4.1 Sampling Procedure

The multi-stage sampling approach was employed in selecting the sample for this study. In the first-stage, 10 communities in the district were selected randomly. In the second-stage, farmers were stratified into adopters and non-adopter. Simple random sampling technique was employed to select 150 adopters and 150 non-adopters. In total, 300 respondents were sampled for the study.

3.5. Types, Sources and Methods of Data Collection

This section of the chapter presents the types of data used for the study, the sources of the data and the various methods used in the collection of the data.

3.5.1 Types and Sources of Data

Both qualitative and quantitative data of primary and secondary sources were employed in the study. Primary data was obtained from responses of small holder farmers in the East Gonja District. Secondary data were obtained from records of the department of agriculture, records of NGOs working to improve soybean production in the district and records of information on soybean production in published and unpublished sources.

3.6 Methods of Data Collection

According to McMillan and Schumacher (2006) data collection may be done with measurement methods, extensive, interviews and observations. A combination of data collection tools were employed to collect qualitative and quantitative data from stallholder farmers surveyed. These included the administration of structured and semi-structured questionnaire to respondents to collect primary data.

3.6.1 Questionnaires

The questionnaire for smallholder farmers feature a mixture of questions that are common on general use of inoculant. The questionnaire comprised of background questions about sex, age, education, number of dependent and farm size, and questions related to income, etc. Structured questions and some dichotomous questions were asked to collect the information from the respondents.

Questions were very specific on knowledge level of farmers on inoculants, farmers' perceptions on the use of inoculants, factors that influence farmers' adoption of soybean inoculants, the effect of soybean inoculants adoption on output and limitations of the inoculants accessibility and utilization by farmers.

The structured questionnaire used multiple-choice questions in which the researcher provided a choice of answers and respondents were asked to select one or more of the alternatives, and dichotomous questions that were having only two response alternatives, yes or no.

The questionnaires were administered to the smallholder farmers who are the majority of the study respondents. Questionnaires were developed for the sampled farmers in the study area, the questionnaires were written in simple terms that minimize rather subjectively and judgment, rather than in broad quality terms. The questionnaire was designed to be as brief as possible while still covering the necessary range of subject matter required in the study. The questionnaire was designed in a manner that ensures study participants' privacy when conducting surveys which enhanced more open and honest responses to the questions asked by the researcher.

3.6.2 Key Informant Interviews

Key informant interviews is a process of data collection is qualitative in nature. Key informants mostly refer to respondents in the sample that are perceived to have more in-depth information and knowledge on the phenomenon under study. The purpose of qualitative methods of data collection techniques is to gather in in-depth data that is based on personal experience and stories and compliment quantitative data collect by the researcher. The key informants for the study were project implementing officers and extension officers of the East Gonja District.

The researcher prepared a key informant interview guide which was administered through face-to-face interviews to one project officer and two district extension officers respectively.

3.6.3 Observation

The researcher employed the observation technique which is a qualitative method of data collection. Observational checklist was prepared and used to guide the observation. Storage of soybean inoculant purchase to be used by farmers were observed, farmers' application of inoculant was observed and disposal of chemical packages after use was also observed.

3.7 Validity and Reliability of Data Collection Instruments

Before the questionnaire developed for stallholder farmers and the checklist used for the key informant interview were used, their validity and reliability were tested. This was to ascertain that the instruments can actual measure the concepts they were designed to measure and that they can be relied upon in collecting the require data.

Validity shows how well an instrument that is designed to measure a particular concept actually measures the concept it is intended to measure. It is concerned with whether we measure the right concept or not.

3.7.1 Validity of Data Collection Instruments

After the instruments were developed, they given to two senior members in my department, including my supervisor, who assessed the face, content and construct validity of the instruments. Through these assessment some questions were rephrased and constructed, some questions were added and others deleted. Their review of the questionnaire for smallholder farmers (Appendix A) also led to reorganization of the questionnaire into sections addressing specific areas of concern.

3.7.2 Reliability of the Data collection Instruments

Reliability generally deals with how consistently the measurement instrument measures the concept of interest under study. It deals with dependability, consistency, accuracy and comparability. In order to ascertain whether the questionnaire possessed reliability, the researcher conducted a pre-test by administering the questionnaire to 15 soybean farmers in Nyankpala in the Tolon District.

Firstly, farmers in the Nyankpala community were interview with questionnaires on the topic understudy, to access whether questionnaires would be appropriate for the main study. This was done in order to assess the instruments in terms of time required for each item; familiarity of the terminologies used and required; and participants' understanding of the statements in the instruments.

Secondly, based on findings from the pre-test results the instruments were further amended to ensure easy understanding. The pre-test also provided data for Cronbach Alpha reliability test to be conducted. The pre-test provided data for assessment of the reliability of the questionnaire designed for smallholder farmers. Results of assessment led to corrections and changes necessary to make the questionnaire more reliable before it was used to collect the data for the main study. From the assessment using the pretest results, internal consistency (Cronbach alpha) of the questionnaire calculated as 0.72, indicating that the questionnaire is reliable (Warner, 2009).

3.8 Method of Data Analysis

SPSS, STATA and Microsoft Excel were used as the software for data input and analysis. Each objective of the research was analyzed using appropriate statistical and analytical techniques.

Descriptive and inferential statistics were employed in the analysis of the data to achieve the study's objectives.

3. 8.1 Analysis of farmers' on inoculants

Descriptive statistics were used in analysing farmers' knowledge on soybean inoculant and its application. The results were summarised in tables. Farmers knowledge were measure on Rogers (1995) assessment of farmers decision to adopt new technology, through exposure to information on new innovations as well as their decision to used it, and the outcome of the technology.

3.8.2 Analysis of farmers' perception and knowledge on inoculants

The study used a Likert scale format to elicit farmers' perception of soybean inoculants use after determining their awareness level. Perception statements on soybean inoculants was measured on a Likert scale of five points, ranging from 1 if strongly agree, 2 if agree, 3 neutral, 4 disagree and 5 if strongly disagree. The results were described and summarised in tables. The perception and knowledge statement were obtained from respondents during the pre-testing stage. Farmers were asked on their perception and knowledge on inoculants usage. Information gathered from farmers were then used to form the individual perception and knowledge statements for the main analysis.

3.8.3 Analysis of Determinant of Inoculant Adoption

The study adopted the Random Utility Theory (RUT) based on farmers' decision to adopt the soybean inoculants. The RUT follows the utility-maximization condition which assumes that rational farmers will select a product only if the product provides him or her highest utility given a constraint.

Based on this theory, the research attempts to deduce farmers' decision to adopt the product as a choice problem. McFadden (1974) developed the RUT which are appropriate for modeling individuals' behaviour based on choices. The utility a farmer derives from a product can be represented as having two components; a utility function of observed characteristics known as the deterministic component of utility and the unobserved component known as the random component. The deterministic component is exogenous and includes farmers' characteristics and product characteristics and a set of linearly related parameters and the random component may result from missing data/variables (omitted variable), measurement errors and misspecification of the utility function.

This function is specified below:

$$U_j = X\beta + \varepsilon \qquad (2)$$

Where,

$X\beta = v$

where U_{ij} is the maximum utility attainable when alternative j is chosen by consumer i; $X\beta$ is the deterministic component of the utility function, X is a vector of observable socio-demographic and economic characteristics, product-specific factors that influence utility, β is the unknown parameter vector to be estimated and ε is the stochastic term.

3.8.4 Tobit regression was used to analysis the level of adoption by the respondents (objective iii).

The explicit Tobit regression is expressed thus:

$Y=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5 \ldots\ldots +b_nX_n+u$ ……………………………………………… (3)

Where,

Y = level of adoption measured as a percentage (%) of technologies adopted

$b_1 - b_6$ = estimated coefficient

$X_1 - X_n$ = variables of the study U = error term

3.8.5 Analysis of the Effect of Inoculant on Soybean Productivity

The Douglas production function and stochastic frontier approach was independently proposed as by Aigner, Lovell and Schmidt (1977) and Meeusen and Broeck (1977). Was used to assess the effects of inoculant adoption on productivity of soybeans

The general form of the Cobb-Douglas model

$$y = A\prod_{i=1}^{n} x_i^{\beta_1} e^{\varepsilon} \quad \ldots\ldots \quad (1)$$

The theoretical specification of the model

$$Y_i = f(X\beta) \quad \ldots\ldots \quad (2)$$

The empirical specification of the Cobb-Douglas model

$$InY = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + e_i \quad \ldots\ldots \quad (3)$$

Where,

Y= *Productivity* $X_1 = In\_farmsize$ $X_2 = In\_weedicide$ $X_3 = In\_inoculant$
$X_4 = In\_total\_lab$

βs *are regression coefficients to be estimated* e_i = *error term*

The empirical model specification of the technical inefficiency model

$$InY = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \ldots\ldots\ldots + \beta_{11} X_{11} + e_i \quad \ldots\ldots\ldots\ldots (4)$$

Where,

X_1 = *years of cultivating soybeans* X_2 = *age* X_3 = *sex* X_4 = *educational level*

X_5 = *household size* X_6 = *soybean farm size* X_7 = *perception of inoculant on cost*

X_8 = *perception of inoculant on environmentally friendly*
X_9 = *perception of inoculant as organic fertilizer*
X_{10} = *perception of inoculant on microorganism* X_{11} = *if cash*

Table 3.1 Description, Measurement and hypothesized sign of variables used in the probit regression model

Variable	Description	Apriori
Cobb-Douglas Model		
Farm size	Acres	+
Weedicide	litres	+
Inoculant	kg	+
Total labour	Total number of people	+
Inefficiency Model		
Years of cultivating soybeans	Years	+
Age	Years	-
Sex	1=male 0=female	+/-
Educational level	1=formal 0=no formal	+
Household size	Number of people in house	+
Soybean farm size	Acres	+
Perception of inoculant on cost	1= yes, 0=no	+/-
Perception of inoculant on environmentally friendly	1= yes, 0=no	+/-
Perception of inoculant as organic fertilizer	1=yes, 0=no	+/-
Perception of inoculant on microorganism	1=yes, 0=no	+/-
If cash	1=yes, 0=no	+

Source: Authors Constructs, 2018

3.8.6 Analysis of constraints to use of inoculant

Factors militating against the effective use of inoculant by farmers are the constraints that they are faced with in the use of inoculant. This objective was analyzed by first establishing the constraints faced by farmers on the use of inoculant in farming and ranking these constraints in order of severity.

The Kendall's concordance analysis was used to test for the agreement among the rankings by the respondents. According Legendre (2005), cited in Awal (2009) Kendall's coefficient of concordance (W) is a measure of the agreement among several (p) judges who are assessing a given set of (n) objects.

W is an index that measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of the ranks. This idea is to find the sum of the ranks for each constraint being ranked. If the ranking are in perfect agreement, the variability among these sums will be maximum (Mattson, 1986). The Kendall's concordance coefficient (W) is therefore given by the equation:

$W = 12S/p^2 (n^3 - n) – pT$……………………………………………………………… (5)

Where W denotes the Kendall's Concordance Coefficient, p denotes number of constraints, n denotes the number of respondents (sample size), T denotes correlation factor for tied ranks and s denotes sum of square statistics. The sum of square statistic (S) is given as:

$S = \sum (R_i – R)^2$ ………………………………………………………………………… (6)

Where: R_i = rows sums of ranks

R = the mean of R_i

The correlation factor for tied ranks (T) is also given as:

$T = \sum (t_k^3 - t^k)$…………………………………………………………………………… (7)

Where: t_k = the number of ranks in each (k) of m groups of ties.

The hypothesis to be tested is stated as follows, where H_o and H_1 denotes null and alternative hypothesis respectively.

H_o: There is no agreement among the rankings of the constraints

H_1: There is an agreement of the Kendall's concordance was done using the chi-square (X^2) statistic which is computed using the formula;

$X^2 = p\ (n - 1)\ W$…………………………………………………………………….. (8)

p = number of constraints

w = Kendall's coefficients of concordance

The decision rule is that if the calculated chi-square is greater than the critical, then the null hypothesis is rejected in favour of the alternate hypothesis that there is agreement among rankings of the constraints. 3.3 Empirical models

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents and discusses the results of the study. Section 4.1 explains the breakdown of the various sections in this chapter. 4.2 present the descriptive statistics of socio-demographic characteristics of the respondents. 4.3 examine soybean farmers' knowledge on soybean inoculants in the East Gonja. 4.4 analysis soybeans farmers' perceptions towards the use of soybean. Also, sections 4.5 assess the determinants of soybean inoculants adoption among soybean farmers in the East Gonja. Whiles, 4.6 analysed the effect of soybean inoculants adoption on output among soybean farmers in the East Gonja.

4.2 SOCIODEMOGRAPHIC CHARACTERISTICS

The study obtained data on farmer's sex, age, education, and farming experience. A result of the analysis of socio-demographic characteristics of respondents is presented in the Table 4.1.

4.2.1 Sex of Respondents

The study revealed that majority (51.2%) of the respondents were females, whiles the remaining 48.8 % were male respondents. This result is not surprising since, soybean production is labour intensive with regard to planting, harvesting, threshing and winnowing which are mostly done by women, (MoFA, 2015). It appear that almost all the work is women friendly and it is difficult to get men doing this kind or work like threshing and winnowing, Perhaps the reasons why the female dominate in the cultivation of soybeans.

4.2.2 Age of the Respondents

Results of analysis of the data collected for this study reveals that 10% of respondents were below the age of 25 years, while 40 % are between 26 to 35 years and 20% and 30% falling within the age categorizes of 36 to 45 years and 46 to 55 years respectively. Overwhelming majority (90%) of the soybean farmers interviewed were between the ages of 30 and 55 years which compares fairly well with the productive age range. The youngest respondent was 22 years and the oldest 53 years with an average age of 37.7 (SD = 9.8).

4.2.3 Education of Respondents

Education has been identified as a major component of human empowerment and a means of enhancing human capital of both men and women for effective and efficient production and productivity (Kabeer, 2003). Caldwell (1967) argues that education helps open up new horizons for human and is also thought to have a positive effect on human participation in formal employment.

However, results of the survey reveal a worrying situation of high illiteracy rate among soybean farmers in the study area. As high as 194 out of 300 respondents interviewed (representing 64.7%) have no formal education, with only 4 respondents having tertiary level education and 27.3% and 6.7% having basic and secondary education respectively, as illustrated in table 4.1.

4.2.4 Household Size

Household size which was measured by the number of persons per household, was assessed among the soybean farmers surveyed. The results as shown in the Table 4.1 found to be 11 persons per household with minimum of 5 person and maximum of 14 persons per household.

Comparing with the national average household of 4 persons per household (GSS, 2012) the average household size of 11 persons per household is more than double the national average. This indicates that the households surveyed were large household which is typical of farming households. Household size is simply used as a measure of labour availability for activities among farming households.

It determines adoption process in that, a larger household have the capacity to relax the labor constraints required during introduction of new technology (Mignouna et al, 2011; Bonabana-Wabbi 2002)

4.2.5 Farmer Experience

The result of the study showed an average farming experience of 16, with a range of 5 to 30 years. However, most of the farmers had a farming experience of less than 15 years. With only a few farmers thus, 20% of the total sample had farming experience of more than 20 years.

4.2.6 Marital Status

According to Gyekye, (1998), marriage is a very essential institution in most Ghanaian societies. As typical of Africa societies, most women want and hope to be married to their own husbands in the society. The analysis shows that, majority of respondents (88.7%) interviewed are married, while very few (6.7%) are single (never married) and 2% and 2,6% divorcees and windows respectively.

4.2.7 Years of Farming Soybeans

Farmers' experiences in soybean cultivation vary from 5 to 10 years. On the one hand, the few years of experience could be due to the fact that farmers are recently interested in the soybean sector.

Table 4.1 Socio-demographic Characteristics

Variable	Group	Frequency	%	Mean	Std. Dev	Min	Max
Age	<=25 years	30	10%	37.7	9.8	21	53
	26-35 years	120	40%				
	36-45 years	60	20%				
	46-55 years	90	30%				
	>55 years	0	0%				
	Total	**300**	**100**				
Sex	Male	145	48.8				
	Female	155	51.2				
	Total	**300**	**100**				
Education	No formal	194	64.7				
	Primary school	24	8				
	Junior high school	58	19.3				
	Senior high school	20	6.7				
	Tertiary	4	1.33				
	Total	**300**	**100**				
Household size	<=5 people	30	10	10.8	2.3	5	14
	6-10 people	90	30				

	>10 people	180	60				
	Total	**300**	**100**				
Farm experience				16.2	6.9	5	30
	<=5 years	30	10				
	6-10 years	60	20				
	11-15 years	60	20				
	15-20 years	90	30				
	>20 years	60	20				
	Total	**300**	**100**				
Marital status	Married	266	88.7				
	Single	20	6.7				
	Divorced	6	2				
	Widowed	8	2.6				
	Total	**300**	**100**				
Years of farming soybean				10.6	5.5	1	35
	<=5 years	69	23				
	6-10 years	99	33				
	11-15 years	99	33				
	> 15 years	33	11				
	Total	**300**	**100**				

Source: Field Survey, 2017

4.2 Farm Characteristics

The study identified the farm characteristics of soybean farmers in the study area of which farm size, soybean output, soybean output stored, soybean out sold, unity price of soybean sold and total revenue obtained were under study. The result in Table 4.2 shows that the average farm size is 1.1 acres with a maximum number of farm size under cultivation being (2) two acres and the minimum of (1) one acre. Also the average soybean output is 9.1bags, with a minimum of 4bags and maximum of 16 bags.

With regards to soybean output sold after harvest has an average value of 6.8, with a minimum of 3 bags are sold and maximum of 13 bags sold. Beside that a famer makes an average income of Ghc 714.0, with minimum revenue Ghc 315.00 from an acre of land and maximum of Ghc 1,365.00 respectively.

Table 4.2 Farm Characteristics

Variable	Obs	Mean	Std. Dev.	Min	Max
soybean farm size	300	1.1	0.3	1	2
Soybean output	300	9.1	3.8	4	16
Soybean output stored	300	2.3	1.4	1	6
Soybean output sold after harvest	300	6.8	3.1	3	13
Unit price of soybean sold	300	105.0	0.0	105	105
Total revenue	300	714.0	328.6	315	1365

Source: Field Survey, 2017

4.3 Reasons for Producing Soybeans

The study (figure 4.1) sought to know why soy beans farmers are cultivating soybeans. The result revealed that all the respondents are cultivating soybean for income, source of food and its ability to improve soil fertility. However there are variations with regards to high market price whiles majority (68%) agree that it's of high market price, 32% of them were not in agreement.

This implies that the economic and nutritional values of soybeans cultivation are major drivers which influence farmers to venture into soybean production. This argument is supported by Mokhtar, et al., (2011), with the view that soybeans is a nutritional crop which contains 30% cholesterol free oil, 40% protein and essential vitamins for effective body nourishment. Also, Mbanya, (2011) reported that, soybeans production is a very prominent source of income and livelihoods for many households in Ghana.

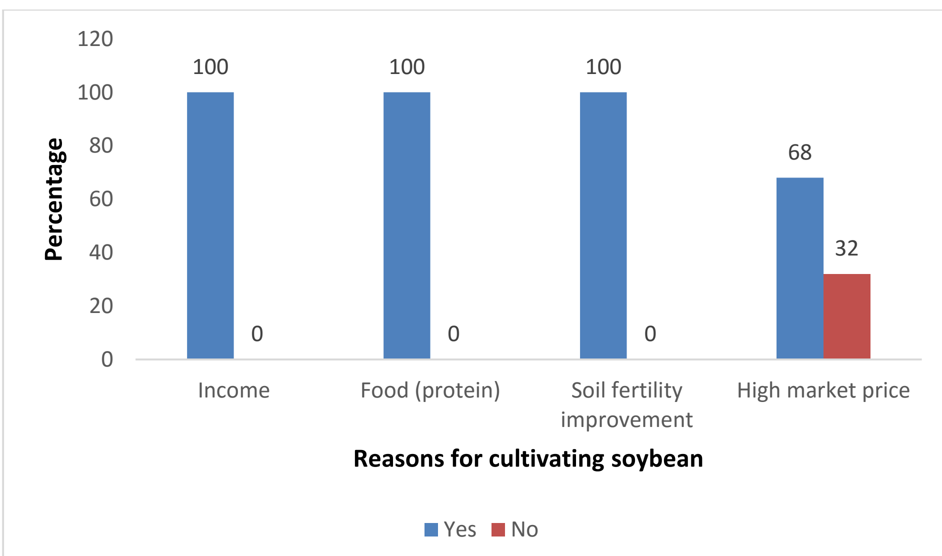

Figure 4.1 Reasons for Producing Soybean

Source: Field Survey, 2017

4.4 Social Networks of Soybean Farmers

The study sought to find out how soybean farmers are linkup with various institutions. The result revealed that about 95% of the farmers belong Farm Based Organizations (FBOs). Also all of them are involved in value chain participation and they were trained. With regards to extension serviced 90% of the soybean farmers have access.Belonging to a social group enhances social capital allowing trust, idea and information exchange (Mignouna et al., 2011).

Farmers within a social group learn from each other the benefits and usage of a new technology. Uaiene *et al*. (2009) suggests that social network are important for individual decisions, and that, in the particular context of agricultural innovations, farmers share information and learn from each other.

Studying the effect of community based organization in adoption of corm-paired banana technology in Uganda, Katungi and Akankwasa (2010) found that farmers who participated more in community-based organizations were likely to engage in social learning about the technology hence raising their likelihood to adopt the technologies. Although many researchers have reported a positive influence of social group on technology adoption, social groups may also have a negative impact on technology adoption especially where free-riding behaviour exists. Foster and Rosenzweig (1995) in studying adoption of Green Revolution technologies in India found that learning externalities within social networks increased the profitability of adoption, but also farmers appeared to be freeriding on their neighbors' costly experimentation with the new technology. Bandiera and Rasul (2002) as cited by Hogset (2005) suggests that, learning externalities generate opposite effects, such that the more other people engage in experimentation with a new technology, the more beneficial it is to join in, but also the more beneficial it is to free-ride on the experimentation of others.

As a result of these contradictory effects, Bandiera and Rasul (2002) propose an inverted U-shaped individual adoption curve, implying that network effects are positive at low rates of adoption, but negative at high rates of adoption.

Access to extension services has also been found to be a key aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agent acts as a link between the innovators (Researchers) of the technology and users of that technology. This helps to reduce transaction cost incurred when passing the information on the new technology to a large heterogeneous population of farmers (Genius et al. 2010).

Extension agents usually target specific farmers who are recognized as peers (farmers with whom a particular farmer interacts) exerting a direct or indirect influence on the whole population of farmers in their respective areas (Genius et al. 2010).

Many authors have reported a positive relationship between extension services and technology adoption. A good example include; Adoption of Imazapyr-Resistant Maize Technologies (IRM) by Mignouna et al. (2011); Factors determining technology adoption among Nepalese Karki and Siegfried (2004); Uaiene et al. 2009; Adoption of improved maize and land management in Uganda by Sserunkuuma (2005); adoption of modern agricultural technologies in Ghana Akudugu et al. (2012) just to mention a few. This is because exposing farmers to information based upon innovation-diffusion theory is expected to stimulate adoption (Uaiene et al. 2009).

In fact, the influence of extension agents can counter balance the negative effect of lack of formal education in the overall decision to adopt some technologies (Yaron, Dinar and Voet, (1992); Bonabana- Wabbi, 2002).

Table 4.3 Social Networks of Soybean Farmers

Social network	YES (%)	NO (%)
FBO	95.33	4.67
Value chain participation	100	0
Extension services	90	10
Training	100	0

Source: Field Survey, 2017

4.5 Farmers' Knowledge of Rhizobium Inoculants

The initial stage in the decision making process regarding adoption is the development of knowledge of the innovation, which corresponds to the model proposed by Rogers (1995). Farmers can have knowledge about the existence of a new technology, how to apply it, and what the outcomes are in terms of products, yield, potential environmental benefits, risks and costs. Knowledge refers to factual information and understanding of how the new technology works and what it can achieve (Meijer et al. 2015).

In trying to find out about farmers knowledge on inoculant from the respondents, knowledge statement were form into a series of questions through a Likert scale (table 4.4) to see their state of understand about the inoculant. It revealed that almost all of the respondents on average agree with the question that one sacket (100g) of inoculant is used for an acre of land. Also on average about 70% of the respondents agree that inoculant should be applied once removed from refrigeration. Beside that about 64% on average agree that inoculant is a form of organic fertilizer.

More of the respondents remained neutral with the question that, inoculant has been manufactured in different forms like powder, liquid or granule with an about 80%.which indicated that they don't know about that.

Table 4.4 Knowledge of Soybean Inoculant

Knowledge items	N	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
One sacket of inoculant fertilizers 1 acre	300	70.0	30.0	0.00	0.0	0.0
Inoculants are recommended to be kept in refrigeration	300	9.0	12.3	76.7	2.0	0.0
Inoculant has been manufactured into powder, liquid or granule	300	7.3	10.7	80.0	2.0	0.0
Inoculant are a form of organic fertilizer	300	6.0	58.0	36.0	0.0	0.0
Inoculant should be applied once removed from refigeration	300	20.0	50.0	30.0	0.0	0.0

Source: Field Survey, 2017

4.6 Farmers' Perceptions of Rhizobium Inoculants

According to Meijer et al. (2015), Perceptions relate to the views farmers hold about it based on their felt needs and prior experiences and these do not necessarily align with reality. The perceptions farmers have about an innovation are very closely related to the knowledge they have about it.

The study revealed (table 4.5) that on average, about 90% of the respondents perceived that inoculant is cheaper in terms of cost compared with inorganic fertilizer. All of the respondents also perceived that inoculant use increased the yield of soybeans. However majority of the respondent could not agree or disagree with remaining items. This trend of indifference seems worrying, because to remain indifferent to the use of the inoculant would mean that the farmers are unaware of the benefits of inoculant use and would therefore not adopt the practice.

Table 4.5 Perceptions of soybeans inoculant

Perception items	Response					
	N	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly agree (%)
Inoculant is Cost-effective (less-expensive compared inorganic fertilizer)	300	20.0	70.0	10.0	0.00	0.00
inoculant is of high-yielding product	300	30.0	70.0	0.00	0.00	0.00
farm management practices will increase the efficacy of inoculant	300	0.00	40.0	58.67	1.33	0.00
inoculant is protecting human health	300	0.00	38.33	57.67	4.00	0.00
inoculant is environmentally-friendly	300	0.00	39.33	59.00	1.67	0.00
Inoculant improve soil fertility	300	11.67	18.00	63.67	6.67	0.00
inoculant does not kill soil microorganism	300	0.00	29.67	67.33	3.00	0.00

Source: Field Survey, 2017

4.7 Comparison of Adoption of Soybean Inoculant by Sex

The study compared adoption of the inoculant by sex (figure 4.2) from the result, majority (52.3%) of female male were adopters of the soybean inoculant compared to male adopters (47.6%). This finding is in agreement with Gender issues in agricultural technology adoption have been investigated for a long time and most studies have reported mixed evidence regarding the different roles men and women play in technology adoption (Bonabana-Wabbi 2002).

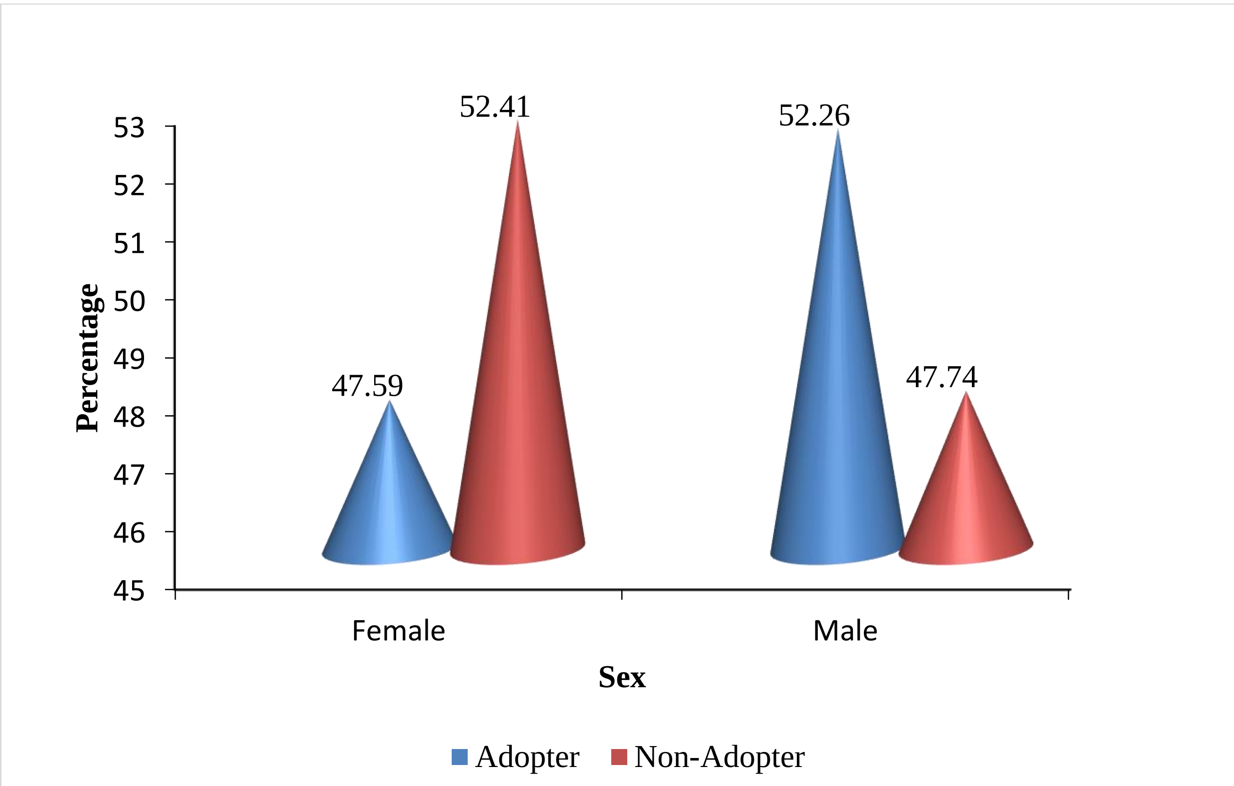

Figure 4.2 Comparison of Adoption of Soybean Inoculant by Sex

Source: Field Survey, 2017

4.8 Comparison of Adoption of Soybean Inoculant by education

Also with regards to education and adoption of the inoculant, the result revealed (figure 4.3) most (54%) no formal educators were (25%) adopters and only a few of the tertiary educators were adopters. Although it was anticipated that those with no formal education (illiterate) may be unwilling to adopt this technology of the rhizobium inoculant under study, the findings rather contradicted with Eze et al. (2006), Ofuoku et al. (2008), Koskei et al. (2013) who reported that literacy level determined the adoption of improved production technologies by farmers since literate farmers could quickly understand agricultural instructions than the illiterate farmers.

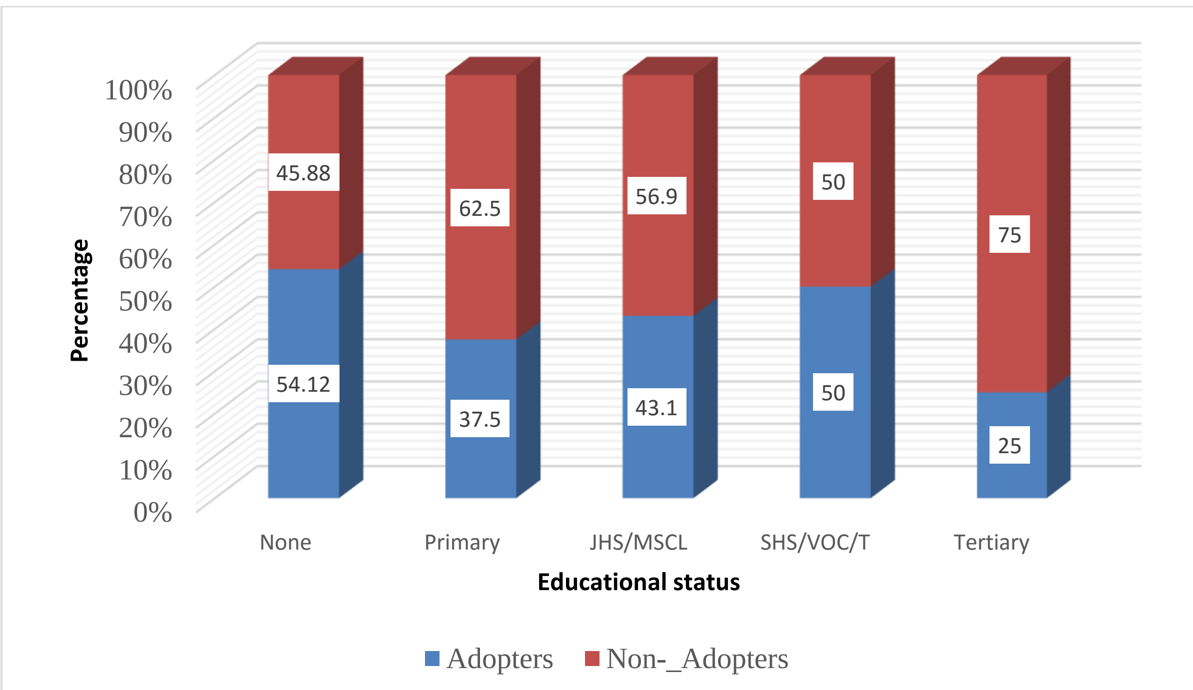

Figure: 4.3: Comparison of Adoption of Soybean Inoculant by Education

Source: Field Survey, 2017

4 .9 Comparison of Adoption of Soybean Inoculant by Age

The study also compared adoption of rhizobium inoculant by age (figure 4.4). The age of the respondents were categorize in to four age groups rang less or equal to 25years and up to 45 to 55years. The result revealed the majority (53.3%) of adopters were within the age of below 25yeas and more (52 5%) also were within age range 26 to 30 of while the few (45.0%) adopters were also within the age range of 25 to 50 years old. This implies that soybean producers are young and will cultivate this crop the next one, two or three decades if they are attracted. Similar results are reported by Dogbe et al. (2013) from Ghana and conclude that soybean production has promising future if these relatively young farmers could be motivated to remain in the sector. Furthermore, Ebong et al. (2011) report a positive relationship between ages and technical efficiency improvement in urban crop production. This is allowing for a strong correlation between ages of the producers and their ability and willingness to improve cultivation practices.

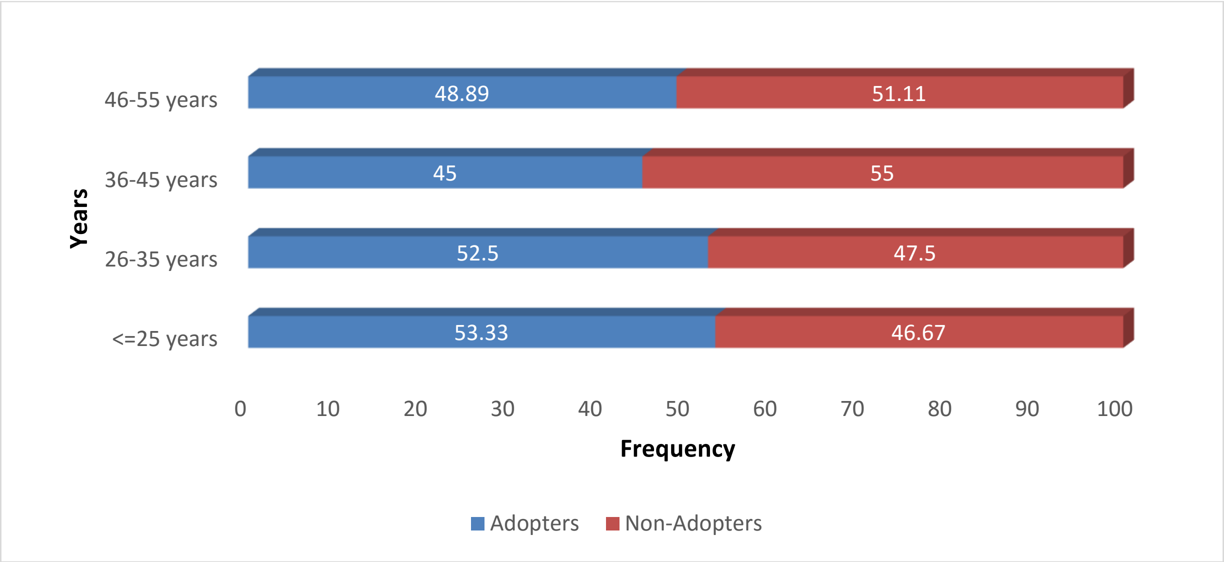

Figure 4.4 Comparison of Adoption of Soybean Inoculant by Age

Source: Field Survey, 2017

4.10 Reason for using the inoculant

The study sought to find out the reasons for soybeans farmers using the rhizobium inoculant. The result in figure 4.5 indicated that, it is economical in terms of cost, easy to transport, it improve yield, it improve soil fertility, it is environmental friendly and maintain soil organisms. This finding is supported by a study by Hardarson et al. (1987), that inoculant provided nitrogen into the soil at a cheaper cost. Also, bacteria are among the most useful soil microorganisms for crop production with a proven benefit of root nodules.

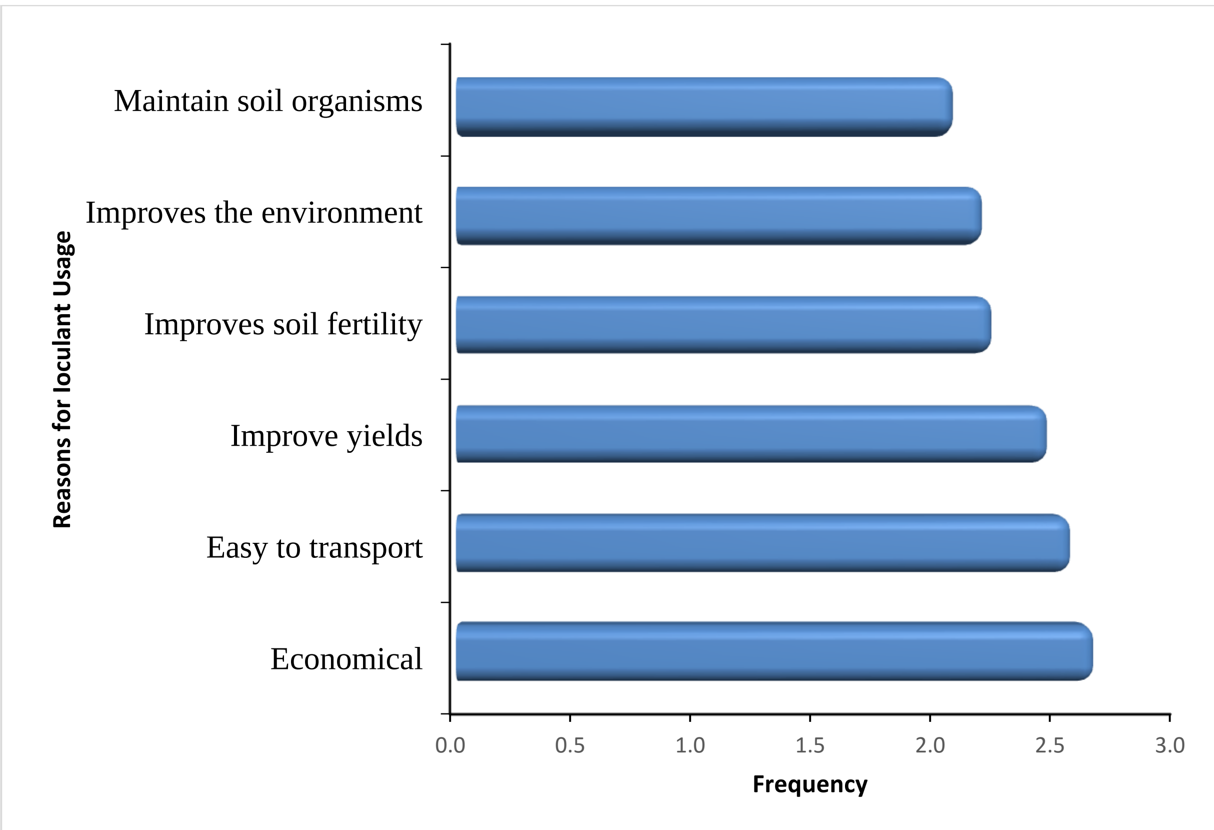

Figure 4.5 Reasons for Using the Inoculant

Source: Field Survey, 2017

4.11 Reason for not using the inoculant

The study sought to know the reasons for not using the rhizobium inoculant by some soy bean farmers. The result indicated the perishability of the inoculant, not easily accessible, inadequate fund, lack of refrigerator for storage and complex technical procedure were some of the reason why some farmers are not using it as indicated in the figure 4.6. This finding is agreement with Dogbe, (2013) observed that a major constraint to agricultural development in the Northern Ghana is farmers' inability to access credit (funds) for agricultural inputs. Moreover, Al-Hassan, Sarpong and Mensah-Bonsu (2006) reported poor accessibility to guaranteed input major problems confronting farmers on adoption of agricultural technologies. Also, Fening and Danso (2002) found that about 68% of the rhizobia inoculant for cowpea in Ghana is unfertile.

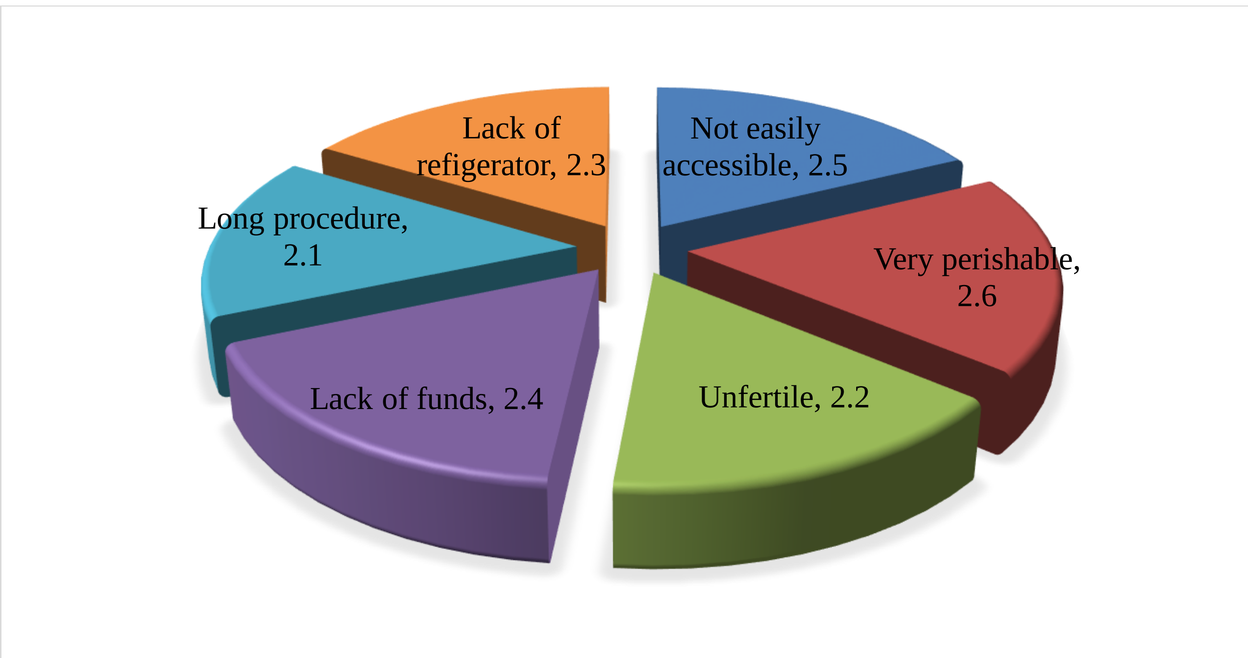

Figure 4.6 Reason for not using the Inoculant

Source: Field Survey, 2017

4.12 Source of Information for Accessing the Inoculant

The study sought to know the source of information for accessing the rhizobia inoculant by the soybeans famers. The result in (table 4.5) revealed that majority (50%) of the respondents' source information in accessing inoculant from NGOs-SEND Ghana, more of the respondents(20%) source information in accessing inoculant from the extension offices and 20% from inputs dealers. A few of the respondents (10%) source information in accessing the inoculant from family members.

Table 4.5: Source of Information for Accessing the Inoculant

Source	**Frequency**	**Percentages**
Input dealers	60	20
NGOs-SEND Ghana	150	50
Family members	30	10
Extension officers	60	20
Total	300	100

Source: Field Survey, 2017

4.13 Determinants of Farmers' Adoption of Rhizobium Inoculant

The study sought to determine the factors influencing farmers' adoption of soybean inoculant. The dependent variable adoption is limited and therefore propels the use of the tobit regression model. The independent variables included in the model were; Years of cultivating soybeans, age, sex, educational level , household size, soybean farm size, perception of inoculant on cost, Perception of inoculant on environmental friendly, Perception of inoculant as organic fertilizer, Perception of inoculant on microorganisms and credit (if cash), Of these, age, sex, household size, perception about inoculant cost, perception of inoculant about the environment, perception of inoculant as an organic fertilizer and perception of inoculant on microorganisms had significant influence on farmers' adoption of Rhizobium inoculant at 1% and 10%.

Age: Respondents' age was found to have negative influence on the intensity of inoculant use with a coefficient of 0.03. This implies that when age increases by one year, the probability that an individual uses soybean inoculant reduces by 0.03 *ceteris paribus.* This confirmed Kariyasa and Dewi (2011), assumption that age is a determinant of adoption of new technology. Older farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers. On contrary age has been found to have a negative relationship with adoption of technology. This relationship is further explained by Mauceri et al. (2005), that as farmers grow older, there is an increase in risk aversion and a decreased interest in long term.

Sex: Respondents' sex was found to have a negative effect on inoculant use with a coefficient of 0.0754. This means that women had a higher probability of inoculant use as compared to their male counterparts. Thus, women have a 0.07 higher chance of inoculant use compared to their male counterparts.

Household size: Household size was found to have a positive significant effect on inoculant use. This means that when the household size of the farmer increases, there is the likelihood that inoculant use would increase. With a coefficient of 0.2431 (Table 4.7) and significant at 1%, with an increase in household size by 1 person, the probability that the farmer would sue inoculant increases by 0.2431 *ceteris paribus*. This is expected because one can argue that with increase in household size, there is available family labour to the farmer and therefore the effort that one person would put in can now be distributed among the several people. Household size is another important component of agricultural technology. A study in land management uses household size as a determinant. An improved land management practice requires labour input from households. Kimaro et al. (2013) observed that a family with larger number of members is more likely to try and continue using a potential profitable technology.

Perception of inoculant on cost: Perception of inoculant on cost was found to have a positive significant effect on inoculant use. This implies that those who perceived inoculant use to be cost effective have a higher probability of use compared to those who perceived otherwise. This is evident in the coefficient of 1.0540, which implies that those who perceive inoculant use as cost effective have a more than double chance on use in their soybean production all else held constant. This is possible because the information on cost is a key determinant in the decision of a farmer to adopt/use inoculant.

Perception of inoculant on environmental friendly: Perception of inoculant on environmental friendly also had a positive effect on the decision of a farmer to use the rhizobium inoculant. Farmers who perceived the inoculant to be environmentally friendly has a higher chance of use compared to their counterparts who perceived otherwise. A coefficient of 0.7057 implies that, holding other factors constant, farmers who perceive inoculants to be environmentally friendly having a 0.7057 higher chance of use as against those who perceive otherwise. This however, is rational human behavior where the quality of the natural environment is now being championed by concerned parties to reduce the adverse effects of poor environmental quality.

Perception of inoculant as organic fertilizer: Perception of inoculant as organic fertilizer was found to positively influence inoculant use. Farmers who perceived the rhizobium inoculant as an organic fertilizer have a higher probability of its use compared to those who perceive otherwise. Holding other factors constant, farmers who perceive soybean inoculant (rhizobium) as organic fertilizer have a 0.1874 higher chance of its adoption and use. Again, with a case for organic foods now the being promoted, farmers may just be realizing the numerous benefits they can derive from going organic informing their decision to use the inoculant.

Perception of inoculant as having microorganisms: Perception of inoculant as having microorganisms to speed up the germination and nutrient fixation process was found to have significant influence on a farmer's decision to adopt and use the inoculant.

With a coefficient of 0.3260 (Table 4.7). it implies that farmers who the inoculant because of their perception on its microorganism actions have a 0.3260 higher chance of adoption and use compared to those who perceived otherwise, *ceteris paribus.* Investment in the farm on the other hand younger farmers are typically less risk-averse and are more willing to try new technologies.

For instance, Alexander and Van Mellor (2005) found that adoption of genetically modified maize increased with age for younger farmers as they gain experience and increase their stock of human capital but declines with age for those farmers closer to retirement.

Table 4.7: Determinants of Farmers' Adoption of Rhizobium Inoculant

Variables	***Coefficient***	***Std. Error***	***T value***	***P-value***
Years of cultivating soybeans	-0.0022	0.0033	-0.67	0.948
Age	-0.0303***	0.0062	-4.85	0.000
Sex	-0.0754*	0.0397	-1.9	0.058
Educational level	0.0256	0.0202	1.27	0.205
Household size	0.2431***	0.0341	7.13	0.000
Soybean farm size	-0.0084	0.0524	-0.16	0.873
Perception of inoculant on cost	1.054***	0.114	9.25	0.000
Perception of inoculant on environmental friendly	0.7057***	0.1287	5.48	0.000
Perception of inoculant as organic fertilizer	0.1874***	0.0654	2.87	0.005
Perception of inoculant on microorganisms	0.326***	0.0953	3.42	0.001
if cash (credit)	0.0001	0.0002	0.5	0.463
Cons	-10.8968***	0.89	-12.24	0.000

Number obs=300, F (11,289) = 345.16, Prob > F = 0.000 R2 = 0.7469 adj R-squared = -106.026

***, ** and * denote that the variable is significant at less than 1%, 5% and 10% respectively

Source: Field Survey, 2017

4.14 Effect of Adoption of Soybean Inoculant on Productivity

This section presents results and discussion on effect of adoption of soybean inoculant on productivity.

4.14.1 Factors Influencing Soybean Productivity and Farmers Inefficiency

The study sought to determine the factors influencing soybean productivity. The variables included in the model were; farm size, weedicide, inoculant use and total labour. Of these, weedicide, inoculant and total labour had significant influence on farmers' adoption of Rhizobium inoculant on productivity. This is contained in the table below.

Table 4.8 shows the maximum likelihood estimation of the Cobb-Douglas function as well as the inefficiency model. On the maximum likelihood estimation of factors influencing soybean productivity, out of four (4) inputs used in the production process, three (3) were significant and at 1%. The significant variables were weedicide, inoculant and total labour whilst farm size was insignificant.

Weedicide use was found to have a positive influence on the productivity of soybean. This is statistically significant at 1% with a coefficient of 0.440. This implies that when weedicide used by a farmer increases by 1 litre, the probability that soybean yield would increase is 0.440, *ceteris paribus*.

This is plausible especially in these days where, weedicide use reduces the time spent in the field manually weeding. This time can now be channeled to other activities that would ensure optimal productivity. Inoculant use was also found to have a positive and significant influence on productivity. The coefficient of 0.353 indicates that, when inoculant use increases by 1 bag (1 kg), soybean yield has a 0.353 probability of increase holding other factors constant.

This is not surprising and it meets a priori as soybean inoculant use is proven to have increasing effect on productivity.

Total labour was found to influence yield of soybean inoculant negatively. This means that as total labour increases, the probability that soybean productivity would decrease is 0.261, all else constant. This is however, unexpected but plausible. Interactions with the respondents revealed that, as the total labour on the available increases, the focus on other crops rather than soybean increases pushing labour to these other crops. This could be the cause of the negative effect of soybean on productivity. Also, management of the labour on the field could be responsible as large numbers may mean that work and supervision are all ineffective contributing to the decrease in productivity.

Additionally, the study sought to determine the factors that influenced the inefficiency of soybean farmers in the East Gonja District. The variables included in the model were; years of cultivating soybeans, age, sex, educational level , household size, soybean farm size, adoption of soybean inoculant, credit (if cash), Soil fertility management, FBO membership, Of these, household size, credit and Soil fertility management had significant influence factors influencing technical efficiency of soybean farmer.

In the efficiency model, a negative coefficient means an increase in inefficiency or a negative effect on productivity, while a positive coefficient means an increase in efficiency or a positive effect on productivity. The estimates of the efficiency model revealed that almost four of the variables were significant at 1% and two of the variables have negative coefficients showing an increase in inefficiency in adoption of rhizobium inoculant by the soybean farmers and a negative effect on their productivity.

Age of a farmer was found to negatively influence the efficiency of a farmer or as a farmer ages, the farmer becomes more efficient. With a statistically significant coefficient of 0.024, it was found out that, when age of a farmer increases by one year, the probability that the farmer would become efficient decreases by 0.024 *ceteris paribus.* This is not unimaginable as age and a farmer's strength and general health are negatively related.

Thus, as a farmer ages, there tend to be a reduction in the abilities of the farmer and this affects farming which requires that a farmer is physically fit holding other factors constant.

Household size was also found to have a positive influence on the technical efficiency of a farmer or inefficiency increases with increase household. This implies that farmers with increasing households are more likely to be technically efficient. It stands to reason as one would expect that a farmer with increasing household would translate into cheap labour for farming. The availability of this labour under supervision would contribute to a farmer being technically efficient, *ceteris paribus.* Thus, as household size increases, the probability that the efficiency of the farmer would increase is 0.304.

Credit was found to have a negative influence on the efficiency of a farmer. Farmers who did not have access to credit were found to have a 0.006 chance more of being technically efficient compared to those who had access to credit or Farmers who did not have access to credit were found to have a 0.006 chance more of being technically inefficient compared to those who had access to credit. The norm would have been that, once you have access to credit, you should be technically efficient as capital is a major factor in production. This is however, not the case as those who did not have access to credit were more technically efficient.

This could be explained by the fact that those who had no access to credit had to pay extra attention to good and improved agricultural practices that would give them the optimum soybean yield.

Soil fertility management was found to have a positive effect on technical efficiency or as soil management practices increase, technical efficiency decreases. The coefficient of 0.223 implies that farmers who adopted more soil fertility management practices have a higher (0.233) chance of being technically inefficient (higher yields) compared to their counterparts who do not adopt any soil management practices, all other factors held constant.

This is quite expected as improved agricultural and agronomic practices have evidently improved crop yields of many crops including soybean. For policy, the campaign on the adoption of improved practices should be intensified as farmers stand to benefit more if they adopt these practices.

Table 4.8: Maximum Likelihood estimates of Factors Influencing Soybean Productivity and Farmers Inefficiency

Variable	Coefficient	SE	Z-value	P-value
Constant	2.644	0.650	4.068	0.000
lnfarm size	0.000	0.000	-0.018	0.998
Lnweedicide	0.440	0.020	22.00	0.000***
Lninoculant adoption	0.353	0.017	20.76	0.000***
Lntotlab	-0.261	0.056	-4.661	0.000***
Inefficiency				
Age	-0.024moreeff	0.002	-12.0	0.000***
Sex	0.005	0.015	0.33	0.739
EDUCATION	0.000	0.008	0.00	0.958
HOUSEHOLD SIZE	0.304eff	0.017	17.88	0.000***
SOYBEAN	0.007	0.018	0.389	0.679
Credit	-0.006moreeff	0.001	-6.00	0.000***
Soybean inoculant	0.003	0.015	0.20	0.831
Soil fertility management	0.223	0.023	9.696	0.000***
FBO membership	0.017	0.035	0.486	0.624
Constant	-0.002	0.424	-0.005	0.996

A log likelihood test revealed that the Cobb-Douglas formulation rather than a trans-log is most suitable for the estimation of effect of rhizobium use on soybean productivity.

Source: Field Survey, 2017

4.15 Challenges of Access and Usage of Rhizobium Inoculant

The study sought to determine the limitations of the inoculants accessibility and utilization by farmers. The result in table 10 revealed the rank of challenge in descending order; in accessibility of the inoculant in the market, In adequate access to credit in order to purchase the inoculant, Inadequate information about the inoculant, poor rainfall, Lack of inoculants, The inoculant easily getting damaged, Technical procedure is complex, Storage of the inoculant impose extra cost and cultural barriers

Kendall's Coefficient of Concordance (W) was used to test for the level of agreement among the ranking of the constraints by farmers on the use of inoculant. The Kendall's Coefficient of Concordance (W) was estimated from the study to be 0.458; chi-square statistic was estimated as 1098.462 with 8 degrees of freedom and asymptotic significance of 0.000.

Kendall's Coefficient of Concordance (W) estimated as 0.458 indicating that there is 45.8% percent agreement among the respondents on the rankings of the constraints.

Table 4.9: Rankings of Constraints faced by Farmers on Accessibility and Utilization of Inoculant

Constraint	Mean Rank	Rank
Inoculant easily losses it viability if not use on time	4.85	5th
Inadequate information about inoculant	3.35	3rd
Lack of inoculant in the open market	3.00	1st
Lack of access to credit in order to purchase the inoculant	3.15	2nd
Cultural barriers	7.70	9th
Technical procedure complex	6.05	7th
Storage of the inoculant imposed extra cost	7.60	8th
Inoculant easily get damage	5.60	6th
Poor rainfall	3.70	4th

Source: Field Survey, 2017

Sample size (N) = 300, Kendall's W = 0.458 Chi-Square = 1098.462, df = 8

Asymptotic significance = 0.000. Rank 1 = Highest Constraint, Rank 9 = Least Constraint

With a mean rank of 3.00, the lack of market for inoculant came out highest and with a general agreement level of about 46% for the entire population. This means on the average, 46% of the respondents agreed with the ranks and identified the lack of access as the highest limiting factor to their use of inoculant in the East Gonja District of Northern Region. The lack of access in order to purchase the inoculant was the second most limiting factor to the use of inoculant with about 46% general agreement.

The inadequate information about inoculants is also, one factor that is preventing its use by the respondents but the least of the factors presented to the respondents that is limiting the use as reported is cultural barriers. The respondents were not limited by culture in their quest to use inoculants and therefore interventions that are towards improving the use of the inoculants should be targeted at address market access, access to credit and inadequate information about the inoculants.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This chapter presents the summary of the findings of the study, conclusions and recommendations which when implemented could enhance the use of rhizobia inoculant among farmers.

5.2. Summary of Findings

The primary objective of this study was to identify factors which influence adoption of soybean inoculant and its effect on output of soybean in the East Gonja District. This study was limited to soybeans farmers in the East Gonja District. The study adopted a multi-stage sampling approach in selecting 10 communities in the district randomly. In the second-stage, farmers were stratified into adopters and non-adopter. Simple random sampling technique was employed to select 150 adopters and 150 non-adopters. In total, 300 respondents were sampled for the study. Statistical package for Social Science SPSS-16 were used for data analysis. Data inputting was done in SPSS and STATA for descriptive analysis and regression analysis. Tobit and ordinary least squares (OLS) regression models was use to understand adoption and its performance. Five research objectives were examined. The first was to determine the knowledge level of farmers on inoculants. The second was to examine farmers' perceptions of inoculants. The third was to determine the factors that influence farmers' adoption of soybean inoculants. The fourth was to analyze the effect of soybean inoculants adoption on output. Whiles, the fifth was to determine the limitations of the inoculants accessibility and utilization by farmers.

This final chapter summarizes and concludes on the findings of the research. A summary of the key finding is provided first and then the conclusions and the recommendations that arises from the findings of the research are presented for policy consideration as well as for future research.

5.2.1 Socio-demographic Characteristics of Soybeans Farmers in the East Gonja

The study revealed that majority (51.2%) of the respondents were females, whiles the remaining 48.8 % were male respondents in the study area. On age status of respondent, the study reveals that 10% of respondents were below the age of 25 years, while 40 % are between 26 to 35 years and 20% and 30% falling within the age categorizes of 36 to 45 years and 46 to 55 years respectively. Overwhelming majority (90%) of the soybean farmers interviewed were between the ages of 30 and 55 years which compares fairly well with the productive age range. The youngest respondent was 22 years and the oldest 53 years. However, on educational status of respondents, the results of the survey reveal a worrying situation of high illiteracy rate among soybean farmers in the study area. As high as 194 out of 300 respondents interviewed (representing 64.7%) have no formal education, with only 4 respondents having tertiary level education and 27.3% and 6.7% having basic and secondary education respectively. With regard to household size, the study found out that minimum household size is 5 people and maximum house hold size is 14 people. Though, the average household size within the EGD is 10 people which is far greater than the national average size of 4 people per household. Finally, on farming experience, the study showed an average farming experience of 16, with ranges of 5 to 30 years. However, most of the farmers had a farming experience of less than 15 years. With only a few farmers thus, 20% of the total sample had farming experience of more than 20 years.

5.2.3 Soybean Farmers Knowledge on Soybean Inoculants in the East Gonja District

In trying to find out about farmers knowledge on inoculant from the respondents, knowledge statement were form into a series of questions through a Likert scale to see their state of understand about the inoculant.

However, the revealed that almost all of the respondents on average agree with the question that one sacket (100g) of inoculant is used for an acre of land. Also on average about 70% of the respondents agree that inoculant should be applied once removed from refrigeration. Beside that about 64% on average agree that inoculant is a form of organic fertilizer. More of the respondents remained neutral with the question that inoculant has been manufactured in different forms like powder, liquid or granule with an about 80%.which indicated that they don't know about that.

5.2.4 Farmers' Perceptions towards the Use of Soybean Inoculants in the East Gonja District.

On farmers' perceptions on the use of inoculant, the study revealed that on average about 90% of the respondents perceived that inoculant is cheaper in terms of cost compared with inorganic fertilizer. All of the respondents also perceived that inoculant use increased the yield of soybeans. However majority of the respondent could not agree or disagree with remaining items. This trend of indifference seems worrying; because to remain indifferent to the use of the inoculant would mean that the farmers are unaware of the benefits of inoculant use and would therefore not adopt the practice.

5.2.5 Determinants of Soybean Inoculants Adoption among Soybean Farmers in the East Gonja.

Farmers' adoptions of agricultural technologies are mostly influence by several factors. The tobit regression model was used for the analysis due to the limited nature of dependent variable

The independent variables included in the model were; Years of cultivating soybeans, age, sex, educational level , household size, soybean farm size, perception of inoculant on cost, Perception of inoculant on environmental friendly, Perception of inoculant as organic fertilizer, Perception of inoculant on microorganisms and credit (if cash), The Tobit regression model revealed that age, sex, household size, perception about inoculant cost, perception of inoculant about the environment, perception of inoculant as an organic fertilizer and perception of inoculant on microorganisms had significant influence on farmers' adoption of Rhizobium inoculant at 1% and 10%.

5.2.6 Effect of Soybean Inoculants Adoption on Output of Soybean in the East Gonja.

The maximum likelihood estimation of the Cobb-Douglas function revealed that, out of four (4) inputs used in the production process, three (3) were significant and at 1%. The significant variables were weedicide, inoculant and total labour whilst farm size was insignificant.

5.2.7 Constraints Face by Soybean Farmers on the Use of Soybeans Inoculants in the East Gonja District.

The study result revealed the rank of challenge in descending order; in accessibility of the inoculant in the market, In adequate access to credit in order to purchase the inoculant, Inadequate information about the inoculant, poor rainfall, Lack of inoculants.

The inoculant easily getting damaged, Technical procedure is complex, Storage of the inoculant impose extra cost and cultural barriers

Kendall's Coefficient of Concordance (W) was used to test for the level of agreement among the ranking of the constraints by farmers on the use of inoculant. The Kendall's Coefficient of Concordance (W) was estimated from the study to be 0.458; chi-square statistic was estimated as 1098.462 with 8 degrees of freedom and asymptotic significance of 0.000. Kendall's Coefficient of Concordance (W) estimated as 0.458 indicating that there is 45.8% percent agreement among the respondents on the rankings of the constraints.

5.3 Conclusion

The studies revealed that, majority of the respondents have much knowledge with regards to the usage and application of soybean rhizobium inoculant in the study area. Having much knowledge is good in the right direction in that it may not be to difficult in building the farmers capacity to increase adoption. Also about 90% of the respondent perceived inoculant to be cheaper in terms of cost as compare with inorganic fertilizers and it also increase the yield of soy beans. In this case inputs dealers and other organization must make a conscious effort to make the inoculant readily available and accessibly to the soybean farmers. Most of the respondent accessed information about the inoculant through NGO, inputs dealers, family and friend other than the mass media such TV and radio and extension officers.

The finding shows that education of the household head, farm size, and participation on training of soybean production, and access to extension services all are positively and significantly related to adoption. Inoculant, weedicide and 'other' input were found to be significantly influence yield of soybean in East Gonja district of northern region.

Weedicide use was found to have a positive influence on the yield of soybean. Inoculant usage was also found to have a positive and significant influence on yield. Some socio-demographic characteristic like age, household size and others like Credit were found to influence the efficiency of soybean farmers in East Gonja District. It is believed that with proper combination of other factors of production farmers inefficiency can also affect the output.

Finally, soybeans farmers faced a lot of challenges when it comes to the use of inoculant, for instance lack of inoculants, the inoculant easily getting damaged, technical procedure is complex, storage of the inoculant impose extra cost and cultural barriers were all challenges farmers faced.

5.4.0 Recommendations

There is the need to improve access to extension services on soybean production, with more emphasis on East Gonja District. Extension services could be improved through scaling up of current agricultural interventions, implementation of new agricultural projects, employment of more agricultural extension agents, improvement in logistical support for agricultural extension agents among others.

In addition, there is also the need to create an enabling environment for soybean farmers, which will serve as an incentive for them to continue to remain in production until they are well advanced in age. Furthermore, policy makers should ensure that rhizobium inoculant should be made available to Agro inputs dealers' shops for easy accessibility and information to farmers. Since markets serves as a drivers of technologies adoption and has been observed in this study.

Promoters of soybean inoculant should organize workshop every seasons to agro Input dealers and farmers on the handling and usage of rhizobium inoculant, since these components have the ability to positively or negatively influence adoption of soybean inoculant in the study area.

Promoters of soybean inoculant should communicate properly to farmers on the benefits of soybean inoculant as organic fertilizer with no adverse effects on environment and human health.

Promoters of soybean inoculant should encourage farmers to production of soybeans in the study, most respondents in the study area cultivated between one and two acres each.

Promoters of soybean inoculant should use both mass media such as radio and video show as well as other interpersonal media to disseminate information on soybean inoculant to farmers in the study area.

5.5. Suggestions for Future Research

This study did not explore the profitability and marketing challenges facing the soybean farmers under study, therefore there is the need for further research on profitability and market challenges of soybean farmers in East Gonja District

This study also recommends future research on the impact of inoculants use on the livelihood of farmers in the district.

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APPENDIX A

FARM HOUSEHOLD QUESTIONAIRE

SOYBEAN PRODUCTION AND ADOPTION OF RHIZOBIA INOCULANTS AMONG FARMERS IN THE EAST GONJA DISTRICT, GHANA

District ____________________ **Name of community** _________________________

Name of Interviewer ____________________________ **Q/No.** ___________

PART I

IDENTIFICATION OF SOYBEAN FARMERS

1. Do you produce soybean you as part of your 2015/2016 farming practice? Yes [ ] No [ ]
2. If yes for how long have you been cultivating soybean? _________________
3. Please indicate the rationale for cultivating soybean [*Please tick the appropriate option for each statement*]

Statement	*Yes*	*No*	*Don't know*	*Comment*
It improve my income				
It provides a good source of oil and protein for my family				
I cultivate soybean because it has good price market				
It improve soil fertility				

PART II

SOCIO-DEMOGRAPHIC CHARACTERISTICS

HH members	Relationship to Head **code 1**	Age	Sex **code 2**	Marital status **code 3**	Highest level of education **code 4**	Is farming the major source of occupation? **Code 5**	If no, please specify your major source of occupation **code 6**
Respondent's name							

[Code 1: *Head = 1; Spouse = 2; Child = 3; Grandchild = 4; other relatives = 5;* Code 2: *Male = 1; Female = 2;* Code 3: *Married = 1; Single = 2; Divorced = 3; Widowed = 4;* Code 4: *None = 1; Primary = 2; JHS/MSCL = 3; SHS/Voc/Tec = 4; Tertiary = 5;* Code 5: *Yes = 1; No = 0*]

4. How many people are living in this household? ____________
5. What is your religion affiliation? Christian [ ] Islam [ ] Traditionalist [ ] others (*please specify*) ______________________
6. Are you a native of this community? Yes [ ] No [ ]
7. How much does your household spend on food items? GHS __________

PART III

Farm Characteristics- Crop Production

1. Indicate the number of years you have been in farming ______________________
2. What is the size of your total land holding (in terms of acres)? _____________(acres)
3. Please, indicate the type of crop cultivated in the 2015/16 season together with soybean and provide information on the farm size, quantities harvested, stored or consumed and sold as well as the price, in the table below:

Crop type	**Farm size (acres)**	**Quantity harvested (maxi-bag)**	**Quantity Stored / consumed (Maxi-bag)**	**Quantity sold (Maxi bag)**	**Unit price (GHS)**	**Total income (GHS)**
Soybean						
Maize						
Rice						
Yam						
Millet						
Sorghum						
Groundnut						
Cassava						
Others						

4. Which variety (s) of soybean do you cultivate and in order of importance rate the reasons for preference? [***1 = Strongly agree; 2 = Agree; 3 = Neutral; 4 = Disagree; 5 = Strongly disagree***

Soybean varieties	1	2	3	4	5
1. early maturity					
2. high yielding					
3. adaptation to poor soils					
4. drought resistant					
5. pest and disease tolerance					
6. quality bean					
7. good taste					
8. long shelf life					
9. Non shuttering					

10. What is the current soybean production practice do you engage in? Monocropping [ ] Mixed cropping [ ]
11. What kind (s) of inputs including the inoculants did you use for your farm in the 2016/2017 season?

Input	**Quantity Bought**	**Unit cost (GHS)**	**Total cost (GHS)**
Seeds (Kg)			
Chemical Fertilizer (50 Bag)			
Weedicide (Litres)			
Pesticide (Litres)			
Organic fertilizer			
Tractor			

LABOUR USE

1) Please indicate the labour employed in relation to the following activities

	Family labour		**Hired labour**	
Activity	**No.**	**Unit cost**	**No.**	**Unit cost**
i. Land preparation				
ii. Sowing/planting				
iii. Spraying				

iv.	Fertilizer application				
v.	Weeding				
vi.	Harvesting/postharvest				

CREDIT ACCESS

1. Did you apply for credit from any financial institution, organization or person for your business in the 2016/17 season? Yes [ ] No [ ]
2. If yes, what type of credit? Cash credit [ ] Input credit [ ]
3. If cash, how much did you receive? GHS _______________

PART IV

AWARENESS, PERCEPTIONS AND ADOPTION OF SOYBEAN INOCULANTS

1. Have you ever heard about soybean inoculant for fertilizing soils? (Code 1)	2. If yes, please indicate the source of your awareness (Code 2)	3. Have you ever used the soybean inoculants to fertilize your farm? (Code 3)	4. Did you apply the soybean inoculant on your farm in the 2016/17 season? (Code 4)

Code 2

1. TV
2. RADIO
3. District assembly (MOFA)
4. NGOs
5. Scientific Research Institutions
6. Newspapers
7. Farmers
8. Friends/family
9. Seminars/Workshops
10. Others *(Please specify…………………)*

Code 1

Aware = 1

Not aware = 2

Code 3

Yes = 1

No = 2

				Code 4 *Yes = 1* *No = 2*

5. For how long have you been using the soybean inoculant? (years) ___________________
6. Did anyone or an organization initially arranged the inoculant for you? Yes [ ] No [ ]
7. If yes, who help you to get the inoculant? Input dealer [ ] NGO-SEND Ghana [ ] Family member [ ] Friend [ ] Extension officer [ ] Others (*Please specify*) _____________
8. What quantity of the soybean inoculant did you apply in the 2015/16 season? (sackets) _______

Soybean farm size	Qty of inoculant use	Unit price	Total cost

9. Is the inoculant specific to a certain variety of soybean? Yes [ ] No [ ]
10. If yes, which variety (s) of soybean does well with the inoculant?______________________

How helpful was the following persons or institutions in accessing the inoculant

[This section of the survey deals with how certain persons or institutions have been influential to farmers in accessing the soybean inoculant. Kindly indicate the extent to which the persons or institutions have been helpful to you in access the soybean inoculants]. ***1 = Very helpful; 2 = Helpful, 3 =Moderate; 4= Not helpful; 5= Not helpful at all*]**

	Persons/Institutions	**1**	**2**	**3**	**4**	**5**
1	NGO-SEND Ghana					
2	Input dealer					
3	FBO					
4	Colleague farmers					
5	Family member					
6	Friend					
7	Extension officer					
8	*District Assembly*					

Reasons for applying or not applying the soybean inoculant

[This section of the survey deals with reasons for applying or not applying the soybean inoculant. Kindly indicate the extent to which you agree or disagree with the following statements about your about the soybean inoculants]. ***1 = Strongly disagree; 2 = Disagree, 3 =Neutral; 4= Agree; 5= Strongly agree*]**

	Reasons for applying inoculant	**1**	**2**	**3**	**4**	**5**
1	It cheap and economical compared to inorganic fertilizer					
2	Improve yields					
3	Improve soil fertility					
4	Doesn’t kill soil microorganisms					
5	Environmentally-friendly					
6	Easy to transport					
7	*Others (Please specify)*					

	Reasons for not applying inoculant	**1**	**2**	**3**	**4**	**5**
1	It’s not easily accessible					
2	It easily get spoiled if not handled properly					
3	My farm is highly fertile					
4	Lack of funds					
5	Soybean itself add a lot of nutrients to the soil					
6	Technical procedure is complex					
7	*Others (Please specify)*					

Source of the Inoculant

Please indicate where you accessed your inoculant in the 2016/17 season

	Persons/Institutions	**Tick**
1	NGO-SEND Ghana	
2	Input dealer	
3	FBO	
4	Colleague farmers	

5	Family member	
6	Friend	
7	Extension officer	
8	*District Assembly*	

2) What species of inoculant do you know?

Farmers' Knowledge of inoculant

[This section of the survey deals with knowledge of the soybean inoculant. Kindly indicate the extent to which you agree or disagree with the following statements about your about the soybean inoculants]. ***1 = Strongly disagree; 2 = Disagree, 3 =Neutral; 4= Agree; 5= Strongly agree]***

	Statements	1	2	3	4	5
1	1 sacket of inoculant can be applied to 1 acre farm					
2	Inoculant must be refrigerated to avoid spoilage					
3	The inoculant comes in three forms (e.g. powder, grains, liquid)					
4	Inoculant is an organic fertilizer specially design for legumes					
7	*Others*					

Farmers' Perceptions of inoculant

[This section of the survey deals with perceptions about the soybean inoculant. Kindly indicate the extent to which you agree or disagree with the following statements about your about the soybean inoculants]. ***1 = Strongly disagree; 2 = Disagree, 3 =Neutral; 4= Agree; 5= Strongly agree]***

	Statements	1	2	3	4	5
1	Cost-effective					
2	High-yielding					
3	Protect human health					
4	Environmentally-friendly					
3	Improve soil fertility					
4	Doesn't kill soil microorganisms					
7	*Others*					

Challenges in accessibility and use of the inoculants

[This section of the survey deals with the challenges in accessing the soybean inoculant. Kindly indicate the extent to which you agree or disagree with the following statements about your about the soybean inoculants]. ***1 = Strongly disagree; 2 = Disagree, 3 =Neutral; 4= Agree; 5= Strongly agree]***

	Challenges	**1**	**2**	**3**	**4**	**5**
1	Lack of inoculants					
2	Inadequate information about the inoculants					
3	Lack of market for the inoculant					
4	Lack of access to credit in order to purchase the inoculant					
5	Cultural barriers					
6	Technical procedure is complex					
7	Storage of the inoculant impose extra cost					
8	The inoculant easily get damage					
9	*Others (Please specify)*					

4. What other soil fertility management methods do you practice?
   Crop rotation [ ] Intercropping [ ] Land fallow [ ] Erosion control [ ] Others (Please specify) ____________

Social Networks

1. Do you participate in any farmer-based organization in this community? Yes [ ] No [ ]
2. Are you a member of any soybean value chain (VC)? Yes [ ] No [ ]
3. Did you receive agric. extension services in relation to soybean production or inoculants in the 2016/17 season? Yes [ ] No [ ]
4. If yes, how many times did you benefited from the extension services? ____________
5. Have you receive training on the use of the inoculant? Yes [ ] No [ ]
6. If yes, by who or which organization? NGOs [ ] Extension officers [ ] Colleague farmers [ ] Input dealers [ ]

THANK YOU

APPENDIX B

CHECKLIST OF KEY INFORMANTS

SOYBEAN PRODUCTION AND ADOPTION OF RHIZOBIA INOCULANTS AMONG FARMERS IN THE EAST GONJA DISTRICT, GHANA

1. Have you ever heard about soybean inoculant as an alternative source of fertilizing soils?
2. Are soybean farmers aware of the inoculant?
3. Where have heard about the soybean inoculant?
4. Which organizations introduce the inoculant to soybean farmers in the district?
5. Which year was the inoculant introduce to farmers?
6. Have you ever used the soybean inoculants to fertilize your farm?
7. What are the reasons for using the inoculant?
8. Which other source or organization can farmer get the inoculant to purchase?
9. How is the inoculant packaged?
10. In which form is the inoculant sold to farmers?
11. What are the procedures in using the inoculant on a farm?
12. Is the inoculant cost effective compared with inorganic fertilizer?
13. Does the inoculant have any effect on our environment?
14. Do soybean farmers belong to any value chain or network?

15. Do you have access to credit facilities to farmers?

16. What other factors may influence farmer to adopt the inoculant

17. What challenges do farmers faces in accessing the inoculant?

Thank you very much for your time.