AN ANALYSIS OF FACTORS INFLUENCING ADOPTION OF THE RECOMMENDED MAIZE TECHNOLOGY'S PACKAGE IN MAKUYU DIVISION, MURANG'A SOUTH DISTRICT, KENYA

BY

MBUGUA FELISTUS

REG. NO. C50/CE/10215/04

A Thesis submitted to the School of Humanities and Social Sciences in partial fulfillment of the requirements for the award of the degree of Master of Arts of Kenyatta University

AUGUST, 2009

DECLARATION

This thesis is my original work and has not been presented for award of a degree in any other University.

Signature________________ Date________________

(Candidate)

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

Signature_____________________ Date_______________

1. DR. Stephen Wambugu
   Department of Geography
   Kenyatta University

Signature___________________ Date_______________

2. DR. Dorothy Mutisya
   Department of Geography
   Kenyatta University

ACKNOWLEDGEMENT

The success of this thesis has been due to the enormous assistance I was given by various people whom I now acknowledge. First I would like to thank my supervisors Dr. Stephen Wambugu and Dr. Dorothy Mutisya both of Kenyatta University for their kind guidance and advice throughout the course of my research and compiling of this thesis. I also thank Mrs. Lucy Ngari of University of Nairobi for all the assistance and encouragement she accorded me. Thanks a lot to the research assistants with whom I collected the data, especially Mr. Joseph Mungai who introduced me to most of the respondents. I also thank Dr. John Kihoro of Jomo Kenyatta University of Agriculture who helped me to analyze the data.

Many thanks go to Mr. Paddy Lukhayo and Mr. John Mbugua both of the Kenya Agricultural Research Institute Kabete for providing me with valuable resource materials for my research.

I am grateful to all my family members for the financial and moral support that they gave me that made my study a success. Finally, I thank all the farmers who provided me with the information used in this thesis. To all these parties and many others not mentioned, receive my hearty appreciation and may God richly bless you.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF ABREVIATIONS AND ACRONYMS

CAN	Calcium Ammonium Nitrate
CIMMYT	International Maize and Wheat Improvement
DAP	Diammonium Phosphate
IFPRI	International Food Policy Research Institute
ITCZ	Inter-tropical Convergence Zone
KARI	Kenya Agricultural Research Institute
KM	Kilometer
LM	Lower Midland
MEDac	Ministry of Economic Development and Cooperation
NPK	Nitrogen, Phosphate, Potassium
OLS	Ordinary Least Squares
UM	Upper Midland
Ha	Hectares

DEFINITION OF KEY TERMS AND CONCEPTS AS USED IN THE THESIS

Adoption: It is acceptance and use of new agricultural technologies by the farmers. At individual level, it is the degree to which a new technology is used in the long- run equilibrium when the farmer has full knowledge about the technology including its potential (Feder et al, 1985).

Technology: New innovations developed by the researchers, that are intended to improve agricultural productivity for high quality and quantity yield gains. Rogers (1971) defined it as a means by which resources are combined to produce the desired output, while innovations are ideas, practices or objects that are perceived as new by their recipients.

Intensity of adoption: The extent or degree of adoption, and is expressed by use of a continuous variable such as hectare or percentage of land devoted to a new technology or the quantity of the technology used per hectare (Feder et al, 1985).

Rate of adoption: The proportion of potential adopters who have adopted the technology.

Perception: The process by which people select, organize and interpret sensory situations connected with a phenomenon into a meaningful and coherent picture of the world.

Agro-ecological Zone: It is the particular environmental condition of a given area that supports growth of a particular crop or plant.

Package: Refers to the maize variety suitable for specific ecological zones and all agronomic practices that must accompany it in order for it to realise maximum yield gains expected

ABSTRACT

Maize is the most important staple food and the major source of sustenance for the majority of the Kenyans. The increasing population trend in the face of declining yields in maize production has intensified the food insecurity problem (Republic of Kenya, 1994). This has created the need to improve maize production techniques so as to meet food security demands. Researches have been conducted on maize varieties suitable for Kenya's different agro-ecological zones (KARI, 2000). From these research findings, packages of improved maize varieties and the recommended agronomic practices that accompany adoption of each variety have been released. Each package contains a specific maize variety and its management practices that should be fully adopted to enable it give its expected maximum yield gains. The improved seeds have high yielding potential especially when the agronomic practices are employed to the recommended levels.

The main objective of this study was to determine the level to which farmers in Makuyu Division of Muranga South District, Kenya have adopted the entire recommended maize variety's package in order to identify and analyze the major socio-economic constraints towards its adoption. This was done in order to identify possible policy options that can promote its entire adoption. A total of three hundred farmers were sampled using a multi-stage purposive technique from six sub-locations in the division namely Makuyu, Gakungu, Kimorori, Mihang'o, Maranjau and Karia-ini. The sampled farmers were interviewed through a structured questionnaire.

The results revealed that, adoption of the entire package is sub-optimal for only 1% of the sampled farmers had adopted all the six technology components in the package as recommended. It was found out that, users of fertilizers and cattle manure applied them at far below the required amounts. Most of the sampled farmers (71.3%) planted after onset of the rains. Awareness of weed control and the recommended crop density is high among the farmers as reflected by 84.7% and 59.2% of the sampled farmers respectively. Only 33.3% of the farmers in the sample applied above 50% of the package components to the required levels, an indication of low levels of adoption of the entire package. The study found a significant relationship between gender, education and income levels of the farmers and adoption of the entire package. Age and contact with extension services did not influence adoption of the entire package while cost of the technology, complexity and high perceived risks had negative influence on adoption of the entire package. Spearman's *rho* test revealed existence of a significant linear relationship between levels of income and formal education and adoption of the entire package.

The study therefore recommends strengthening of contact between farmers and technology promoters. There is need to improve methods of disseminating agricultural technologies to the farmers through increased demonstrations. Farmers need to be given less complex technologies to enable them adopt them more readily. The study further recommends subsidies on farm inputs and provision of credits to the farmers to enable them afford the costs involved in adoption of agricultural technologies. Finally, there is need for further research on water use efficiency methods as intervention measures against weather variability.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study Problem

The economy of Kenya is agro-based and heavily dependent on rain fed agriculture. The agricultural sector contributes about 25 percent of the overall gross domestic product. Agriculture is the engine of Kenya's economy whose aim is to ensure food security, creation of employment and provision of incomes and livelihood to the majority of the Kenyans. To enable agriculture play this important role in the economy of Kenya in a more sustainable way, there is need for rapid growth in agricultural output and productivity (Ouma et al, 2002). This can be achieved through sustained flow and utilization of improved agricultural technologies of which improved seeds and agronomic practices that accompany them are very important. According to IFPRI (2002), success in Kenya's agriculture lies in improvement of agricultural technologies and their subsequent diffusion to the farmers.

Maize is the main staple food in Kenya and the most important cereal crop grown by over 90 percent of rural house-holds in most parts of the country. It is the most widely consumed staple as either whole maize or maize-based food. It dominates all food security considerations and accounts for more than 20 percent of all agricultural production (Hassan, 1998). However, the amount of maize produced is far below the amount required to feed Kenya's high population of over 35 million people, and which is growing at a very high rate (IFPRI, 2002). Yields have been declining making it impossible to feed this population adequately. Karugia (2003) noted that, despite the release of improved maize varieties, the trend of maize production and yields has been registering fluctuations since the 1980s. The high population growth rate creates a high national domestic food consumption that exceeds annual production. This creates a food demand gap, hence food insecurity.

One of the major factors behind the current yield gaps between what farmers get and what has been demonstrated by researcher-managed on-farm trial is the low adoption rates of new agricultural technologies among the smallholder farmers. The problem of food insecurity is worsened by inability to expand land under maize production. Karugia et al (2004) observed that, the average yield of maize has stagnated at 1.7 tons per hectare, a level representing less than a third of the optimal yield on farms. There is, however, limited potential for further expansion of area under maize cultivation due to diminishing availability of arable land. Given the limited arable land area and low irrigation development capability, Kenya has to rely more on yield improvement than area expansion for future increases in maize production especially in marginal lands which are worst hit by frequent cases of drought.

Technological transformation of traditional farming practices is therefore urgently required to cope with increasing food demands of the population that is growing at an alarming rate. It requires the introduction of farming techniques that address short-term food availability concerns of the farmers. The adoption of agricultural-enhancing technologies is seen as critical to the future development of the sahelian region (Sanders et al., 1995). Much of the technological change is particularly expected in rainfed agriculture because of the limitations in achieving large output gains from irrigation (Day et al., 1992). It appears that, future growth in maize production in Kenya would have to depend mainly on yield gains, made possible by widespread use of technologies that promote maize production such as use of improved germplasm contained in hybrid maize varieties available in the Kenyan seed market (KARI, 2002).

This realization has caused increased attention on issues relating to the development and dissemination of improved agricultural technologies especially in view of the fact that, there is limited potential for further expansion of arable land. One of the technologies is the innovation and use of improved maize varieties package. Improved maize varieties suitable for various ecological zones in Kenya are developed by researchers with an aim of providing a means of achieving sustained increase in maize yields (KARI, 2002).Farmers are expected to adopt the maize varieties suitable for their region and all the agronomic practices recommended for those varieties in order to realize the maximum yield gains expected from them. The improved maize seeds have potentials of giving high yields, tolerate drought and resist pests. This makes adoption of the entire package more relevant to the marginal lands such as Makuyu Division. Hassan (1998) noted that, modern seed varieties are accompanied by a package of chemical fertilizers or pesticides and recommended crop husbandry practices in order for them to sustain the expected high yield. Kamau (2002) noted that, access to high quality inputs especially seed and fertilizers is a prerequisite for high maize productivity. He further observed that, many small scale farmers could double their maize yield through increased use of improved seed and crop husbandry practices. Allan (1971) argued that recommending the farmers to use expensive fertilizers in the absence of high levels of husbandry is not sufficient enough to realise the high yield gains expected. It requires farmers to have full knowledge of maize package suitable for their ecological zones. The World Bank (1984) contends that, maize production in Kenya could be increased by up to 70 percent if the current maize technology is improved.

Since researchers have played their role of introducing improved maize packages suitable for various specific ecological zones of Kenya, the remaining part is for the farmers to adopt the package fully. The contentious issue is to establish the manner in which farmers are adopting the entire package, since maize production in Kenya seems to remain low despite the researchers' efforts. This scenario has motivated this study to shed light on the extent to which farmers in Makuyu are adopting the entire package as a measure against food insecurity in the region.

1.2 Statement of the Problem

Maize dominates food security considerations in Kenya. It is the most important staple food and the major source of sustenance for the majority of the Kenyans. The maize growing zones in Kenya are unique as regards to maize varieties requirements. The diverse and complex ecologies call for the farmers' full awareness of the appropriate maize technologies recommended for their ecological zones. These technologies are developed at the research centers and are disseminated to the farmers mainly through extension services. Farmers' decision to integrate these agricultural technologies into their farming practices is greatly influenced by their socio-economic characteristics as well as the technology-specific attributes. These characteristics may lead to either partial adoption or non-adoption of the agricultural technologies at all.

Huge areas of sub-saharan Africa are still characterized by technological stagnation (Sanders et al., 1995). This is the case despite the existence of technological innovations within the continent itself and from international Agricultural Research Centers (Byerlee, 1994). Many researches conducted on maize technologies such as Akpoko and Aroko (1999), Nkonya et al. (1997), Mureithi (2000) and Ransom et al. (2003) have focused on adoption of improved maize seed and fertilizer, but not on other agronomic practices necessary for the seed to give maximum yields. Findings of these studies have not contributed to a significant increase in maize yields. It therefore appears that, adoption of the improved seed and use of fertilizer alone are not the solution to the declining maize yields in Kenya. Rather, there is need to explore the manner in which farmers are adopting other maize management techniques such as timely planting, weed control, proper crop density as well as use of organic manures. This is in order to enable a sustainable maize production policy to be put in place to facilitate its high productivity. This is supported by the fact that, researchers emphasize on adoption of all technology components in order for that technology to realize the maximum yield gains expected from it (KARI, 2002). They ascertain that, maximum yield gains from improved maize seeds would only be realized if all the technology components contained in the package are adequately adopted. This motivates the present study to examine the level to which farmers are adopting the entire package in Makuyu Division for food security purposes.

Farmers in Makuyu Division heavily depend on maize and maize products as their main source of food sustenance. Maize production therefore forms the major economic enterprise in the region. These farmers have over the years planted the local maize varieties called 'Gikuyu' and 'Nyagithigu'. These varieties have low production potential. Continuous use of these local varieties has led to low food supplies hence food insecurity problems and therefore dependency on food donations many times. Following this, researchers have introduced improved maize varieties suitable for the region which include; H511, H513, Nduma 42, Pioneer Seed and Pannar 5243 together with their required agronomic practices (Wanjohi, 2005). These seeds and the agronomic practices constitute the package recommended for the region. However, farmers continue to realize low maize yields although they plant these improved varieties and are therefore unable to meet their food demands. Therefore, it is necessary to examine the manner in which they adopt these varieties, with a view to finding out whether they adopt the whole package or part of it; and if so, why? Thus the present study examines the extent to which farmers in Makuyu Division have adopted the entire package recommended for their region.

1.3 Objectives

1.3.1 General Objective of the Study

The overall general objective is to establish the extent to which farmers in Makuyu Division have responded to the package of improved maize technology recommended for their region, as a strategy of meeting food security needs. The study also seeks to establish the factors that influence farmers' adoption behaviour in as far as the whole package is concerned. The package contains the specific improved maize variety, its fertilizer or manure requirements, crop density, planting time and weed control requirements, in order for it to give maximum yields expected from it.

1.3.2 Specific Objectives

Specifically, the study seeks to:

1. Identify the socio-economic characteristics of the maize farmers in Makuyu Division.
2. Determine the extent to which farmers have adopted the whole package of improved maize varieties recommended for their region.
3. Analyze the factors influencing adoption of the whole package of improved maize variety or part of it.

1.4 Hypotheses

The specific hypotheses tested were:

1. There is no significant difference in farmers' age, level of formal education, income levels and size of land holdings between the adopters and non-adopters of the entire package recommended for their region.
2. There is no significant difference in the intensity of adoption of the entire package among the farmers in Makuyu Division.
3. Farmers' socio-economic characteristics and technology-specific attributes have no influence on adoption of the entire package.

1.5 Justification of the Study

Food insecurity in Kenya has become a worrying developmental problem and a major concern to the government. Yields in maize, the staple diet are falling drastically, though new technologies on how to improve its production and productivity are being developed and released to the farmers by the researchers. Byerlee (1994) noted that, intensification of agricultural production in Kenya through the development of modern technologies is necessary if the current problem of food insecurity is to be improved. Adoption and optimal use of these technologies by the farmers is the key to improved maize production. It is important to focus on adoption of entire package recommended for each agro-ecological zone. A related study on adoption of composite soil fertility enhancement technologies by Makokha et al. (1999) in Embu District showed that, all farmers were applying the technologies, but at rates far below the standard recommended hence, low production potential. Consequently, there is need to promote utilization of agricultural technologies to the optimal level for high production potential of the land to be achieved.

This study is based on the factors that influence adoption of the whole package of improved maize varieties in Makuyu Division. Differences in intensity of adoption of the package may lead to differences in maize yields and consequently varying degree of food insecurity problem among the farmers in the division. It also widens the gap of income obtained from maize yields between the farmers who adopt the whole package and those who adopt part of it. There is therefore need to identify and understand the various factors that affect the degree of adoption of the entire package of improved maize technology. This would guide the agricultural policy makers to identify areas that require intervention in order to bring the desired change in as far as adoption of the whole package is concerned.

Researchers will use this knowledge as a guide in developing agricultural technologies that are farmers' demand-driven and are feasible within their farming circumstances. They will incorporate those factors in their plan to develop new agricultural technologies that would enable the expected impact of the technology to be realized by the farmers. This study will also identify and reveal the context within which the farmers make their decision about adoption of the entire package. Evaluation of the effect of adoption of the whole package on yields will show the benefits realized from adoption of the entire package. It will reveal the relevance of adopting the entire package as a measure against food insecurity problem, and therefore promote its adoption.

This study is necessary, in order to identify and analyze the factors that influence intensity of adoption of the entire package of maize technology in Makuyu. It unearthens some constraints faced by the farmers in their efforts to adopt the whole package and which impede its adoption by some farmers. Further, the study adds knowledge to issues in agricultural geography and opens frontiers for further investigations in food security. According to Adesina and Zinnah (1993), farmers' decision to adopt a technology and utilize it is shaped by personal economic, socio-cultural and environmental factors under which farmers operate. It therefore becomes important to understand the various factors that influence farmers' decision to adopt the package either entirely or partially. The current study provides information on the factors affecting intensity of adoption and use of the entire package of improved maize technology in Makuyu Division.

1.6 Assumptions and Limitations of the Study

This study is based on the general hypothesis that, maize production in Makuyu can be increased to levels that would adequately meet the food security needs of the farmers. This can be achieved if the farmers adopt the entire package of the improved maize variety recommended for their agro-ecological zones. It also assumes that, farmers would not resist adopting the entire package if their perception about the benefits associated with the package is strengthened through change incentives. Level of knowledge about a technology and its expected outcome is important in explaining adoption behaviour of farmers because it influences perception. It is assumed that, farmers close to the source of information about a technology may adopt it more readily than farmers further away. This is due to their ability to seek more clarifications about it incase of constraints about it. This study assumes that, the farmers who get agricultural information from the technology promoters adopt new technologies more than the farmers who lag behind in receiving new agricultural technologies.

This study also assumes that, farmers readily adopt technologies whose economic benefits are appealing and which involve relatively low costs. Farmers may be aware of agricultural technologies that promote production, but some socio-economic constraints impede their adoption.

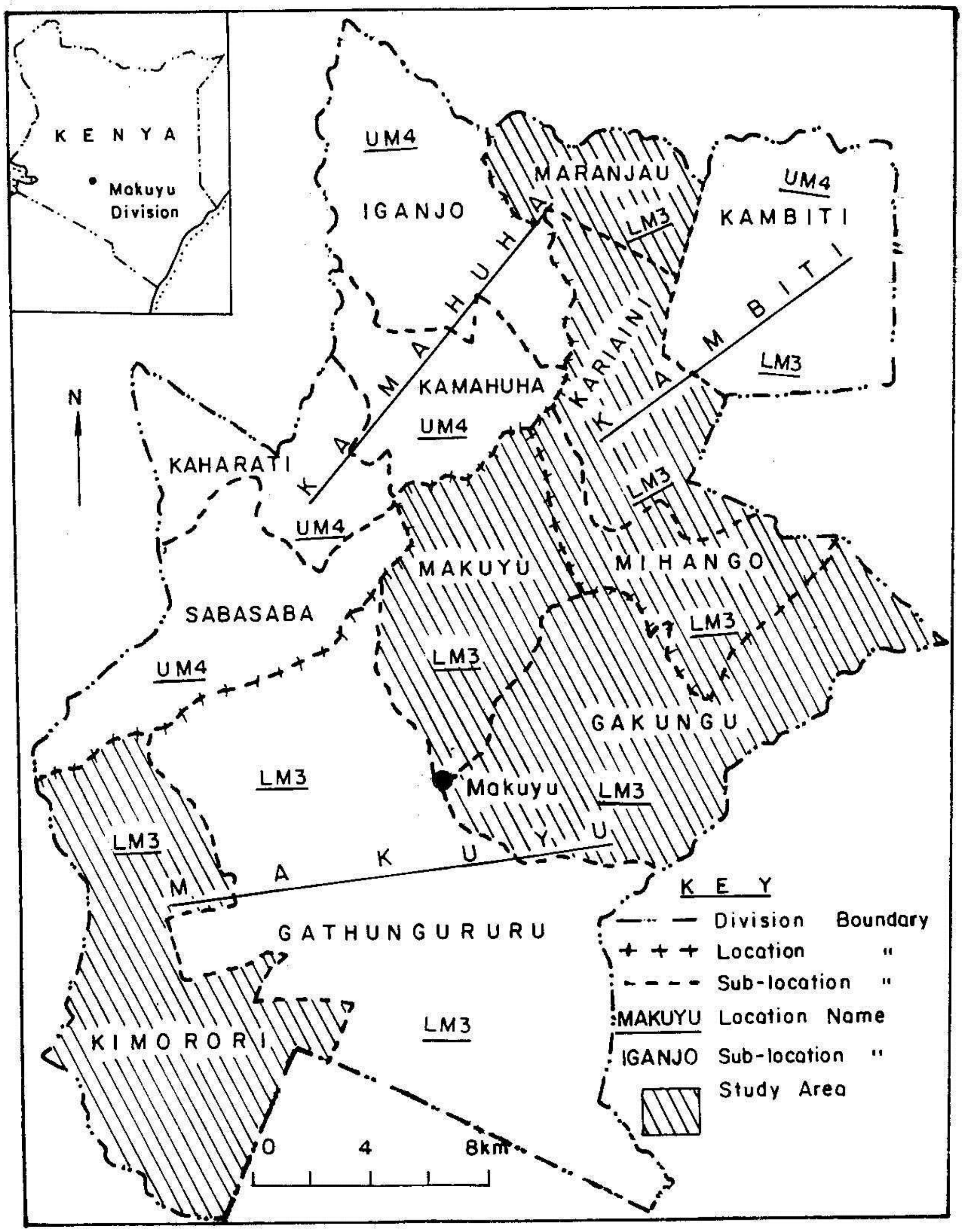
This study is limited to small scale farmers. Most farmers in Makuyu Division are resource-poor smallholders with less than two acres of land. The survey was cross-sectional involving farmers who have attained formal education and those who have no formal education, including old and young farmers, some with off-farm employment and others without any form of employment and fully depend on farm production to earn a living. Other limitations of the study included false information from some respondents and encounter with unco-operative farmers which made data collection take more time than was expected.

1.7 Description of the Study Area

The study was carried out in Makuyu Division of Murang'a South District. The division was chosen because it is a dry region prone to frequent cases of drought and any anomalies in rainfall triggers crop failures and consequently food insecurity problems. Specifically, the study was carried out in Gakungu, Kimorori and Makuyu sub-locations in Makuyu location and also in Mihang'o, Karia-ini and Maranjau sub-locations in Kambiti location.

These Sub-locations were selected because they are the driest regions in the division. Makuyu Division is one of the Kenya's local drought-prone areas as evidenced by occurrence of droughts in the years 1992, 1998, 2000, 2003 and 2004 and food insecurity is a major issue (Wanjohi, 2005). The division covers an area of 195 square kilometers, out of which 145 square kilometers is agricultural land (ibid). Makuyu Division borders Murang'a North District to the North, Machakos District to the East, Thika District to the South and Maragua Division to the West. The Division has three Locations and twelve Sub-locations, out of which six were selected for the study (Fig. 1.1).

Fig.1. 1 Location of Makuyu Division



Source: A Manual of Agro-ecological zones of Murang'a South District, (2007)

<u>Agro-Ecological Zones</u>

LM3 – Cotton Zone. (Maize, Cotton, Beans, Pigeon Peas, Mango Grazing Lands)
UM4 –Transitional Zone. (Maize, Beans, Bananas, Grazing Lands)

The division receives low to moderate rainfall ranging between 500mm to 700mm on average. It is associated with the movement of the Inter-tropical Convergence Zone (ITCZ) of the Northeast and Southeast trade winds. This causes a bimodal pattern of rainfall distribution, long rains in March to May and short rains in October to December. Its rainfall pattern is both unreliable and erratic, with some regions like Ithanga receiving less than 500mm. Drought occurrences in the area are common phenomena leading most of the times to food shortages. The mean maximum temperature range is from 26^0c to30^0c while the minimum temperature range is between 14^0c and 18^0c. Soils are poor and shallow, derived from the basement complex. They are friable sandy and clay loam with low humus content, ranging from dark to yellowish red. They are easily erodable leaving unproductive wasteland dominated by deep gullies on extensive parts of the division. Most parts have rocky, bouldery and stony soils especially Kambiti location. The climate pattern and soil characteristics cause food deficits forcing many people to depend on food donations from other districts or organizations like the World Vision International (Wanjohi, 2005).

The division was under sisal and coffee estates during the colonial period. After independence, the estates were sub-divided into small pieces of land and sold to the former squatters of the estates. Land availability encouraged migrants from the neighbouring districts, leading to moderately high population which is unevenly distributed and also created pressure on land. Consequently, farm sizes are generally small less than two acres on average.

Topographically, the division consists of a gently rolling land. To the west, the relief rises to about 1034m above sea level. The eastern part is low at around 914m above sea level, though broken by some small hills like Kakuzi and Ithanga hills. The vegetation is characterized by wooded grassland mainly of Acacia-Thermada associations. The division has little agro-ecological variation. It lies within transitional maize sunflower zone and cotton zone. Kambiti and Makuyu Locations which form the specific areas of this study lie within Transitional Zone (UM4) and Cotton Zone (LM3). The agricultural potential is low due to rainfall variability and unreliability. Subsequently, any anomalies in rainfall triggers crop failure and consequently food insecurity problem (Wanjohi, 2005).

The main economic activity in Makuyu Makuyu is farming. The farming system is mixed farming where farmers raise livestock and grow crops as well. Maize is the major economic enterprise and is grown by nearly all the farmers. It is planted in a cropping system of either maize sole crop or intercrop of maize and beans or maize and cowpeas or maize and pigeon peas. The climatic pattern in Makuyu Division has dictated farmers to plant the drought resistant local maize varieties over years though their yield potential is low. However, with introduction of improved maize varieties suitable for marginal lands by the researchers, farmers have started to plant them in Makuyu. These varieties have high yielding potentials especially when all the agronomic practices recommended for them are fully adopted. Farmers usually intercrop these improved maize varieties with beans, cow peas or pigeon peas as a way of increasing returns to land and also as a form of crop diversification strategy against risks of crop failure. However, they still devote small farm portions to the local varieties; ‘Gikuyu’ and ‘Nyagithigu’, which they believe are more resistant to drought despite their low yielding potential. Other than food crops, there are varieties of fruits grown in Makuyu Division which include paw paws, oranges and mangoes. They are mainly grown for both subsistence and commercial purposes. Arable agricultural practice is characterized mainly by continuous cropping and over cropping with little use of organic and inorganic fertilizers. This leads to low food production and food insecurity problems prevail frequently. Food insecurity problem is also contributed by the huge losses of harvests that are experienced from pests attack on crops while in the field or in the stores. This creates the need to adopt the pests and drought resistant maize strains, as well as the agronomic practices that are recommended in the package.

1.8 Organisation of the Thesis

This thesis is organized into five chapters. Chapter one provides introduction and the background to the research theme, research problem, objectives of the study, hypotheses tested, justification of the study and description of the study area. Chapter two is the literature review covering studies on adoption of agricultural technologies in Kenya and other parts of the world as well as drought management strategies in Makuyu Division. Methodological approaches in the context of adoption studies are also covered in this chapter. Chapter three describes the conceptual model adopted by the study. It also provides a description of the analytical models used in data analysis. Chapter four presents a discussion on the findings of the study and results of the hypotheses tested. Chapter five summarizes the main findings, giving the conclusions and recommendations that have been drawn from the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

In this chapter, literature related to adoption of agricultural technologies and improved maize varieties is reviewed. The chapter explores farmers' adoption behaviour of agricultural technologies exposing the gaps therein. The chapter also contains the adoption paradigms and the methodological approaches which guide this study.

2.1 Improved Maize Varieties Packages

Maize occupies a central position in Kenya's diets and farm production activities. When all crops grown in Kenya are considered, maize occupies the largest area and a wide variety of agro-ecological zones (Karugia, 2003). Despite its importance, maize has experienced fluctuating trends in yields. Anon (1997) highlighted that, the main challenges to increased maize production are biotic constraints mainly pests and diseases and also abiotic constraints mainly drought, low soil fertility and lack of improved seeds.

Research in maize production is accorded high priority above other food crops and has received substantial extension attention (Republic of Kenya, 1994). Since the 1970s, varieties of maize suitable for various agro-ecological zones have been developed by researchers. The introduction of improved maize seeds was closely followed by introduction of complementary inputs that must be employed together with the seed in order for it to achieve the maximum economic benefit expected. The improved maize seeds and the complementary inputs constitute the improved maize variety's package (KARI, 2000). The package contains the seed,fertilizer or manure requirement, planting time, weed control, spacing and crop density. Each technology package consists of several technological components that a potential adopter is expected to adopt entirely if the maximum yield gains are to be achieved (Batz et al., 1999).

The maize sub-sector experienced a considerable breakthrough in the 1970's due to varietals development supplemented by purchased inputs especially fertilizers. It registered a tremendous increase in yields between 1964 and 1975, which was fueled by the introduction of maize hybrids and related technologies often dubbed "Kenya's Green Revolution" (Karanja, 1996), similar to rice increase in Pakistan due to the "Green Revolution" (Khan, 1975). However, Karugia and Kosura (2005) note that, this early promise was lost in 1980's and since then, achieving sustained increases in productivity has been an elusive goal. This could be attributed to the fact that, either farmers adopt the improved seed but ignore the recommended agronomic practices or adopt the entire package but at standards far below the recommended rates. The improved maize varieties have a high yielding potential, high degree of tolerance to drought, pests and diseases and some mature early. Researchers have released a package of various improved maize varieties suitable for Makuyu. The package contains the seeds and the agronomic practices recommended for those varieties (Table2.1).

Table 2.1 Maize Varieties' Package Recommended for Makuyu Division

Maize variety	Fertilizer/Manure Requirement	Top-dressing	Crop density	Planting time	Weed Control
H511 H513 Nduma 42 Pioneer Pannar 5243	D.A.P N.P.K.20:20, 17:17,23:23 (200kg/ha) or Manure (2 tons/ha)	C.A.N, when D.A.P was used in planting	75cmx30cm, one seed per hole or 90cmx60cm two seed per hole	Before onset of the rains	Twice per season

Source: Wanjohi (2005).

This study examines the intensity of adoption of this package and analyses the factors that either promote or impede its adoption to the optimal level. A related study about diffusion and adoption of technologies in Embu by Batz et al. (1999) observed that, improved maize is not a new technology to many farmers as they have already replaced the local variety with it. However, they ignore the agronomic practices contained in the package partially or entirely leading to low yields. Yet, early planting is vital for high maize yields because at the time of germination, maize roots have a high demand for oxygen and plant growth can be severely limited if soils are soaked by a succession of rainy days so that air is largely replaced by water and soil temperatures decline. Consequently, this lowers the yield potential for the seed. Also, weed control is important as it reduces competition for water, soil nutrients and light which can adversely affect the yields. Carry's (1989) study in Ethiopia showed that, yield losses caused by weeds ranged between 30% and 80% of potential yield. Weeding at least twice using "pangas" is recommended for the study area. The present study shares the view of these researchers and seeks the validity of their view in Makuyu Division. It goes further to examine the level to which farmers are adopting the entire package as recommended, which these researchers have failed to address.

A report by International Food Policy Research Institute (IFPRI), (2002) shows that, about 30 percent of the total area planted under maize in Kenya is under local varieties. This is because the hybrid varieties are expensive to purchase relative to traditional varieties, and also require complex agronomic practices. This limits their adoption by many small scale resource-poor farmers. The current study provides information on the factors that determine farmers' adoption behaviour in as far as the entire package of improved maize varieties is concerned.

2.2 Adoption of Improved Maize Technologies

Adoption is acceptance and use of new agricultural technologies by the farmers. It is a dynamic process that is determined by various factors such as farmers' perception of benefits of the technology, efforts made by the extension services to disseminate these technologies to the farmers, risks involved, costs involved, profitability and complexity i.e. the likelihood that farmers will be able to apply it correctly. Adoption of agricultural technologies by the farmers is an essential pre-requisite for economic prosperity in less developed countries (Nkonya et al., 1997). Farmers' decision to adopt a technology is greatly influenced by their perception about it. If certain groups of farmers are not adopting improved agricultural technologies or are adopting them at a lower rate than other groups, then, there is need to determine why. Consequently concerted efforts are needed to unearth the exact reasons behind low levels of adoption of agricultural technologies, otherwise the appropriate technologies could remain on the shelves while yields in agricultural production and especially maize the staple diet continue to decline. This is because; it is only by understanding the reasons, that the researchers will be able to develop improved technologies that are appropriate for all i.e. technologies that will influence farmers' perception towards adopting them entirely.

Most empirical studies on adoption of agricultural technologies such as Mureithi et al. (2000), Mulugeta (2001) and Ransom et al. (2003) concentrate on farmers' characteristics as the main factors that influence adoption or rejection of agricultural technology's package. They compare farmers who have adopted or rejected a certain technology at a point in time against their own socio-economic characteristics. They overlook the influence that technology characteristics can have on adoption. Technology specific attributes can influence the farmer's adoption decision in the same way as his/ her own socio-economic circumstances can influence his/her decision to adopt or reject a technology. These technology characteristics include initial cost, risk involved, relative profitability and complexity of technology. The present study has used some selected socio-economic and technology characteristics to examine how they have influenced adoption of the entire package of improved maize varieties in Makuyu Division.

According to Batz et al.'s (1999), study in Embu District, adoption decision depends upon utility consideration and adoption will take place if utility of the new technology is greater than the traditional technology. The expected utility is determined by technology characteristics (Tc) as attributed by farmer's characteristics (Fach), farming system (Fsch) and the farming circumstances (Fc) thus:-

$Yn = 1 \text{ if } Eun > Eut.$

$Eu = f(Tc, Fach, Fc, Fsch).$ (Batz et al., 1999).

Where; Yn is adoption of new technology, Eun is utility of new technology and Eut is utility of traditional technology. Adoption of a new technology takes place if its utility is greater than the utility of the traditional technology. Farmers tend to adopt technologies whose returns are high relative to their traditional alternatives. That is technologies whose relative profitability is high compared with their traditional alternatives. They also choose to adopt technologies with relatively low risks as compared to their traditional alternatives (Cheryll et al., 2000). This is because farmers are sensitive to great losses encountered in risks of crop failure. Complex technologies are slowly adopted especially when a farmer has to carry out a number of activities in order to adopt a technology. It becomes more difficult to adopt such technologies especially when those activities are not feasible within the farmers' farming circumstances. Studies done by Beets (1990), Ndiema et al. (2002) and Juliet (2004) have supported this view.

Kabede et al. (1990) in Ethiopia and Adesina and Zinnah (1993) in West Africa observed that, availability and regularity in supply of new technologies, convenience in use and impact on crop yield influence adoption of a technology. Adesina and Baidu- Forson (1995) in West Africa also showed that, farmers' perception of technology-specific attributes inherent in new agricultural technologies influence their subjective preferences and thus adoption decisions. Their decision making is based upon the appropriateness of the technology under investigation in the light of their prevailing socio-economic and communication conditions. Their view agrees with the economic constraint model advanced by Aikens et al. (1975), which considers economic constraint as a major contributor to observed adoption decisions.

Just and zilberman (1983) revealed that capital, access to land, risk attitude and complexity in use of a technology influence perception and thus, decision to adopt or reject a technology. According to them farmers are willing and are capable of making investment in a new technology when they have sufficient capital to finance it and when the future of that technology does not show some uncertainties such as risk of crop failure. They viewed capital and risk attitude factors as some probable reasons for low adoption of technologies among the resource- poor small holder farmers. Studies by these researchers (Aikens et al., 1975 and Just and Zilberman, 1983) provide valuable resource materials in understanding the relationship between farmers' socio-economic characteristics, technology characteristics and adoption decision of agricultural technologies. They motivate the present study to examine the relevance of their views in Makuyu Division.

Barret (2001) in Ethiopia observed that, farmers continue to loose in terms of crop yields despite introduction of new agricultural technologies since the cost of fertilizers and improved seeds continue to be high. He further said that, if the technology is not cost - reducing, the farmers are not likely to adopt it in future seasons to come, unless policy options such as provision of credit facilities are effected. Gerhart (1975), Misiko (1976) and Mose (1997) in Western Kenya, found that farmers' adoption behavior is influenced by costs of inputs especially maize seed and fertilizers, access to credits, off - farm income, perceived yields and risks. A similar study on factors influencing adoption by Ransom et al. (2003) on the hills of Nepal revealed that, a significant and positive relationship exists between years of use of fertilizer, off-farm income, contact with extension and adoption. Neither of these studies attempted to examine adoption of the entire package as well as influence of other technology –specific attributes on adoption. This study endeavored to correct this lacuna.

Researchers such as Gehart (1975), Mugunieri (1997) and Mureithi et al. (2000) have basically dwelt on fertilizer and seeds adoption and none of them attempted to analyze the factors that affect adoption of agronomic practices comprehensively which this study has undertaken to analyze. For instance Mugunieri's (1997) study on adoption of fertilizers among smallholder farmers in Kisii District concluded that, farmers should be encouraged to improve on field management practices before encouraging them to apply fertilizer recommendations obtained from the experimental data. This view is based on his finding that maize yield response to Nitrogen and Phosphate fertilizers under well managed crop was higher than that under farm conditions where levels of farm management were sub-optimal. Further, Gerhart (1975) observed that, users of hybrid maize had shown low levels of adoption of related practices such as use of fertilizers, planting before the onset of the rain, planting in rows, planting in pure stand and weeding more than once, all which are components of hybrid package. Findings of these researchers formed the foundation of the present study. Akpoko and Arokoyo's (1999) study on maize technology adoption among farmers in Kaduna in West Africa dealt with agronomic practices that are critical to maize production among which they included planting dates, spacing and seed rates, fertilizer application as per recommendations, fertilizer type and weeding. They found farmers to be applying fertilizers at amounts far below the recommended standards. However, all these studies did not examine the technology characteristics that could have influenced farmers' adoption behaviour, an aspect which this study has endeavored to examine.

The level of farmers' knowledge about a technology is important in explaining his/her adoption behaviour. Knowledge about a technology, its components and expected outcome promotes its adoption. Dissemination of knowledge and demonstration of the level of gains from the technologies and the potential risk reduction characteristics play a great role in adoption. Therefore adequate information must be attained by the farmers before adoption takes place. Farmers as individuals are known to gain a lot from access to information provided by agricultural extension. Extension education makes a substantial contribution to motivating adoption or intensity of use of land-enhancing technologies. The present study sheds light on the influence of access to information on adoption of the entire package.

This view is supported by the innovation-diffusion model which considers access to information as a key factor in determining adoption decision. The model reduces the problem of adoption of a technology to communicating information on the technology to potential users. This model was advanced by Rogers (1962), Agrarwal (1983) and Benor et al. (1984). Influence of extension services on adoption of agricultural technologies is supported by several researchers. Gerhart (1975) in Kakamega, Adesina and Baidu - Furson (1995) in Burkina Faso, Dorfman (1996) and Makokha et al.(1999) in western Kenya, all contend that extension visit, farmers' attendance to agricultural technology's demonstrations during field -days and participation in on-farm trials influence their perception of the technologies being demonstrated and the subsequent adoption decision. A survey of wheat growers in the western Australian wheat belt by Noonan and Goddard (1995) indicated that, growers place more credibility on information from local trials and field days than on trials and field days conducted further from their district.

Demonstration of a technology increases the rate of its adoption. The introduction of demonstration and training extension system in Ethiopia saw an increase in the rate of adoption of improved maize and wheat varieties leading to high yields. Majority of the farmers who participate in demonstration programmes adopt the new technologies (MEDac, 2000). Karugia's (2003) study in Nyeri and Kakamega Districts revealed that, extension services are absent in most villages and where they are available, they are often irregularly provided. Many farmers are therefore unaware of many yields - improving farming techniques. Although new technologies are available on shelf, the farming communities have not benefited from them since research findings do not flow to majority of them. This study explores how the level of awareness about the improved maize package has influenced its adoption.

Researches on agricultural innovations show that, farmers' different personal characteristics lead some to adopt innovations more readily than others (KARI, 2002). Rogers (1971) has characterized early adopters of innovations as those who have attained more education, have higher social status and have specialized more farm operations while "laggards" on the other hand are "localite" in their outlook, past oriented and "alienated". According to Misiko (1976), farmers who have received formal education and are at youthful or middle age groups are rigorous in trying new practices and are ready to undertake risks involved in those practices. The better educated farmers are likely to apply modern farm inputs more efficiently. Education enables them to try out new innovations as they acquire enhanced information that motivates them to demand for and utilize complex agricultural technologies. Similarly, Ndiema et al.'s (2002) study in Njoro showed that, a significant relationship exists between adoption of agricultural technologies and farmers' level of education but no relationship between adoption, farm size and gender was found. Karanja et al. (1998) also revealed that, education at post-secondary level positively influences use of fertilizers. This is because; the educated farmers have a better ability to evaluate the difference that use of fertilizer makes on productivity. However, all these researchers have not addressed the level to which the whole package of improved maize varieties has been adopted. The current study has examined how the technology-specific attributes and socio-economic characteristics of the farmers have influenced adoption of the whole package of improved maize varieties in Makuyu Division.

2.3 Adoption Paradigms and Methodological Approaches

This section explains the adoption paradigms that have guided this study. Also, the methodological approaches in the context of adoption studies that have been used to guide the present study.

2.3.1 Adoption Paradigms

A study on adoption of a sample of mangrove swamp rice in Sierra Leone (Adesina and Zinnah, 1993) tested the role of farmers' perceptions in technology adoption decision. The study identified three main paradigms that explain adoption decisions. The first was the "innovation diffusion model" which holds access to information about innovation as the key factor that determines adoption decision by the potential users. The model holds that, appropriateness of the technology is taken as given and the problem of technology adoption is reduced to communicating information on the technology to the potential users. Therefore, improving communication through the use of extension, media, local opinion leaders, visits to experiment stations and on-farm trials can promote the technology adoption decision. The second paradigm is the "economic constraint model" which holds that, economic constraints reflected in the asymmetrical distribution patterns of resource endowments are the major determinants of adoption decisions (Aikens et al., 1975 and Adesina and Zinnah, 1993). Inadequate access to factors of production limits farmers' ability to adopt agricultural technologies.

The third model is the "adoption perception's paradigm" which holds that, perception attributes play a major role in adoption (Adesina and Zinah, 1993). According to this model, farmers' subjective perception about a new technology in relation to their prevailing socio-economic situations influences their adoption behaviour. The three paradigms however, did not consider the role played by the technology attributes in influencing the adoption decision. Yet, the attributes of a new technology influences its adoption decision especially in terms of cost, complexity and perceived risks. Batz et al. (1999) included technology characteristics inherent in a new innovation as a factor affecting adoption decision that, a new technology is adopted only if it is considered to have a higher utility than the existing traditional technology. They established that, there is a higher probability of adopting a technology whose utility is greater than adopting a technology considered to have less utility thus;-

$A_i = 1$ if $Eun > Eut$

$A_i = 0$ if $Eun < Eut$. (Batz et al.,1999).

Where A_i is the probability and intensity of adopting a new technology; Eun is utility of new technology and Eut is utility of traditional technology. A new technology is adopted only if its utility is higher than the utility of the traditional technology. The present study adopted the three paradigms in determining the factors influencing farmers' decision to adopt the entire package in Makuyu Division. It has gone further to examine the effects of technology characteristics in influencing farmers' perception hence adoption decision.

2.3.2 Methodological Approaches

Several models have been developed to facilitate investigations of the effects of various independent variables such as farmers socio-economic characteristics and technology attributes on adoption of either dichotomous or polychotomous dependent variables. The most common models are the logit and probit models. The two models establish relations between probability of adoption and various explanatory variables of farmers. Regression analysis is one of the most common analytical tools in econometrics while ordinary least squares (OLS) methodology is the most common estimation technique, though it finds little application in the type of regression done in adoption models. The inappropriateness of the OLS can however be appreciated in estimating qualitative descrete choice models such as adoption of a particular agricultural technology if it is considered that the assumption of normality of disturbances is obviously inappropriate for assessing the hypotheses concerning the impact of various factors in the adoption process (Amemiya, 1981 and Kennedy, 1985).

The more appropriate model then is the continuous probability distribution models such as the logit procedure which relies on the logistic probability distribution to estimate the parameters of concern (Kennedy, 1985). However, their outcomes are technically implausible and it is impossible to conduct usual hypotheses tests on the estimates. The two models provide statistical evaluation of the directional impact of the variables on the probability of adoption but fail to provide quantitative information on the economic importance of these variables. This means that, the two models isolate some important factors that condition adoption behaviour. Those factors are then analyzed in order to establish their statistical importance in influencing adoption behaviour. The present study has in this case used Spearman's *rho* test to determine the factors that influence adoption of all the technology components contained in the package.

Mureithi et al. (2000) used a logit analysis model to analyze the factors affecting adoption of maize production technologies in Embu District. The variables they analyzed were age of the farmer, farm size in acres, gender of the household head, access to credit by the farmer, access to extension services, use of organic manure, education level of the farmer and use of hired labour. The results indicated that, adoption of maize production technologies is significantly influenced by gender, extension services, hired labour and access to credit facilities. Their study did not consider technology-specific attributes as a factor influencing adoption decision which Mulugeta et al. (2001) included in their study on the factors determining adoption of physical soil conservation measures in Central Highlands of Ethiopia. Their analysis showed that, farm size, education level, off-farm income and technology-specific characteristics influence adoption of physical soil conservation measures. The present study has adopted some of these variables in determining their influence on adoption of the entire package of improved maize technology in Makuyu Division using the same model.

CHAPTER THREE

3.0 METHODOLOGY

This chapter analyses the conceptual model that has guided this study and the variables that were hypothesized to influence farmers' adoption behaviour. The chapter also contains information on data sources and the methods that were used to analyze the data.

3.1 Conceptual Models and Hypotheses Tested

Adoption is the degree to which a new technology is used in the long run equilibrium when farmers have complete information about the technology and its potential (Feder et al, 1985). Farmer's choice of a technology in the midst of several technological options is determined by the prevailing environment in terms of its feasibility in the light of his/her socio-economic circumstances. In the context of smallholder farming systems of Kenya, it is the farmers' own specific socio-economic constraints that may present the most important constraining factors in technology adoption.

This study has been guided by the random utility model which holds that, profit maximization is the drive towards a technology adoption. A particular technology option will be adopted if and when it possesses those attributes that will maximize its utility and minimize the costs of production (Batz et al., 1999). As rational consumers of agricultural technologies, farmers were conceptualized to choose technology packages that give them maximum utility in terms of profits realized. Adoption decision is a behavioral response arising from a set of alternatives and constraints facing the decision maker. The alternatives are taken to be the returns or the benefits realized from adopting a technology, while constraints are taken to be costs involved in adopting a technology and can impede its adoption. They are disincentives to a technology's adoption. Adoption decision is undertaken only when the incentives outweigh the disincentives. Successful adoption and continued use of technologies depend on farmers' perception of the incentives and disincentives provided along with those technologies. If the perceived benefits are higher than the costs, farmers are motivated to adopt a technology as they expect high returns on investment. If on the other hand the costs involved in adopting a technology are perceived to be higher than the perceived benefits, then farmers are discouraged from adopting such a technology. Such a technology is perceived to have low utility hence, no adoption or low rate of adoption. In this study, the incentives and disincentives are the agronomic practices contained in the improved maize variety's package and the benefits associated with adoption of the entire package. They condition farmers to adopt the package either entirely or partially.

Further, adoption was assumed to be a function of household characteristics, technology specific characteristics and the farming objectives (Adesina and Zina, 1993). The decision to adopt the package either entirely or partially is influenced by farmers' socio-economic characteristics and their perception about the technology's characteristics. These factors influence farmers' perception about the utility of the improved maize variety's package hence, their adoption behaviour. This study categorized farmers as either adopters or non-adopters of the entire package. Adoption was quantified using a binary variable, whereby, farmers who had adopted above fifty percent of the package components were given a value of 1. They were grouped as adopters of the package. Farmers who had adopted below fifty percent of the package components were grouped as non-adopters and given a value of 0. Adoption decision by the two categories of farmers was influenced by their perceptions about the incentives and the disincentives contained in the package. Since farmers adoption behaviour is subjected to two opposing forces of the incentives and disincentives contained in a technology, adoption decision can be facilitated by increasing incentives and weakening disincentives. This study has identified and analyzed the factors that influence farmers' adoption behaviour. It has further proposed some recommendations which if effected may weaken the disincentives hence promote adoption of the entire package.

This study has adopted Leagans (1979) "behavioural differential model" in its attempt to analyze farmers' adoption behaviour in Makuyu Division. This model investigates and explains the intricate adoption behaviour of farmers. It accommodates discipline specific variables and takes into account the interdisciplinary nature of other variables which commonly affect adoption. It treats adoption of agricultural innovations as the dependent variables, while the independent variables are all interdisciplinary factors comprising a primary set of socio-economic, physical and institutional factors. In this study, the dependent variables are the technology components contained in the improved maize technology's package while the independent variables are the socio-economic characteristics of the farmer and the technology-specific attributes.

This model conceptualizes the incentives and disincentives to be exerting opposing forces that motivate actions that result to change towards either adoption or non-adoption decision and that; adoption begins when incentives outweigh disincentives. To activate the change process, the model holds that, change incentives such as technologies and education to the farmers must be improved in greater magnitudes to overcome disincentives or weaken them so that large number of farmers can adopt the change over time. Adoption occurs when disincentives are weakened or removed completely. The incentives change that would encourage farmers towards adoption of the entire package in this study includes provision of credit facilities, subsidies on inputs, increased extension advice and demonstrations. This study has analyzed the factors that influence adoption of the entire package of improved maize technology in Makuyu Division.

3.1.1 Dependent Variables Used in the Study

The dependent variables used in the study were the technology components contained in the package which the farmers are required to adopt entirely in order to realize the maximum yield gains expected from the improved maize varieties recommended for their region. For the maize varieties, the dependent variable was adoption of H511, H513, Nduma 42, Pioneer seed or Pannar 5243. For the fertilizer and manure, the dependent variable was the fertilizer type and amount required for planting and for top dressing and the manure amount required for planting. For planting, the dependent variable was planting before onset of the rain. For weeding, the dependent variable was weeding twice per season while for crop density the dependent variable was 75cmx30cm, one seed per hole or 90cmx 60cm, two seeds per hole.

3.1.2 Independent Variables Hypothesized to Influence Adoption of the Entire Package

The Independent variables used in the study were some selected socio-economic characteristics of farmers and technology-specific attributes that were hypothesized to influence adoption of the entire package according to the stated objectives and hypotheses of the study. The socio-economic characteristics of the farmers included age, education level, gender, contact with agricultural extension and level of income. The technology characteristics included profitability, complexity, risk perceived and the relative investment.

3.1.2.1 Socio-economic Characteristics of the Farmers

This section analyses the socio-economic characteristics of the farmers that were hypothesized to influence their adoption behaviour of the recommended improved maize package for their region.

3.1.2.1.1 Age

Age was conceptualized to influence adoption of the package because younger farmers are likely to respond to new farming changes than older ones who may be rigid to changes.

3.2.1.1.2 Education

This was the level of education attained by the farmer. It was postulated to influence probability of adoption of the entire package because more years of schooling tend to make farmers less risk averse thus, enabling them to try out new innovations (Welch, 1979). Education increases a person's awareness of his environment and his ability to acquire and process information about his environment and to detect changes in it. It also enhances farmers' ability to identify alternatives and compare benefits and costs associated with each of the alternatives possibly under different state of nature (Schultz, 1981). Educated farmers easily acquire and comprehend new information hence, are more rigorous to demand and utilize new presumably superior agricultural technologies. In this study education level of the farmer was expected to have a positive influence on probability of adoption of the entire package. This concurs with Gehart (1975) who found education to have had a positive influence on adoption of hybrid maize in Western Kenya.

3.1.2.1.3 Gender

Female-headed households are expected to adopt the technologies more as females provide most of the farm labour for food production. The package adoption process requires a lot of labour thus; high adoption rate is expected from female-headed households. Also, more males tend to have off-farm employment since they are more educated than females and therefore do farming as part time activity. So, their adoption level is expected to be low.

3.1.2.1.4 Contact with Agricultural Extension

This was the number of times a farmer had contact with the agricultural extension officers at least in the last four years. Contact with extension programs through farm visits, participation in field days and demonstrations have been found as important factors in promoting adoption of new technologies (Chambers, 1992 and Adesina and Seidi, 1995). It was therefore hypothesized that, exposure to technology information would enhance adoption of the entire package. Regular information about a technology and its potential to give high outcomes of farm productivity may hasten a farmer's decision to adopt it though some studies such as Omiti et al. (1999) showed no influence on adoption of fertilizers by extension contact.

3.1.2.1.5 Off-farm Employment

This is whether the farmer is employed outside the farming practices. It was assumed that, farmers with off-farm employment earn incomes that would make them more likely to afford the cost involved in new innovations. Also, they are likely to be more exposed to information about new innovations than farmers who are confined within their local environment thus; expectation of high adoption rates among them. Increased off-farm incomes improve farmers' financial position which would encourage them to invest part of it in the farm. Therefore high rate of adoption of new technologies is expected among them.

3.1.2.2 Technology Characteristics

In this section, technology characteristics that were hypothesized to influence farmers' adoption decision of the recommended package for their region are discussed.

3.1.2.2.1 Profitability

This was the profit attained from use of a new technology, measured in terms of yield gain.

Actual yields and profits realized as well as experience accumulated during the period and information on outcomes obtained by other farmers tend to update the parameters the farmers will use in their decision making for the next period. It is worth noting that, farmers will only employ the recommendation if doing so will be profitable as conditioned by extra returns generated because they are rational consumers of a technology. In as much as resource constraints would be regarded as the overriding factors impending adoption of improved farming practices, it is also fair to hypothesize that farmers will adopt those technologies whose yield gains are highest in relation to their resource expenditure. Such are the technologies perceived to be possessing maximum utility to the farmers. High yield gains from adopting the entire package were therefore hypothesized to positively influence its adoption.

3.1.2.2.2 Complexity

These are the many activities that a farmer is expected to undertake while adopting a technology. Technologies that involve a lot of activities in their adoption are assumed to impede adoption. This is because; those farm activities call for huge labour supply that may involve extra costs of production. Less complex technologies are likely to be more adopted.

3.1.2.2.3 Risk Perceived

This is the loss perceived to be experienced should the innovation fail. Technologies with high perceived risks have a negative effect on adoption, they are assumed to be slowly adopted compared with the less risky technologies. Farmers fear to invest in a risky technology especially where costs involved in it are high.

3.1.2.2.4 Relative Investment

This is the total cost involved in investing in a technology in relation to return benefits i.e. relationship between initial costs and relative profitability. High relative investment index means that, the initial costs are high compared to the additional profit that can be obtained. Technologies with high relative investment index are adopted more slowly than those with low relative investment index.

3.2 Data Sources

Data Utilized in this study were collected from both Primary and Secondary sources. The data covered four main areas: The socio-economic characteristics of the farmers, the level to which they have adopted the entire package, factors which determine their adoption behavior of the whole package and effect of adoption of the whole package on yields. Primary data was collected from farmers through a questionnaire (Appendix I) which contained structured and unstructured questions. Data collection was conducted with assistance from three trained research staff. It was collected from six sub-locations sampled out from Kambiti and Makuyu locations. The data covered socio-economic characteristics such as farmers' age, level of formal education, off-farm employment, and access to agricultural information and also farmers' adoption behaviour of the technology's package. Secondary data was extracted from various agricultural economic journals and research reports on adoption of agricultural technologies from other researchers, who conducted their studies both within and outside Kenya. They included works of researchers such as Adesina and Baibu-forson (1995), Barret (1999), KARI (2002), Cheryll et al. (2000), Karugia and Kosura (2005), Juliet (2004) and Wanjohi (2005) among others. These were obtained from institutional libraries such as Kenyatta University, Kenya Agricultural Research Institute (KARI), University of Nairobi Kabete Campus among others. The data included literature review on adoption of agricultural technologies. In this study, adopters were taken to be the farmers who adopted technology components above fifty percent of the recommended standards while non-adopters were those farmers who adopted the technology components below fifty percent of the recommended levels.

3.3 Sampling Technique

This study utilized a multi-stage purposive sampling technique to draw a sample of three hundred farmers for the study. In the first stage, Makuyu and Kambiti locations were purposively selected in Makuyu Division. This is because; they are the driest locations in the division. In the second stage, six sub-locations were purposively selected from these two loctions. They were Gakungu, Makuyu and Kimorori in Makuyu location and also Mihang'o, Karia-ini and Maranjau in Kambiti location. These sub-locations are relatively drier than the rest in their respective locations and experience food problems quite oftenly. The sampled sub-locations formed the strata for the study. Since the total population varied across the strata (sub-locations), the method of proportional allocation technique was used to compute the sample size to be selected from each stratum. The method considered the population size in each stratum (sub-location) in relation to the total population in the sampled region for the study (locations) and the required sample size. This was done in order to remove probability of selection bias. In this method, the sizes of samples from the different strata are kept proportional to the sizes of the population of each stratum using the formula:

$$n1, n2, n3 \ldots\ldots nk = \frac{n \cdot pi}{N}$$ (Mead and Curnow, 1983)

Where; n1, n2, n3…………nk = Sample size for each stratum

N = Total Sample Size

Pi = The Proportion of the Population included in the stratum i.

n = Sample Population for the study i.e. 300 farmers.

Thus, using this formula the sample size from each stratum was obtained as follows; Gakungu 74, Makuyu 64, Kimorori 62, Mihang'o 49, Karia-ini 34 and Maranjau 17 farmers, making a total of three hundred sample farmers.

In the third stage, systematic sampling was used to get the actual unit of study or the farmers to be interviewed. The starting point for every stratum was randomly selected from a central point which was either a market place or a road junction. Then, following either a road or a footpath, every tenth household was selected for the interview until the desired number was achieved in each sample unit (stratum). Random sampling was based on the notion that, every farmer had equal probability of being selected for the interview.

3.4 Data Collection Techniques

The methods used to collect data for this study are analyzed in this section. Data was collected mainly through questionnaire and interview methods.

3.4.1 Questionnaire Technique

The sampled farmers were interviewed using a questionnaire (Appendix I) which contained both structured and unstructured questions as the survey instrument. They were administered to the sampled farmers with assistance of three well trained research assistants. The questions focused on farmers' socio-economic characteristics, sources of information about agricultural technologies and their adoption behaviour of the whole package.

3.4.2 Interview Technique

Interview schedule was conducted on the sampled farmers. They were engaged in a face to face interview schedule of between ten to twenty minutes using structured questions (Appendix II). The questions mainly focused on in-depth information about the level of adoption of the whole package. Also, the reasons underlying the adoption behaviour by both partial adopters and the adopters of the entire package. The questions also included farmers' views about the incentives which if accorded to them would promote adoption of the entire package. The survey was conducted during the 2007 cropping season. The interview process achieved one hundred per cent response.

3.5 Methods of Data Processing and Analysis

This section provides a description of the methods used in the actual analysis of the data set to test the statistical significance of the various factors hypothesized to influence adoption of the entire package. Logit regression model was used to analyze the data (Kennedy, 1985). Also, descriptive statistical summaries were computed to describe the data set.

3.5.1 Descriptive Statistics

Descriptive statistics focusing on frequencies, means and percentages were used to summarize the farmers' adoption behaviour and to characterize adopters of the package components. Cross tabulation was done on the data set in order to establish existence of any relationship between selected socio-economic and technology-specific attributes and adoption of the technology components. This method establishes or explores relationships between variables i.e. how each variable influences the other. Chi-square test was also carried out on the data set. The test explores for existence of a relationship between variables in a data set whose variables are numerical or dichotomous. The method assumes data to be a random sample. This study used chi-square test because data was collected through random sampling technique and it was also a dichotomous data. Each socio-economic and technology characteristics (independent variable) tested for a relationship with the improved maize variety's package components (dependent variable) has both a null hypothesis (H_o) and an alternative hypothesis (H_1). To show that there is no relationship, the rejection level is 0.05 or 5% level of significance. The null hypothesis (Ho) is rejected and the alternative hypothesis (H_1) accepted when the calculated p value is at less than or equal to 5% level of significance ($p \leq 0.05$) (Appendix Iv). The selected socio-economic variables which were tested for relationship with adoption of the entire package included age, education level, gender, contact with extension and off-farm employment. The selected technology-specific variables which were tested for relationship with adoption of the entire package included cost involved, complexity, profitability and risks perceived.

3.5.2 Logit Model

Many models used in adoption studies fail to meet the statistical assumptions necessary to validate the conclusions based on the hypothesis tested (Feder et al., 1985). This calls for use of qualitative response models. The most commonly used are probit and logit. This is because; their probabilities are bounded between 0 and 1. Also, they compel the disturbance terms to be homoscedastic because the forms of the probability functions depend on the distribution of the difference between the error terms associated with one particular choice and another. Logit analysis in this study was chosen because the dependent variable is dichotomous. The study focused on farmers' decisions to adopt the entire package of improved maize varieties and sought to quantify the probabilities of significant factors influencing the decision to adopt the package components entirely.

Farmers were categorized as adopters and non-adopters. Adopters of the package were defined as those farmers who adopted over 50% (more than three out of the six) of the package components to the recommended standards. Non-adopters were the farmers who adopted below 50% (three and below) of the package components. The rationale for this categorization was because the study established that only 1% of the interviewed farmers had adopted the package components as required. These results were not sufficient enough to draw a conclusion for the study hence need to transform the data set into a dichotomous data of adopters and non-adopters using this adoption index.

Defining Y as adoption of the package, and the adoption decision as a function of a set of farmers' characteristics and technology-specific attributes, the empirical model used was;

$Y= \beta o+\beta_{X1}+ \beta_{X2}+ \beta_{X3}+ \beta_{X4} + \beta_{X5}+ \beta_{X6}......+U$ (Maddala, 1983 and Amemiya, 1994).

Where; Y= Adoption of package components

X_1= Age

X_2= Education level

X_3= Income level

X_4= Contact with extension

X_5= Cost of technology

X_6= Complexity

U=Disturbance term

β's= are the coefficients of the independent variables

Further, logit regression based on stepwise multiple regression method was used to establish the variables that had the most significant influence on adoption index. Logit regression is suitable in predicting the outcome based on values of a set of predictor variables as long as the dependent variables are dichotomous while the independent variables are either categorical or interval (Amemiya, 1994). Spearman's *rho* correlation coefficient test was used to establish the factors that had linear relationship with adoption of the entire package.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

In this chapter, the major results of the study are discussed. Statistical methods such as percentages, frequencies and cross tabulations were used to analyze the socio-economic characteristics of the farmers, the extent to which farmers are adopting the entire package and the factors which influence their level of adoption of the whole package as recommended. Statistical tests such as the chi-square and Spearman's *rho* were carried out to check for existence of any statistical relationship between some selected socio-economic characteristics of the farmers and technology-specific attributes and adoption behaviour. These factors were thought to influence farming decisions in as far as adoption of improved agricultural technologies are concerned.

4.1 Results of Descriptive Analysis

This section used frequencies and percentages to discuss the socio-economic characteristics of the farmers that were likely to influence adoption pattern of the recommended maize technology's package in Makuyu Division. These characteristics included age of the farmers, gender, level of formal education, level of off-farm income and contact with agricultural extension agents.

4.1.1 Socio-economic Characteristics of the Farmers

The study interviewed three hundred farmers of whom one hundred were from Kambiti and two hundred from Makuyu locations respectively. The study found that a majority of 96.6%of farmers in the sample have less than two acres of land. So they are smallholder farmers. That means there was no much difference in landholdings between the adopters and the non-adopters of the entire package. This being the case, farm size was not considered as a factor influencing adoption of the package since all the interviewed farmers have small land size. Farmers were also found to be devoting nearly every available land to farming activities.

Most of the interviewed farmers were females (62%) while males were 38% (Table 4.1). Those female farmers are the managers of their farms and therefore the main decision makers of farming activities. Adoption of the entire package along the gender line was found to follow the same pattern that, female farmers were found to have adopted the package components more than their counterpart male farmers. Being the main decision makers, they tend to be more rigorous in trying out new agricultural innovations unless when economic constrains restrains their efforts.

Table 4.1 Gender of the Farmers

Sex	Frequency	Percent
Male	113	38.0
Female	187	62.0
Total	300	100.0

Source: Field Work, 2007

Ages of the farmers appeared to be evenly distributed across the four categories of age groups with a very minimal difference (Table 4.2). Most of the sampled farmers fell within the middle ages category of between fourty and fifty years. It would be expected under normal circumstances that, such middle aged people are engaged in some kind of employment outside farming activities (Cheryll et al., 2000) other than doing farming as their main economic activity. However, being farmers it is expected that, they would be more anxious to adopt new agricultural technologies which was not the case as discussed in another section in this chapter.

Table 4.2 Ages of the Farmers

Age category	Frequency	Percent
21-30	58	19.3
31-40	79	26.4
41-50	82	27.3
50+	81	27.0
Total	300	100.0

Source: Field Work, 2007

Most of the interviewed farmers had gotten formal education up to primary level (67.3%) while only 14.7 % have not had any formal education (Table 4.3). However, farmers who had gone beyond primary school level were few (about 18%) which reflect some handicap in education standards. This implies that, there are some problems that hinder education progress among children in the division which requires further research because such low levels of education can affect adoption of new agricultural technologies among farmers.

Table 4.3 Farmers' Level of Education

Level of Education	Frequency	Percent
Non-formal	44	14.7
Primary	202	67.3
Secondary	50	16.7
Higher Level	3	1.0
Total	299	99.7
Missing value	1	.3
Total	300	100.0

Source: Field Work, 2007

Farming was the primary occupation of the interviewed farmers for 88.7% had no off-farm employment and therefore had no off-farm income. They depend on their farms entirely for their livelihood. Among those with an off-farm employment, majority receive an income of less than ten thousand shilling per month and may therefore be economically constrained (Table 4.4)

Table 4.4 Farmers' Level of Off-farm Income

Level of Income	Frequency	Percent
No Off-farm Income	266	88.7
Less than 5000	17	5.7
5000-10, 000	13	4.3
10, 000	4	1.3
Total	300	100.0

Source: Field Work, 2007

Contact between farmers and the agricultural extension staff was found to be very little. Out of the three hundred interviewed farmers, only 3.7% reported that they had received extension advice within the last four years (Table 4.5). However, most of them reported that they were visited only once and were given agricultural information orally. Without demonstrations, they perceived the information given as irrelevant to their region in relation to their farming circumstances.

Table 4.5 Contact with Agricultural Extension Staff

Contact with Extension	Frequency	Percent
Contacted	41	13.7
Not contacted	259	86.3
Total	300	100.0

Source: Field Work, 2007

4.2 Descriptive Statistics on Adoption of the Entire Package

In this section, the extent to which farmers have adopted the entire package of the improved maize varieties recommended for Makuyu Division is discussed. Frequencies and percentages were used to establish the level of adoption of the improved maize seeds and the agronomic practices that go with those maize seeds. These statistical methods together with the cross tabulation were used to categorize the data as dichotomous and therefore grouped the farmers as either adopters or non-adopters of the entire package. The criteria for this categorization and the level of adoption of the entire package using this criteria are also discussed in this section.

4.2.1 Adoption of Improved Maize Varieties in Makuyu Division

The improved maize variety's package contains a specific maize variety and the agronomic practices which any farmer planting that maize variety needs to employ in order to realize the maximum yield gain expected from it. Among the improved maize varieties planted as a sole maize crop variety in the farm, H511 was the most popular and was planted by 24% of farmers in the sample. Pioneer seed was the second most popular variety and was planted by 11.3% of the farmers in the sample. Farmers also adopted other improved maize varieties suitable for the region at different proportions as indicated in Table 4.6. Some farmers also plant the local maize varieties called 'Gikuyu' and 'Nyagithigu' together with the improved varieties as shown in table 4.6 but not in a mixed intercrop system. They devote small portions of their farms to these local maize varieties mainly during the short rains.

Table 4.6 Adoption of Improved Maize Seeds in Makuyu Division

Maize Variety	Frequency	Percent
Pioneer/ 'Gikuyu'/ 'Nyagithigu'	83	27.7
H511	72	24.0
Nduma/ 'Gikuyu'/ 'Nyagithigu'	55	18.3
Pioneer	34	11.3
Nduma 42	31	10.3
Panner 5243	16	5.4
H513	9	3.0
Total	300	100.0

Source: Field Work, 2007

All the farmers in the sample were found to be planting improved maize varieties. These results show that, there is high awareness of the improved maize varieties suitable for Makuyu Division among the farmers. Most of the interviewed farmers reported that, they have been planting these varieties every year during the long rains season (March to May) because of their high yielding potential.

Further, the results revealed that, farmers also plant the "local" or "traditional" varieties called 'Gikuyu' and 'Nyagithigu' occasionally out of their strong traditional attachment to the seeds. Farmers also believe that, these local varieties are more droughts tolerant though their yield potential is low compared to the improved varieties as such, they have not fully abandoned them. They prefer to plant these varieties mostly during the short rains' season (October and December) because their moisture requirement is lower than the improved seeds.

4.2.2 Adoption of the Agronomic Practices

The recommended package for the study area contains the specific improved maize seed and the agronomic practices that must accompany that seed in order for it to realize the maximum yield gains expected. Hassan (1998) observed that, modern seed varieties are employed with a package of chemical fertilizers or pesticides and recommended crop husbandry practices in order for them to sustain the expected high yield. The agronomic practices prescribed in the package are shown by table 4.7.

Table 4.7 Agronomic Practices Recommended for Makuyu Division

Agronomic Practices	Description
Planting Fertilizer	D.A.P or N.P.K 20:20, 23:23 or 17:17 200kg/ha (80kg/acre)
Cattle Manure	2 tons per hectare (0.8 tons per acre)
Top dressing	C.A.N at crops' knee-high height
Planting Date	Before onset of the rains
Weed Control	Twice per season
Crop Spacing	75cmx35cm, 1 seed per hole or 90cmx60cm, 2 seeds per hole

Source: Wanjohi (2005).

The study revealed that, farmers are not adopting the agronomic practices to the recommended standards. As for soil fertility management, 90% of the farmers in the sample used either fertilizer or cattle manure or a mixture of both, while 10 % did not apply either of them. Fertilizer use was defined as the application of any amount of basal fertilizer during planting or during top dressing (Ouma et al., 2002). However, the rate of application of fertilizer was far below the recommended rates of 80kgs per acre i.e 200kg/ha. (Table 4.8) and also Appendix III.

Table 4.8 Level of Application of Fertilizer by the Farmers in Makuyu Division

Fertilizer Amount in kg/acre	Frequency	Percent
0-9	12	3.9
10-19	26	8.6
20-29	23	5.6
30-39	7	2.4
40-49	12	3.9
50-59	36	11.0
60-69	7	2.4
70-80	2	0.6
Above 80	2	0.6
Total	117	39.0
Missing System	183	61.0
Total	300	100.0

Source: Field Work, 2007

Application of cattle manure was also far below the recommended amount of 0.8 tons per acre for manure. Only 23% of farmers in the sample applied either fertilizer or manure to the recommended amount. This is an indication of low level of adoption of fertilizer and cattle manure. Further, the farmers were found to be applying the correct types of fertilizer prescribed in the package. Among the recommended types of fertilizer for planting, compound fertilizer Diammonium Phosphate (D.A.P) was the main basal fertilizer used by the adopters (51.8%). From these results, it becomes reasonable to support that farmers are aware of the right types of fertilizers to apply when planting but some constraints unearthed in another session of this study hinder them from meeting the recommended amounts. This is congruent with Akpoko and Arokoyo’s (1999) study on adoption of maize and fertilizer technologies in Nigeria which established that, all the sampled farmers had adopted fertilizer but only 0.4% of them had adopted it at the correct rate.

This study also revealed that, a higher percentage of farmers in the sample used cattle manure. Application of cattle manure is the traditional method of maintaining soil fertility used by the farmers in the region because it is less expensive. However, their rate of application was also low as many were applying less than the recommended amount of 2 tons per hectare. This could be attributed to the fact that, the amount of cattle manure available at farm level is low yet the cost of purchasing the deficit amount is high. This constrains the farmers from adopting it to the recommended standards. Cattle manure requires to be further composted by covering it for at least three weeks to prevent nitrogen escape as it decomposes further in readiness for use. This agronomic practice is inadequately adopted for none of the interviewed farmers was found to be decomposting it for the period recommended. They were not aware of this requirement. This information gap was identified as an impending factor towards adoption of this technology component.

Top dressing is vital for crop growth as it increases growth vigour (Welch, 1979). It is done when maize is at height of 45cm or at knee-high (Wanjohi, 2005). The recommended type of top dressing fertilizer is Calcium Ammonium Nitrate (C.A.N.). Many farmers (46.3%) were found to be top dressing their crops at the right time but they used planting fertilizers. Only 24.3% of the interviewed farmers used the right type of top dressing fertilizer. This reflects lack of adequate information about top dressing technology.

Of the sampled farmers, 28.7% planted before the onset of the rain as recommended while 71.3% planted after onset of the rains which is not the recommended time for planting. The uncertainty of rainfall continuity causes them to fear the risk of huge losses should the rain fail after they had planted. Many farmers also argued that, the soil becomes very hard to penetrate during the dry season which discourages them from planting before the rains begin. This concurs with Allan's (1971) observation that, small-scale farmers find it difficult to plant early due to the hardness of the soil. Farmers also fear that, the rains may be late and the dry-planted seed get wasted though planting after onset of the rains results to loss in yields. This is a clear indication that, adoption of timely planting in the region is low, implying lack of awareness about planting time and the principles behind it.

As for weed control, 84.7% of the sampled farmers weeded twice per season as required, though they do it as a common farming tradition in the region. Fifty nine percent of the farmers in the sample applied the correct crop spacing of 75cmx35cm, one seed per hole or 90cmx60cm, two seeds per hole as per the recommendation. This is an indication of high level of awareness of adoption of crop density among the farmers. The non-adopters of the right crop density supported the view that, high crop density provides livestock fodder and reduces the weed biomass thereby reducing weeding frequency as the crop cover smothers the weeds. Table 4.9 gives a summary of adoption of the package components.

Table 4.9 Summary of Adoption of the Package Components

Technology's package	Adopters Count	%	Non-Adopters Count	%	Total Count
Improved Seed	300	100.0	0	0	300
Planting before onset of the rains	86	28.7	214	71.3	300
Fertilizer or Manure	254	84.7	46	15.3	300
Top Dressing	69	23.0	231	77.0	300
Weed Control	73	24.3	227	75.7	300
Correct Crop Density	177	59.0	123	41.0	300

Source: Field Work, 2007

4.2.3 Level of Adoption of the Entire Package

As for adoption of all the six technology components that constitute the package recommended for Makuyu Division, only 1% of the farmers in the sample were found to have adopted it as required. Adoption level was determined using formulae;

$$Y = d_1 + d_2 + d_3 + d_4 + d_5 + d_6$$

Where; Y is adoption of the entire package, d_1 is improved maize seed, d_2 is planting before onset of the rains, d_3 is weeding twice, d_4 is correct crop density, d_5 is planting with the standard amounts of fertilizer or manure and d_6 is top dressing appropriately. Farmers were found to have adopted these technology components at different levels. Table 4.10 shows the level to which farmers had adopted each technology component.

Table 4.10 Level of Adoption of the Package Components

Adoption Level	Technology Component	Count	Percentage
	d_1	300	100.0
	d_2	86	28.7
	d_3	254	84.7
	d_4	177	59.0
	d_5	69	23.0
	d_6	73	24.3
Total		300	100.0

Source: Field Work, 2007

These results show low level of adoption of the entire package. They were therefore not found to be sufficient enough to draw a comprehensive adoption conclusion for the study area. The data was then classified as dichotomous whereby; adopters were taken to be those farmers who adopted above 50% of the package components i.e more than three of the technology components to the recommended level. This was taken as satisfactory level of adoption. Non-adopters were those farmers who adopted three technology components and below, to the recommended level. This was taken as adoption below expected level. Following this criteria, adoption index level established that, only 33.3% of the sampled farmers had adopted the entire package to satisfactory level while 66.7% of the sampled farmers had adopted it at below the expected level (Table 4.11).

Table 4.11 Adoption Index of the Package in Makuyu Division

Number of Technology Components Adopted	Percentage of Adoption	Frequency	Percent	Percentage of Adopters	Percentage of Non-adopters
1	16.67	7	2.3	–	2.3
2	33.33	58	19.3	–	19.3
3	50.00	135	45.0	–	45.0
4	66.67	72	24.0	24.0	–
5	83.33	25	8.3	8.3	–
6	100.00	3	1.0	1.0	–
	Totals	300	100.0	33.3	66.7

Source: Field Work, 2007

This analysis of the dichotomous data therefore revealed a low level of adoption of the entire package. This concurs with Batz et al.'s (1999) study in Embu District who found that, farmers had largely adopted the improved maize variety but had ignored the agronomic practices contained in the package partially or entirely leading to low yields as was established by this study. The results are also congruent with a study on adoption of composite soil fertility enhancement technology by Makokha et al. (1999) which established that, all farmers were applying the technologies but at rates far below the standards recommended hence , low production potential. This reveals that, there is need to promote utilization of agricultural technologies to the optimal level to enable high production potential of the land to be achieved.

The adopters reported various incentives contained in the package as motivational factors in their adoption decisions. High yields was cited by 45.1% of farmers in the sample, 39.2% cited early maturity, 9.8% cited drought resistance while 5.9% cited well filled maize cobs. The main reasons for not adopting the entire package as given by the non-adopters included a combination of high cost involved in technology adoption as reported by 67.9% of the interviewed farmers, complexity of the technology (71.4%), high perceived risks (86.7%) and lack of technical knowledge about it (8.3%). Adesina and Zinnah (1993) made similar observations that, inadequate access to factors of production limits farmers' ability to adopt agricultural technologies. Four farmers did not give reasons for their non-adoption decision.

4.3 Socio-economic and Technology Characteristics and Adoption of the Entire Package

Cross tabulation and Chi-square test were used to establish whether there were any relationships between selected socio-economic variables, technology characteristics and adoption of the entire package components.

4.3.1 Socio-economic Characteristics and Adoption of the Entire Package

4.3.1.1 Age and Adoption of the Entire Package

Age of the farmers had no effect on adoption of the entire package. Low adoption of the package components was found across farmers of different ages. Of those who had adopted the package entirely, 23% were between ages twenty one and thirty years, 29% were between thirty one and fourty years, 23% were between fourty one and fifty years while 25% were above fifty years. This shows that adopters were evenly distributed across the four different age categories used in the study. The calculated p-value of 0.44 (Table 4.12) shows no significant relationship between farmers' age and adoption level at 5 % level of significance ($p>0.05$). Hence adoption of the entire package was not in any way influenced by the farmers' age. This is contrary to Adesina and Forson's (1995) findings in West Africa that older farmers could have had preferential access to new technologies through increased contact with technology promoters and other development projects in the area thus promoting their probability of adopting new agricultural technologies.

Table 4.12 Ages of the Farmers and Adoption Status

Technology adoption status	Age in Years				X^2	P-value
	21-30	31-40	41-50	50+		
Adopters	23.3	29.0	23.0	25.0	2.701	0.440
Non-Adopters	17.5	25.0	29.5	28.0		

[N S =Not Significant at 0.05 (5% level of significance)]

Source: Field Work, 2007

Age of the farmers was found to have no influence on their adoption decision, though young farmers would be expected to be more curious in trying out new agricultural technologies. These results are contrary to Ashby's (1991) findings that, adoption of new farming technologies is greatly influenced by the age of farmers. According to him, young farmers are eager to participate in agricultural research more than old farmers and therefore become more anxious to adopt new agricultural technologies. Contrary to his findings, this study established no significant difference in ages between the adopters and the non-adopters across the four age categories because there were many adopters and also non-adopters of the technology components in each category.

4.3.1.2 Gender and Adoption of the Entire Package

Gender was found to have a significant influence on adoption of the entire package at 5 percent level of significance. High level of adoption of the entire package was found among female farmers. Fifty four percent of the adopters were females while fourty six percent were males. These findings differ from the norm that, females are disadvantaged economically and may not afford costs involved in adoption of new agricultural technologies. Female farmers normally tend to be less curious in trying out new innovations unlike their male counterparts. They would therefore be expected to lag behind male farmers in adopting new agricultural technologies which was not the case in this study. The calculated p-value of .035 (Table 4.13) is an indication of a positive and significant relationship between gender of the farmers and adoption of the entire package at 5% level of significance.

Table 4.13 Gender of the Farmers and Adoption Status

Technology Adoption Status	Females	Males	X^2	P-value
Adopters	54.0	46.0		
Non-adopters	66.5	33.5	4.437	0.035*

[* Significant at 0.05 (5% level of significance)]

Source: Field Work, 2007

These findings may be attributed to the fact that, female farmers are more likely to adopt the recommended package when farming represents their major economic enterprise and they explore all available mechanisms and opportunities of achieving maximum benefits from farming. Women do most of the farm work unlike their male counterparts and as a result make more reliable farming decisions. In this region of study, women were found to be better and faster adopters of new agricultural technologies since farming form the main economic enterprise for most of them. Further, males may be more educated than females giving them a wider opportunity of off-farm employment and therefore farming may be a part time activity for them. Low levels of education among females generally tend to limit their chances of being absorbed in off-farm employment. They are mostly confined in the farms and are expected to be more likely to adopt new agricultural technologies that provide high yields, due to their obligations of meeting food demands for their families. This contradicts Ndiema et al. (2002) who found no significant relationship between adoption of improved seed varieties and gender of the farmers.

4.3.1.3 Education Level and Adoption of the Entire Package

Among the adopters, 27.3% had not received formal education, 30.7% had attained primary school education while 50% had attained education beyond primary school level. Therefore as the level of education increases, the level of adoption of the whole package also increases. The p-value of 0.050 (Table 4.14) reveals some relationship between education level and adoption of the whole package at 5% level of significance ($p \leq 0.05\%$)). This concurs with Nkonya et al.’s (1997) study in Northern Tanzania on adoption of improved maize technologies who made similar observations that, farmers’ level of education had significant influence on adoption of fertilizer and hybrid seeds.

Table 4.14 Education Level of the Farmers and Adoption Status

Technology adoption status	Non-formal	Primary	Secondary	Tertiary	X^2	P-value
Adopters	27.3	30.7	48.0	66.7	7.786	0.050*
Non-Adopters	72.3	69.3	52.0	33.3		

[* Significant at 0.05 (5% level of significance)]

Source: Field Work, 2007

This implies that, formal education is vital in promoting adoption of agricultural technologies as farmers may use the information given more effectively. Education enables them to assess the relative benefits and risks from using alternative complex technologies and therefore make rational decision on farming. Also, it may widen their scope of understanding the rationale behind adoption of all the technology components contained in a package. Education increases managerial competence, thereby enhancing the ability to assess, comprehend and respond to new ideas. It also enables the farmers to choose wisely from a stock of available technologies. These findings concur with those by Amudavi (1993) in which education was found to invariably enhance technology utilization. Extension system must, therefore, seek to compensate for lack of formal education among the farmers by going beyond the extension role of prescriptive communication and emphasize on education and skill enhancement (Byerlee, 1994).

The many adopters who had attained formal education beyond primary school show the importance of formal education in promoting adoption of agricultural technologies among the farmers. Educated farmers are more likely to undertake risks associated with adoption of new agricultural technologies in their efforts to practice agricultural skills learnt from various institutions or agricultural seminars. Hence, high level of adoption among them. However, the relatively high number of non-adopters who had attained formal education is an indication that, there are other factors that influence adoption of the package components other than education levels.

4.3.1.4 Income Level and Adoption of the Entire Package

Income level showed significant relationship with adoption of the entire package. Most adopters had off-farm income while many non-adopters had no off-farm income. Among the farmers who had no off-farm income, only 30 % adopted the package entirely, 41.2% of the farmers with an income of less than five thousand shillings per month adopted the package entirely, 50% of adopters earned an income of between five to ten thousand shillings per month while 69.2% from among the farmers who earned an income of above ten thousand shillings per month adopted the entire package. Hence adoption of the entire package increased with increase in levels of off-farm income. This implies that, an increase of a farmer's income would probably raise the level of adoption of the entire package by improving the ability of that farmer to buy farm inputs. Income level was positively related to adoption of the entire package at 5% significant level (Table 4.15). Farmers with an off-farm income invested part of it to purchase farm inputs. They were able to afford the costs involved in the package adoption. This is contrary to Juliet's (2004) findings that, off-farm income had no positive relationship with intensity of adoption of soil fertility management technologies in Western Kenya. Furthermore, farmers employed outside their local environment have more exposure that result in greater access to information about new agricultural technologies and are therefore more likely to try them out.

Table 4.15 0ff- farm Income and Adoption Status

Technology adoption status	No Off-farm Income	Less than 5000 Ksh	5000-10,000 Ksh	10,000+ Ksh	X^2	P-value
Adopters	30	41.2	50.0	69.2	9.261	0.026*
Non-Adopters	70	58.8	50.0	30.8		

[*Significant at 0.05 (5% level of significance)

Source: Field Work, 2007

Most adopters had an income of more than five thousand shillings per month. The positive relationship between income level and adoption of the entire package implies that, farmers with off-farm income expect to realize high returns from investing it in the farm and therefore use part of it to improve farming practices. The small percentage of adopters among farmers without off-farm income is a further indication that, farmers could be aware of the benefits associated with adopting the whole package but their efforts are limited by financial constraints other factors held constant. This implies that, economic intervention measures such as reduced costs of farm inputs would promote the levels and intensity of adoption of the entire package among such farmers.

4.3.1.5 Contact with Extension and Adoption of the Entire Package

Knowledge about the technology is crucial to the potential adopters in their adoption decision. The traditional conceptualization about the adoption process favoured by Rogers (1983) considers awareness and knowledge about new technologies as the first stage through which potential adopters go through before they finally decide to adopt or reject a technology. During this stage farmers seek information that can help them in their adoption decision. The results of this study revealed no significance difference in adoption between the farmers who had received extension advice and those who had not. The adopters who had not been contacted by the technology promoters within the last four years were more (33.6%) than the adopters who had been contacted at least once in the last four years (31.7%). This shows no significant difference between them ($p > 0.05$) at significant level of 5%.

Though contact with technology promoters is hypothesized to promote adoption of new agricultural technologies the p-value of 0.812 (Table 4.16) is an indication of no relationship between contact with extension staff and adoption of the package at significant level of 5%. This is congruent with Omiti et al., (1999) that extension contact had no significant influence on adoption of fertilizer because extension messages may neither be practical nor relevant to the large number of farmers contacted. Furthermore, extension recommendations may not be suitable within the farmers' farming circumstances (Byerlee, 1994).

Table 4.16 Contact With Extension and Adoption Status

Technology Adoption Status	Contacted by Technology Promoters	No Contact with Technology Promoters	X^2	P-value
Adopters	31.7	33.6		
Non-adopters	68.3	66.4	0.570	0.812

[N S =Not Significant at 0.05 (5% level of significance)]

Source: Field Work, 2007

Technology promoters provide technical backstopping in terms of information which makes it easier for the contacted farmers to adopt a technology or increase intensity of its use. However, the high percentage (68.3%) of non-adopters who had been contacted by the agricultural extension agents implies that, there are problems either in the manner in which agricultural technologies' information is disseminated to the farmers or that there are some constraints which hinder farmers from implementing the technologies. Many farmers who had been contacted by agricultural extension staff reported oral method to have been the main method of dissemination of agricultural information to them. Only 1.3% of the interviewed farmers reported to have attended agricultural demonstrations, while a bulk of 86.7% reported they had not heard of agricultural demonstrations in their region within the last four years. Yet, demonstrations enable farmers to assess the feasibility of new agricultural technologies within their environment and farming circumstances. Exposure to agricultural technologies has been found to highly enhance intensity of their adoption (Ransom et al., 2003). This is contrary to the findings of this study.

The higher number of adopters who had no contact with extension advice (33.6%) than the adopters who had been contacted by technology promoters (31.7%) is an indication that, farmers' awareness of improved agricultural practices does not necessarily result from contact with extension services. Rather, information about agricultural technologies can diffuse to the farmers through other channels than from the extension system even if the original source of that information was the extension system. Information gap was clearly evidenced in the study area. This causes farmers to have inadequate conceptualization of the importance of adopting the whole package. Therefore the level of adoption of the whole package among them is low. This concurs with the innovation-diffusion model (Agrawal, 1983) that considers access to information as a key factor in determining adoption decision. Diffusion of information about agricultural technologies and measures that promote diffusion process are important in influencing adoption decision. There is therefore need for frequent contact between farmers and the promoters of technology and also need to improve channels of communication about agricultural technologies in order to promote their adoption.

4.3.2 Technology Characteristics and Adoption of the Entire Package

Farmers make adoption decision based on the appropriateness of a technology. Technology attributes influence farmers' adoption decision as much as their own socio-economic characteristics influence adoption decision of a new agricultural technology (Mulugeta et al., 2001). This is why farmers need to fully understand the technology attributes in order to increase its adoption. Perception of technology characteristics as a problem was high among the farmers in the sample as many non-adopters cited them as the factors that have been influencing their adoption decision. Among the non-adopters, 71.4% gave complexity of the technology as an impeding factor to adoption of the entire package while 86.7% and 67.9 % reported high risks perceived and high costs respectively as the factors that affect their adoption decision (Table 4.17). Also, 63.2% of non-adopters perceived the benefits of adopting the entire package in terms of yields to be low. This is more so because the improved seeds are affected by rainfall variations more than the local seeds and any shortfalls in the amount of rainfall received results to crop failure. Technology-specific attributes were also perceived to be a problem among the adopters. They also cited complexity, risks of loss should rains fail and high costs involved in adopting the entire package as factors affecting their adoption decision. The three factors had negative influence on adoption of the entire package at 5% level of significance. This implies the importance of understanding a technology's attributes by the farmers in order to promote its adoption. Table 4.17 shows the technology-specific attributes that influenced farmers' adoption decision as given by both adopters and the non-adopters.

Table 4.17 Technology Characteristics and Adoption Status

Technology Adoption Status	Complexity of Technology	Risk Perceived	Cost of Adoption	X^2	P-value
Adopters	28.6	13.3	32.1		
Non-adopters	71.4	86.7	67.9	3.080	-0.688*

[* Negatively Significant at 0.05 (5% level of significance)]

Source: Field Work, 2007

Technology characteristics negatively influenced adoption of the entire package. A high percentage of the farmers in the sample were found to be affected more by the technology-specific attributes in their adoption decision. Farmers tend to adopt technologies that give them high profits as this is the major reason for any adoption of a technology. Perception of low benefits from adopting a technology in relation to its complexity or high perceived risks or costs involved discourages its adoption. This is because, farmers prefer to adopt technologies that give them maximum yields at minimum cost of production and which would also ensure achievement of the targeted objectives.

Among the technology-specific attributes, high costs and complexity of the technology were cited by both the adopters and the non-adopters to have influenced their adoption decision. The two variables are disincentives towards adoption of the entire package. The recommended package is complex in the sense that, the seeds must be planted with specific fertilizer types and amounts or specific amount of cattle manure. Also, planting before onset of the rains involves advance land preparation when the soil is dry and difficult to penetrate hence, hard labour. Further, crop spacing and weed control involve a lot of labour all which account for complexity of technology. Both the seeds and fertilizers are expensive to purchase, and use of hired labour in land preparation and weed control all amount to high costs involved in adopting the entire package. Many farmers therefore fail to apply these agronomic practices to the expected level out of fear that, should the rains fail, investment losses would be high in terms of both capital and human labor involved. This concurs with Just and Zilberman (1983) and Adesina and Baidu-Forson (1995) who made similar observations that, perception of technology-specific attributes inherent in a new agricultural technology such as risks and complexity in use of a technology influence farmers' subjective decision to adopt or reject a technology.

As far as the socio-economic and technology characteristics were concerned, the variables that were found to affect the probability of adoption of the entire package positively were education level, income level, gender, and perceived benefits in terms of yields. Complexity of technology, risks perceived and costs involved negatively influenced adoption of the entire package at 5% level of significance. Age of the farmers and contact with technology promoters did not influence adoption of the entire package. This leads to rejection of the stated hypothesis that, there is no significant relationship between farmers' socio-economic characteristics, technology's characteristics and adoption of the whole package.

4.4 Results of Logit Regression Analysis

Logit regression model was used to analyze the data. The method was chosen because it is suitable in predicting the outcome based on values of a set of predictor variables. It is applicable in analyzing data whose dependent variables are dichotomous while the independent variables are either interval or categorical.

4.4.1 Factors Affecting Adoption of the Entire Package

Logistic regression based on stepwise selection method was used to establish the variables that had influenced adoption of the entire package. The method has a probability selection criteria of selecting those variables based on ANOVA model F_1 and F_2 (Appendix v), at 5% (0.05) level of significance. The models established education and income levels of the farmer to have significant influence on adoption of the entire package at 5% level of significance ($p < 0.05$). For education level, the calculated p value of 0.003 ($p<0.05$) is an indication of a significant relationship between education level and adoption of the entire package while for the income level, the calculated p value of 0.032 ($p<0.05$) implies a significant effect of off-farm income on adoption of the entire package. Also, the βeta index values of 0.136 and 0.127 for education and income levels respectively are indicators of existence of a significant relationship between the two variables and adoption of the entire package. Further, the model established no relationship between ages of the farmers and contact with extension agents and adoption of the entire package at significant level of 5%. The p values of 0.634 for age of the farmers and 0.726 for contact with extension staff ($p>0.05$) are evidences of no relationship between the two variables and adoption of the entire package at 5% level of significance. Table 4.18 shows the factors that were found to have influenced adoption of the entire package by the two models.

Table 4.18 Factors Affecting Adoption of the Entire Package Based on the ANOVA Model

Model	Constant	Beta In	t	Coefficient
1	Education Level	.136	2.951	.003*
	Income Level	.127	2.150	.032*
	Age	-.029	-.477	.634
	Contact with extension	-.020	-.351	.726
2	Education Level	.136	2.314	.021*
	Income Level	.127	2.150	.032*
	Age	-.042	-.697	.486
	Contact with extension	-.021	-.376	.707

[* Significant at 0.05 (5% level of significance)]

Source: Field Work, 2007 and Data Analysis

Levels of education and income of the farmers had significant effect on adoption of the entire package while age and contact with technology promoters had no effect on adoption. This implies that there is need to provide farmers with credit facilities to enable those with low incomes or with no off-farm incomes to afford farm inputs to the recommended amounts. There is also need to provide farmers with agricultural education. Agricultural-based education through agricultural extension services would enable the farmers to comprehend the benefits of adopting agricultural innovations hence promote their level and intensity of adoption of the entire package for more food security gains.

4.5 Results of Spearman's *Rho* Test

Spearman's *rho* test was applied to investigate existence of a correlation coefficient between the dependent and independent variables. The method was chosen because the dependent variables were dichotomous and the independent variables are interval. The method is also easy to compute and the outcome is clearly indicated hence easy to understand and interpret.

The Spearman's *rho* test rejection level of the null hypothesis is at 1% (0.01) level of significance. The null hypothesis is rejected and the alternative hypothesis accepted when the calculated p value is at less than or equal to 1% significant level ($p \leq 0.01$). On the factors determining adoption of the entire package, a positive and significant correlation coefficient was established between levels of education and income and adoption of the entire package at 1% level of significance ($p<0.01$). The p values of 0.003 and 0.004 ($p \leq 0.01$) respectively are indicators of existence of positive and significant relationship between the two variables and adoption of the entire package at 1% level of significance. Table 4.19 indicates that, there is a significant linear relationship between adoption of the entire package and levels of education and income. This implies that as the level of formal education increases, the level of adoption of the entire package also increases. Also, as the level of farmers' off-farm income increases, the level of adoption of the entire package also increases. Farmers with more income are able to meet the cost involved in adopting the entire package.

Table 4.19 Spearman's *Rho* Results on Factors Affecting Adoption of the Entire Package

			Adoption index	age of the farmer	level of education	Income level
Spearman's rho	Adoption index	Correlation Coefficient	1.000	-.096	.169(**)	.167(**)
		Sig. (2-tailed)	.	.097	.003	.004
		N	300	300	299	300
	age of the farmer	Correlation Coefficient	-.096	1.000	-.351(**)	-.043
		Sig. (2-tailed)	.097	.	.000	.454
		N	300	300	299	300
	level of education	Correlation Coefficient	.169(**)	-.351(**)	1.000	.198(**)
		Sig. (2-tailed)	.003	.000	.	.001
		N	299	299	299	299
	Income level	Correlation Coefficient	.167(**)	-.043	.198(**)	1.000
		Sig. (2-tailed)	.004	.454	.001	.
		N	300	300	299	300

[** Correlation is significant at the 0.01 level (2-tailed)].

Source: Field Work, 2007 and Data Analysis

Education and income levels of the farmers were the only variables which were found to influence adoption of the entire package. The relationships were positive and significant ($p<0.01$). As earlier stated, educated farmers are likely to apply modern farm inputs more efficiently because education increases their managerial competence by enhancing their ability to comprehend, evaluate and respond to new ideas. Also, farmers with an off-farm income are capable of investing part of it in the farm while expecting returns on their investment. They are able to withstand risk of losses should the investment fail since they have financial resources to embark on. Age of the farmers and contact with technology promoters which were also hypothesized to influence adoption of the entire package and were included in the model were not significant at 1% probability level in explaining the adoption decision.

4.6 Summary of the Key Findings on the Factors Influencing Adoption of the Entire Package

The major premise regarding factors that affect adoption is that, farmers' own socio-economic characteristics and their perception of specific attributes inherent in a technology represent the most important factors in determining farmers' adoption decision of given technology alternatives. Farmers were found to be aware of the improved maize varieties suitable for their region for all the interviewed farmers were found to have adopted them. However, most of them do not adopt the agronomic practices that accompany those varieties to the recommended levels. As a result, the level of adoption of the whole package recommended for the region is low.

Among the socio-economic characteristics of the farmers that were found to be influencing their adoption decision of the entire package were level of formal education, gender and off-farm income. Age of the farmer, farm size and contact with technology promoters did not affect their adoption decision. The technology-specific attributes that negatively influenced adoption of the entire package included cost involved, complexity of the technology and high perceived risks.

Adopters of the entire package were motivated to do so by the benefits of high yields realized from adopting the entire package and the fact that those varieties mature early.

The improved maize varieties have a high yielding potential, mature early and also resist draught. Among the adopters of the entire package, about 60% reported that they have been harvesting an estimate of more than ten bags per acre per season. Many non-adopters harvest less than five bags per acre on average most of the times. Though they plant the improved maize varieties suitable for their region, their level of adoption of agronomic practices is low. They cited technology-specific attributes of costs, complexity and perceived risks as the major factors that hinder their efforts to adopt the entire package. Overall, the factors that influence adoption of the entire package of improved maize varieties recommended for Makuyu Division seem to lie more on technology-specific attributes and economic constrains other than the social characteristics of the farmers.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The study was carried out in Makuyu Division of Murang'a South District. It analyzed the socio-economic and technology-specific attributes that influence adoption of the entire package of the improved maize varieties recommended for the region. The socio-economic variables considered were age of the farmers, gender, level of formal education, income level and contact with agricultural extension services. The technology-specific attributes considered were cost of the technology, complexity, perceived risks and benefits expected from adopting the entire package. Data was collected through formal interviews and use of questionnaires. A multi-stage purposive sampling and proportional allocation techniques were used to obtain sample farmers. A total of three hundred farmers were sampled and interviewed using structured and unstructured questionnaires.

Adopters of the package were taken as those farmers who planted the recommended maize varieties and had also applied the recommended agronomic practices that go with the seed upto a level of above fifty percent in the last four years. Non-adopters were taken as the farmers who planted the improved seed but applied below fifty percent of the recommended agronomic practices. The recommended agronomic practices included planting with D.A.P or Nitrogenous fertilizers amount of 200 kg per hectare or cattle manure 2 tons per hectare, top dressing with C.A.N, planting before onset of the rains, weeding twice per season, seed spacing of 75cm x 35cm for one seed per hole or 90cm x 60cm, for two seeds per hole.

Descriptive statistic summaries of frequencies and percentages were used in determining the level of adoption of the entire package. They were also used to investigate the influence of socio-economic characteristics of the farmers and technology characteristics' on adoption of the entire package. Cross tabulation and chi-square test were used to investigate existence of any relationship between socio-economic characteristics of farmers, technology-specific attributes and adoption of the entire package. Further, logit regression, specifically stepwise multiple regression and spearman's *rho* test were carried out to explore for existence of statistical relationship between the selected socio-economic characteristics of the farmers, technology-specific attributes and adoption of the entire package.

Results from the descriptive statistics showed that, all the interviewed farmers planted improved maize seed. Fifty four percent planted the improved maize varieties as a sole maize variety in the farm, with H511 being the most popular variety while fourty six percent mixed it with the local seeds called 'Gikuyu' and 'Nyagithigu'. Further, the results about level of adoption of the entire package revealed that 90% of farmers in the sample planted with either fertilizer or manure or a mixture of the two, while 10% of the interviewed farmers did not apply either fertilizer or cattle manure at all. However, though majority of the interviewed farmers used the recommended types of fertilizers, only 3.3% among them applied the required amount of 200 kg per hectare while only 19.7% of the farmers in the sample applied cattle manure to the required amount of 2 tons per hectare. A total of 44% of the interviewed farmers adopted top dressing technology out of whom 23.3% used the correct type of fertilizer (C.A.N) for top dressing and did it at the right time. Weed control and seed spacing practices were well adopted with 84.7% of the sampled farmers weeding twice per season as recommended and 59.2% applying the correct seed spacing. Most of the farmers in the sample (71.3%) planted after onset of the rains instead of the recommended time before rains. As far as the adoption of the entire package was concerned, only one percent of the sampled farmers were found to have adopted the package as recommended. This is an indication of very low level of adoption of the entire package in Makuyu Division.

The computed p values showed that, gender, levels of education and income positively influenced adoption of the entire package at significant level of 5% (0.05). Cost of the technology, complexity, high perceived risk and low perceived benefits had negative influence on adoption of the entire package. Age of the farmer and contact with extension staff had no significant influence on adoption of the entire package.

Stepwise multiple regression analysis found a coefficient correlation between education and income levels and adoption of the entire package at 5% or 0.05 level of significance ($p<0.05$). Age of the farmer and contact with extension staff were found to have no significant influence on adoption of the whole package. Spearman's *rho* test established existence of a positive correlation coefficient between adoption of the entire package and levels of education, income. There was a significant linear relationship between adoption of the entire package, levels of education and income at 1% level of significance ($p<0.01$).

Non-adopters cited lack of information and high cost involved in the technology adoption in terms of purchasing the seed, lack of fertilizer and manure at times as the main constraints hindering adoption. Complexity of the technology was also cited as an impeding factor especially in manure adoption as it requires further decomposing. Planting before onset of the rains was hindered by uncertainty of rainfall continuity and many farmers reported a high risk of loss of seeds and fertilizer incase the rains fail. They preferred to plant after onset of rains as security against losses. Weeding twice is a common practice among the farmers regardless of the seed variety planted. Many farmers across different socio-economic backgrounds planted two seeds per hole using the correct spacing of seeds and holes. Adopters of the entire package gave high yield as the major benefit of adopting it in terms of well filled maize cobs and more than one maize cob per stalk.

5.2 Conclusion

The results of descriptive analysis showed that, awareness of the improved maize variety is high among all the farmers across different socio-economic backgrounds. However, adoption of the agronomic practices that go with the improved seed in order for it to realise maximum yield expected is low. Fertilizer and cattle manure amounts were adopted far below the recommended levels of 200 kg and 2 tons per hectare respectively. Their adoption lags behind adoption of other components. This can be attributed to the high costs of purchasing fertilizers and cattle manure. Users of cattle manure did not fully decompose it which is an indication of inadequate technical knowledge about manure application. Many farmers who did top dressing did not use the correct type of fertilizer. This could also reflect inadequate information about top dressing among the farmers. From these findings it can be concluded that high costs and information gap affect adoption of soil replenishing agronomic practices.

Awareness of weed control and crop density is relatively high among the farmers. These are not new practices because they have been applied from long ago. Farmers hope to get high maize yields and livestock fodder from the two practices. These technologies are also simple and common and therefore not influenced by the socio-economic characteristics of the farmers. Planting before the rain has been influenced by variability of rainfall pattern. Past experience about rainfall unreliability and uncertainty has conditioned the farmers to be planting after onset of the rains in order to reduce the risk of loosing the planted seeds and fertilizer used should the rains fail. The level of adoption of all the technology components contained in the package was low among the farmers in the sample. The conclusion is that, farmers experience some constraints which condition them to adopt the agronomic practices at levels far below the recommended standards.

Logit analysis results showed that, factors that are related to resources affect adoption. Costs of input and income level influence farmers' ability to afford new technologies. This implies that resource factors influence farmers' adoption decision. Education level had a positive effect on adoption of the entire package. It enhances farmers' evaluation of the benefits of adopting new technologies. It enables them to synthesize information about new technologies thus influencing their decision-making process especially regarding relatively complex technologies. There is therefore need to provide farmers with more practical agricultural education and advise them to invest any income available in agriculture especially in adoption of agricultural enhancing technologies in order to meet food security needs. Technical backstopping is very important in terms of information which enhances adoption of agricultural technologies. Technology profitability in terms of high yields was significant in influencing adoption decision. This shows the importance of enlightening the farmers about the technology attributes. They need to be encouraged with motivating information about the gradual realization of benefits associated with adopting a new technology. They should be made to know that, the full potential profitability of a technology may not be realized in the initial years of its adoption but it increases with increased intensity of its use as the farmer gets used to it.

Age had no influence on adoption though it would be expected that older farmers have more experience in the farming enterprise thus a higher likelihood of adopting a new technology than younger farmers. Alternatively younger farmers would be expected to be more vigorous in trying out new innovation thus; have a higher adoption level of a new technology which was not the case in this study. This may be a proof that, technologies are very specific and the factors affecting their adoption are very diverse. Contact with extension services had no influence on adoption. This was attributed to the poor method of disseminating the agricultural information to the farmers. Increase in yield with increased level of adoption of the entire package is an indication that, none of the technology component in the package is efficient on its own and therefore there is need to combine all of them to the required standards in order to achieve maximum yield gains expected from adopting the entire package.

Overall, this study identified economic and information constraints as the main factors that impede adoption of the entire package. These two factors need to be given more attention during introduction and implementation of new agricultural technologies. Communication factor and cost of farm inputs are very powerful in influencing farmers' response towards adoption of the entire package. This study therefore supports the notion that above other factors contact of farmers with the technology promoters and subsidies on farm inputs or provisions of agricultural credits can influence them to adopt all technology components in the package adequately. The problem of non-adoption of the entire package seems to lie more on economic constraints and information gap than on social characteristics of the farmers. Further, the problem also lies on environmental factor of rainfall uncertainty. This makes it necessary for the researchers and the crop breeders to investigate ways of reducing the magnitude of output variability in the face of weather variations especially by introducing seed varieties with more drought tolerance potentials.

In general conclusion, promotion of the agricultural sector needs a package of policies which include inputs, price policies, credit availability and adequate incentives to farmers. This means incorporation of the factors that have negative influence on adoption of agricultural technologies in the design of policies and strategies for promoting their adoption so as to meet food security needs.

5.3 Recommendations

This study established economic constraints and information gap as the main factors impending adoption of the entire package of improved maize varieties recommended for

Makuyu Division. Following these findings, the study has made the following research and extension policy recommendations to be put in place as measures to promote adoption of the entire package. The study has also suggested areas for further research in order to come up with more precautional measures against food insecurity problems in the face of variation in climatic patterns in the region.

5.3.1 Research and Extension Policy Recommendations

The following recommendations were made from this study:-

- The study established information gap as one factor that impedes adoption of the entire package of the improved maize varieties recommended for Makuyu Division. There is therefore need to strengthen contact between the technology promoters and the farmers. This can be done by raising the number of agricultural extension officers in the region and improving their access to the farmers by providing them with transport means and all the necessary materials required for dissemination of agricultural technologies.

- The study also found that, there is weakness in the method of disseminating agricultural technologies to the farmers since most of the interviewed farmers cited oral communication method as the main media of dissemination. Another recommendation therefore is improvement of the methods of diffusing agricultural technologies to the farmers. This can be done in various ways. One of them is allowing grass root participation in the dissemination of agricultural technologies. This can be done by linking the agricultural extension agents with interested organizations such as farmers groups, common interest groups, church groups and

- community based organizations whom they can work closely with and educate them through demonstrations. Then, the same would disseminate the agricultural information to the rest of the farmers within their region. Further, demonstration of agricultural technologies needs to be encouraged. It plays an important role as it enables farmers to see the feasibility of new technologies within their own region. This calls for the need to establish on-farm trials within farmers' reach and involving them in demonstrations in order for them to assess the feasibility and the benefits of adopting those technologies. Dissemination can be further improved by use of mass media such as radios using both Kiswahili and local languages to enhance understanding among the illiterate and semi-literate farmers. Another way of improving dissemination can be by printing information about new agricultural technologies on posters and then displaying them on strategic places such as market places and shopping centers where they can capture attention of many farmers. Those farmers would then seek further clarification about the displayed information from the agricultural extension agents.

- The study further established that, many farmers learnt about the package from other farmers. The study therefore recommends the need to strengthen farmer-to-farmer extension whereby few progressive farmers would be trained on new agricultural innovations. The same would in turn disseminate the technology to the rest of the farmers in their region. Many farmers tend to take information from their colleagues more seriously than from other sources. Strengthening farmer- to-farmer extension would therefore promote adoption of agricultural technologies to a great extent.

- Cost of farm inputs was identified as a major drawback towards adoption of the entire package. There is need to use innovative dissemination mechanisms that are cost-effective and responsive to the needs of the farmers. This would require the research institutions to involve the farmers more in research development and dissemination mechanisms. This is likely to increase adoption rate as farmers would prefer to adopt technologies which have been developed with their full participation. Farmers feel part and parcel of those technologies and would take delight in adopting them.

- Most of the farmers in the sample were found to be adopting the technologies at rates far below the recommended levels and thus, not achieving the expected yield gains. High cost of farm inputs has been mentioned as the main cause of this adoption behaviour. There is therefore need to subsidize costs of seeds and chemical farm inputs especially fertilizers and pesticides in order to enable low income farmers to afford them to the required amounts and therefore achieve high production potentials of their farms.

- To overcome cost problem which affected many non-adopters, the study further recommends provision of credit to the farmers at affordable rates and also advising them on how to invest it in improving agricultural productivity especially in adoption of new innovations. Credit would enable farmers to access the resources needed especially farm inputs. Capital is necessary to finance the uptake of new agricultural technologies. This is especially so when adoption of a particular technology requires huge capital outlay that constitutes a significant proportion of the total amount of capital available to the farmer (Feder and Zilberman, 1985). Further, Khan's (1975) study in Pakistan showed that, majority of smallholder farmers reported shortage of funds as a major constraint to adoption of divisible technology like fertilizer use.

- The study also found out that, technology-specific attributes mainly complexity and perceived risks discourage adoption of the entire package. It therefore recommended that technologies whose adoption process does not involve many activities outside the usual traditional farming practices be developed and embraced. Also development of technologies that are less risky to adopt. Priority can be given to development of maize varieties whose fertilizer requirement is low and which are more droughts tolerant.

- Formal education had significant influence on adoption of top dressing and use of fertilizer and manure. The study therefore recommends the need to encourage teaching of agriculture in all learning institutions as it may enhance the ability of the farmers who have attained formal education to understand and interpret the benefits associated with adoption of new agricultural innovations hence, promote their adoption.

- Most of the farmers planted after onset of the rain because of the erratic rainfall pattern. It is necessary to teach farmers about water harvesting techniques to enable them store enough rain water for irrigating their crops when rain fails before the crop matures. There is also need to put in place water intervention measures such as rock water harvesting to ensure water supply at all times to irrigate the crops if needs arise.

5.3.2 Suggestions for Further Research

The study suggests further research in the region on:

- Water use efficiency methods that can help to conserve soil moisture such as mulching, planting of cover crops, crop rotation and fallow farming among others.

- Diversification of traditional draught resistant crops as a precautional measure against draught phenomena in the region.

- Sustainable and cost-effective control of post harvest losses as a measure against food insecurity in the region.

- Integration of agro-forestry into the farming systems as a measure against food insecurity in the region.

LIST OF REFERENCES

Adesina, A.A and Baidu-forson, J. (1995). "Farmers Perceptions and Adoption of New Agricultural Technology: Evidence from Analysis in Burkina Faso and Guinea, West Africa". **Agricultural economics**, Vol. 13:1-9.

Adesina,A.A and Seidi, (1995). "Farmers Perception and Adoption of New Agricultural Technology. Analysis of Modern Mangrove Rice Varieties in Guinea-Bissau". **Agricultural Economics**, Elsevier Science Publishers, Amsterdam.

Adesina, A.A and Zinnah, M.M. (1993). "Technology Characteristics, Farmers' Perceptions, and Adoption Decisions: A Tobit Model Application in Sierra Leone". **Agricultural Economics**, Vol. 9:297-311.

Agrarwal, B. (1983). "Diffusion of Rural Innovations: Some Analytical Issues and the Case of Wood-burning Stoves". **World Development** , Vol.11: 359-376

Aikens,M.T.,Haven,A.and Flinn,W. (1975). **The Adoption of Innovations: The Neglected Role of Institutional Constraints.** Mimeograph, Department of Sociology, OhioState University: Columbus, O.H.

Akpoko, J.G and Arokoyo, J. (1999). **Maize Technology Adoption Among Farmers in Kaduna Agricultural Development Project Villages**. In Baidu-Apraku, B. MAB Fakorede,,M. Ouedraogo and F.M.Quin. **Strategy for Sustainable Maize Production in West and Central Africa.** Proceedings of a Regional Workshop, I I T A-Cotonou Benin, I I T A Ibadan.

Allan, (1971). **"The influence of Agronomic Factors on Maize Yields in Western Kenya With Special Reference to the Time of Planting".** Ph D Thesis University of E.A. Kampala, Uganda.

Amemiya, T. (1981). Qualitative Response Models: A Survey. **Journal of Economics Literature**,Vol.19:1483-1536.

Amemiya, T. (1994). **Advanced Econometrics.** United Kingdom: Basil Blackwell.

Amudavi, M.D. (1993).”Influence of Social-economic Factors on Adoption of Maize related technology.” The case of Small Holder Farmer in Hamisi. **Agricultural economics**

Anon, I.(1997).**“Republic of Kenya Development Plan”**: National Transformation for 2020.

Ashby, J. (1991). **Adopters and Adapters: The Participation of Farmers in Research.** In R.Tripp(ed) Planned Change in Farming System: **Progress in On-farm Research.** A Handbook of Sustainable Agricultural Development. Holland: Agbe publishers.

Barret, C. (2001). “Does Food Aid Stabilize Food Availability?” **Economic Development and Cultural Change** , Vol.49: 335-349.

Batz, F.J, Peters, K.J. and Janssen, (1999). “The Influence of Technology Characteristics on the Rate and Speed of Adoption”. **Agricultural Economics** , Vol.21:121-130

Beets, W.C.(1990). **Raising and Sustaining Productivity of Smallholder Farming Systems in the Tropics. A Handbook of Sustainable Agricultural Development.** Holland: Agbe Publishers.

Benor, D., Harison, J.Q and Barter, M. (1984). **Agricultural Extension: The Training and Visit system.** Washington DC: World Bank.

Byerlee, (1994). **Technology Transfer System for Improved Crop Management: Lesson for the International Community.** In Anderson, R.J (ed). **Agricultural**

Technology: Policy Issues for the International Community. Centre for Agriculture and Biosciences International (CABI) and the World Bank: Wallingford Oxford.

Carry, S. J. (1989). Technology for Small-Scale Farmers in Sub-Saharan Africa-Experince With Food Crop Production in Five Major Ecological Zone. **Journal of Agricultural Economics,** Vol. 58: 1-12.

Chambers, R. (1992). **First-Farmer Innovation and Agricultural Research.** Ladder: Intermediate Technology Publications.

Cheryll, R, Doss Michael and Morris, (2000). How Does Gender Affect the Adoption of Agricultural Innovations? The case of Improved Maize Technology in Ghana. **Agricultural Economics,** Vol. 7:267- 287.

Day, J.C, Huges,D.W, Butcher,W.R. (1992). "Soil, Water and Crop Management Alternatives in Rainfed Agriculture in the Sahel: an Economic Analysis". **Agricultural Economics,** Vol. 25:27- 39.

Dorfman, J.H. (1996). "Modeling Multiple Adoption Decisions in a Joint Framework". **American Journal of Agricultural Economics,** Vol. 78:547-557.

Feder, G, Just, R.E. and Zilberman, D. (1985). "Adoption of Agricultural Innovations in Developing Countries": **A Survey: The University of Chicago**, pp. 255-298.

Gerhart, J. (1975). **"The Diffusion of Hybrid Maize in Western Kenya".** Ph.D.Thesis, Princenton University, New Jersey.

Hassan, R.M. (1998). **Maize Technology Development and Transfer. A GIS Application for Research Planning in Kenya.** Nairobi: Hassan.

International Food Policy Research Institute, (2002,). **Agricultural Technology**

Diffusion and Price Policy. 2020 Vision Network for East Africa.

Juliet, W. (2004). **" Socio-economic Factors Influencing the Intensity of Use of Improved Fallows, Indigenous Rock Phosphate and Biomass Transfer in Food Production in Western Kenya".** M.A Thesis, 2004.University of Nairobi.

Just, R and Zilberman, D. (1983). "Stochastic Structures, Farm Size and Technology Adoption in Developing Agriculture". **Oxford Economics,** Vol.35: 207-328.

Kabede, Y, Gunjal K. and Coffin, G. (1990). "Adoption of New Technologies in Ethiopian Agriculture: the Case of Tagulet-Bulga District Shoa Province". **Agricultural Economics,** Vol. 4: 27-43.

Kamau, M. (2002). **An Overview of the Kenya Seed Industry in a Liberalized Environment:** A Case Study of Maize Seed. 2020 Vision Network for East Africa.

Karanja, D.D. (1996, January). **An Economic and Institutional Analysis of Maize Research in Kenya.** A Research Paper, Conference of Agricultural Networks.

Karanja, D.D, Thomas, Jayne and Straberg, P. (1998). **Determinants of Input Use and Maize Productivity in Kenya: Implications of Cereal Market Reform.** Research Paper, Michigan State University.

Karugia, J.T (2003). **A Micro-level Analysis of Agricultural Intensification in Kenya: the Case of Food Staples.** Lund, Sweden.

Karugia, J.T, Wambugu, S.K and Olouch-Kosura, W (2004). **The Role of Infrastructure and Government Policies in Determining the Efficiency of Kenya's Maize Marketing System in the Post-liberalization Era.** A Research Report Submitted to the International Food Policy Research Institute (IFPRI) 2020 Vision Network for East Africa. Nairobi.

Karugia, T. and Olouch-Kosura, W. (2005). **Why the Early Promise for Rapid Increases in Maize Productivity in Kenya was not Sustained:** Lessons for Sustainable Investment in Agriculture. Nairobi.

Kennedy, P. (1985). **"A Guide to Econometrics".** (2nd Ed.) Basil Blackwell.

Kenya Agricultural Research Institute, (2000). **Collaborative and Participatory Researches for Sustainably Improved Livelihoods.** Proceedings of 7th KARI Biennial Scientific Conference. Nairobi: KARI.

Kenya Agricultural Research Institute, (2002). **Demand-driven Agricultural Research for Sustainable National Resource Base, Food Security and Incomes.** Proceeding of the 8th Biennial Scientific Conference. Nairobi: KARI.

Khan Mohamood H., (1975). **The Economics of Green Revolution in Pakistan.** New York: Paeger.

Leagans, J.P. (1979). **"Adoption of Modern Agricultural Technology by Small Farm Operators". An Interdisciplinary Model for Researchers and Strategy Builders.** New York: Cornell University, Ithaca.

Maddala, G.S. (1983). **Limited Dependent and Qualitative Variables in Econometrics.** Cabridge University Press:Cabridge.

Makokha, M, Odera H, Maritim, I.K, Okalebo, J.R and Iruria, D.M. (1999). "Farmers Perceptions and Adoption of Soil Management Technologies in Western Kenya". **African Crop Science Journal,** Vol. 7: 549-558.

Mead, R.and Curnow, R.N, (1983). **Statistical Methods in Agriculture and Experimental Biology.** London: Chapman and Hall.

Ministry of Economic Development and Co operation, (2000). **"Survey of the Ethiopian**

Agriculture". Addis Ababa Draft.

Misiko, P.A (1976). **Incentives and Disincentives Influencing Farmers in Adoption of Agricultural Innovations:** the Case of Bungoma District, Kenya. Ph.D. Thesis Cornel University.

Mose, L. O. (1997). **"An Economic Analysis of the Determinants of Fertilizer use in Small Maize Farms in Western Kenya".** M.Sc. Thesis, University of Nairobi.

Mugunieri, L.G.(1997). **"Economics of Fertilizer Use in Maize Production Among Smallholder Farmers in Kisii District".** MSc. Department of Agriculture Economics, Thesis University of Nairobi: Nairobi.

Mulugeta, E. Belay and Dadi, L. (2001). "Determinants of Adoption of Physical Soil Conservation Measures in Central Highlands of Ethiopia. The Case of Three Districts of North Shewa". **Journal of Agricultural Economics**

Mureithi, M.F., Okuro,O. J., Verkuij, H., Mwangi, W., Groote, H., and Gethi, M. (2002, November). **An Assessment of Factors Affecting Adoption of Maize Production Technologies in Embu District, Kenya.** Research Paper, KARI Scientific Conference, Nairobi. Nairobi.

Ndiema, A.C, Kinyua, M.G and Kamundia, W. (2002). **Technology Awareness and Farmers' Perception of Wheat Production Technologies:** Case Study in Njoro and Rongai Divisions". Paper Presented in KARI 8th Biennial Scientific Conference: Nairobi

Nkonya, E., Schroeder and Norman, D. (1997). "Factors Affecting Adoption of Improved Maize Seed and Fertilizers use in Northern Tanzania". **Journal of Agricultural Economics,** Vol. 48: 1-12.

Noonan, J., Gorddard, B. (1995, February). **"Time Lags to Adoption: Acquisition of Variety information by West Australian Wheat Growers".** Research Paper, 39th Annual Conference of the Agricultural Economic Society, University of West Australia.

Ouma, J., Mureithi, F., Mwangi, W.and Groote, H. (2002). **Adoption of Maize Seed and Fertilizer Technologies in Embu District, Kenya.** Mexico: D.F., CIMMYT.

Omiti, J.M., Freeman, H.A., Kaguongo, W. and Bett, C.,(1999). **Soil Fertility Maintenance In Eastern Kenya:, Current Practices, Constraints and Opportunities.** Carmasak Working Paper No.1, KARI-ICRISAT.

Ransom, J.K, Paudyal, K. and Adhikar,I. K. (2003). "Adoption of Improved Maize Varieties in the Hills of Nepal". **Journal of Agricultural Economics,** Vol. *29*: pp 299- 305

Republic of Kenya, (1994). **Kenya Population Census.1994, Vol.1.** Nairobi, Kenya Government Printer.

Rogers, E.M. (1962). **Diffusion of Innovations.** Glancoe, I L: Free Press.

Rogers, (1971). "The Importance of Personal Influence in the Adoption of Technological Changes". **Social Forces,** p.36

Rogers, (1983). **Diffusion of Innovations** (3rd Edition.) New York: The Free Press New.

Sanders, J.A, Southgate, D.D. and Lee, J.G. (1995). **"The Economics of Soil Degradation Technological Change and Policy Alternatives".** SMSS Technical Monograph No_22, World Soil Resources, Washington D.C.

Schultz,T.W., (1981). **Investing in People: The Economics of Population Quality.** University of Califonia Press, Berkely.

Wanjohi B.K, (2005). **District Farm Management Guidelines:** Murang'a South.

Welch, F. (1979. "Education in Production". **Journal of Political Economy,** Vol.78:341-359.

World Bank, (1984). **"Kenya Agricultural Sector Report".** Report Number 4620- KE, Washington D.C.

LIST OF APPENDICES

Appendix I - Questionnaire

Enumerator's Name: ________________________________

Questionnaire Serial No.______________________________

Location____

Sub-location_______________________________________

A. Farmers characteristics.

(Put a tick where appropriate)

Interview date _____________________

1. (a) Farmer's name (optional) ______________________________________

(b) Sex; Male ☐ Female ☐

(c) Age of the farmer in years.

21-30 ☐ 31-40 ☐ 41-50 ☐ 50+ ☐

(d) Level of education

Non formal education ☐ Primary ☐ Secondary ☐

Other level specify ____

2. (a) Apart from being a farmer, do you have any other form of employment?

Yes ☐ No ☐

(b) If yes, how much income do you earn per month on average from off-farm employment?

Less than 5,000 Ksh ☐ 5,000-10,000 Ksh ☐ 10,000 + Ksh ☐

3. What portion of your farm do you devote to maize growing? (In acres)_______________

B. Awareness of the recommended maize package and adoption behaviour

1. What maize varieties do you plant? (Tick)

(a) H511 ☐ (b) H513 ☐

(c) Nduma 42 ☐ (d) Pioneer seed ☐

(e) Pannar 5243 ☐

(f) Others (specify) ____

2. When do you plant your maize? (Tick)

Before the onset of rains ☐

After the rain starts ☐

Other (specify) ____

3. How many times do you weed your maize? (Tick)

(a) Once ☐ (b) twice ☐

(c) None ☐

4. What spacing do you apply when planting? (Tick)

(a) 75 cmx30 cm, 1 seed per hole ☐

(b) 90 cmx60 cm, 2 seeds per hole ☐

(c) Others (specify) ____

5. Give reasons for the following practices given in questions (2-4) above.

(i) Number of seeds per hole and spacing_____________________________

(ii) Number of weeding____

(iii) Planting time____

6. How much maize do you harvest per a season, in terms of bags per acre?__________

(i) Less than 5 bags per acre

(ii) 5-10 bags per acre

(iii) 10-15bags per acre

(iv) More than 15 bags per acre

7. (a) When did you start using this variety? (Year)________________________

(b) For how long have you used it? (i.e. continued use.)____________________

(c) What are the advantages of that variety over other varieties? (List)

Information on use of Fertilizer/Manure

8 (a) Do you plant with fertilizer or cattle manure? (Tick)

(b) If fertilizer, what type do you use?

(i) D.A.P ☐ (ii) N.P.K.; 20:20 ☐

(iii) N.P.K.; 17:17 ☐ (iv) N.P.K.; 23:23 ☐

(c) How much do you use per acre? (In kgs)__________________________

(d) If you use cattle manure, how much do you use per acre?

(i) Less than 1 ton per acre ☐

(ii) 1ton per acre ☐

(iii) More than 1ton per acre ☐

(iv) Others (specify) ____

9. (a) Do you top-dress your maize crop? Yes ☐ No ☐

If yes, what type of fertilizer do you use?

(Name)____

(b) At what time do you top-dress it?

(i) After four weeks ☐

(ii) After six weeks ☐

(iii) After eight weeks ☐

Others (specify)____

10. What reasons do you have for **Not** adopting the whole package? (Tick)

(i) Complexity of the technology ☐

(ii) High risks perceived ☐

(iii) Involves high costs ☐

(iv) Low benefits perceived in terms of yields ☐

Others (specify) ____

C. Information system

1. Do the agricultural extension officers visit your farm?

Yes ☐ No ☐

2. If yes, how often?

(i) Once per season ☐ (ii) Twice per season ☐ (iii) Once per year ☐

Others specify ____

3. What methods do they use to disseminate information to you? (Tick)

(i) Oral information ☐ (ii) Demonstration ☐

(iii) Use of charts ☐ (iv) Video ☐

Others (specify) ____

4. How often are the agricultural demonstrations held in this region?

(i) Once per season ☐ (ii) Once per year ☐

(iii) Not at all ☐

5. How do you rate their importance as methods of improving farming practices?

(i) Very important ☐ (ii) Important ☐

(iii) Not important ☐ (iv) Don't know ☐

6. What are your other sources of information about agricultural practices?

(i) Radio ☐ (ii) Newspaper ☐

(iii) Posters ☐ (iv) Other farmers. ☐

Others (specify)____

7. What are the benefits of adopting the entire package of improved maize varieties as seen from your farm? (Tick)

(a) More than one maize cob per stalk ☐

(b) Well grain filled maize cobs ☐

(c) Early maturity ☐

(d) Withstand dry period ☐

(e) Tall healthy maize plant ☐

(f) High yields (Specify how much per acre in terms of bags) ☐

(g) Any other (Specify)____

8. What help would you like to be given to enable you adopt all the recommended practices in as far as planting this variety (ies) is concerned? (Briefly)

Appendix II - Interview Schedule

Section A

1 (a) Interviewer_____________________________________

(b) Interviewee_____________________________________

(c) Date of interview_________________________________

(d) Place of interview________________________________

(e) Age of interviewee_______________________________

(f) Marital status; Single ☐ Married ☐ Widow(er) ☐

2. Occupation; Farmer ☐ Other__________________________

3. Farm size devoted to maize production (in acres)________________________

4. Education level;

i, Non formal ☐ (ii) Primary ☐ (iii) Secondary ☐

Others (specify)____

Section B

1.(a) i, Which specific maize varieties do you plant? (Names)______________________

ii, When did you start planting these varieties? (year)________________________

2.(a) Do you apply the following practices in your farm?(Tick)

i, Use of fertilizer ☐

If so, how much? (In kg per acre)?__________________________________

ii, Use of Manure ☐

If so, how much do you use? (in tons)

iii, Top- dressing ☐

If so, which fertilizer do you use?____________________________________

(b) How do you space the seed when planting? 90cmx60cm, 2 seeds per hole or 75cmx30, 1 Seed per hole?

(c) How many times do you weed the crop?

(d) At what time do you plant?

3.(a) Where do you obtain information about improved maize technology from? (Names)

(b) i, If from agricultural officers, how often do they visit you?

ii, What methods do they use to deliver agricultural information to you?

Section C

4. **For Partial Adopters Only.**

(a) For any practices **Not** applied in (2) above, give reasons for not applying them.

(b) How much maize do you harvest on average per acre? (in terms of bags)

(c) What challenges do you face in your effort to adopt the entire package recommended for this region? (List them)

(d) What do you think could be solutions to these challenges?

5. **For those who Adopt the Entire Package.**

(a) What are the benefits of adopting the entire package as seen from your own farm? (List them).

(b) How much maize do you harvest on average per acre? (in terms of bags)

(c). In your view, what help would you like to be accorded in order to promote more adoption of the entire package?

Enumerators Own Judgment After The Survey

1. How did the respondents provide the information?

Willingly ☐ Reluctantly ☐ With Persuasion ☐

2. How reliable is the information given by the respondents?

Highly reliable ☐ Moderately reliable ☐ Less reliable ☐

END

Appendix III - Amount of Fertilizer Used by the Farmers in Kilograms Per Acre

Fertilizer Amount in Kg/acr.		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	1	.3	.7	.7
	3.00	1	.3	.7	1.5
	4.00	2	.7	1.5	3.0
	5.00	3	1.0	2.2	5.2
	6.00	3	1.0	2.2	7.5
	7.00	1	.3	.7	8.2
	8.00	1	.3	.7	9.0
	10.00	14	4.7	10.4	19.4
	12.00	2	.7	1.5	20.9
	13.00	1	.3	.7	21.6
	15.00	7	2.3	5.2	26.9
	16.00	1	.3	.7	27.6
	18.00	1	.3	.7	28.4
	20.00	12	4.0	9.0	37.3
	23.00	1	.3	.7	38.1
	25.00	8	2.7	6.0	44.0
	26.00	1	.3	.7	44.8
	29.00	1	.3	.7	45.5
	30.00	7	2.3	5.2	50.7
	40.00	10	3.3	7.5	58.2
	45.00	2	.7	1.5	59.7
	50.00	36	12.0	26.9	86.6
	60.00	5	1.7	3.7	90.3
	65.00	2	.7	1.5	91.8
	75.00	1	.3	.7	92.5
	80.00	1	.3	.7	93.3
	100.00	6	2.0	4.5	97.8
	125.00	1	.3	.7	98.5
	150.00	2	.7	1.5	100.0
	Total	134	44.7	100.0	
Missing System		166	55.3		
Total		300	100.0		

Source: Fieldwork, 2007

Appendix IV - Stepwise Criteria Probability to Reject or Accept the Null Hypothesis

Model	Method
1	Stepwise criteria probability to enter P < = 0.050
2	Stepwise criteria probability to reject P > = 0.050

Appendix V - Stepwise Probability Selection Criteria

Model		Sumof Squares	df	Mean Square	F	Sig.
1	Regression	2152.076	1	2152.076	8.709	.003(a)
	Residual	73392.332	297	247.112		
	Total	75544.407	298			
2	Regression	3281.092	2	1640.546	6.720	.001(b)
	Residual	72263.315	296	244.133		
	Total	75544.407	298			

(a and b, Predictors: (Constant), level of education and income)