FACTORS INFLUENCING AGRICULTURAL TECHNOLOGY ADOPTION: THE CASE OF DISEASE FREE IRISH POTATO VARIETIES IN SOUTH KINANGOP DIVISION NYANDARUA DISTRICT, KENYA

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A Thesis submitted to the Graduate School in partial fulfillment for the requirement of the Master of Science Degree in Agriculture and Applied Economics of Egerton University

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DECLARATION AND RECOMMENDATION

DECLARATION

I declare that this is my original work and has not been presented in this or any other university for the award of a degree.

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Date: 28/8/2008

RECOMMENDATION

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DEDICATION

This work is dedicated to my wife Leah and children; Wanjiku, Njoki, Wanjiru and Njogu for their never ending support, prayers and encouragement.

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ABSTRACT

The projected increase in population and aggregate demand for food pose a great challenge to farmers. To address this, intensification of agricultural production is necessary. Irish potato is the second staple food after maize in Kenya. However, over time, its productivity has been declining as result of many factors. A major contributor to this phenomenon is pests and disease, majority of which have well established methods of control. Among the diseases, Bacterial Wilt presents a real challenge in that there is no known chemical control method. It therefore, requires the farmer to practice Integrated Disease Management (IDM) method. Within this recommendation, planting of disease resistant varieties is an important practice as it acts as window for introduction of the other practices. Despite the existence of a well researched package and various farmers' trainings on this aspect, few farmers have fully adopted disease free Irish potato varieties in South Kinangop division. This trend, if ignored, may lead to serious decline in potato yields leading to food insecurity and low farm incomes. This study examined the factors that influence adoption of disease free Irish potato varieties at farm level in South Kinangop division, Nyandarua district. The main focus was on household characteristics in the study area. Data from a random sample of 120 farm households in the division was used. Heckman two stage model was used to estimate the determinants of adoption due to a presumption that factors that influence the decision to adopt are different from those that affect the degree of adoption. The advantage of the approach used in this study is that it was possible to segment factors in each of the adoption processes that need to be targeted for improvement.

As expected, there were different sets of factors behind the decisions to adopt and to what extent. Age, education, previous encounter with Bacterial Wilt, market price, extension contacts and labour, had significant effect on farmers' decision to adopt. On the other hand, the factors that were significant on farmers' decision as to the degree of adoption were; age, experience in growing disease free Irish potato varieties, and extension. It is recommended that such factors be pursued in their own perspective to improve the adoption process of the disease free Irish potato varieties to combat the spread of the disease. Such effort would facilitate achievement of food security and income generation by the farmers.

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LIST OF ACRONYMS AND ABBREVIATIONS

IPM Integrated Pest Management

BW Bacterial Wilt

KARI Kenya Agricultural Research Institute

SPFS Special Program for Food Security

ADC Agricultural Development Corporation

IDM Integrated Disease Management

ML Maximum Likelihood

MD Man Day

DAEO Divisional Agricultural Extension Officer

GDP Gross Domestic Product

Kg Kilogram

Ksh Kenya Shilling

MoA Ministry of Agriculture

CIG Common Interest Groups

CIP International Irish potato Centre

SSPS Small-Scale Seed Production System

SPSS Statistical Package for the Social Sciences

t/ha Tons per hectare

OLS Ordinary Least Square

Obs Observations

SUR Seemingly Unrelated Regression

IMR Inverse Mills Ratio

IRR Internal Rate of Return

No. Number

Pa Per annum

% Percentage

et al and others

^{o}C Degree Centigrade

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Irish potato was introduced primarily by British farmers and colonial officials to Kenya and other areas of East Africa during the 1880s. As early as 1909, European farmers in Kenya were attempting to export Irish potatoes to South Africa. The initial effort was frustrated by the fungal infection *Nectarius solani*, but some export of Irish potatoes occurred successfully over the following decade. The British colonial government encouraged Irish potato cultivation during the First World War as a means of feeding troops stationed in East Africa. Seed imports for research purposes and formal variety trials date from this period (Waithaka, 1976).

Nearly all Irish potato produced is locally consumed (imports and exports are negligible), and hence per capita consumption can be estimated by total production. Kenya's production estimate for 2003 of 900,000 tons, consumed by 31.5M people, averaged to 28.5 kg annual per capita consumption (FAOSTAT, 2004). This is moderately high by world standards, but much less than comparable figures for some regions suitable for Irish potato production, such as the Andes in Peru (Kelly, 2006).

Over the 1970s and 1980s, Irish potato grew in importance as a food crop for home consumption and for income generation through local markets, though international exports declined. By the early 1990s Irish potato had become Kenya's second most important food, in terms of tons production, after maize (Kelly, 2006).

In South Kinangop, Irish potato is grown both for cash and home consumption. It can also be processed into crisps and chips for food and factory starch, an important component in cloth industry. Central Province produces most of the national crop, with some cultivation of Irish potatoes in nearly all districts. Nyandarua is one of the chief suppliers of Irish potatoes and cabbages to the Nairobi city markets. Fewer horticultural farmers in Nyanadarua sell cabbages than Irish potatoes in Nairobi (Dijkstra, 1996).

Table 1.1: Examples of Research impact at farm level

Research area	IRR	Adoption (%)	Yield
Maize	> 66	> 80	2-10 t/ha
Disease free Exotics breeds	38	> 90	7 – 40 kg/day
Wheat	44	100	2 – 5 t/ha
Irish potatoes	84	40-80	20 – 40 t/ha
Sahiwal Breeds	48	22	5-12kg/day
ECF Vaccine	43	23	
Disease free poultry	58	44	
Flowers	64	80	Various

Source: Kenya Agricultural Research Institute 2004

Table 1.1 indicates that despite the high Internal Rate of Return (IRR) for Irish potato, its adoption rate was the lowest amongst the crop research projects under KARI in 2004. This implies that much attention is required to improve on adoption of potato technologies to boost production of the crop in Kenya.

1.2 Technology adoption

Technology adoption by farmers is crucial to increasing agricultural productivity hence meeting food and nutrition challenges in Africa (Sinja et al, 2007). Technological innovation and adoption was the major contributor to the spectacular increases in agricultural productivity during the twentieth century (Gardner, 2002). Kenya's development policy for the medium term continues to recognize agriculture as a pillar of the economy, with priority cantered on ensuring food security, increasing export earnings, providing employment and incomes for over 70% of the population (Okuro et al, 2000).

Agricultural productivity is constrained by a number of factors, including high cost of inputs (especially the price of fertilizer and seeds), poor livestock husbandry, limited extension services, over-dependence on rain-fed agriculture, lack of markets, and limited application of agricultural technology and innovation (Vision 2030, 2007).

For the agricultural sector to play this central role in a sustainable manner, rapid growth in output and productivity is critical. It is widely recognized that sustained flow and use of disease free potato varieties is key to increased growth and agricultural productivity (Ouma et al, 2001).

Since technological change can positively affect the level of output, product quality, employment, trade and profits, the adoption of new technologies offers economic opportunities and challenges. Consequently, understanding the adoption process continues to be of interest to researchers, extension agents and policymakers. Of particular interest to policymakers is the tangible impact of new technologies on farm household characteristics and vice versa, and the role that this plays in the adoption process. This is important because it can guide policy formulation process.

Disease management is an important aspect of Irish potato production and requires costly inputs. Farmers need reliable, cost-effective technologies in order to maintain yields. Agricultural research institutions are actively developing new productivity enhancing technologies meant to fulfill the farmers' needs. In many cases, appropriate technologies exist but not all farmers choose to adopt. For example, disease free Irish potato varieties are available for the management of Bacterial Wilt. Various factors affect farmer expectations of profitability, adoption and the extent of adoption thereof. By necessity, farmers consider a host of factors which potentially affect willingness to adopt a technology.

1.3 Review of Bacterial Wilt Control Technology in Irish potato

Integrated Disease Management (IDM) strategies including use of clean seeds, crop rotation and field sanitation, have proved successful in reducing BW incidence elsewhere (Pradhanang et al., 1992) and has been recommended for Kenya (Ajanga, 1992). A two year rotation has been found to reduce BW incidence (Ajanga, 1992). Farmers should renew their seed stocks from clean sources such as research stations at least every 2-3 years (Kabira et al, 2006). The small land sizes owned by the majority of the Irish potato farmers further compound the problem by making effective crop rotations

difficult (Kinyua et al., 2001). Planting of resistant varieties is one of the major IDM control strategies (Ramos & Micheka, 1988).

Trials on Tigoni and Asante varieties were conducted in Njabini, South Kinangop Division and Meru Central. Certified seed tubers were planted in small plots. These varieties are known to be resistant to Bacterial Wilt. In a trial conducted in South Kinangop, variety Tigoni produced 2.54 times more tubers per unit area in seed plot, than in ware plots production system. Within five consecutive plantings, BW declined to insignificant levels on farmers' fields (Kinyua et al., 2001).

In Kenya, Agricultural Development Corporation (ADC) was responsible for the provision of certified seed to farmers for several years. As of 1989, ADC's supply of seed potato had declined such that, the corporation met less than one percent of national demand for Irish potato seed tubers. This was primarily because certified seed was too expensive to produce. Most farmers rely on their own retained seed or other "informal" sources (Gebremariam et al., 1998), which contributes to the spread of many Irish potato diseases including Bacterial Wilt.

More recently, Kenya Agricultural Research Institute (KARI) has taken over the responsibility of selection and multiplication of promising Irish potato varieties, with the more active involvement of farmers (Kelly, 2006).

Given that clean tubers are not readily available in the market; scientists from KARI devised seed plot system where farmers multiply clean tubers. All the hygienic practices are observed to make sure that the resultant tubers are clean before they are planted in the main field for ware Irish potato production. Another advantage of the seed plot system is that yield is higher than in ware potato production.

The importance of the crop can be deduced by the proportion of land devoted to the crop in the area. Ng'ang'a et al., (2003) found that, amongst the regions where Irish potato is grown in Kenya, South Kinangop farmers devote 57% of the cultivated land to the crop.

Despite this the productivity of the crop has been declining due to various factors, amongst them being Bacterial Wilt. Bacterial Wilt caused by Ralstonia solanacearum is one of the most damaging diseases of Irish potato (Solanum tuberosum) in Kenya and worldwide. The disease is damaging especially in humid climates and at low, medium

and high elevations in tropical and subtropical regions (Ajanga, 1982). In Kenya, yield losses caused by BW are estimated at 50-100 % in traditional Irish potato production areas (Muriithi, 2000).

The disease incidence, spread and severity have recently been on a steady increase both in old and newly cultivated areas (Muriithi et al., 2004). To address this, various technologies have been developed to control the disease. Increased incidences of Bacterial Wilt have been documented in the recent past, an indication that many farmers are not adopting the technologies as expected.

Build-up of the disease is also exacerbated by declining soil fertility due to intensive cultivation as a result of high population density (Low, 1997), favorable highland climate and use of infected seed potato (Shekhawat and Verma, 1991; Tusiime et al., 1996).

The total area under Irish potato has been increasing steadily in recent years, though productivity has declined, making the crop the second most important food crop after maize in Kenya (Guyton et al., 1994). In South Kinangop, maize is grown for fodder; hence Irish potato is the main staple.

A survey conducted by the Ministry of Agriculture and KARI found the rate of spread of the disease in terms of acreage, at 17%, 15% and 10 % in Njabini, Nyakio and Magumu locations respectively (DAEO, South Kinangop 2004).

1.4 Statement of the Problem

In South Kinangop division Irish potato production has been declining due to increased incidences of Bacterial Wilt. A package of new technology to mitigate against the spread of the disease has been developed and introduced in the area. Planting of disease free Irish potato varieties acts as a window for introduction of other measures in the package. The Ministry of agriculture has established and trained Common Interest Groups (CIG) on propagation of the disease free Irish potato varieties. Despite these measures, disease incidences are still a threat to production of the crop. Various factors may have constrained the technology adoption. However, the extent to which these factors affect adoption of disease free Irish potato varieties has not been established in the study area.

1.5 Objectives

The overall objective of the study was to establish the effect of household characteristics on adoption process of the disease free Irish potato varieties as a means of mitigating against Bacterial Wilt and document related constraints faced by farmers.

The specific objectives were:

- To determine the effect of household characteristics on decision whether to adopt disease free Irish potato varieties or not.
- To determine the effect of household characteristics on the degree of use of disease free Irish potato varieties.
- To document the constraints faced by households in adoption of disease free Irish potato varieties

1.6 Hypotheses

- Farmers' characteristics have no affect on decision whether to adopt disease free Irish potato varieties or not.
- Farmers' characteristics have no affect on the degree of use of disease free Irish potato varieties.

1.7 Justification of the Study

Focusing on farmers' characteristics that influence adoption of technologies may provide a better understanding of adoption process. Since farmers deal with the technologies and probably perceive them differently from researchers and extension agents, it is important that we understand their perception. The findings of the study can therefore, benefit the agricultural extension providers and research scientists by indicating the most critical factors that affect adoption of disease free Irish potato varieties.

To a researcher, this assists in designing technologies that address the factors that influence adoption. For an extension officer the knowledge helps in designing extension messages that respond to the identified factors.

Understanding the determinants of technology adoption has clear implications for the formulation of agricultural policies. This can contribute to better policies that

facilitate efficient production of Irish potatoes. The study is also important as it adds to the existing body of knowledge in adoption of agricultural technology in Kenya. Findings of the study can be of benefit to other interested players along the value chain, like farm input stockists and other market participants.

1.8 Definition of Terms

Technology: Is the science and art of getting things done through the application of skills and knowledge.

Adoption: Is the systematic application of scientific knowledge to practical farming practice.

Household: Comprise of a person or group of persons who are generally bound together by ties of kinship or joint decision making process.

Diffusion: Refers to the spreads of technology in terms of percentage allocation of disease free potato varieties .

Disease free Irish potato varieties: Refer to Tigoni and Asante varieties which were officially released by the KARI.

Formal seed source: Refers to seed producers or distributors recognized by KARI.

Informal seed source: Refers to any other source other than the one mentioned above.

1.9 Scope and limitations

Complete framework of adoption usually includes investigating the extent and intensity of use of the new technology at each point through out the adoption process through time. However, this study only looked at the determinants of adoption of disease free Irish potato varieties for control of Bacterial Wilt. The study was based on data from 1997 to 2007. This is the period when a project by the name Promoting Irish potato seed-tuber management for increased ware yields in Kenya, Uganda and Republic of South Africa has been operational at the farm level. The project proposed an on-farm small-scale seed production system (SSPS) to counter Irish potato production constraints.

The study only covered South Kinangop division, where trials and farmers training have been taking place. The study was confined to factors related to adoption of disease free Irish potato varieties as a means of mitigating against Bacterial Wilt in Irish

potatoes. Unavoidable errors from respondents and those arising from sampling design may have affected the precision of the results.

CHAPTER TWO

LITERATURE REVIEW

2.1 Review of Adoption of Agricultural Technologies

Feder et al, (1982), distinguished between individual (farm level) adoption and aggregate adoption. They defined individual adoption as the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the new technology and its potential; while aggregate adoption is the spread of new technology within a region.

The smallholder farming system is highly complex; it forms part of a sector which is characterized by a fragile, heterogeneous agro-ecological environment. The demand for new technology and its adoption differs greatly within the universe of the smallholder production systems (Kasseba, 1989). Although research institutions engage in making scientific discoveries and in development of new technologies for farmers, the adoption of innovations is frequently gradual and incomplete; sometimes technologies that would improve productivity are not adopted (Abdulai and Huffman, 2005). There is need for a more participatory approach in technology development by 'putting people first' (Chambers, 1983).

Access to extension services is important as it provides to farmers information about new technologies and new production methods. However, extension systems are usually top-down supply driven approaches which do not adequately address the socio-economic situation of resource poor smallholder farmers (Kasseba, 1989).

Pineiro (cited by Kasseba, 1989) noted that an assumption that strongly influenced the operation of extension services is the idea that the main factor hindering adoption of technology is the farmer's lack of information regarding the technologies. He argued that this may be true in some cases but in others, lack of information is not the limiting factor, but the appropriateness of the new technology.

Farmers in developing countries have traditionally relied upon other farmers for access to new technologies, ideas, and production methods. These traditional dissemination and transfer methods have a far greater impact on the spread of selected technologies than either public or private firms' dissemination efforts (Grisley, 1994).

Several authors have noted that the traditional dissemination methods are of importance in the secondary stages of diffusion for varieties and other technologies introduced by the government or private sector entities (Grisley, 1994).

Eusebius et al (2005) found that, farmer-to-farmer extension approach reveals that the relationship between a farmer and extension agent may be influenced by extension messages learned from past interactions. Poorer farmers with little education are often apathetic as attempts to improve their situation have failed in the past. It is therefore fair to initiate extension projects involving simple technologies that have been proven successful under similar circumstances. Any intervention that fails will confirm their fears that their conditions cannot improved. In addition, most farmers learn by observing the experiences of others.

Rogers (1962) noted that if certain individuals in a social system are active adopters or active rejecters of a given innovation , they would try to exert personal influence on others to follow suit whilst passive adopters or passive rejecters would exert little or no influence on others in relation to acceptance or rejection of a given innovation (Saeed, 1989). Pressure from social emulation and localized competition encourage farmers to adopt new and profitable technologies.(Abdulai and Huffman, 2005).

2.2 Factors that Influence Adoption of Agricultural Technologies

In theory, adoption of innovations can be expected to be affected by several factors such as: availability of credit, access to information, aversion to risk, land tenure, investment in human capital, farm size, labour availability, supply of complementary inputs, and access to product market (Feder et al., 1985). These factors can be classified as personal, physical, institutional and socio-economic (Ervin and Ervin, 1982; Feder et al., 1985; Shortle and Miranowski, 1986; Napier et al., 1991) in their respective influence on the decision to adopt a given agricultural technology.

2.2.1 Personal Characteristics

Personal characteristics relate to an individual's management skills or entrepreneurial ability (Feder et al., 1985) and include attributes such as the level of education, farming experience, gender, age, and any vocational training. They reflect the

farmer's ability to understand farm technologies and their effect on farming as farmers do vary in their management skills (Feder et al., 1985; Belknap and Saupe, 1988). The synthesis of the adoption process presented by Feder et al. (1985) suggests that generally the level and quality of human capital affects the choice of new technologies in agriculture which plays a particularly positive role for early adopters derived from an efficient use of inputs, Shortle and Miranowski (1986) found that personal characteristics affect the choice of conservation tillage practices. Similarly Ervin and Ervin (1982) found that education has a positive impact on the adoption of soil conservation technology. They also found that older farmers are less likely to use soil conservation practices, whereas younger farmers may be better educated and involved with more innovative farming. Shortle and Miranowaski (1986) found that experience has a positive effect on the adoption of conservation tillage practices in the Four Mile Creek Watershed of eastern Iowa.

2.2.2 Gender of the Farmer

In most parts of the developing world most extension workers are men and are usually biased towards men in their extension activities (Langyintuo, 2005). This is contrary to the fact that women, especially widows play a significant role in agriculture. It is therefore important to include gender in assessing the determinants of adoption of disease free potato varieties. Langyintuo and Mekuria (2005) recommened that, it is important to assess the relative benefits to be gained in redirecting extension efforts by gender.

2.2.3 Age of the Farmer

The role of a farmer's age in explaining technology adoption is somewhat controversial in the literature. Older people are sometimes thought to be less amenable to change and hence reluctant to change their old ways of doing things. In this case, age will have a negative impact on adoption. On the other hand, older people may have higher accumulated capital, more contacts with extension, stable base, hence better preferred by credit institutions and large family sizes hence more labour. All of this may make them more prepared to adopt a technology than younger ones. Whatever the condition, it is therefore important to include age as a factor that would help explain adoption decisions.

Adesina and Forson (1995) indicated that the expected result of age is an empirical question. The objective is therefore to bring into fore the advantage to be gained in targeting younger farmers versus older ones and vice versa.

2.2.4 Labour Availability

Sometimes new technologies are known to be either labor saving or labor intensive. Labor is known to affect farm enterprise decisions. When the supply of rural labor increases then the likelihood of adopting new labor intensive innovations is higher. If the technology increases seasonal labor demands, it may be less attractive to the farm family with limited labor supply. Hicks and Johnson (1974) found that higher rural labor supply led to greater adoption of labor intensive rice varieties in Taiwan. It is measured by use of family labor or availability and costs of hiring labor. Labour availability is expected to have a positive effect on adoption of disease free Irish potato varieties.

2.2.5 Farm Size

Grisley, (1994) in his study found that farm size can be a useful indicator of farmer's willingness to transfer grains of new bean varieties to other farmers. Grisley and Shamanbo (1990) in their study of the adoption of Carioca bean seed in Zambia found that the total land in cultivated crops and hectarage of maize were directly related to the decision to adopt, while variables such as education of household head, average number of fields in continuous cultivation, and the number of cattle owned were indirectly associated with adoption (Csaki et al, 1990). Earlier theoretical work emphasized the importance of farm size and credit constraints on the adoption process. Recent literature has increasingly focused on the capacity of farmers to make decisions and learn or the role of learning in the diffusion process (Abdulai and Huffman, 2005).

2.2.6 Market Access

Zeller et al (1997), found that access to agricultural markets and related improvements in rural infrastructure and marketing institutions are essential for adoption of new technology and transformation of subsistence-oriented smallholder agriculture. Market access factors, which refer to the existence of local markets offering good sales opportunities and adequate infrastructure, are obvious prerequisites for an agricultural enterprise. As most consumers with greater purchasing power live in cities,

intensification of an enterprise should be initiated at least in areas having a good road network and transport facilities. Market opportunities are the main incentives for the farmers to ensure that production is improved. Hence it is hypothesized that time taken by the farmers to the nearest market centre as a proxy for market access negatively affects the decision to adopt a technology. Farmers that are able to take advantage of the good return from the technology may find its adoption economically attractive. Therefore, farmers with larger proceeds derive more utility from being aware of technological advancements than producers with smaller expected benefits.

2.2.7 Availability of Credit

Credit availability may also positively influence adoption of a technology by relaxing the binding capital constraints that farmers face during initial investments or helps to finance the variable costs associated with adopting the technology. Simtowe and Zeller (2006) found that, credit significantly increased farmers' ability to finance the purchase of inputs required for the production of hybrid maize which leads to an expansion of the area under hybrid maize. Therefore, conditional on adoption, credit constrained households with higher amounts of credit allocated more land to hybrid maize production.

2.2.8 Access to Agricultural Extension

Agricultural extension may also enhance the efficiency of making adoption decisions. In the world of less than perfect information, the introduction of new technologies creates a demand for information useful in making adoption decisions (Wozniak 1984). Of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Based on the innovation-diffusion literature, it is hypothesized that the number of extension visits is positively related to adoption by exposing farmers to new information and technical skills about crop husbandry, post harvest management and marketing (Adesina and Forson 1995).

2.3 Adoption Theory

The Individual Innovativeness theory (Rogers, 1995) states that, individuals who are predisposed to being innovative will adopt an innovation earlier than those who are

less predisposed. Figure 1 shows the bell shaped distribution of Individual Innovativeness and the percentage of potential adopters theorized to fall into each category. On one extreme of the distribution are the Innovators. Innovators are the risk takers and pioneers who adopt an innovation very early in the diffusion process. On the other extreme are the Laggards who resist adopting an innovation until rather late in the diffusion process.

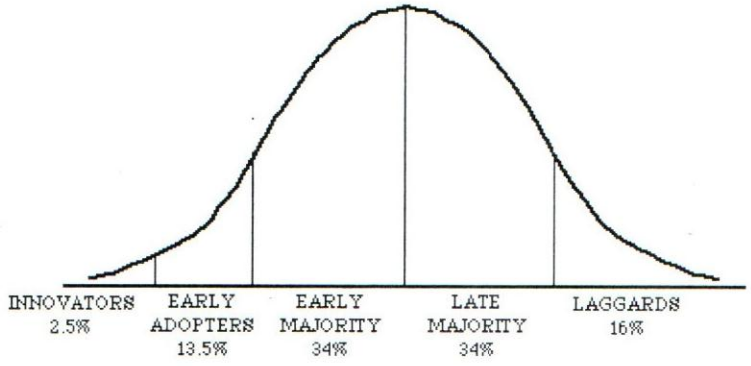


Figure 1: Bell Shaped Curve Showing Categories of Individual Innovativeness and Percentages within each Category (Source: Adopted from Surry, 1997)

Cochrane (1979) studied the uptake of agricultural technologies and divided the farming population into early adopters; followers and laggards (Sunding and Zilberman, 2001). The early adopters are a small fraction of the population and tend to profit from the innovation while the followers adopt during the takeoff stage of innovation and they tend to reduce output prices and profits. The laggards either adopt at the lag stage or do not at all; they tend to lose from technological change (Sunding and Zilberman, 2001).

2.4 Rate of Adoption

The widely-used diffusion theory discussed by Rogers (1995) is the theory of rate of adoption. The theory states that innovations are diffused over time in a pattern that resembles an s-shaped curve. Rate of adoption theorizes that an innovation goes through a period of slow, gradual growth before experiencing a period of relatively dramatic and rapid growth. An example of how rate of adoption might typically be represented by an s-curve is shown in Figure 2. The theory also states that following the period of rapid growth, the innovation's rate of adoption will gradually stabilize and eventually decline.

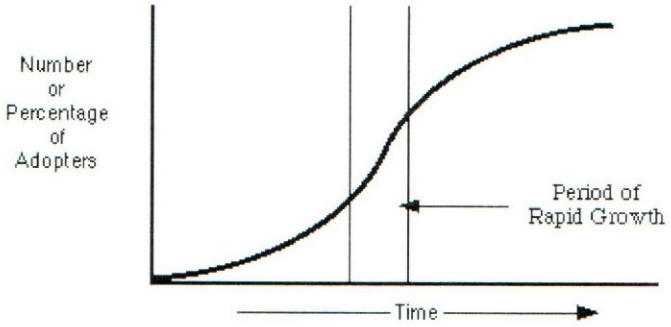


Figure 2: S-curve representing rate of adoption of an innovation over time (Source: Adopted from Surry, 1997)

In agricultural perspective, the theory assumes that the technology is appropriate for the farmer's problem, and that information access is the principle factor that determines adoption. In this model, the acquisition of knowledge leads to a change in farmer perceptions. Thus, farmers who are knowledgeable about profit-enhancing technologies will choose to adopt (Negatu and Parikh, 1999).

A certain critical level of cumulative information must be attained before adoption of a new variable input takes place, therefore larger farmers, and farmers with better access to information or farmers with more human capital will adopt earlier than other farmers (Feder and Slade, 1984). Access to information about an innovation results in the formation of attitudes and perceptions regarding the innovation, exposure to information most often occurs through various communication forums such as extension meetings, on-farm trials and agricultural training (Masangano and Miles, 2004).

Adoption of technological changes is vital in achieving growth in agricultural productivity. The contribution of such changes to agricultural productivity in developing countries has been documented (Arndt et al., 1977). Yet, the distributional effect of the changes still provokes an interesting debate of international interest in both academic and policy circles.

The debate on the distributional effect of technological change in the policy circle emerged following the success of the Green Revolution in Asia. Critiques of the Green Revolution argued that the gain in production from technological changes was offset by the loss in equity because small farmers were unable to use modern varieties efficiently. However, this argument proved to be wrong when empirical studies provided evidence that both small and large farms achieved approximately equal gains in efficiency (Ruttan, 2002) .

The distribution of gains in economic welfare between consumers and producers depends on the price elasticities of demand and supply for a commodity. If, for example, the demand for a given agricultural product is price inelastic, which is the case for many agricultural products in developing countries (Foster, 1992), consumers will be better off while producers will be worse off.

Hayami and Herdt (1977) show that semi-subsistence farmers can gain from technological change even in the face of an inelastic demand. Hence, one may tend to conclude that both producers and non-producers in developing countries can benefit from technological change and may even suggest that there is no need for government intervention in redistribution of benefits between non-producers and producers through policies. However, given that technologies are not adopted by all producers at the same time, one need to look into the dynamics of adoption to gain an insight into the distributional effects of technological change and the rationale for government intervention. When a cost saving technology is introduced, only few farmers adopt it first. These innovators benefit from the reduction of per unit costs while the price of output is still the same. But, as many farmers follow suit, and more farmers become integrated into the market system, the increase in production will be large enough to shift the supply curve to the right and lower the price. At this point, the profit of adopters will fall, and non-adopters will be negatively impacted. Mitchel, (2001) notes that with any innovation, non-adoption can be costly in the long run, because when a new technology is adopted widely, output will increase, leading not only to a reduction in prices, but to a reduced incentive to invest for those who have not yet adopted the technology.

Adoption studies can provide information for improving the efficiency of agricultural research, extension services, and policy hence drawing implications for government intervention thereby reducing the cost of non-adoption and facilitating a rapid technological change. Several adoption studies have been conducted in several countries since Griliches pioneering work on the adoption of hybrid corn in the United States in 1957 (Sheikh et al., 2003).

It is on foregoing basis that this study was designed since no study has been carried out so far to determine the factors influencing adoption of disease free Irish potato varieties as a means of controlling Bacterial Wilt in South Kinangop division. Also of

interest is documentation of the constraints faced by the farmers in their attempt to adopt the technology

2.5 Theoretical Model

Adoption studies typically use various types of logistic models to analyze survey data. These models recognize adoption as a dependent categorical variable. Linear regression is not an appropriate method for adoption studies for several reasons. Continuous linear regression typically uses the Ordinary Least Squares (OLS) estimator for making predictions. In the case of adoption, where the dependent variable takes on a limited number of values and the error term is not normally distributed, OLS regression produces biased results. Particularly, in adoption studies, a significant proportion of the population chooses to adopt 0% of the technologies. The adopters in the population tend to aggregate around a few specific values. In addition, adoption models attempt to predict probabilities of adoption. OLS predictions can lie outside of the [0, 1] range and thus cannot be interpreted as probabilities. Using the random utility theory (Greene, 2000), we can define the utility of farmer i associated with using an disease free variety or traditional variety as $uij = \mu ij + \varepsilon ij$, where μij is a systematic utility, which is a non-stochastic function of explanatory variables and unknown parameters, and εij is an unobserved random utility component which accounts for taste variation along with measurement errors. When confronted with a choice between two alternative practices, the ith farmer compares the expected utility with the modern technology, EUmi(W) to the expected utility with the traditional technology, EUti(W). While direct measurement of farmers' perceptions and risk attitudes on farming technology are not available, inferences can be made for variables that influence the distribution and expected utility evaluation of the technology. These variables are used as a vector 'X' of attributes of the choices made by farmer 'i' and εi is a random disturbance term that arises from unobserved variation in preferences, attributes of the alternatives, and errors in optimization. Given the usual discrete choice analysis and limiting the amount of non-linearity in the likelihood function, EUmi(W) and EUti(W) may be written as:

$$EUmi(W) = \alpha mXi + \varepsilon mi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$EUti(W) = \alpha tXi + \varepsilon ti \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The difference in expected utility may then be written

$$EUmi(W) - EUti(W) = (\alpha mXi + \varepsilon mi) - (\alpha tXi + \varepsilon ti)$$
$$= (\alpha m - \alpha t) Xi + (\varepsilon mi - \varepsilon ti)$$
$$= \alpha Xi + \varepsilon i \qquad (3)$$

A preference for the modern technology will result if $EUmi(W) - EUti(W) > 0$; whereas, a preference for the traditional technology will be revealed if $EUmi(W) - EUti(W) \leq 0$. The observed adoption choice of an agricultural technology is hypothesized to be the end result of socio-economic characteristics of farmers and a complex set of inter-technology preference comparisons made by farmers (Adesina and Forson 1995). The empirical analysis permits the investigation of the decision whether or not to adopt disease free Irish potato varieties and the conditional level of the technology if the initial adoption decision was made.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study covered South Kinangop division of the larger Nyandarua District. The district was composed of North Kinangop, Kipipiri, Oljolrok, Olkalou, Ndaragua and South Kinangop divisions. South Kinangop division is composed of three locations i.e. Magumu, Nyakio and Njabini. The division borders Naivasha district to the west, Aberdare ranges to the east, Kiambu West district to the south and North Kinangop division to the north.

The soils are sodic planosol on the Kinangop plateau. Rainfall is bimodal starting in the months of April/May and Oct/Nov and averaging 900 to 1,500 mm per year. The Aberdare ranges influence temperatures, which range from 11-21oC. Very cold weather is frequent in the months of January, July and September when night temperatures get as low as 1.7oC (Ng'ang'a, 2002). Crop farming and dairy are the main economic activities in the division.

3.2 Sampling Procedure

The population composed of Irish potato farmers in the larger Nyandarua district. Purposive sampling was used to select South Kinangop division, based on the fact that seed plot trial and farmers trainings were conducted in the area and its high Irish potato production potential. The three locations in the division were covered in this study. Proportionate random sampling was used to select farmers from each location based on the total number of farmers growing Irish potatoes in respective locations. The sample frame was a list of all Irish potato farmers provided by respective locational offices. A total of 120 farmers were interviewed out of 52000 farmers, a random assignment was used to come up with two groups; adopters and non adopters.

On determination of the sample size, Nassiuma (2000) says that in most surveys or experiments, coefficient of variation of at most 30% are usually acceptable. The study took a coefficient of variation of 22% and a standard error of 0.02. Sample size generation formula given by Nassiuma is as below: -

$$n = \frac{NC^2}{C^2 + (N-1)e^2} \quad \text{.....(4)}$$

Where n = Sample size

N = Population

C = coefficient of variation

e = Standard error

In this case; $n = \frac{52000(22\%)^2}{(22\%)^2 + (52000-1)(0.02)^2} = 120$

3.3 Data Collection

A pre-tested questionnaire was used during household survey to collect primary data to capture (operationalize the variables) factors affecting the decision to adopt disease free Irish potato varieties and degree of the technology by the farmers in the study area.

3.4 Types of Data

The data collected included socio-economic characteristics i.e. farmer and household characteristics. These included; age, sex, marital status, family size and composition, number of years in formal schooling, technical training received on Irish potato production and access to extension service. Other variables considered included; land tenure, cultivated land size, area under Irish potato, area planted with disease free Irish potato varieties, access to off-farm income, labor requirement and usage, amount and source of disease free Irish potato varieties used per season, Irish potato yield, amount of Irish potato marketed, market prices, input usage e.g. fertilizer and pesticides, membership to farmers' organizations, number of livestock owned among others as shown in table 3.1.

3.5 Data Analysis

To determine which factors had significant impact on adoption and the extent of adoption, econometric analysis of the collected data was undertaken using Stata and SPSS econometric software to estimate the Heckman's two-stage model. Descriptive statistic was also used for data analysis.

3.6 The Empirical Model

Qualitative response models are used particularly for panel, time series, or cross-sectional data in which dependent variable takes on a limited number of discrete values. Binary response models (probit and logit) are used where adoption is considered as a yes or no decision by farmers. A probit model is used when the dependent variable is limited and continuous between 0 and 1, and logit models for discrete dependent variables (Maddala, 1983). However, farmers often manage risk through diversification, which can be reflected in partial adoption of technologies. This study therefore looked not only at whether adoption occurred, but also the degree of adoption of the technology. Therefore, the model considered more than one possible response.

Following Feder, Just and Zilberman (1985) we define adopters as households that reported that they planted disease free Irish potato varieties. The extent of adoption is defined as degree of use of a technology, which for this study is taken as the proportion of Irish potato land that is allocated to disease free Irish potato varieties. The decision whether or not to adopt the varieties and how much land to allocate to disease free Irish potato varieties can be estimated using a censored Tobit model (Zilberman and Just 1984) or a P-Tobit model (Deaton and Irish (1984). However, the main weakness with the Tobit model is that it only allows one type of zero observation, namely, a corner solution, since it is based on the implicit assumption that zeros arise only as a result of the respondent's economic circumstances (Martínez-Espiñeira, 2006). In the same context Moffat (2003) observes that in some cases there are household that would never take some positive values, (thus they would never adopt under any circumstances because they consider the technology to be inferior), then the use of a restrictive Tobit model without considering the group that would never adopt may give biased results. Deaton and Irish (1984) proposed a relaxation of this restriction by considering the probability that one would never adopt. The Tobit model would apply for the group of potential adopters while it wouldn't for the "never adopters" since the intensity of adoption would be automatically zero. Tobit regression model has also been widely used in estimation when the dependent variable is observed within a limited range (Greene 2000). Underlying the tobit model is the assumption that the coefficients on the probability and extent of adoption are the same

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(Greene 2000). Thus, the tobit model fails to separate the two decisions that characterize the adoption of a divisible technology.

To predict changes in the likelihood of adoption and disease free varieties, a two-stage Heckman model of variety choice following the theoretical framework of the household farm (Edmeades, 2003) was used in this study.

This model was used because it addressed simultaneity problems. The Heckman's two-stage model involves two estimation steps. In step 1, a probit equation is estimated. The probit model is used because its likelihood function is well behaved as it gives consistent Maximum Likelihood Estimate (MLE) coefficients and the standard error of the estimate (Maddala, 1983).

Results of the first equation show the influence of independent variables on the probability of adopting a given technology. The results are the same as any other probit model estimated as a single equation. A Seemingly Unrelated Regression (SUR) is a system of equations whose individual equation random errors are believed to have some correlation. For instance, in this case, error term of equation estimating the decision of adoption of disease free Irish potato varieties is believed to be correlated with error term of the equation estimating intensity of adoption of the varieties. In this situation, the equations are estimated as a system and not individually, in order to account for the cross equation relationship of random errors.

In step 2, the intensity of adopting the varieties is estimated as follows:

$E(yi|yi>0) = bxi + sf(bxi)/F(bxi)$ ..... (5)

where yi = intensity of adoption of a technology (proportion of area under disease free Irish potato seeds), xith = independent variables, f(bxi)/F(bxi) is the Inverse Mills Ratio (IMR), evaluated at each sample observation. IMR is calculated from the probit results of the first step. Using the data from adopters only, an Ordinary Least Squares (OLS) model, including the IMR as regressor, is estimated for each endogenous variable. The impacts of the same factors on intensity of adoption are estimated using a system of Seemingly Unrelated Regression (SUR) equations.

There are two advantages to using the Heckman's approach. The first is that we use SUR in the second stage because only adopters are included in this stage of analysis. Table 2.1: Nature and a priori Expected Signs of Variables. The second advantage is that

the use of SUR purges the heteroscedasticity of the estimates obtained from the second step (Greene, 1993).

3.7 Choice of Independent Variables for the Model

There is no firm economic theory that dictates the choices of independent variables in adoption studies. However, adoption literature suggests that farmers' decision to adopt an agricultural technology depends on their economic position and institutional environment (Shiferaw and Tesfaye, 2005). Hence, the choice of explanatory variables in this study is made based on a review of past adoption studies and the farmers' environment in the study area.

The descriptions of the explanatory variables included in the model are as presented in the table 3.1 below:

Table 3.1: Nature and a priori Expected Signs of Variables

Independent Variables	Explanation	Measurement	Expected sign
GENDER	Gender of the household head	Dummy (1=male, 0=female)	±
AGEHH	Age of the household head	Years	±
HHSIZE	Size of the household	Number	+
EDUCLVL	Level of education achieved by the household head	(1= none, 2=primary,3= secondary, 4= tertiary)	+
ASSETVLE	Value of durable assets on the farm	Amount (Ksh)	+
LDSZE	Size of the cultivated land	Hectares	+
MKTPRICE	Price per bag received by farmer in the previous season	Amount (Ksh)	+
POTMKD	Proportion of Irish potato sold	Percentage	+
OFFINC	Off farm income	Dummy 1=accessed, 0=not accessed	+
SCSEED	Source of seed acquired	(1= formal, 0=informal)	±
MEOR	Membership to farmers organization	Binary; 1= affiliated, 0=not affiliated	+
LABFOR	Labour available per year	Man days	+
PFAMLAB	Proportion of labour provided by the family	Percentage	+

TINSKST	Time taken to the nearest inputs stockist.	Hours	-
TOMKT	Time taken to the nearest market centre.	Hours	-
EXT	Extension contact per season	Number	+
IPVEXP	Experience in growing disease free potato varieties	Years	+
EXBW	Whether farmer experienced BW	Dummy 1=experienced 0=never experienced	+
Dependent variables			
POTLAND	Proportion of the total land under Irish potato devoted to disease free Irish potatoes varieties	Percentage	
ADPTION	Whether an adopter or not	Dummy (1= adopter, 0= non adopter)	

Source: Author compilation.

The farmer's economic position on Irish potato enterprise in the study area is characterized by social economic characteristics of the farmer and other factors. Hypotheses were therefore tested to determine the significance of these characteristics to achieve objectives one and two.

To determine the effect of the factors on decision whether to adopt or not (objective one), a binary probit model was used as specified bellow:

ADPTION=

$$\beta_0 + \beta_1(GENDER) + \beta_2(AGEHH) + \beta_3(EDUCLVL) + \beta_4(EXBW) + \beta_5(MKTPRICE) + \beta_6(SCSEED) + \beta_7(MEOR) + \beta_8(EXT) + \beta_9(LABFOR) + \varepsilon \quad (6)$$

where ADPTION is whether the ith farmer adopted disease free Irish potato varieties or not, β_0 is the intercept, and $\beta_1 \ldots\ldots \beta_9$ are the parameters estimated.

To determine the effect of factors on the degree of use of disease free Irish potato varieties (objective two), an OLS regression model was used as specified bellow:

POTLAND=

$$\beta_0 + \beta_1(AGEHH) + \beta_2(EDUCLVL) + \beta_3(IPVEXP) + \beta_4(MKTPRICE) + \beta_5(SCSEED) + \beta_6(MEOR) + \beta_7(EXT) + \varepsilon \quad (7)$$

where POTLAND is the proportion of land under disease free Irish potato varieties out of the total land devoted to Irish potato for the ith farmer, β_0 is the intercept, and β_1..... β_7 are the parameters estimated.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Descriptive Statistics

By the use of descriptive statistics, such as, percentages, means, and tabulations, the results from the study, decomposed in terms of adopter and non adopter, were summarized as indicated in table 4.1.

Table 3.1: Descriptive Statistics

Variable	Non adopters (n=32)		Adopters (n=88)		Total (n=120)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Gender	.594	.499	.659	.477	.642	.482
Age of Household head	48.25	12.144	50.182	10.932	49.667	11.248
Household size	4.844	1.687	4.773	2.153	4.792	2.033
Education level of HH head	2.34375	0.5453	2.53341	0.6600	2.4833	0.6349
Value of fixed assets	779281.3	702561.2	1262324	129746	1133513	118546**
Land size (Ha)	3.152	2.999	1.889	3	2.225	2.49**
Market price (Kshs)	479.6875	67.0332	858.523	121.821	757.5	2.449***
% of Irish potato marketed	73.875	8.586	81.563	144.508	79.513	10.082***
Off farm income access	.4375	.504	.2954	.45886	.3333	.473**
Source of seed	.03125	.1767	.5681	1.2298	0.425	1.082
Membership to Groups	.78125	.4200	.72727	.4479	.742	.440
Total Labour force	235.344	127.207	288.046	.448	273.992	184.962
% of labour from family	48.281	30.364	52.414	200.69	51.303	29.296***
Time to nearest input stockist	2.106	.865	1.575	7	1.717	.906***
Time to nearest market centre	4.875	1.5811	1.4454	.96103	2.368	1.9136
No. of extension contact p.a	3.844	3.3322	16.466	3.3595	13.1	6.524***

Source: Survey data, 2007.

Difference in means: *Statistically significant at the $p < 0.10$ level. ** Statistically significant at the $p < 0.05$ level. *** Statistically significant at the $p < 0.01$ level.

Means of descriptive statistics for selected variables included in the adoption model differentiated by the adoption status are presented in Table 4.1. They included factors like age, sex and education level of a household head. Also included are wealth status indicators such as land size, the value of fixed assets, access to off farm income and market access factors (supply related factors) such as, distance to markets, and access to the extension services. Our a priori expectation is that wealth proxy variables will have a positive effect on the adoption of disease free Irish potato varieties (Feder et al., 1985).

There were significant differences in means between adopters and non adopters in terms of value of fixed assets, land size, market price, proportion of Irish potato marketed, source of seeds, number of extension contacts and time taken to both the nearest input stockist and the market centre.

However, there were no significant differences between adopters and non-adopters in terms of gender, age, household size, and level of education, access to off farm income, membership to farmers' organizations, total labor force and proportion of family labor. However, adopting households were more than non adopters. The former were 88 whereas the latter were 32. It was also observed that adopting households had smaller mean land holdings (1.88 hectares) than non adopters (3.15 hectares). With regards to wealth, adopters were on average wealthier with significantly larger asset values (Kshs 1.26M) than non adopters (Kshs 780,000).

4.1.1 Education Level Achieved by the Household Head

Table 4.2: Highest Education Level Achieved by the Household Head

Education	Non adopters			Adopters		
level	Freq.	Percent	Cum.	Freq.	Percent	Cum.
None	0	0	0	2	2.27	2.27
Primary	22	68.75	68.75	43	48.86	51.14
Secondary	9	28.13	96.88	37	42.05	93.18
Tertiary	1	3.13	100.00	6	6.82	100.00
Total	32	100.00		88	100.00	

Source: Survey data, 2007

Table 4.2 shows the highest educational level achieved by the household head. 66% of sample members who had finished primary school were adopters, as compared to

80% of those who had completed secondary school. Most of non adopters at 69% had completed primary school as compared to 48.86 of the adopters who had achieved the same level of education. The data shows that there were many adopters than non adopters who had received secondary and tertiary education.

4.1.2 Age of the Household Head

Table 4.3: Age of the Household Head

	Non adopters			Adopters		
Age(years)	Freq.	Percent	Cum.	Freq.	Percent	Cum.
20 - 29	-	-	-	1	1.14	1.14
30 -39	9	28.15	28.15	12	13.63	14.77
40 - 49	9	28.14	56.29	33	37.5	52.27
50 - 59	8	25.01	81.3	21	23.86	76.13
60 - 69	4	12.52	93.82	15	17.05	93.18
> 70	2	6.18	100.00	6	6.82	100.00
Total	32	100.00		88	100.00	

Source: Survey data, 2007

For the adopters, the largest age bracket in the sample, 37.5 %, was in the 40 – 49 age category, whereas the smallest, 1.14%, was in 20 – 29 category. In the non adopter's category, the largest age bracket in the sample, 28.15%, was in 30 – 39 age category and the smallest, 6.18%, was in the > 70 bracket.

4.1.3 Gender of the Household Head

Table 4.4: Gender of the Household Head

	Non adopters			Adopters		
	Freq.	Percent	Cum.	Freq.	Percent	Cum.
Female	13	40.62	40.63	30	34.09	34.09
Male	19	59.38	100.00	58	65.91	100.00
Total	32	100.00		88	100.00	

Source: Survey data, 2007

In terms of gender, of the 120 randomly selected respondents, 77 were male (64.17%) whereas the rest were female. 59.38% of the non adopter were male whereas

the rest were female in that category. For the adopters 65.91% were male and the rest were female. 69.77% of the females in the whole sample were adopters compared to 75.32% of the males who were adopters.

4.1.4 Occupation of the Household Head

Table 4.5: Occupation of the Household Head

	Non adopters			Adopters		
	Freq.	Percent	Cum.	Freq.	Percent	Cum.
Farming	27	84.38	84.38	69	78.41	78.41
Labourer	-	-	-	1	1.14	79.55
Trader	4	12.5	96.88	8	9.09	88.64
Others	1	3.12	100.00	10	11.36	100.00
Total	32	100.00		88	100.00	

Source: Survey data, 2007

A larger proportion of non adopters (84%) than adopters (69%) rely on farming as their primary occupation. The main source of livelihood for the whole sample was farming at 80%. Of those who relied on farming as the main source of income, 71.9% were adopters as compared to 66.7% in the traders' category.

4.1.5 Membership to Groups

Table 4.6: Membership to Farmers' Organizations

	Adopters			Non adopters		
Group type	Freq.	Percent	Cum	Freq.	Percent	Cum
Farmers' Group	10	12.50	12.50	3	75	75
Merry go Round	20	25.00	37.50	--	--	--
Common Interest Groups	6	7.50	45.00	--	--	--
Cooperative	2	2.50	47.50	1	25	100
Self Help Groups	16	20.00	67.50	--	--	
In more than 1 group	26	32.50	100.00	--	--	
Total	80	100		4	100	

Source: Survey data, 2007

For the adopters the most, 32.50%, belonged to more than one group, and the least, 2.5%, belonged to cooperatives. 25% of the adopters belonged to Merry go Round groups. For the non adopters the majority, 75%, belonged to farmers' groups. Out of 32

non-adopters, only 4 participated in groups (12.5%), while 90% of adopters (80 out of 88) did.

4.2 Empirical Results

Number of obs = 119, Censored obs. = 32, uncensored obs. = 87

Wald chi2(15) = 8022.05, Prob > chi2 = 0.0000

Table 4.7: Results of the Heckman Two Steps Model

	Marginal effect	Std. Err.	P>|z|
Adoption			
Gender	-.0015634	.0232341	0.946
Age of House hold head	.004961	.000907	0.000***
Educational Level	.0536427	.0163058	0.001***
Experienced BW	.0359969	.0212127	0.090*
Market price	.0004834	.0000704	0.000***
Source of seeds	.0083466	.0084706	0.324
Membership to farmers organizations	.0482683	.0255157	0.059*
Annual extension contacts	.0073437	.0033757	0.030**
Labour force (M/days)	.0000347	.0000525	0.509
% potato land with improved varieties			
Age of hold head	-.0426182	.0236178	0.071*
Educational Level	-.7346175	.4879253	0.132
Experience in growing disease free potatoes	.2981297	.1531512	0.052*
Market price	.0036315	.002874	0.206
Source of seeds	.2679951	.7984439	0.737
Membership to farmers organizations	-1.59774	.9886554	0.106
Annual extension contacts	.2213197	.0786934	0.005***
Mill Ratio	-.0347936	.1084959	0.748

Source: Survey data, 2007.

rho -0.37328 sigma .09321018 lambda -.03479361 .1084959

*Statistically significant at the $p < 0.10$ level. ** Statistically significant at the $p < 0.05$ level. *** Statistically significant at the $p < 0.01$ level.

Age of the household head had positive and significant effect on probability of adoption but a negative and significant effect on extent of adoption meaning that age was

a disincentive towards expansion of the enterprise. This implies that old farmers should be targeted as first adopters. The old farmers may have required resources to adopt the technology, because it is capital intensive, but younger farmers tend expand the technology more upon adoption. This is in line with Simtowe, 2007 who found that households headed by the elderly allocate smaller proportions of land to hybrid maize than those that are younger. This can be explained by the fact that, older farmers are usually associated with high risk aversion and sometime may have fixed areas allocated to different enterprises on the farm.

Education had a positive and significant effect on probability of adoption reflecting the high degree of knowledge that first adopters require. However the same factor had a negative and insignificant effect on extent of adoption. This can be interpreted to mean that those who are educated are more likely to adopt but upon adoption level of education does not influence expansion of the technology in the farm. Other studies have also found a positive association between education and adoption of agricultural technology (Ervin and Ervin 1982; Mwakubo et al. 2004).

Those who had experienced the disease were more likely to adopt the technology. This implies that areas where the disease is prevalent should be targeted for faster adoption of the technology. Concentrating adoptions campaigns in such areas can play a big role in curbing the spread of the disease.

Market price had positive and significant effect on probability of adoption. This implies that, the factor is very crucial at the adoption stage. Attractive market prices can only be realized in an efficient marketing system. Good market access is one of the factors that influence price levels (Minten, 1999). It has been shown that deficient transport infrastructure is an important determinant of low technological adoption, cropping choices and of low agricultural productivity in developing countries (Omamo, 1998; Zeller et al., 1998; Von Oppen et al., 1997).

Membership to farmers' organizations returned a positive and significant effect on probability of adoption. The results indicate that the membership acted as an incentive to adoption. This is because farmers learn of new innovation through interaction. Upon adoption reliance on group dynamics is not key in determining the extent of adoption. This is because farmers initially, rely on groups as the source of seeds which are planted

on individual farms. It was observed that, seeds from common interest groups are cheaper than those from the research station.

The number of extension contacts a farmer received returned a positive and significant effect on probability of adoption and the degree of adoption. The results confirm the a priori expectation that farmers who receive extension messages are more likely to adopt. Upon adoption, extension is still important to the farmers, as it plays a key role in expanding the size of the enterprise. This implies that farmers require continuous training on how to handle a new technology. This observation is in line with Eusebius et al (2005), who reported that, it is better to start extension projects involving simple technologies that have been proven successful under similar circumstances. In addition, most farmers learn by observing the experiences of others.

The results of the model show that there are not only separate sets of variables that determine the probability of adoption and the degree of adoption in terms of proportion of Irish potato land allocated to the disease free Irish potato varieties, but also that the variables may have opposite effect.

4.2.1 Interpretation of the Marginal Effects

Marginal effects are popular in economics because they often provide a good approximation to the amount of change in the dependent variable that will be produced by a 1-unit change in one independent variable holding others constant.

To evaluate the effects of each independent variable on the adoption of disease free Irish potato varieties, marginal effects were estimated (Table 4.7). It can be seen that the same set of independent variables used in the primary index function show a significant effect on the adoption of disease free Irish potato varieties. The marginal effect of 0.004961 for age of the household head implies that every 10 years increase in age would increase the probability of adoption of disease free Irish potato varieties by 5%. However, the study did not establish the maximum age up to which this holds. Similarly, increase in market price by ten shillings would increase the probability of adoption by 4.8%. an increase of number of extension contact by ten would increase probability of adoption by 7.3%. It can also be noted that being a member of farmer's organization increases the probability of adoption by 4.8%.

On the other hand, increase of the age of the household head's age by one year discouraged expansion of adoption by 4.3%. At the same time experiencing the disease increased the rate of expansion of the technology by 30%. Access to formal source of seed also influenced the rate of expansion by 26.8%.

4.2.2 Farmers' Constraints to Adoption of Disease free Irish potato Varieties

Table 4.8: Reasons for not Adopting the Disease free potato varieties

Reason for not adopting disease free Irish potato varieties	Frequency	Percentage	Cumulative
Never heard about them	4	12.5	12.5
Expensive	5	15.6	28.1
No production know how	3	9.4	37.5
Not available	6	18.75	56.25
Risky venture	14	43.75	100.00
Total	32	100.00	

Source: Survey data, 2007

Most of the farmers (43.75 %) reported risks as the most constraining factor leading to non adoption. The attitude of farmers to risk is an important factor in adoption. It is generally understood that risk-averse farmers are reluctant to invest in innovations of which they have little first-hand experience (IFAD, 2007).

Seed availability was ranked second, 18.75%, in terms of reasons for not adopting the varieties. Some 15.6% termed the seeds as expensive hence non adoption.

Farmers explained that seeds were not always available. The little that was available at KARI seed multiplication centre at Njabini was usually expensive at 1900/= for a 50kg bag. Complementary to this was high input prices, including fertilizers and fungicides and poor road net work.

12.5% of the farmers had not heard about disease free varieties, whereas 9.45 had no production know how. This implies that intensification of extension is required to reach many farmers and impart the technical know-how. All means that can improve publicity should be pursued to improve uptake of the varieties.

Tigoni variety, which was the most popular with the consumers, suffers from a major set back in that it greens very fast after harvesting.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

In this chapter, conclusions, implications of the findings and recommendations of the study are given.

5.1 Conclusions

One aspect in which the results are interesting is the apparent differences in explanatory variables between the two steps. The study revealed that, farmers who had access to secondary and post secondary education were significantly more likely to adopt the technology, but once the farmer adopted the technology; such factors did not influence the decision to intensify the adoption of the technology. The positive impact of this factor on adoption of disease free Irish potato varieties is an indication that this can be intensified to influence the adoption process. The results also indicate that focusing on old farmers who are educated and had previous experience of the disease would yield better results in term of adoption of the technology.

The results also suggest that marketing problem is one of the constraints contributing to low adoption of disease free Irish potato varieties as depicted by the market prices. The marketing system is generally informal and poorly developed. This implies facilitating access to marketing of Irish potato is an obvious prerequisite for improvement of adoption of disease free Irish potato varieties. Farmers' organizations can be a good avenue for the supplying timely and affordable inputs to the farmers. They can also address the issue of product marketing. Such systems will protect the interests of individual farmers and attract technical assistance and cooperation, which would be impossible for an individual small holder. For almost any intervention a level of farmer organization is required (Gildemacher et al, 2007).

All players should focus on improving the availability of disease free potato varieties. Community-based seed production programs should be supported until commercial seed enterprises develop to fill the current void caused by high prices which majority of the farmers cannot afford. The reported 67.5% spread of Bacterial Wilt indicates the importance of disease free Irish potato varieties in the study area as a counter measure to the spread of the disease.

It was also apparent that extension is key in adoption of the technology; however, in practice extension service often tends to focus on very few farmers who are early adopters. Because this approach narrows the benefits that can be derived from the use of better practices, extension should rather address its basic main aim in a more integrated manner. The analysis clearly indicates that there has been limited contact between farmers and the extension system in its broadest sense (including the non-governmental organizations, active in agricultural development) with an annual mean contact of 13.1, other studies have found that lack of information transfer, and especially the limited contacts between research, extension and farmers, has been raised as a concern, in Nyandarua (Gildemacher et al, 2007).

Greater emphasis on exposing farmers, especially women, to disease free varieties is therefore, urgently needed as a first step in improving adoption. This implies that, for an effective information communication, the relationship between farmers and extension agents must be sustained even after the farmer has adopted the technology.

5.2 Recommendations

The following recommendations have been made from the study:

1. Facilitation on formal education expansion should be given priority for future improvement of technology adoption. Agricultural related courses in secondary and post secondary institutions could yield the desired results.
2. Ways should be devised for improving market prices of the farmers. This can be done by providing, timely market information infrastructure, such as roads and market sites; which can increase the efficiency of both marketing and production as they reduce transactions costs and ensure more competitive pricing conditions in marketing than would occur in their absence.
3. The existing extension packages should be beefed up and better ones developed. Continued extension contact with the farmers who have already adopted is likely to yield better results. Ways should be devised to reach farmer who are outside the focal area who are not members of CIGs. More campaigns in areas where the disease is prevalent would generate good results.

4. In order to address the issue of high prices of the seeds, farmers should be encouraged to bulk potato seeds in groups. This would create better avenues for other joint interventions in form of farmers training, seed acquisitions, multiplication and distribution.
5. Access to risk coping instruments should be improved at the farm level. This may allow households to take higher risks in production and achieve higher expected incomes. Such instruments include flexible credit, provision of starter input packages to well organized group and trainings on all aspects of Irish potato production.
6. Future research should focus on other issues that the current study has not been able to cover due to its limitations, such as adoption of the disease free varieties over time and post harvest management of Tigoni variety. The study also exposed risk as the most constraining factor to adoption of the technology. Since adoption has significant policy relevance, a study on risk preference is recommended. Risk considerations are important in the analysis of the agricultural sector as there exists a number of possible cases where well articulated policy formulation should consider more than the marginal contributions of disease free potato varieties to the mean of the crop output.

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APPENDICES

Appendix I: Correlation matrix for the explanatory variables

	gender	agehh	educlvl	exbw	mktprice	scseed	meor	ext	labfor	ipvexp
gender	1.0000									
agehh	0.1278	1.0000								
educlvl	-0.1793	-0.1360	1.0000							
exbw	0.0232	-0.0766	-0.0529	1.0000						
mktprice	0.1379	0.0508	0.1337	-0.0920	1.0000					
scseed	0.0733	-0.0133	-0.0875	0.0214	0.2060	1.0000				
meor	-0.0496	-0.0332	-0.0541	0.0047	-0.0707	-0.1670	1.0000			
ext	0.0822	0.1258	0.1059	-0.1702	0.7582	0.1904	0.0596	1.0000		
labfor	0.1628	-0.1125	-0.0113	-0.0057	0.2241	0.0167	0.1744	0.2501	1.0000	
ipvexp	0.064	0.109	0.029	-0.118	0.339	0.263	-0.0697	0.335	-0.113	1.000

Appendix II: Results of the Descriptive Statistics

adption = non adop

Variable	Obs	Mean	Std. Dev.	Min	Max
gender	32	.59375	.4989909	0	1
agehh	32	48.25	12.14429	30	76
hhsize	32	4.84375	1.68694	1	8
educlvl	32	2.34375	.5453247	2	4
assetvle	32	779281.3	702561.2	106000	3656500
ldsze	32	3.151188	2.999549	.5	12
mktprice	32	479.6875	67.03318	400	700
potmkd	32	73.875	8.586373	50	95
offinc	32	.4375	.5040161	0	1
scseed	32	.03125	.1767767	0	1
meor	32	.78125	.4200134	0	1
labfor	32	235.3438	127.2066	91	525
pfamlab	32	48.28125	30.36364	10	100
tinskst	32	2.10625	.8650704	.4	3
tomkt	32	4.875	1.581139	1	7
ext	32	3.84375	3.332241	0	20

adption = adopter

Variable	Obs	Mean	Std. Dev.	Min	Max
gender	88	.6590909	.4767313	0	1
agehh	88	50.18182	10.93192	29	74
hhsize	88	4.772727	2.153464	1	10
educlvl	88	2.534091	.6600046	1	4
assetvle	88	1262324	1297463	95500	7408000
ldsze	88	1.888812	2.136829	.19	13
mktprice	88	858.5227	121.8209	600	1200
potmkd	88	81.5625	9.974915	42.5	100
offinc	88	.2954545	.4588614	0	1
scseed	88	.5681818	1.229853	0	11
meor	88	.7272727	.447914	0	1
labfor	88	288.0455	200.6974	1	1270
pfamlab	87	52.41379	28.9934	0	100
tinskst	88	1.575227	.8827413	.16	3
tomkt	87	1.445402	.9610324	.5	6
ext	88	16.46591	3.359491	10	25

Variable	Obs	Mean	Std. Dev.	Min	Max
gender	120	.6416667	.4815213	0	1
agehh	120	49.66667	11.2484	29	76
hhsize	120	4.791667	2.032905	1	10
educlvl	120	2.483333	.6348868	1	4
assetvle	120	1133513	1185463	95500	7408000
ldsze	120	2.225445	2.448731	.19	13
mktprice	120	757.5	200.802	400	1200
potmkd	120	79.5125	10.17855	42.5	100
offinc	120	.3333333	.4733811	0	1
scseed	120	.425	1.082034	0	11
meor	120	.7416667	.4395535	0	1
labfor	120	273.9917	184.9623	1	1270
pfamlab	119	51.30252	29.29585	0	100
tinskst	120	1.716833	.905674	.16	3
ext	120	13.1	6.523906	0	25

Appendix III: Results of the Two Stage Heckman Model

```
Heckman adption gender agehh educlvl exbw mktprice scseed  meor ext
labfor, noconstant twostep select(potl
> and = agehh educlvl ipvexp mktprice scseed meor ext, noconstant)
rhosigma

Heckman selection model -- two-step estimates   Number of obs =      119
(regression model with sample selection)
                                                Censored obs  =       32
                                                Uncensored obs =       87

                                                Wald chi2(15) =  8022.05

                                                Prob > chi2   =   0.0000

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
adption      |
      gender |  -.0015634   .0232341    -0.07   0.946    -.0471015    .0439747
       agehh |    .004961   .000907     5.47   0.000     .0031833    .0067388
     educlvl |   .0536427   .0163058     3.29   0.001     .0216839    .0856014
        exbw |   .0359969   .0212127     1.70   0.090    -.0055793    .0775731
    mktprice |   .0004834   .0000704     6.87   0.000     .0003454    .0006213
      scseed |   .0083466   .0084706     0.99   0.324    -.0082556    .0249488
        meor |   .0482683   .0255157     1.89   0.059    -.0017415    .098278
         ext |   .0073437   .0033757     2.18   0.030     .0007274    .01396
      labfor |   .0000347   .0000525     0.66   0.509    -.0000682    .0001376
-------------+----------------------------------------------------------------
potland      |
       agehh |  -.0426182   .0236178    -1.80   0.071    -.0889083    .0036719
     educlvl |  -.7346175   .4879253    -1.51   0.132    -1.690933    .2216985
      ipvexp |   .2981297   .1531512     1.95   0.052     -.0020411   .5983005
    mktprice |   .0036315   .002874     1.26   0.206    -.0020015    .0092645
      scseed |   .2679951   .7984439     0.34   0.737    -1.296926    1.832916
        meor |   -1.59774   .9886554    -1.62   0.106    -3.535469    .3399887
         ext |   .2213197   .0786934     2.81   0.005     .0670836    .3755559
-------------+----------------------------------------------------------------
mills        |
      lambda |  -.0347936   .1084959    -0.32   0.748    -.2474417    .1778545
-------------+----------------------------------------------------------------
         rho |   -0.37328
       sigma |   .09321018
      lambda |  -.03479361   .1084959
------------------------------------------------------------------------------
```

Appendix IV: Questionnaire

EGERTON UNIVERSITY

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS MANAGEMENT, MSc. THESIS PROJECT

TITLE: Factors Influencing Agricultural Technology Adoption: The Case of Disease Free Irish Potato Varieties in South Kinangop Division, Nyandarua District, Kenya

CONFIDENTIAL: This questionnaire is being administered for the purpose of research. The information gathered will be used to investigate the factors that influence adoption of disease free Irish potato varieties in South Kinangop Division. Your participation in answering these questions will be very much appreciated. Confidentiality will be strictly adhered to.

Questionnaire No Date ..

Time start Time end .

(PI) Enumerators Name .

(P2) Location ☐ (P4) Sub location ☐

(P3) Village ☐ (P5) Agro-ecological zone

Genera information

(P6) Respondent Name hhnum _

(P7) Marital status ☐

S = Single M= Married

(P8) Please list durable assets and livestock on the farm and their estimated value

Asset	Estimated Value (Ksh)	Type of livestock	Estimated Value (Ksh)
1.			
2.			
3.			
4.			
5.			

(P9) Household Profile

hhnum	Name NAME	Age AGE	Position in household PHLD	Sex SEX	Level of education LEDUC	Potato production experience (years) POTEX	Occupation
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Code: Sex, 1= Male, 2= Female Position in household, l= Head, 2= Otherwise, Level of education, l= None, 2= Primary level, 3= Secondary level, 4= Tertiary level, Experience in potato production in years, 1= <5, 2= 5-10,3= 10-15 and 4= >15 Occupation, 1= Farming, 2=Laborer, 3= Trader, 4=Other self employment, 5=Unemployed ,6= Others, please specify

(A)Land Issues

(Please indicate land size in Hectares)

(A1) Owned land ☐

(A2) Area of land leased outside the farm ☐

(A3) Area leased out ☐

(A4) Total land size ☐

(A5) Approximate annual land rental price . kshs / ha (last 12 months)

(A6) Land use in hectares (last 12 months)

1. Land under potato ☐ 2. Homestead ☐ 3. Woodlot ☐

4. Land under disease free Irish potato variety/s ☐

5. Grazing area ☐

6. Cabbages ☐

7. Fodder ☐

8. Carrots ☐

9. Peas ☐ 10. Kales ☐

11. Orchard ☐ 12.Floriculture

13. Others (Please specify)

.....

Total ☐

(A6) Have you ever planted disease free Irish potato varieties?

1, Yes ☐ 2, No ☐

(A 7) If no, what were the reasons for not planting the varieties?

1. Never heard about them ☐ 3. No production technical know how ☐

2. Expensive ☐ ☐

4. Not available ☐

5. Risky venture

Others, (please specify) .....

(A8) If yes, for how long have you been growing the varieties? Years.

(A9) For what purpose do you grow the varieties?

1. Own use ☐ 2.For sale ☐ 3.Others, (please specify)

(A10) Have you ever experienced bacterial wilt on your farm?

1. Yes ☐ 2. No

5. Others, (Please specify) .

(A11) If yes, what precautionary measure do you employ?

1. Plant clean seeds ☐
2. Crop rotation ☐
3. Field sanitation ☐
4. Combination of the above ☐ (please state the combination).....
5. Others, (please specify).....

(B) FARM ENTERPRISES

(B1) Which is the major agricultural enterprise in the farm in terms of income? (tick)

1 Livestock (please specify) 2. Crop (please specify) .

3. Others, (please specify)

Crop enterprise		Total Production	% sold	% consumed	% retained As seeds	Others uses		Amount Sold (units)	Average Price//unit
		TPRDN	ASOLD	ACONSD	ASEED	AOUSE		ASOLD	AVPSE
Ordinary potato (Specify variety)	1					%	(specify)		
Disease free varieti (Specify variety)	2								
Cabbages	3								
Carrots	4								
. Kales	5								
Peas	6								
Floriculture	7								
Fruits	8								
Others, please specify	9								
.....									

(B2) Sources of income (Last 12 months) (Tick first column and rank the second column, 1, highest etc)

	Tick	Rank
(1) Potato	☐	☐
(2) Other crops	☐	☐
(3) Livestock	☐	☐
(4) Salary/wages	☐	☐
(5) Relative remittance	☐	☐

(6) Others, specify.....

(Please rank the income sources in order of importance in the second column above)

(C) PRODUCTION INFORMATION

(C1) What is your main reason for growing potatoes?

1. For home consumption ☐ 2. Ware potato ☐

Source

3. For commercial seeds ☐

4. Others (please specify).....

(C2) Please state the quantity and amount of the following farm inputs used in disease free Irish potato production for the past 12 months;

	Qty.	Amt(Ksh)		Qty.	Amt(Ksh)
1. Seed	☐	☐	2.Land	☐	☐
3. Fertilizers	☐	☐	4. Fungicides	☐	☐
5. Farm yard manure	☐	☐	6. Insecticides	☐	☐
7. Labour	☐	☐			

8. Others specify.....

(C3) Please state the quantity and amount of the following farm inputs used in ordinary potato production for the past 12 months;

	Qty.	Amt(Ksh)		Qty.	Amt(Ksh}
1. Seeds	☐	☐	2. Land	☐	☐
3. Fertilizers	☐	☐	4. Fungicides	☐	☐
5. Farm yard manure	☐	☐	6. Insecticides	☐	☐
7. Labour	☐	☐			

8. Others, (please specify)

(C4) Source of disease free Irish potato varieties;

Source	Tick	Rank
1. Own seed plot	☐	☐
2. Individual potato seed producers	☐	☐
3. Organized groups potato seed producer	☐	☐
4. Farm input stockist	☐	☐

(Please rank the sources in order of importance in the second column above)

5. Others (please specify) .....

(C5) Type of disease free Irish potato variety grown in the last twelve months

1. Tigoni ☐ 2. Asante ☐ Others .

(C6) Reasons for preferring the variety stated above:

	Tigoni		Asante		Others	
	Tick	Rank	Tick	Rank	Tick	Rank
1. Taste and preference	☐	☐	☐	☐	☐	☐
2. Keeping quality	☐	☐	☐	☐	☐	☐
3. Preferred in the market	☐	☐	☐	☐	☐	☐
4. Tolerant to pests and diseases	☐	☐	☐	☐	☐	☐
5. High yielding	☐	☐	☐	☐	☐	☐
6. Early maturing	☐	☐	☐	☐	☐	☐

7. Others (please specify).....

(C7) Seed plot establishment and management expenses. Please indicate the seed plot area in M^2 .....

Inputs		Amount	Unit	Unit Cost(Ksh)	Total cost(Ksh)
		Amt	Unt	UCOST	TCOST
Seeds	1				
Fertilizer TSP/DAP	2				
Fungicides/Insecticides	3				
Foliar feed	4				
Labour expenses	5				
Total					

(D) PROVISION OF SUPPORT SERVICES (last twelve months)

(DI) Who is the main provider of?

i) Potato production extension services ☐
ii) Crop protection services ☐
iii) Marketing Information service ☐
iv) Farm labour services ☐

Code: 1 = Public Agricultural extension agent, 2=NGO, 3=Neighbor/Farmer, 4= Private agent, 5=Educational bodies, 6=Community Based Organization (CBO) 7=Radio/Television, 8=Mobile phone, 9=Farmer organization/co-operative, 10. Others, Specify.....

(D2) Do you belong to any group in your area? 1. Yes ☐ 2. No ☐

(D3) If yes, which of the following?

1. Farmer group ☐ 4. Cooperative ☐
2. Merry - go - round ☐ 5. Selfhelp group ☐
3. CIG ☐ 6. Others, Specify .....

(D4) Are you in any leadership position? Yes ☐ No ☐

(D5) Please state how you benefit from the group.....

(D6) For the last one year have you been visited by (Tick)

		Yes	No
i.	Public Agricultural extension agent	☐	☐
ii.	Private agricultural agent	☐	☐
iii.	Researcher	☐	☐

iv. Educational organization agent ☐☐

v. NGO ☐☐

vi. Others who have visited (please specify).....

(D7) Have the neighboring farmer played any role in influencing your attitude towards disease free Irish potato varieties adoption?

1. Yes ☐ 2. No ☐

If yes, please indicate the kind of influence .....

(D8) Did you actively seek advice on potato production in the last twelve months?

1. Yes ☐ 2. No ☐

(D9) If yes, from where did you seek the advice.....

(DI0) Did you succeed in getting the advice? 1. Yes ☐ 2. No ☐

(D11) If no, why didn't you succeed?

1. Time consuming ☐
2. Long Distance ☐
3. Service agents not available ☐
4. Expensive ☐
5. Others, specify.....

(D12) Has any member of the household attended any of the following training on potato production over the last one year? (tick)

	1. Yes	2. No
1. Workshop/Seminar	☐	☐
2. Group trainings	☐	☐
3. ASK show/field day	☐	☐
4. Others (please specify).....		

D13) Who normally attend such training? (tick)

1. Household Head ☐ 2. Spouse ☐
3. Son/Daughter ☐ 4. Worker ☐

(D14) Did any research organization involve the household with issues related to disease free Irish potato production? 1. Yes ☐ 2. No ☐

(D15) If yes, please specify .....

(F) CREDIT (PAST TWELVE MONTHS)

(F1)Did any member of the household apply for credit? (tick)

1. Yes ☐ 2. No ☐

(F2) If yes, how much was applied for? Kshs ☐

(F3) Was the credit given? (tick)

1. Yes ☐ 2. No ☐

(F4) If yes, how much was given? Kshs ☐

(F5)What was the purpose of the credit? (tick)

1. Crops 2. Potato production

3. Others (please specify) .....

(F6) If No, what was the reason for not being granted credit? (tick)

1. Had outstanding loan ☐ 2. No security ☐

3. Others, (Please specify).....

(F7) If yes, was the credit given in kind or in cash? (tick)

Cash ☐ 2. Kind ☐

(F8) Amount in cash. Kshs ☐ **Equivalent amount in kind Kshs.** ☐

(F9) Which was the source of the credit? (tick)

Source		Amount (kshs)		Source		Amount	
1. Neighbour	☐	☐		2.NGO	☐	☐	
3. Commercial bank	☐	☐		4.Relative	☐	☐	
5. Saccos	☐	☐		6. Local Group	☐	☐	
7.Microfinance	☐	☐					

8. Others, specify.....

G MARKETING OF POTATO

(G1) Where do you sell your potato?

Outlet	Proportion	Tick	Price/bag (wet season)	Price/bag (dry season)	Distant (Km)	Rank
Sell at farm gate						
Local market/s						
Private						
Distant market/s						
Institutions						
Local Consumers						

(Please rank the market outlet in order of importance in the last column above)

(G2). Mode of transport of potato to market (tick)

	Tick	Rank	Approximate cost Ksh/Km/bag
1. Head load			
2. Hand cart/Donkey/Oxen			
3. Bicycle			
4. Motor vehicle			
5. Motorcycle			
6. Collected at farm			

(G3).Why do you prefer the current buyer? (tick)

1. Regular payments
2. Lump sum pay
3. Volume of sales
4. Will buy always
5. Offers credit

6 Others (please specify) .....

(H) LABOUR ASPECTS (Last twelve months)

Enterprise	Labour requirement (dry season)	Labour requirement (wet season)	Labour allocation (dry season)	Labour allocation (wet season)
Livestock				
Ordinary potato (Specify variety)				
Disease free varieties (SpecifY variety)				
Cabbages				
Carrots				
Kales				
Peas				
Floriculture				
Fruits				
Others, please specify				

(H1) Did you employ someone for potato production in the last twelve month? (tick)

1. Yes ☐ 2. No ☐

(H2). Average monthly salary rate for a farm laborer in Kshs ☐

(H3). Average daily wage rate for a farm laborer in Kshs ☐

(H8) Of the total annual labour requirement, what percentage is contributed by family members'? ☐

(H9). Of the family labour, what proportion (%) is contributed by?

1. Men ☐ 2. Women ☐ 3. Children ☐

(J) Infrastructure (Roads)

(JI) Distance from homestead to the nearest;

	Distance (Time)	Distance (KM)	Road type
(1) Input stockist			
(2) Extension service provider			
(3) Source of disease free varieties			
(4) Potato research station			

Code:	Distance in time(t)	Road types
1.	$t<1/_2$ hrs	1. Marrum
2.	$\frac{1}{2} \leq t < 1$ hrs	2. Tarmac
3.	$1 \leq t < 1\ \frac{1}{2}$hrs	3. All weather
4.	$1\ \frac{1}{2} \leq t < 2$ hrs	4. Dry weather
5.	$t \geq 2$hrs	5. Foot path

Please give any general view on disease free Irish potato varieties.....

.....

.....

.....

.....

THANK YOU FOR YOUR COOPERATION

Appendix IV: Questionnaire

EGERTON UNIVERSITY

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Questionnaire No Date ..

Time start Time end .

(PI) Enumerators Name .

(P2) Location ☐ (P4) Sub location ☐

(P3) Village ☐ (P5) Agro-ecological zone

Genera information

(P6) Respondent Name hhnum _

(P7) Marital status ☐

S = Single M= Married

(P8) Please list durable assets and livestock on the farm and their estimated value

Asset	Estimated Value (Ksh)	Type of livestock	Estimated Value (Ksh)
1.			
2.			
3.			
4.			
5.			

(P9) Household Profile

hhnum	Name NAME	Age AGE	Position in household PHLD	Sex SEX	Level of education LEDUC	Potato production experience (years) POTEX	Occupation
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Code: Sex, 1= Male, 2= Female Position in household, 1= Head, 2= Otherwise, Level of education, 1= None, 2= Primary level, 3= Secondary level, 4= Tertiary level, Experience in potato production in years, 1= <5, 2= 5-10,3= 10-15 and 4= >15 Occupation, 1= Farming, 2=Laborer, 3= Trader, 4=Other self employment, 5=Unemployed ,6= Others, please specify

(A)Land Issues

(Please indicate land size in Hectares)

(A1) Owned land ☐

(A2) Area of land leased outside the farm ☐

(A3) Area leased out ☐

(A4) Total land size ☐

(A5) Approximate annual land rental price . kshs / ha (last 12 months)

(A6) Land use in hectares (last 12 months)

1. Land under potato ☐ 2. Homestead ☐ 3. Woodlot ☐

4. Land under disease free Irish potato variety/s ☐

5. Grazing area ☐

6. Cabbages ☐

7. Fodder ☐

8. Carrots ☐

9. Peas ☐ 10. Kales ☐

11. Orchard ☐ 12.Floriculture

13. Others (Please specify)

.....

Total ☐

(A6) Have you ever planted disease free Irish potato varieties?

1, Yes ☐ 2, No ☐

(A 7) If no, what were the reasons for not planting the varieties?

1. Never heard about them ☐
2. Expensive ☐
3. No production technical know how ☐
4. Not available ☐
5. Risky venture ☐

Others, (please specify) .....

(A8) If yes, for how long have you been growing the varieties? Years.

(A9) For what purpose do you grow the varieties?

1. Own use ☐ 2.For sale ☐ 3.Others, (please specify)

(A10) Have you ever experienced bacterial wilt on your farm?

1. Yes ☐ 2. No

5. Others, (Please specify) .

(A11) If yes, what precautionary measure do you employ?

1. Plant clean seeds ☐
2. Crop rotation ☐
3. Field sanitation ☐
4. Combination of the above ☐ (please state the combination).....
5. Others, (please specify).....

(B) FARM ENTERPRISES

(B1) Which is the major agricultural enterprise in the farm in terms of income? (tick)

1 Livestock (please specify) 2. Crop (please specify) .

3. Others, (please specify)

Crop enterprise		Total Production	% sold	% consumed	% retained As seeds	Others uses		Amount Sold (units)	Average Price//unit
		TPRDN	ASOLD	ACONSD	ASEED	AOUSE		ASOLD	AVPSE
Ordinary potato (Specify variety)	1					%	(specify)		
Disease free varieti (Specify variety)	2								
Cabbages	3								
Carrots	4								
. Kales	5								
Peas	6								
Floriculture	7								
Fruits	8								
Others, please specify	9								
.....									

(B2) Sources of income (Last 12 months) (Tick first column and rank the second column, 1, highest etc)

	Tick	Rank
(1) Potato	☐	☐
(2) Other crops	☐	☐
(3) Livestock	☐	☐
(4) Salary/wages	☐	☐
(5) Relative remittance	☐	☐

(6) Others, specify.....

(Please rank the income sources in order of importance in the second column above)

(C) PRODUCTION INFORMATION

(C1) What is your main reason for growing potatoes?

1. For home consumption ☐ 2. Ware potato ☐

Source

3. For commercial seeds ☐

4. Others (please specify).....

(C2) Please state the quantity and amount of the following farm inputs used in disease free Irish potato production for the past 12 months;

	Qty.	Amt(Ksh)		Qty.	Amt(Ksh)
1. Seed			2.Land		
3. Fertilizers			4. Fungicides		
5. Farm yard manure			6. Insecticides		
7. Labour					

8. Others specify.....

(C3) Please state the quantity and amount of the following farm inputs used in ordinary potato production for the past 12 months;

	Qty.	Amt(Ksh)		Qty.	Amt(Ksh}
1. Seeds			2. Land		
3. Fertilizers			4. Fungicides		
5. Farm yard manure			6. Insecticides		
7. Labour					

8. Others, (please specify)

(C4) Source of disease free Irish potato varieties;

Source	Tick	Rank
1. Own seed plot		
2. Individual potato seed producers		
3. Organized groups potato seed producer		
4. Farm input stockist		

(Please rank the sources in order of importance in the second column above)

5. Others (please specify) .....

(C5) Type of disease free Irish potato variety grown in the last twelve months

1. Tigoni ☐ 2. Asante ☐ Others .

(C6) Reasons for preferring the variety stated above:

	Tigoni		Asante		Others	
	Tick	Rank	Tick	Rank	Tick	Rank
1. Taste and preference	☐	☐	☐	☐	☐	☐
2. Keeping quality	☐	☐	☐	☐	☐	☐
3. Preferred in the market	☐	☐	☐	☐	☐	☐
4. Tolerant to pests and diseases	☐	☐	☐	☐	☐	☐
5. High yielding	☐	☐	☐	☐	☐	☐
6. Early maturing	☐	☐	☐	☐	☐	☐

7. Others (please specify).....

(C7) Seed plot establishment and management expenses. Please indicate the seed plot area in M^2 .....

Inputs		Amount	Unit	Unit Cost(Ksh)	Total cost(Ksh)
		Amt	Unt	UCOST	TCOST
Seeds	1				
Fertilizer TSP/DAP	2				
Fungicides/Insecticides	3				
Foliar feed	4				
Labour expenses	5				
Total					

(D) PROVISION OF SUPPORT SERVICES (last twelve months)

(DI) Who is the main provider of?

i) Potato production extension services ☐
ii) Crop protection services ☐
iii) Marketing Information service ☐
iv) Farm labour services ☐

Code: 1 = Public Agricultural extension agent, 2=NGO, 3=Neighbor/Farmer, 4= Private agent, 5=Educational bodies, 6=Community Based Organization (CBO) 7=Radio/Television, 8=Mobile phone, 9=Farmer organization/co-operative, 10. Others, Specify.....

(D2) Do you belong to any group in your area? 1. Yes ☐ 2. No ☐

(D3) If yes, which of the following?

1. Farmer group ☐ 4. Cooperative ☐
2. Merry - go - round ☐ 5. Selfhelp group ☐
3. CIG ☐ 6. Others, Specify .....

(D4) Are you in any leadership position? Yes ☐ No ☐

(D5) Please state how you benefit from the group.....

(D6) For the last one year have you been visited by (Tick)

		Yes	No
i.	Public Agricultural extension agent	☐	☐
ii.	Private agricultural agent	☐	☐
iii.	Researcher	☐	☐

iv. Educational organization agent ☐ ☐

v. NGO ☐ ☐

vi. Others who have visited (please specify).....

(D7) Have the neighboring farmer played any role in influencing your attitude towards disease free Irish potato varieties adoption?

1. Yes ☐ 2. No ☐

If yes, please indicate the kind of influence .....

(D8) Did you actively seek advice on potato production in the last twelve months?

1. Yes ☐ 2. No ☐

(D9) If yes, from where did you seek the advice.....

(DI0) Did you succeed in getting the advice? 1. Yes ☐ 2. No ☐

(D11) If no, why didn't you succeed?

1. Time consuming ☐
2. Long Distance ☐
3. Service agents not available ☐
4. Expensive ☐
5. Others, specify.....

(D12) Has any member of the household attended any of the following training on potato production over the last one year? (tick)

	1. Yes	2. No
1. Workshop/Seminar	☐	☐
2. Group trainings	☐	☐
3. ASK show/field day	☐	☐

4. Others (please specify).....

D13) Who normally attend such training? (tick)

1. Household Head ☐ 2. Spouse ☐
3. Son/Daughter ☐ 4. Worker ☐

(D14) Did any research organization involve the household with issues related to disease free Irish potato production? 1. Yes ☐ 2. No ☐

(D15) If yes, please specify .....

(F) CREDIT (PAST TWELVE MONTHS)

(F1)Did any member of the household apply for credit? (tick)

1. Yes ☐ 2. No ☐

(F2) If yes, how much was applied for? Kshs ☐

(F3) Was the credit given? (tick)

1. Yes ☐ 2. No ☐

(F4) If yes, how much was given? Kshs ☐

(F5)What was the purpose of the credit? (tick)

1. Crops 2. Potato production

3. Others (please specify) .....

(F6) If No, what was the reason for not being granted credit? (tick)

1. Had outstanding loan ☐ 2. No security ☐

3. Others, (Please specify).....

(F7) If yes, was the credit given in kind or in cash? (tick)

Cash ☐ 2. Kind ☐

(F8) Amount in cash. Kshs ☐ **Equivalent amount in kind Kshs.** ☐

(F9) Which was the source of the credit? (tick)

Source		Amount (kshs)		Source		Amount	
1. Neighbour	☐		2.NGO	☐			
3. Commercial bank	☐		4.Relative	☐			
5. Saccos	☐		6. Local Group	☐			
7.Microfinance	☐						

8. Others, specify.....

G MARKETING OF POTATO

(GI) Where do you sell your potato?

Outlet	Proportion	Tick	Price/bag (wet season)	Price/bag (dry season)	Distant (Km)	Rank
Sell at farm gate						
Local market/s						
Private						
Distant market/s						
Institutions						
Local Consumers						

(Please rank the market outlet in order of importance in the last column above)

(G2). Mode of transport of potato to market (tick)

	Tick	Rank	Approximate cost Ksh/Km/bag
1. Head load			
2. Hand cart/Donkey/Oxen			
3. Bicycle			
4. Motor vehicle			
5. Motorcycle			
6. Collected at farm			

(G3). Why do you prefer the current buyer? (tick)

1. Regular payments
2. Lump sum pay
3. Volume of sales
4. Will buy always
5. Offers credit

6 Others (please specify) .....

(H) LABOUR ASPECTS (Last twelve months)

Enterprise	Labour requirement (dry season)	Labour requirement (wet season)	Labour allocation (dry season)	Labour allocation (wet season)
Livestock				
Ordinary potato (Specify variety)				
Disease free varieties (SpecifY variety)				
Cabbages				
Carrots				
Kales				
Peas				
Floriculture				
Fruits				
Others, please specify				

(H1) Did you employ someone for potato production in the last twelve month? (tick)

1. Yes ☐ 2. No ☐

(H2). Average monthly salary rate for a farm laborer in Kshs ☐

(H3). Average daily wage rate for a farm laborer in Kshs ☐

(H8) Of the total annual labour requirement, what percentage is contributed by family members'? ☐

(H9). Of the family labour, what proportion (%) is contributed by?

1. Men ☐ 2. Women ☐ 3. Children ☐

(J) Infrastructure (Roads)

(JI) Distance from homestead to the nearest;

	Distance (Time)	Distance (KM)	Road type
(1) Input stockist			
(2) Extension service provider			
(3) Source of disease free varieties			
(4) Potato research station			

Code:	Distance in time(t)	Road types
1.	$t<1/_2$ hrs	1. Marrum
2.	$\frac{1}{2} \leq t < 1$ hrs	2. Tarmac
3.	$1 \leq t < 1\ \frac{1}{2}$hrs	3. All weather
4.	$1\ \frac{1}{2} \leq t < 2$ hrs	4. Dry weather
5.	$t \geq 2$hrs	5. Foot path

Please give any general view on disease free Irish potato varieties.....

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THANK YOU FOR YOUR COOPERATION