ECONOMIC EVALUATION OF SOYBEAN GENOTYPES UNDER SOIL FERTILITY VARIABILITY IN NORTHERN AND EASTERN UGANDA

BY

TANYIMA EDWARD

BSc. AGRIC (MAK)

REG.NO:2010/HDO2/703U

A THESIS SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS OF MAKERERE UNIVERSITY

JULY, 2015

DECLARATION

I hereby declare that this thesis is my original work and effort and has not been submitted for a Degree Course in Makerere or any other University before.

Tanyima Edward

Signed …………………………………………….

Date ………………………………………………

Approval

This thesis has been submitted for examination with our approval as University supervisors.

Dr. Gabriel Elepu

Signed …………………………………………….

Date ………………………………………………

Dr. Peter Ebanyat

Signed …………………………………………….

Date ………………………………………………

DEDICATION

This thesis is dedicated to my Family and especially to my Mother Margret Kamuzaana and my Sister Janet Baringi.

ACKNOWLEDGEMENTS

It is not possible to enumerate the names of all the people who helped me during the period I was working on this thesis. Nevertheless it would be ungracious of me if I did not thank some of them by name and others in general terms. I wish to express my profound gratitude to Dr. Gabriel Elepu and Dr. Peter Ebanyat, my supervisors who worked with me and guided me right from the beginning of my research till its completion

My sincere thanks also go to Professor Johny Mugisha for the moral support and encouragement during the course even at times when it was hard for me. Lots of thanks to my course mates: John Sekamwa and Steven Anecho and to my M&E classmates at UMI especially Teddy Angida, Nicolas, Eng. Mugavu, Mukiiza and Eng. Asiimwe who always encouraged me during my research work.

I cannot forget to thank those farmers, NAADS coordinators, service providers, district and village level officials who worked with me in Lira, Kole, Budaka and Kibuku. They were really wonderful for they gave me their time freely.

Finally, I thank RUFORUM for funding this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ANOVA	Analysis of Variance
AVRDC	Asian Vegetable Research and Development Center. (World Vegetable Center)
CIAT	The International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical)
CIMMYT	The International Maize and Wheat Improvement Center (Centro Internacional de Mejoramiento de Maíz y Trigo)
DSIP	Development Strategy and Investment Plan
FAO	Food and Agricultural Organization
IITA	International Institute for Tropical Agriculture
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MRR	Marginal Rate of Return
NACRRI	National Crop Resource Research Institute
NARL	National Agricultural Research Laboratories
SARI	Savanna Agricultural Research Institute
SNV	Netherlands Development Organization
SPSS	Statistical Package for the Social Sciences
TSP	Triple Super Phosphate
UBOS	Uganda Bureau of Standards
UNHS	Uganda National Household Survey
VEDCO	Volunteer Efforts for Development Concern

ABSTRACT

Soybean (*Glycine Max (L.) Merrill*) is an important crop in Uganda as it is the cheapest source of plant protein and income to farmers. Despite breeding for high yielding and disease tolerant soybean genotypes, there has not been a significant increase in production in the recent years. In addition, farmers' preferences and heterogeneity of farmers' fields have been neglected. This study was conducted to establish farmers' preference and profitability of the soybean genotypes in varying soil fertility management of smallholder farms. The study was conducted in Northern and Eastern Uganda where soybean on-farm experimental plots had been set up. A random sample size of 240 farmers participated in the study. Matrix ranking method and logistic preference ranking analysis tool were used to determine farmer's preference for soybean genotypes. Profitability of soybean genotypes was established and compared using the partial budget approach and marginal rates of return. Results indicated that in both regions, Maksoy 3N and Maksoy 1N were the most preferred soybean genotypes with Maksoy 3N being the most preferred in Northern region whereas Maksoy 1N in Eastern. There was a significant difference in farmer's preference of soybean genotypes across and within field types at 1% level in both regions. Consistent results were obtained using a logistic regression tool which indicated that Maksoy 3N and Maksoy 1N had positive intercepts and their chi-square values were significantly different ($p<0.15$) from zero implying that they had a strong likelihood of acceptance by farmers in both regions. In either regions, soybean production is profitable (MRR above 100%) but profitability varies with different fertilizer levels. The most profitable genotype in Northern Uganda was Namsoy 4M whereas in Eastern Uganda it was Maksoy 3N. However, considering specific field types of Northern Uganda, Maksoy 3N was the most profitable genotype in good fields whereas Maksoy 3N was most profitable in both medium and poor fields. In Eastern Uganda, Maksoy 1N was most profitable across all the field types. Application of rhizobia and phosphorus at rates between 5kg ha^{-1} and 10 kg ha^{-1} was most profitable across field types. It is therefore recommended that, targeting of soybean genotypes should consider farmers' preferences, heterogeneity in soil fertility and appropriate nutrient management in soybean production.

CHAPTER ONE

INTRODUCTION

1.1 Background

Soybean (*Glycine Max (L.) Merrill*) is one of the oldest crops grown by human beings. Soybean cultivation reached Africa in the late 1800s; although little is known of the countries to which it was first introduced (Shurtleff and Aoyagi, 2009). Soybean was introduced to Uganda in 1938. Severe soybean rust epidemic broke out in Uganda in the year 1996 and wiped out all available soybeans leading to the collapse of the sector. The disease caused high yield losses of the two major commercial varieties (Nam 1 and Nam 2) in the major soybean growing areas of the country (Kawuki *et al*., 2003). With research funds provided under the Vegetable Oil Development Project (VODP), Makerere University in collaboration with National Crop Resource Research Institute (NACRRI) developed new varieties resistant to soybean rust disease namely; Maksoy 1N, Namsoy 4M, Maksoy 2N, and Maksoy 3N and currently over 30 potential high yielding and rust tolerant elite varieties of soybean exist (MAAIF, 2007). Maksoy 1N and Namsoy 4M were released in 2004 whereas Maksoy 2N and Maksoy 3N were also released in 2008 and 2010 respectively (SNV, 2011).

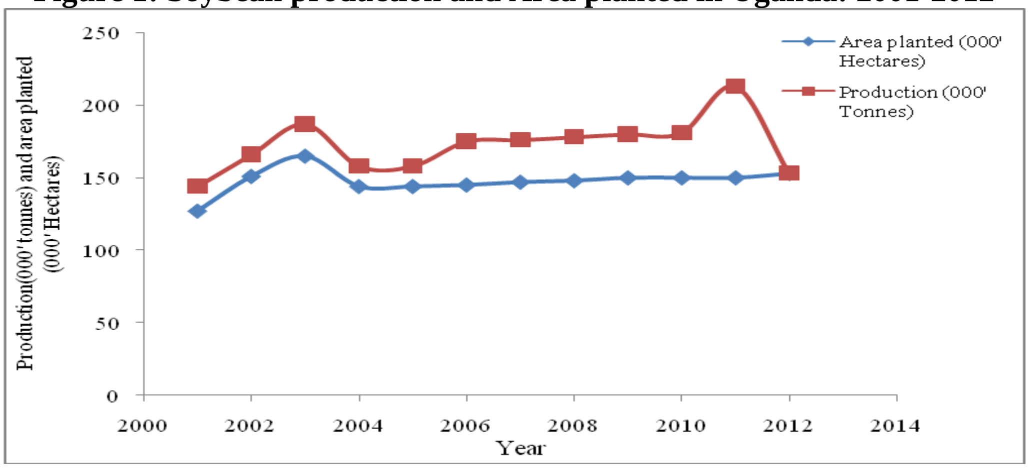
In Sub-Saharan Africa, the use of soybean has been low and of little interest until of recent when the crop gained importance as a source of food, vegetable oil, animal feed, raw material for industries. In addition soybean is frequently rotated cash crop between second and first cereal crops such as rice (Coulibaly *et al.,* 2009). Like any leguminous crop, soybean production leads to the sustainability of both small and large scale agricultural production because of its ability to improve soil fertility by adding nitrogen to the soil. Generally, a legume crop is preferred with cereals in the crop rotation for maximum beneficial effects and best soil management practice. Guimaraes and Yokoyama (1998) studied effects of upland rice–soybean rotation and upland rice planted in monoculture on Oxisol of Brazil and found out that Upland rice yield was significantly reduced in monoculture compared with rotation including soybean. Soybean in cropping system can be valuable for its positive effect on yields of the follower crop as reported for finger millet in Uganda (Ebanyat *et al.,* 2010) and maize in Nigeria (Yusuf *et al.,* 2009) and Malawi (Kabuli *et al.,* 2005). As a cash crop, soybean provides farmers with income to purchase essential farm inputs such as fertilizer and meet other family needs (CIAT, 2006).

Additionally, soybean can be processed into animal feed and its seed contains oil which can be used for cooking, making margarine and other industrial uses. Estrada (2004) found soybean uses in South Africa to be 56% for livestock feed, 12% for oil, 23% for food relief, and 9% as textured soybean protein products. Similar importance was reported by SNV (2011) in Uganda. Soybean is a source of income for farmers, a source of edible oil and a potential nontraditional export crop (Bashaasha, 1992). It is the most common legume and is being hailed as a poor man's meat and crop of the future (Tukamuhabwa, 2010). Soybean provides the cheapest source of plant protein known to man in terms of accessibility especially in developing countries (Idrisa *et al.*, 2010). Soybean has the highest concentration of protein amongst the many grain legumes and whereas most other grain legumes contain about 20% protein by volume, soybean contains about 40% protein (Greenberg and Hartung, 1998). When sold it leads to increased farmers income, improved food security and poverty eradication at rural household level (Tukamuhabwa, 2010). Soybean has therefore the potential to contribute to poverty alleviation.

According to FAO (2012), in 2012, United States of America was the largest global producer of soybean with (82,054,000 tonnes) followed by Brazil (65,848,857 tonnes), Argentina (40100,197 tonnes) and then China (12,800,159 tonnes). Globally, South Africa which is the largest producer in Africa is ranked in the 13th position globally with (650,000 tonnes) and Nigeria with (580,000 tonnes) in the 14th position. Uganda is recognized among the top four African countries that produce soybean others being South Africa, Nigeria and Zimbabwe. The Uganda census of agriculture conducted by UBOS in collaboration with MAAIF in 2008 indicated that Northern Uganda was the major soybean producing area contributing (67%) of the total national production followed by Eastern Uganda (25%), western (8%) and Central region (1%) (UBOS, 2013).

Soybean production in Uganda has been low till 2005 when a slight increase in soybean production was experienced from 158, 000 tonnes in 2005 to 175,000 tonnes in 2006. There was no significant increase in production from 2006 to 2010. A slightly sharp increase was experienced from 181,000 tonnes in 2010 to 213,000 tonnes in 2011 and then production declined to 185,000 tonnes (FAO, 2012) (Figure 1). The decline in soybean production has been attributed to several factors including low soil fertility, inappropriate management practices and attack by pests and diseases (AVRDC, 1987). In 2012, there was also in Northern and Eastern Uganda that affected yield.

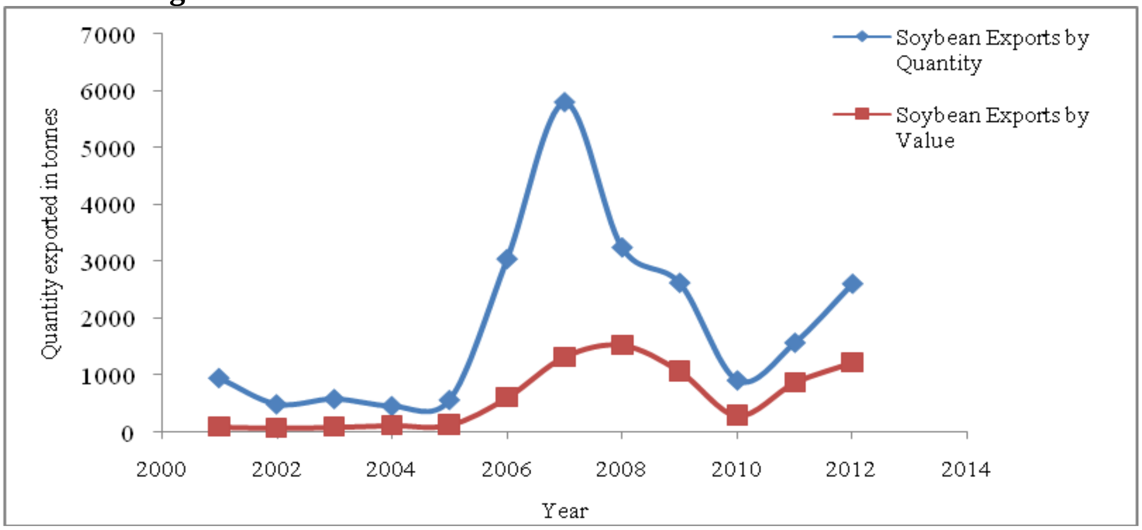
Figure 1: Soybean production and Area planted in Uganda: 2001-2012



Source: FAO Statistical Database

Uganda's soybean export volume increased from 574 tonnes in 2005 to 5798 tonnes in 2007 (Figure 2) and this was attributed to the steady increase in soybean production in the same years (Figure 1). Soybean export volumes then declined till 2010 and thereafter, a steady increase was realized from 918 tons in 2010 to 2613 tonnes in 2012 (Figure 2). The decline in soybean export between the years 2007 and 2010 could have been attributed to the increased domestic demand for soybean and yet the production was not significantly increasing. The little that was being produced was consumed in the local markets. In fact, a report by SNV (2011) found out that over 50% of soybean farmers believed that most of their produce was being utilized within the country. However, the experienced increase in soybean exports from 918 tonnes in the year 2010 to 2613 tonnes in 2012 was as a result of the good market prices of soybeans especially in regional markets such as Southern Sudan.

Figure 2: Soybean export quantities (tonnes) and exports by value ('000 US $) in Uganda: 2001-2012



Source: UBOS (2006, 2011 and 2013)

Despite governments' efforts to increase soybean production in Uganda through breeding high yielding and rust resistant varieties, soybean production is still very low compared to other Africa soybean producing countries such as South Africa and Nigeria and, far low compared to developed countries such as United States of America and Brazil. Production still faces several socio-economic and technical challenges, such as low quality seeds and poor access to good seeds, inadequate finance for acquiring improved technologies, poor traditional methods of farming, poor marketing system and poor road system (SNV, 2011; VEDCO, 2011). Bashaasha (1992) noted that amongst the constraints affecting soybean production, only breeding and agronomic constraints were given first priority by Government and other development agencies. This implies that the rest of the challenges remained affecting soybean production.

Further, as reported by SNV (2011) the major soybean production challenges indicated by farmers (in order of importance) in Northern Uganda include; access to seed, pests and diseases, low prices, inadequate agriculture finance, limited access to extension services and storage facilities. Also related to production are market access challenges; farmers have inadequate marketing skills and have limited market information regarding prices, quality specifications, quantity demanded and how to establish market linkages. The transaction costs are high due to poor infrastructural facilities in terms of road network, storage facilities and reliable weighing scales. Limited access to credit and lack of storage facilities make farmers more vulnerable to price fluctuations.

1.2 Statement of the problem

The collapse of the soybean sector due to outbreak of soybean rust in the 1990's led research programs to prioritize breeding for disease resistance and high yielding soybean varieties (MAAIF, 1992; 2007). Despite development of high yielding and rust resistant genotypes, national production of soybean has remained low in the last decade (UBOS, 2012). Soybean yields in smallholder farms are variable and often less than half those reported on research stations (2-3.5 t ha^{-1}) (Tukamuhabwa *et al.*, 2006). This is because probably knowledge gaps still exist about the state of soil fertility, fertilizer usage and farmer's preferences for soybean genotypes. The research programs rarely emphasize soil fertility management such as proper fertilizer use. In addition, many farmers are not aware of the benefits of rhizobial inoculants in the various agro-ecological zones (Nkwiine and Rwakaikara, 2007). A study by Wortmann and Kaizzi (1998) in Eastern and Central Uganda showed that most farmers did not inoculate soybean before planting and due to poor availability of phosphorus, biological nitrogen fixation was low.

Whereas efforts are underway to improve productivity of soyabean by including within-farm variability and nutrient management (fertilizer application) in production strategies (Ebanyat et al., 2010; Kaizzi et al., 2012), acceptability and profitability of such production options are yet unknown. Farmer's preferences for soybean genotypes in the various agro ecological zones of Uganda have not been considered in soybeans breeding program (MAAIF, 2007). Their participation in most of these breeding programs has been largely passive, limited to providing land for on-farm evaluations (Tukamuhabwa *et al.,* 2006). In addition, smallholder farming systems are highly diverse and heterogeneous in soil fertility (Giller *et al.,* 2006). Fertilizer recommendations have often ignored soil and climatic variations in the areas farmed by smallholders (Kumwenda *et al.,* 1996). Targeting of soil fertility management interventions according to heterogeneity of smallholder farming systems and considering farmer's preferences lead to identification of best fitting technologies (Vanlauwe *et al.,* 2006). This study aimed at providing information about smallholder farmers' preference for soybean genotypes and profitability of using fertilizers in different field types in Northern and Eastern Uganda.

1.3 Objectives of the study

The overall objective of the study was to conduct an economic evaluation of the performance of soybean genotypes on varying soil fertility management by smallholder farmers in Northern and Eastern Uganda.

The specific objectives were;

(i) To characterize soybean production systems in Northern and Eastern Uganda

(ii) To establish farmers' preferences for soybean genotypes in Northern and Eastern Uganda.

(iii) To determine the profitability of soybean genotypes with and without nutrient management as affected by heterogeneity in soil fertility.

1.4 Hypotheses of the study

The study was guided by the following hypotheses;

(i) There is a significant difference in soybean production system between Northern and Eastern Uganda

(ii) Farmers' preferences for soybean genotypes are significantly different across fields and agro-ecological zones

(iii) Profitability of soybean genotypes differ under different nutrient management as affected by heterogeneity in soil fertility

1.5 Justification of the Study

Uganda's economy hinges on its ability to increase agricultural production and profitability (Kasule *et al.,* 2009). Establishing farmers' preferences and targeting of soybean genotypes to a heterogeneous soil fertility will increase the probability of their adoption (Chianu *et al.,* 2006) and this is likely to improve production. In addition, use of fertilizers can be highly profitable as indicated in several studies (Kidoido, 2001; Okoboi, 2009; Kasule *et al.,* 2011 and Kaizzi *et al.,* 2012). Despite the many studies done in Uganda, there is no study that has established farmers' preferences for soybean genotypes and determined the profitability of fertilizer usage putting into consideration the heterogeneity of smallholder farmers' fields. Due to heterogeneity, targeting of integrated soil management practices for smallholder agriculture is essential (Ebanyat *et al.,* 2010). Screening soybean genotypes and determining their profitability with nutrient management according to soil fertility variability can help to identify the most suitable fertilizer soybean genotype combinations for a given field type and agro-ecological zone and this will improve the resource use efficiency. This is likely to increase farmer's adoption of soybean genotypes, improve production, help farmers to maximize profits and increase their incomes.

1.6 Structure of the thesis

Chapter one gives a brief background of the study including production levels and production constraints in Uganda. In addition, chapter one presents the problem statement, objectives and justification of the study. The second chapter presents the relevant work that has been done regarding farmers' preferences for agricultural technologies and profitability. The third chapter presents the methodology used in the study. Results from evaluations of farmers' preference and profitability of soybean genotypes are presented and discussed in the fourth chapter. The fifth chapter gives the summary, conclusions and recommendations arising from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Soil fertility heterogeneity in smallholder farms

Heterogeneity in soil fertility exists within very small farms of Africa is large (Tittonell *et al.*, 2005). This is caused by inherent soil-landscape and human-induced variability due to differential nutrient management (Tittonell *et al.*, 2007). Ojiem (2006) established that biophysical and socio-economic factors such as rainfall, soil fertility, land, labour and livestock ownership were important determinants for choice of legumes for the smallholder socio ecological niches in Kenya.

Ebanyat *et al.* (2010) evaluated the impacts of heterogeneity in soil fertility on legume-finger millet productivity to establish farmers' targeting to specific fields in Pallisa district, Eastern Uganda. Results indicated that farmers preferentially targeted grain legumes to good fields except for mucuna and pigeon which they said they would grow only in poor fields. Studies elsewhere in East and Southern Africa have shown that targeting nutrient management resources to heterogeneity in soil fertility increases crop production and resource use efficiencies (Tittonell *et al.*, 2007). According to Valerie (2006), fertilizer response is highly variable across locations due to climate and soil, across farmers due to different management practices, and across time due to changes in climate and soil quality. The study by Ikeogu and Nwofia (2013) reported that genotype-environment interactions (GEI) played a significant role and should be given considerable attention in soybean breeding programs for development of genetic materials adapted to a wide range of environments.

2.2 Farmers' preferences for soybean genotypes

Knowledge of farmers' preference is vital in establishing the choice of farmers given a number of alternative options. It is important to consider farmers' needs for any intervention to allow its uptake and adoption. The best way to achieve this is by allowing farmers to make selections of their choice from several alternatives in a choice set (Asrat *et al.,* 2009). Each alternative is described by a number of attributes that take on different levels. (Alpizar *et al,* 2003 and Louviere *et al.,* 2000). Knowledge of farmers' preferences for these attributes is key in order for breeders to accurately assess trade-offs between yield and non-yield productive and consumptive quality attributes (Agbola *et al.*, 2002). In commercial farming, a farmer's decision to grow a given crop variety is influenced by market demand which is in turn influenced by consumers preferences.

There are various ways and methods used in establishing farmers preferences for technologies in Agriculture; some are social while others include economic and econometric evaluations. Most of the social evaluations use participatory approaches. Participatory rural appraisal (PRA) is a growing family of approaches and methods to enable local people share, enhance and analyze their knowledge of life and conditions to plan and act (Chambers, 1992). Participatory technology selection is a form of participatory rural appraisal used by researchers and other agencies involved in research and selection of a given technology. This may involve using matrix ranking for preference, hedonic models and econometric methods such as logistic regression analysis of probabilities of acceptance among others.

The above methods have been used in different studies which include among others; Asrat (2008) employed a logit model in a choice experiment approach to conduct an economic analysis of farmers' preferences for sorghum variety traits whereas Ndjeunga *et al.* (2010) used ordered probit models to establish farmers' preferences for groundnut traits and varieties in West Africa. Many other studies have adopted hedonic models to establish both producer and consumer preferences for crop quality characteristics. Such studies include maize and sorghum (Ajambo, 2010), rice (Horna *et al.*, 2007: Dalton, 2003), maize (Hintze *et al.*, 2002) and chick pea (Agbola *et al.*, 2002; Mishili, 2005). Consumer preference is demonstrated by the price a consumer is willing to pay for given crop and this price is influenced by the individual crop characteristics or traits.

The focus of this study was on producer (farmers' preferences) and the focus was on farmer's preference for soybean genotypes. This study employed matrix ranking and logistic regressing analysis. Matrix ranking eradicates bias and helps to quickly get a good idea of what people think are the priority problems or preferences (Adebo, 2000). The logistic regression analysis helps to make a choice of either to reject or accept a given genotype (Nyende and Delve 2004).

Both matrix ranking and logistic regression analysis were employed by Ebanyat (2010) in the Teso farming system of Uganda to establish farmers' acceptance of legume species. In Malawi, Nkongolo *et al*. (2008) used participatory approaches as selection tools for diversified sorghum lines that possessed farmer-preferred plant and grain traits. The research used matrix ranking which allowed selection of sorghum landraces that have out-performed breeder-developed lines and enabled selection of accessions with acceptable digestible protein. Nadu (2005) as well used matrix ranking method to elicit the preferences and opinions of participants with regard to a particular subject. In this way participants could share their knowledge or opinions on, for example, different fodder species, crop varieties, credit sources, and develop specific criteria by which to make comparisons.

Furthermore, Bucheyeki *et al*. (2008) in the same way used matrix ranking to evaluate five groundnut varieties for yield under researcher and farmer managed conditions in Tanzania. Results indicated, Pendo (1444 $kgha^{-1}$) and Johari (1163 $kgha^{-1}$) out yielded other varieties and were ranked as the best varieties. The approach was also used by Chianu *et al.* (2006) to carry out farmer evaluation of soybean varieties screened in five locations in Kenya where farmers generated 17 criteria and used them in the evaluation. Results indicated that of the seven dual-purpose varieties tested; only TGx1740-2F was acceptable in all the five locations.

Likewise, in Uganda, Nyende and Delve (2004) used preference ranking and logit regression analysis to evaluate potential legume cover crops for soil fertility replenishment in on-farm adaptive trials. Results showed that Mucuna had high probabilities of acceptance, Tithonia and Crotalaria had intermediate, and Canavalia, Lablab and Tephrosia had low probabilities of being accepted.

2.3 Profitability of fertilizer usage

There are different definitions of profitability. Doll and Orazem (1984) define profitability as the total revenue minus the cost whereas Crawford and Kamuanga (1988) define profitability as the way of comparing returns to the funds invested. Therefore, the benefits must be greater than the costs if profits are to be realized. Kidoido (2001) indicated that increased yields and reduced costs results into higher profit margins. His study indicated that soil fertility management by using fertilizers increased finger millet production. Okoboi (2009) elucidated that grain and plantain farmers who use fertilizers earn considerably higher profits compared with their counterparts who do not use fertilizers. The study by Ogbomo and Emokaru (2009) conducted in Nigeria indicated that more profits from yam production were obtained through the application of fertilizers.

It is however important to note that profitable input use can be realized if seed of improved varieties and fertilizers are readily accessible and if the prevailing socio-economic environment is sufficiently favorable (Ebanyat *et al.,* 2010). Similarly, a study by Yanggen *et al.* (1998) indicated that fertilizer yield response was highly dependent on the development of improved fertilizer-responsive plant varieties. In addition to selection of improved plant varieties, other management practices that increase yield should be considered. This can be attained through providing farmers with the right information about the nutrient deficiencies in their agro ecological zones, empowering them to know the correct type of fertilizer to use and other complimentary agricultural inputs like improved seed (Bayite-Kasule *et al.,* 2011). In agreement, a study by Mulat *et al.* (1997) indicated that farm management practices which included the rate, time of fertilizer application, weed, pest and disease and moisture conservation were among the important determinants of the output response to fertilizer application. Therefore, performance of fertilizers depends on their application, the soils, weather and crop management (Agwe *et al*., 2007).

Soybean like other nodulated legumes, utilizes nitrogen for its growth. As emphasized by Eaglesham (1989), nitrogen is not always the only primary limiting factor. Phosphorus is also a common limiting nutrient in many soils and its management is important for attaining high yields of soybean. Application of phosphorus increases the amounts of nitrogen fixed and hence increased yield. A study by Kaizzi *et al.* (2012) indicated that application of phosphorus to soybean increased the mean yields by 111 %. More to that, in Ethiopia appropriate inoculation and use of phosphorus increased soybean yield compared to unfertilized inoculation of soils (Bekere and Hailemariam, 2012).

Several methods can be used to determine profitability of a given farm enterprise. These include Value Cost Ratio (VCR) which carries the same principle as Benefit Cost Ratio (BCR) and gross margin analysis (GM). As employed by Valerie (2006), the VCR is the value of additional production obtained from using fertilizers divided by the cost of fertilizer treatment. Average Value Cost Ratio (AVCR) equal to two was considered a minimum requirement for a farmers to use fertilizer and if the benefit cost ratio is greater than one, the benefits exceed the costs (Vorgelegt, 2001). Although these methods are simple, they cannot establish the most profitable fertilizer dosage because they do not consider the alternative uses of resources. Such methods therefore were not appropriate for this study.

Partial budget analysis is concerned with evaluating the consequences of the changes in farm practices or organization that affect only part rather than the whole farm (Dillon and Hardaker, 1993). Likewise, CIMMYT (1988) defined partial budgeting as a method of organizing experimental data and information about the costs and benefits of various alternative treatments. Different scholars have reviewed CIMMYT's approach in the economic analysis of agronomic data including economic analysis of trials for the formulation of farmer recommendations (Crawford and Kamuanga 1988). The partial budget therefore provides a basis for comparing profitability of alternative treatments (Boughton *et al*., 1990). In partial budget analysis, Gross Margin (GM) and Marginal Rate of Return (MRR) analysis can be used as tools for measuring profitability.

Elsewhere, several studies have used partial budgets in evaluation of agricultural technologies. For example, the study by Haile and Boke (2011) in southern Ethiopia used a partial budget analysis in the determination of potassium levels that gave economically feasible yield of potato. In the same way, Irambu *et al.* (2009) in Kenya used a partial budget in conducting on-farm economic and agronomic evaluation of nitrogen and phosphorus fertilizer use in snow peas whereas Makinde *et al.* (2007) in Nigeria used partial budgeting and marginal rate of return to determine the economic viability of fertility management options in cassava based cropping systems. Mukhtar *et al.* (2007) also used partial budgeting to study different sowing technologies of wheat where zero tillage was recommended to wheat farmers as an economically beneficial technology. Shiluli, (2003) also applied a partial budget technique to assess the costs and benefits associated with different treatment levels in the economic analysis of maize yield response to nitrogen and phosphorus in the sub-humid zones of western Kenya.

In Uganda, Wagoire (2006) used the partial budget approach to quantify the value of the improved wheat production options and results indicated that the marginal rate of returns for changing from the use of local varieties (land races) to improved genotypes were 206% which is above the recommended 100 % and hence, it is profitable. Kidoido (2001) also used a partial budget and marginal rate of returns in analysis of profitability of finger millet production in Eastern Uganda. Results indicated that use of fertilizer significantly increased yield. Likewise, Ekiyar (2003) used a partial budget and marginal rate of returns to evaluate integrated pest management (IPM) technologies in cowpea and groundnut growing in Eastern Uganda. Kakuhenzire *et al*. (2005) used marginal analysis to determine the response of four selected potato cultivars to fungicide and fertilizer application at various levels. In the same way, gross margin analysis and marginal rate of returns were employed by Semalulu *et al.* (2012) to determine the productivity and profitability of groundnuts with phosphorus fertilizer application in Mbale district, Uganda.

The partial budget procedure was therefore adopted and used to outline the gross margins between the variable cost and value of the gross soybean grain output. Gross margin analysis was used because it attempts to give better relationship between revenue and cost structures to enable better decision making.

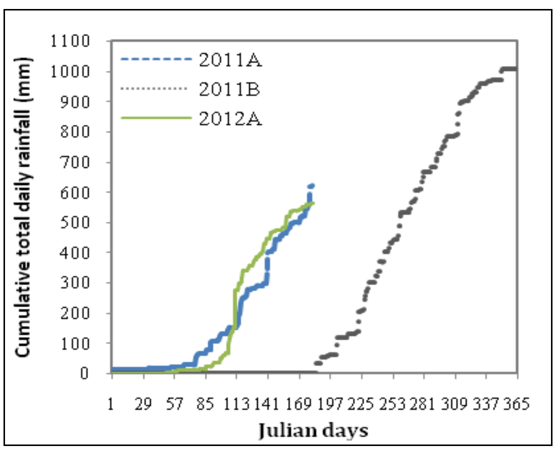
CHAPTER THREE

METHODOLOGY

3.1 Description of the study area

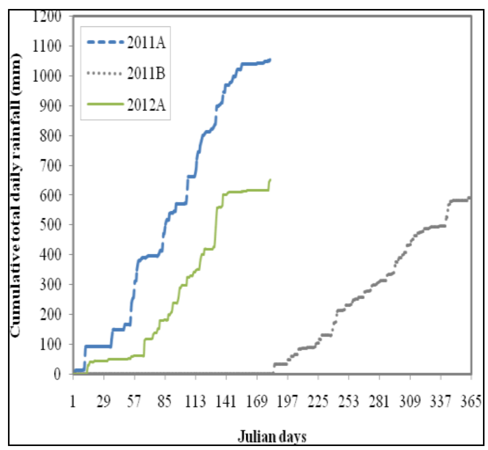
The study was carried out in Kibuku, Budaka and Pallisa districts in the Lake Kioga Plain basin representing in Eastern Uganda, Kole, Lira and Apach districts representing Northern Moist farm lands in Northern. The two regions were selected because they are the major soybean producing areas. This was revealed by UBOS (2009) which indicated that Northern region produced 49.9% and Eastern Uganda produced 35.2% of the total national production compared to Western and Central Uganda which produced 10% and 4.9% respectively. Both regions have a bimodal rain fall pattern. The average monthly rainfall pattern in Northern Uganda was 121.6mm across the seasons whereas in Eastern Uganda, it was 131mm. Although this rainfall was high above normal, in some days it was unevenly and spatially distributed. Figures 3 and 4 indicate the daily rainfall patterns for Northern and Eastern Uganda respectively in three seasons between 2011 and 2012

Figure 3: Daily rainfall patterns for Northern Uganda



Source: Iki-Iki Meteorology Department

Figure 4: Daily rainfall patterns for Eastern Uganda



Source: Ngetta Zardi Meteorology Department

3.2 Soil physical and chemical properties

Soil physical and chemical analysis was carried considering critical values of the major soil nutrients, PH and organic matter. The critical level is the minimum test level which statistically correlates to maximum yield. It gives the lowest test value necessary to support the highest yields attainable in the area (Dahnke, 1993). In both regions, the soil PH was moderately acidic, phosphorus and nitrogen levels were generally low below the critical values. Potassium, calcium and magnesium were in adequate levels and organic carbon was moderate (Table 3.1). The critical values used in Table 3.1 below are nutrient critical values for most crops in East Africa (Okalebo *et al.*, 2002). Initially, the basis for soil classification was based on farmer's perceptions. Famer's perception were validated using soil analysis on the basis of nutrient critical values. Classification of soils type into good, medium and poor was based mainly on the critical value for PH (5.5), Organic matter (3%), Nitrogen (0.2%) and Phosphorus (15mgKg^{-1}). Good fields had nutrient level at critical values, medium fields have nutrient values close to critical values whereas poor fields have nutrient value far from critical values.

Table 3.1: Soil Physical and Chemical Properties in Northern and Eastern Uganda for 2011A, 2011B and 2012A seasons

	Experimental sites						
	Northern region			**Eastern region**			
Soil Properties	Good	Medium	Poor	Good	Medium	Poor	Critical values
PH	5.5	5.3	5.1	5.4	5.1	5.3	5.5
OM (%)	3.2	2.9	2.4	2.2	1.8	1.2	3
Tot N (%)	0.2	0.2	0.2	0.2	0.1	0.1	0.2
Bray 1 P (mgKg^{-1})	5.5	4.9	6.6	6.5	6.0	8.9	15
K	0.5	0.5	0.4	0.5	0.4	0.3	0.4
Na (Cmo1kg^{-1})	0.1	0.1	0.1	0.1	0.1	0.1	0.01
Ca (Cmo1kg^{-1})	6.4	5.6	4.9	4.7	3.9	3.6	4.5
Mg (Cmo1kg^{-1})	2.3	2.0	1.8	2.0	1.5	1.5	0.6
% Sand	64.3	62.4	66.6	63.6	71.4	73.5	N/A
% Clay	21.9	21.5	20.2	20.3	15.2	13.0	N/A
% Silt	13.6	16.2	13.3	16.1	13.5	13.5	N/A

Source: Makerere University Soil Science laboratory data (2011/2012)

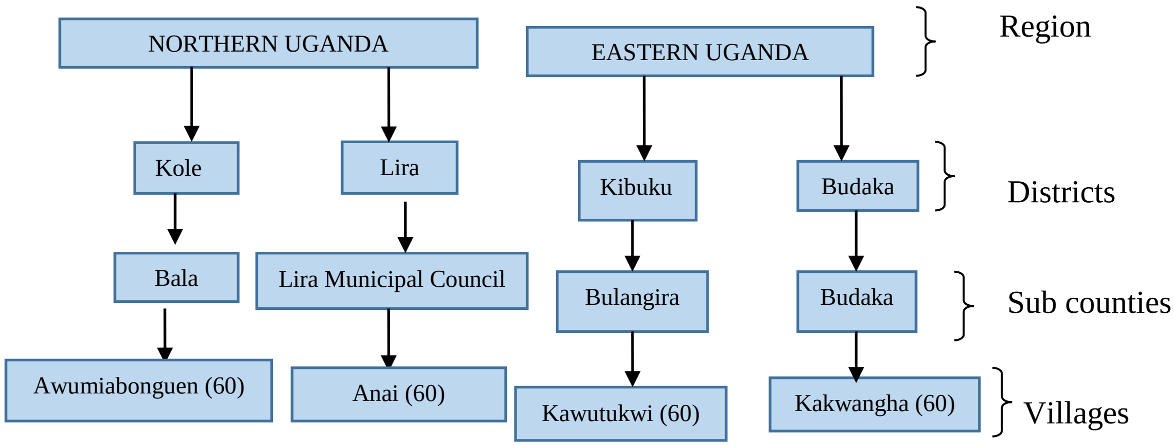
3.3 Research design

The study was done in districts within on-going experiments which were set up by the soil scientist to evaluate Genotype, environmental and management interactions (GxExM) of six soybean genotypes during the seasons 2011A, 2011B and 2012A under the soybean adaptability project. The experiments were set up and hosted by farmers in Lira, Apach and Kole districts representing Northern Uganda, Budaka, Kibuku and Pallisa representing Eastern Uganda.

The experiments were arranged in a split plot design to lay out the fields on farmer's gardens. The selected fields were ox ploughed twice, and plots of 15m x 6m demarcated on each field type. The selected fields were ox ploughed twice, and plots of 15m x 6m demarcated on each field type. Six soybean genotypes 5 released varieties resistant to rust (Maksoy 1N, Maksoy 2N, Maksoy 3N, Nam 1, Namsoy 4M,) and one elite genotypes (MNG 2:14) that were obtained from the Crop Science Department, Makerere University were planted at a spacing of 60cm by 5cm. Half of the seed of each variety was inoculated with Maksoy rhizobia inoculants (Mak N biofixer) from Soil Science Department Makerere University prior to planting in subplots of 3x3 m basally treated with fertilizer at 0, 5, 10 and 20 kg P ha^{-1}. Each treatment was replicated once in each of the 12 fields. The field types (Poor, Medium and Good) were the main blocks while genotypes were the main plots on which fertility management was done through applying TSP fertilizers with/without rhizobia.

3.4 Sampling procedure and Sample size

A survey was carried out two regions but in the districts where experiments were located and soybean evaluations were done on within on going experiments. One sub-county from each district was randomly selected from which one village was randomly selected in each of the sub counties. The sampling procedure used is summarised below.



In each of the villages respondents who participated in the survey and in experimental evaluations were obtained by using a systematic random sampling technique. They included farmer field visit participants and project member participants who belonged to three farmers groups in each district. Systematic sampling method was employed to select the required sample (Taylor-Powell *et al.*, 1996) where a skip interval of 2 was used to select farmers from the group list in a village. 60 farmers were selected at the village level and hence sub county level, 60 from each district and a total of 120 farmers participated in the survey and evaluation exercise in each regional. A total of 240 farmers participated in the experimental evaluations in both North and Eastern region.

3.5 Data types and data collection methods

At the beginning of the experiments, primary data was collected using a structured questionnaire that captured socio-economic and demographic characteristics of soybean farmers. These included: age, education, gender, level of education, household size, farm size, land size under soybean and annual income from farming. Other information gathered from farmers included, access to extension services, soil fertility rating, fertilizer and manure use, production and marketing constraints of soybean. In addition, a matrix scoring card was used to collect data concerning farmers' preferences for soybean genotypes during second season of 2010B (August to December, 2010).

Later, primary data were obtained from experiments with the help of farmers and research assistants. At the start of the experiment farmers in both regions were trained by researchers in record keeping and then given books to record any information pertaining to production. Using record books, experimental data was collected which included seasonal quantities produced (grain yield data per ha), production costs such as (labor costs, fertilizer costs, seed costs) and farm gate prices of output. This was done in three seasons of 2010B, 2011A and 2011B. Where A is the first season and B is the second season of each year. In addition, soil analysis data was obtained from the Makerere University Soil Science Laboratory with the assistance of the soil science student with whom we worked on the same project. The soil data results helped to guide on nutrient levels and determination of the fertility level for a particular field.

3.6 Data preparation and analytical methods

Data from the field was coded, entered and edited to ensure accuracy, uniformity, completeness, validity and consistency. Data analysis was done using Excel and SPSS. To achieve objective one of characterizing soybean farmers in North and Eastern Uganda, Statistical Package for Social Scientists (SPSS) was used to analyze data about the socio-economic and demographic characteristics of farmers. Inferential statistics that included; chi-square, F-test and t-tests were generated to elaborate objective one. To establish any significant differences in soybean farmers between Northern and Eastern Uganda, independent sample t-test and ANOVA were used. Different analytical methods were employed to achieve the stated objectives (2 and 3) in section 1.3. These included Matrix ranking, Logistic Preference Ranking analysis, Dominance analysis and Marginal rate of return (MRR).

3.6.1 Matrix Ranking

To determine farmers' preferences for soybean genotypes, matrix ranking for participatory performance evaluation was employed as was used in previous studies (Theis and Grady, 1991). This method eradicates bias and helps to quickly get a good idea of what farmers stated as priority problems or preferences (Adebo, 2000).

Using the matrix ranking method, soybean genotypes were scored using selected criteria on a scale of 1 to 6, where 1 is very poor, 2=poor, 3=fair, 4=good, 5= very good, 6= excellent. This was used to score 13 soybean attributes which included: grain yield, pest tolerance, disease tolerance, time to maturity, drought tolerance, pod numbers, number of seed per plant, adaptation to soil fertility, growth vigor, plant height, biomass, hairiness and pod shattering. A total score of the attributes was obtained and an overall rank position by each farmer obtained. Frequencies of the number of times each of the 6 soybean genotype was ranked in a given position (i.e. 1 = most preferred and 6 = least preferred) were then established and the probability of a particular soybean genotype being ranked was calculated as:

Probability = frequency/total number of observations

Cumulative probabilities of each soybean genotype (the sum of the probability for that rank and the probabilities for all previous ranks) were then computed. Each farmer also gave reason (s) for the preference for a particular genotype in a given region and field type. The mean score on all the 13 attributes on each variety was estimated for all the farmers and this represented their respective level of preference for each genotype. The researcher's decision rule was that the soybean genotypes with the average mean score below 4 were not preferred and those above 4 were preferred. This is because basing on the scale (1-6) used by the researcher, any attribute with a score below 4 was not good. The mean scores were also compared to determine whether they were significantly different across genotypes, field types and Agro-ecological zones by carrying out ANOVA tests.

3.6.2 Logistic preference ranking analysis

The logistic preference ranking analysis tool for evaluating technology options (Hernandez-Romero, 2000) was used to establish the likelihood of acceptance or rejection of each of the soybean genotypes.

The tool was originally designed to conduct participatory evaluation of cassava varieties (Hernandez-Romero, 2000) and has been applied successfully in evaluation of acceptance of legume cover crop technologies (Nyende and Delve, 2004). The tool generates probabilities of acceptance or rejection with the respective levels of significance at 15%. This is the extent of the margin of error which the tool can allow. The genotypes with positive intercept indicate that they would more likely be accepted while those with negative intercepts indicate that they would more likely be rejected. If the probability distribution of the chi-square value is less than the significant level ($P<0.15$), then there is significant evidence that the genotype is more likely to be accepted or rejected depending on the sign of the intercept. The magnitude of the slope indicates the extent of preference (whether the genotype is ranked low or high)

3.6.3 Partial budget analysis

Partial budget analysis was used to determine the profitability of the preferred soybean genotypes under different fertilizer levels. The method was used by Crawford and Kamuanga (1988) in a review paper of the CIMMYT (1988) to establish the profitability and feasibility of experimental treatments from the farmer's point of view as part of the process of formulating farmer recommendations. The partial budget is a method for the economic analysis of on-farm trial (CIMMYT, 1988). It entails carrying out gross margin analysis for a given production technology and was calculated as the change in net farm income as a result of use of a given production technology (Castle *et al.*, 1987). Partial budgeting therefore can aid researchers and extension agents in selecting technologies and best practices that are the most profitable and have the best chance of being adopted by farmers.

Profitability of Soybean genotypes was determined by carrying out MRR. This was established by carrying out gross margin and dominance analysis to establish which fertilizer treatments were dominated and un-dominated. Yields, prices, variable cost data were used to establish marginal returns. The production costs included; cost of fertilizers, cost of rhizobia, cost of seed, cost of planting, weeding and harvesting. The market prices for soybean in the two regions at the time of the study were established in the experiment areas.

Gross margin Analysis

The gross margins of the soybean genotypes were determined including those which were introduced in the last 10 years (Maksoy 1N, Maksoy 2N, Maksoy 3N, and MNG) and Nam1 (which is the commonly known genotype and has existed since 1990's), that is;

$$GM_p = TR_p - TCp \quad \text{...} (3)$$

Where,

GM_p =Gross Margin of a given production technology

TR_p =Total Revenue for a given production technology

TC_p =Total variable cost from a given production technology, the costs considered included, cost for seed, fertilizer (TSP), Rhizobia and labor (cost of ploughing, planting, weeding and harvesting)

P =Production technology (Variety x fertilizer combination)

Dominance Analysis

Dominance analysis was done by sorting the technologies including the one the farmer was using on the basis of costs, listing them from the lowest to the highest together with their net benefits. By moving from lowest to the highest, any technology that costed more than the previous ones but yielded less net benefits than the previous treatments was said to be dominated and hence excluded from further analysis (Irambu *et al.* 2009). The un-dominated alternatives which are the profitable treatments were used to compute Marginal Rates of Returns (MRR)

Marginal rate of return analysis

MRR is defined as the change in net benefits (marginal net benefit) divided by the change in costs that vary (marginal variable cost), expressed as a percentage. The % MRR between any pair of un dominated treatments denotes the return per unit of investment in fertiliser expressed as a percentage (Irambu *et al.,* 2009)

$$MRR = \left({MNB}/{MVC} \right) * 100 \qquad (4)$$

Where

$MNB =$ Marginal net benefits or change in Gross margins

$MVC =$ Marginal Variable Cost or change in Total variable costs

$MNB = GMf_2 - GMf_1$, and $MVC = TVC_2 - TVC_1$

GM*f1*=is the Gross Margin for fertilizer treatment/technology with higher TVC

GM*f2*= is the Gross Margin for fertilizer treatment/technology with lower TVC

TVC1= is the lower total variable cost

TVC2= is the higher total variable cost

The procedure involves comparing the established marginal rates of return (MRR) of treatments with the targeted MRR=100% acceptable to farmers. The MRR of 100% means a return of one unit resulting from a unit change in expenditure on a given variable input used under a particular production technology (CIMMYT, 1988). All those treatments with equal or higher MRR than the targeted MRR (100 %) are profitable and hence useful for making recommendation to farmers.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-Economic characteristics of soybean farmers in Northern and Eastern Uganda

4.1.1 Demographic characteristics

The demographic characteristics of farmers considered in this study were; age, gender, level of education and household size. Results in Table 4.1 indicate that Eastern region had more males farmers (51%) participating in the study compared to 41% in Northern region and was significantly different at 10%. Results also indicate that there was a significant difference in the education levels of farmers in the two regions. There were more uneducated farmers (27%) in Northern Uganda compared to Eastern Uganda (9%). Also more farmers reached tertiary institutions in Eastern Uganda (10%) compared to Northern Uganda (3%). This is in agreement with Gelsdorf *et al*. (2012) who stated that despite the advances of Universal Primary Education, education remains problematic in Northern Uganda due to lords resistance army insurgence/conflict which intentionally targeted schools, destroyed them and abducted children and teachers. The youth who have returned generally received absolutely no education during their captivity yet they are over the age for primary school. The mean age for respondents across the two regions was 36 years.

Further, results show that the average household size in Eastern Uganda (7 members) was significantly higher than that in Northern region (5 members) at 1% level of significance (Table 4.2). The high household size in Eastern Uganda could be attributed to the higher population growth rate and large number of children per house hold (Hyuha, 2007). Furthermore, there was limited opportunity for earnings from non-farm sources, as only 19% of the respondents in Northern Uganda and 29% in Eastern Uganda were engaged in nonfarm employment activities (Table 4.2). A study by Hyuha (2007) carried out in Tororo, Lira and Pallisa Districts indicated limited opportunities for earnings from non-farm sources.

Table 4.1: Socio-economic characteristics of soybean growing households in Northern and Eastern Uganda (%)

Characteristics	Northern (n=120)	Eastern (n=120)	Total (n=240)	χ^2
Gender				
Male	41	51	46	2.417*
Female	59	49	54	
Level of education				
None	27	9	18	17.377***
Primary level	54	57	55	
Secondary level	16	24	21	
Tertiary institution	3	10	6	
Employment				
Nonfarm employment	19	29	24	3.274*
Farm employment	81	71	76	

*** 1%, *10% level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

The average annual income from farming activities in Northern Uganda was Shs 1,872,600 whereas in Eastern region it was Shs 853,250 and was significantly different at 1% in the two regions. In addition the average annual income from non-farming activities in Northern Uganda was Shs 497,830 and was less than that obtained in Eastern region (Shs 788,160) and was significantly different at 10% in the two regions (Table 4.2). This is possibly due to limited land for farming as a result of the high population density in Eastern Uganda.

Table 4.2: Socio-economic characteristics of soybean growing households in Northern and Eastern Uganda

Characteristics	Northern (n=120)	Eastern (n=120)	Total (n=240)	t-statistics
Average age (years)	35	37	36	-1.414
Average household size (numbers)	5	7	6	-4.933***
Average price of soybean (shs)	1000	900	950	19.37***
Average annual Income from farming (Ushs)	1872600	853250	1362925	4.022***
Average annual Income from Non-farming (Ushs)	497830	788160	642995	-1.689*

*** 1%, *10% level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.1.2 Reason for producing soybean

Results show that there was a significant difference in the purpose of producing soybean between the two regions and was significantly different at 1% level. In Northern Uganda, 80% of the respondents grew soybean for both cash and food, 17% for cash and 3% for food where as in Eastern region, 76% grew soybean for both cash and food, 11% for cash and 13 % for food (Table 4.3). These results seem to suggest that soybean was taken more of a cash crop than food crop in Northern Uganda. This is opposed to UBOS (2013) which considered soybean in both region to be purely a cash crop. This trend therefore seems to be changing as farmers in both regions were found to be growing soybean for both food and cash.

Table 4.3: Percentage of respondents producing soybean by purpose (%)

Purpose for soybean production	Northern (n=120)	Eastern (n=120)	Total (n=240)	χ^2
Food	3	13	8	10.57***
Cash	17	11	14	
Both	80	76	78	

*** 1% level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.2.2 Soybean area and yield

The total average land size owned by respondents in Northern Uganda was 1.5 hectares, of which 0.2 hectares was allocated to soybean production whereas in Eastern region, the total land size was 0.7 hectares with 0.1 hectares allocated to soybean production. Results indicated that there was a significant difference at 1% significant level in total land size and land allocated to soybean production between the two regions. (Table 4.4). This is in agreement with UBOS (2013) which indicated that more land was allocated to soybeans (26,195 ha) in the Northern than in Eastern region (7,279 ha). The observed results could possibly explained by the fact that there is high population density in Eastern Uganda and hence, the less total land size available compared to Northern Uganda. The average price of soybeans in Northern Uganda was Shs 1002 per kg while in Eastern Uganda, it was Shs 900 per kg and was a significant difference at 1% significant level. Further, the average yield in Northern Uganda was 0.519t/ha and for Eastern Uganda was 0.321t/ha significantly different at 1% level. However, generally, the average soybean yield in both regions was much less than the potential yield (2-3t/ha) as indicated by (http://www.soybeanafrica.com) (Table 4.4). These prices were not different from those reported in 2011 (SNV, 2011). The lowest prices were said to prevail in June and November. This is the time when most farmers harvest soybeans and the supply is highest. The prices were reported to be highest between January and March when the supply is lowest. Higher prices reported in Northern Uganda than Eastern Uganda was attributed to the bigger Southern Sudan market with high demand for soybeans.

Table 4.4: Soybean area and yield obtained in Northern and Eastern Uganda (%)

Soybean area and Yield	Northern (n=120)	Eastern (n=120)	Total (n=120)	t-statistics
Total land size (Ha)	1.5	0.7	1.1	8.491***
Land size under Soybean (Ha)	0.2	0.1	0.15	7.443***
Yield(t/ha)	0.519	0.321	0.42	15.34***
Average Price per Kg (Shs)	1002	900		19.38***

*** 1% level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.2.3 Sources of inputs used in soybean production

Table 4.5 shows that the major source of seed was the local market in both regions. It's indicated that majority (89%) of the farmers purchased their soybean seed from the local market. The major source of labor in the two regions was family labor that accounted to 90% of the total labour input (Table 4.5). This is due to the high poverty levels in both regions hindering farmers' ability to purchase and hire other sources of labor.

Table 4.5: Source of input used in soybean production in Northern and Eastern Uganda (%)

Source of input used in soybean production	Northern (n=120)	Eastern (n=120)	Total (n=240)	χ^2
Source of seed				
Previous harvest	7	10	8	0.985
Local market	90	87	89	
Seed company	3	3	3	
Source of labor				
Family labor	88	92	90	0.741
Hired labor	12	8	10	
Oxen usage				
Yes	28	41	35	4.144**
No	72	59	65	

**5 % level of significance. *Source: Field survey data (Nov 2011 –Jan 2012)*

Generally there was low oxen usage in both regions. This is perhaps because of cattle rustling and theft that occurred during insurgency as well as the high poverty levels in addition to dependence on mainly farming as the major source of capital which limits farmers' ability to invest in livestock. However, in Eastern Uganda, 41% of the respondents used oxen to open land compared to 28% in Northern Uganda and was significantly different at 5% level (Table 4.5). The National Household Survey, 2009/2010 indicated that northern Uganda had the highest poverty levels (46.2%) compared to Eastern region with 24.3% (UBOS, 2010). This could be due to the Lord Resistance Army (LRA) war. High poverty affects farmer's ability to purchase inputs and farm implements including oxen. In addition, due to the fact that Northern Uganda had few farmers (19%) participating in non farming activities, their ability to raise non farm income to purchase or hire oxen was limited. Research by IFPRI (2013) indicated that diversification of household income increases capital availability which increases uptake of modern purchased inputs.

4.2.4 Soybean varieties grown by farmers

Maksoy 1N and Namsoy 4M were the most commonly grown soybean genotypes across the two regions. This is probably because in addition to the preferred yield related traits they possess, these two genotypes were released quite early and have been on the market since 2004. However, there was a significant difference in soybean varieties grown at 1% between the two regions (Table 4.6). In Northern Uganda, the most commonly grown soybean genotype was Namsoy 4M (45%) followed by Maksoy 2N (30%). Similar results were obtained by SNV (2011) where Namsoy 4M was the most grown variety in Northern Uganda (57.1%) followed by Maksoy 2N with 52% of farmers. This is because the two varieties are high yielding, tolerant to rust and adapt well to the soil conditions of Northern Uganda. In the Eastern region, the most grown soybean genotype was Maksoy 1N as reported by 57% of the respondents. Maksoy 1N is a short genotype, very early maturing and does not shatter.

Table 4.6: Soybean varieties grown by farmers in Northern and Eastern Uganda (percent)

Variety	Northern (n=120)	Eastern (n=120)	Total(n=240)	χ^2
Maksoy 1N	22	57	39	30.55***
Nam 1	3	1	2	
Maksoy 2N	30	17	23	
Namsoy 4M	45	26	36	

***1 % level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.2.5 Soil fertility status

Farmers were asked to give their perception on the status of fertility of their soybean fields, that is; good, medium and poor. The basis for considering a field to fall in any of the categories depended on the yield obtained in the field. Field types which give good yields are considered to be good, fields where fair or moderate yield is obtained is considered medium and fields where the yield obtained is extremely poor is a poor field. In Northern Uganda 31% of the respondents thought they had good soils, 65% reported medium fields and only 4% regarded their fields to be of poor soils. In contrast, only 7% of the farmers in Eastern Uganda rated their fields to be good, 49% classified their fields as medium and 44% reported that they had poor fields (Table 4.7). These findings show that there was a significant difference in farmer perceptions about soil fertility in their fields between Northern and Eastern Uganda. This is an indication that soils in Northern Uganda are more fertile compared to Eastern Uganda. In fact, it is not surprising since most of the land in Northern Uganda regained soil fertility after resting following a long period of insecurity there. In addition, due the high population, land has been fragmented and soils have been over tilled in eastern Uganda leading to soil erosion and the depletion of soil fertility (Clay *et al.*, 1994). This is in agreement with Pender *et al.* (2004) who reported that population density is positively correlated with rates of soil erosion.

Table 4.7: Soil fertility rating by farmers in Northern and Eastern Uganda

Soil fertility rating	Northern (n=120)	Eastern (n=120)	Total (n=240)	χ^2
Poor	4	44	24	61.048***
Medium	65	49	57	
Good	31	7	19	

***1 % level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.2.6 Soil management practices used in soybean production

Results indicate that the majority (97%) of the farmers in both regions did not apply inorganic fertilizers or any compost manure in their fields. Similar results were reported by the Uganda National Household Survey 2005/06 which established that few farmers were found to be using fertilizer. The UNHS survey results indicate that only 1% of the total farm households surveyed applied inorganic fertilizer to their crops (UBOS 2007). The study by Okoboi, 2010 revealed a significant effect improved use of fertilizer on yield but not gross profit. Farmers who used commercial improved seed with fertilizer obtained superior yield but lower gross profit compared to farmers who planted recycled seed (of improved variety) without fertilizer. This affects adoption of fertilizers in farmer’s production systems. However, crop rotation was practiced by the majority (85%) of farmers in both regions (Table 4.8)

Table 4.8: Soil management practices used in soybean production in Northern and Eastern Uganda (%)

Soil management practice	Northern (N=120)	Eastern (N=120)	Total (N=240)	χ^2
Inorganic fertilizer				
Yes	3	2	3	0.684
No	97	98	97	
Organic manure				
Yes	1	2	2	0.338
No	99	98	98	
Crop rotation				
Yes	88	81	85	2.588
No	12	19	15	

***1 %, **5% level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.2.7 Access to credit and extension services by soybean farmers

Results in Table 4.9 indicate that only 7% of the respondents in both Northern and Eastern Uganda had ever accessed credit from micro finance institutions and even the few who obtained credit invested it in non farming activities. Also, 45% of the farmer's accessed extension services in Northern and Eastern region largely by sub county NAADS officers. The low access to credit and extension services is not unique to soybean production because Hyuha (2007) also found that access to credit and extension services by rice farmers in Tororo, Pallisa and Lira Districts was limited. Poor access to credit was as a result of the low education levels of farmers in Northern and Eastern Uganda coupled with lack of collateral. Mpuga (2008) indicated that most farmers in Uganda lack education, which means many of them do not fully understand the concept of commercial credit. In addition, lack of collateral also creates a challenge to extending credit in rural Uganda.

Table 4.9 Soybean farmer access to credit and extension services in Northern and Eastern Uganda (%)

Service	Northern (n=120)	Eastern (n=120)	Total (N=240)	χ^2
Credit service				
Yes	7	8	7	0.063
No	93	92	93	
Extension service				
Yes	48	52	45	0.420
No	43	57	55	

Source: Field survey data (Nov 2011 – Jan 2012)

4.2.8 Production constraints faced by soybean farmers

Farmers encountered a number of production constraints as shown in Table 4.10. The major production constraints faced by soybean farmers in both regions included; Lack of improved seeds (74%), drought (72%) and lack of capital (74%). This is due to presence of counterfeits products on the market. Farmers also depend on natural rainfall to grow their crops and hence face drought challenges especially during the short rains. The high poverty levels also limit the farmers' ability to purchase inputs such as improved seed and invest in irrigation systems. In addition, farmers in Eastern Uganda also encountered pests and diseases (72%), soil exhaustion (83%), land shortage (73%) and weeds (75%). And, all these constraints were more important there than in the Northern region. This might be as a result of high population density in Eastern Uganda which has reduced land acreage for farming, led to over cultivation of land leading to soil exhaustion.

Table 4.10: Soybean production contraints in Northern and Eastern Uganda (%)

Production constraints	Northern (n=120)	Eastern (n=120)	Total (N=240)	χ^2
Lack of improved seeds	72	77	74	0.783
Pests and diseases.	54	72	63	7.876***
Lack of labour	33	50	41	7.582***
Lack of extension	22	16	19	1.34
Soil exhaustion	23	83	53	84.304***
Drought	70	74	72	0.518
Lack of land	31	73	52	41.71***
Lack of capital	72	77	74	0.783
Weeds	45	75	60	22.5***

*** 1% level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.2.9 Marketing constraints faced by soybean farmers

Farmers encountered a number of marketing constraints as shown in Table 4.11. The major marketing constraints faced by soybean farmers in the Northern region included; low prices (51%), poor roads (54%), lack of ready market (68%) and distance to the market (68%). In Eastern, the major constraints include; low prices (63%), lack of market information (48%), lack of ready market (61%) and distance to the market (60%).

Table 4.11 Soybean marketing constraints in Northern and Eastern Uganda (%)

Marketing constraints	Northern (n=120)	Eastern (n=120)	Total (N=240)	χ^2
Low prices	51	63	57	3.326**
Poor storage facilities	30	43	36	4.057***
Poor roads	54	43	48	3.27*
Lack of market information	37	48	43	3.342**

*** 1%, level of significance. *Source: Field survey data (Nov 2011 – Jan 2012)*

4.3 Farmers' preferences for soybean genotypes in Northern and Eastern Uganda

This subsection of the thesis details results about farmers' preferences where farmers ranked soybean genotypes based on soybean attributes and further establishes farmers' likelihood to reject or accept a given soybean genotype in a given region and field type.

4.3.1 Farmers' ranking of soybean attributes.

Farmers suggested soybean attributes which they considered important for soybean. The proportion of farmers who suggested a given attribute was established in the two regions. Results in Table 4.12 indicate that in both regions, among the 12 attributes reported, the most important attributes to farmers were yield related (such as pod numbers, grain yield, and seed numbers), disease, pest tolerance and time to maturity. These results are similar to those reported by Chianu *et al*. (2006) where the most important criteria were number of pods, maturity period, size of pods and disease tolerance. However, a study by Asrat *et al.* (2010) indicated that farmers are not only looking for a single attribute like productivity of the variety when making their seed selection decisions but also other more important but non-tradable attributes like environmental adaptability (drought and frost resistance), disease and pest resistance forcing them to make complicated trade-offs.

In both regions, the most important soybean attributes were ranked from 1 to 12 in order of their importance. In Northern Uganda, The seven most important soybean attributes were grain yield (97.5%), pod numbers (97%), disease tolerance (96.7%), seed number (92%), pest tolerance (91.7%), time to maturity (74.2%) and drought tolerance (73.3%) whereas in Eastern Uganda, the highly ranked soybean attributes were grain yield and disease tolerance (100%), time to maturity (95.8%), pod numbers (95%), number of seeds per pod (93.3%), drought tolerance (86.7%). Much as adaptation to soil fertility and plant height in Eastern Uganda were not among the first seven most important attributes they were ranked higher in Eastern than Northern Uganda as indicated in the Table 4.12. This is probably because of the challenges of land shortage and soil exhaustion in Eastern Uganda which requires varieties that can easily adapt to the poor soil conditions and short genotypes which can be intercropped with other crops in the same field so as to maximally utilize the small available land.

Table 4.12: Proportions of farmers who considered particular attributes important

Attributes	Northern (n=120)	Rank	Eastern (n=120)	Rank	Total (n=240)	Rank	χ^2
Grain yield	97.5	1	100	1	98.8	1	3.038*
Pest tolerance	91.7	5	87.5	5	89.6	5	1.116
Disease tolerance	96.7	3	100	1	98.3	2	4.068**
Time to maturity	74.2	6	95.8	2	85	6	22.092***
Drought tolerance	73.3	7	86.7	6	80	7	6.667***
Pod numbers	97	2	95	3	95.8	3	0.417
Number of seed per plant	92	4	93.3	4	92.5	4	0.24
Adaptation to soil fertility	30.8	8	60	7	45.4	8	20.59***
Growth vigor	26.7	10	43.3	9	35	10	7.326***
Plant height	30	9	55.8	8	42.9	9	16.345***
Biomass	14.2	11	15	10	14.6	11	0.033
Hairiness	12.5	12	5	11	8.8	12	4.227**

*** 1%, ** 5% ,* 10% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012)*

4.3.2 Farmers' ranking of soybean genotypes

Farmers were further asked to rate soybean genotypes by scoring attributes using a score of 1 to 6. Keeping in mind that a mean score of attributes from 4 and above implies that the soybean genotype is good according to farmers and this determines the rank and hence preference. In Northern region across field types, Maksoy 3N (5.0), Maksoy IN (4.5) and Maksoy 2N (4.1) had highest mean scores of attributes indicating that they were the top three and therefore most preferred soybean genotypes. The same genotypes were ranked highest in Eastern Uganda with mean scores of; Maksoy 1N (5.1), Maksoy 3N (5.0) and Maksoy 2N (4.4). However, the attributes of MNG and Nam1 were least scored making them the least ranked soybean genotypes. There was a significant difference in mean scores of attributes (farmers ranking) of soybean genotype at 1% level in a particular region (Table 4.13).

Table 4.13: Mean score and ranking of soybean genotypes in Northern and Eastern Uganda

	Northern		Eastern	
	Mean score (Rank)	Std error	Mean score (Rank)	Std error
Genotype				
Nam 1	2.9(6)	0.031	2.9(6)	0.031
Maksoy 1N	4.5(2)	0.022	5.1(1)	0.016
Namsoy 4M	3.9(4)	0.232	3.8(4)	0.024
Maksoy2N	4.1(3)	0.025	4.4(3)	0.023
Maksoy 3N	5.0(1)	0.020	5.0(2)	0.016
MNG 2:14	3.1(5)	0.335	3.2(5)	0.031
F-statistics	865.2***		1358***	

*** 1% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012) and Value in brackets are ranks*

Farmers' ranking of soybean genotypes within field types was also established. Results indicated that in good fields of Northern region, Maksoy 3N (5.1) was ranked highest in position 1, followed by Maksoy1N (4.4), Maksoy 2N (4.2) and then Namsoy 4M (4.0) were the most preferred soybean genotypes. In Medium fields of Northern Uganda, the same soybean genotypes (Maksoy 3N (4.9), Maksoy1N (4.4) and Maksoy 2N (4.0)) and same sequence but different ranks was obtained in positions 1, 2 and 3 respectively whereas in Poor fields only Maksoy 3N (4.8) and Maksoy 1N (4.6) were ranked highly in positions 1 and 2.

Table 4.14: Mean score and ranking of soybean genotypes by field type in Northern and Eastern Uganda

	Northern region			Eastern region		
	Field Type			Field Type		
	Good	Medium	Poor	Good	Medium	Poor
Genotype						
Nam 1	2.8(6)	3.1(5)	3.1(5)	3.1(6)	2.7(6)	3.1(6)
Maksoy 1N	4.4(2)	4.4(2)	4.6(2)	5.3(1)	5.1(1)	4.9(1)
Namsoy 4M	4.0(4)	3.9(4)	3.8(4)	3.8(4)	3.8(4)	3.8(4)
Maksoy2N	4.2(3)	4.0(3)	3.9(3)	4.4(3)	4.4(3)	4.4(3)
Maksoy 3N	5.1(1)	4.9(1)	4.8(1)	5.1(2)	5.0(2)	4.8(2)
MNG 2:14	3.2(5)	3.1(5)	3.1(5)	3.2(5)	3.2(5)	3.2(5)
F-statistics	394.8***	275.9***	281.9***	502.1***	536.9***	387.7***

*** 1% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012) and Value in brackets are ranks*

In Eastern region the same soybean genotypes (Maksoy IN, Maksoy 3N and Maksoy 2N) were ranked highly compared to other genotypes. In good fields, Maksoy 1N was ranked first with mean score of 5.3 followed by Maksoy 3N (5.1) and then Maksoy 2N (4.4). The same sequence was obtained in both medium and poor fields of Eastern region. MNG and Nam1 were ranked low in all the field types of either region. There was a significant difference in farmers' ranking of soybean genotypes within field type at 1% level in either region (Table 4.14).

4.3.3 Farmers' acceptance of soybean genotypes

In order to conduct a comparative analysis of farmers' acceptance of soybean genotypes, a logistic regression technique was used. Both regional and across fields comparisons of farmers' acceptance of soybean genotypes were done.

4.3.3.1 Famers' acceptance of soybean genotypes by region

Analysis of cumulative probability versus ranking position showed that in Northern Uganda, Maksoy 3N had the highest probabilities of being ranked in the first position (78.8%) and second (95.2%) followed by Maksoy 1N in the first (18%) and second position (81%) as shown in Fig 5a. Whereas in Eastern Uganda, Maksoy 1N had the highest probabilities of being ranked in the first position (84.4%) and second (98.6%) followed by Maksoy 3N in the first (10.8 %) and second position (86.7%) as indicated in Figure 5b.

Figure 5a: Farmer acceptance of soybean genotypes across field types of Northern Uganda

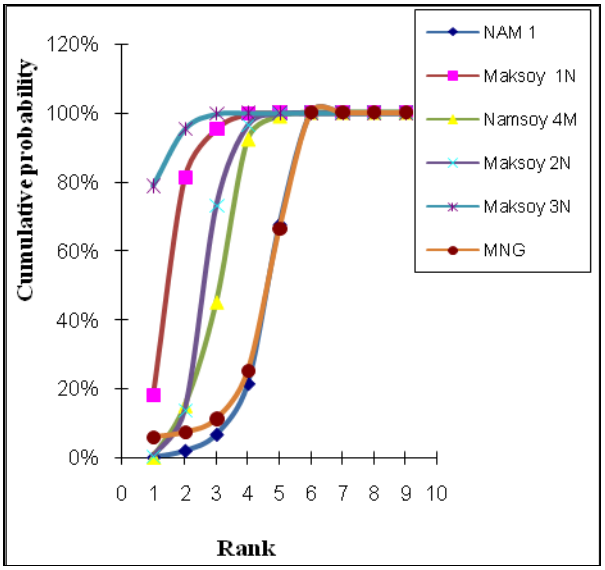
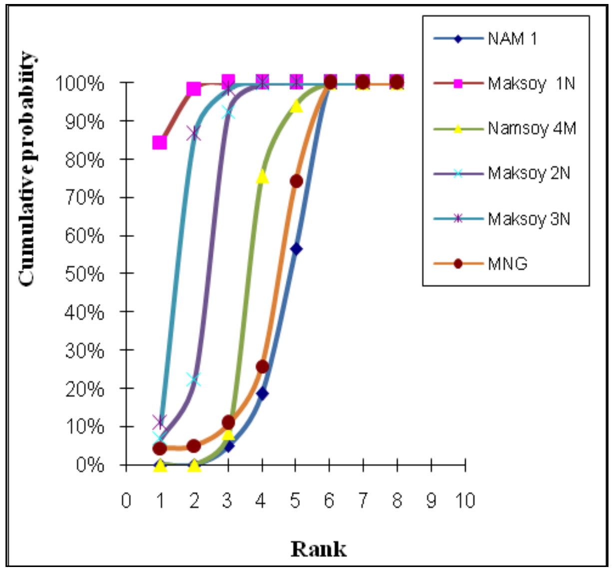


Figure 5b: Farmer acceptance of soybean genotypes across field types of Eastern Uganda



Source: *Field evaluation data (Nov 2011 – Jan 2012)*

In both regions, Maksoy 3N, Maksoy 1N, and Maksoy 2N had positive intercepts on the y-axis indicating the probability of being accepted by farmers. Namsoy 4M had a positive intercept in Northern Uganda (likely to be accepted) and negative intercept in Eastern Uganda (not likely to be accepted in Eastern Uganda). Nam 1 and MNG 2:14 had a negative intercept and hence was detested in both regions (Fig 5a & 5b; Table 4.15). These results are in agreement with the research earlier on conducted in Kenya by Chianu *et al*. (2006) which indicated that some soybean genotypes were acceptable in specific locations while others were accepted in all locations.

Further analysis of the slope of the regression lines and using a Wald chi-square test showed that Maksoy 1N and Maksoy 3N had low slopes in both Northern and Eastern Uganda. In Northern Uganda, the slopes obtained are 0.07 and 0.02 respectively for Maksoy 1N and Maksoy 3N and in Eastern Uganda it was 0.01 and 0.03 respectively for Maksoy 1N and Maksoy 3N. The low slope values indicate that these genotypes were highly ranked (in position 1 and 2). In addition, these genotypes also had positive intercepts and their chi-square values were significantly different (p<0.15) from zero implying that there was a strong likelihood of acceptance for these genotypes by farmers in the two regions. Nam 1 and MNG 2:14 had negative intercepts in both regions indicating a probability of being rejected by famers. The chi-square values in respect to Nam 1 was significantly different (p<0.15) from zero in Eastern region, indicating a strong likelihood of rejection by farmers. Namsoy 4M had a negative intercept in Eastern Uganda indicating a probability of being rejected and a positive intercept in Northern Uganda indicating a probability of being accepted by famers (Table 4.15).

Table 4.15: Statistical analysis of the logistic regression and likelihood of farmer acceptance for soybean genotype in Northern and Eastern Uganda

	Northern region			Eastern region		
Variety	Intercept (b)	Slope (m)	Chi-square	Intercept (b)	Slope (m)	Chi-square
Nam1	-0.25	0.16	1.9	-0.34	0.18	2.6**
Maksoy 1N	0.55	0.07	3.5**	0.92	0.01	25.5**
Namsoy 4M	0.08	0.13	0.49	-0.20	0.18	1.2
Maksoy 2N	0.16	0.12	0.91	0.21	0.13	1.03
Maksoy 3N	0.88	0.02	21.4**	0.49	0.08	2.5**
MNG 2:14	-0.18	0.15	1.48	-0.26	017	2.03

** 15% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012)*

4.2.3.2 Farmer acceptance of soybean genotypes across field types

Comparison of farmer acceptance of soybean genotypes was also done across different field types in both regions. This included comparisons of farmer acceptance of soybean genotypes in good, medium and poor fields as shown below:

Good field types

Analysis of cumulative probability versus ranking position showed that in good fields of Northern Uganda, Maksoy 3N had the highest probabilities of being ranked in the first position (90%) and second (99%) position followed by Maksoy 1N (with 8% in position 1 and 70% in position 2) as shown in Fig 6a Whereas in the good fields of Eastern Uganda, Maksoy 1N had the highest probabilities of being ranked in the first position with 92.5% and 100% in position 2) followed by Maksoy 3N (with 5 % in position 1 and 90% in position 2) as indicated in Figure 6b below.

Figure 6a: Farmer acceptance of soybean genotypes in good fields Northern Uganda

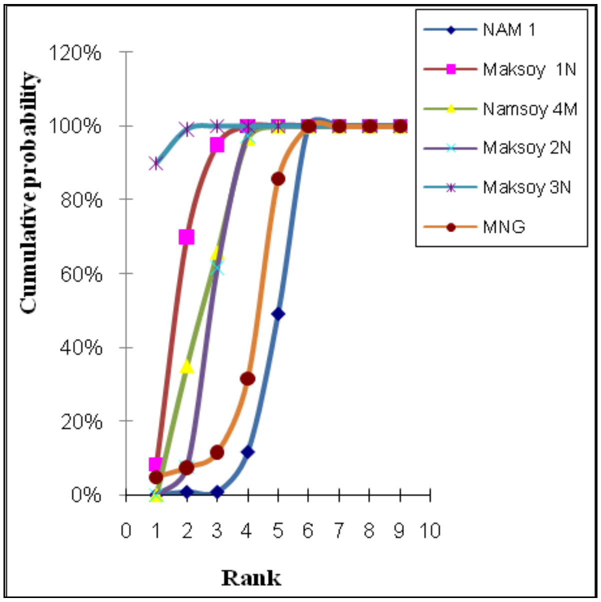
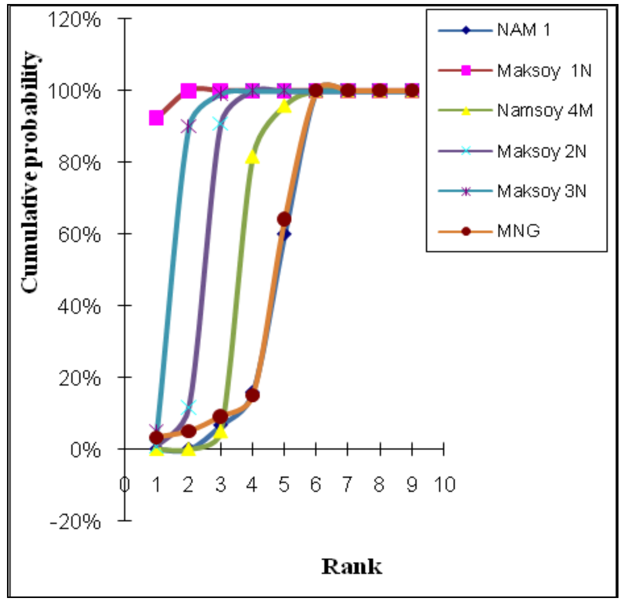


Figure 6b: Farmer acceptance of soybean genotypes in good fields Eastern Uganda



Source: *Field evaluation data (Nov 2011 – Jan 2012)*

Analysis of the slope of the regression lines and using a Wald chi-square test showed that Maksoy 1N and Maksoy 3N had low slopes in good fields of both Northern and Eastern Uganda. In good fields of Northern Uganda, the slopes obtained were 0.08 and 0.007, respectively for Maksoy 1N and Maksoy 3N and in Eastern Uganda it was 0.01 and 0.07, respectively for Maksoy 1N and Maksoy 3N. The low slope values indicate that these genotypes were highly ranked (in position 1 and 2). In addition, these genotypes also had positive intercepts and their chi-square values were significantly different ($p<0.15$) from zero implying that there was a strong likelihood of acceptance by farmers in the good fields of both regions. Nam 1 and MNG 2:14 had negative intercepts in the good fields of both regions indicating a probability of being rejected by famers. The chi-square values in respect to Nam 1 was significantly different ($p<0.15$) from zero in the good field fields of Eastern region indicating a strong likelihood of rejection by farmers. Namsoy 4M had a negative intercept in Eastern Uganda indicating a probability of being rejected and a positive intercept in Northern Uganda indicating a probability of being accepted by famers (Table 4.16).

Table 4.16: Statistical analysis of the logistic regression and likelihood of farmer acceptance for soybean genotype in good fields of Northern and Eastern Uganda

	Good fields of Northern Uganda			**Good fields of Eastern Uganda**		
Variety	Intercept (b)	Slope (m)	Chi-square Value	Intercept (b)	Slope (m)	Chi-square value
Nam1	-0.31	0.16	2.16**	-0.27	0.16	2.1
Maksoy 1N	0.47	0.08	2.73**	0.97	0.01	59.5**
Namsoy 4M	0.22	0.11	1.36	-0.11	0.15	0.60
Maksoy 2N	0.11	0.13	0.60	0.21	0.11	1.03
Maksoy 3N	0.95	0.007	45.73**	0.54	0.07	2.8**
MNG 2:14	-0.15	0.15	1.11	-0.23	0.16	1.72

** 15% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012)*

Namsoy 4M and Maksoy 2N had a positive intercept in good fields of Northern Uganda but their chi-square values were not significantly different from zero. This implies that it is not conclusive that these genotypes are suitable for good fields in Northern Uganda. However, in the absence of Maksoy 3N and Maksoy 1N, the two soybean genotypes (Namsoy 4M and Maksoy 2N) may be suitable for production in Northern region and only Maksoy 2N could be suitable in Eastern region.

Medium field types

Analysis of cumulative probability versus ranking position showed that in medium fields of Northern Uganda, Maksoy 3N had the highest probabilities of being ranked in the (first position (83.3%) and second position (95%) followed by Maksoy 1N (with 11% in position 1 and 80% in position 2) as indicated in Fig 7a below Whereas in the medium fields of Eastern Uganda, Maksoy 1N had the highest probabilities of being ranked (with 84% in position 1 and 98% in position 2) followed by Maksoy 3N (with 12.5% in position 1 and 88% in position 2) as indicated in Figure 7b below.

Figure 7a: Farmer acceptance of soybean genotypes in medium fields Northern Uganda

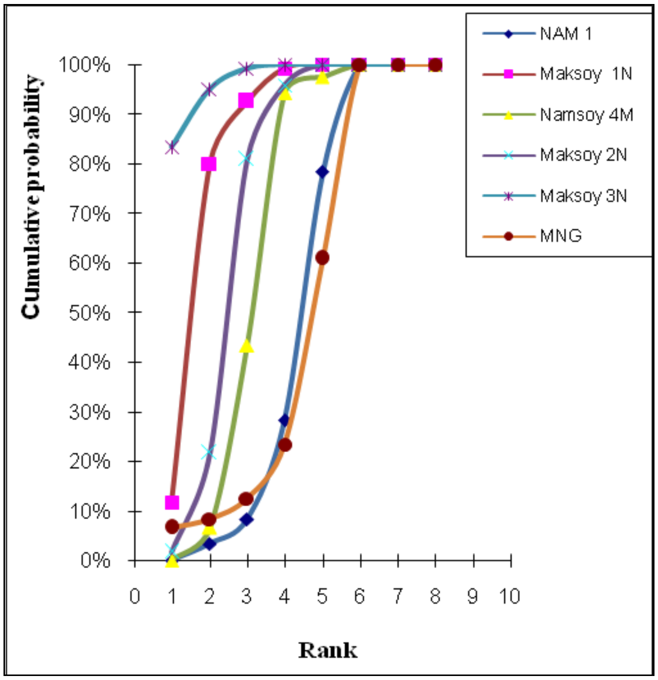
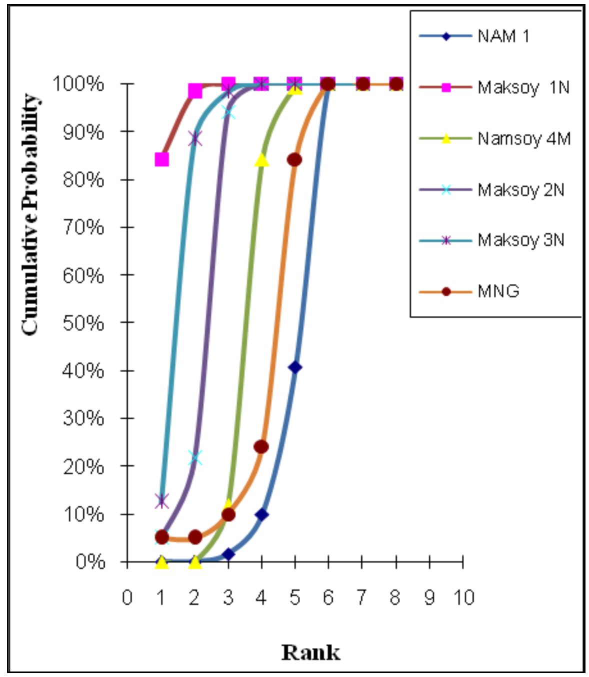


Figure 7b: Farmer acceptance of soybean genotypes in medium fields Northern Uganda



Source*: Field evaluation data (Nov 2011 – Jan 2012)*

Analysis of the slope of the regression lines and using a Wald chi-square test showed that Maksoy 1N and Maksoy 3N had low slopes in medium fields of both Northern and Eastern Uganda. In medium fields of Northern Uganda, the slopes obtained were 0.09 and 0.02, respectively for Maksoy 1N and Maksoy 3N and in Eastern Uganda it was 0.01 and 0.08, respectively for Maksoy 1N and Maksoy 3N. The low slope values indicate that these genotypes were highly ranked (in position 1 and 2). In addition, these genotypes also had positive intercepts and their chi-square values were significantly different (p<0.15) from zero implying that there was a strong likelihood of acceptance by farmers in the medium fields of both regions. Nam 1, Namsoy 4M and MNG 2:14 had negative intercepts in the medium fields of both regions indicating a probability of being rejected by famers. The chi-square values in respect to Nam 1 was significantly different (p<0.15) from zero in the medium fields of Northern region indicating a strong likelihood of rejection by farmers (Table 4.17). Maksoy 2N had a positive intercept but its chi-square value was not significantly different from zero in both regions. Thus, it cannot conclusively be said that this genotype was suitable for medium fields of both regions.

Table 4.17: Probability of farmer acceptance of soybean genotypes in medium fields

Variety	Medium fields of Northern Uganda			Medium fields of Eastern Uganda		
	Intercept (b)	Slope (m)	Chi-square Value	Intercept (b)	Slope (m)	Chi-square value
Nam1	-0.29	0.18	2.23**	-0.37	0.18	2.43**
Maksoy 1N	0.46	0.09	2.51**	0.91	0.01	25.1**
Namsoy 4M	-0.04	0.16	0.24	-0.17	0.18	0.94
Maksoy 2N	0.14	0.14	0.74	0.20	0.13	0.96
Maksoy 3N	0.89	0.02	26.1**	0.51	0.08	2.61
MNG 2:14	-0.24	0.17	1.98	-0.25	0.18	1.76

** 15% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012)*

Poor field types

Analysis of cumulative probability versus ranking position showed that in poor fields of Northern Uganda, Maksoy 3N had the highest probabilities of being ranked in the first position (63.3%) and (91%) in the second position, followed by Maksoy 1N (with 34% in the first and 93.3% in the second position) as shown in Fig 8a. Where as in the medium fields of Eastern Uganda, Maksoy 1N had the highest probabilities of being ranked in the first position (76.6%) and (97.5%) in the second position, followed by Maksoy 3N (with 15% in position 1 and 81.7% in position 2) as indicated in Figure 8b below.

Figure 8a: Farmer acceptance of soybean genotypes in poor fields Northern Uganda

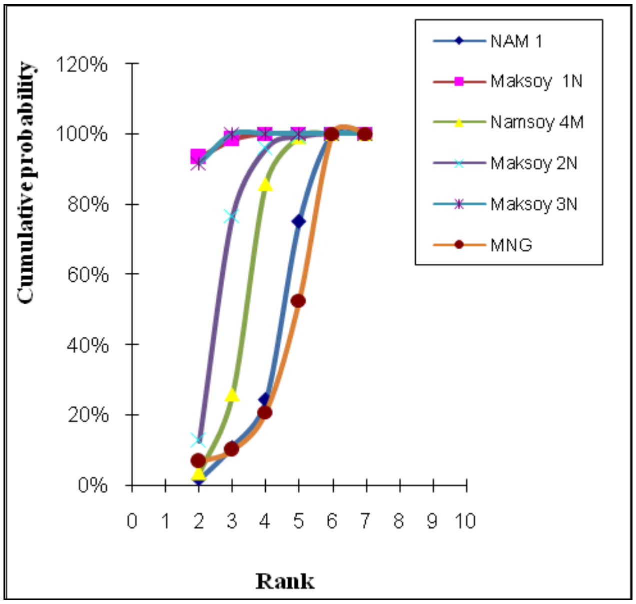
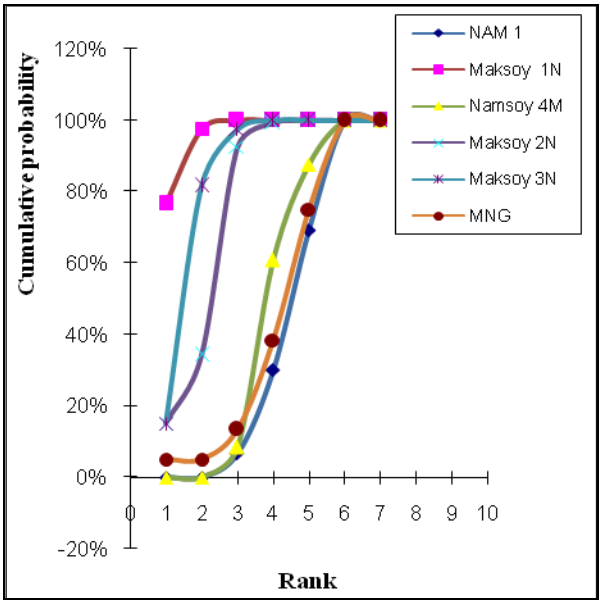


Figure 8b: Farmer acceptance of soybean genotypes in poor fields Northern Uganda



Source: *Field evaluation data (Nov 2011 – Jan 2012)*

In poor fields in Northern region , analysis of the slope of the regression lines and using a Wald chi-square test showed that Maksoy 1N and Maksoy 3N had low slopes of 0.08 and 0.05 respectively and a low slope of 0.03 was obtained for Maksoy 1N. The low slope values indicate that these genotypes were highly ranked (in position 1 and 2). In addition, these genotypes also had positive intercepts and their chi-square values were significantly different ($p<0.15$) from zero implying that there was a strong likelihood of acceptance by farmers in the poor fields. Nam 1, Namsoy 4M and MNG 2:14 had negative intercepts in the poor fields of both regions indicating a probability of being rejected by famers. The chi-square values in respect to Nam 1 was significantly different ($p<0.15$) from zero in the poor fields of both regions whereas chi-square values in respect to MNG was significantly different ($p<0.15$) from zero in the poor fields of Eastern region implying that there was a strong likelihood of rejection of these soybean genotypes (Table 4.18).

Table 4.18: Probability of farmer acceptance of soybean genotypes in Poor fields

	Poor fields of Northern Uganda			**Poor fields of Eastern Uganda**		
Variety	Intercept (b)	Slope (m)	Chi-square Value	Intercept (b)	Slope (m)	Chi-square value
Nam1	-0.36	0.20	2.69**	-0.37	0.20	2.97**
Maksoy 1N	0.59	0.08	3.51**	0.86	0.03	14.19**
Namsoy 4M	-0.22	0.20	1.32	-0.32	0.21	2.35**
Maksoy 2N	-0.019	0.18	0.09	0.21	0.14	1.12
Maksoy 3N	0.75	0.05	8.50**	0.43	0.11	2.11**
MNG 2:14	-0.30	0.18	2.04	-0.28	0.19	2.60**

** 15% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012)*

4.3.4 Reasons for farmers' preferences for soybean genotypes

Farmer preferences for soybean genotypes were influenced by the individual attributes which these genotypes possessed. Following the Lancaster theory (1966) which states that consumers derive utility from the attributes of goods rather than the goods per se. In this study, a farmer is a producer but acts as a consumer of a planting material. Farmers scored soybean genotype attributes on the scale of 1 to 6 with 1 being least score and 6 being the best score. The attributes that scored less than 4 were considered not to be preferred and those that scored 4 and above were deemed to be preferred by famers.

Generally, in the two regions, yield related attributes such as grain yield, pod numbers and number of seed were ranked highly for all soybean genotypes. Chianu *et al*. (2006) indicated that much more than any other single criterion, yield-related criteria influence farmers' choice of any given soybean genotype. In this study, results indicated that Maksoy 1N, Maksoy 3N and Maksoy 2N were scored highly in most of the attributes and this indicates that they were most preferred by famers. However, Maksoy 2N was scored low for biomass production, time to maturity, hairiness and drought tolerance. Maksoy 1N was scored low for drought tolerance whereas, Namsoy 4M, Nam1 and MNG were scored lowly for most of the attributes implying that these genotypes were less preferred by farmers. Namsoy 4M was scored low for plant height, drought, hairiness, time to maturity and pod shattering. Genotypes which shatter tend to cause a lot of seed losses. With pod shattering, a seed loss of 50-100% can occur in susceptible varieties as a result of delayed harvesting after physiological maturity (IITA, 1986) and this is the same issue with Namsoy 4M.

Maksoy 3N was scored low only for hairiness, Nam1 was scored low for growth vigor, biomass production, number of pods, seed number, grain yield, drought, pest and disease tolerance, hairiness and pod shattering across the two regions whereas MNG was scored low for biomass production, adaptation to soil fertility, time to maturity, number of pods, seed number, grain yield, drought and pest tolerance. Generally MNG and Nam1 were scored low for most of the attributes and hence were ranked lowest (Table 4.19).

Table 4.19: Farmers' preferences for attributes of soybean genotypes across Agro-ecological zones

	Preference rating (using mean scores) of attributes on a scale of 1-6													
Genotype	Height	Growth Vigor	Biomass production	Adaption to fertility	Number of pods	Seed number	Grain yield	Time to maturity	Drought tolerance	Pest tolerance	Disease tolerance	Hairlines	Pod shatter	F-values
Nam1														
North	4.3	3.0	3.3	4.1	3.0	2.8	3.0	4.1	2.3	2.1	1.9	2.9	1.8	156.2***
East	4.7	3.3	3.3	3.9	2.9	2.4	3.0	4.4	2.0	2.0	1.8	2.6	2.1	191.9***
Maksoy 1N														
North	5.2	4.5	4.9	4.9	4.3	4.7	4.2	5.3	2.3	4.8	5.3	4	4.3	197.12***
East	4.9	4.8	4.9	5.1	5.6	5.7	5.5	5.8	3.7	5.2	5.3	4.9	5.5	
Namsoy 4M														
North	2.2	3.9	4.0	4.5	4.3	4.9	4.6	3.5	2.4	5.3	5.3	3.9	3.4	249.7***
East	1.9	4.1	4.5	4.0	3.8	4.1	4.0	2.6	2.5	4.7	5.3	3.9	2.5	254.9***
Maksoy 2N														
North	3.4	3.6	3.7	3.6	3.8	4.5	5.0	3.5	2.7	5.3	5.2	3.1	5.5	214.02***
East	4.5	4.3	3.7	5.4	3.8	4.5	5.0	3.5	3.0	5.3	5.3	3.9	5.5	183.53***
Maksoy 3N														
North	4.1	5.5	5.1	5.3	5.4	5.4	5.5	5.0	4.7	5.3	5.2	3.0	5.5	195.77***
East	4.0	5.1	5.2	5.1	5.6	5.7	5.5	5.8	4.3	5.3	5.3	2.5	5.5	414.31***
MNG														
North	4.0	4.8	2.6	3.3	1.9	1.8	1.7	1.5	4.0	2.7	5.1	2.5	4.8	416.9***
East	3.9	4.8	2.6	3.3	2.4	2.4	2.0	1.9	4.0	2.7	5.0	2.5	4.8	322.2***

*** 1% level of significance. *Source: Field evaluation data (Nov 2011 – Jan 2012)*

Generally, the attributes of the two soybean genotypes (Maksoy 1N and Maksoy 3N) were rated highly (with a score of 4 and above) by famers compared to other genotypes in the two regions. In addition, the two genotypes also had the highest probabilities of being ranked in the first two positions, had positive intercepts and their chi-square values were significantly different ($p<0.15$) from zero implying that they had a strong likelihood of acceptance by farmers. This was due to the fact that they were considered by famers to be high yielding, with many pods and seeds, adapt well to soil fertility conditions, tolerant and resistant to pests and diseases. A study conducted in Kenya by Chianu *et al.*(2006) reported similar findings, though shorter cooking time was also a preferred attribute there, which was not the case in this study because farmers' evaluations did not go beyond field evaluations.

Additionally, Maksoy 1N and Maksoy 3N were highly scored than Nam 1 which used to be the commonly and locally grown soybean variety. This is in conformity with the study by Bucheyeki *et al.* (2008) which found farmers to be receptive of new technologies that have an added advantage over their current existing technologies. Moreover, farmers normally adopt varieties that yield more than their locally adapted cultivars; and meet the preferred traits which differ from one community to another (Gowda *et al.,* 2000).

Some genotypes are more adaptable to a certain agro ecological zones than others. In fact, Asrat *et al.* (2009) indicate that farmers are willing to forego some income or output in order to obtain a more stable and environmentally adaptable crop variety. Besides, each of these varieties had unique attributes that were identified and considered by farmers as being important in a specific region. This rendered such varieties to be accepted in specific areas. For instance, in Eastern Uganda, Maksoy 1N which is a short genotype, very early maturing and does not shatter was preferred probably because of the nature of the soils there which is sandy coupled with high population density. Being densely populated, farmers in Eastern Uganda face a problem of limited land and hence short soybean genotypes which allow optimal utilization of land through intercropping are preferred. In addition, early maturing varieties allow the crop to escape adverse weather effects such as drought, unreliable rainy season, ensure the early provision of food to households to alleviate hunger and allow farmers to engage in other farming and non-farming activities. Further, such genotypes give farmers greater flexibility in the use of their land and labor. Similar results were obtained by previous studies in Kenya (Chianu *et al.,* 2006).

Maksoy 3N was the most preferred soybean genotype in Northern region probably because it's a very high yielding, tolerant to soybean rust and early maturing genotype (*http://www.soybeanafrica.com*). In addition, it was established that farmers liked its height. The tolerance to soybean rust reduces yield losses and a tall height (associates it with more branches, more pods, more seed and better ability to suppress weeds). The genotype has high growth vigor and its adaptation to soils in Northern region was good. It has good biomass which can be used as mulch after harvesting, make manure and increase soil fertility.

Although the chi-square values of Maksoy 2N across the two regions were not significant, it was fairly ranked by farmers and had positive intercepts indicating a possibility of preference. This is because farmers ranked its attribute of grain yield, pod shattering, pests and disease tolerance highly. However it was ranked very low for time to maturity but this did not significantly affect its performance. In fact Singleton *et al.* (1988) indicated that late maturing cultivars fix more N, and yield more than earlier types due to a longer reproductive phase. In the absence of Maksoy 1N and Maksoy 3N, this genotype would act as a good substitute.

Nam 1 had a negative intercept and its chi-square value was significantly different ($p<0.15$) from zero in good fields of Northern region and also in both medium and poor fields of Northern and Eastern regions, indicating a strong likelihood of rejection by farmers. This was due to its low yields, poor tolerance to pests (caterpillars) and diseases especially (soybean rust) compared to other genotypes. In poor fields of Eastern Uganda, Namsoy 4M and MNG had negative intercepts and their chi-square values were significantly different ($p<0.15$) from zero. This is because soils in Eastern Uganda dry up very easily, affecting soybean performance especially the late maturing genotypes such as Namsoy 4M and MNG. Such late maturing genotypes cannot escape adverse weather such as drought and unreliable rainy season. The situation is worsened if the field type is poor. This is because poor fields lack nutrients, lack organic matter and cannot hold water for a long time to support late maturing genotypes. In addition, MNG 2:14 was highly infested by pests and diseases and gave poor yields. Adequate and balanced fertility is important in reducing disease losses whereas inadequate phosphorus or potassium can increase losses from soybean cyst nematode, charcoal rot, other root rots, and pod and stem blight. Hence, vigorous plants are more tolerant to pathogens and are better able to produce an almost normal yield despite diseases (Malvic, 1998).

4.4 Profitability of soybean production technologies

To establish profitability of soybean production technologies, experimental data was used which included seasonal quantities produced (yield data), production costs such as (labor costs, fertilizer costs, seed costs) and market prices of output. In Northern Uganda, the average price of soybeans was Shs 1,002 per kg while in Eastern Uganda, it was Shs 900 per kg. Generally, the mean yield obtained from experiments ranged from 367-1582 kg ha^{-1} in Northern Uganda and in Eastern region, it was between 809-1831 kg ha^{-1}. The yield varied with variety and treatment and was more in Eastern Uganda compared to Northern Uganda. These results were consistent with those obtained by UBOS (2010) which indicated that the Eastern region produced higher yields compared to Northern region. However, the yields in both regions were low if compared to the yield (2-3.5 t ha^{-1}) reported on station by Tukamuhabwa *et al.* (2006). This low yield and the low farm gate prices obtained by farmers subsequently affected the gross margins and hence, low profitability obtained from soybean production as shown in Tables 4.22 (A, B, C and D). The low yield was also probably attributed to both abiotic factors (such as climate change impacts), biotic constraints to production (pests like caterpillars and diseases especially soybean rust) and the interaction between the genotype, environment and management practices.

Additionally, this low yield from soybean genotypes in the two regions could have been as a result of late planting at the experimental sites and hence, extending crop growth into a dry season. Early sowing dates give highest seed yield and late sowing date affect soybean genotypes plant stature resulting in pre- mature flowering before the plant could attain its full size (Ngalamu *et al.,* 2012).

Based on experimental plots, the variable costs incurred in soybean production in each region were established which included; cost of seed, cost of fertilizer and transportation costs, cost of rhizobia, land preparation, planting and fertilizer application, weeding and harvesting costs. Results indicated that variable costs varied with fertilizer treatment level and that the variable costs in Eastern region were more than that incurred in Northern region. The difference in the total variable cost (TVC) between the two regions was due to differences in the labor and transportation costs incurred. Highest labour costs were observed in Eastern than Northern Uganda whereas higher transportation costs were obtained in Northern than Eastern Uganda. However; uniform total variable costs were observed for Maksoy 1N and Nam 1 (at a seed rate of $50kgha^{-1}$). Likewise, Maksoy 2N, Maksoy 3N, and MNG had same TVC (at a seed rate of $60kgha^{-1}$) across field types per region. The difference seed rates used in one way contributed to the differences in the TVC as shown in Tables 4.20 and 4.21.

Table 4.20: Variable costs incurred in production of Maksoy 1N, Nam 1 Maksoy 2N, Maksoy 3N, and MNG in Northern Uganda

Table 4.20 (A) Variable costs incurred in production of Maksoy 1N and Nam 1

Treatment	Seed	fertilizer	Rhizobia	Transportation	1st ploughing	2rd ploughing +planting	weeding	Harvesting +threshing	Total Variable Cost
Control	250000	0	0	70000	100000	75000	250000	100000	845000
Rhizobia (R)	250000	0	6250	70000	100000	75000	250000	100000	851250
P(5Kgha^{-1})	250000	67600		70000	100000	75000	250000	100000	912600
R + P(5Kgha^{-1})	250000	67600	6250	70000	100000	75000	250000	100000	918850
P(10Kgha^{-1})	250000	135200		70000	100000	75000	250000	100000	980200
R+P(10Kgha^{-1})	250000	135200	6250	70000	100000	75000	250000	100000	986450
P(20Kgha^{-1})	250000	270400		70000	100000	75000	250000	100000	1115400
R+ P(20Kgha^{-1})	250000	270400	6250	70000	100000	75000	250000	100000	1121650

Table 4.20 (B) Variable costs incurred in production of Maksoy 2N, Maksoy 3N, and MNG

Treatment	seed	fertilizer	Rhizobia	Transportation	1st ploughing	2rd ploughing +planting	weeding	Harvesting +threshing	Total Variable Cost
Control	300000	0	0	70000	100000	75000	250000	100000	895000
Rhizobia (R)	300000	0	7500	70000	100000	75000	250000	100000	902500
P(5Kgha^{-1})	300000	67600	0	70000	100000	75000	250000	100000	962600
R + P(5Kgha^{-1})	300000	67600	7500	70000	100000	75000	250000	100000	970100
P(10Kgha^{-1})	300000	135200	0	70000	100000	75000	250000	100000	1030200
R+P(10Kgha^{-1})	300000	135200	7500	70000	100000	75000	250000	100000	1037700
P(20Kgha^{-1})	300000	270400	0	70000	100000	75000	250000	100000	1165400
R+ P(20Kgha^{-1})	300000	270400	7500	70000	100000	75000	250000	100000	1172900

Source: Experimental data **R=Rhizobia, P=Phosphorus,**

Table 4.21 Variable costs incurred in production of Maksoy 1N, Nam 1 Maksoy 2N, Maksoy 3N, and MNG in Eastern Uganda

Table 4.21(A) Variable costs incurred in production of Maksoy 1N and Nam 1

Treatment	seed	fertilizer	Rhizobia	Transportation	1st ploughing	2rd ploughing +planting	weeding	Harvesting + threshing	Total Variable Cost
Control	250000	0	0	60000	125000	100000	300000	125000	960000
Rhizobia (R)	250000	0	6250	60000	125000	100000	300000	125000	966250
P(5Kgha^{-1})	250000	67600		60000	125000	100000	300000	125000	1027600
R + P(5Kgha^{-1})	250000	67600	6250	60000	125000	100000	300000	125000	1033850
P(10Kgha^{-1})	250000	135200		60000	125000	100000	300000	125000	1095200
R+P(10Kgha^{-1})	250000	135200	6250	60000	125000	100000	300000	125000	1101450
P(20Kgha^{-1})	250000	270400		60000	125000	100000	300000	125000	1230400
R+ P(20Kgha^{-1})	250000	270400	6250	60000	125000	100000	300000	125000	1236650

Table 4.21(B) Variable costs incurred in production of Maksoy 2N, Maksoy 3N, and MNG

Treatment	Seed	fertilizer	Rhizobia	Transportation	1st ploughing	2rd ploughing +planting	weeding	Harvesting + threshing	Total Variable Cost
Control	300000	0	0	60000	125000	100000	300000	125000	1010000
Rhizobia (R)	300000	0	7500	60000	125000	100000	300000	125000	1017500
P(5Kgha^{-1})	300000	67600	0	60000	125000	100000	300000	125000	1017600
R + P(5Kgha^{-1})	300000	67600	7500	60000	125000	100000	300000	125000	1085100
P(10Kgha^{-1})	300000	135200	0	60000	125000	100000	300000	125000	1145200
R+P(10Kgha^{-1})	300000	135200	7500	60000	125000	100000	300000	125000	1152700
P(20Kgha^{-1})	300000	270400	0	60000	125000	100000	300000	125000	1280400
R+ P(20Kgha^{-1})	300000	270400	7500	60000	125000	100000	300000	125000	1287900

Source: Experimental data **R=Rhizobia, P=Phosphorus**

4.4.1 Profitability of soybean production systems

Computation of soybean profitability was done using partial budgeting at various phosphorus levels in Eastern and Northern Uganda. Gross margin results used in this discussion as indicated in Tables 4.22A, 4.22B, 4.22C and 4.22D were extracted from the partial budgets (Appendix II-IX). Gross margins in from different soybean genotypes across different fertilizer treatment levels were determined in each of the region. Results indicate that in Northern Uganda highest gross margins from Maksoy 1N (215,549 $shsha^{-1}$) were obtained with application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} whereas for Maksoy 2N (Shs 124,194 $shsha^{-1}$), Nam1 (Shs 65,670 $shsha^{-1}$), Maksoy 3N (97, 612 $shsha^{-1}$), MNG (104,323 $shsha^{-1}$) and Namsoy 4M (Shs 168,137 $shsha^{-1}$) were obtained with application of rhizobia and phosphorus at a rate of 10 kg ha^{-1}. On the other hand in across field types of Eastern Uganda, highest gross margins from Nam1 (Shs 189,664 $shsha^{-1}$) and Maksoy 3N (310, 520 $shsha^{-1}$) were obtained with application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} whereas for Maksoy 1N (282,755 $shsha^{-1}$), Maksoy 2N (Shs 198,117 $shsha^{-1}$), MNG (316,105 $shsha^{-1}$) and Namsoy 4M (Shs 278,795 $shsha^{-1}$) were obtained with application of rhizobia and phosphorus at a rate of 10 kg ha^{-1} as shown in Table 4.22 (A)

In each field type, the gross margins from different soybean genotypes varied across different fertilizer treatment levels. In the good fields of Northern Uganda, highest gross margins from Maksoy 1 (663,463 $shsha^{-1}$), Maksoy 2N (Shs 225, 973 $shsha^{-1}$) and Nam1 (Shs 45,150 $shsha^{-1}$) were obtained with application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} whereas for Maksoy 3N (Shs 175,539 $shsha^{-1}$), MNG (Shs 449,408 $shsha^{-1}$) and Namsoy 4M (Shs 298,500 $shsha^{-1}$) were obtained with application of rhizobia and phosphorus at a rate of 10 kg ha^{-1}. On the other hand in good fields of Eastern Uganda, Maksoy 1N (439,511 $shsha^{-1}$) and MNG (Shs 35,868 $shsha^{-1}$) obtained highest gross margins with application of rhizobia and phosphorus at a rate of 10 kg ha^{-1} whereas Maksoy 2N (Shs 35,567.9 $shsha^{-1}$), Maksoy 3N (Shs 40,104 $shsha^{-1}$), Nam 1 (109,609 $shsha^{-1}$) and Namsoy 4M (188,133 $shsha^{-1}$) obtained highest gross margins with application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} as shown in Table 4.22 B.

In medium fields of Northern Uganda, only two soybean genotypes had positive and highest gross margins and these were Maksoy 2N (281,300 $shsha^{-1}$) and Nam 1 (66,909 $shsha^{-1}$) obtained with application rhizobia and phosphorus at a rate of 10 kg ha^{-1}. In Medium fields of Eastern Uganda on the other hand had positive gross margins for all genotypes. With application of rhizobia and phosphorus at a rate of 5 kgha^{-1}, highest gross margins were obtained for Maksoy 1N (507,587 shsha^{-1}), Maksoy 3N (491,554 shsha^{-1}) and Nam 1 (388,883 shsha^{-1}). With application of rhizobia and phosphorus at a rate of 10 kg ha^{-1}, highest gross margins for Maksoy 2N (254,651 shsha^{-1}), MNG (450,305 shsha^{-1}) and Namsoy 4M (430,548 shsha^{-1}) were obtained as shown in Table 4.22C

Finally in the poor fields of Northern Uganda, highest gross margins for Maksoy 2N (191,246 shsha^{-1}), Maksoy 3N (255,997 shsha^{-1}), MNG (144,300 shsha^{-1}), Nam 1 (370,550 shsha^{-1}) and Namsoy 4M (321,612 shsha^{-1}) were obtained with the application of application rhizobia and phosphorus at a rate of 10 kg ha^{-1}. In the poor fields of Eastern Uganda, highest gross margins obtained with application of rhizobia and phosphorus at a rate of 10 kg ha^{-1}for Maksoy 2N (498,800 shsha^{-1}), Maksoy 3N (495,200 shsha^{-1}), MNG (462,143 shsha^{-1}), Nam 1 (390,280 shsha^{-1}) and Namsoy 4M (250,148 shsha^{-1}). Finally Maksoy 1N had the highest gross margin of (344,483 shsha^{-1}) with application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} as shown in Table 4. 22 D.

To compare profitability of soybean genotypes across different fertilizer levels, dominance analysis and marginal rate of return (MRR) were employed. During dominance analysis, technologies that cost more than the previous ones but yielded less net benefits than the previous treatments were said to be dominated and hence excluded from further analysis of MRR. Marginal rates of return (MRR) are rates at which benefits change as investment changes (Bereket and Asefu-Adjaye, 1999). It gives an indication of what a farmer is likely to receive on average by switching technologies (Irambu *et al.*, 2009). This section therefore looks at the changes in returns from different soybean genotype production as a result of the given alternative phosphorus fertilizer treatments and application of rhizobia inoculants.

In establishing MRR, gross margin and dominance analysis for soybean genotype treated with a given fertilizer level were carried out in both Northern and Eastern regions across the three field types as indicated in Tables 4.22 (A), (B) (C) and (D). According to guidelines given by

CIMMYT (1988), nearly all the recommended fertilizer levels must have yielded MRRs above 100% which is acceptable. This implies a profit of 100% earned for every shilling invested. The gross margins marked D in Tables 4.22 (A), (B), (C) and (D) were given by dominated fertilizer treatments implying that these fertilizer levels gave a lower gross margin compared to the previous ones and yet they had higher total variable costs. These dominated treatments were subsequently eliminated from further considerations during marginal rate of return analysis.

Generally, irrespective of the field type and soybean genotypes, application of either rhizobia or phosphorus obtained higher grain yield and gross margins compared to control (where neither rhizobia nor phosphorus was applied). This was in agreement with Herridge and Bergersen (1988) who suggested that increasing the amounts of nitrogen fixed in soybean and the portion of total plant nitrogen derived from fixation increases yield. However, soybean performed better when rhizobia inoculation was added together with phosphorus. Synergistic interaction between nitrogen and phoshorus increase nodulation further relative to sole application of the rhizobial inoculants (Majengo *et al.,* 2011). Keyser *et al.* (1992) emphasized that addition of phosphorus and inoculation improved yields as it was established that each input gave approximately 300 kg yield increase and when applied together a 600 kg increase was realized. Results from soil analysis (Table 3.1) indicated that there were low initial phosphorus and nitrogen levels across field types in the two regions and hence the reason why all the soybean genotypes responded to rhizobia and phosphorus application in all the field types.

Across all the field types of Northern Uganda, highest MRR for Maksoy 1N (577.8 %), Mak soy 3N (1621 %) and MNG (2801.4 %) were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1}. Highest MRR for Maksoy 2N (496%) and Nam 1 (3520.1%) were obtained by changing from control to application of rhizobia alone whereas for Namsoy 4M (2,809.6 %) was obtained by changing from application of phosphorus at a rate of 10 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 10 $kgha^{-1}$. Similarly, across fields of Eastern Uganda, highest MRR for Maksoy 1N (1,106 %), Maksoy 2N (1,146 %) and Maksoy 3N (2,352 %) were obtained by changing from application of phosphorus at a rate of 5 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1}. Highest MRR for MNG (527 %) and Nam 1 (795 %) were obtained by changing from application from control to application of rhizobia alone whereas highest MRR for Namsoy 4M (1,209 %) was obtained by of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kg ha^{-1} whereas (Table 4.22A)

In good fields of Northern Uganda, highest MRR for Maksoy 1N (6,558.6 %), Namsoy 2N (794 %), MNG (5,524 %) and Nam 1 (289 %) were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1}. Highest MRR for Namsoy 4M (2,884.8 %) were obtained by changing from control to application of rhizobia alone whereas for Maksoy 3N (255.4 %) highest MRR was obtained by changing from application of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kgha^{-1}. Similarly, in good fields of Eastern Uganda, highest MRR for Maksoy 1N (1,460.6 %), Maksoy 2N (1,042.2 %), Maksoy 3N (610.4 %) and Nam 1 (832 %) were obtained by changing from application of phosphorus at a rate of 5 kgha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1}. Highest MRR for MNG (1,317 %) was obtained by changing from application of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kg ha^{-1} whereas highest MRR for Namsoy 4M (850.3 %) was obtained by changing from control to application of rhizobia alone (Table 4. 22B)

Generally in medium fields of Northern Uganda, highest MRR were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kgha^{-1} except Maksoy 2N. Specifically highest MRR obtained for Maksoy 1N (225.2 %), Maksoy 3N (17261.7 %), MNG (1166.9 %), Nam 1 (395.1 %) and Namsoy 4M (1463.3 %) were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} except Maksoy 2N (594.4 %) where highest MRR was obtained by changing from application of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kg ha^{-1}. In medium fields of Eastern Uganda for all the soybean genotypes, highest MRR were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1}. Specifically MRR obtained for these soybean genotypes include; for Maksoy 1N (1391.3 %), Maksoy 2N (1115.2 %), Maksoy 3N (428 %), MNG (245.5 %), Nam 1 (293.8 %) and Namsoy 4M (230.4 %)

where highest MRR were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1} as indicated in Table 4. 22(C)

In poor fields of northern region, highest MRR for Maksoy 1N (3,090.5 %), Maksoy 2N (1351 and Nam1 (1429.3 %) and Namsoy 4M (1351.4 %) %) were obtained by changing from application of phosphorus at a rate of 10 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 10 $kgha^{-1}$ whereas highest MRR for Maksoy 3N (3319.1 %) and MNG (1713.3 %) were obtained by changing from application of phosphorus at a rate of 5 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 5 $kgha^{-1}$. On the other hand in poor fields of Eastern Uganda, most of the soybean genotypes which include Maksoy 1N (1149.1 %), Maksoy 2N (1280 %), Maksoy 3N (701.4 %) and MNG (760.8 %) obtained highest MRR by changing from application of phosphorus at a rate of 5 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 5 $kgha^{-1}$ except Nam 1 (150.4 %) and Namsoy 4M (1064.6 %) where highest MRR were obtained by changing from application of phosphorus at a rate of 10 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 10 $kgha^{-1}$ as shown in Table 4. 22 D.

Results indicate that application of phosphorus in soybean production was profitable but at different phosphorus rates an indication that some varieties respond differently to phosphorus application. Similar findings were established by Kaizi *et al.*, (2012). Ebanyat *et al.* (2010) too indicated that more benefits could be obtained with phosphorus application necessary for establishment of legumes and accumulation of nitrogen. Further, results indicated that in most soybean genotypes, changing from control to application of rhizobia was profitable. A study by Majengo *et al.* (2011) indicated that rhizoidal inoculation resulted in significantly higher nodulation compared to the control which resulted into high biomass. The high biomass implies increase in the rate of photosynthesis and grain yield production due to high leaf number and leaf area.

Generally, application of rhizobia together with phosphorus was more profitable compared to sole application of phosphorus. This is because rhizobia enhance nitrogen fixation and phosphorus solubilisation in low phosphorus systems (Majengo *et al.*, 2011). In this study, results indicated that growing of soybean with application of rhizobia and phosphorus at a rate of

5kgha^{-1} and above but not exceeding 10 kgha^{-1} of phosphorus obtained higher MRR across all soybean genotypes in both Northern and Eastern Uganda. These results are in agreement with that obtained by Kaizi *et al.* (2012) which indicated that net returns to fertilizer application in soybean production were maximized with application of phosphorus at a rate of 7kgha^{-1}.

Table 4.22 (A): Gross Margin, Dominance analysis and MRR for soybean genotype fertilizer application in Northern and Eastern region

		NORTHERN UGANDA				EASTERN UGANDA			
	Treatment	Yield	TVC	GM	MRR	Yield	TVC	GM	MRR
Maksoy 1N	0	634	845000	-211191		1119	960000	47187	
	R	549	851250	-302388	D	1145	966250	63861	267
	5	844	912600	-68281	D	1337	1027600	175999	183
	R+5	**1134**	**918850**	**215549**	**577.8**	**1421**	**1033850**	**245097**	**1106**
	10	781	980200	-199116	D	1069	1095200	-133404	D
	R+10	889	986450	-97804	-464	1538	1101450	282755	56
	20	733	1115400	-382113	D	1384	1230400	15341	D
	R+20	818	1121650	-303710	-152.3	1384	1236650	8672	D
Maksoy 2N	0	706	895000	-189344		1041	1010000	-72808	
	R	**750**	**902500**	**-152141**	**496**	1062	1017500	-61601	
	5	798	962600	-164658	D	1187	1077600	-9255	94
	R+5	978	970100	7951	237	**1291**	**1085100**	**76681**	**1146**
	10	881	1030200	-148801	D	1197	1145200	-67880	D
	R+10	1162	1037700	124194	172	1501	1152700	198117	180
	20	838	1165400	-327852	D	1271	1280400	-136179	D
	R+20	751	1172900	-421527	D	1164	1287900	-240231	D
Maksoy 3N	0	575	895000	-320104		1229	1010000	95948	
	R	580	902500	-322534	D	1214	1017500	75161	D
	5	736	962600	-226955	137.8	1346	1077600	134097	56
	R+5	**865**	**970100**	**-105400**	**1621**	**1551**	**1085100**	**310520**	**2352**
	10	769	1030200	-261134	D	1452	1145200	161183	D
	R+10	1135	1037700	97612	300.3	1493	1152700	191185	-177
	20	771	1165400	-394598	D	1289	1280400	-120417	D
	R+20	832	1172900	-341048	-324.5	1256	1287900	-157835	D
MNG	0	546	895000	-349017		1118	1010000	-3735	
	R	480	902500	-422988	D	1170	**1017500**	**35805**	**527**
	5	640	962600	-322873	38.7	1144	1077600	-47880	D
	R+5	**857**	**970100**	**-112767**	**2801.4**	1306	1085100	89852	80
	10	726	1030200	-304033	D	1218	1145200	-48859	D
	R+10	1142	1037700	104323	321.1	**1632**	1152700	316105	335
	20	601	1165400	-564702	D	1227	1280400	-176009	D
	R+20	905	1172900	-268122	-275.5	1241	1287900	-171068	-360
Nam1	0	521	845000	-324233		1193	960000	113937	
	R	**747**	**851250**	**-104226**	**3520.1**	**1255**	**966250**	**163627**	**795**
	5	668	912600	-244727	D	1301	1027600	143283	D
	R+5	904	918850	-14759	132.3	1359	1033850	189664	39
	10	802	980200	-177951	D	1307	1095200	81249	D
	R+10	1052	986450	65670	119.0	1320	1101450	86175	-153
	20	750	1115400	-365770	D	1324	1230400	-38805	-97
	R+20	805	1121650	-316329	-282.5	1369	1236650	-4398	551
Namsoy 4M	0	479	895000	-415888		1080	1010000	-38030	
	R	578	902500	-324048	1224.5	1185	1017500	48609	1155
	5	847	962600	-115433	347.1	1076	1077600	-108779	D
	R+5	885	970100	-85442	399.9	1400	1085100	175050	187
	10	988	1030200	-42583	71.3	1481	1145200	188146	22
	R+10	**1206**	**1037700**	**168137**	**2809.6**	**1591**	**1152700**	**278795**	**1209**
	20	830	1165400	-335532	D	1272	1280400	-135896	D
	R+20	894	1172900	-278897	-330.6	1354	1287900	-68922	-257

(a) Average soybean price in Northern Uganda was Ug shs1000 and in Eastern Uganda it was Ugshs 900
(b) D is a dominated treatment
(c) GM is Gross Margin, TVC is Total Variable Cost, MRR is Marginal Rate of Return

Table 4.22 (B): Gross Margin, Dominance analysis and MRR for soybean genotype fertilizer application in Good fields of Northern and Eastern region

	GOOD FIELDS NORTHERN REGION					GOOD FIELDS EASTERN REGION			
	Treatment	Yield	TVC	GM	MRR	Yield	TVC	GM	MRR
Maksoy 1N	0	876	845000	30605.4		1160	960000	84089	
	R	664	851250	-187362.5	D	1192	966250	106179	353.4
	5	1166	912600	253553.5	329.8	1411	1027600	241936	221.3
	R+5	1582	918850	**663463.4**	**6558.6**	1519	1033850	333222	**1460.6**
	10	882	980200	-97876.7	D	1326	1095200	98166	D
	R+10	934	986450	-52278.2	D	1712	1101450	**439511**	157.2
	20	900	1115400	-215217.8	D	1405	1230400	33828	D
	R+20	1031	1121650	-91128.7	-372.1	1668	1236650	264358	-129.6
Maksoy 2N	0	900	895000	5345.9		1054	1010000	-61400	27.8
	R	961	902500	58906.1	**714**	1055	1017500	-67854.9	D
	5	906	962600	-56415.1	D	1150	1077600	-42600	D
	R+5	1206	970100	**235972.8**	262	1295	1085100	35567.9	**1042.2**
	10	745	1030200	-285125.7	D	1022	1145200	-225400	D
	R+10	938	1037700	-99965.3	-497	1104	1152700	-159100	-287.9
	20	979	1165400	-185900.2	D	1251	1280400	-154500	3.6
	R+20	897	1172900	-276393.8	D	1081	1287900	-315000	D
Maksoy 3N	0	709	895000	-186313.2		1107	1010000	-14043.71	
	R	657	902500	-245590.0	D	1092	1017500	-34602.3	-274.1
	5	946	962600	-16232.2	251.6	1191	1077600	-5680.5	48.1
	R+5	940	970100	-30000	D	1250	1085100	**40104.5**	**610.4**
	10	695	1030200	-335001.2	D	1265	1145200	-6418.2	D
	R+10	1213	1037700	**175538.7**	**255.4**	1299	1152700	16441.5	-35.0
	20	671	1165400	-493995.3	D	1129	1280400	-264162.2	D
	R+20	972	1172900	-200878.4	-278.4	1180	1287900	-225675.5	-179.0
MNG	0	639	895000	-256204.0		809	1010000	-282301.4	
	R	626	902500	-276260.5	D	840	1017500	-261090.5	282.8
	5	721	962600	-241400	21.9	879	1077600	-286205.6	D
	R+5	1143	970100	172900	**5524**	942	1085100	-237275.7	35.2
	10	953	1030200	-77700	D	1202	1145200	-62964.4	290
	R+10	1487	1037700	**449408.1**	409.0	1321	1152700	**35868.2**	**1317.8**
	20	826	1165400	-339300	D	870	1280400	-497327.8	D
	R+20	1354	1172900	181100	-198.5	1027	1287900	-363577.9	-295.4
Nam1	0	616	845000	-228929.0		1025	960000	-37467.5	
	R	701	851250	-150250.0	**220**	1000	966250	-66250.0	188.3
	5	735	912600	-177393.4	D	1206	1027600	57606.3	135.8
	R+5	964	918850	45150.0	289	1271	1033850	109608.5	832.0
	10	741	980200	-238807.8	D	1293	1095200	68388.2	D
	R+10	946	986450	-40450.0	-126.6	1001	1101450	-200636.5	D
	20	698	1115400	-417303.1	D	1044	1230400	-290860.1	D
	R+20	792	1121650	-329687.4	-213.9	1171	1236650	-182379.6	-188.4
Namsoy 4M	0	563	895000	-331821.2		901	1010000	-199100	
	R	787	902500	-115453.9	**2884.8**	980	1017500	-130823.9	850.3
	5	1040	962600	77480.1	321.0	872	1077600	-292735.8	D
	R+5	1093	970100	122623.9	601.9	1415	1085100	188133.2	478.5
	10	1035	1030200	5196.6	D	1405	1145200	119137	D
	R+10	1336	1037700	**298500**	260.2	1244	1152700	-33164.2	D
	20	898	1165400	-267454.3	D	1314	1280400	-98152.2	D
	R+20	1085	1172900	-87959.9	-285.8	1269	1287900	-145646.2	D

(d) Average soybean price in Northern Uganda was Ug shs1000 and in Eastern Uganda it was Ugshs 900
(e) D is a dominated treatment
(f) GM is Gross Margin, TVC is Total Variable Cost, MRR is Marginal Rate of Return

Table 4.22 (C): Gross Margin, Dominance analysis and MRR for soybean genotype fertilizer application in Medium fields of Northern and Eastern region

	MEDIUM FIELDS NORTHERN REGION					MEDIUM FIELDS EASTERN REGION			
	Treatment	Yield	TVC	GM	MRR	Yield	TVC	GM	MRR
Maksoy 1N	0	458	845000	-386538		1098	960000	-1840.4	
	R	458	851250	-393078	-104.6	1135	966250	144854.0	431.9
	5	663	912600	-249726	D	1309	1027600	150628.9	156.1
	R+5	678	918850	-240850	**225.2**	1413	1033850	507587.2	**1391.3**
	10	561	980200	-418856	D	872	1095200	-310400.1	D
	R+10	744	986450	-242450	-2.4	1315	1101450	81904.0	-230.3
	20	565	1115400	-549922	D	1301	1230400	-59912.7	D
	R+20	646	1121650	-475444	-172.3	1159	1236650	-193100.2	D
Maksoy 2N	0	551	895000	-343821		1191	1010000	61874.7	
	R	580	902500	-322068	290.0	1232	1017500	91450.5	394.3
	5	798	962600	-165066	261.2	1299	1077600	91634.3	0.3
	R+5	774	970100	-196335	D	1400	1085100	175276.1	**1115.2**
	10	779	1030200	-251200	D	1360	1145200	78858.6	D
	R+10	1319	1037700	**281300**	**594.4**	1564	1152700	**254651.2**	117.4
	20	811	1165400	-354436	D	1369	1280400	-48237.6	D
	R+20	716	1172900	-456511	D	1141	1287900	-260792.1	D
Maksoy 3N	0	473	895000	-422000		1502	1010000	342050.4	
	R	527	902500	-375500	620	1502	1017500	334300.0	D
	5	610	962600	-352600	38.1	1563	1077600	328812.0	141.1
	R+5	747	970100	-223100	**1726.7**	1752	1085100	**491554.1**	**428.0**
	10	677	1030200	-353200	D	1420	1145200	133068.4	D
	R+10	899	1037700	-138700	124.9	1350	1152700	61913.8	D
	20	659	1165400	-506400	D	1484	1280400	55188.1	D
	R+20	735	1172900	-437957	-221.3	1538	1287900	96244.9	-90.7
MNG	0	538	895000	-356665		1324	1010000	181971.6	
	R	445	902500	-457205	D	1469	1017500	196600.0	195.0
	5	693	962600	-269619	128.8	1259	1077600	55323.5	D
	R+5	788	970100	-182100	**1166.9**	1608	1085100	362533.1	**245.**5
	10	640	1030200	-390200	D	1399	1145200	113588.9	D
	R+10	757	1037700	-280740	-145.9	1781	1152700	**450305.3**	129.8
	20	537	1165400	-628407	D	1396	1280400	-24361.9	D
	R+20	788	1172900	-384566	-76.8	1310	1287900	-109125.0	D
Nam1	0	425	845000	-419770		1275	960000	187493.2	
	R	424	851250	-427250	D	1485	966250	370257.1	44.2
	5	379	912600	-533226	D	1367	1027600	202998.1	D
	R+5	791	918850	-128024	**395.1**	1581	1033850	**388883.**3	**293.8**
	10	604	980200	-376266	D	1338	1095200	109444.9	D
	R+10	1053	986450	**66909**	288.4	1300	1101450	68880.2	D
	20	826	1115400	-289608	D	1346	1230400	-18551.9	D
	R+20	624	1121650	-497650	D	1326	1236650	-43238.2	-213.1
Namsoy 4M	0	373	895000	-521999		1278	1010000	176200.0	
	R	427	902500	-475500	620.0	1481	1017500	191203.9	200.1
	5	510	962600	-452704	37.9	1449	1077600	68467.3	D
	R+5	627	970100	-142958	**1463.3**	1591	1085100	346970.3	**230.4**
	10	577	1030200	-453200	D	1748	1145200	184192.0	D
	R+10	922	1037700	-115700	336.2	1969	1152700	**430548.2**	123.6
	20	559	1165400	-606161	D	1477	1280400	48900.0	D
	R+20	723	1172900	-449878	-247.2	1746	1287900	107919.0	-238.6

(a) Average soybean price in Northern Uganda was Ug shs1000 and in Eastern Uganda it was Ugshs 900
(b) D is a dominated treatment
(c) GM is Gross Margin, TVC is Total Variable Cost, MRR is Marginal Rate of Return

Table 4.22 (D): Gross Margin, Dominance analysis and MRR for soybean genotype fertilizer application in Poor fields of Northern and Eastern region

		POOR FIELDS NORTHERN REGION				POOR FIELDS EASTERN REGION			
	Treatment	Yield	TVC	GM	MRR	Yield	TVC	GM	MRR
Maksoy 1N	0	567	845000	-533828		1020	960000	-42388	
	R	525	851250	-524662	146.7	1118	966250	39551	15.0
	5	704	912600	-300250	365.8	1292	1027600	135432	36.0
	R+5	1143	918850	-527108	D	1531	1033850	**344483**	**1149.1**
	10	900	980200	-686435	-571.3	1008	1095200	-187979	D
	R+10	988	986450	-493276	**3090.5**	1587	1101450	326850	299.4
	20	734	1115400	-570897	D	1447	1230400	72108	D
	R+20	777	1121650	-615825	-90.6	1324	1236650	-45242	D
Maksoy 2N	0	665	895000	-229558		879	1010000	-218900	
	R	709	902500	-193262	483.9	899	1017500	-208400	140.0
	5	690	962600	-272494	D	979	1077600	-196500	219.8
	R+5	954	970100	-15783.5	262.5	1257	1085100	343200	**1280**
	10	1120	1030200	89921.7	175.9	1209	1145200	-57100	D
	R+10	1229	1037700	**191246.9**	**1351.0**	1835	1152700	**498800**	-332.8
	20	722	1165400	-443221	D	1194	1280400	-205800	D
	R+20	641	1172900	-531678	D	1270	1287900	-144900	45.0
Maksoy 3N	0	543	895000	-352000		1078	1010000	-40164	
	R	556	902500	-346511.91	73.2	1048	1017500	105787	-454.0
	5	651	962600	-312032	57.4	1285	1077600	79159	D
	R+5	907	970100	-63100	**3319.1**	1650	1085100	399900	**701.4**
	10	935	1030200	-95200	D	1669	1145200	356900	D
	R+10	1294	1037700	255997.4	472.0	1831	1152700	**495200**	141.0
	20	982	1165400	-183400	D	1253	1280400	-152275	D
	R+20	789	1172900	-384309.34	D	1049	1287900	-344073	D
MNG	0	461	895000	-434182		1221	1010000	89124	
	R	367	902500	-535500	D	1202	1017500	63906	D
	5	505	962600	-457600	-34.6	1294	1077600	87243	-2.8
	R+5	641	970100	-329100	**1713.3**	1366	1085100	144300	**760.8**
	10	586	1030200	-444200	D	1053	1145200	-197201	D
	R+10	1182	1037700	144300	700.3	1794	1152700	462143	470.2
	20	439	1165400	-726400	D	1416	1280400	-6338	D
	R+20	572	1172900	-600900	-551.2	1386	1287900	-40500	D
Nam1	0	521	845000	-324000		1280	960000	191785	
	R	731	851250	-23560.9	66.1	1281	966250	186874	-78.6
	5	889	912600	-23560.9	483.0	1330	1027600	169244	D
	R+5	957	918850	38595.31	994.5	1227	1033850	70499	D
	10	1061	980200	81221.87	69.5	1290	1095200	65914	D
	R+10	1357	986450	370550	**1429.3**	1657	1101450	390280	**150.4**
	20	725	1115400	-390400	D	1582	1230400	192996	D
	R+20	1000	1121650	-121650	-364.1	1610	1236650	212425	D
Namsoy 4M	0	501	895000	-393843		1060.9	1010000	-55190	
	R	521	902500	-381189	168.7	1092	1017500	-34251	279.2
	5	992	962600	-31075.6	582.6	908	1077600	-260100	D
	R+5	934	970100	24006.8	734.4	1195	1085100	-9782	36.2
	10	1350	1030200	220255.7	326.5	1292	1145200	17300	-59.8
	R+10	1359	1037700	321612.5	**1351.4**	1559	1152700	250148	**1064.6**
	20	1032	1165400	-132982	D	1024	1280400	-358436	D
	R+20	874	1172900	-298854	D	1048	1287900	-344619.5	-280.2

(a) Average soybean price in Northern Uganda used was Ug shs1000 and in Eastern Uganda it was Ugshs 900
(b) D is a dominated treatment
(c) GM is Gross Margin, TVC is Total Variable Cost, MRR is Marginal Rate of Return

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Soybean is an important crop that provides food for both humans and animals. The crop is a source of income for farmers, a source of protein and a prospective export crop. However, farmers' preferences for soybean genotypes in Uganda. Many interventional programs have rarely consider soil fertility management and heterogeneity in soil fertility. Therefore, this study evaluated soybean genotypes on varying soil fertility management in northern and eastern Uganda**.** This included establishing farmers' preferences for soybean genotypes and determining the profitability of soybean genotypes with and without nutrient management as affected by heterogeneity in soil fertility in northern and Eastern Uganda.

This study was conducted in the Northern districts of Lira, Kole and Apach and Eastern districts of Pallisa, Kibuku and Budaka where soybean on-farm experimental plots had been set up. Data was collected from a sample of 240 respondents and analyzed using descriptive statistics to characterize soybean farmers. A matrix ranking technique and a logistic regression tool were used to establish farmers' preference for soybean genotypes and a partial budgeting approach was used to determine the profitability of soybean genotypes.

The majority (55%) of soybean farmers in both Northern and Eastern region had basic primary education. However more farmers (27%) from Northern Uganda had not attained any education level as compared to (9%) in the East. On the whole, few farmers (24%) participated in non farming activities. Farmers in Eastern Uganda had bigger household size (7 members) than Northern region (5 members). The main source of income in both regions was from farming (1,362,925 $shsha^{-1}$) compared to (642,995 $shsha^{-1}$) from non farming. However, farmers in Northern Uganda obtained more income (1,872,600 $shsha^{-1}$) from farming than (853,250 $shsha^{-1}$) in Eastern Uganda. On the other hand farmers in Eastern Uganda obtained more income (788, 160 $shsha^{-1}$) from non-farming activities compared to (497,830 $shsha^{-1}$) in the Northern region.

Soybean was generally grown as both food and cash crop in both regions though it was taken as more of a cash crop than food crop in Northern Uganda. Land possessed by farmers in Northern Uganda was bigger (1.5 ha) compared to (0.7 ha) in Eastern region. Twice as much land as in the Eastern region was allocated to soybean production in the Northern region with more soybean yield (0.519 t/ha) produced in Northern Uganda compared to (0.321 t/ha) in Eastern Uganda. Generally, farmers in Northern Uganda seemed to possess more fertile land compared to the farmers of Eastern Uganda. But on the whole very few farmers applied either inorganic fertilizers or composite manure. The most commonly grown soybean genotypes in both regions were Maksoy 1N and Namsoy 4M. However, there was a significant difference in soybean varieties at 1% between the two regions. Namsoy 4M was mostly grown in Northern region whereas Maksoy 1N was mostly grown in the Eastern region. Farmers majorly obtained soybean seed from local markets and their major source of labor was family. In both regions, few farmers used oxen although more farmers in the Eastern region used oxen compared to those in the Northern region.

Farmers in both regions had limited access to extension and credit facilities. Production constraints such as pests and diseases, lack of labor, soil exhaustion, limited land and weed infestation were experienced by farmers more in Eastern than Northern Uganda and were significant at 1 % level. In both regions, farmers' experienced; low prices, lack of ready market and long distances to markets as the major marketing constraints. Other marketing constraints that include; low prices of soybean, poor storage facilities and lack information were faced more in Eastern region than in Northern Uganda and were significantly different. However, farmers in Northern Uganda faced challenges of poor roads and lack of ready market and these were significantly different.

Further, the study established farmers' preferences for soybean genotypes in both Northern and Eastern Uganda. The matrix ranking technique was used to establish the most highly ranked soybean genotype in both regions. In both regions, Maksoy 3N and Maksoy 1N were ranked highly compared to other genotypes. Regional ranking of soybean genotypes indicated that in Northern Uganda Maksoy 3N (5.0) was most preferred whereas in Eastern Uganda, it was Maksoy 1N (5.1). Consistent results were obtained using a logistic regression tool which established the likelihood for farmers' acceptance for soybean genotypes. Results indicated that Maksoy 3N and Maksoy 1N had positive intercepts and their chi-square values were significantly different (p<0.15) from zero implying that they had a strong likelihood of acceptance by farmers in both regions.

Profitability of soybean production technologies was determined using the partial budget approach. Here, gross margins and the marginal rates of return of soybean genotypes were determined for various fertilizer levels. Soybean genotypes in the two regions, gave higher MRR above 100% but at different fertilizer levels indicating different response rate to fertilizer application. All the soybean genotypes across soil fertility fields responded to rhizobia and phosphorus application. This is because in both regions, the total phosphorus and nitrogen levels in all the three field types were generally low below the critical values explaining the reason for soybean response to rhizobia and phosphorus application.

In good fields of Northern Uganda, highest MRR for Maksoy 1N, Maksoy 2N, MNG and Nam 1 were obtained by changing from application of phosphorus at a rate of 5 kgha^{-1} to application of rhizobia and phosphorus at a rate of 5 kgha^{-1} whereas for Maksoy 3N highest MRR was obtained by changing from application of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kgha^{-1}. In good fields of Eastern Uganda, highest MRR for Maksoy 1N, Maksoy 2N, Maksoy 3N and Nam 1 were obtained by changing from application of phosphorus at a rate of 5 kgha^{-1} to application of rhizobia and phosphorus at a rate of 5 kgha^{-1}. Highest MRR for MNG was obtained by changing from application of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kgha^{-1}. In both regions, highest MRR for Namsoy 4M were obtained by changing from control to application of rhizobia alone.

Generally in medium fields of Northern Uganda, highest MRR from most soybean genotypes were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kgha^{-1} except Maksoy 2N where highest MRR was obtained by changing from application of phosphorus at a rate of 10 kgha^{-1} to application of rhizobia and phosphorus at a rate of 10 kg ha^{-1}. In medium fields of Eastern Uganda for all the soybean genotypes, highest MRR were obtained by changing from application of phosphorus at a rate of 5 kg ha^{-1} to application of rhizobia and phosphorus at a rate of 5 kg ha^{-1}.

In poor fields of northern region, highest MRR for most soybean genotypes were obtained by changing from application of phosphorus at a rate of 10 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 10 $kgha^{-1}$ except Nam 1 and Namsoy 4M where highest MRR were obtained by changing from application of phosphorus at a rate of 5 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 5 $kgha^{-1}$. In poor fields of Eastern Uganda, highest MRR for most soybean genotypes were obtained by changing from application of phosphorus at a rate of 5 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 5 $kgha^{-1}$ except for Nam 1 and Namsoy 4M where highest MRR were obtained by changing from application of phosphorus at a rate of 10 $kgha^{-1}$ to application of rhizobia and phosphorus at a rate of 10 $kgha^{-1}$.

5.2 Conclusions

Based on the findings of this study, the following conclusions are drawn:
Soybean is a smallholder crop grown for cash and food in both northern and eastern Uganda. The production systems for soybeans in both regions are generally characterized by use of non certified seed obtained from local markets, use of family labor, use of hand hoe with no fertilizer application and low yield. Major constraints to soybean production are lack of improved seeds, drought, pests and diseases in both regions. But, lack of land, soil exhaustion, and weeds are also major soybean production constraints in eastern than northern Uganda. At the marketing level, lack of ready market for soybean and low output prices are problems in both regions.

The most preferred soybean genotypes across the two regions were Maksoy 1N and Maksoy 3N with Maksoy 1N most preferred in Eastern Uganda and Maksoy 3N most preferred in Northern Uganda. These genotypes were preferred by farmers because they were high yielding, early maturing, tolerant and resistant to pests and diseases, and adaptable to Agro-ecological climatic conditions in the two regions.

Soybean production was found to be profitable but profitability varies with different fertilizer levels, field types, genotypes and by region. Specifically, in Northern Uganda, Namsoy 4M was the most profitable genotype whereas Maksoy 3N was the most profitable genotype in Eastern Uganda. However, in specific field types of Northern Uganda, Maksoy 1N was the most profitable soybean genotype in good fields with the highest MRR compared to other genotypes whereas Maksoy 3N was most profitable in both medium and poor fields. In Eastern Uganda, Maksoy 1N was most profitable across all the field types. Generally, in both Northern and Eastern Uganda growing of soybean with application of rhizobia and phosphorus at a rate of 5kgha^{-1} and above but not exceeding 10 kgha^{-1} of phosphorus was most profitable across field types.

5.3 Recommendations

Based on the aforementioned conclusions, the following recommendations are made to different actors and stakeholder including policy makers, researchers and extension workers involved in the development and promotion of the soybean in Uganda.

In both Northern and Eastern Uganda farmers were found to be characterized of using non certified seeds obtained from local markets and limited use of fertilizers, this call for government and non-government initiatives to promote intensification through increased access to certified seed and fertilizer. These interventions may be achieved through promotion of market and input supply efficiency, input subsidies, increased access to information and strengthening the seed certification process.

Farmers were also found to be characterized of using family labor and hand hoe, this limits the scale of production thus leading to low output. This requires that the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) to revise and streamline the Agricultural extension system to effectively focus more to promoting the use of appropriate technologies which will help shift farmers from relying on family labor and hand hoe . In addition, this will also help farmers to access information on the availability and advantages of using improved seed and fertilizer. This may be through; recruiting and training more extension workers to increase farmers' access to information. The focus should be to enable soybean farmer's access the right and timely information concerning input usage as well as market information. This will enable soybean farmers make informed decisions during purchase of inputs and output marketing.

More so, a collaboration between government and private sector needs to be promoted to avail credit services to soybean farmers. Financial institutions in partnership with other stakeholders should extend affordable credit services to soybean farmers. Here, all government and non-government funded programs should encourage farmer groups to guarantee security for loan recovery. This will in addition encourage collective marketing which increase farmers' ability to bargain for better prices and in turn enable farmers to purchase improved inputs such as seed, fertilizers and afford technologies such as irrigation systems and labor saving technologies.

All development programs should always put into consideration farmers' preference for soybean genotypes. Breeding programs should emphasize characteristics which are liked by farmers in specific regions. For instance, attributes such as tolerance to soybean rust, multiple pods and many seeds, very early maturing and none-shattering should be emphasized in breeding programs.

In addition, implementers such as extension workers and other programs that supply inputs to farmers should give priority to varieties which are preferred by farmers. For instance, Maksoy 3N and Maksoy 1N were identified by farmers as preferred genotypes due to their superior characteristics as indicated by farmers in both regions. In situations where a farmer cannot access the best two genotypes; (that is Maksoy 3N and Maksoy 1N), the farmer could grow Maksoy 2N in good and medium fields of Northern Uganda and across all field types of Eastern Uganda. Namsoy 4M should be targeted only to farmers with good fields in Northern Uganda.

Soybean production was found to be profitable but profitability varied with different fertilizer levels, field types, and soybean genotypes and by region. It is therefore important to always establish the fertility status of a given field and apply appropriate levels of fertilizers to specific field types in a given region.

Since growing of soybean with application of rhizobia and phosphorus at a rate of 5 $kgha^{-1}$ and 10 $kgha^{-1}$ of phosphorus was profitable in both regions, this study therefore recommends that farmers should apply rhizobia and phosphorus fertilizers in soybean production but at levels not exceeding 10 kg ha^{-1}.

Despite the application of appropriate levels of fertilizers and use of improved seed, the yield in both regions was generally low compared to what is reported on station. The low yield obtained was considered to be as a result of poor management and agronomic practices such as late planting and weed infestation. This study therefore, recommends that promotion of mineral fertilizer use should go hand in hand with the implementation of measures to improve fertilizer use efficiency such as early planting of crops in the rainy season, regular weeding of the fields, pest and disease control.

5.4 Recommendations for further studies

Future evaluations need to be extended to examine consumer preferences for soybean genotypes in terms of protein, taste and palatability. This might require involvement of multi-stakeholders such as processors, traders and consumers. Another gap that has not been fully explored is soybean marketing linkages. Furthermore, research should be carried out to establish the factors that affect adoption of these soybean genotypes. Finally, this research recommends that studies should be done to understand how soybean as a legume could influence profitability of follower cereal crops (such as rice) in a rotation.

REFERENCES

Adebo, S. (2000). Training Manual on Participatory Rural Appraisal, pp.34. Downloadable at: http://www.fsnnetwork.org/sites/default/files/pra_guide.pdf

Agbola, F., Kelley, G., Bent, M. and Parthasarathy, R. (2002). Eliciting and Valuing Market Preferences with Traditional Food: The Case of Chickpea in India. International Food and Agribusiness Review 5:7-21.

Agwe, J.,Morris, M. and Fernandes, E. (2007). Agricultural and Rural Development. World Bank.

Ajambo, R., Bashaasha, B., Okori, P., Elepu, G., Adipala, E., Tusiime, G., et al. (2010). Producer and consumer preferences for maize and sorghum quality characteristics in Uganda. Paper presented at the Second RUFORUM Biennial Regional Conference on" Building capacity for food security in Africa", Entebbe, Uganda, 20-24 September 2010.

Alpizar, F., Carlsson, F. and Martinsson, P. (2003). Using Choice Experiments for Non-Market Valuation. Economic *Issues* 8(1): 83-109.

Asian Vegetable Research and Development Center. (1987). Soybean varietal Improvement. The World Vegetable Center. Shanhua, Taiwan.

Asrat, S. (2008). Economic Analysis of Farmers' Preferences for Crop Variety Traits Using a Choice Experiment Approach. Lessons for On-farm Conservation and Technology Adoption in Ethiopia. A Thesis submitted to the school of graduate studies of addisababa University in partial fulfillment of the requirements for the Degree of Master of Science in Economics.

Asrat, S., Yesuf, M., Carlsson, F., & Wale, E. (2010). Farmers' preferences for crop variety traits: Lessons for on-farm conservation and technology adoption. *Ecological Economics, 69*(12): 2394-2401.

Bashasha, B (1992). A report on Soybean research in Uganda. Downloadable at: http://pdf.usaid.gov/pdf.

Bayite-Kasule, S., Korugyendo, P. L., & Benson, T. (2011). 'Fertilizer use among smallholder farmers in Uganda: Increasing Agricultural Productivity and Enhancing Food Security in Africa.Paper presented at the conference: 13 November 2011; Africa Hall, UNECA, Addis Ababa, Ethiopia

Bekere and Hailemariam, A. (2012). Influences of Inoculation Methods and Phosphorus Levels On Nitrogen Fixation Attributes and Yield of Soybean (Glycine max L.) At Haru, Western Ethiopia. *American Journal of Plant Nutrition and Fertilisation Technology 2(2):*45-55.

Bereket, A. and Asafu-Adjaye, J. 1999. Returns to farm level soil conservation on tropical steep slope: The case of the Eritrea highlands. *Journal of Agricultural Economics* 50 (3): 589-605.

Boughton, D., Crawford, E., Krause, M. and Frahan, B. H. (1990). Economic Analysis of on-farm trials: A review of approachesand implications for research program design. Department of Agricultural Economics. Michigan State University. Staff Paper No. 90-78. pp3.

Bucheyeki,T. L., Shenkalwa, E. M., Mapunda, T. X., and Matata, L. W. (2008). On-farm evaluation of promising groundnut varieties for adaptation and adoption in Tanzania. *African Journal of Agricultural Research, 3*(8): 531-536.

Chambers R. (1992). Rural appraisal: Rapid, Relaxed and Participatory. Discussion Paper 311.

Castle, E. N., Berker, M. H. and Nelson, A. G.(1987). Farm Business Management. Third edition. Macmillan Publishing co., NewYork. USA

Chianu, J., Vanlauwe, B., Mukalama, J., Adesina, A., Sanginga, N. (2006). Farmer Evaluation Of Improved Soybean Varieties Being Screened in Five Locations in Kenya: Implications for Research and Development. African Journal of Agricultural Research Vol.1 (5):pp. 143-150, December 2006.

CIAT. (2006). Soybean: a new role in western Kenya.The Highlightsseries summarizes research results and policy implications from the work of CIAT and its partners in Africa. Downloadable at: ttp://ciat-library.ciat.cgiar.org/articulos_ciat/highlight35.pdf [accessed 5th Jan 2014]

CIMMYT. (1988). From Agronomic Data to Farmer Recommendations: An Economic Training Manual. Completely Revised Edition. CIMMYT, Mexico.

Clay, D. C., Guizl M., and Wallace, S. (1994). Population and Land Degradation. Department of Agricultural Economics and Sociology, Geography and Resource Development Michigan State University.

Coulibaly, O., Alene A. D., Manyong V., Sanogo D., Abdoulaye T., Chianu J., Fatokun C., Kamara, A., Tefera H., and Boukar, O. (2009). A report on the situation and outlook for Cowpea and Soybean in Sub-Saharan Africa. Downloadable at: http://www.icrisat.org/what-we-do/impi/projects/tl2-publications/regional-situation-outlook-reports/rso-cwp-sbean-sub-SaharaAfrica.pdf.

Crawford, E and Kamuanga, M. (1988). Economic Analysis of Agronomic Trials for the Formulation of Farmer Recommendations.

Dahnke, W.C. 1993. Soil test interpretation. Communications in Soil Science and Plant Analysis 24(1&2):11-27.

DSIP (2010). Development Strategy and Investment Plan. 2010/11-2014/15. Downloadable at: http://agriculture.go.ug/userfiles/Agricultural%20Sector%20Development%20Strategy%20and%20Investment%20Plan(2).pdf [accessed 12th Feb 2014]

Dalton. T. (2003): A Hedonic Model of Rice Traits; Economic Values from farmers in West Africa. Paper presented at the 25th International Conference of Agricultural Economists, Aug 16-22, 2003. www.maine.edu

Dillon, J. L. and Hardaker, J.B. (1993). Farm Management for Small Farmer Development. FAO, Rome, Italy. 302pp.

Doll, J and Orazem, F. (1984). Production Economics: Theory with Applications, 2nd Edition, John Wiley and Sons.

Eaglesham, A. R. J. (1989). Global importance of Rhizobium as an inoculant. In Microbial Inoculation of Crop Plants. Eds. R Cambell and R M MacDonald, pp. 29-48. Oxford University Press, Oxford.

Ebanyat, P., De Ridder, N., De Jager, A., Delve, R., Bekunda, M., &Giller, K. (2010). Impacts of heterogeneity in soil fertility on legume-finger millet productivity, farmers' targeting and economic benefits. *Nutrient Cycling in Agro ecosystems, 87*(2): 209-231.

Ekiyar, V.(2003). Economic Evaluation of Pest Management Technologies in Cowpea and Groundnut Growing in Eastern Uganda. A Thesis submitted for award of the degree of Master of Science in Agricultural Economics of Makerere University.

Estrada, J.M. (2004). Regional Overview of the Soybean Markets: Challenges and Opportunities for Smallholder Farmers in Southern Africa. ICRISAT, Patancheru 502 324, Andhra Pradesh, India, pp. 1-48.

FAO Statistical Database, crop data. Food and Agricultural Organization of the United Nations. Online database available at: http://faostat.fao.org/site/567 [accessed 12th Feb 2014] at 11:29 am.

Gelsdorf, K., Maxwell, D and Mazurana, D. (2012). Livelihoods, basic services and social protection in Northern Uganda and Karamoja. Working paper. August 2012.

Giller, K.E., Rowe, E., de Ridder, N., van Keulen, H., 2006. Resource use dynamics and interactions in the tropics: Scaling up in space and time. Agric. Syst. 88, 8-27.

Greenberg, P. and Hartung, H.N.(1998). The whole soy cookbook: 175 delicious, nutritious, easy to-prepare recipes featuring tofu, tempeh, and various forms of nature's healthiest bean. Three Rivers Press, New York.

Gowda BTS, Halaswamy BH, Seetharam A, Virk DS, Witcombe JR (2000). Participatory approach in varietal improvement: A case study in finger millet in India. Current Science. 79: 366-368.

Guimaraes, C.B., Yokoyama, L.P. (1998). Upland rice in rotation with soybean. In Technology for Upland Rice; Breseghello, F., Stone, L.F., Eds.; Embrapa Rice and Bean National Center: Santo Antonio de Goias, Brazil, 1998: 19-24.

Haile, W. and Boke, S. (2011). Response of Irish Potato (*Solanumtuberosum*) to the Application of Potassium at Acidic Soils of Chencha, Southern Ethiopia, Hawassa Agricultural Reseach Center, Ethiopia. International Journal of Agricuture and Biology. ISSN Print: 1560-8530; ISSN: Online 1814-9596. Available online at: http://www.fspublishers.org

Hernandez-Romero, L. A. (2000). Logistic preference ranking analysis for evaluating technology options. A User Manual, No 319. CIAT, Columbia IITA (1986). Annual report. Ibadan, Nigeria.

Herridge D F and Bergersen F J 1988 Symbiotic nitrogen fixation. In Advances in Nitrogen Cycling in Agricultural Ecosystems. Ed. J R Wilson, pp. 46-65. C.A.B. International, Wallingford, UK.

Hiep, N. H., Diep, C. N., &Herridge, D. F. (2002). Nitrogen fixation of soybean and groundnut in the Mekong Delta, Vietnam. *Inoculants and nitrogen fixation of legumes in Vietnam. ACIAR Proceedings*.

Hinga, G., Njihia, C.M. and Muchena, F.N. (1980). Physical and Chemical Methods of Soil Analysis. Ministry of Agriculture, National Agricultural Research Laboratories, Nairobi.

Hintze, H., Renkow, M., &Sain, G. (2002). *Variety characteristics, transactions costs, and maize adoption in Honduras.* Paper presented at the documentopresentado en la conferenciainternacionalsobre Impacts of agricultural research and development, San José.

Horna, J. D., Smale, M and Openn, V. M. (2007). Farmers' willingness to pay for seed related Information: Rice varieties in Nigeria and Benin. Journal of Environment and Development Economics 12:799-825.

Hyuha, T.S., Bashaasha, B., Nkonya, E and Kraybill, D. (2007). Analysis of Profit Inefficiency in Rice Production in Eastern and Northern Uganda. *African Crop Science Journal*, Vol. 15, No. 4, pp.243-253.

Idrisa, Y. L., Ogunbameru B.O and Amaza P. S. (2010). Influence of Farmers' Socio Economic and Technology Characteristics on Soybean Seeds Technology Adoption in Southern Borno State, Nigeria. *African Journal of Agricultural Research* Vol. 5(12), pp. 1394-1398.

IITA. (1986). Annual report. Ibadan, Nigeria.

Ikeogu, U. N. and Nwofia, G. E. (2013). Yield Parameters and Stability of Soybean [*Glycine max.* (L.) merril] as Influenced by Phosphorus Fertilizer Ratesin two Ultisols. Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.*Journal of Plant Breeding and Crop Science*. Vol. 5(4) pp.54-63.

International Food Policy Research Institute. (2013). Impact of Off-farm Income on Agricultural Technology Adoption Intensity and Productivity. Evidence from Rural Maize Farmers in Uganda.

Irambu, E.M., Ndegwa, A.M., Wepukhulu, S., Nguthi, F., Muriuki, A.W., Gatambia, E.K., Kamau, M. and Faraay, R. (2009). On-Farm Economic and Agronomic Evaluation of Nitrogen and Phosphorus Fertilizer use in Snowpeas in Kabaru, Kenya. African. *Journal. Horticultural. Science.* (2009) 2:152-159.

Kabuli. A., Phiri, M. A. R. and Khalil, E. A. (2005) . Economic Assessment of the Benefits of Soybeans Incorporation in Smallholder Maize-Based Farming Systems and the Factors Affecting its Adoption in Malawi. African Crop Science Conference Proceedings, Vol. 7 pp. 881-885.

Kaizzi, C. K., Byalebeka, J., Semalulua, O., Alou, I. N., Zimwanguyizza, W., Nansamba, A., Odama, Emmanuel., Musinguzi, P., Ebanyat, P., Hyuha, T., Kasharu, A. K., Wortmann, C. S. (2012). Optimizing Smallholder Returns to Fertilizer Use: Bean, Soybean and Groundnut. Field Crops Research 127(2012) 109-119.

Kakuhenzire, R., Hakiza, J. J., Lemaga, B., Adipala, E., Olanya, M., Wagoire, W. and Kashaija, I. (2005). Response of Four Selected Potato Cultivars to Fungicide and Fertilizer Application. African Crop Science Conference Proceedings, Vol. 6. 69-75.

Kasule, B.S. (2009). Inorganic Fertilizer in Uganda. Knowledge Gaps, Profitability, Subsidy and Implications of a National Policy. International Food Policy Research Institute. Kampala, Uganda.

Kawuki, R., Adipala, E. and Tukamuhabwa, P. (2003). Yield Loss Associated with Soybean Rust (*Phakopsorapachyrhizi*Syd.) in Uganda. *Journal of Phytopathology*151**:**7-12.

Keyser, H. H., & Li, F.(1992). Potential for increasing biological nitrogen fixation in soybean *Biological Nitrogen Fixation for Sustainable Agriculture* (pp. 119-135).

Kidoido, M. M. (2001). Analysis of Profitabilitility of Finger Millet Production in Eastern Uganda: Acase study of KumiPallisa and Kamuli District- A Thesis submitted to the School of Graduate Studies of Makerere University in Partial Fulfilment of the Requirements for the Degree of Master of Science in Agricultural Economics.

Kumwenda, J.D.T., Waddington S.R., Snapp, S.S., Jones, R.B., and Blackie, M.J. (1996). Soil Fertility Management Research for the Maize Cropping Systems of Smallholders in Southern Africa: A Review. NRG Paper 96-02. Mexico, D.F. CIMMYT.

Lancaster. K. (1966). A New Approach to Consumer Theory. *The Journal of Political Economy*, Vol. 74, No. 2, pp. 132-157.

Louviere, J.J., Hensher, D.A., Swait, J.D. and Adamowicz, W.L. (2000). Stated Choice Methods: Analysis and Applications. Cambridge University Press.

Majengo, C., Okalebo, J., Lesueur, D., Pypers, P., NG'ETICH, W., &Mutegi, E. (2011). Interaction between nitrogen and phosphorus microbial inoculants on soybean production in Bungoma, Kenya. Paper presented at the African Crop Science Conference Proceedings.

Makinde, E. A., Saka, J. O. and Makinde, J. O. (2007). Economic Viability of Fertility Management Options in Cassava Based Cropping Systems. *African Journal of Agricultural. Research* Vol. 2(1): 7-13

Malvic, K. (1998). Illinois Soybean Disease Management Program. Report on Plant Disease University of Illinois, College of Agricultural, Consumer and Environmental Sciences. Department of Crop Sciences. RPD No. 507.

Ministry of Agriculture Animal Industry and Fisheries. (1992). Namulonge Research Station Annual Report 1992.

Ministry of Agriculture Animal Industry and Fisheries. (2007). Vegetable Oil Development Project Impact Assessment Study Report.

Mishili, J. (2005). Cowpea markets and consumer preferences in Ghana. Msc Thesis, Purdue University, available online at: www.purdue.ac.

Mpuga, P. (2008). Constraints in Access to and Demand for Rural Credit: Evidence from Uganda. A paper for presentation during African Economic Conference. African Development Band, Tunis, Tunisia.

Mukhtar, A., Shahbaz, A., Ashraf, M and Gill, M. A. (2007). Partial Budgeting of Different Sowing Technologies Of Wheat.Sarhad J. Agric. Vol. 23, No. 4.

Mulat, D., Said, A. and Jayne, T.S. (1997). Promoting Fertiliser Use in Ethiopia: The Implications of Improving Grain Market Performance, Input Market Efficiency and Farm Management. Working Paper 5, Grain Makert Research Project. Adis Ababa, Ethiopia.

Nadu, K. (2005). Participatory Monitoring and Evaluation: Field Experiences. NGO Programme Karnataka-Tamil Nadu Series 1. Intercooperation Delegation, Hyderabad, India. 46 pp.

Ndjeunga, J., Ntare, B., Abdoulaye, A., Ibro, A., Zarafi, M., Cisse, Y., et al. (2010). Farmer preferences for groundnut traits and varieties in West Africa: Cases of Mali, Niger and Nigeria. Working Paper Series no. 27.

Ngalamu, T., Meseka, S and Ashraf, M (2012). Performance of Soybean (Glycine max L Merrill) Genotypes under Different Planting Dates in Sennar State of the Sudan. *Journal of Applied Biosciences* 49: 3363– 3370.

Nkongolo, K. K., Chinthu L., Malusi, M. and Vokhiwa, Z. (2008). Participatory Variety Selection and Characterization of Sorghum (*Sorghum bicolor* (L.) Moench) Elite Accessions from Malawian Gene Pool Using Farmer and Breeder Knowledge. African Journal of Agricultural Research Vol. 3 (4), pp. 273-283.

Nkwiine, C. and Rwakaikara-Silver, M.C. (2007). A review of studies on decomposer micro biota in Uganda. *AfricanJournal of Ecology*45 (2):36 - 44.

Nyende, P and Delve R. J. (2004). Farmer Participatory Evaluation of Legume Cover Crop and Biomass Transfer Technologies for Soil Fertility Improvement Using Farmer Criteria, Preference Ranking and Logit Regression Analysis. ExpAgric 40:77–88.

Ogbomo, K.E. andEmokaro, C.O. (2009). Economic Analysis of the Effect of Fertilizer Application on the Performance of White Guinea Yam in Different Ecological Zones of Edo State, Nigeria World Journal of Agricultural Sciences 5 (1): 121-125, 2009 ISSN 1817-3047

Ojiem, J.O., Ridder N. de.,Vanlauwe B and Giller, K.E. (2006). Socio-ecological niche: A conceptual framework for integration of legumes in smallholder farming systems. *International Journal of Agricultural Sustainability* 4:79-93.

Okalebo, J.R., Gathua, K. W. and Woomer, P.L. (2002). Laboratory methods of soil and plant analysis: Aworking manual. 2nd Edition. TSBFCIAT and SACRED Africa, Nairobi, Kenya

Okoboi, G. (2009). Economic Viability of Inorganic Fertiliser Use in Uganda's Agriculture pp16

Pender, J., Nkonya, E., Jagger, P., Sserunkuuma, D., &Ssali, H. (2004). Strategies to increase agricultural productivity and reduce land degradation: evidence from Uganda. *Agricultural* Economics, 31(2 ‐ 3), 181-195.

Salami, A., Abdul, B., Kamara and Brixiova, Zuzana. (2010). Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities, Working Papers Series No. 105 African Development Bank, Tunis, Tunisia.

Semalulu, O., Kasenge, V., Makhosi, P., Gita, R. and Gumisiriza, C. (2012). Productivity and Profitability of Groundnuts with Phosphorus Fertiliser in Mbale district, Uganda. National Agricultural Research Laboratories and Makerere University.

Shiluli M. C., Macharia, C.N. and Kamau, A. W. (2000). Economic Analysis of Maize Yield Response to Nitrogen and Phosphorus in the Sub-Humid Zones of Western Kenya. *African Crop Science Journal*, Vol. 11. No. 3, pp. 181-187, 2003.

Shurtleff, W and Aoyagi, A. (2009). History of Soybeans and Soyfoods in Africa. Soyfoods Center. Lafayate, California, pp.731. Downloadable at: http://www.soyinfocenter.com/pdf/134/Afri.pdf.

SinafikehAsrat, Mahmud Yesuf, Fredrik Carlsson, Edilegnaw Wale (2009) Farmers' Preferences for Crop Variety Traits: Lessons for On-FarmConservation and Technology Adoption

Singleton, G. P W and Bohlool, B. B. (1988).Yield soil nitrogen uptake and nitrogen fixation by soybeans from four maturity groups grown at three elevations. *Agronomy. Journal*. 80, 563-567.

SNV. (2011). Increased Competitiveness of the Oilseed Value Chain Through Improved Information on the Markets for Soybean in Uganda. Downloadable at: http://api.ning.com/files/Z5VV7E.

Soybean Africa: http://www.soybeanafrica.com[Accessed 17 August 2014]

Taylor-Powell, Steele, E., Douglah, S., & Mohammad. (1996). Planning a program evaluation. *Madison, WI: University of Wisconsin Cooperative Extension, 27:4*.

The International Center for Tropical Agriculture **(**2006). Soybean: a new role in western Kenya. The Highlights series summarizes research results and policy implications from the work of CIAT and its partners in Africa. No.36.

Theis, J and Grady, H. M. (1991). Participatory Rapid Appraisal for Community Development. A Training Manual Based on Experiences in the Middle East and North Africa.

Tittonell, P., Vanlauwe B., Leffelaar P. A., Rowe E., Giller, K. E. (2005). Exploring diversity in soil fertility management of smallholder farms in western Kenya. I. Heterogeneity at region and farm scale. *Agriculture Ecosystems &Environment* 110:149–165.

Tittonell, P., Vanlauwe B., Ridder N., de Giller, K. E. (2007). Heterogeneity of crop productivity and resource use efficiency within smallholder Kenyan farms: soil fertility gradients or management intensity gradients. *Agricultural Systems* 94:376–390.

Tukamuhabwa, P., Ssali, W., Matovu, M., Bwayo. (2006). Evaluation of Soybean Genotypes and Promotion of Soybean Processing and Utilisation at Rural Households. Mid term report, February, 2006.

Tukamuhabwa. (2010).Soybean poor man's meat, Crop of the future.18th Oct-2010 new vision article.

Tukamuhabwa,P.(2011).Grow new soybean varieties for better yields. Downloadable at: *http ://www.soybeanafrica.com*/Commercial-soybean-varieties-Uganda [Accessed 24th Feb 2014]

UBOS. (2007). Uganda Bureau of Statistics, Statistical Abstract. Downloadable at: *http://www .ubos.org/onlinefiles*[Accessed11 Jan 2014]

UBOS. (2009). Uganda Bureau of Statistics, Statistical Abstract. Downloadable at: *http://www .ubos.org/onlinefiles*[Accessed 11 Jan 2014]

UBOS. (2010). Uganda National Household Survey 2009/2010. Socio-Economic Module. *Abridged Report.* Kampala, Uganda: UBoS.[Accessed 12 Jan 2014]

UBOS. (2011). Uganda Bureau of Statistics, Statistical Abstract: Downloadable at: *http://ww w.ubos.org/onlinefiles*[Accessed 12 Jan 2014]

UBOS. (2012). Uganda Bureau of Statistics, Statistical Abstract:Downloadable at: *http://www .ubos.org/onlinefiles*[Accessed 12 Jan 2014].

UBOS. (2013). Uganda Bureau of Statistics, Statistical Abstract: Downloadable at: *http://www .ubos.org/onlinefiles*[Accessed8 April 2014]

Vanlauwe B., Tittonell P and Mukalama, J. (2006). Within-farm soil fertility gradients affect response of maize to fertilizer application in western Kenya. *Nutrition Cycle Agro ecosystems*. 171–182.

Vanlauwe, B and Giller K.E. (2006). Popular myths around soil fertility management in sub-Saharan Africa. *Agriculture, Ecosystems and Environment*116:34-46.

VEDCO. (2011). Stakeholders report for the Soybean Value Chain Meeting.

Valerie, A. K. (2006). Factors affecting Demand for Fertilizers in Sub-Saharan Africa. Agriculture and Rural Development. Discussion Paper 23.

Vlek, P.L.G. (1993). Strategies for Sustaining Agriculture in Sub-Saharan Africa. Rogland, J., Lal, R. (Eds.). Technologies for Sustaining Agriculture in the Tropics. ASA, CSSA, and SSSA,Madison, WI, pp. 265-277, ASA Spec. Publ. 56.

Vlek, P. L. (1990). The role of fertilizers in sustaining agriculture in sub-Saharan Africa. Fertilizer Research, 26(1-3)

Vorgelegt, C.B. (2001). Costs and Benefits of Adopting Runoff Irrigation Systems. A case Study from Kakuma, Northern Kenya.

Wagoire, W.W. (2006). Quantification of the Value of Improved Wheat Production Options in South-Western Uganda. *Uganda Journal of Agricultural Sciences*, Vol. 12 No.1.

Wortmann, C. S and Kaizzi, C. K. (1998). Nutrient Balances and Expected Effects of Alternative Practices in Farming Systems of Uganda. *Agriculture, Ecosystems and Environment*, 71**,** 115- 129.

Yanggen, D., Valerie, K.,Reardon, T. and Naseem, A. (1998). Incentives for Fertiliser Use in Sub-saharan Africa: A Review of Empirical Evidence on Fetiliser Response and Profitability.MSU International Development Working Paper No.70.

Yusuf, A.A., Iwuafor, E.N.O., Abaidoo, R., Olufajo, O.O and Sanginga, N., (2009). Grain legume rotation benefits to maize in the Northern Guinea Savanna of Nigeria: fixed nitrogen versus other rotation effects. *Nutrition Cycle Agroecosyst*. 84, 129–139.

APPENDICES

Appendix I: Distribution of acceptance frequencies for soybean genotypes

Table 1 A) Distribution of acceptance frequencies in good fields of Northern region							
Ranking order							
Genotypes	R1	R2	R3	R4	R5	R6	TOTAL
Nam1	0	1	0	13	45	61	120
Maksoy 1N	10	74	30	6	0	0	120
Namsoy 4M	0	42	37	37	4	0	120
Maksoy 2N	0	9	65	43	3	0	120
Maksoy 3N	108	11	1	0	0	0	120
MNG 2:14	6	3	5	24	65	17	120
B) Distribution of acceptance frequencies in Medium fields of Northern region							
Nam1	0	4	6	24	60	26	120
Maksoy 1N	14	82	15	8	1	0	120
Namsoy 4M	0	8	44	61	4	3	120
Maksoy 2N	2	24	71	18	5	0	120
Maksoy 3N	100	14	5	1	0	0	120
MNG 2:14	8	2	5	13	45	47	120
C) Distribution of acceptance frequencies in Poor fields of Eastern region							
Nam1	0	2	11	16	61	30	110
Maksoy 1N	41	71	6	2	0	0	120
Namsoy 4M	0	4	27	72	16	1	120
Maksoy 2N	0	15	77	23	4	1	120
Maksoy 3N	76	34	10	0	0	0	120
MNG	8	0	4	13	38	57	120

Table 2 (A)Distribution of acceptance frequencies in good fields of Eastern region							
Nam1	0	0	8	11	53	48	120
Maksoy 1N	111	9	0	0	0	0	120
Namsoy 4M	0	0	6	92	17	5	120
Maksoy 2N	1	13	95	11	0	0	120
Maksoy 3N	6	102	11	1	0	0	120
MNG 2:14	4	2	5	7	59	43	120
B) Distribution of acceptance frequencies in Medium fields of Eastern region							
Nam1	0	0	2	10	37	71	120
Maksoy 1N	101	17	2	0	0	0	120
Namsoy 4M	0	0	14	87	18	1	120
Maksoy 2N	6	20	87	7	0	0	120
Maksoy 3N	15	91	12	2	0	0	120
MNG 2:14	6	0	6	17	72	19	120
C) Distribution of acceptance frequencies in Poor fields of Eastern region							
Nam1	R1	R2	R3	R4	R5	R6	TOTAL
Maksoy 1N	0	0	8	28	47	37	120
Namsoy 4M	92	25	3	0	0	0	120
Maksoy 2N	0	0	10	63	32	15	120
Maksoy 3N	18	23	70	8	1	0	120
MNG 2:14	18	80	19	3	0	0	120

Table 3 (A) Distribution of probabilities of acceptance of soybean genotypes across fields in the Northern Region							
Nam1	0	2	6	18	55	39	120
Maksoy 1N	22	76	17	5	0	0	120
Namsoy 4M	0	18	36	57	8	1	120
Maksoy 2N	1	16	71	28	4	0	120
Maksoy 3N	95	20	5	0	0	0	120
MNG	7	2	5	17	49	40	120
B) . Distribution of probabilities of acceptance of soybean genotypes across fields in the Eastern region							
Nam1	0	0	6	16	46	52	120
Maksoy 1N	101	17	2	0	0	0	120
Namsoy 4M	0	0	10	81	22	7	120
Maksoy 2N	8	19	84	9	0	0	120
Maksoy 3N	13	91	14	2	0	0	120
MNG	5	1	7	18	58	31	120

Appendix II: Partial budget for soybean production technologies in across fields of Northern Uganda, 2012

					Maksoy 1N									Maksoy 2N			
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	634	549	844	1134	781	889	733	818	706	750	798	978	881	1162	838	751
GVP(1000*Y)	633809	548862	844319	1134399	781084	888646	733287	817940	705656	750359	797942	978051	881399	1161894	837548	751373
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-211191	-302388	-68281	215549	-199116	-97804	-382113	-303710	-189344	-152141	-164658	7951	-148801	124194	-327852	-421527
					Maksoy 3N								MNG			
Yield	575	580	736	865	769	1135	771	832	546	480	640	857	726	1142	601	905
GVP(1000*Y)	574896	579966	735645	864700	769066	1135312	770802	831852	545983	479512	639727	857333	726167	1142023	600698	904778
TVC	895000	902500	962600	970100	1030200	1037700	1165400	1172900	895000	902500	962600	970100	1030200	1037700	1165400	1172900
GM	-320104	-322534	-226955	-105400	-261134	97612	-394598	-341048	-349017	-422988	-322873	-112767	-304033	104323	-564702	-268122
					Nam 1								Namsoy 4M			
Yield	521	747	668	904	802	1052	750	805	479	578	847	885	988	1206	830	894
GVP(1000*Y)	520767	747024	667873	904091	802249	1052120	749630	805321	479112	578452	847167	884658	987617	1205838	829868	894003
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-324233	-104226	-244727	-14759	-177951	65670	-365770	-316329	-415888	-324048	-115433	-85442	-42583	168137	-335532	-278897

a- Average price of soybean price in Northern Uganda at the time of the study was Ug shs1000 per kg.

b- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

c- TVC is the Total Value product

Appendix III: Partial budget for soybean production technologies in across fields of Eastern Uganda, 2012

					Maksoy 1N								Maksoy 2N			
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1119	1145	1337	1421	1069	1538	1384	1384	1041	1062	1187	1291	1197	1501	1271	1164
GVP(900*Y)	1007187	1030111	1203599	1278947	961796	1384205	1245741	1245322	937192	955899	1068345	1161781	1077320	1350817	1144221	1047669
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	47187	63861	175999	245097	-133404	282755	15341	8672	-72808	-61601	-9255	76681	-67880	198117	-136179	-240231
					Maksoy 3M								MNG			
Yield	1229	1214	1346	1551	1452	1493	1289	1256	1118	1170	1144	1306	1218	1632	1227	1241
GVP(900*Y)	1105948	1092661	1211697	1395620	1306383	1343885	1159983	1130065	1006265	1053305	1029720	1174952	1096341	1468805	1104391	1116832
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	95948	75161	134097	310520	161183	191185	-120417	-157835	-3735	35805	-47880	89852	-48859	316105	-176009	-171068
					Nam1								Namsoy 4M			
Yield	1193	1255	1301	1359	1307	1320	1324	1369	1080	1185	1076	1400	1481	1591	1272	1354
GVP(900*Y)	1073937	1129877	1170883	1223514	1176449	1187625	1191595	1232252	971970	1066109	968821	1260150	1333346	1431495	1144504	1218978
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	113937	163627	143283	189664	81249	86175	-38805	-4398	-38030	48609	-108779	175050	188146	278795	-135896	-68922

a- Average price of soybean price in Eastern Uganda at the time of the study was Ug shs 900 per kg.

b- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

c- TVC is the Total Value product

Appendix IV: Partial budget for soybean production technologies in Good fields of Northern Uganda, 2012

	Maksoy 1N								Maksoy 2N							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	876	664	1166	1582	882	934	900	1031	900	921	1129	1196	745	938	979	897
GVP(1000*Y)	875605	663887	1166153	1582313	882323	934172	900182	1030521	900346	921000	1129000	1196073	745074	937735	979500	896506
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	30605	-187363	253553	663463	-97877	-52278	-215218	-91129	**5346**	**18500**	**166400**	**225973**	**-285126**	**-99965**	**-185900**	**-276394**
	Maksoy 3N								**MNG**							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	709	657	946	940.1	695	1213	671	972	639	626	721.2	1143	952.5	1487	826.1	1354
GVP(1000*Y)	708687	656910	946368	940100	695199	1213239	671405	972022	638796	626240	721200	1143000	952500	1487108	826100	1354000
TVC	895000	902500	962600	970100	1030200	1037700	1165400	1172900	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-186313	-245590	-16232	-30000	-335001	175539	-493995	-200878	**-256204**	**-276260**	**-241400**	**172900**	**-77700**	**449408**	**-339300**	**181100**
	Nam 1								**Namsoy 4M**							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	681	701	735	964	741	946	698	792	563	787	1040	1093	1035	1336.2	898	1085
GVP(1000*Y)	681000	701000	735207	964000	741392	946000	698097	791963	563179	787046	1040080	1092724	1035397	1336200	897946	1084940
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-164000	-150250	-177393	45150	-238808	-40450	-417303	-329687	-331821	-115454	77480	122624	5197	298500	-267454	-87960

d- Average price of soybean price in Northern Uganda at the time of the study was Ug shs1000 per kg.

e- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

f- TVC is the Total Value product

Appendix V: Partial budget for soybean production technologies in Medium fields of Northern Uganda, 2012

	Maksoy 1N								**Maksoy 2N**							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	458	458	663	678	561	744	565	646	551	580	798	774	779	1319	811	716
Gross value of production(900)	458462	458172	662874	678000	561344	744000	565478	646206	551179	580432	797534	773765	779000	1319000	810964	716389
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross margin	-386538	-393078	-249726	-240850	-418856	-242450	-549922	-475444	-343821	-322068	-165066	-196335	-251200	281300	-354436	-456511

	Maksoy 3N								MNG							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	473	527	610	747	677	899	659	735	538	445	693	788	640	757	537	788
Gross value of production(900)	473000	527000	610000	747000	677000	899000	659000	734943	538335	445295	692981	788000	640000	756960	536993	788334
TVC	895000	902500	962600	970100	1030200	1037700	1165400	1172900	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross margin	-422000	-375500	-352600	-223100	-353200	-138700	-506400	-437957	-356665	-457205	-269619	-182100	-390200	-280740	-628407	-384566

	Nam1								Namsoy 4M							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	425	424	379	791	604	1053	826	624	373	427	510	627	577	922	559	723
Gross value of production(900)	425230	424000	379374	790826	603934	1053359	825792	624000	373001	427000	509896	627142	577000	922000	559239	723022
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross margin	-419770	-427250	-533226	-128024	-376266	66909	-289608	-497650	-521999	-475500	-452704	-342958	-453200	-115700	-606161	-449878

a- Average price of soybean price in Northern Uganda at the time of the study was Ug shs1000 per kg.

b- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

c- TVC is the Total Value product

Appendix VI: Partial budget for soybean production technologies in Poor fields of Northern Uganda, 2012

Variety				Maksoy 1N						Maksoy 2N						
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	299	343	497	725	752	904	542	417	665	709	690	954	1120	1229	722	641
Gross value of production(900)	299000	343000	497000	725000	752000	904000	542000	417000	665442	709238	690106	954316	1120122	1228947	722179	641222
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-546000	-508250	-415600	-193850	-228200	-82450	-573400	-704650	-229558	-193262	-272494	-15784	89922	191247	-443221	-531678
		3N		Maksoy									MNG			
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	543	556	651	907	935	1294	982	789	461	367	505	641	586	1182	439	572
Gross value of production(900)	543000	555988	650568	907000	935000	1293697	982000	788591	460818	367000	505000	641000	586000	1182000	439000	572000
TVC	895000	902500	962600	970100	1030200	1037700	1165400	1172900	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-352000	-346512	-312032	-63100	-95200	255997	-183400	-384309	-434182	-535500	-457600	-329100	-444200	144300	-726400	-600900
				Nam1								Namsoy 4M				
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	521	531	689	957	1061	1157	725	1000	501	521	932	994	1250	1359	1032	874
Gross value of production(900)	521000	531381	689039	957445	1061422	1157000	725000	1000000	501157	521311	931524	994107	1250456	1359313	1032418	874046
TVC	845000	851250	912600	918850	980200	986450	1115400	1121650	895000	902500	962600	970100	1030200	1037700	1165400	1172900
Gross Margin	-324000	-319869	-223561	38595	81222	170550	-390400	-121650	-393843	-381189	-31076	24007	220256	321612	-132982	-298854

a- Average price of soybean price in Northern Uganda at the time of the study was Ug shs1000 per kg.

b- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

c- TVC is the Total Value product

Appendix VII: Partial budget for soybean production technologies in Good fields of Eastern Uganda, 2012

				Maksoy 1N					Maksoy 2N							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1160	1192	1411	1519	1326	1712	1405	1668	1054	1055	1150	1245	1022	1104	1251	1081
GVP(900*Y)	1044089	1072429	1269536	1367072	1193366	1540961	1264228	1501008	948600	949645	1035000	1120668	919800	993600	1125900	972900
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross margin	84089	106179	241936	333222	98166	439511	33828	264358	-61400	-67855	-42600	35568	-225400	-159100	-154500	-315000
			Maksoy 3M										MNG			
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1107	1092	1191	1250	1265	1299	1129	1180	809	840	879	942	1202	1321	870	1027
GVP(900*Y)	995956	982898	1071919	1125204	1138782	1169141	1016238	1062224	727699	756409	791394	847824	1082236	1188568	783072	924322
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross margin	-14044	-34602	-5681	40104	-6418	16441	-264162	-225676	-282301	-261091	-286206	-237276	-62964	35868	-497328	-363578
			Nam1						Namsoy 4M							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1025	1000.0	1206	1271	1293	1001	1044	1171	901	980	872	1415	1405	1244	1314	1269
GVP(900*Y)	922532	900000	1085206	1143458	1163588	900814	939540	1054270	810900	882176	784864	1273233	1264337	1119536	1182248	1142254
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross margin	-37468	-66250	57606	109608	68388	-200636	-290860	-182380	-199100	-135324	-292736	188133	119137	-33164	-98152	-145646

d- Average price of soybean price in Eastern Uganda at the time of the study was Ug shs 900 per kg.

e- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

f- TVC is the Total Value product

Appendix VIII: Partial budget for soybean production technologies in Medium fields of Eastern Uganda, 2012

Maksoy 1N

Treatment	0	R	5	R+5	10	R+10	20	R+20
Yield	1098	1135	1309	1413	872	1315	1301	1159
GVP(900*Y)	987860	1021104	1178229	1271437	784800	1183354	1170487	1043550
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650
Gross Margin	27860	54854	150629	237587	-310400	81904	-59913	-193100

Maksoy 2N

Treatment	0	R	5	R+5	10	R+10	20	R+20
Yield	1191	1232	1299	1400	1360	1564	1369	1141
GVP(900*Y)	1071875	1108950	1169234	1260376	1224059	1407351	1232162	1027108
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	61875	91450	91634	175276	78859	254651	-48238	-260792

Maksoy 3M

Treatment	0	R	5	R+5	10	R+10	20	R+20
Yield	1502	1502	1563	1752	1420	1350	1484	1538
GVP(900*Y)	1352050	1351800	1406412	1576654	1278268	1214614	1335588	1384145
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	342050	334300	328812	491554	133068	61914	55188	96245

MNG

Treatment	0	R	5	R+5	10	R+10	20	R+20
Yield	1324	1349	1259	1608	1399	1781	1396	1310
GVP(900*Y)	1191972	1214100	1132923	1447633	1258789	1603005	1256038	1178775
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	181972	196600	55323	362533	113589	450305	-24362	-109125

Nam1

Treatment	0	R	5	R+5	10	R+10	20	R+20
Yield	1275	1285	1367	1581	1338	1300	1346	1326
GVP(900*Y)	1147493	1156507	1230598	1422733	1204645	1170330	1211848	1193412
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650
Gross Margin	187493	190257	202998	388883	109445	68880	-18552	-43238

Namsoy 4M

Treatment	0	R	5	R+5	10	R+10	20	R+20
Yield	1318	1343	1273	1591	1477	1759	1477	1551
GVP(900*Y)	1186200	1208704	1146067	1432070	1329392	1583248	1329300	1395819
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross Margin	176200	191204	68467	346970	184192	430548	48900	107919

a- Average price of soybean price in Eastern Uganda at the time of the study was Ug shs 900 per kg.

b- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

c- TVC is the Total Value product

Appendix IX: Partial budget for soybean production technologies in Poor fields of Eastern Uganda, 2012

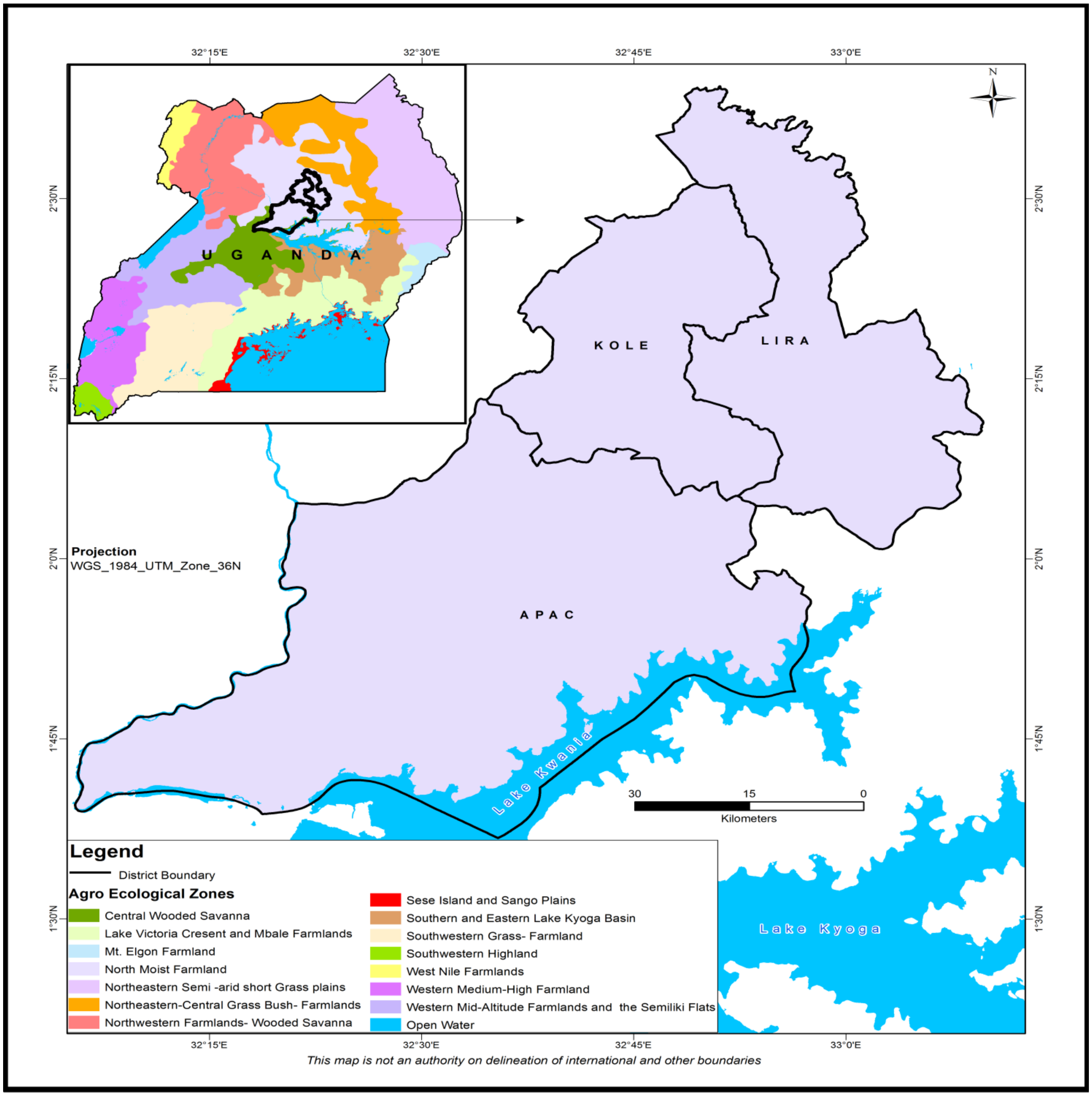
Variety	Maksoy 1N								Maksoy 2N							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1100	1108	1200	1287	1008	1587	1447	1324	879	899	1112	1227	1209	1835	1194	1270
GVP(900*Y)	989612	996801	1080232	1158300	907221	1428300	1302508	1191408	791100	809100	1000800	1104300	1088100	1651500	1074600	1143000
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross margin	29612	30551	52632	124450	-187979	326850	72108	-45242	-218900	-208400	-76800	19200	-57100	498800	-205800	-144900
Variety	Maksoy 3M								MNG							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1078	1048	1285	1650	1669	1831	1253	1049	1221	1202	1294	1366	1053	1794	1416	1386
GVP(900*Y)	969836	943287	1156759	1485000	1502100	1647900	1128125	943827	1099124	1081406	1164843	1229400	947999	1614843	1274062	1247400
TVC	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross margin	-40164	-74213	79159	399900	356900	495200	-152275	-344073	89124	63906	87243	144300	-197201	462143	-6338	-40500
Variety	Nam1								Namsoy 4M							
Treatment	0	R	5	R+5	10	R+10	20	R+20	0	R	5	R+5	10	R+10	20	R+20
Yield	1280	1281	1330	1227	1290	1657	1582	1610	1061	1092	908	1195	1222	1319	1024	1048
GVP(900*Y)	1151785	1153124	1196844	1104349	1161114	1491730	1423396	1449075	954810	983249	817500	1075318	1099500	1186848	921964	943280
TVC	960000	966250	1027600	1033850	1095200	1101450	1230400	1236650	1010000	1017500	1077600	1085100	1145200	1152700	1280400	1287900
Gross margin	191785	186874	169244	70499	65914	390280	192996	212425	-55190	-34251	-260100	-9782	-45700	34148	-358436	-344620

a- Average price of soybean price in Eastern Uganda at the time of the study was Ug shs 900 per kg.

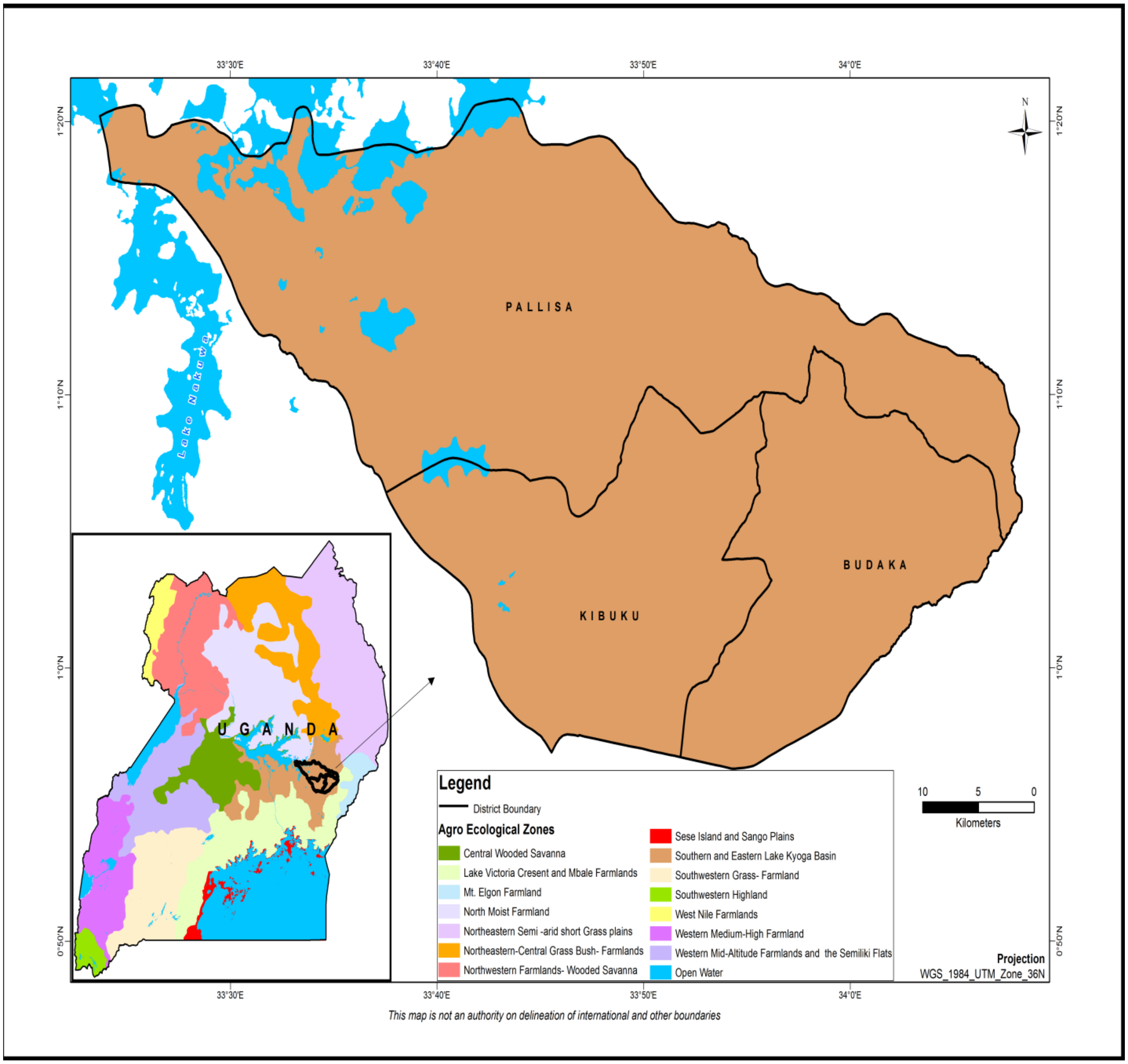
b- GVP is the gross value product or total revenue obtained by multiplying yield with the price, Y is the yield per hectare

c- TVC is the Total Value product

Apendix X: Map of Northern region indicating Apac, Kole and Lira Districts



Apendix XI:Map of Eastern region indicating Pallisa, Kibuku and Budaka Districts



Appendix XII QUESTIONNAIRE

QUESTIONNAIRE ON ECONOMIC EVALUATION OF SOYBEAN GENOTYPES UNDER SOIL FERTILITY VARIABILITY IN NORTHERN AND EASTERN UGANDA

District…………………………….. County……………………………………………..

Sub-county………………………… Parish……………………. Village…………………

(A) Background Information about Farmers

1. Respondent's Names……………….……..
2. Gender: (i) Male (ii) Female
3. Age: …………………..years
4. Highest education level: (i) None (ii) Primary (iii) Secondary (iv) Tertiary
5. Total household size:…………………. members
6. Main occupation: (i) Farming (ii) Non farming (specify)………………
7. Do you participate in any non-farming activity to earn a leaving (i) Yes (ii) NO
8. Membership in a farmers organization/Association (i) Yes (ii) No
9. Annual total household farm income:……………………..Ush
10. Annual total household off farm income: …………………Ush
11. How much land do you have in total?……………………..acres
12. How do you rate the fertility of the soils on your farm as compared to other farms you have visited?
    (i) Poor (ii) Medium (iii) Good

(B) Soybean Production and Marketing

13. Do you grow soybean? (i)YES (ii)NO
14. What is the average soy bean harvest do you get from your field?........Kg

15. If No, why don't you grow soybean? Give reasons why you don't grow soybean.

(i)………………………………………………………………………………………

(ii)……………………………………………………………………………………...

(iii)……………………………………………………………………………………..

(iv)……………………………………………………………………………………..

(v) ……………………………………………………………………………………..

16. Which crops do you grow?

(i)……………………………………………………………………………………..

(ii)…………………………………………………………………………….....

(iii)……………………………………………………………………………………

(iv)……………………………………………………………………………………

17. If yes, what is your main purpose of producing soybean?

(i) Food (ii) Cash (iii) Both

18. How much land is under soybean?....................... acres.

19. What soybean varieties have you planted?

(i)……………………………………………………………………………

(ii)………………………………………………………………………….

(iii)…………………………………………………………………………

(iv)………………………………………………………………………….

20. What are the good qualities/characteristics of these soybean varieties?

(i)……………………………………………………………………………

(ii)……………………………………………………………………………

(iii)…………………………………………………………………………...

(iv)……………………………………………………………………………

(v)…………………………………………………………………………….

(vi)……………………………………………………………………………

(vii)…………………………………………………………………………..

21. Where did you get the soybean seed from?

(i) Previous harvest/recycled seed
(ii) Local market

(iii) Seed company (specify) …………………………………………
(iv) Other source (specify)……………………………………………

22. If recycled seed, how old is the seed? ………………….. years

23. Do you use any inorganic fertilizer in soybean production?

(i) Yes (ii) No

24. If yes, what is the application rate?......................... Kg/acre.

25. Do you use compost or farm yard manure in soybean production?

(i) Yes (ii) No

26. If yes, what is the application rate?......................... Kg/acre.

(i) Yes (ii) No

27. Which tillage practices are you using in soybean production?

28. Do you use oxen to open up your land?

(i) YES (ii) No

29. Do you practice crop rotationin soybean production?

(i) Yes (ii) No

30. What is the major source of labor you use in soybean production?

(i) Family labor (ii) Hired Labor

31. Have you ever got credit from any financial institution to produce soybean?

(i) Yes (ii) No

32. Do you get any extension services related to the production of soybean?

(i) Yes (ii) No

33. If yes, who provides the extension services?

(i) NAADS (iii) Other (specify)………..
(ii) Agricultural extension agents

34. Which soybean market outlets do you use?

(i) Farm gate (ii) Local market (iii) Town market

35. What is the distance to the Market?............Km

36. List all the problems/constraints that normally affect you in soybean production.

(i)………………………………………………………………………………………

(ii)………………………………………………………………………………………

(iii)……………………………………………………………………………………..

(iv)………………………………………………………………………………………

(v)………………………………………………………………………………………

37. Which problems/ Constraints do you face in the marketing of Soybean?

(i)…………………………………………………………………………………..

(ii)……………………………………………………………………………………..

(iii)……………………………………………………………………………………

(iv)…………………………………………………………………………………….

(C) Farmer's preferences for soybean varieties.

38. Give the good qualities/characteristics/attributes that should be used to evaluate these soybean varieties.

(ii)…………………………………………………………………………………

(iii)………………………………………………………………………………...

(iv)…………………………………………………………………………………

39. Farmer Evaluation for soybean variety preferences.

(i) Field type: **Good field** Date of planting………..Date of evaluation…

	Height	Growth Vigor	Biomass Production	Adaptation to field fertility level	Number of pods per plant	Number of seed Per plant	GrainYield	Time to maturity	Drought Tolerance	Pest & disease tolerance	Disease Tolerance	Hairlines s
NAM 1												
MAKSOY 1N												
NAMSOY 4M												
MAKSOY 2N												
MAKSOY 3N												
MNG												

Scoring Scale of 1 up-to 6 (1 being the lowest score and 6 the highest score)

Give reasons for variety preferences

……
……
……

(ii) Field type; **Medium field**. Date of planting…………Date of evaluation

	Height	Growth Vigor	Biomass Production	Adaptation to field fertility level	Number of pods per plant	Number of seed Per plant	GrainYield	Time to maturity	Drought Tolerance	Pest & disease tolerance	Disease Tolerance	Hairliness
NAM 1												
MAKSOY 1N												
NAMSOY 4M												
MAKSOY 2N												
MAKSOY 3N												
MNG												

Scoring Scale of 1 up-to 6 (1 being the lowest score and 6 the highest score).

Give reasons for variety preferences

……
……
……
……

(iii) Field type; **Poor field**. Date of planting…………Date of evaluation

	Height	Growth Vigor	Biomass Production	Adaptation to field fertility level	Number of pods per plant	Number of seed Per plant	GrainYield	Time to maturity	Drought Tolerance	Pest & disease tolerance	Disease Tolerance	Hairlines s
NAM 1												
MAKSOY 1N												
NAMSOY 4M												
MAKSOY 2N												
MAKSOY 3N												
MNG												

Give reasons for variety preferences

……
……
……
……
……
……
……
……

(C) Data Sheet used to collect on-farm experimental data

Name ……………………………,AEZ…………………………..Season………………………
District………………………Village……………………………Plot Nob………………….

(i) Information about Soybean Production

Yield (Y1=Yield sold, Y2=Yield eaten, Y3=Yield given away), Activity (1=Land preparation,2=Planting,3=weeding,4=Harvesting)

Variety	Production technology	Yield (Y1-Y3) (Kg)	Activity (1-4)	Total Oxen (days)	Cost oxen per Unit(Ushs)	Total Oxen cost (Ushs)	Human labour working on the activities			Total cost of labour (Ushs)	Total operational costs (Ushs)
							Days worked per activity	Number of workers per day per activity	Cost of labour per activity per day(Ushs)		

(ii) Information about Soybean Marketing

Variety	Production technology	Quantity of seed Planted (Kg)	Cost of seed used (Ushs)	Quantity of fertilizers (Kg)	Cost of fertilizer (Ushs)	Total Input cost(Ushs)	Price of Soybean			
							Lowest Price (Ushs)	Highest Price (Ushs)	Current Price (Ushs)	Average Price (Ushs)

Thank you for your participation.