EVALUATING FARMERS' AND CONSUMERS' ACCEPTANCE OF NEW COOKING BANANA HYBRIDS IN UGANDA: MICRO-ECONOMIC ANALYSIS AND POLICY IMPLICATIONS

by

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Submitted in fulfilment of the academic requirements for the degree of Doctor of Philosophy in Agribusiness

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DECLARATION 1 - PLAGIARISM

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We hereby agree to the submission of this thesis for examination:

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1. Professor GF Ortmann (Supervisor)

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2. Dr E Wale (Co-supervisor)

DECLARATION 2 – PUBLICATIONS

The following publications (submitted, in press and published) form part of the research presented in this thesis.

Publication 1 - Chapter 3 of this thesis

Akankwasa K., G. F. Ortmann, E. Wale and W. K. Tushemereirwe. Early stage adoption of improved banana "Matooke" hybrids in Uganda: a count data analysis based on farmers‟ perceptions. Currently under review with the *International Journal of Innovation and Technology Management*.

Publication 2 - Chapter 4 of this thesis

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Publication 3 - Chapter 5 of this thesis

Akankwasa K., G. F. Ortmann, E. Wale and W. K. Tushemereirwe. 2013. Determinants of consumers‟ willingness to purchase East African Highland cooking banana hybrids in Uganda. *African Journal of Agricultural Research* 8(9): 780-791.

The data collection, analyses and discussion of the empirical results for all the above listed publications were conducted in their entirety by K. Akankwasa with technical advice from Prof G. F. Ortmann and Dr E. Wale and Dr W. K. Tushemereirwe. All figures and tables were produced by same, unless otherwise referenced in the respective publications.

Conference papers

Akankwasa K., G. F. Ortmann, E. Wale and W. K. Tushemereirwe. 2012. Ex-ante adoption of new cooking banana (Matooke) hybrids in Uganda based on farmers' perceptions. Paper presented at the International Association of Agricultural Economists (IAAE) Triennial 2012 Conference, August 18-24, 2012, Foz do Iguaçu, Brazil.

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ABSTRACT

Banana is an important world food crop supporting the food security and livelihoods of millions of smallholders in tropical countries of Africa, including Uganda. Despite the crop‟s importance in Uganda, its productivity has been declining over time due to pests (banana weevils and nematodes), diseases (black Sigatoka, banana bacterial wilt), soil fertility decline, and socio-economic constraints (high costs of managing the crop, competition for labour with other enterprises, marketing difficulties and low genetic diversity, among others). The decline in banana yields has resulted in food shortages, thus putting consumers heavily dependent on banana at risk of food insecurity, particularly in most rural areas of Uganda where the crop is regarded a staple food.

In response to this trend, the National Banana Research Programme (NBRP) in Uganda initiated a breeding programme in 1994 using a participatory plant breeding approach. The programme has so far developed four new banana 'matooke' hybrid varieties (M2, M9, M14, and M17). These varieties have been under evaluation in different agro-ecological regions of Uganda since 2008 with Mbwazirume (a traditional variety) as a local check. Despite the research and extension efforts to popularise these hybrids in Uganda, to date, no attempt had been made to document consumer acceptance and the likelihood of farmer adoption of these hybrid bananas. Little is known about the socioeconomic factors that influence farmers‟ early-stage adoption of the banana hybrids, farmers‟ preferences of the varieties, consumers‟ willingness to purchase the bananas of the hybrids when found on the market, and the likelihood of these hybrid varieties contributing to solving rural household food insecurity and low incomes.

Given this context, the objectives of this study were to: (i) analyse farmers‟ preferences regarding varietal attributes and assess how these preferences, along with farm and farmer specific characteristics, determine the variations in the levels of early stage adoption of hybrid banana varieties in Uganda with the application of factor analysis and a Zero-Inflated Poisson (ZIP) regression model; (ii) analyse the effects of farmer characteristics, variety attributes and agro-ecological conditions on banana variety choice in Uganda, with the application of a multinomial logit model; and (iii) determine the consumption characteristics and sensory attributes that are most important in predicting the likelihood of consumers‟

purchase of hybrid banana varieties using binary logit models. The research focused on four regions of Uganda (namely, Mid-Western, Central, Western and Eastern) representing six major agro-ecological zones, including the Lake Albert crescent area, Lake Victoria crescent, Western highlands, Southern highlands, South-east and Eastern agro-ecologies where the National Banana Research Programme of the National Agricultural Research Organisation is evaluating the new hybrid banana varieties. The data were collected from 454 farmers that included participating (149) and non-participating (305) respondents, and 908 consumers that participated in farmer field days to evaluate various hybrid banana varieties from across the four regions of Uganda.

The results show that, compared to Mbwazirume, four of the hybrids (M2,M9,M14 and M17) are preferred in terms of production characteristics (resistance to Sigatoka, weevils, nematodes, tolerance to poor soils, good bunch size, and sucker production) but are regarded as inferior in terms of consumption characteristics (taste, colour when cooked, and flavour). Field observations suggest that farmers" preferences for production attributes dominate in their variety choice decisions. The hybrid M9 is regarded as having a relatively good performance with respect to most of the production and consumption characteristics.

The results suggest that land constraint, taste and regional location (central region compared with eastern region) were negatively associated with hybrid variety choice while perceptions that hybrid bananas could reduce food insecurity and enhance tolerance to pests and diseases were positively associated with probabilities of hybrid variety choice. Probabilities of choosing hybrids for food security increase in favour of M2 (by 0.06) and M9 (by 0.28), and decrease for M2 (by 0.23), M9 (by 0.07) and M14 (by 0.09) due to unfavourable taste relative to Mbwazirume. Among the consumers, the study suggests that hybrids M2 and M9 were not significantly ($P>0.05$) different in terms of taste, flavour, texture and colour, while differences were observed between M14 and M17 when introduced on the market. Hybrid M14 is regarded as better than M17 in terms of taste, flavour and texture.

The results show that the Eastern region would pay significantly higher prices for the hybrid varieties compared to other regions of Uganda. This result could be attributed to the limited availability of cooking banana varieties in this region. The results suggest that age, education, good taste, flavour and texture were the most important factors that are likely to positively influence the purchase of most of the hybrid banana varieties.

The results further suggest that 41% of the host farmers were having more than sufficient food supplies, while 85% mentioned that their household food situation had substantially improved for the better over the past 3-5 years. The results show that 78% of the host farmers perceived their quantity of food supplies at household level had increased compared to a period before having access to hybrid banana varieties. This clearly shows that adoption of these hybrid banana varieties would enhance rural food security in the country.

The results show that the majority of the respondents were planning to expand production with hybrids M2, M9, M14 and M17. High yield, food security and income generation, resistance to diseases and pests, drought tolerance and the longevity of the hybrid plantations were the reasons given by farmers for their preference for the new hybrid varieties. The study has demonstrated that farmers have relevant knowledge that can be used in setting banana breeding priorities so that they can select varieties that potentially have traits of their preferences. Therefore, involving farmers in the early stage evaluation of new technologies is likely to shorten the time required for evaluation and adoption of the preferred varieties.

Future breeding efforts should target attributes like bunch size, good taste, soft food and agronomic characteristics (including early maturity, performance in a good season, high yielding, plant height and sucker production). Efforts should be made to promote and make available planting materials to more farmers particularly of the most preferred hybrids like M9. The Eastern region of Uganda could be targeted, especially with hybrids M9 and M14 given the scarcity of planting materials in this region and farmers" willingness to offer higher prices for the hybrid bananas.

Further work needs to be done to determine the dynamics of adoption and dis-adoption of these hybrids, and the impact of hybrid bananas on household income and food security. A panel data study could also be conducted to extend the dimensions of the current study and allow for the control of unobserved effects that remain relatively fixed over time at the household and community levels.

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DEDICATION

This thesis is dedicated

My dear wife

Annah

And our children

Treasure, Mwebaze and Praise

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This thesis is the outcome of my long journey that I was determined to take. I thank God Almighty for enabling me to undertake and complete this project.

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LIST OF ABBREVIATIONS

AfDB………………………...African Development Bank

ANOVA.................................Analysis of variance

CGIAR..................................Consultative Group on International Agricultural Research

EET...Early Evaluation Trial

FAO..Food and Agricultural Organisation of the United Nations

GDP..Gross Domestic Product

GM..Genetically Modified

IFAD.......................................International Fund for Agricultural Development

IITA...International Institute for Tropical Agriculture

LPMs.......................................Linear Probability Models

LSD... Least significant differences

MAAIF...................................Ministry of Agriculture, Animal Industry and Fisheries

MNL..Multinomial Logit Model

NARO.....................................National Agricultural Research Organisation

NBRP......................................National Banana Research Programme

NGOs......................................Non-Governmental Organizations

PCA...Principal Component Analysis

UBOS......................................Uganda Bureau of Statistics

WTP...Willingness to pay

ZINB..Zero-Inflated Negative Binomial

ZIP...A Zero-Inflated Poison Regression

CHAPTER 1

INTRODUCTION

1.1 Background

For most of the world‟s poorest countries, agriculture provides a source of livelihoods for an estimated 86% of rural people (World Bank, 2008a). In most African countries, agriculture provides livelihoods and household income for 70% of the people (Borlaug and Dowswell, 2005; AfDB, 2010). The rural areas, where agriculture is the mainstay of people, support 70-80% of the total African population, including 70% of the continent's extreme poor and undernourished (World Bank, 2008b). Agriculture accounts for 20% of the region‟s GDP, and most of the rural poor depend, directly or indirectly, on agriculture for their livelihoods (Dixon et al., 2001). Population increase, among other factors, will drive global demand for food that is expected to grow by 70% by 2030. The size and rate of population increase has been the single most important factor influencing the growth in the demand for food in the poorer countries in the world (Borlaug and Dowswell, 2005). It is estimated that if Africa‟s food supplies do not increase, it will spend about $150 billion on food imports by 2030 (Okyere and Jemaneh, 2012).

Moreover, the African high population growth rate (approximately 3% per year), declining soil fertility and increases in urban migration have increased demand for food (Spilsbury et al., 2002; Dorelien, 2008). This has put pressure on land and other resources for food production in different farming systems. To feed the world‟s growing population, projected to exceed 9 billion in 2050 (United Nations, 2013), it is estimated that food production will have to grow by 70 to 100% (Okyere and Jemaneh, 2012) from lands already in cultivation (FAO, 2011). To meet this demand, there are generally two options: increase the land cultivated (also called extensification) and/or improve technology and production methods (also called intensification). It has been demonstrated in many parts of the world that increasing agricultural productivity can increase food availability and improve rural incomes (Okyere and Jemaneh, 2012).

Despite its importance, in Africa, the agricultural sector is marked by low productivity with little application of science and technology. Agricultural yields in Sub-Saharan Africa remain lower than in other developing regions. Africa‟s low agricultural productivity has many causes, including scarce and scant knowledge of improved practices, poor soils, poor use of improved technologies (including seed and fertilizer), and prevalence of diseases, among others (Okyere and Jemaneh, 2012). An important way to increase food production is through the introduction of improved agricultural technologies and management systems (Doss, 2006; World Bank, 2008a). In areas where agriculture faces severe challenges, such as drought, pest and disease pressure, there is a growing need for improved crop varieties that tolerate stress (FAO, 2011). Farmers will need new technologies to produce more from less land and labour, and the most common solution that science can offer is improved crop varieties through breeding. This solution aims to improve varieties that are highly targeted to local farmers‟ needs. To satisfy the growing demand for food, there is a need for improving productivity on existing farmland by enhancing the yields of food crops per unit area, through advancing science and technology (Edgerton, 2009).

Many technologies have been developed during the past 20 years by national research programs in many countries together with the Consultative Group on International Agricultural Research (CGIAR) (Douthwaite et al., 2001). However, many of these promising innovations have not been taken up by farmers because of the failure of institutions and organisations to take into account the wide range of factors that influence a smallholder farmer‟s decision-making in adopting technologies (Sheikh et al., 2003). The technologies also fail to meet farmer‟s preferences and needs. These technologies range from new varieties to soil protection, fertilizer usage or water conservation techniques that are aimed at increasing production, enhancing food security and reducing poverty (Douthwaite et al., 2001). The challenge for agricultural researchers is to understand how and when these technologies are used by farmers and the impact of technology adoption on agricultural productivity, food security and rural household income.

1.2 The research problem

1.2.1 Banana production and its importance in Uganda

Banana and plantain (*Musa* spp.), commonly called banana, is an important world food crop important to food security and livelihoods of millions of smallholders in tropical countries of Africa (Lorenzen et al., 2010). The crop is grown in over 120 countries, with an annual world production of around 104 million tons (Tripathi et al., 2010). The vast majority of global *Musa* production is for domestic consumption, with a high proportion of production coming from small farms and gardens (Lorenzen et al., 2010), where they constitute a major staple food crop for millions of people, as well as providing a valued source of income. In Africa, bananas and plantains provide more than 25% of food energy requirements for more than 70 million people (Faturoti et al., 2006; Tripathi et al., 2010) .

In the East African highland bananas (EAHB, AAA genome), cooking and beer types predominate, and it is in this region that banana reaches its greatest importance as a staple food crop (Karamura et al., 1998). East Africa is the largest producing and consuming region in Africa (Tripathi et al., 2010), with Uganda being the world‟s second leading producer of about 10.2 Million tons (FAOstat, 2011). More than 65% of the population depends on banana (FAO, 2011).It is estimated that 75% of Ugandan farming households grow the crop on about 1.5 million hectares, which accounts for over 38% of utilised arable land (FAO, 2004). In Uganda, it is produced by smallholder farmers, with average farm sizes of 0.24ha/household (Nowakunda et al., 2010).

The continuous production of banana all year round, offers a significant income generation advantage over traditional cash crops for many smallholder farmers who grow the bulk of the crop in Uganda. Household surveys (UBOS, 2010) indicate that areas where banana production is the main activity are resilient to famine and are relatively stable in terms of household incomes. Banana is mainly produced for local consumption (FAO, 2011) and it meets the immediate household consumption needs and provide suitable options for income generation in local markets (Edmeades and Smale, 2006). Above all, it is potentially a high yielder and the least labour demanding food to produce, provided the plantations last for more than five years to enable the farmer to recover the initial high cost of establishing the plantation. The major type of banana grown is a diverse range of locally adapted East African highland banana (EAHB) cultivars. Banana in Uganda is classified into four major groups based on utilisation. They include cooking banana, juice banana, dessert banana and roasting banana. The cooking types are largely own-consumed at farm level and sold among the urban consumers, whereas dessert types are sold and constitute a significant part of the cash income in banana growing communities.

1.2.2 Constraints to banana production in Uganda and NARO's interventions

Despite the crop‟s importance, banana productivity has been progressively declining, particularly in central Uganda where plantation life has reduced to 3-5 years compared to 50 years or more in south-western Uganda (Tushemereirwe et al., 2003). The banana yields in Uganda are low (5-30 t/ ha/year) and are declining further, compared to potential yield (70 t/ ha/year) (Asten et al., 2005; Barekye, 2009). Banana bunch weights at farm level have dropped from 60kg to 10kg, or even less (Barekye, 2009). The decline in banana yields has contributed to food shortages and subsequently putting banana consumers at risk of food insecurity particularly in areas where the crop is regarded as an important staple food.

A countrywide rural appraisal conducted in June 1991 (Gold et al., 1993; Tushemereirwe et al., 1996) and subsequent surveys (Tushemereirwe et al., 2003) revealed that the leading factors responsible for the decline in productivity of the East African highland cooking bananas include: pests (banana weevil and nematodes), diseases (black Sigatoka, banana bacterial wilt), soil fertility decline, and socio-economic constraints (high costs of managing the crop, competition for labour with other enterprises, marketing difficulties and low genetic diversity, among others). All these constraints affect banana production, leading to significant production and income losses (Gold et al., 1993; Tushemereirwe et al., 1996).

One of the key constraints being addressed by the National Banana Research Programme (NBRP) is black Sigatoka, a disease that causes yield losses estimated at 37% on banana in Uganda (Tushemereirwe et al., 1996). It is an airborne fungal disease that reduces the number of fruit per bunch and fruit weight by reducing the photosynthetic area, thus causing poor bunch filling. All the East African highland banana cultivars are susceptible to black Sigatoka (Tushemereirwe et al., 1996). Of all the fungal leaf diseases affecting banana, it is considered the most important disease throughout the world (Arias et al., 2003). The fungus attacks the leaves and it develops faster in regions of high humidity and rainfall, causing severe defoliation, delayed harvest and premature ripening of the fruit. Following the appearance of black Sigatoka, the disease builds up and often reaches an epidemic level in a few years. The rapid spread of the disease thus endangers the food security of resource-limited farmers and reduces income.

The disease also adversely affects the post-harvest fruit quality (Gold et al., 1993; Craenen, 1998) and is the main reason for the banana fruit to be rejected by exporters (Arias et al., 2003). The existence of black Sigatoka has become a major feature of banana production systems in Uganda in recent years. The severity of the disease seems to be correlated with the altitude of banana production regions. It appears to have a significant impact on most tropical humid lowland ecologies (Craenen, 1998). Although it is believed that the potential damage of black Sigatoka may be limited by altitude, the virulence of this pathogen in highland situations remains unknown (Gold et al., 1993). The first sighting of the disease in Uganda occurred in 1990 (Craenen, 1998; Johanson et al., 2000). Although chemical control of black Sigatoka is possible, it is expensive and not suitable for small-scale farmers (IITA, 2006).

The production and cultivation of alternative resistant cultivars is potentially more economical and considered as the most appropriate intervention for controlling the disease. The introduction and adoption of less susceptible cultivars with appropriate agronomic and quality characteristics is expected to have considerable economic impact on small- and medium-scale farmers (Craenen, 1998; Vuylsteke, 2000). Resistant banana varieties were identified as the highest priority technology to be developed as an intervention to resolve the pest and disease problems. The Uganda National Agricultural Research Organization (NARO), through its research programme, the NBRP, has conducted research to address the biophysical constraints (banana cultivars that are tolerant to pests and diseases). The Programme has targeted several pests and diseases that cause yield losses of economic importance in highland bananas.

Development of resistant varieties, improved agronomic practices and biological controls of pests have been identified as the highest priority technologies and practices to be used as interventions to address the problem of pests and diseases, which are partly responsible for severe decline of banana productivity in parts of Uganda (Kalyebara et al., 2005). As part of the intervention to address the problem of black Sigatoka, resistant banana varieties were introduced, and mainly imported from Honduras, with appropriate agronomic and quality characteristics and were expected to have considerable economic impact on small and medium-scale farmers (Vuylsteke, 2000). These were evaluated and disseminated in Uganda but their adoption rates have been low (Rutherford and Gowen, 2003; Nowakunda and Tushemereirwe, 2004). Low adoption rates could be attributed to their low adaptability to local conditions, like acceptability to farmers, consumers and traders who consider their suitability for the prevailing forms of utilization (Ssemwanga et al., 2000).

In recognition of this challenge, the NBRP in Uganda, in collaboration with the International Institute for Tropical Agriculture (IITA), started a participatory banana-breeding programme in 1998 focusing on the improvement of East African highland cooking bananas, the most important genotype grown in the East African region (and accounting for about 80% of bananas in that region). The breeding programme uses conventional approaches with the goal of developing pest and disease tolerant Matooke hybrids (a "Matooke" hybrid is a banana genotype produced from a cross of two different cultivars) that are acceptable by small-scale farmers, urban consumers and the market in general. Banana cultivars that are tolerant to pests and diseases would enhance the productivity of land allocated to bananas and potentially improve household incomes. The breeding programme relies on pollinating locally adapted banana cultivars with a wild uncultivated diploid banana as a source of resistant genes (Pillay et al., 2004).

The programme started with assembling all local banana cultivars in one collection for characterisation; evaluating the highland bananas to select female fertile cultivars; introducing diploids with resistance to target pests/diseases to serve as males and sources of resistance; developing improved Matooke hybrids for use by farmers; in parallel with the previous activity, developing improved male parents for use as sources of the resistance; and, finally, evaluating and disseminating the developed hybrids (Ssebuliba et al., 2006). The first banana hybrids produced by the breeding programe were mainly tetraploids, with partial resistance to black Sigatoka (Ssebuliba et al., 2006). These progenies were evaluated in the early evaluation trials at the Kawanda research station of NARO for agronomic performance and response to black Sigatoka, and 16 promising hybrids were selected for further development. The 16 tetraploids were crossed with improved males (Ssebuliba et al., 2006).

The tetraploids were further crossed with improved diploids following a breeding scheme suggested by Pillay et al. (2004) from the International Institute for Tropical Agriculture

(IITA) and Honduras. This cross generated hundreds of secondary triploid lines were then planted in the Early Evaluation Trial (EET). Out of these, 11 hybrids were selected on the basis of black Sigatoka resistance, bunch size and sensory qualities. These together with six selections from the IITA programme were advanced for the farmer participatory evaluation in 2005. They were planted in one ecological zone representative of the most highly pest/disease affected areas of Uganda (Kasangombe sub-county-Nakaseke district, formerly Luweero district) (NARO, 2006). New Matooke hybrids generated a lot of excitement at the site where they were being evaluated under farmer conditions in central Uganda.

In 2008, the programme initiated a project "Multiplication and promotion of the Black Sigatoka resistant banana genotypes in Uganda" with the objective of availing and exposing to the broader community of Ugandan banana farmers whose plantations were badly affected by black Sigatoka disease, to the four farmer selected hybrids (M2, M9, M14 and M17). A national stakeholder workshop was conducted and developed the following criteria to select the participating farmers: knowledge in banana growing, sufficient resources to maintain the plot (about a quarter of an acre), willingness to host and meet maintenance costs of the trial (including fencing / protection), willingness to allow other farmers to learn from the farm, and accessibility of the farmer‟s trial site. Consequently, new varieties (M2, M9, M14 and M17) and Mbwazirume (a local variety) were planted. Mbwazirume was included as a local check so that farmers could compare and make informed decisions. These varieties are being evaluated with the 312 farmers in 39 Districts covering all the Agro- ecological Zones, under farmer managed conditions across all the four major regions of Uganda (namely Mid-Western, Central, Western and Eastern) representing six major Agro-Ecological Zones, including the Lake Albert crescent area, Lake Victoria crescent, Western highlands, Southern highlands, South-east and Eastern Agro-ecology (Wortmann and Eledu, 1999). While selecting the above Regions and agro-ecological Zones, the program considered disease/pest severity as a major factor.

1.2.3 Farmers' and consumers' acceptance of new cooking banana hybrids

Despite the research and extension efforts to introduce and popularise the hybrids in Uganda, to date no attempt has been made to document the likelihood of farmers‟ adoption of these hybrid bananas. It remained uncertain whether varietal attributes along with farm and farmer characteristics will determine the variations in the levels of potential adoption of these hybrid bananas varieties by the farming communities and with what impact. Above all, the demand for improved banana varieties is likely to increase if such varieties are designed to include end users" preferred traits. It is essential that the efforts by researchers and extension workers to disseminate these hybrids among the farming communities be evaluated to confirm whether their results fit into the patterns of agricultural change in which farmers participate. According to Smale and Groote (2003), farmers will not adopt a variety unless they can see the benefits. More over the choice of an unsuitable variety for the farmers is likely to deter technology adoption. It is, therefore, important that extension workers, researchers and policy makers are provided with information about the attributes of the varieties that farmers are more likely to use.

Research is also needed to determine the variety preferences and choice among the banana hybrids by the farming community. An exploratory analysis of the effects of farmer characteristics, variety attributes and agro-ecological conditions on banana variety choice will determine which variety to promote to the wider farming communities in Uganda. The choice of a wrong variety has many consequences, such as loss of yield, food security and profit (Setimela et al., 2004). The choice of a hybrid banana variety may differ depending upon the concerns of the farmers, which are likely to be defined by agro-ecological location, the physical characteristics of the farmers" plots and hybrid banana attributes. According to Smale et al. (2001), variety choice can be viewed as a process by which a farmer assembles various bundles of traits to satisfy consumption preferences, meet specific production conditions, or fulfil marketing requirements. Understanding people"s response about the variety choice will guide the breeders in their future breeding programme interventions aimed at improving rural livelihoods. With many varieties being developed by the NBRP, it is important for farmers to select varieties most suitable for their conditions and likely to meet the demand for other end users and with better returns.

Given that these hybrid banana varieties are recently developed, there is a knowledge gap in the understanding of how consumers will perceive them when found on the market, and the purchase intentions with respect to critical sensory and agronomic qualities. It is not yet clear which attributes will drive consumer acceptance and purchase decisions for the newly developed hybrid varieties once introduced to the Ugandan market. Banana is a farmer"s main source of household income in the banana growing regions. It is, therefore, important that a variety is acceptable to the consumers.

The adoption of these hybrid bananas in Uganda will only be successful if the consumers‟ preferences are sufficiently understood and taken into account. The demand for improved banana varieties is likely to increase if such varieties are designed to include end users‟ producers‟ and consumers‟ preferred cooking traits. The knowledge of traits preferred by consumers is valuable for this important crop improvement programme and provides the market signals for producers. Within this context, attention is needed in the understanding of the consumer and agronomic desired attributes in a consumer demand model and their effect on the likely purchase of the hybrid bananas when found in the market. According to Graff et al. (2006) agricultural households who adopt new technology in their own production activities can benefit from increased production for home consumption, more nutritious foods, higher gross revenues derived both from higher sales volumes and switching to higher value products, lower production costs, and lower yield risks. For the new agricultural technologies developed by any research system to be adopted readily, they have to be in harmony with the existing farming systems and be consistent with farmers‟ objectives and their resource endowments (Sheikh et al., 2003).

The success of the selected hybrids, therefore, will depend on their ability to meet the needs, tastes and requirements of target end users. In effect, it is hypothesized that farmers may find it difficult to adopt these bananas depending on the concerns of the end users which are defined by the banana attributes. According to Bellon and Risopoulos (2001), farmers can view some attributes of new crop varieties as positive and others as negative. The choice of one variety technology over others is greatly influenced by the balance between these preferences for attributes. Depending on preferences, resource endowments and constraints that an individual farmer faces, a beneficial attribute for one farmer may be an undesirable one to another, or a balance between positive and negative traits of the new technology may be acceptable for one farmer but not to another farmer (Bellon and Risopoulos, 2001).

1.3 Objectives of the study

The introduction and utilisation of the hybrid banana varieties in Uganda will only be successful if the needs of the end users are sufficiently understood and taken into account. It is, therefore, of primary importance to understand how the farmers and consumers will perceive the hybrid banana varieties and how the critical sensory qualities will drive consumer acceptance and purchase decisions once these hybrid banana varieties are found on the market. The study, therefore, evaluates factors affecting smallholder farmers‟ early stage adoption of the banana hybrids, and their likelihood to contribute to solving the problem of rural poverty. It also explores the consumers‟ willingness to pay for these varieties once introduced into the market which hybrid banana varieties being newly developed and disseminated to the farming communities in Uganda, no potential adoption study has been done specifically with respect to farmers‟ perceptions regarding varietal attributes and farmer specific characteristics that are likely to determine their potential adoption. Hence, the scarcity of insights in farmer variety preferences and consumer decision-making processes towards purchasing these hybrid bananas varieties is the rationale for this thesis. More specifically, the following research objectives are considered:

- To analyse farmers‟ perceptions regarding varietal attributes and assess how these perceptions, along with farm and farmer specific characteristics, determine the variations in the levels of potential adoption of hybrid banana varieties,
- To analyse the effects of farmer characteristics, variety attributes and agro-ecological conditions on banana variety choice in Uganda, and
- To evaluate the effect of banana cooking qualities and consumption characteristics on purchase decisions for the newly developed hybrid banana varieties in Uganda.

1.4 Expected outcomes and policy relevance of the study

It is expected that the outcome of the research will inform breeders and policymakers on farmers‟ preferred hybrid banana traits and farmer characteristics that will influence the likely adoption of the hybrid bananas varieties. This would, in turn, contribute to the breeding programmes in guiding the potential varietal improvements. It is expected that the outcomes of this study would guide the future promotional activities of these varieties particularly in knowing the preferred varieties, the regions and the category of farmers to target. This knowledge would be of much value to researchers and extension agencies in the dissemination of research technologies like National Advisory Services, Zonal Agricultural Research Institutes, and Non-Governmental Organisations involved in agricultural extension services.

1.5 Overview of the data acquisition methodology

Data used for this study were collected from the study sites for the NBRP in the four regions of Uganda where the programme is evaluating the new hybrid banana varieties. The regions were purposively selected to cover the banana producing areas and the farmers hosting the hybrid demonstration plots. At farm level, random sampling procedures were adopted to select the districts and respondents that participated in this study.

The data collection process involved farmers hosting the demonstration plots, called participating farmers, and the non-participating farmers randomly selected from the neighbourhood of the host farmers. From the mid-western region of Uganda, Bullisa, Masindi, Hoima and Mubende districts represented the Lake Albert crescent area. In the central region of Uganda, Mukono, Wakiso, Luwero, Kiboga and Mityana districts represented the Lake Victoria crescent agro-ecological zone. From western Uganda, Kyenjojo, Kamwengye, Bushenyi, Kasese, Kanungu and Rukungiri districts represented the western and southern Highland agro ecologic zones. In the eastern Uganda region, Butalegya, Mayuge, Iganga, Kaliro, Jinja and Sironko districts represented the south-east and eastern highlands agro-ecologic zones.

A structured and pre-tested questionnaire (Appendix 5.2) was used as an instrument to collect the data. Primary data were collected on socio-economic characteristics of sampled farmers, farmer perceptions of banana hybrid attributes and institutional factors (like access to credit and extension services). Farmers were asked to choose the most desirable hybrid banana varieties and the reasons for their choice based on a five-point Likert scale. They were also asked to list the desirable and undesirable attributes for each variety for each of the hybrid banana varieties with respect to a local variety. Data on farmers‟ perceptions of certain qualitative aspects of hybrid banana adoption, like whether farmers would buy planting materials when made available to them, their future expansion plans and reasons for expansion of the varieties, were collected. The study also collected data on farmers‟ perception of change in their food security status and other benefits due to participation in the project, the trend regarding the household food situation before the hybrid banana project and during its implementation. Data on farmers‟ perceptions on their change in the livelihood systems as a result of their participation and their opinions about the hybrid varieties were also captured, as was whether the farmers would expand production of these varieties based on the current experiences, and reasons for their expansion.

One farmer field day was conducted in each of the above mentioned districts at a host farmer‟s plot. Participants included producer consumers (consumers that produce, consume and sell the surplus) and those who purely buy bananas from the markets. Participants were presented with cooked banana variety samples (presented in random order and coded with random numbers) and were asked to do visual and taste evaluations while filling out a two-page data sheet (Appendix 5.3). They assessed and scored their perception for sensory parameters, namely flavour, taste, texture and colour of the food when cooked based on a five-point Likert scale (5=Excellent, 4=Good, 3=Fair, 2=Bad, 1=Very bad) (Dadzie and Orchard, 1997). This was followed by a field visit during which participants were allowed to do a visual inspection of the physical appearance like bunch size and other plant characteristics such as finger shape and the leaves for each variety. The aim of this field visit was for the participants to examine the appearance of the varieties they had tested and evaluate each in the light of whether they would purchase them if found in the market.

1.6 The structure of the thesis

The remainder of this thesis is organised as follows: Chapter one describes the background of the study, statement of the problem, objectives and research methodology used to select the study sites and to generate the data used in the study. Chapter two presents early adoption, variety choice and consumers" willingness to pay for their products, drawing from the literature. Chapter three empirically examines the early stage adoption of improved banana "Matooke" hybrids in Uganda, using a count data model. Chapter four is another empirical chapter on farmers" choice among these hybrid varieties, using multinomial logit analysis. Chapter five then empirically examines the determinants of consumers" willingness to purchase the products of East African Highland Cooking banana hybrids in Uganda. Finally, chapter six summarises the key findings, and presents the conclusions, policy implications and the directions for future research.

CHAPTER 2

FARMERS' EARLY ADOPTION, VARIETY CHOICE AND CONSUMERS' WILLINGNESS TO PAY FOR THE PRODUCTS OF IMPROVED VARIETIES: AN OVERVIEW OF THE LITERATURE

2.1 The agricultural sector in Uganda and the need for improved crop varieties

Uganda has a population growth rate of 3.2% per annum, the third highest rate of population increase in the world (MAAIF, 2010). The population that was 6 million in 1969 has grown to 37.5 million (United Nations, 2013). Given that 73% of all households in Uganda are engaged in the agricultural sector, its performance matters greatly for the livelihoods of the people and the drive to eradicate poverty. Agriculture is the most important sector of the Ugandan economy, contributing up to 20% of GDP, accounting for 48% of exports (UBOS, 2008), and employing nearly 75% of the country‟s labour force (IFAD, 2013). Uganda‟s poorest people, including hundreds of thousands of smallholder farmers, live in remote areas scattered throughout the country (IFAD, 2013). Since the majority of poor people are engaged in the agricultural sector, and particularly in the production of food crops, improving the performance of the agricultural sector will improve farmers‟ livelihoods, economic growth and reduce poverty.

Despite its importance, the performance of the agricultural sector has been poor, with a low growth rate of 1.3% per year (UBOS, 2011). The sector suffers from various problems such as small and fragmented landholdings, limited technological progress and low productivity (Nayenga, 2008; Dethier and Effenberger, 2012). Low productivity in the Ugandan smallholder agricultural sector is mainly due to factors such as decline in soil fertility, pests and diseases, use of low yielding varieties, and harsh climatic conditions (Strange, 2005; Shively and Hao, 2012). Due to lack of alternatives through other means, this situation has often resulted in food shortages among the rural poor households. To reverse the widespread food shortages among the smallholder farmers in most parts of the country, there is a need, among other things, to develop and diffuse suitable agricultural technologies that can address the prevailing production constraints. Technology development and transfer in this regard seems to be a necessity for increasing productivity, as well as for transforming subsistence farming to commercial agriculture.

At the global level, the adoption of improved agricultural technology is considered critical to the attainment of the Millennium Development Goal (MDG) of reducing extreme poverty and hunger. Although substantial public resources have been devoted to the development and provision of modern crop varieties in Sub-Saharan Africa, the overall adoption rates for improved technologies have lagged behind other regions (World Development Report, 2008). According to Brocke et al. (2010), the poor success in disseminating modern varieties to farmers is related to failure of breeding programmes to consider farmers‟ needs, preferences and the prevailing farming conditions. The development of improved varieties that are resistant to pests and diseases and produce relatively high yields, and their dissemination through different mechanisms, affect farmers‟ perceptions, expectations and preference towards different varieties used in production (Asfaw et al., 2012).

Adoption may depend on a wide set of determinants including innovation and policy characteristics, farmer expectations, farm structure and the socio-economic environment (Blazy et al., 2011). Various technological innovations and products are becoming available to farmers in Uganda but not adopted by the majority (Kasirye, 2013). For new agricultural technologies to be adopted, they have to be in harmony with the existing farming systems and be consistent with farmers‟ objectives and their resource endowments (Sheikh et al., 2003; Wale & Yalew, 2007). Before a technology is commercialized, it needs to be tested on farmers‟ fields and farmers have to evaluate the production and consumption attributes of the technology. That is why this study focuses on early adoption, variety choice and consumers‟ willingness to pay for the products of hybrid banana varieties in Uganda. Research was needed to determine the variety preferences and choice among the banana hybrids by the farming community.

An understanding of the likelihood of farmers‟ adoption of these hybrid bananas, their variety preferences, choice among the banana hybrids by the farming communities, understanding of how consumers will perceive the hybrid banana varieties when found on the market, and their purchase intentions was, therefore, crucial for formulating effective policies. It is expected that the outcome of the research will inform the breeders and policymakers on farmers‟ preferred hybrid banana traits and farmer characteristics that will influence the likely adoption of hybrid banana varieties. This would, in turn, contribute to the breeding programmes in guiding the potential varietal improvements. Farmers, being the ultimate consumers of the invention of agricultural research (such as a new hybrid banana variety), their knowledge of the production environment, and variety and attribute preferences are critically important in influencing, not only the decision for the variety choice, but also the level of adoption. Hence, it was expected that policy makers, based on the results of the study, will prioritize farmers‟ involvement in varietal improvement and development programmes so as to address their concerns and preferences. It was expected that the outcomes of this study would guide the future promotional activities of these varieties particularly in knowing the preferred varieties, the regions and the category of farmers to target.

This chapter is designed to provide an overview of the literature on early adoption, variety choice and consumers‟ willingness to pay the products of improved varieties. To this end, the rest of this chapter is organized as follows. The section that follows examines the literature on potential factors affecting early adoption of improved crop varieties and farmers‟ willingness to purchase improved planting materials. This is followed by a section that deals with empirical models on farm technology adoption (2.3). Section 2.4 then deals with farmers‟ preferences and choice among improved varieties, followed by the empirical models to explain variety choice (2.5). Section 2.6 reviews the relevant literature on explaining consumers‟ willingness to pay for the products of improved varieties, followed by a section on the empirical models to explain consumers‟ willingness to pay (2.7). The chapter closes with a brief summary.

2.2 Potential factors affecting early adoption of improved crop varieties and farmers’ willingness to purchase improved planting materials

Adoption is the acceptance of an innovation or the incorporation of new elements in an existing situation. Many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely realized by potential adopters, and that the innovation will, therefore, diffuse rapidly (Rogers, 2003). However, most innovations are adopted at a slow rate. Many years pass between the time people first hear about some innovations and the time they adopt them (Rogers, 1995; Halaweh, 2013). Agricultural technologies are location specific and react to environmental changes. The characteristics of the intended user group, economic support system and political or administrative conditions surrounding the target area influence the scaling up of a technology. Failure to critically examine the factors likely to affect the adoption and uptake of new technologies (like the newly developed hybrid banana varieties) could result in slow rate and intensity of adoption or rejection of the new technologies. If these factors are understood, they can be integrated into further refining and dissemination of the technologies to accelerate farmers‟ uptake of new varieties and improve livelihoods. This knowledge is also key to enhance the impact of the new technologies and scale-up the impacts. Development of user-oriented technology has to be well targeted to farming system zones and socio-economic categories. Also the economic support systems and politico-administrative conditions for widespread adoption have to be indicated. Therefore, when technologies are planned and tested, priorities must be set based on potential benefits and risks for different groups of farmers and the ease with which farmers may be able to adopt them. The next section presents the potential factors affecting early adoption of technologies and farmers‟ willingness to purchase crop varieties for new technologies, drawing from the literature.

2.2.1 Potential factors affecting early adoption of improved crop varieties

The adoption and diffusion of agricultural innovations are widely regarded as a way to transform traditional agricultural systems and enhance agricultural productivity (Datt and Ravallion, 1996). The major challenge is to understand farmers‟ perceptions towards a new technology and its impact on farm production (Doss, 2006). Adoption is an outcome of a decision to accept a given innovation. According to Feder et al. (1985), adoption is defined as the degree of use of a new technology in long-run equilibrium when a farmer has full information about the new technology and its potential. According to Rogers (1995), a technological innovation encompasses at least some degree of benefit for its potential adopters. Adoption of a new technology is a choice between traditional and new technologies such as hybrid banana varieties and should have an advantage over conventional practices.

Rogers (1962) describes adoption as a five step "innovation-decision process" in which farmers: gain knowledge of an innovation; seek information about the likely consequences of adoption and form an attitude towards it; decide to adopt or reject the innovation; implement the innovation; and confirm their innovation decision by seeking reinforcement, and discontinue it if they are exposed to conflicting experiences and messages. This study is mainly about the first four steps.

Time is an important factor in the decision-making process; innovativeness and an innovation‟s rate of adoption require a lengthy period, often of many years, from the time they become available to the time they are widely adopted (Rogers, 1995). Cameron (1999) suggests that the dynamic process of adoption involves learning about a technology over time. The average time between initial information and final adoption varies considerably by person, place and practice. Alston et al. (1995) demonstrate that the time after the initial investment in research through the generation of pre-technology knowledge up to maximum adoption by producers involves many long, variable and uncertain lags. Considering the fact that adoption is a decision making process (involving awareness, interest, evaluation, trial, trust and adoption), time is a critical element for sustainable uptake of new technologies. For stance, farmers may require sufficient time to evaluate quality attributes of a new variety before its wide scale cultivation. Given the perennial nature of the banana crop, there is need for sufficient time for farmers to evaluate many harvest cycles compared with annual crops like beans, implying that there is a time lag element from awareness to adoption. Promoting new varieties which have not been given adequate time for farmers‟ approval, particularly with regard to taste and utilization, sometimes ends in the rejection of all the varieties.

Adoption studies are carried out to monitor the level and pathways of adoption and the impact of proven technologies on farm-level productivity during the technology promotion stage (Alene et al., 2006). According to Rogers (1962), adoption is "the mental process an individual passes from first hearing about an innovation to final adoption." When a new innovation is introduced, farmers go through periods of gaining knowledge about the new technology, to forming positive or negative attitudes toward the technology, and ultimately deciding whether to adopt the technology or not and by how much (intensity). Differences in adoption rates are explained by differences in information set, *i.e.* farmers‟ imperfect knowledge of the characteristics of new and improved inputs and their ability and willingness to adjust to new technological developments. Ma and Shi (2011) argue that adoption of agricultural technology is often sequential, with farmers first experimenting with a new technology on part of their plot(s) and then adjusting their use of the new technology in later years based on what was learnt from the initial partial adoption. The outcome of the learning curve will decide on the adoption path. In the early stages of the introduction of, for example, new crop varieties, few farmers may obtain full information after utilisation. Then more farmers acquire information in the subsequent periods about the merits and demerits of the variety. Aldana et al. (2011) argue that the potential adopters are hesitant of what a new technology may offer and over time information from different sources and from the farmer"s own experience reduces this uncertainty. Farmers in most cases first experiment with the new varieties on offer and update their information sets with time to improve their skills and knowledge about the new technology and, consequently, increase land allocations to new varieties given their physical production environment (Ma and Shi, 2011). Farmers may choose to apply a new technology to part of their land first, and then adjust adoption practices in later years after observing outcomes from the earlier partial adoption. According to Hall and Khan (2002) and Aldana et al. (2011), adoption of new technologies advances slowly at first, accelerating as it spreads throughout the potential adopters, and then slows down as the relevant population becomes saturated. As a technology develops and improves, more people become familiar with it and comfortable about using it, and this accelerates the speed of adoption.

The likelihood that farmers will adopt a technology depends on how well the technology is adapted to the local conditions. For example, is the technology likely to deliver what is intended? Is the proposed variety likely to be superior to the existing ones? How is the technology expected to perform compared to the existing alternatives? The technology has to be adapted to suit local conditions such as soil content, type of variety and the extent of farmers" knowledge about the variety and its management conditions. In some cases, new crop varieties selected after having considered their agronomic performance on station may fail to express similar performance under less favorable conditions on-farm. This is because trials are conducted under management that is very different from that of local farmers. According to Manzanilla et al. (2011), farmers are risk-averse and would like to be assured of potential net gains before engaging in the use of new varieties. Farmers" attitudes can, therefore, be an important source of individual heterogeneity, in an early adoption of new technologies, particularly when most farmers are unfamiliar with the new varieties. Blazy et al. (2011) suggest that farmers may differ in their degree of risk aversion and belief in new technology performance (credibility), which may modify the perception of the utility, particularly when considering early stage adoption of technologies when the technology is not yet marketed.

Farm characteristics are also identified as determinants of farm-level adoption of new technologies (Feder and Slade, 1984; Nkonya et al., 1997; Wubeneh and Sanders, 2006; García, 2007). According to Olson et al. (2012), the role of farm size emerges as an important factor. Farmers with large land sizes can afford to host some experimental trials with the new technologies compared with those farmers with small portions of land. This may motivate these farmers to adopt the new technologies and stay with them because they can withstand the shocks that may discourage smaller farmers. Sometimes a technology is site-specific, making it important to be cognizant that not only the size but also the geographic location and the associated agro-climatic characteristics of a farm are imperative to adoption (Feder and Slade, 1984; Nkonya et al., 1997; Wubeneh and Sanders, 2006; García, 2007). Farming systems research in the late 1970s and early 1980s emphasized the need to determine adoption potential based on priorities and circumstances of farmers (Byerlee and Collinson, 1980). In other words, in the adoption process for new technologies, farmers make rational adoption decisions having considered the conditions where they operate. Some farmers may not have sufficient land resources for trying new varieties and hence may opt to continue with their local varieties. According Franzel et al. (2002), adoption potential was evidenced to be involved requiring an understanding of biophysical performance under farmers‟ conditions, profitability from the farmers‟ perspective and acceptability to the farmers, compared to the existing method/input. The biophysical performance of a technological innovation is measured and compared among different options through evaluation trials on-farm.

According to Pannell (1999), there are four conditions necessary for farmers' adoption of innovative farming systems, including perception of risk, suitability to accepted gender roles, cultural acceptance, and compatibility with other enterprises. Farmers have multiple objectives (such as food security, adequate cash income, a secure asset or resource base, and social security) and they select „livelihood strategies‟ to pursue these objectives with the resources available to them (Cramb, 2000). In this regard, farmers assess the relevance of a new technology with respect to their resource availability and objectives in the adoption process. In other words, for farmers to adopt new technologies successfully, new technologies must target and address the problems which the farmers face and address them before being accepted by the farmer. For instance, a new high yielding variety may be rejected because it is not targeting the needs and objectives of the farmer. Both the objectives and available resources vary between farmers and change over the life-cycle of the farm household (e.g., farmers sometimes may rely on off-farm work as a major source of livelihood, restricting their capacity to invest in labour-intensive conservation measures). Therefore, farmers in the same environment may have different objectives and livelihood strategies, and so respond differently to a given technology.

The adoption framework further simplifies the analysis of the early stage adoption decision by its implicit assumption of an individual decision maker. Individual or household preferences may affect the perceived benefits from adoption, which may vary within the household (Kelsey, 2013). For instance, Almekinders and Hardon (2006) argue that productivity increases due to the introduction of high-yielding varieties have been successful in ecologically favourable areas but have often bypassed smallholders on marginal land. According to Biot et al. (1995), "different behaviours may be as much a function of different opportunities and constraints as of different perceptions". In the farm household, the ability to make decisions regarding resource use and technology varies according to age, gender and other categories, and actual decisions can depend on a complex chain of bargaining processes among household members (Biot et al., 1995).

According to Adesina and Baidu-Forson (1995), factors influencing adoption of new agricultural innovations can be divided into three major categories: farm and farmers" associated attributes, attributes associated with the technology, and the farming objective. In the first category, factors discussed in the literature include human capital, the risk and risk management strategies and the institutional support system, such as marketing facilities, research and extension services (Goodwin and Schroeder, 1994). For farmers to adopt a technology, they must first know about it before they can consider adopting it (Doss, 2006). The information may come from many sources, including extension officers and through experimentation (Lunduka et al., 2012), other farmers, field days/tours, farmer exchange visits, and agricultural shows. Adesina et al. (2000) demonstrated that adoption of alley farming in the forest zone of southwest Cameroon was higher with farmers having contacts with extension agents working on agroforestry technologies. Mariano et al. (2012) reported that extension-related variables were found to have the biggest impact on technology adoption of certified seeds, and integrated crop management practices, in rice production in the Philippines. These results confirm that presence of extension and research agencies influences farmer adoption of new technologies. Feder et al. (1985) survey of the literature on agricultural technology adoption suggests that factors important at the included farm size, risk and uncertainty, human capital, labour availability and credit constraints.

Technology adoption decisions are conditional on the farmers' perceptions of the performance of the new technology relative to that of the technology currently being used (Kshirsagar et al., 2002). Individual preferences around product attributes, including taste and cultivation practices, will affect how profitability is perceived by the farmers. This is particularly true of production for home consumption. This implies that farmers' perceptions of the desirable attributes of the new technology should be considered early enough to enhance the adoption of new technologies. Farmer perceptions of technology attributes, such as ease of preparation and cooking, have been linked directly to adoption outcomes (Adesina and Zinnah, 1993). According to Kelsey (2013), technologies imported from other regions may have different flavours and textures than local substitutes and may not be adopted even if they increase yields and income. Farmers assess a new technology in terms of a range of attributes such as yield (adoption is conditional on a variety considered to be associated with a high average yield) and input requirements (Kshirsagar et al., 2002). For instance, Useche et al. (2009) investigated the effect of heterogeneity in both farmers and GM corn seeds on farmers" adoption decisions of GM technology and found that farmers adopt different types of GM seeds according to their preferences for different traits embedded in the seeds.

Agro-ecological factors also play an important role in the adoption of new technologies. Therefore, failure to account for agro-ecological diversity may produce results that are biased and hence lead to invalid policy prescriptions. The agro-ecological environments define the potential agricultural production activities from which the household can select (Bellon and Taylor, 1993). Farmers select and adapt varieties to specific ecological conditions such as soil quality, water availability, topography, seasonal temperature changes or the presence of pests or diseases that could damage the crops. According to Blazy et al. (2011), land quality and soil type may be important factors influencing acceptance of a new technology. Noltze et al. (2012) study the adoption of system technologies in smallholder agriculture. Accordingly, several plot level variables had significant effects on the system of rice intensification (SRI) adoption in Timor Leste and the number of different SRI components used. Seo and Mendelsohn (2008) while exploring how South American farmers adapt to climate by changing crops, found those farmers choose fruits and vegetables in warmer locations and wheat and potatoes in cooler locations. They also found that farms in wetter locations are more likely to grow rice, fruits, potatoes, and squash and in dryer locations maize and wheat. Agro-ecological heterogeneity plays a substantial role in the pattern of technology adoption and evaluation of individual traits (Useche et al., 2009). According to Dalton and Guei (2003), limited varietal adoption is due to failure of the technology development process to produce varieties adapted to heterogeneous production conditions or with traits valued by producers and consumers

The socio-economic environment (markets, services and infrastructure) gives incentives or disincentives to select and adopt new technologies (FAO, 2011). Access to markets has become a major concern to the majority of farmers in many developing countries. Farmers need market outlets for their increased marketable surplus due to adoption of new technologies. If there are no markets for the extra output due to the use of new technologies, it drives down the prices for a commodity and this reduces farmers" incentives to invest in the new technology. The introduction of new crop varieties to resource-poor farmers requires an understanding of their food consumption patterns and marketing behaviour, which is largely related to the socio-economic position of a household. The farmer"s ability to physically access different markets, which mainly depends on proximity to the transport infrastructure, also affects early stage adoption of new technologies.

According to Bantilan and Dar (2001), adoption studies measure the extent of use of the technology, the performance of the technology (productivity changes, advantages and disadvantages), changes in farm management induced by the new technology, and characteristics of the diffusion process. The essential information packaged in the study includes: (1) levels and speed of adoption, and reasons for non-adoption of the technology; (2) farmers" perceptions of desirable traits or features of the technology options; (3) farm-level productivity and income gains due to the alleviation of biotic and abiotic constraints; (4) impact on the welfare of the farm household; for example, in terms of the intra-household distribution of income, nutrition, and health; and (5) infrastructural, institutional, and policy constraints hindering technology adoption. Adoption is a result of a decision to accept a given innovation. Most of the literature of interest on adoption falls in two categories, i.e. the rate of adoption, and intensity of adoption. It is often essential to differentiate between these two concepts as they have different policy implications. The rate of adoption is the relative speed with which farmers adopt an innovation and has as one of its pillars the element of „time". On the other hand, intensity of adoption refers to the level of use of a given technology in any time period (Noltze et al., 2012).

A number of research institutions have been attempting to generate and disseminate improved crop varieties to farmers in Uganda. A study by Abele et al. (2007) while analysing the development and dissemination of improved cassava varieties in Uganda, an analysis of adoption rates, variety attributes and speed of adoption, identified the specific cassava varieties adopted and the desirable and undesirable attributes. The results of this study indicated that farmers consider disease resistance, maturity period, taste and dry matter content in their decision to adopt new cassava varieties. This implies that farmers select varieties that have these attributes. The results further suggested that adoption of the varieties were influenced by age of household head, household size and access to extension services. A study by Kassie et al. (2011) evaluated the ex post impact of adopting improved groundnut varieties on crop income and poverty in rural Uganda. The study indicated that adopting improved groundnut varieties (technology) significantly increases crop income and reduces poverty. The study concluded that reaching the poor with better technologies required policy support for improving extension efforts, access to seeds and market outlets that stimulate adoption in Uganda.

Another study by Mugisha and Gracious (2010) explaining the adoption of improved maize varieties and its effects on yield among smallholders in Eastern and Central Uganda, showed very high levels of adoption (about 80%) and a low level of adoption intensity. Results from the study that extension advisory services are strongly associated with adoption of improved. Wanbi et al. (2006) estimated Logit Models of integrated pest management adoption in Uganda and found that the single most important category of influential factors across all crops and technologies is economic/market forces, including labor availability, technology resource requirements, technology complexity, and the level of expected benefits.

According to Doss (2003), adoption behaviours differ across socioeconomic groups. Household wealth may have both positive and negative effects on the adoption decisions of farmers. Wealthier farmers may adopt new technologies faster since they are in a better position to experiment with new varieties due to their higher risk-bearing ability, better financial resources, and larger size of landholdings (Doss, 2006). On the other hand, wealth may have a negative effect with those with lower wealth resources likely to accept newer varieties because they may be more motivated in searching for new technology due to their subsistence pressure (Langyintuo and Monogamy, 2008).

This section has looked at the potential factors affecting early adoption of improved crop varieties and farmers‟ willingness to purchase improved planting materials. The next section will highlight farmers‟ willingness to pay for improved planting materials.

2.2.2 Farmers' willingness to pay for improved planting materials

Plant seed is the basic input in raising agricultural productivity, of which the performance and efficiency of other inputs depend, and is central in farmers‟ livelihoods worldwide (Setimela et al., 2004). Despite its importance, the seed sector faces challenges which include increasing demand for new plant varieties and quality seeds in the context of food security in relation to population growth. According Horna et al. (2007), farmers are considered to be consumers of seed as a production input, preferring one variety over another based on the utility they obtain from its attributes, which depends on their own socio-economic characteristics. Dalton (2004) argues that consumption technology is the seed variety, or genotype, that is consumed by the farmer as a production input. A combination of production and consumption characteristics best explains the willingness to pay for new crop varieties (Dalton, 2004). Variety-specific production attributes (e.g. yield, disease resistance) and consumption attributes (e.g. taste) play an important role in the planting decisions of semi-subsistent farmers (Edmeades et al., 2004). According to Minot et al. (2007), seed attributes can be categorized into 1) agronomic, 2) morphological, and 3) grain quality for rice, cowpea, and maize. Badstue et al. (2007) argue that securing access to seed of the desired varieties and of good quality is, therefore, a very important issue for farmers and a concern for society to achieve food security.

Dalton (2004) estimated a non-separable household model specification and determined that four traits explain the willingness to pay for new rice varieties: plant cycle length, plant height, grain elongation/swelling and tenderness. Quality attributes such as yield, disease tolerance, maturity period, drought resistance and intensity of crop management are production-related, and determine the attractiveness of a variety from a farming perspective (Abebe et al., 2013). According to Liu (2001), farmers are not sensitive to the price of good-quality seeds, but they are interested in the brand of seeds and mainly depend on their own experiences when purchasing seeds. Horna et al. (2007) examined farmers‟ preferences for new rice varieties and their willingness to pay for information as a measure of WTP for rice production advisory services in Nigeria and Benin. The study indicated that variety attributes are important determinants of farmers‟ seed preferences. The study also reported that farmers‟ choice of new rice varieties was mainly made in accordance with their social experience, economic conditions as well as their understanding of the characteristics of the variety.

Farmers‟ willingness to pay for a given agricultural service (or planting material) is a function of knowledge, attitude and intention (Aryal et al., 2009). This implies that farmers‟ awareness and knowledge about the technology‟s sensory characteristics influence their willingness to pay decisions. The less information farmers have, the weaker their willingness to choose new varieties. Farmers‟ adoption of improved seeds can be limited because they have no knowledge about such varieties, are unaware of their existence, or do not regard those varieties as significantly more useful than the traditional varieties, even when they have good information about the improvements (Minot et al., 2007). Thus, it is important to assess farmers‟ awareness and knowledge about the improved varieties that are available to them. According to Pender and Kerr (1998), the awareness level of agricultural technology has a positive effect on farmers‟ willingness to participate in technology investments. The promotions of seed companies, government and the media may help farmers to obtain more information on new seed varieties. The more information they get, the stronger their willingness to adopt new varieties. Asrat et al. (2004) reported that farmers who were aware of the available options for agricultural technology were more receptive to paying for these technologies. Sajeev and Gangadharappa (2011) argue that willingness to adopt any technology requires awareness regarding the working and application of the technology. Without proper awareness no farming population can move towards informed decision on adoption of a technology. Aryal et al. (2009) argue that consumers decide whether to buy a product or not based on three main aspects: knowledge, attitude and intention. Knowledge about products and their benefits influences their willingness to pay for the products. Knowledge and awareness have respectively direct and indirect effects on attitudes of consumer to choose the products, and the willingness to pay a price premium, so they are important factors determining the demand. Thus, awareness and knowledge about new varieties are critical in the farmers‟ willingness to pay more for planting materials.

Socioeconomic characteristics (such as age, gender, and income) also shape a farmer‟s willingness to pay, because those characteristics affect attitudes toward agricultural services. In addition, market characteristics such as accessibility and prices affect purchase behaviour and ultimately farmers‟ willingness to pay. Willingness to pay can be influenced by individual characteristics and personal attitudes of farmers, and by the fact that farmers often face heterogeneous soil, climate and socio-economic conditions, which can affect their expected profitability and risk levels. For instance, Asrat et al. (2004) examined the determinants of farmers‟ WTP for soil conservation practices in Ethiopia‟s South-Eastern highlands and reported that the majority of the farmers in the study area were less willing to pay cash. However, the farmers were willing to spend substantial amounts of labour and time on soil conservation. A higher level of education is expected to increase farmers‟ ability to get, process, and use information. Thus, education is hypothesized to have a positive role in the decision to pay for new agricultural technologies (Asrat et al., 2004).

Farm and non-farm income are also expected to have an impact on farmers‟ decision to invest in agricultural technologies. For the farmers engaged in production, the stability of increased production income has a strong impact on farmers‟ selection of new varieties. Generally, an income increase will strengthen their willingness (Li et al., 2010). Furthermore, the higher the crop yield, the stronger the farmers‟ preference to adopt new varieties. Non-farm income is expected to have a positive influence, given the assumption that diversification out of agriculture would enable households to earn income; thereby easing the liquidity constraint needed for new technology investments. Low income reduces a household‟s willingness and ability to invest in agricultural technologies (Holden and Shiferaw, 2002). Estimating the demand for a new technology (Bt cotton and insecticide), Hubbell et al. (2000) reported that farmers will be willing to pay extra dollars/acre and adopt the Bt technology on a given acre if utility with the new income minus the cost of the technology is at least as high as utility without the new technology.

With respect to family size, one can expect a larger family to have a higher probability of possible future benefits from new technology investments. Households with more human capital are more likely to adopt new technologies that require more labour. This factor further depends on household income and product price to make a decision to purchase. The impact of a farmer‟s age can be considered a combination of the effect of farming experience and planning horizon. Although more experience has a positive effect, young farmers may have longer planning horizons and, hence, may be more likely to invest in agricultural technologies (Asrat et al., 2004; Holden and Shiferaw, 2002).

According to Minot et al. (2007), sub-Sahara African farmers generally demand seed from off-farm sources for only three reasons: seed replacement, variety change, and emergency response. The important factors in the process include agro-ecological, natural and man-made disasters, uneven market development, farmers‟ preferences about channels and timing of seed distributions, and farmers‟ level of awareness about improved seeds. This can generally explain the differences among farmers in their decisions as to when they demand seed, which varieties they prefer, and at what quantities. The factors influencing farmers‟ willingness to purchase and use new varieties can be summarized as the individual characteristic variables, the income structure variables, the cognition degree variables and the environmental variables.

Minot et al. (2007) argue that the better the yield-increasing effect of seed, the stronger the farmers‟ willingness to change to the new varieties. When farmers choose seed, they pay more attention to such features as disease-resistance, pest-resistance, high-quality, and high temperature-resistance. Normally, farmers tend to choose new varieties which have high disease-resistance, pest-resistance and loading-resistance. Usually, the price of a new variety is higher than that of the already existing ones. If the price is too high, farmers‟ demand for new varieties may be reduced. In addition, farmers get information about some varieties through production practices.

Minot et al. (2007) also suggest that in areas with good soils, the more the varieties are productive, the stronger the farmers‟ willingness to adopt new varieties. Furthermore, farmers have perceptual knowledge of the effect of previously planted varieties. If farmers have formed a certain preference or loyalty to the brand of existing seeds, their demand for new varieties will decrease (Minot et al., 2007). If their neighbours and relatives prefer to adopt new varieties, farmers would tend to change too. In addition, if mutual trust has been established between farmers and agro-technicians, the possibility of farmers changing a variety will be higher.

The majority of farmers in Uganda obtain banana planting materials they need from traditional or informal systems such as farmer-based systems, neighbouring families, friends, and relatives while some are obtained through buying from commercial dealers (Kikulwe et al., 2007). Farmers are driven by their tastes and preferences of a particular variety while seeking planting materials. The traditional or informal farmer-based system of obtaining planting materials has been considered to be contributing to the spread of pests and diseases. Farmers do not recognize infested or diseased planting materials or fully understand the life cycles and transfer mechanisms of pests and diseases, especially given continual evolution of new races and pathogens (Kikulwe et al., 2007). Regarding the farmers‟ willingness to pay for tissue culture banana planting materials, their capability to pay for tissue culture planting materials is low.

The vast majority of planting materials in Uganda change hands without the exchange of money under the informal farmer-based systems. The banana market in Uganda is dominated by farmers who still produce primarily for local markets and therefore invest relatively little in planting materials and other commercial agricultural inputs. Farmers with sufficient resources and commercial orientation would be willing to pay for quality tissue-culture plantlets at commercial rates from private laboratories (Smale et al., 2006). The farmers" willingness to pay for planting materials also is determined by their expectations of what they will achieve with the variety and their affordability. Demand for pest-free and high-quality planting materials has been on the increase for initiating new plantations as a result of the Banana Bacterial Wilt (BBW) disease that has wiped out many farmers" plantations in the country. Tissue Culture (TC) could be a solution for producing clean planting materials in Uganda. There are recent varieties that are highly demanded in some regions and yet there is a shortage of clean planting materials. Although farmers recognise the importance of pests and disease, the majority still lack knowledge on the general management of the diseases for better productivity. Details on the models to explain farmers" willingness to pay for improved varieties are contained in section 2.7.

2.3 Empirical models to explain technology adoption on the farm

Adoption is treated as an investment choice, where the farm household is seeking to maximize agricultural profit in relation to a chosen set of inputs and outputs (Jones, 2005). According to the random utility theory, the decision of whether to adopt or not is based on whether the new technology will bring more utility to the farm household than the current technology (Caviglia-Harris, 2003). The decisions of a farmer in a given period to adopt a new technology are assumed to be derived from the maximization of expected utility subject to input constraints (Feder et al., 1985). A particular technology is adopted when the anticipated utility from it exceeds that of non-adoption (Rahm and Huffman, 1984). Since utility is not observable, change in utility can be inferred from farmers" decisions of adopting or not adopting a technology (incidence of adoption) and/or the level or intensity of adoption (Kazianga and Masters, 2002). In the case of a divisible technology, a continuous variable describing the intensity of adoption (e.g., hectares devoted to a new technology) or extent of adoption (e.g., share of land devoted to a new technology) are used. In most cases, the method of analysing adoption depends on the study objective, available data, and sometimes the available computer package (Feder et al., 1985; Doss, 2006).

Several analytical frameworks have been developed to study adoption of agricultural technologies. Shiferawa et al. (2008) note that the choice of analytical framework depends on the nature of the data set and the goals of the study in question. For econometric analysis, the basic logistic model was the starting model specified and estimated to explain the diffusion process (Knudson, 1991). Accordingly, the diffusion process assumes a cumulative proportion of adoption following an S-shaped curve in which there is slow initial growth in the use of the new technology, followed by a more rapid increase and then a slowing down as the cumulative proportion of adoption approaches its maximum. A logistic function is estimated where the y-axis represents the proportion of farmers adopting a technology and the x-axis represents time. A study by Feleke and Zegeye (2003) using a logistic regression model analysed factors that influence the decision behaviour of farmers in Southern Ethiopia in adopting improved maize varieties. The results indicated that access to credit is more powerful than other factors in terms of raising the probability of adoption.

In adoption studies there is a need not only for predicting the adoption as a 0-1 decision but also foreseeing the extent or intensity of adoption and this could be analysed within the framework of Tobit models (Tobin, 1958) and more recently Double-Hurdle model (Cragg, 1971). A Tobit model is a method that is appropriate for studying decisions in cases where the error terms are truncated or censored (McDonald and Mott, 1980). This method estimates the likelihood of adoption and the extent (i.e. intensity) of adoption and it has been extensively used (eg. Akinola and Young, 1985; Norris and Batie, 1987; Adesina and Zinnah, 1993; Sall et al., 2000). The advantage of the Tobit model over the dichotomous choice models (such as probit and logit) is that it permits determining not only the probability of the Yes/No adoption decision but also the intensity of adoption once the adoption decision has been made. However, the main weakness of 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 zeroes arise only as a result of the respondent"s economic decisions (Martínez-Espiñeira, 2006). However, in some cases there are households 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 (Moffatt, 2003).

A study by Sall et al. (2000) estimated a Tobit a model while assessing the improved rice variety adoption basing on the farmer‟s perspective in Senegal. The results indicated that both farmers' perceptions, as well as farm and farmer characteristics, were found to be important in determining the decision to adopt and the intensity of adoption of the improved rice varieties. Wubeneh and Sanders (2006) estimated separate Tobit regression models to determine the adoption of Striga resistant sorghum varieties and inorganic fertilizer on small subsistence farms in Tigray, Ethiopia. Results indicated that access to information, soil type, and farmers‟ perceptions of technology characteristics and rainfall risk were the factors associated with the adoption of the new sorghum cultivars. The study also indicated that in contrast, availability of adult family labour, farm size, manure use, and soil type were the major determinants of the adoption of inorganic fertilizers while Farm size was negatively related to fertilizer adoption as small farms are more pressured to adopt inorganic fertilizer and intensive production techniques.

A common alternative to the Tobit model in the analysis of farmers‟ adoption decisions is the hurdle model. The Double-Hurdle model first proposed by Cragg (1971) is based on the underlying assumption that individuals make two decision (hurdles) with regard to the adoption of a technology, namely, adoption status and intensity. Farmers will make a decision on whether they will grow a new variety, and then decide how much land they will allocate to the new variety. The two decisions are, therefore, whether to grow a new variety and how much to grow. In most cases, two hurdles can be estimated separately using a binary outcome model for the first stage (which is often estimated as a standard logit model) and a Tobit model for the second stage (Noltze et al., 2012). The Double-Hurdle (DH) model allows for the possibility that two decisions are affected by a different set of variables. This is the attractive feature compared to Tobit. The DH model has been extensively applied in several contexts (Newman et al., 2001; Moffatt, 2003; Martínez-Espiñeira, 2006). Shiferaw et al. (2008) applied an augmented DH model while estimating variety technology adoption under seed access constraints in Tanzania. They indicated that seed access (local supply), extension, education, participatory decision making, capital, and household assets were crucial in determining adoption. Kaguongo, et al. (2012) applied a DH model while estimating the factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties:

evidence from an extension intervention in Nyanza and Western provinces, Kenya. The study indicated that district where the farmer comes from, knowledge on value addition and nutritional benefits, and availability of vines were the key factors for adoption.

Adoption can also be studied applying the switching regression framework. The endogenous switching regression (ESR) framework estimates two separate equations (one for adopters and one for non-adopters) to account for both endogeneity and sample selection (DiFalco et al., 2011). The econometric problem will thus involve both endogeneity (Hausman, 1978) and sample selection (Heckman, 1979).

Adoption could also be analysed within the framework of a count data model approach. Studies have also investigated adoption intensity with continuous models (Just and Zilberman, 1983; Sall et al., 2000), or the adoption of package components or a joint or integrated adoption of technologies with count data approaches (Lohr and Park, 2002; Sharma et al., 2010; Noltze et al., 2012). Count data regression is appropriate when the dependent variable is a non-negative integer valued count, y = 0, 1, 2..., where y is measured in natural units on a fixed scale (Cameron and Trivendi, 1998; Coxe et al., 2009). The Poisson regression model is considered as the benchmark model to analyse count data. It assumes that the probability of an event occurring during a brief period of time is constant and proportional to the duration of time. Park and Florkowski (2003) estimated a poison regression model in the selection of peach varieties and the role of quality attributes. The model identified the impact of farm characteristics such as the farmer's quality preferences, on-farm agronomic and orchard conditions, as well as geographic effects in Georgia peach growing regions. However, this model does not fit the data well when there are a large number of extra-zeroes in the distribution within the outcome variable, for which there is a Zero-Inflated Poisson (ZIP) (Lambert, 1992). Edmeades and Smale (2006) used a Zero-Inflated Poisson (ZIP) regression model to predict farmers" potential demand for genetically transformed varieties of a food crop, the cooking banana of the East African highlands. The study indicated that the choice of host variety can have social consequences, favoring one rural population compared with another. It further concluded that clients for transgenic banana planting material are likely to be poorer, subsistence-oriented farmers in areas greatly affected by biotic constraints.

Adoption can also be analysed with the stepwise adoption models. Stepwise regression is an approach to selecting a subset of effects for a regression model. Stepwise regression is used when there is little theory to guide the selection of terms for a model, and the modeller wants to use whatever seems to provide a good fit. It is a type of multiple linear regression that can select the best-fitted combination of independent variables for dependent variable prediction with forward-adding and backward deleting variables (Chen et al., 2013). The stepping procedure begins as an initial model definition, with a stepped forward addition of a variable to the previous model. Forward adding and backward deleting are repeated until no variable is added or removed. According to Prost et al. (2008), the main value of stepwise selection is that it can be used to select a subset of explanatory variables by using statistical criterion computed from a dataset, like the Akaïke information criteria, the Bayesian information criterion, or statistical tests. The number of parameters in the final model obtained with this procedure is expected to be less than in the full model, and the variance of the estimated parameters can also be reduced.

2.4 Farmers' choice among improved varieties

Economic models for analysing crop variety choice are derived from household models and the partial adoption literature (Rosen, 1974; Feder et al., 1985). If farmers" technology choices are a result of profit maximization behaviour, then variety choice will depend on the determinants of profit (Feder and Umali, 1993). Furthermore, modelling farmers" crop variety choice is done following the general framework of consumer demand theory, the so called the characteristics model (Lancaster, 1966; Rosen, 1974), which suggests that consumers derive utility not from a good but from the characteristics embedded in a good. Lancaster"s (1966) approach to consumer theory assumes that consumption is an activity in which goods, singly or in combination, are inputs, which generate output in terms of a collection of characteristics. A good which does not possess all the characteristics a consumer desires cannot be a dominant good no matter how low its price. According to Lancaster (1966), a consumer buys particular goods as inputs that will generate the characteristics he/she values. Rosen (1974) argues that consumers value goods based on their utility-generating attributes, and assess product characteristics when making a purchase decision. According to Lancaster (1966), preferences for a good can, therefore, be described by the characteristics that generate utility or disutility to individuals. In this context, the Lancaster consumer demand model (1966) is more appropriate to analyse variety choice. The most influential theoretical framework for the choice of a variety is that individuals can choose between alternative options that are described by a number of attributes with different levels. In the Lancaster tradition, the farmer will choose the variety that possesses the combination of attributes that maximises his/her utility. Farmers are aware of the differences in performance of their varieties and these differences involve trade-offs that involve farmers choosing their most preferred option among different alternatives.

Variety choice is a process of selecting various bundles of attributes by farmers to satisfy consumption preferences, meet specific production conditions or fulfil marketing requirements (Smale et al., 2001). Previous literature (Edmeades and Smale, 2006; Wale and Yalew, 2007) suggests that farmers choose varieties based on the bundles of observable characteristics that each variety embodies and produces. The observed choice of variety is, therefore, hypothesised to be the result of a complex set of inter-variety preference comparisons made by farmers. Useche et al. 2009) suggests that in the context of the farmers‟ rational choice problem, they are assumed to collect information on alternative varieties, use the rules of probability to convert this information into perceived traits, and then go through a cognitive process that can be represented as aggregating the perceived trait levels into a stable one-dimensional utility index which is then maximized. According to Birol et al. (2008), preferences of small farmers who are oriented towards the satisfaction of the household‟s needs are described by the mean of the preferred choice sets, and translated into monetary terms.

According Bellon (1996), farmers consider a variety of factors when evaluating what to grow. For instance, farmers analyse what the expected yield is and how appropriate are the characteristics of the different technologies available to them. Farmers in most cases recognize that choosing the best variety is the most important step towards realizing high yields on the farm. According to Horna et al. (2007) farmers prefer one variety based on its attributes and how they perceive them. Choices or preferences among alternatives depend on the attributes of the variety, the characteristics of farmers, and the level of information they have about the variety (Bellon et al., 2006). According to Smale et al. (2001) variety choice is driven by farmers‟ demand for a number of variety traits. Adesina and Zinnah (1993) suggest that when farmers perceive an improved variety to be inferior to a traditional variety in terms of one or more attributes (such as taste and flavour), they are unlikely to adopt it. Abebe et al. (2013) reported that farmers were able to sacrifice yield, disease resistance, and maturity period in preference for local varieties because of the perceived better stew quality attributes in farmers‟ decisions about adopting improved potato varieties in Ethiopia. For new crop varieties, a household chooses between whether or not to plant the new crop in order to maximize their utilization of the land (Jones, 2005). The chance of a variety/technology to stay on farmers‟ fields is a function of the extent to which it embeds the important attributes relevant to the farm households and, therefore, attributes of varieties are essential for farmers‟ decisions to utilize the varieties of a given crop (Wale and Yallew, 2007). Farmers choose which crop variety to grow, where, and in what proportions, allocating them to a range of biophysical and social environments over both space and time (Lacy et al., 2006). However, in most cases, a single variety is likely to possess all the desirable and undesirable attributes demanded by the farm household (Smale et al., 2001). Variety choice is, therefore, conditional on the existence of a bundle of desired attributes (as perceived by the farmer) conferred by a given variety. The desired attributes may include only consumption attributes (e.g. taste and colour), only production attributes (e.g. yield and disease resistance), or both (e.g. taste and yield). Farmers seek to maximize stable preferences for the attributes of the crop varieties they plant.

According to Edmeades et al. (2005), a variety is chosen not only because of specific household characteristics (e.g. size and composition), exogenous factors (e.g. agro-climatic conditions) or endogenous household preferences (e.g. risk-aversion, learning), but also because of a set of intrinsic attributes of the variety, as perceived by the household. According to Brush et al. (1992), variety choice is determined by comparing the genetic traits between improved and local varieties or within a specific crop population. De Groote et al. (2013) argued that farmers consider a wide range of criteria to evaluate varieties; for instance, they consider field characteristics (such as yield and pest resistance), and consumer characteristics (such as cooking and taste qualities). According to Bellon and Taylor (1993), given that genetic traits are not observable to farmers, the differences are evaluated on the basis of morphological (i.e. physically observable) characteristics of crops.

Farmer variety choice is influenced by differences in performance of different varieties in different environments (Ceccarelli, 1994; Simmonds and Smart, 1999) and differences in physical (agro-climatic) farm characteristics such as soil quality (Bellon and Taylor, 1993). Environments can vary along temporal, spatial, and management dimensions; e.g., seasons, years, fields, locations within fields, and labour or fertilizer inputs. According to Sheikh et al. (2003) the physical features of a farm, such as topography, soil type, infrastructure (roads and canal) and climate, do affect the choice of new technologies, depending on the nature of the technology. Farmer variety choice could also be analysed in the context of varietal adaptability. The crop(s) and the variety(ies) to be grown should be selected based on their adaptability to the prevailing conditions on the farm (Edmeades et al., 2005). Variety choice is conditional on farmers‟ subjective beliefs and the availability of high-yielding varieties with specific ecological characteristics (e.g. moisture retention, resistance to lodging, tolerance to biotic and abiotic stresses).

With respect to resistance to pests and diseases, regardless of the purpose of farming, Greig (2009) suggests that it is important to select a crop and variety with resistance to important pests and diseases. In agricultural production, minimizing potential production problems is essential to all farming operations. Pests and diseases are the major areas of consideration for farmers; they need to select varieties that are resistant or tolerant to pests and diseases. According to Strange (2005), the use of susceptible varieties may result in high cost of production or in a worst scenario, total crop failure. Performance of a variety can include a wide range of traits including yield and yield stability, resistance to biotic (e.g., pests and disease) and a-biotic stresses (e.g., drought, soil acidity), processing and food quality, and seed colour and shape (Lacy et al., 2006). Quality attributes such as yield, disease tolerance, maturity period, drought resistance and intensity of crop management are production-related, and determine the attractiveness of a variety from a farming perspective.

Farmers‟ attitude, resource availability and education and knowledge are especially important in making choices. Olson et al. (2012) investigated the factors that influence farmers‟ choices between landraces and improved varieties of maize and found that farmers with small plots of land appear to prefer local maize varieties despite the availability of improved seeds. This implies that farmers consider land availability when choosing from improved and local varieties. Farmers may be risk averse towards making changes in cropping decisions or adopting new agricultural practices, or might have very conservative attitudes towards technology or lower or higher levels of concern for the natural environment (McCann et al., 1997). For farmers who want to engage in cash crop farming or ensure financial sustainability, variety selection must consider marketability and profitability. Katungi et al. (2011) argue that farmers assess varieties both on their agronomic characteristics and marketability and therefore consider production-related and market-related attributes.

Farmers involved in banana farming in remote areas of Uganda should benefit from improved banana varieties with higher yields and good pest and disease resistance. Thus, a new banana variety has to fit within farmers" agronomic and taste preferences. According to Gold et al. (2002), farmers in Uganda consider attributes like cultivar longevity, tolerance to biophysical constraints (marginal soils, drought, pests and diseases), bunch size, marketability and availability of planting materials. While studying the variety selection criteria of Musa cultivars in Uganda through a farmer participatory appraisal survey, Gold et al. (2002) reported that farmers in Central Uganda gave high priority to cultivar longevity and marketability. The Eastern Region of Uganda is particularly where banana production constraints have reduced plantation life (Rutherford and Gowen, 2003).

Having varieties that are tolerant to most of the banana constraints with preferred production attributes would promote banana production in this region. In Uganda, bananas are the major staple food, therefore, cooking quality traits need to be emphasised since they might be more important in the adoption of a new banana variety. Among the Ugandan banana farmers, the most important banana consumption attributes are taste, food colour, texture and flavour, among others. The production attributes desired in new bananas include bunch size, tolerance to diseases and pests. Therefore, there is a need to document the production attributes that farmers would desire to have in new banana materials and quantify the relative importance of the food quality attributes. Sall et al. (2000) reported that improved rice varieties that compared favourably with local varieties in terms of cooking traits (tenderness and stickiness of grains once cooked) were more likely to be adopted by farmers. According to Kornegay et al. (1996), farmers were able to sacrifice yield over quality differences in the adoption of new bean varieties.

2.5 Empirical models to explain variety choice

There are several analytical frameworks developed to analyse variety choice. The appropriate specification of the analytical model is motivated largely by the goals of the research and the data that are available to the researcher (Train, 2003). This section gives a review of the various analytical models developed for studying choice of varieties.

The origins of choice modelling can be traced to Thurstone's research into food preferences in the 1920s and to random utility theory (Louviere et al., 2010). Choice modelling started with the early developments by Thurstone (1927) with the concept of psychological stimuli as characterising the appeal of a given option. Marschak (1960) later interpreted stimuli as utilities in the development of random utility models. He argues that agents choose options which maximise their utility. Major theoretical developments and large scale empirical applications followed in the 1970s, especially with the ground-breaking work of McFadden (1974). The 1970s developments largely took place in a transport context, but contribution to wider science was recognised by the Nobel Prize in Economics for Dan McFadden in 2000. Researchers have been working on improving the specification of the traditional choice models in terms of the flexibility of choice models (McFadden, 2001). This has seen the development of the new Generalized Extreme Value (GEV) family of models and mixed logit models. These are extensively applied as they avoid the restrictions of standard logit and nested logit models (Ben-Akiva et al., 2002).

The choice modelling approach has a theoretical foundation in Lancaster"s model of consumer choice (Lancaster, 1966), and an econometric basis in models of random utility in which decision makers are assumed to be utility maximisers (Luce, 1959; McFadden, 1974). The choice models attempt to analyse decision maker"s preferences amongst alternatives (Train, 2003). Choice modelling posits that with human choice there is an underlying rational decision process and that this process has a functional form (McFadden, 1974). Depending on the behavioural context, a specific functional form may be selected as a candidate to model that behaviour (Carter et al., 2010). In modelling choice, individuals are expected to act rationally by evaluating all alternatives before proceeding to choose the alternative from which they are expected to derive the greatest relative utility. In the context of variety choice, the farmers are faced with the choice set of varieties available to him for choices (Jaeger and Rose, 2008). The selection process is influenced by the characteristics of the farmers and information about the variety. To fit within a discrete choice framework, Train (2003) suggests that the set of alternatives must meet the following requirements: (i) alternatives need to be mutually exclusive, (ii) alternatives must be exhaustive, and (iii) the number of alternatives must be finite. An increasing number of studies have used the discrete choice approach to estimate farmers" and consumers" preferences for various agricultural technologies and foodstuffs. For example, Ruto et al.(2008) employed this approach for the valuation of livestock attributes. Hu et al. (2004), Kontoleon and Yabe (2006), and,Kikulwe et al. (2011) used it to investigate consumer preferences for genetically modified (GM) food.

Among discrete choice models, the multinomial logit (MNL) and the multinomial probit (MNP) models are the most commonly used (Train, 2003). The multinomial logit model is the most popular and widely used discrete choice model due to its relative simplicity. Originally derived by Luce (1959), the multinomial logit model assumes independence of irrelevant alternatives (*IIA*). The unobserved factors are uncorrelated over alternatives, as well as having the same variance for all alternatives (Luce, 1959). This assumption provides a very convenient form for the choice probability. However, its derivation is based on strong independence assumptions, namely, error terms in the utility functions are supposed to be independent across alternatives and individuals. However, the assumption of independence can be inappropriate in some situations. A MNL model describes in detail the structure of decisions leading to the choice of a specific variety, allowing for the study of how actual changes in traits affect adoption.

The MNL is also based on the random utility model. The MNL model, developed by Nerlove and Press (1973) on the basis of the random utility theory, is appropriate to identify consumers' preferences towards hybrid varieties in this application. The utility (U) to an adopter to choosing a particular alternative is specified as a linear function of the farm and farmer characteristics (β) and the attributes of that alternative (X) as well as a stochastic error component. It is also important to stress that the model is more flexible than traditional models because it allows an individual farmer"s tastes for an attribute to deviate from average tastes. Also, it allows for correlation in the unobservable components of the utility for different alternatives when the degree of correlation depends on how close the two alternatives are. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories (Wooldridge, 2002). A study by Joshi and Bauer (2006) estimated MNL to determine farmers" choice of the modern rice varieties in the rain-fed ecosystem of Nepal. The results showed that both production and consumption attributes valued by the farmers and farm and farmer related variables are significant in determining the demand for a specific variety. Seo and Mendelsohn (2008) applied a multinomial logit model while studying how South American farmers adapt to climate by changing crops through an analysis of farmer"s choice of crops. The results indicated that farmers choose fruits and vegetables in warmer locations and wheat and potatoes in cooler locations. The study also indicated that farms in wetter locations are more likely to grow rice, fruits, potatoes, and squash and in dryer locations maize and wheat.

In a MNL model, direct interpretation of parameters of the random utility function on the probabilities is not very meaningful due to the non-linearity of the probability function. Therefore, an appropriate way is to interpret each variable‟s marginal contribution to choice probabilities. The marginal effects do not necessarily bear either the same value or sign as the parameters themselves (Greene, 2003). However, the derivation of MNL is based on strong independence assumptions, which are not valid in many contexts (Bierlaire, 2007). Improvements in econometric modelling have over the years seen the introduction of the family of Multivariate (or Generalized) Extreme Value (MEV) models. These relax the assumption of independence across alternatives. This family, proposed by McFadden (1978), includes the nested logit model, the cross-nested logit model (NL), the network MEV, the exploded logit and the ordered response choice models (Daly, 1987) and, more recently, the mixed logit (ML) model (Train, 2003).

The nested logit (NL) model and the mixed logit (MXL) model, also referred to as random parameter logit (RPL) models, are the commonly used models that relax the IID assumption. The nested logit model was developed by assuming that the error terms are not independently distributed *i.e.* the alternatives are correlated. The model is based on the assumption that the alternatives from the choice set can be divided into mutually exclusive and collectively exhaustive groups (nests) in such a way that the error term is represented as the sum of the group-related and alternative-specific components, where the group-related component expresses the similarity among the alternatives. This model has been applied by many researchers in a variety of contexts (Wen and Koppelman, 2001; Moreno and Sunding, 2005). A nested logit model is appropriate when the set of alternatives faced by a decision maker can be partitioned into subsets, called nests, in such a way that for any two alternatives that are in the same nest, the ratio of probabilities is independent of the attributes or existence of all other alternatives. A study by Moreno and Sunding (2005) estimated a nested logit model of technology and crop choices that accounts for unobserved correlation among decisions. The results indicated that adoption of precision irrigation technology was more sensitive to financial incentives affecting input price and technology cost than suggested by previous studies.

For the case of a mixed logit model approach, it allows the unobserved factors to follow any distribution. The mixed logit relaxes the assumptions of independently and identically distributed error terms and allows for the influence of unobserved heterogeneity in variety choice. A study by Useche et al. (2005) applied a mixed logit (MMNL) model to examine the adoption patterns of GM crop varieties among corn farmers in Minnesota. The results demonstrated that individuals' tastes for some traits significantly vary across the population. The study findings also suggested that labor saving technologies have a much wider potential to be adopted. According to Useche et al. (2005), the mixed logit provides an appropriate econometric structure for analysing technology choice of multiple related varieties, with a range of potentially related traits. The mixed logit model can be specified to consider the set of all possible vectors of characteristics as the choice set, is very flexible, and can approximate any random utility model (Train, 2003).

The choice of a variety can be analysed with the probit model (PM), where it is assumed that the random component is normally distributed. Although it is not as frequently used in discrete choice data analysis as the NL or MNL models, it can also give sound results in the choice options. A study by Magnusson and Cranfield (2005) applied a probit model to assess what food products consumers would purchase if available in pesticide free production form and what factors affect demand for pesticide free production food products. The results suggested a strong consumer interest in food products containing grains and oilseeds produced in pesticide free production cropping system. This model does not rely on the IIA assumption as the MNL model does. The PM provides an alternative way to fix the problem of the limitations of the multinomial logit model, especially regarding the IID and IIA properties.

Variety choice can be analysed within an ordered probit approach. An ordered probit model allows for multiple ordered values for the dependent variable and analyses the effect of each independent variable on the dependent variable. Ordered probit forms are often applied to a context where an agent such as an individual, household or decision maker chooses among a discrete set of alternatives (similar to random-utility models). A study by Horna et al. (2007) applied ordered probit model to examine farmers" preferences for seed of new rice varieties (improved and NERICA) in villages of Nigeria and Benin. The results from this study indicated that farmers prefer one variety based on the utility they obtain from its attributes, which depends on their own social and economic characteristics. For discrete dependent variables, the linear probability model has a number of shortcomings. The error term is heteroscedastic and it produces inefficient estimates (Greene, 2003). Due to this challenge an ordered probit model, consisting of U as an unobservable dependent variable, Rγ (where γ = 0,1,2,3,… , w) as the choice alternative or observable dependent variable, γ as the block of independent variables, and w as the threshold variable, can be formulated. The ordered probit measures the probability that the dependent variable falls in one of discrete categories conditioned on levels of the independent variables (BaiduForson et al., 1997).

In this study, the MNL Model is applied. The multinomial logit model provides a convenient closed form for the underlying choice probabilities without any requirement of multivariate integration. Therefore, choice situations characterized by many alternatives can be treated in a computationally convenient manner. More details on the application and interpretation of this model are contained in Chapter4.

2.6 Explaining consumers' willingness to purchase the products of improved varieties

Under normal circumstances, consumers choose the good that satisfies better their needs or expectations, or that provides them with a higher utility (Luce, 1959; Lancaster, 1966; McFadden, 1973). According to Yiridoe et al. (2005), the observed market price for food products is an aggregate of the implicit prices for the constituent product characteristics. Thus, product prices not only provide signals about the inherent quality characteristics of a product but also reflect the value of inputs used in the production of such agricultural goods. These issues have relevance in hybrid banana varieties purchase decisions because they are more consistent with such product purchase behaviour compared to parallel assumptions under traditional consumer theory which posit that utility helps to rank goods directly and that individuals possess utility functions in commodity space. The study analyses the likely consumer purchase of new hybrid banana varieties, borrowing from the theory of the consumer demand model (Lancaster, 1966).

Consumers may not adequately differentiate between the hybrid banana varieties with respect to general attributes. They may recognise the unique taste, the visual appearance or the freshness of a particular variety. However, sensory characteristics like taste, flavour, and visual colour of the food alone may not be sufficient for consumers to make a decision to purchase a product. Consequently, consumers will consider purchasing a banana variety which meets their preferences, regardless of agronomic traits. According to Bonti-Ankomah and Yiridoe (2006), a consumer‟s decision in favour of a product is made by comparing a bundle of (observable and unobservable) characteristics of the good. Consumer purchasing behaviour is assumed to be a function of several factors, including perceptions of the quality and value of the product in question (Jekanowski et al., 2000). The quality of a specific item as evidenced through consumers‟ acceptance and purchase is not determined by a few visible characteristics. It is more of a complex composition of several traits where many of them are not visible.

A study by Brunsø et al. (2002) suggested that characteristics of a product which influence the quality and therefore the value for consumers can generally be separated into two groups, namely, extrinsic and intrinsic characteristics. Extrinsic traits like colour or shape are visible to consumers whereas intrinsic traits (such as taste and flavour) are not visible and can only be judged after consumption (Brunsø et al., 2002). De Groote and Kimenju (2008), while comparing consumer preferences for colour and nutritional quality of maize in Kenya, reported a strong consumer preference for white maize. The intrinsic quality characteristics cover the physical characteristics of the product and are related to the product‟s technical specifications, which also include its physiological characteristics, i.e. characteristics which can be measured objectively (Brunsø et al., 2002). Stevens and Winter-Nelson (2008) found that participants preferred the taste, texture and appearance of their local white maize over an orange, bio-fortified variety and over a white variety with similar texture and flavour as the bio-fortified maize.

Various studies indicate that sensory characteristics, particularly taste, are the primary drivers for consumers‟ food choice and purchasing intention (Sabbe et al., 2009). This implies that most of the new commodities, say food products introduced to the market, should be designed to satisfy the needs of consumers. Quality is a major concern among the consumers when making food purchase decisions for household consumption. In most cases, the acceptance of a good quality product mainly depends on the sensory characteristics associated with that food product, especially among the regular users of a product. The literature evidence shows that if the first impression of taste is poor, there may be no way to tempt a person to try a product for a second time, nor to repeat consumption in the future (Sabbe et al., 2009). This suggests that consumers‟ likelihood of repeated purchase and future product use is influenced by the degree to which their expectations are met upon its tasting (van Kleef et al., 2005). A study by Probst et al. (2012) reported a positive relationship between appearance, taste and the vendor choice while investigating the marketing potential of organic vegetables in the food vending sector of Benin. Insights into the perceived importance and evaluation of different attributes are essential for an improved comprehension of consumers‟ behaviour and purchasing intention (van Kleef et al., 2005). According to Bonti-Ankomah and Yiridoe (2006), product characteristics such as freshness, taste, and food safety influence consumers‟ willingness to purchase a product. Quality attributes such as cooking quality and shape are market-related, as these attributes determine the attractiveness of a variety from the customers‟ point of view.

A study by Kamphuis et al. (2006) argues that consumers‟ purchase decision is the result of complex interactions among socio-demographic, psychosocial and environmental factors. Consumers‟ education, occupation, gender, household size along with product attributes affect their attitude and preference to buy the products. For instance, socio-economic status affects food choices of a household. Consumers from low income households in most cases tend to purchase low price products compared with those from the high income category. In the case of gender, women often decide on the types of food products and prepare meals for the household and therefore have their own preferences and tastes that are likely to influence what the household will consume. De Groote and Kimenju (2008) reported that maize consumer preferences for colour and nutritional quality were affected by socioeconomic factors such as gender, education and income, with women having preference for white maize in Kenya, implying that colour is the major determinant in consumer preference for commodities. Pollard et al. (2001) suggest that emphasis of many studies has been on socio-demographic characteristics as important determinants of fruit intake. The economic literature suggests that willingness to pay for a product depends on socio-economic factors such as gender, age, income, education, and place of residence. For instance, Carlos et al. (2005) show that studies on willingness to purchase organic food indicated that women, youth, high income earners and educated people were willing to pay an additional premium for a product perceived to have good quality characteristics/attributes. In a survey conducted by Loureiro and Hine (2002), income and education were found to influence willingness to pay for organic and GMO-free products. Consumers will then strive to attain a product with attributes they most desire given their budget constraints.

The empirical literature (e.g. Liu et al., 2009; Darby et al., 2008) suggests that consumers‟ socio-economic characteristics such as age, gender, level of education, income level, household size as well as the level of consumers‟ awareness and perceptions, product price, taste, size, freshness and cleanness tend to influence consumers‟ willingness to pay for organic food products. Some studies have shown women in particular to be more willing to pay higher premiums for safe foods. Darby et al. (2008) and Liu et al. (2009) found education to be positively and significantly correlated with willingness to pay. Employing a two-limit Tobit model, Gifford and Bernard (2006) reported that the likelihood consumers will purchase organic foods is influenced by the potential benefits from organic methods and perceived risk from conventional agricultural methods. Other studies have measured consumers‟ willingness-to-pay for a product with an ordered probit model. While the use of the ordered probit model is novel, such an analysis cannot lead to the estimation of a premium; it can only lead to what is associated with being in one of the willingness to pay (WTP) categories. Xue et al. (2010) estimated both probit and tobit models to examine the relationship between consumers‟ sensory evaluations and their beef preferences and found that palatability attributes play a central role in determining consumers‟ preferences and WTP. The results suggested that consumers‟ nutrition knowledge, beef consumption behaviour, health condition, and household size had significant impacts on consumers‟ WTP for grass-fed beef.

2.7 Empirical models to explain consumers’ willingness to pay for the products of improved varieties

Empirical models of consumer willingness to pay for a product depend on the goal of the researcher, the nature of the phenomenon under investigation and the availability of relevant theories and data to support the analysis (Roberts and Lilien, 1993). According to Roberts and ilien (1993), a consumer goes through a number of steps before reaching a decision: Consumers first recognise that there is a need they would like to satisfy; the choice of a product to satisfy that need; the actual purchase; and preferences and perceptions that follow consumption to guide future purchase behaviour.

In the first category, the commonly used models to measure the binary response behaviour include the linear probability model, logit and probit models and the discriminant function analysis (Gessner et al., I988). See section 2.3 for details. In the absence of major violations to their assumptions, all of these models fit and predict reasonably well, giving qualitatively similar results (Gessner et al., 1988). For instance, a study by Quah and Tan (2010) applied a

Logit model to examine the likelihood of Penang (Malaysia) consumers to purchase organic food products (OFP) and found that organic food products purchases by consumers of various ethnicities are affected by similar and dissimilar socio-demographical and attitudinal factors. A study by Mesı´as Dı´az. (2012) applied a logit model to analyze the levels of knowledge and consumption of organic tomatoes in Spain, and their influence in consumer willingness to pay for this type of food. In this study, the results indicated a clear relationship between consumers‟ levels of knowledge and consumption of organic foods and their willingness to pay a premium for these products. Muzhingi et al. (2008) estimated a probit model while studying consumer acceptability of yellow maize products in Zimbabwe. The study indicated that nutritional education can potentially promote yellow maize consumption, especially if targeted at low income households.

In the second category of consumers‟ information search, consumers often do not satisfy an aroused need immediately. Once a consumer recognizes a need, he enters a state of heightened awareness in which he seeks more information about brands or products that could satisfy that need. Then evaluation and brand choice takes place based on the information resulting from this search. In this category, the commonly used models include among others the hedonic pricing approach (Lad and Martin, 1976; Larue, 1991). The approach is based on the assumptions of perfect competition and utility maximization. That is, all the participants are price-takers and have full information and the product is assumed to be purchased by consumers for its attributes. A high WTP for a certain trait should lead to increased demand for the new technology, while a low WTP for other traits may decrease the demand for a new technology.

The hedonic approach imputes prices of attributes based on the relationship between the observed prices of differentiated products and the number of attributes associated with these products. However, it provides very little guidance on the choice of the proper functional form and as such may lead to inconsistent estimates (Brown and Ethridge, 1995). A study by Dalton (2003) applied a hedonic price model for upland rice and found that a combination of production and consumption characteristics best explains the willingness to pay for new upland rice varieties. The results from this study indicated that five traits explain the willingness to pay for new rice varieties: plant cycle length, plant height, grain colour, elongation/ swelling and tenderness. Mishili et al. (2009) applied hedonic pricing methods in the study to determine the impact of cowpea grain quality characteristics on market price.

The results indicated that cowpea consumers in Ghana, Mali, and Nigeria are willing to pay a premium for large cowpea grains.

A third category is the evaluation stage. Under this category, Gessner et al. (1981) suggest that consumers first establish their beliefs about the features of the alternative products that they consider (perceptions) and then determine, based on those perceptions, their attitudes towards the products (preferences). According to Grunert (2005), consumers perceive a particular product in terms of the set of attributes they consider most relevant. The common analytical models include the multidimensional scaling (MDS) and compositional methods, based on factor analysis (FA). The multidimensional scaling (MDS) procedure is a technique that helps to identify key dimensions underlying respondents‟ evaluations of products. Multidimensional scaling (MDS) is conducted because it is an effective way to detect similarities and differences in individuals‟ perceptions (Hair et al., 2006; David, 2009). It is often used to identify key dimensions underlying consumer evaluations of products or services. Factor analysis (FA) is a method for investigating whether a number of variables of interest are linearly related to a smaller number of unobservable factors based on theory. A study by Krystallis and Chryssohoidis, (2005) applied a factor analysis to analyze the factors that influenced the willingness to pay (WTP) for organic products and the purchasing of conventional foods. The factors include food quality and security, trust in the certification, and, for some products, brand name. Gifford and Bernard (2008) applied factor analysis and cluster analysis to study the willingness to pay for organic and non-GM food.

Another category includes the models of purchase decisions. These relate the product preferences to purchase probabilities. One way to measure consumer preferences for attributes is their willingness to pay (WTP) for the attributes. According to Useche et al. (2005), estimates of farmers‟ WTP for traits shape the type of varieties offered in the market including the potential value to farmers of “stacked” or “bundled” traits. The popular approach used to study consumers‟ WTP is the contingent valuation (CV) approach (Mitchell and Carson, 1989). A study by Rodríguez et al. (2008) applied the contingent valuation method in order to calculate the WTP for five organic selected products: regular milk, leafy vegetables, whole wheat flour, fresh chicken and aromatic herbs. The empirical results revealed that consumers were willing to pay a premium for these products and that although prices play an important role, lack of store availability and of a reliable regulatory system to mitigate quality risks constrained consumption of organic products in this country in Argentina.

The last category includes preferences and perceptions that follow consumption for future purchase behaviour (Gessner et al., 1981). Under this category, a number of analytical tools have been applied in measuring WTP for consumer products including the multinomial logit, the nested logit, and mixed multinomial logit (MMNL) models of crop-variety choice (details in section 2.5). Briz and Ward (2009) applied a multinomial logit model to study consumer awareness of organic products and reported that consumer awareness of organically-produced foods alone does not necessarily translate into actual consumption. Alfnes et al. (2006) applied a mixed logit model to study consumers" willingness to pay for the colour of salmon and reported that the pink-red colour is one of the most important quality traits for Atlantic salmon. The results of this study also indicated that consumers related colour with quality and therefore were willing to pay significantly more for salmon fillets with normal or above-normal redness, as compared with paler salmon fillets. Other studies have employed a bivariate Tobit model to quantify the effects of the determinants of WTP premiums. This approach is justified because it takes account of the possible zero WTP responses of the joint cross-equation correlation among the WTP premiums for a given product. The study applied a binary logit model while determining the factors influencing farmers" willingness to purchase new banana varieties. The Binary logit model was adopted because it was more suitable to the empirical objective under investigation. More details of the application and interpretation of this model are contained in Chapter 5.

2.8. Summary

Many technologists believe that advantageous innovations will sell themselves, that the obvious benefits of a new idea will be widely realized by potential adopters, and that the innovation will, therefore, diffuse rapidly. However, most of the innovations are adopted at a slow rate. The literature review has established that agricultural technologies are location-specific and react to environmental changes. The characteristics of the intended user group, economic support system and administrative conditions surrounding the target area influence the scaling-up of a technology.

The literature review has established that the challenge in disseminating modern varieties to farmers could be attributed to failure of breeding programmes to consider farmers" needs, preferences and the prevailing farming conditions. Adoption may depend on a wide set of determinants including innovation and policy characteristics, farmer expectations, farm structure and the socio-economic environment. The literature has shown that the average time between initial information and final adoption varies considerably depending on the nature of the innovation, suggesting that the dynamic process of adoption involves learning about a technology over time. The literature also shows that the decision to adopt or not is based on whether the new technology will bring more utility to the farm household than the current technology. Also factors influencing adoption of new agricultural innovation can be divided into three major categories: farm and farmers‟ associated attributes, attributes associated with the technology, and the farming objective. Therefore, there is a need for understanding farmers‟ preferences regarding varietal attributes and how these preferences and farmer specific characteristics influence the potential adoption of hybrid banana varieties. This is crucial to inform development of relevant agricultural technologies and policies.

Review of the literature has revealed that a combination of production and consumption characteristics best explains the willingness to pay for new crop varieties. That variety-specific production attributes (e.g. yield, disease resistance) and consumption attributes (e.g. taste) play an important role in the planting decisions of semi-subsistent farmers. Other factors influencing farmers‟ willingness to purchase and use new varieties can include user characteristics and the environmental factors.

The literature review has also shown that the observed choice of variety is hypothesised to be a result of a complex set of inter-variety preference comparisons made by farmers. While choosing a new crop variety, a household chooses between whether or not to plant the new crop to achieve rural household objectives. The literature further suggests that variety choice is determined by farmers‟ perceptions of the comparisons in the levels of attributes conferred by different varieties. Also, farmers consider a wide variety of criteria to evaluate varieties, including field characteristics (such as yield and pest resistance), consumer characteristics (such as cooking and taste qualities), and genetic traits that are not observable to farmers. Review of the literature has suggested that consumers value goods based on their utility-generating attributes and that purchasing behaviour is assumed to be a function of several factors, including perceptions of the quality and value of the product in question and socio-economic factors such as gender, age, income, and education. This needs to be tested within the framework of new hybrid cooking banana varieties to determine the effect of quality and consumption characteristics on purchase decisions for the newly developed hybrid banana varieties in Uganda. This will help in guiding the further promotional activities for these hybrid banana varieties especially among the farming communities. Several analytical frameworks have been developed to study adoption of agricultural technologies. The literature review has established that progress has been made in areas of early stage adoption, variety choice and consumer"s willingness to pay for improved technologies, but the production and consumption attribute preferences of the hybrid bananas among the farming communities in Uganda is not well understood.

The literature review suggests that a Zero-Inflated Poison (ZIP) regression model is fit to assess how the farmer perceptions, along with farm and farmer specific characteristics, determine the early stage adoption of hybrid banana varieties in Uganda. The model fits the data well given the presence of the large number of extra-zeroes in the distribution within the outcome variable while measuring the early stage adoption of hybrid banana varieties in Uganda. The literature review has shown that the MNL model is a convenient closed form for the underlying choice probabilities without any requirement of multivariate integration. The literature further suggests that the choice situations characterized by many alternatives can be treated in a computationally convenient manner with a MNL model. Similarly, the review of the literature has demonstrated that a binary logit model is justified because it takes account of the possible zero WTP responses of the joint cross-equation correlation among the WTP premiums for a given product.

This chapter has provided a literature review on the early adoption, variety choice and consumers" willingness to pay for the products of improved varieties. The next chapter will provide details on the production and consumption attribute preferences of banana hybrids in Uganda based on score rating, factor analysis and a zero-inflated poison model.

CHAPTER 3

FARMERS' PRODUCTION AND CONSUMPTION ATTRIBUTE PREFERENCES OF BANANA HYBRIDS IN UGANDA: SCORE RATING, FACTOR ANALYSIS AND ZERO-INFLATED POISSON REGRESSION[1]

3.1 Introduction

Banana and plantain (*Musa* spp.), commonly called banana, is an important world food security crop for the livelihoods of millions of smallholders, particularly in tropical countries (Lorenzen et al., 2010). The crop is grown in over 120 countries, with an annual world production of around 104 million tons, of which East Africa is the largest producing and consuming region in Africa (Tripathi et al., 2010). Uganda is the world"s second leading producer, after India, of about 10.2 million tons (FAOstat, 2011). It is estimated that 75% of Ugandan farming households grow the crop on about 1.5 million hectares, which accounts for over 38% of utilised arable land (FAO, 2004). The continuous production of bananas all year round offers a significant income generation advantage over traditional cash crops for many smallholder farmers who grow the bulk of the crop in Uganda. Household surveys (UBOS, 2010) indicate that areas where banana production is the main activity are never hit by famine and are relatively stable in terms of household incomes.

Despite the crop"s importance for food security, its productivity has been declining over time, particularly in central Uganda, where plantation life has reduced to less than five years compared to 50 years or more in south-western Uganda (Tushemereirwe et al., 2003). The banana yields in Uganda are low (5-30 t/ha/year) and are declining further, compared to potential yield (70 t/ha/year) (Asten et al., 2005; Barekye, 2009). Banana bunch weights at farm level have dropped from 60kg to 10kg, or even less (Barekye, 2009). The decline in banana yields has contributed to food shortages, thus putting consumers heavily dependent on banana at risk of food insecurity, particularly in areas where the crop is regarded as a staple food. A country-wide rural appraisal conducted in June 1991 (Gold et al., 1993;

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[1] This chapter gave rise to the following draft paper: Akankwasa K., G. F. Ortmann, E. Wale and W. K. Tushemereirwe. Early stage adoption of improved banana "Matooke" hybrids in Uganda: a count data analysis based on farmers" perceptions. Currently under revision to be resubmitted to the *International Journal of Innovation and Technology Management*.

Tushemereirwe et al., 1996) and subsequent surveys (Tushemereirwe et al., 2003) revealed that the leading factors responsible for the decline in productivity of the East African highland cooking bananas (*Musa genome group* AAA-EA) include: pests (banana weevil and nematodes), diseases (black Sigatoka, banana bacterial wilt), soil fertility decline, and socio-economic constraints (high costs of managing the crop, competition for labour with other enterprises, marketing difficulties and low genetic diversity, among others). All these constraints affect banana production, leading to significant production and income losses (Gold et al., 1993; Tushemereirwe et al., 1996; Bagamba et al., 1998). Unless vigorous measures are taken to address these challenges and improve yield growth, the result could be food insecurity for millions of poor consumers. In response, NBRP initiated a breeding programme in 1994 using a participatory plant breeding approach. The programme has so far developed 4 new banana 'Matooke' hybrid varieties (M2, M9, M14, and M17), which have been under on-farm evaluation in different agro-ecological regions of Uganda since 2008 with Mbwazirume (a traditional variety) as a local check.

Despite the research and extension efforts to popularise these hybrids in Uganda, to date no attempt has been made to document the likelihood of farmers‟ adoption. The demand for these varieties is likely to increase if they are designed to include end users‟ (farmers) preferred traits. The objective of this chapter, therefore, is to analyse farmers‟ preferences regarding varietal attributes and assess how these preferences, along with farm and farmer characteristics, determine the variations in the levels of potential adoption. Though a few studies have considered consumption and production attributes as explanatory variables in empirical adoption models (Adesina and Baidu-Forson, 1995; Hintze et al., 2003; Edmeades et al., 2005; Wale and Yalew, 2007; Edmeades et al., 2008; Kikulwe et al., 2011 and Abebe et al., 2013), the determinants of farmers‟ early stage adoption of new banana hybrid varieties have not been investigated in Uganda. The study, therefore, is one of only a few that has included variety characteristics as factors influencing early banana variety adoption. Furthermore, the analysis done in this study is using information obtained from on-farm trials to evaluate farmers' preferences on varietal traits and has considered farm characteristics in the early stage adoption of the newly developed hybrid bananas. Considering that farmers are the final decision-makers for adoption of any technology, it is important for the banana breeders to know how farmers view these hybrid varieties.

The remainder of the chapter is organized as follows: The following section presents the research methodology with details of the study area and sampling procedures. Section 3.3 presents the results and discussions. Finally, section 3.4 presents the conclusions and implications of the results for future breeding priority setting and variety dissemination strategies.

3.2 The research methodology

The description of the study areas is included in section 1.5. The study areas are the regions where the NBRP is evaluating the new hybrid banana varieties. While selecting the regions and agro-ecological zones for the project, the programme considered disease and pest severity as a major factor. This is mainly because a major objective of hybrid banana development was to produce banana varieties resistant to black Sigatoka, which has negatively affected banana production in these major areas. The data collection process was participatory from the outset, involving farmers and other stakeholders, particularly while selecting the sub-counties and host farmers of the demonstration plots.

A national workshop was held to share with the stakeholders the objectives of the project and during this workshop a criteria for selection of sub-counties and farmers to host the plots was developed. Four main banana producing sub-counties were purposively selected in each district, and from these sub-counties two villages were randomly selected. The following criteria were used to select the participating farmers: Farmers‟ knowledge in banana cultivation and consumption, availability of sufficient resources to maintain the plot (about a quarter of an acre), willingness to host and meet maintenance costs of the trial (including fencing / protection), willingness to allow other farmers to learn from the farm, and accessibility of the farmers‟ trial site. At village level a list of banana growing farmers was drawn following the above criterion and from this list two farmers were randomly selected to host the demonstration plots. This gave a total of eight farmers in each district, constrained by the resources available to manage these plots throughout the country.

Consequently, ten plants per variety of the four hybrids (M2, M9, M14 and M17) and a local check (Mbwazirume) were given to the selected farmers. Mbwazirume was included so that farmers could have a complete choice and make fully informed decisions by comparing the old variety with the new varieties. These were planted in lines along the slope at a spacing of three metres from each plant and three meters from another plant of a different variety at the farmers‟ plots and at their own expense. They were introduced to 312 farmers in 39 districts covering all the above Agro-Ecological Zones. The four new hybrids developed are being evaluated under farmer-managed conditions across all the Agro-Ecologic Zones in the four major regions.

3.2.1 Sampling procedures and data collection

The chapter is based on primary data collected from a survey of 192 participating (host farmers of the demonstration plots) and 576 non-participating farmers (neighbours with no demonstration plots) located across the six Agro-Ecological Zones in the four Regions. Out of the 39 districts where the project is being implemented, six districts were randomly selected in each of the four regions. In each district, eight farmers were selected for the interview, totalling 192 respondents. In addition, in each district 24 non-participating farmers were selected randomly from the villages where participating farmers are located, totalling 576 farmers. The interviews were held between May and September 2010 using a pre-tested questionnaire with the assistance of trained enumerators.

Primary data were collected on socio-economic characteristics of sampled farmers, farmer preferences of banana hybrid attributes and institutional factors (like access to credit and extension services and membership in farmer groups), market-related characteristics, and total land owned by the farmers (Acres[2]). Data were also collected on livestock and household asset ownership and their values. Due to missing responses, 149 participating and 305 non-participating farmers were included in the analysis, giving a total of 454 valid responses, after accounting for missing responses and incomplete data. The missing observations were from farmers who could not have had an opportunity to access the new hybrids for their evaluations.

Farmers‟ preferences about the consumption and production attributes of the hybrid banana varieties were then elicited. Each hybrid variety was evaluated by farmers for each attribute on a 5-point Likert scale, namely 1= Very Poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very Good. The early stage adoption was measured as the number of banana mats of a hybrid variety grown by a particular farmer since the inception of the project. Bananas are grown in

[2] 1 Acre = 0.404685 Hectares

a mat (a plant mat is the whole set of bananas emerging from the initial plant of bananas planted) consisting of the mother plant and suckers from which they are vegetatively propagated from a banana sucker (Thomas, 1998). Thus, the demand for a variety is expressed as a variety"s count of plant mats. Each host farmer received 10 plants per variety for all the five varieties (M9, M2, M14, M17 and Mbwazirume) and all were planted in a single plot (1/4 acre). A variety preferred by the farmers has been multiplied by them while a variety that is not preferred has either been eliminated from the plot or not expanded at all. Since the response variable is "count" data, count data models were considered more appropriate in order to avoid biased and inefficient estimators. It is easy to count the plant mats per variety because they are completely unique from each other.

Respondents were also asked to rate the hybrid banana variety characteristics according to their level of importance in variety choice. The rating for each of the characteristics was based on a five-point Likert scale, namely 5 = Strongly Agree; 4 = Agree; 3 = Disagree; 2 = Strongly Disagree; and 1 = Don't Know. Farmers were asked to choose the most desirable hybrid banana varieties and the reasons for their choice using the above ratings. They were also asked to list the desirable and undesirable attributes for each of the hybrid banana varieties with respect to a local variety.

3.2.2 Variables considered to explain early adoption

The variables to explain early stage adoption of new hybrid banana varieties presented here are based on the theory of agricultural household models (Singh et al., 1986 ; Hintze et al., 2003; Benin. et al., 2004; Cavatassi et al., 2011). According to these models, decisions of a farmer in a given period to adopt a new technology are assumed to be derived from the maximization of expected utility subject to input constraints (Feder et al., 1985). In what is now called the characteristics theory of consumer choice, Lancaster (1966) argued that goods are as good as their desirable and undesirable characteristics, and the attributes embedded therein give rise to utility. Drawing from this model, farmers" demand for the hybrid banana plants is derived from the utility that farm households obtain from their attributes. Therefore, crop variety adoption is driven by farmers" demand for variety traits (Smale et al., 2001). Farmers are unlikely to adopt these varieties if they fail to offer the attributes they demand, including the demand for consumption and production attributes supplied by the variety (Edmeades and Smale, 2006).

In this study, farmers‟ perceptions about the characteristics embedded in the hybrid banana varieties and socio-economic characteristics are incorporated into the analysis of early-stage adoption decisions. Not only adoption but also rejection (before or after use) of hybrid bananas can be explained using the characteristics model. According to Sinja et al.(2004), for instance, users will reject a technology that is not relevant to their needs and not suited to their work environment. The variables identified to explain farmers‟ early stage adoption of banana hybrids are meant to explain variety trait preferences. The variables that affect production and consumption decisions are relevant to explain attribute preferences as the attributes are, in turn, relevant for those decisions.

Education of the respondent is one of the variables included in the model. At the technical level, information acquisition as well as the capacity to process, understand, and use the technical aspects and returns related to alternative and complementary different technologies is largely determined by formal education and indigenous knowledge. Hence, educated farmers are often more likely to adopt a new technology (Isgin et al., 2008). Education level in this study is measured in terms of the number of years spent in school, and is expected to positively influence the response variable.

The effect of farmer‟s age could be positive or negative depending on the farmer‟s position in the life cycle. Both age and age^2 are included in the regression model because it allows for diminishing or increasing effects of an additional year of age. By including age^2, the effect of age is allowed to vary across different age brackets (Long and Freese, 2001). Farmer‟s age may influence adoption in one of several ways. Older farmers may have more experience, resources, or authority that would allow them more possibilities for trying a new technology (CIMMYT, 1993). They may have more experience in farming, more stock of indigenous knowledge and are better able to assess the characteristics of modern technology. It could also be that older farmers are more conservative (risk averse) than younger farmers and therefore have a lesser likelihood of adopting new technologies. They might want to continue with old and proven inputs and practices. That is why the expected sign remains an empirical question (Adesina and Baidu-Forson, 1995; Zavale et al., 2005).

Family size was another variable considered. There is no agreement in the adoption literature regarding the direction of influence of this variable (Ajewole, 2010). A larger family size could be an indicator of food consumption requirement. Also, many members in a household imply labour availability that is frequently associated with the adoption of a new technology (Feder et al., 1985). In this case, the variable was predicted to be positively related to the demand for hybrid banana varieties as banana production is labour-intensive and is a dominant food crop in Uganda.

Labour endowment was also included to test whether this factor had any measurable effects on the level of adoption of improved varieties. This considered the active household members between the ages of 15 and 64 years in the household. This is the age group that provides most of the on-farm labour force in Uganda. According to Doss (2003), where labour markets do not function effectively, households must supply their own labour for farm activities and therefore may choose not to adopt technologies that would require more labour the household can provide. Therefore, households with a relatively larger number of household members are expected to have a positive relationship with the use of hybrid banana varieties.

Farm size was also considered in this study. Farm size was measured as the total acres available to the farmer. It has been found to be positively related to technology adoption as those operating larger farms have more land to allocate to the improved technologies (Feder and Slade, 1984; Nkonya et al., 1997; Wubeneh and Sanders, 2006; García, 2007). Farmers with a larger land size may be more willing to devote portions of the land to an untested and new variety compared to those with smaller areas. In Uganda, it takes time for farmers to gain confidence in the performance of new technologies and hybrid bananas, especially in terms of food palatability and market availability.

Ability to access new varieties may be influenced by endowment of some key household wealth assets. The wealth effects were captured through a household asset ownership (values of radio sets, bicycle, chairs, tables, car, mobile phones, television sets, and sofa sets) and livestock ownership. The values of all these assets were estimated in current Ugandan Shillings. A household wealth index is included and is expected to be positively associated with the early stage adoption of hybrid banana varieties.

Agricultural extension is regarded as one of the most important sources of information dissemination for agricultural production (Sall et al., 2000), particularly in Uganda where farmers have very limited access to information. The number of extension visits received by a farmer is expected to be positively related with the response variable. This is because the stock of information available to farmers increases with extension efforts (Feleke and Zegeye, 2006; Wubeneh and Sanders, 2006) .

Regarding gender, it is hypothesized that male farmers are better able to adopt hybrid bananas. Based on previous empirical adoption studies (Adesina et al., 2000; Doss and Morris, 2001; Ajewole, 2010), women are more constrained to accumulate assets, and have limited access to productive resources such as credit and land. Consequently, their access to improved technologies is negatively affected.

Hybrid banana variety attributes included in the model (such as sensory, agronomic qualities and biotic constraints) are expected to be positively associated with the likely adoption of the new banana hybrids. A positive relationship is expected for a hybrid banana variety with attributes farmers perceives to be better relative to their traditional varieties. If a variety is perceived to better meet desirable consumption and production attributes relative to traditional varieties, then it will be highly demanded by farmers. On the other hand, when the undesirable varieties of a new variety are perceived to outweigh its attractive features, in comparison to the existing traditional varieties, then the demand for that variety is expected to be low.

Average walking time from home to the nearest market by the respondent was included as the transaction cost of market participation (Edmeades et al., 2008). It is hypothesized that these factors are positively related to variety demand decision. The demand-driven agricultural technologies are usually enhanced by improved access to markets for the farmers. Farmers far away from market centres tend to be less market-oriented. The technology use decisions of these farmers rely more on subsistence production than profitability considerations. These farmers may not be interested in investing their limited resources on improved varieties as long as the traditional varieties provide a subsistence level of output for their families. The variables considered to explain the determinants of early adoption of hybrid banana varieties in terms of the number of plant mats found at the time of interview for each variety are summarised in Table 3.1.

3.2.3 The empirical model

Using the ratings given by farmers, a paired sample t-test was used to compare the attribute score of each hybrid variety with Mbwazirume. In order to identify the underlying dimensions among the variety attributes and to determine whether they could be represented by a smaller number of factors, principal components analysis was performed based on the important attribute scores rated by farmers (Birol et al., 2008; Katungi et al., 2011). Variety attributes were then grouped into independent attributes for each variety based on the criterion of an Eigen value greater than unity (Kaiser, 1961). The effect of farmers‟ perception of banana attributes and other factors on the adoption of hybrid banana varieties was estimated using the number of banana plant mats grown by the household, since the inception of the project from 2008 to 2010, as the dependent variable. This variable was chosen considering the short period of farmer assessment of hybrid varieties from the time they were recruited into a trial programme (year 2008), the subsequent establishment of hybrid trials and also considering the nature of the banana crop which takes a period of one year after planting to begin fruiting. Thus, the demand for a variety is expressed as a count of plant mats (Edmeades and Smale, 2006). The number of plant mats can be easily counted in a given plot by the farmers who are aware of the number of plant mats for each of the varieties they currently grow. Moreover, some farmers may choose to plant many or few plant mats of a given variety based on its desirable and undesirable attributes, and farmer needs and preferences.

The count approach used in this chapter has advantages for understanding the likely demand for the hybrid banana varieties. Instead of depicting an "adoption" decision, with associated problems of choosing whether to use a zero-one dependent variable (Logit or Probit) or a censored variable that represents the extent of adoption (Tobit), the count approach is more general and allows to combine the categorical data (adoption or not) with the count data (number of plant mats). When the adoption (dependent variable) is measured as the number of plant mats planted by farmers, observations on the dependent variable are represented by non-negative integer counts, and failure to account for the integer nature of the data can bias the results (Haab and McConnell, 1996; Isgin et al., 2008). Furthermore, any resulting policy measure based on continuous demand models (e.g., OLS or Tobit), when the variable is a non-negative integer, is inaccurate and misleading (Ganguly et al., 2010). However, the presence of many zeroes in the dependent variable could not allow application of the ordinary Count Models like Poisson. Zero-Inflated Negative Binomial (ZINB) Regression models do better with over-dispersed data (variance much larger than the mean) (Cameron and Trivendi, 1998).

In the presence of many zero values in the discrete count variable, Lambert (1992) and Greene (2003) suggest the application of Zero-Inflated Poisson (ZIP) regression. There were many zeroes in the outcome variables (64.9% for M2, 71.9% for M9, 85.75% for M14, 85.75% for M17, and 73.25% for Mbwazirume) of the current data set. The inability to account for the extra "pull" exerted by the disproportionately high response of zeroes may result in biased parameter estimates and misleading inferences (Ganguly et al., 2010). For this reason, the ZIP regression model (Vuong, 1989) was applied in this study. The existence of many zeroes in the response variable could have been due to the fact that some non-participating farmers may not have had an opportunity to access the planting materials because hybrid bananas have recently been introduced among the farming communities in Uganda.

Following Mullahy (1986) and Lambert (1992), the model takes the following form:

$$Pr[y = 0] = f_1(0)$$
$$\Pr[y = j] = \frac{1 - f_1(0)}{1 - f_2(0)} f_2(y), j > 0 \qquad (1)$$

This collapses to the standard normal model only if $f_1(.) = f_2 = (.)$ (Cameron and Trivendi, 1998). In the ZIP model, a proportion of zeroes (φ_i) is added to the $\Pr\ [\mu_i]$ distribution, and other frequencies are reduced by a corresponding amount:

$$\Pr[y_i = 0] = \varphi_1 + (1 - \varphi_i)e^{-\mu_i}$$
$$\Pr[y_i = \mathrm{r}] = (1 - \varphi_1)\frac{e^{-\mu_i}\mu_i^{\mathrm{r}}}{\mathrm{r}!}$$
$$\mathrm{r} = 1,2, \ldots \qquad (2)$$

For the hybrid banana varieties adoption the model is:

$$Y[HBAN] = Exp\left(\beta_0 + \sum_{k=1}^{13} \beta_k \mathrm{X}_i\right) \qquad (3)$$

Where $HBAN$ refers to the number of plant mats planted by i, and X_i is a vector of covariates that are expected to determine early adoption (probability of adoption of hybrid banana varieties). R, where r = 0 indicates non-participants in the adoption process, j = 1 indicates participants in the adoption process. Five equations were estimated: one for each variety because each variety has different production and consumption attributes and farmers respond differently to each one. The model for each of the five varieties was preferred because it has not been commonly applied. To test for the zero-inflated models against their non-zero-inflated counterparts, Vuong's test-statistic was performed and the results support the ZIP model. Where Vuong's test-statistic is greater than 1.96, the ZIP is considered a better model than the ordinal probit. If Vuong's test-statistic is less than −1.96, the ordinal probit is preferred, at the 95% confidence level.

3.3 The results and discussion

Table 3.1 defines the variables considered to explain the determinants of the early adoption of hybrid banana varieties in terms of the number of plant mats planted for each variety from 2008 to 2010. With respect to education, on average, the respondents reported to have spent eight years of schooling, while participating farmers had more years (9.4). Eight years of schooling is slightly higher than the last level of mandatory formal education in Uganda that is equivalent to primary seven. The household head"s average age was 46 years with the participating farmers having a higher age on average than non-participating farmers (48.4 vs. 45). The average family size of the participating farmers was almost the same (6.54) as for the non-participating (6.10) ones. The majority of respondents (55%) reported to have been visited by extension agents, the percentage being much higher for participating farmers (80.5%). The survey results also show that 50.7% of respondents were male. In terms of market accessibility, the average walking time to the nearest market was 43 minutes, with slightly better market access for participating farmers. Information on the total land owned (in acres) showed that participating farmers owned, on average, about one acre more than their non-participating counterparts (Table 3.1).

Table 3.1 Variables included in the analysis and summary of descriptive statistics, adoption of hybrid banana varieties, Uganda

Variable	Variable description	Total farmers (N = 454)	Participating farmers (N = 149)	Non-participating farmers (N = 305)
		Mean (standard deviation)		
Educ	Years of schooling of the household head	7.91 (4.67)	9.40 (4.66)	7.19 (4.51)
H size	Total number of household members	6.24 (3.54)	6.54 (3.36)	6.10 (3.62)
Labor endowment	Active household members between the ages 15 and 64 years in the household	3.04 (1.73)	3.61 (1.97)	2.79 (1.55)
Age	Age of the household head (Years)	46.11 (15.96)	48.37 (15.76)	45.01 (15.97)
Age^2	Age squared	2380.37 (1483.43)	2586.13 (1492.08)	2280.51 (1471.29)
Farm size	Total land owned (in acres)	9.24 (9.98)	9.88 (10.48)	8.92 (9.73)
Market access	Time of walking to the nearest market (in minutes)	43.08 (56.55)	42.42 (54.71)	43.41 (57.51)
		%		
Gender	Dummy (1: if household head is male; 0 if female)	50.66	57.05	47.56
Extension	Dummy (1: if a farmer was visited by extension agents in two years; 0 otherwise)	54.61	80.54	42.02

Source: Survey data (May 2010 - April 2011).
Note: Figures in parentheses show the standard deviations.

3.3.1 Analysis of farmers' preferences for hybrid banana variety attributes

The new hybrid banana varieties were evaluated with a local variety Mbwazirume for agronomic characteristics and quality traits, mostly by the participating farmers. Farmers in essence compared each hybrid variety with a local variety with respect to these attributes. A paired sample t-test was performed to compare farmer assessments of individual varieties compared to Mbwazirume (Tables 3.2 and 3.3).

Table 3.2 Average score rating of respondents' preferences for the attributes of hybrid bananas M2 and M9 in relation to Mbwazirume, Uganda (paired t-test), 2010/11 (n=149)

Variables	M2	Mbwz	Mean Difference	P-Value	M9	Mbwz	Mean Difference	P-Value
Yield	3.76	3.77	-0.01	0.94	4.28	3.74	0.54	0.00
Tolerance to drought	3.99	3.69	0.30	0.04	3.99	3.69	0.30	0.04
Early Maturity	3.74	4.17	-0.43	0.02	3.98	4.12	1.31	0.30
Bunch size	3.73	3.62	0.12	0.48	4.44	3.61	0.83	0.00
Sucker production	3.82	3.80	0.03	0.88	4.17	3.78	0.39	0.00
Plant height	3.68	3.78	-0.09	0.53	4.16	3.78	0.38	0.01
Resistance to wind	3.59	3.80	-0.21	0.18	4.00	3.79	0.21	0.07
Performance in good season	4.00	4.03	-0.03	0.85	4.41	3.99	0.42	0.00
Resistance to black Sigatoka	3.99	3.12	0.87	0.00	4.09	3.13	0.97	0.00
Resistance to weevils	4.10	3.23	0.86	0.00	4.23	3.25	0.98	0.00
Resistance to nematodes	4.01	3.33	0.87	0.00	4.12	3.33	0.79	0.00
Tolerance to poor soils	3.68	3.44	0.24	0.10	3.92	3.37	0.55	0.00
Taste	3.69	4.69	1.12	0.00	4.04	4.60	-0.56	0.00
Texture (softness) when cooked	3.61	4.56	-0.96	0.00	3.99	4.49	-0.50	0.00
Colour when cooked	3.58	4.64	1.06	0.00	3.80	4.58	-0.78	0.00
Flavour	3.70	4.51	-0.81	0.00	3.80	4.49	-0.69	0.00
Longer storage after harvest	3.82	3.82	0.00	1.00	3.98	3.81	0.17	0.26
Skin colour	3.53	4.45	-0.92	0.00	3.84	4.45	-0.61	0.00
Easiness to peel	3.81	4.58	-0.78	0.00	3.95	4.59	-0.64	0.00
Suitability for Matooke	4.28	4.32	-0.04	0.77	3.95	4.35	-0.40	0.00

Source: See Table 3.1
Notes: Mbwz denotes Mbwazirume. Farmers" perceptions of variety attributes are coded using a 5-point Likert scale, where 1= Very Poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very Good.

The results indicate that farmers in general perceived significant differences among the hybrid banana varieties compared to the local variety. Farmers preferred the hybrid varieties in terms of production characteristics and disease resistance but they are regarded as inferior in terms of consumption characteristics. Farmers indicated a clear preference for the traditional variety with regard to characteristics like flavour, taste, texture (softness) and colour when cooked. The results further reveal that, with the exception of Hybrid M14, all the Matooke hybrid bananas were scored above 3.0 (out of 5.0) in terms of the cooking attributes, implying that they have acceptable cooking qualities. Hybrid M9 was close to the reference variety with regard to all cooking quality traits (Table 3.2). In terms of storability after harvest, variety M9 was perceived to last longer after harvest compared to Mbwazirume. This is typically an important attribute for consumers. In general, hybrid M9 is regarded as having a relatively good performance with respect to most of the characteristics in relation to Mbwazirume (Table 3.2).

Table 3.3 Average score rating of farmer preferences for the attributes of hybrid bananas M14 and M17 in relation to Mbwazirume, Uganda (paired t-test), 2010/11 (n=149)

Variables	M14	Mbwz	Mean difference	P -Value	M17	Mbwaz	Mean difference	P-Value
Yield	3.67	3.73	-0.06	0.67	4.00	3.67	0.33	0.03
Tolerance to drought	3.67	3.73	0.29	0.14	3.80	3.46	0.34	0.08
Early Maturity	3.51	4.20	-0.69	0.00	3.56	4.04	-0.48	0.02
Bunch size	3.65	3.59	0.06	0.76	3.79	3.71	0.08	0.67
Sucker production	3.00	3.86	-0.86	0.00	3.73	3.73	0.00	1.00
Plant height	3.76	3.82	-0.06	0.78	3.52	3.80	-0.28	0.16
Resistance to wind	3.50	4.02	-0.52	0.00	3.66	3.84	-0.18	0.31
Performance in good season	3.82	3.98	-0.16	0.25	4.04	3.98	0.07	0.66
Resistance to black Sigatoka	3.90	3.14	0.76	0.00	3.92	3.16	0.76	0.00
Resistance to weevils	4.17	3.19	0.98	0.00	3.98	3.13	0.85	0.00
Resistance to nematodes	4.00	3.19	0.81	0.00	3.94	3.17	0.76	0.00
Tolerance to poor soils	3.67	3.49	0.18	0.35	3.85	3.35	0.50	0.01
Taste	3.86	4.64	-0.78	0.00	3.28	4.60	-1.32	0.00
Texture (softness) when cooked	2.94	4.56	-1.63	0.00	3.00	4.56	1.39	0.00
Colour when cooked	3.22	4.59	-1.37	0.00	3.12	4.56	1.24	0.00
Flavour	3.28	4.66	-1.38	0.00	3.47	4.53	1.18	0.00
Longer storage after harvest	3.29	3.71	-0.42	0.02	3.42	3.76	-0.33	0.15
Skin colour	3.35	4.54	-1.19	0.00	3.45	4.49	-1.04	0.00
Easy to peel	3.63	4.69	-1.06	0.00	3.62	4.69	-1.07	0.00
Suitability to Matooke	3.49	4.35	-0.86	0.00	3.27	4.37	1.30	0.00

Source: See Table 3.1

Among the new varieties, respondents reported that M9 was the most preferred variety for nearly all the attributes except taste, texture, colour when cooked, flavour, skin colour, easiness to peel and suitability for Matooke and most of the differences were statistically significant at the 5% and 10% levels of probability compared to the local variety (Table 3.3). Results also suggest that Hybrid M2 was significantly better than a local variety in terms of attributes like tolerance to drought, resistance to black Sigatoka, weevils and nematodes.

Notable for the hybrid banana varieties is that all of them have been evaluated to significantly outperform Mbwazirume with respect to resistance to pests (banana weevils and nematodes) and diseases (black Sigatoka). Among all the hybrid banana varieties, hybrids M9 and M17 are perceived to significantly outperform Mbwazirume in terms of good performance in poor soils (Tables 3.2 and 3.3). This could have been due to tolerance to diseases like Sigatoka, an attribute farmers are associating with tolerance to poor soils. Among the diverse factors responsible for declining banana production in Uganda, farmers have reported poor soils as a major factor affecting yield (Bagamba et al., 1998).

3.3.2 Farmers' intentions to expand hybrid banana cultivation in the future

The farmers" future expansion plans for growing hybrid bananas are presented in Table 3.4. The results show that both participating and non-participating farmers were willing to expand on the production of the hybrid varieties based on the current experiences, if there was access to planting materials for the non-participating farmers. The majority of the participating farmers planned to increase production from the current number of mats planted at the time of the survey. The majority of farmers grew a few hybrid bananas for the first time during the survey period, to first test them and were planning to grow more of the most preferred variety. The results show that the majority of the respondents were planning to expand with hybrids M9, M2, M14 and M17 (Table 3.4). For non-participating farmers, the majority would increase production of hybrid M9 and a local variety when planting materials were made available to them.[3]

[3] A plant mat is the whole set of bananas emerging from the initial plant of a banana planted.

Table 3.4 A comparison of the future expansion plans for hybrid banana growing in Uganda, 2010/11

Expansion plan	Participating farmers % (n= 128)		Non-participating farmers % (n= 273)	
Expected to expand production of M9 in the next 3 years				
Expected to expand production of M2 in the next 3 years	Freq	%	Freq	%
Increase production	60	83.33	69	76.67
Decrease production	5	6.94	4	4.44
No intention to change	7	9.72	17	18.89
Increase production	94	93.07	116	92.06
Decrease production	1	0.99	7	5.56
No intention to change	6	5.94	3	2.38
Expected to expand production of M14 in the next 3 years				
Increase production	32	72.73	44	81.48
Decrease production	4	9.09	6	11.11
No intention to change	8	18.18	4	7.41
Expected to expand production of M17 in the next 3 years				
Increase production	27	72.97	47	92.16
Decrease production	7	18.92	2	3.92
No intension to change	3	8.11	2	3.92
Expected to expand production of Mbwazirume in the next 3 years				
Increase production	92	94.85	120	98.36
Decrease production	4	4.12	1	0.82
No intention to change	1	1.03	1	0.82

Source: See Table 3.1

Regarding the number of plant mats farmers would grow in addition to what they had planted, statistically there was no significant difference between hybrid M9 and Mbwazirume, a local variety (Table 3.5). However, farmers would plant less number of plant mats of the rest of the hybrids compared with a local variety with significantly less number of M2 plants. This suggests that, among the hybrids, M9 could be close to Mbwazirume when farmers are prioritising the growing of these new varieties.

Table 3.5 Average number of plant mats farmers would plant in the next three years for hybrid bananas M2, M9, M14, and M17 in relation to Mbwazirume, Uganda (paired t-test), 2010/11

A comparative number of plant mats of hybrids and a local variety	Mean number of mats	Mean Difference	Std. Error Mean	t-value	df
Hybrid M2	39.57	-23.37	10.67	-2.190**	119
Mbwazirume	62.94				
Hybrid M9	61.29	-0.64	9.24	-0.069	163
Mbwazirume	61.93				
Hybrid M14	33.74	-10.88	5.57	-1.955	67
Mbwazirume	44.62				
Hybrid M17	37.33	-16.59	8.7	-1.908	63
Mbwazirume	53.92				

Source: See Table 3.1
Notes: ** Mean differences are significantly different from zero at the 5% level.

3.3.3 Farmers' reasons for continuing to expand hybrid banana cultivation

During the survey, farmers mentioned a number of reasons for continuing to expand growing the hybrid varieties. High yield, food security and income generation were the most frequently mentioned reasons by both participating and non-participating farmers (Table 3.6). Declining yields due to pests, diseases and decreasing soil fertility have always compromised food and income security. Most farmers would consider expanding growing of the hybrid varieties particularly M9 and M2 because these varieties were perceived to be tolerant to poor soils (Table 3.6). Poor soils have been one of the main reasons identified by farmers to be responsible for shortening the longevity of banana plantations, particularly in the central region of Uganda. Additionally, the study suggests that farmers would consider expanding the hybrid banana varieties because they relate these varieties to being high yielding especially M9. During field visits, farmers growing these hybrid bananas indicated that the yields of the hybrid banana varieties have been relatively stable compared to the plantations with the landraces that were established at the same time. It can therefore be argued that larger size households might view these varieties as a better option for household food security.

Table 3.6 Reasons for expansion of hybrid banana varieties (percent of respondents), Uganda, 2010/11 (n =454)

Attributes	M2		M9		M14		M17		Mbwazirume	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Tolerant to poor soils	20	16.14	22	12.43	10	14.28	6	8.69	17	10.3
High yielding	28	22.95	47	26.55	14	20.00	12	17.39	35	21.21
Good taste and flavour	9	7.38	8	4.52	16	22.86	14	20.90	44	26.67
Can be for commercial and food security	15	2.30	21	11.86	13	18.57	10	14.49	23	13.94
Availability of market	4	3.28	4	2.26	3	4.29	2	2.90	2	1.21
Better than any other varieties	1	0.82	1	0.56	-	-	-	-	2	1.21
Food security	15	12.30	19	10.73	-	-	15	21.74	-	-
Income generation	13	10.65	28	15.82	3	4.29	-	-	23	13.94
Big bunch size	5	4.10	8	4.52	5	7.14	3	4.35	5	3.03
Tolerant to drought	7	5.74	4	2.26	-	-	1	1.45	1	0.61
It"s the variety liked by many farmers	2	1.64	2	1.13	-	-	-	-	1	0.61
Matures quickly	2	1.64	5	2.82	1	1.43	5	7.25	-	-
Soft food	-	-	1	0.56	-	-	-	-	6	3.64
Good colour	1	0.82	1	0.56	1	1.43	-	-	-	-
Availability of land	-	-	5	2.82	2	2.86	1	1.45	2	1.21
Tolerant to diseases	-	-	1	0.56	1	1.43	-	-	2	1.21
Easy to peel			-	-	1	1.43	-	-	2	1.21
Total	122	-	177	-	70		69		165	-

Source: See Table 3.1

3.3.4 Farmers' willingness to pay for hybrid banana planting materials

With regard to farmers" willingness to pay for the planting materials if made available, more than 90% of the respondents suggested that they would pay. Comparing with the local variety, the majority of respondents reported that they were willing to pay for the planting materials with no significant difference in prices across varieties (Table 3.7). The results show that farmers were willing to pay, on average, low prices for plantlets compared to the current market price of UGX Sh 2000-2500 per plantlet (the exchange rate between February to August was US$ =UGX 2192). Farmers would be willing to pay up to UGX Sh 700 for a plantlet, yet the actual cost of a plantlet is up to Sh 2000-2500. The lack of clean planting materials has been identified as one of the major causes in spreading pests and diseases in banana growing because farmers do not recognize infested or diseased planting material or fully understand the life-cycles and transfer mechanisms of pests and diseases (Smale et al., 2006). Use of clean tissue culture plantlets would be the most appropriate solution to this challenge. However, improving access and affordability to the clean planting materials could increase adoption of the hybrid banana varieties in the country.

Table 3.7 Average price per plant farmers were willing to pay for hybrid bananas M2, M9, M14, and M17 in relation to Mbwazirume, Uganda (paired t-test), 2010/11

Comparative price of hybrids and Mbwazirume	Mean price (UGX)	Mean Difference	Std. Error Mean	t-value	df
Hybrid M2	687.69	16.3	18.91	0.862	157
Mbwazirume	671.39				
Hybrid M9	708.32	18.7	20.8	0.899	206
Mbwazirume	689.62				
Hybrid M14	741.92	24.24	37.28	0.65	98
Mbwazirume	717.68				
Hybrid M17	678	-25.5	24.18	-1.055	99
Mbwazirume	703.5				

Source: See Table 3.1

3.3.5 Farmers' perceptions of hybrid banana varieties

To get a detailed picture about the likely influence of farmers‟ perceptions of the variety attributes on the demand for a hybrid banana variety, farmers were asked about their perceptions towards each of the variety attributes. To identify the underlying dimensions among the farmers‟ perceptions of the hybrid banana variety attributes, principal component analysis was performed and, based on the criterion of Eigen values being greater than 1 (Kaiser, 1961), some principal components were retained (Tables 3.8 and 3.9). Factor naming was based on variables that factored together and the relative magnitude of the factor loadings in absolute terms (Birol et al., 2008). Principal components for M17 are given in Appendix 3.1.

Table 3.8 Factor analysis of farmer perceptions of variety attributes on demand for M2 and M9, Uganda (n=149)

Variety attribute	Factor loadings for variety (M2)				Factor loadings for variety (M9)			
	Factor 1 Sensory	Factor 2 Biotic	Factor 3 Abiotic	Factor 4 Agronomic	Factor 1 Agronomic	Factor 2 Sensory	Factor 3 Biotic	Factor 4 Abiotic
Tolerance to drought	-	-	0.51	-	-	-	-	-
Yield	-	-	-	0.58	0.69	-	-	-
Performance in good season	-	-	-	0.62	0.74	-	-	-
Early Maturity	-	-	-	0.79		-	0.42	-
Bunch size	-	-	0.77	-	0.67	-	-	-
Sucker production	-	-	-	0.43	0.71	-	-	-
Plant height	-	-	0.42	0.58	-	-	-	0.46
Resistance to wind	-	-	0.44	-	-	-	-	0.71
Tolerance to poor soils	-	-	0.64	-	-	-	-	0.76
Resistance to black Sigatoka	-	-	0.54	-	-	-	0.53	0.50
Resistance to weevils	-	0.67	-	-	-	-	0.63	-
Resistance to nematodes	-	0.84	-	-	-	-	0.75	-
Taste	-	0.82	-	-	-	-	0.71	
Texture(softness) when cooked	0.74	-	-	-	-	0.63	-	-
Colour when cooked	0.76	-	-	-	-	0.63	-	-
Flavour	0.79	-	-	-	-	0.69	-	-
Longer storage capability after harvest	0.67	-	-	-	-	0.68	-	-
Skin colour	-	0.65	-	-	-	0.78	-	-
Easiness to peel	-	-	-	-	-	-	-	-
Exp. Var. (%)	0.17	0.16	0.16	0.12	0.15	0.14	0.13	0.10
Eigen values	7.73	1.78	1.50	1.13	7.02	1.50	1.34	1.19

Source: See Table 3.1
Notes: Farmers" perceptions on variety attributes are coded using a 5-point Likert scale, where 1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very Good. Only attributes with absolute factor loadings >0.4 are included.

Table 3.9 Factor analysis of farmer perceptions of variety attributes on demand for M14, Uganda (n=149)

Variety attribute	Factor Loadings for variety (M14)				Factor Loadings for variety (Mbwazirume)			
	Factor 1 Agronomic	Factor 1 Biotic	Factor 3 Sensory	Factor 4 Abiotic	Factor 1 Sensory	Factor 2 Biotic	Factor 3 Agronomic	Factor 4 Plant attributes
Tolerance to drought	0.42	0.58	-	-	-	0.63	-	-
Yield	0.78	-	-	-	-	-	0.76	-
Performance in good season	0.81	-	-	-	-	-	0.73	-
Early Maturity	0.67	-	-	-	-	-	0.43	0.43
Bunch size	0.76	-	-	-	-	-	0.81	
Sucker production	0.54	-	-	-	-	-	-	0.75
Plant height	0.67	-	-	0.60	-	-		0.65
Resistance to wind	-	-	-	0.77	-	0.51	-	0.43
Tolerance to poor soils	-	0.70	-	-	-	0.72	-	-
Resistance to black Sigatoka	-	0.74	-	-	-	0.82	-	-
Resistance to weevils	-	0.77	-	-	-	0.88	-	-
Resistance to nematodes	-	0.68	-	-	-	0.86	-	-
Taste	-	0.68	-	-	0.75	-	-	-
Texture(softness) when cooked	-	-	0.57	-	0.74	-	-	-
Colour when cooked	-	-	0.82	-	0.80	-	-	-
Flavour	-	-	0.63	-	0.76	-	-	-
Longer storage capability after harvest	-	-	0.85	-	-	0.49	0.42	
suitability to Matooke local food	-	-	0.51	-	0.77	-	-	-
Skin colour	0.44	-	0.55	-	0.60	-	-	-
Easiness to peel	-	-		0.48	0.53	-	-	-
Exp. Var. (%)	0.18	0.17	0.16	0.10	0.19	0.19	0.15	0.09
Eigen values	7.08	2.30	1.83	1.12	6.54	3.35	1.72	1.13

Source: See Table 3.1

Notes: Farmers‟ perceptions on variety attributes are coded using a 5-point Likert scale, where 1= Very Poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very Good. Only attributes with absolute factor loadings >0.4 are included.

Generally, for each variety (M2, M9, M14 and Mbwazirume) four principal components were identified through varimax rotation and explained 60.63%, 60.55%, 61.65% and 64.95%, respectively, of the total variation in the data (Tables 3.8 and 3.9). The components were accordingly named as “Sensory qualities”, “Biotic constraints”, “Abiotic constraints” and “Agronomic qualities”. The grouping “Sensory qualities” consists of attributes like texture, colour when cooked, flavour, and storage duration after harvest, easiness to peel skin, and suitability for Matooke (Tables 3.8, 3.9 and Appendix 3.1). For hybrids M2 and M17, flavour had the highest loading while the skin colour of the fruit had the highest loading for hybrid M9. This implies that farmers attached priority importance to these hybrid attributes. The attribute storage duration after harvest was the highest loading in variety M14 while colour of the food when cooked was highest for Mbwazirume. These are the banana consumption qualities farmers consider when evaluating a good cooking banana variety (Dadzie and Orchard, 1997).

Another grouping that appeared across all the hybrids was “biotic constraints”. This consisted of attributes like resistance to black Sigatoka, weevils and nematodes, tolerance to poor soils, and tolerance to drought (Tables 3.8 and 3.9 and Appendix 3.1). Resistance to nematodes had the highest loadings for varieties M2 and M9 (Table 3.8), while tolerance to weevils was highest for M14, M17 and Mbwazirume (Table 3.9 above and Appendix 3.1). This indicates that farmers are considering these varieties as tolerant to nematodes. Speijer and Kajumba (1996) reported a yield reduction of up to 50% in banana production in Uganda due to nematodes.

The third grouping was named as “abiotic constraints”. This factored together across all variety attributes like bunch size, tolerance to poor soils, tolerance to drought, resistance to wind and sucker production (Tables 3.8 & 3.9). Tolerance to poor soils had the highest loading for M9 while resistance to wind registered the highest loadings in hybrid M14.

The fourth grouping common across all the varieties was named as “agronomic qualities”. Attributes that featured in all varieties include early maturity, performance in a good season, high yielding, plant height, sucker production, bunch size and finger size (Tables 3.8 and 3.9). Attribute performance in a good season had the highest loadings for varieties M9 and M14 while early maturity had the highest loading for hybrid M2.

3.3.6 Determinants of farmers'early adoption of hybrid banana varieties

The banana hybrid varieties are still new among the Ugandan farming communities and the present study was undertaken during the second and third years of their on-farm evaluation. The results of the ZIP regression to explain early adoption are presented in Table 3.10. Marginal effects are summarised in Appendix 3.2. A validity test for the ZIP model was undertaken for each variety, by using Vuong"s statistic (Vuong, 1989). The test supported the ZIP model over the Poisson model having values greater than 1.96 (Table 3.10). A regression with principal components was chosen above a principal components regression (PCR) in this study because, given that all the hybrid banana variety attributes were potential explanatory variables within the regression, it was found appropriate to simplify the sample space by a transformation to principal components. The identified groupings through PCR allow selecting one variable (overall standardized composite index) that has uncorrelated elements with each other.

Table 3.10 ZIP regression results for early stage adoption of hybrid banana varieties in Uganda, 2010/11 (N= 454) (figures in parenthesis are Z values)

Variable	M2 coefficient estimate (Z)	M9 coefficient estimate (Z)	M14 coefficient estimate (Z)	M17 coefficient estimate (Z)	Mbwazirume coefficient estimate (Z)
Educ	0.025*** (5.67)	-0.035*** (-7.56)	0.004 (0.41)	-0.003 (-0.31)	0.016*** (3.10)
HH size	0.000 (-0.07)	0.090*** (18.24)	0.033*** (3.55)	-0.010 (-0.85)	0.006 (1.00)
Working	-0.110*** (-9.94)	-0.047*** (-4.05)	-0.043** (-2.05)	-0.100*** (-4.48)	-0.006 (-0.46)
Gender	0.106*** (2.73)	0.355*** (9.39)	0.162*** (2.21)	-0.149** (-1.85)	0.047 (1.11)
Age	0.012** (2.46)	-0.014** (-2.76)	-0.004 (-0.50)	-0.003 (-0.36)	0.025*** (3.60)
Age^2	0.000*** (-3.66)	-2.950E-05 (-0.51)	-2.120E-05 (-0.25)	-3.760E-05 (-0.33)	-3.061*** (-4.16)
Farm size	0.000 (-0.15)	0.009*** (4.91)	0.005 (1.13)	0.018*** (4.30)	-0.004*** (-2.13)
Mkt access	-0.002*** (-4.44)	0.001*** (4.38)	-0.001 (-1.02)	-0.002** (-2.55)	-0.001 (-2.69)
Extension	-0.355*** (-8.97)	0.142*** (3.44)	-0.129 (-1.53)	-0.045 (-0.51)	9.630*** (2.18)
Sensory	-0.100** (-2.85)	0.087** (2.89)	0.077 (0.73)	0.078 (0.82)	0.253*** (6.56)
Biotic	0.073*** (2.71)	0.273*** (10.24)	3.221*** (2.79)	0.233** (1.69)	-0.014 (-0.45)
Abiotic	0.084*** (2.37)	0.228*** (10.27)	-0.213 (-1.60)	-0.164** (-1.68)	-
Agronomic	0.056** (1.99)	0.101*** (3.83)	0.020 (0.22)	-3.905 (-0.31)	0.105*** 3.06
Constant	3.195*** (24.48)	3.271*** (26.55)	2.883*** (15.99)	3.327*** (14.34)	2.441*** (14.27)
Number of observations	425	425	431	431	431
Log likelihood	-1776.317	-1551.268	-547.8183	-496.7308	-1248.291
Non-zero observations	154	127	63	64	121
Zero observations	271	298	368	367	310
LR chi^2	294.33	1013.04	55.50	65.61	90.22
Prob > chi^2	0.0000	0.0000	0.0000	0.0000	0.0000
Vuong test of ZIP vs. z = Pr>z =	0.0000 8.56	0.0000 10.93	0.0000 6.66	0.0000 6.25	0.0000 11.15

Source: See Table 3.1

Notes: ***, ** and * denote significance at the 1%, 5% and 10% levels of probability, respectively.

The model estimates show that the effect of education level of the household head was positive and significant for variety M2 and Mbwazirume while negative and significant for

M9. This implies that educated farmers are more likely to plant more banana mats of M2 and Mbwazirume, and plant less mats of M9. This may be due to the fact that hybrid M2 and Mbwazirume look alike in terms of external bunch appearance. Another possible explanation could be the importance of production attributes like bunch size, resistance to black Sigatoka and tolerance to poor soils associated with hybrid M9 that the less educated farmers currently planting hybrid M9 consider important compared with the educated farmers. The marginal effects (Appendix 3.2) suggest that when education of the farmer increases by a unit, the expected likelihood of farmers planting more plant mats increases by 0.25 and 0.16 for varieties M2 and Mbwazirume, respectively, and decreases by 0.01 for M9, other factors held constant. Related studies, like Hossain and Crouch (1992) on improved farming practices in Bangladesh and Zavale et al. (2005) on improved maize seed in Mozambique, have reported that farmers with higher levels of education have a higher probability of adopting the technology.

Household size, as an indicator of availability of farm labour and food consumption requirement, is significantly and positively associated with the demand for hybrids M9 and M14. A possible explanation could be that these hybrids are perceived to have good production attributes (tolerance to pests, good performance in poor soils and capacity to produce good bunch sizes) (Table 3.10). These attributes are perhaps likely to attract households with larger families to harvest more and achieve household food security. Considering the active household members between the ages of 15 and 64 years as an indicator of availability of farm labour, the results show that there is a significant and negative association with the demand for all the hybrid banana varieties. This confirms that consumption preferences will determine production decisions for the hybrid banana varieties in a household. This is mainly because most rural households in Uganda produce bananas for household consumption and sell whatever is left. For instance, the per capita annual consumption of bananas in Uganda is the highest in the world at approximately 0.70 kg per person per day (Kalyebala et al., 2003). National banana production in 2008-2009 was estimated at 4 Million Tons (UBOS, 2010). The marginal effects (Appendix 3.2) further suggest that if family size increases by one member, the likelihood of farmers increasing the number of plant mats of variety M9 increases by 0.53 and for M14 by 0.18.

Gender of the household head was found to positively and significantly influence the demand for all hybrid banana varieties with the exception of M17, implying that male farmers are likely to plant more mats of most of these hybrids. This could be due to the fact that banana is a perennial crop and requires land to which men have more access and control than women. Farmers suggest that compared to the rest of the hybrids, M17 has a disadvantage of having small fingers, relatively poor cooking qualities, taking longer to mature and producing relatively small bunch sizes. Also, the banana crop in Uganda is regarded as an important source of income for most of the resource poor farmers (Karamura et al., 1998). This attracts men to participate in its production and would particularly plant more of the varieties that are suitable for commercial purposes.

The estimated coefficient of respondent‟s age was statistically significant and negative on the early adoption of hybrid M9 and positive for M2 and Mbwazirume (Table 3.10). The results suggest that older farmers are less likely to plant more mats of variety M9 and are more likely to plant more mats of M2 and Mbwazirume than younger farmers. A possible explanation for this could be that the younger farmers are relatively more adventurous compared to the older ones who have more attachment to heritage and tradition and may want Matooke to look and taste the way it has always been. The food of M2 is relatively yellow in appearance and therefore looks closer to what Matooke has always been. The age-squared variable is positively and negatively related to M2 and Mbwazirume, respectively. This suggests that for older farmers, early adoption increases with age for hybrid M2 and decreases for Mbwazirume. This may be due to the fact that younger farmers tend to favour new innovations and may have a lower risk aversion. The marginal values show that a one unit increase in farmer‟s age will increase the number of plant mats likely to be planted of M2 by 0.16 and Mbwazirume by 2.68 and reduce M9 by 0.17. The marginal effects for the age-squared variable (Appendix 3.2) suggest that a one unit increase in the older age range will increase the number of plant mats likely to be planted of M2 by 0.002 and M9 by 0.002. In the case of Mbwazirume, the results suggest that the number of plant mats increases with age until a certain threshold, but decreases with age afterwards. This suggests that the number of plant mats for Mbwazirume will decrease in age at an increasing rate. This could be associated with the susceptibility of this variety to biotic and abiotic attributes (tolerance to drought, resistance to black Sigatoka, weevils and nematodes) that tend to shorten the longevity of a banana plantation life. This increases the cost of re-establishing the plantation that may not be feasible in the old age.

The results further show that farm size (total land area in acres) has a significant negative association with the probability of demand for Mbwazirume, while it is positively associated with the likely early adoption of hybrids M9 and M17. This implies that farmers with larger land sizes are the potential early adopters of these hybrids compared to farmers with less land. The marginal effects further suggest that if land size increases by one acre, the likelihood of farmers planting variety M9 increases by 0.02 and by 0.004 for M17, while it decreases for Mbwazirume by 0.02. A possible explanation for this could be that producers with larger farms may be more willing to take risks and devote portions of the land to an untried variety compared with those with smaller areas. According to Feder and Slade (1984), households with larger farms have more land to allocate to improved technologies.

The time of walking to the nearest market (market access) appears to affect negatively and significantly the number of M2 and M17 plant mats farmers are likely to plant. The estimated coefficient is positive and significant for M9. This implies that farmers located far away from markets are less likely to plant the new hybrid banana varieties M2 and M17. A possible explanation could be that these two particular hybrids look alike in terms of the external bunch and finger appearance with the local bananas that dominate the market. Hybrid M9 is perceived to produce good bunch sizes that are likely to attract households that strive to meet their subsistent household consumption needs. The marginal values indicate that each unit increase in the distance of travel to the nearest market (in minutes) reduces the likelihood of planting more mats of M2 and M17 by 0.011 and 0.006, respectively, and increases by 0.016 for M9. A possible explanation for this could be that farmers further away from market centres will tend to be less market-oriented (Feleke and Zegeye, 2006) and focus to meet their subsistent household consumption needs.

Keeping other factors constant, extension workers" contact with respondents is positively and significantly related to the number of M9 and Mbwazirume plant mats farmers are likely to cultivate. A negative sign for M2 implies that farmers are less likely to plant this hybrid, given the services of extension agents. Each additional unit increase in extension contacts is estimated to increase the number of plant mats farmers are likely to plant by 4.261 and 3.383 for M9 and Mbwazirume, respectively (Appendix 3.2). This is consistent with Feleke and Zegeye (2006) who found that farmers with more extension contacts are more likely to be adopters of improved maize varieties than those with less extension contacts. The result for M2 is unexpected because the majority of the respondents have not had an opportunity to plant this particular variety in their demonstration plots and, therefore, may not have fully evaluated its characteristics compared to the other varieties.

With reference to the sensory qualities index, the estimated coefficients show that varieties M9 and Mbwazirume had a positive and significant sign. The index for M2 was negative and significant. This implies that respondents seem to prefer M9 and Mbwazirume compared to M2 in terms of sensory qualities and, therefore, are likely to plant more mats of these varieties compared to hybrid M2. Farmers are used to their local varieties and may often consider them better than this new hybrid especially in terms of the desirable attributes such as soft food and colour of the food when cooked. The majority of farmers hosting these hybrids suggest that M9 is close to the local variety with reference to these desirable attributes.

The results also suggest that the biotic constraints index is having a positive and significant effect on the likelihood of farmers" demand for all the hybrids. This implies that with respect to biotic constraints (diseases and pests like black Sigatoka, weevils, and nematodes) there was a general perception that all the hybrids perform better compared to the local variety. This is a favourable perception to the new hybrids as the original purpose of introducing hybrid bananas to the farming communities was to counter mainly black Sigatoka. Diseases and pests have often been cited as important constraints to banana production in several studies (Gold et al., 1999; Tushemereirwe et al., 2006). However, more on-farm evaluation is required to confirm or reject farmers" perceptions as the time is relatively short and the coverage of the tests is not wide enough.

In terms of the hybrids" tolerance to abiotic constraints, the results suggest a positive and significant sign for M2 and M9. The index for M17 was negative and significant implying that the probability of early adoption of these particular hybrids is higher for M2 and M9 with respect to tolerance to abiotic constraints (like poor soils, wind damage and drought). This could be attributed to the strong Pseudo-stem of the hybrids to support the bunch size and limit wind damage. Another explanation could be that these hybrids tolerate poor soils and disease pressure better than the local variety. In the central region of Uganda, variety selection in most cases considers the tolerance to marginal soils and drought prevalent characteristics (Edmeades et al., 2005).

The results further show that the agronomic constraint index has a significant and positive association with the probability of demand for varieties M2, M9 and Mbwazirume. This implies that with respect to agronomic traits (early maturity, performance in good season, high yield and plant height), there was a general perception that M2 and M9 perform better among all the hybrids with no significant difference from a local variety. The majority of the farmers in Uganda consider early maturity as a desirable characteristic because such a variety is considered more likely to be high yielding over time. Varieties that are short in terms of height are also preferred, especially in areas that experience strong winds.

3.4 Summary

Considering the efforts by the Uganda National Banana Research Programme to introduce new banana hybrids, this chapter has analysed the factors that are likely to induce early adoption of these hybrids. Based on the early experiences of farmer preferences for attributes of hybrid banana varieties, it can be concluded that the hybrids are preferred due to better production characteristics (tolerance to Sigatoka, weevils and nematodes, and good agronomic and yield attributes) but are regarded as slightly inferior in terms of consumption characteristics (taste, flavour, skin colour, and suitability as Matooke) compared to Mbwazirume. The loadings for plant height and early maturity were less than 0.4 in the agronomic index for M9. Furthermore, plant height was a complex structure for M2 while complex structure exists for early maturity for Mbwazirume. However, the results suggest that, with the exception of hybrid M14, all the Matooke hybrid bananas considered were scored above 3.0 (out of a maximum of 5.0) regarding their cooking attributes, implying that they have acceptable cooking qualities.

Hybrid M9 was closest to the reference variety with regard to all cooking quality traits. The findings demonstrate that among all the hybrid banana varieties considered, variety M9 is preferred as having a relatively good performance with respect to most production and consumption traits. The study also demonstrated that the hybrid bananas combining the desirable characteristics of pests and disease tolerance and yield and consumption attributes (M2, M9 and M17) can be more successful in terms of adoption by farming communities in Uganda. More details on the conclusions and policy implications of the empirical results of this chapter are contained in Chapter 6. Chapter 4 will dwell on farmers" choice among the recently developed hybrid banana varieties in Uganda.

CHAPTER 4

FARMERS' CHOICE AMONG RECENTLY DEVELOPED HYBRID BANANA VARIETIES IN UGANDA: A MULTI-NOMIAL LOGIT ANALYSIS[4]

4.1 Introduction

Research has demonstrated that farmer involvement in varietal selection promotes varietal development, dissemination and sustainability (Halewood et al., 2007). Professional plant breeders have in most cases experienced considerable difficulty in developing viable modern varieties, partly because of an incomplete understanding of why farmers choose the varieties they grow (Morris and Bellon, 2004; Lacy et al., 2006). As a result, many farmers do not have the real choice of varieties appropriate for their growing environments. According to (Kitch et al., 1998), utilizing local farmer knowledge as an additional screening tool in the selection process is critical for successful participatory breeding. Farmer participation in the breeding of crop varieties is regarded by some as necessary to help ensure acceptance and eventual adoption (Sperling et al., 1993; Franzel et al., 1995). Understanding the production problems and varietal preferences of the local farmers in various agro-ecological and social economic contexts is important to the selection of varieties that will ensure long-term adoption by farmers (Mekbib, 1997). Consideration of farmers‟ variety preferences and choice in variety selection by adjusting the breeders‟ criteria will achieve better adoption rates (Sperling et al., 1993; Misiko et al., 2008). This will contribute greatly to hybrid banana varieties being retained in the cropping system at farm level as farmers will choose and adopt varieties that bear characteristics they prefer. This will also serve as an input to future variety development and diffusion.

Agriculture in Uganda is dominated by smallholder subsistence farmers who occupy the majority of land and meet their consumption requirements largely from own production (Salami et al., 2010). Over 75% of the total agricultural outputs are produced by smallholder farmers with farm sizes of about 2.5ha on average, producing mainly for home-consumption and using traditional technologies. Bananas in Uganda occupy the largest cultivated area among staple food crops with more than 75% of all farmers growing bananas (Zake et al.,

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2000). Bananas are primarily grown as a subsistence food crop, with marketable surplus sold in local markets. Most of the banana production takes place on small subsistence farms of less than 0.5 ha using farming methods with low levels of external inputs (Gold et al.,1998). Banana farmers in Uganda plant different banana varieties, taking into consideration both production and consumption attributes. Each variety contributes a unique composition and level of these attributes (Edmeades et al., 2008). Bananas are grown across diverse agro-ecological environments and socio-economic conditions and they represent an important source of income and food security for resource-poor farmers (Karamura et al., 1998). Banana is consumed as a staple food for more than a half of the Ugandan population (Bagamba et al., 1998).

In spite of banana"s importance, the banana farmer is currently facing major challenges due to soil exhaustion, pests and diseases (such as weevils, nematodes, black Sigatoka) and socio-economic constraints (such as high costs of production and stiff competition for labour with other enterprises) (Bagamba et al., 1998). In response, NBRP in collaboration with the International Institute of Tropical Agriculture (IITA), initiated a banana breeding program in 1994. The program has so far developed new banana hybrids, including M2, M9, M14, and M17. These have been under evaluation since 2008 in different agro-ecological regions of Uganda, with Mbwazirume as a local check (control).

This is the first study focusing on the choice of the hybrids by the farming community. The chapter analyses the effects of farmer characteristics, variety attributes and agro-ecological conditions on banana variety choice in Uganda, with the application of a multinomial logit model. According to Smale et al. (2001), variety choice can be viewed as a process by which a farmer assembles various bundles of traits to satisfy consumption preferences, meet specific production conditions, or fulfil marketing requirements. The choice of a hybrid banana variety may differ depending upon the concerns of the farmers, which are likely to be defined by agro-ecological location, the physical characteristics of the farmers" plots and hybrid banana attributes. In this study, we quantify which hybrid bananas farmers are likely to choose and how dependent this choice is on agro-ecological and farmer characteristics.

The rest of the chapter is organized as follows. The theoretical framework is presented in the next section. Section 4.3 presents the empirical model, the data and variables considered in the empirical analysis. Section 4.4 presents and discusses the empirical results, while section 4.5 provides a summary of the results and policy implications.

4.2 The choice of hybrid banana varieties: a conceptual framework

Modelling farmers‟ choice is considered under the general framework of consumer demand theory (Lancaster, 1966; Rosen, 1974) which suggests that consumers derive utility not from a good but from the characteristics embedded in a good. Variety choice is driven by farmers‟ demand for a number of variety traits (Smale et al., 2001). The chapter argues that farmers choose varieties based on the bundles of observable characteristics that each variety embodies and produces (Smale et al., 1998 ; Edmeades and Smale, 2006; Wale and Yalew, 2007; Kikulwe et al., 2011). In this study, we assume that an individual farmer faces a choice amongst alternative hybrid banana varieties. The individual farmer is assumed to consider the full set of offered alternative hybrid bananas in a choice situation and has to choose the alternative that maximizes utility (Hensher et al., 2005). New hybrid banana varieties have observable and unique attributes that make them different from one another; for example, plant vigour, size of bunch, finger size and shape, tolerance to pests and diseases, and colour of food (visual appearances). The unobservable attributes like taste and flavour make the hybrid bananas different compared to the local check. A farmer‟s decision to choose a variety is made by comparing both the observable and unobservable attributes of all the banana varieties (Gracia and deMagistris, 2008). Consider a farmer‟s choice of a variety, and assume that utility depends on the choice made from a set (C), that is the choice set that includes all the possible variety alternatives. Thus, the farmer is assumed to have a utility;

$$U_{ij} = Q(Z_j, S_i) + \varepsilon(Z_j, S_i) \qquad (1)$$

Where for any farmer i, a given level of utility will be associated with any alternative variety j. The utility derived from any alternative variety depends on the attributes (Z) of the variety and other socio-economic and agro-ecological factors affecting farmers‟ decisions.

Choices made between alternatives will be a function of the probability that the utility associated with a particular option (j) is higher than that associated with other alternatives. The statistical model of the probability (Pij) that alternative j is chosen by individual i is given by

$$P_{ij} = \text{Prob}(Uij > Uia ; \quad a = 1, 2, 3, \ldots, j ; a \nparallel j) \qquad (2)$$

Thus, if the ith farmer selects variety type j, then Uij is the highest utility obtainable from among the j possible choices.

4.3 Research methodology

4.3.1 The empirical model

In this chapter, the farmer‟s choice from among the hybrid banana varieties was estimated within the multinomial-logit (MNL) framework (McFadden, 1974). The MNL model is applied to analyse the factors that affect the choice of hybrid banana varieties (M2, M9, M14) and Mbwazirume. The MNL model has been applied widely in earlier studies (Goktolga et al., 2006; Wale and Yalew, 2007; Dragos and Dragos, 2009). The MNL is a suitable model because it allows the analysis of decisions across more than two categories of hybrid banana varieties (Wooldridge, 2002; Deressa et al., 2009). The response variable includes four distinct unordered alternatives: M2, M9, M14 and Mbwazirume. Hence, we specify an MNL model (discrete choice method) as follows (Greene, 2003):

$$\text{Prob}(Y_i = j) = \frac{e^{x_i \beta_j}}{\sum_{k=1}^{4} e^{x_i \beta_k}} \quad \text{with} \quad j = 1,2,3,4 \ldots\ldots\ldots\ldots\ldots\ldots \qquad (3)$$

Where Y_i is the dependent variable representing the hybrid banana varieties chosen by the farmer and takes the values of 1, 2 or 3 if the farmer chooses a hybrid variety M2, M9 or M14. Variety Mbwazirume is used as the reference category. X_i represents a vector of explanatory variables that include socio-economic characteristics, varietal attributes, and market and agro-ecological factors that affect farmers‟ variety choice. β_j represents the coefficients to be estimated. The results of the MNL model are interpreted in terms of the odds ratios, that is, the ratios of the probability of choosing one outcome category over the reference category.

These ratios are defined as

$$l_n\left[\frac{P_{ij}}{P_{ik}}\right] = X_i(\beta_j - \beta_k) = X_i\beta_j \ if \ k = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (4)$$

A positive parameter indicates that the relative probability of choosing a hybrid banana variety over a local variety increases relative to the probability of choosing a local variety over a hybrid banana variety.

While other statistical options such as a discriminant function analysis could be used to analyse the choice of the variety among alternative banana varieties, a decision has been made to retain the MNL results because they are relatively easy to interpret in line with the purpose of this study. Compared to the MNL model, a discriminant analysis describes the differences in groups, predicts membership on the basis of response variable measures but does not estimate the marginal effects that present the actual magnitude of change or probabilities (Rencher, 2002). Moreover, the discriminant function assumes linear relationships between the response variable and the explanatory variables which are restrictive.

However, discriminant function estimates were made using the same data set and only one of the functions was statistically significant (P<.0000) (Appendix 4.1 and Appendix 4.2), suggesting that the MNL results explain the data-set better. Since only the first function is significant, it shows that it is the only function that has substantial discriminating power in differentiating the hybrid banana varieties. The discriminant function results do not have any new value-adding insights. Besides, the focus in this study was to measure the impact of each independent variable on the choice of each variety relative to the local variety. For all these reasons, interpretations and conclusions are made based on the MNL results.

4.3.2 The study area and data description

The study area and the sampling procedures are described in section 3.2.1. The dependent variable in the empirical estimation was the choice of banana variety option from the set of varieties. We use "varietal choice" to mean farmers' stated preferences among the hybrid banana varieties and Mbwazirume being evaluated on farm. Previous studies on variety choice (Edmeads, 2007; Edmeades and Smale, 2006) were based on area share allocated to a variety and the number of plants to imply the demand for a variety. In the present study, farmers‟ variety choices from the set of newly developed hybrid “Matooke” banana varieties (M2, M9, M14) are considered, with Mbwazirume as a local check. M17 was excluded in the analysis because it was never chosen. Farmers noted that, compared to Mbwazirume, M17 has a disadvantage of producing small fingers, has relatively poor cooking qualities and has a long period of maturity. The variety choice data were collected from the banana garden directly from farmers at the same time while observing each banana variety in the garden. This strategy allowed us to obtain farmers‟ true preferences about the banana varieties. Moreover, in the banana garden, the survey gave participants an opportunity to inspect the actual banana variety they were being asked to consider due to the presence of all the variety alternatives.

The choice of the explanatory variables is based on theory, data availability and previous literature (Deressa et al., 2009; Bellon and Hellin, 2011). The description of how each explanatory variable influences variety choice is presented below. Age is one of the potential factors affecting farmer‟s choice of varieties as an indicator for decision-making in variety choice (Bellon and Hellin, 2011). Age is also an indicator of traditional preferences, farming experience and local knowledge, which can be expected to be related positively to the cultivation of local variety and negatively to hybrids (Bellon and Hellin, 2011). The effect of farmers‟ age (AGE) could be positive or negative depending on the farmer‟s position in the life cycle (Zavale et al., 2005). Younger households may be more willing to try out new varieties, while older households may be less likely to try new crops or varieties (Adesina and Baidu-Forson, 1995).

The effect of the gender composition of the household on variety choice is difficult to predict. This variable is measured as a dummy. The effect may be related to type of farming system or access to resources such as credit or extension (CIMMYT, 1993). Female-headed households are hypothesized to have limited access to productive resources (land and credit) and are less likely to have access to new information than male-headed households (Doss and Moriis, 2001); consequently, their access to improved technologies is negatively affected.

Family size (total number of household members) was another variable considered. There is no agreement in the adoption literature regarding the direction of influence of this variable (Ajewole, 2010). A larger family size could be an indicator of food consumption requirement. Also, many members in a household imply labour availability that is frequently associated with the choice and adoption of a new technology. In this case, the variable was predicted to be positively related to the demand for hybrid banana varieties as banana production is labour-intensive and is a dominant food crop in Uganda.

Farmer access to extension agents is expected to influence variety choice among the available banana alternatives. According to various researchers (Doss, 2003; Sall et al., 2000; Wubeneh and Sanders, 2006) extension is regarded as one of the most important sources of information. It is hypothesized that contact with extension agents measured as a dummy variable is positively related to variety choice by exposing farmers to new information. According to Feder et al. (1985) more exposure to information through various extension agents reduces subjective uncertainty about the technology.

Availability of credit eases the cash constraints and allows farmers to buy purchased inputs such as fertilizers, improved planting materials and other inputs. Access to credit was measured as a dummy variable and is expected to influence variety choice among the hybrid banana varieties. Studies on adoption of agricultural technologies indicate that farm size has positive effects on adoption (Bradshaw et al., 2004). Land size (a proxy for farm size) is expected to have a positive effect on the choice of hybrid banana varieties. Larger farm areas can be allocated among varieties, the most preferred variety taking a larger share (Janaiah and Hossain, 2003). Farm size can be positively related to adoption because larger farmers can experiment with new technologies on a portion of land without worrying about endangering the family‟s food security (Wubeneh and Sanders, 2006.).

A household wealth index is also included and expected to have a positive effect on variety choice. Data were collected on household asset ownership (values of radio sets, bicycle, chairs, tables, car, mobile phones, television sets, and sofa sets) and livestock ownership. The values of all these assets were estimated in current Ugandan Shillings. The PCA method through factor analysis was used to construct an overall household wealth index (Filmer and Pritchett, 2001). In this study, farmers' perceptions about the hybrid banana variety attributes were measured as a dummy: 1 = if a farmer perceives a variety to have good attributes and 0 otherwise, relative to the local variety). Consumption and production attributes are variety specific (Edmeades et al., 2005). Therefore, better performance in relation to these attributes is positively associated with variety choice decisions. According to Kshirsagar et al.(2002) farmers assess a new technology such as an improved variety in terms of a range of attribute requirements. Most bananas produced in Uganda are for home consumption (about 65%) with a smaller portion being sold to urban consumers (Smale and Tushemereirwe, 2007). Therefore, better taste and large bunch sizes give a specific variety more chances of being selected.

We include farmers‟ perceptions of the role of hybrid bananas in food security, measured as a binary variable (Yes = 1; No = 0), to examine farmers‟ perceptions about the role of the new hybrid banana varieties to reduce food insecurity problems among the farming communities. The banana crop is regarded as an essential crop for food security in Uganda as it is an all-year crop with all stages of the crop cycle occurring at any one time of the year (Eledu et al., 2004). Banana varieties that are perceived to possess important desirable attributes that are effective in food security (like short maturity period, large bunch sizes, provision of volumes of food after cooking, and good resistance to drought stress, diseases and pests) are preferred (Gold et al., 2002), and more likely to be chosen and stay longer with the farming communities.

A regional dummy variable was included to measure the effect of regional location as a determinant of variety choice to capture the cultural and physical environment in which farmers make their decisions. The likelihood of a variety being chosen increases with the better physical environment of the area with farmers having a higher preference for a variety that is relevant to the agro-climatic conditions and the farming systems in their locations. The agro-ecological zones are based on differences in farming systems, weather and climatic, altitude and major vegetation cover (Wortmann. and Eledu, 1999). Moreover, the differences in farming conditions (plot slope, soil fertility, diseases and pest severity) across regions tend to increase differences in variety choice (Benin et al., 2004). In Uganda, the Eastern and Central regions of the country are located in the lowland areas where banana production has been severely affected by pests and diseases in the past 20 years (Kikulwe et al., 2011).The Western region is the main banana producing region located in the highlands of the country and it is characterized by low incidences of pests and diseases (Nelson et al., 2006). Most banana varieties are susceptible to certain severe diseases like black-Sigatoka, but some varieties are far more sensitive than others.

Farmer perceptions of the hybrid banana plot characteristics (soil and slope) were measured as ordered variables (1 = Fertile, 2 = Medium, and 3 = Low; and 1 = Steep 2 = Gentle and 3 = Flat) to control for soil differences across agro-ecological regions. The choice of a hybrid banana variety is affected by soil conditions although the direction of the effect is difficult to predict *a priori*. Other variables included are: average walking time from home to the dry weather road (hours) and the nearest market, and education level of the respondent (Deressa et al., 2009; Isgin et al., 2008). It is hypothesized that these factors are positively related to variety choice decision.

4.4 Empirical results and discussion

4.4.1 Descriptive results

According to the survey results, the average household size was 6.5 members - slightly above 5, the mean household size in Uganda (2009/2010) - of which children constitute an average of 3.6 members. The results show that respondents had completed, on average, 8.6 years in school, slightly above the primary level of education in Uganda (Table 4.1). The survey results also show that 50.4% of the respondents were male. The mean age of the household head was 47.13 years. About 76.9% of the respondents reported farming as their main activity and, on average, households had 8.9 acres of land. When asked whether they believed the hybrid banana varieties could reduce food insecurity, 92.5% of the respondents agreed. The results further revealed that 29% of the respondents had access to credit (Table 4.1). On average, respondents had been visited by extension workers 2.5 times in a period of two years. In terms of market accessibility, the average walking time to the nearest market was 43 minutes while it took 53.5 minutes to walk to the nearest tarmac road.

Table 4.1 Descriptive statistics of sampled households, Uganda, 2010/11(n = 454)

Variable	Variable description	Mean (SD)	Expected sign
Reduc	Years of schooling of the respondent	8.6 (3.91)	+
Fhsize	Total number of household members	6.5 (3.23)	+
HHAGE	Respondent age (years)	47.1 (14.30)	+/ -
Walking to road	Average walking time from home to the tarmac road (minutes)	53.5 (96.05)	+
Walking to market	Average walking time from house to the nearest market (minutes)	43.0 (56.66)	+/ -
Labour force	Active household members between the age group 15 and 64 years in the household	3.04 (1.73)	+
Tlarea	Total land operated (acres)	8.9 (10.60	+
Iwealth	An index derived from factor analysis of the total values in Ush for household assets and livestock	.0014729 (1.00)	+
	In percentage (%)		
Gender	Dummy (1 if household head is male; 0 otherwise)	50.4	+/ -
Taste	Binary (1 if the preference for taste attribute is important; 0 otherwise)	47.8	+
Diseases	Binary (1 if farmer perceives variety indicates a good resistance to pests and diseases; 0 otherwise)	62.6	+
Drought	Binary (1 if farmer perceives varieties are tolerant to drought; 0 otherwise)	31.5	+
Good bunch	Binary (1 if farmer perceives varieties produce good bunch size; 0 otherwise)	62.3	+
Maturity	Binary (1 if farmer perceives varieties take a short time to mature; 0 otherwise)	36.6	+
Hbrfood	Farmers" perception about the role of hybrid banana to food security (Yes = 1; No = 0)	92.5	+
DCentral	Binary (1 if farmer is located in Central region; 0 otherwise)	21.8	+ / -
Dwest	Binary (1 if farmer is located in Western region; 0 otherwise)	23.8	+/ -
Dmidw	Binary (1 if farmer is located in Mid-western region; 0 otherwise)	22.0	+/ -
Deast	Binary (1 if farmer is located in Eastern region; 0 otherwise)	32.4	+/ -
Sought credit	Binary (1 if a farmer has access to credit; 0 otherwise)	29.1	+
Extension	Binary (1 if a farmer was visited by extension agents in two years; 0 other-wise)	54.4	+
Farming	Binary (1 if farming is the major economic activity for the respondent; 0 otherwise)	76.9	+
Hybrid banana Plot slope	An ordered variable representing slope 1 = Steep; 2 = Gentle; 3 = Flat		+/ -
SoilFertily	An ordered variable representing soil fertility 1 = High; 2 = Medium; 3 = Low	12.7	+/ -

Source: See Table 3.1

The descriptive results indicate that the majority of farmers‟ plots (83.9%) are gently sloped, 12.7% had steep plots while 3.4% were flat. In terms of soil fertility, most farmers (63.1%) perceived their soils to be medium, 31% high and 6% low in fertility.

4.4.2 Farmers' perception of the hybrid banana varieties contributing to food security

When the farmers were asked about their perception of varieties contributing to food security, 90% of respondents see the improved banana varieties reducing food insecurity (Table 4.2). In comparison to the local variety, 77% of the farmers reported that the improved varieties were better in yield performance, 6% reported resistant to diseases and drought tolerance, and 4% reported that banana hybrid plantations could last longer with high production (Table 4.3), reasons farmers suggested could contribute to food security. There is need for further analysis to determine the causation of these factors on food security.

Table 4.2 Perception of factors contributing to food security with the hybrid banana varieties, 2010/11

Can hybrid bananas reduce your food insecurity	**Frequency**	**% of responses**
Yes	316	90.3
No	34	9.7
Total	**350**	**100.0**

Source: See Table 3.1

Table 4.3 Reasons farmers cited why hybrid bananas could reduce food insecurity, 2010/11 (n=213)

Reasons for hybrid bananas reducing food insecurity	**Frequency**	**% of responses**
Has better yields that can boost food security in the home	165	77.5
Plantation lasts longer and high production	10	4.7
Resistance to diseases	15	6.9
Drought tolerant	14	6.6
Early maturity	9	4.2
Total	**213**	**100**

Source: See Table 3.1

4.4.3 Farmers' perceptions of the benefits attributable to the hybrid banana varieties

In this section, changes in food security and other benefits from early adoption of hybrid bananas varieties are examined. Respondents were asked if they had observed any improvement due to participation in the project while comparing with the situation before the project (Table 4.4).

Table 4.4 Farmers' perceptions of changes in food security and other benefits due to hybrid banana varieties in Uganda, 2010/11

What is your household food situation	Participating farmers %/ (n= 128)	Non -participating farmers %/(n= 273)
More than sufficient	41.1	24.6
Just sufficient	55.0	63.8
Insufficient	3.9	11.6
Over the past 3-5 years, how was the trend regarding your household food situation		
Has improved substantially for the better	85.2	45.8
Has remained the same as before	8.6	34.4
Has declined slightly	6.3	14.7
Has deteriorated substantially	-	5.1
Have you experienced a problem of satisfying the food needs of your house (1=Yes, No=0	49.2	57.0
Rate the food situation at your household before the hybrid banana project and now during the implementation of the project?		
Remained the same	19.5	55.4
Quantity of food has increased	78.9	43.48
Quantity of food has reduced	1.6	1.09
In your opinion, do you think the hybrid banana varieties could reduce your food insecurity problem? 1=Yes; 0=No	92.8	88.89

Source: See Table 3.1

Results suggest show that 41% of the host farmers were having more than sufficient food supplies due to participation in the project, while 85% mentioned that their household food situation had tremendously improved for the better over the past 3-5 years (Table 4.4). Results show that, 78% of the host farmers perceived, their quantity of food supplies at household level had increased compared 43% of the non-participating farmers (Table 4.4). They suggest that quantity of food had increased tremendously compared to a period before having access to hybrid banana varieties. However, it cannot yet be concluded that all these could be entirely attributed to the adoption hybrid banana varieties. This needs a follow up study to produce more definitive conclusions on these parameters.

During the survey, respondents were asked about their household expectations for the hybrid banana varieties. Results show that 63% of the farmers expected the hybrid varieties can be a source of money and food, 13% expected varieties to contribute to their food security at household level, while 6% expected the varieties to be resistant to pests, diseases and high yielding compared to the local variety (Table 4.5). This suggests that while farmers are choosing a particular variety, they would consider a variety that will ensure food security and income.

Table 4.5 Farmer's household expectations in growing the hybrid banana varieties, Uganda 2010/11

Household expectations of the hybrid banana project	Frequency	% of responses
Sources money and food	90	63.4
School fees and food	6	4.2
Food security	19	13.4
Access to income	11	7.7
Getting a more resistant variety	8	5.63
Access to good yielding banana varieties	3	5.63
Total	**142**	**100.0**

Source: See Table 3.1

4.4.4 Farmer's perceptions of the desirable and undesirable attributes of the banana hybrids

Farmers were asked to indicate the most desirable and undesirable attributes of the banana hybrids. The results of Tables 4.6 and 4.7 shows the most frequently mentioned desirable and undesirable attributes of all the hybrid banana varieties. Good taste, large bunch size, soft food and good flavour were the most frequent desirable attributes that farmers reported (Table 4.6).

Table 4.6 Farmer desirable attributes for banana hybrids (percent of respondents), Uganda, 2010/11 (n =454)

	M2		M9		M14		Mbwazirume	
Attributes	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Good Taste	45	29.6	29	14.7	12	12.5	60	31.6
Big bunch	40	26.3	76	38.4	33	34.4	21	11.1
Big fingers	-	-	10	5.1	10	10.4	7	3.7
High yielding	-	-	11	5.6	9	9.4	9	4.7
Early maturity	18	11.8	12	6.1	7	7.3	14	7.4
Tolerance to pests and disease	12	7.9	3	1.5	8	8.3	4	2.1
Tolerance to drought	-	-	12	6.1	4	4.2	6	3.2
Good performance in poor soils	9	5.9	4	2.0	2	2.1	-	-
Suitable for market	12	7.9	5	2.5	-	-	11	5.8
Soft food	4	2.6	19	9.7	5	5.2	28	14.7
Good flavour	6	4.0	5	2.5	6	6.3	19	10.0
Good colour	-	-	7	3.5	-	-	5	2.6
Good height	4	2.6	-	-	-	-	6	3.2
Longer storage	2	1.3	2	1.0	-	-	-	-
Total	**152**	**100**	**198**	**100**	**96**	**100**	**190**	**100**

Source: See Table 3.1

Table 4.7 Farmer undesirable attributes for hybrid banana varieties (percent of respondents), Uganda, 2010/11 (n =454)

	M2		M9		M14		Mbwazirume	
Attributes	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Not easy to sell	7	11.7	-	-	-	-	-	-
Small fingers	8	13.3	13	20	12	44.4	3	6.5
Hard food	12	20.0	9	13.9	7	25.9	1	2.2
Poor taste	14	23.3	13	20	5	18.5	1	2.2
Delays to mature	11	18.3	10	15.4	-	-	4	8.7
Requires a lot of management	-	-	6	9.2	-	-	-	-
Not resistant to disease	4	6.7	3	4.6	-	-	21	45.7
Not tolerant to drought	-	-	6	9.2	-	-	2	4.4
Not tolerant to wind	2	3.3	5	7.7			2	4.4
Small bunches	2	3.3	-		3	11.1	12	26.1
Total	**60**	**100**	**65**	**100**	**27**	**100**	**46**	**100**

Source: See Table 3.1

Notes: Taste is the stimulation of the receptors on the tongue for sweet, sour, salty, and bitter flavours while flavour is the quality in a food that imparts a particular taste in the palate.

Most of the respondents preferred hybrid M2 because of its relatively good taste among all attributes compared to Mbwazirume (Table 4.6); this also applies to bunch size, early maturity period, tolerance to diseases and suitability for the market. Many respondents

(38.4%) choose to grow hybrid M9 because of its relatively large bunch size, good taste, soft food and good flavour compared to Mbwazirume. Notable desirable attributes for hybrid M14 are its bunch size, good taste and soft food and flavour. While investigating the variety selection in Uganda, Gold et al. (2002) also found that bunch size was ranked as the most important selection criterion of Musa cultivars.

Despite the desirable attributes associated with the hybrid banana varieties, some of the farmers also mentioned that the hybrid bananas have some undesirable attributes (Table 4.7). Respondents suggest that variety M2 food that is hard when cooked, takes long to mature, and also is not easy to sell. The results also show that Hybrid M9 is associated with poor taste and small fingers and takes long to mature, while hybrid M14 is associated with small fingers, hard food and poor taste (Table 4.7). Despite Mbwazirume‟s good desirable features in other traits, the results show that the farmers perceived it as not being tolerant to pests and diseases and it produces small bunches.

4.4.5 Farmers' choice and their preferences for the hybrid bananas

For this study, farmers were asked to choose their most preferred variety among those under evaluation. There were four variety options or response probabilities (Figure 4.1). Results showed that many farmers selected reference variety Mbwazirume (39.0%) as their first choice. Among the hybrids, M9 was the most preferred variety (27.3%), followed by M2 (21.8%) and M14 (11.9%) (Figure 4.1). M17 was excluded in the analysis because it was never chosen. Farmers suggest that compared to Mbwazirume, M17 has a disadvantage of small fingers, relatively poor cooking qualities and takes long period to mature.

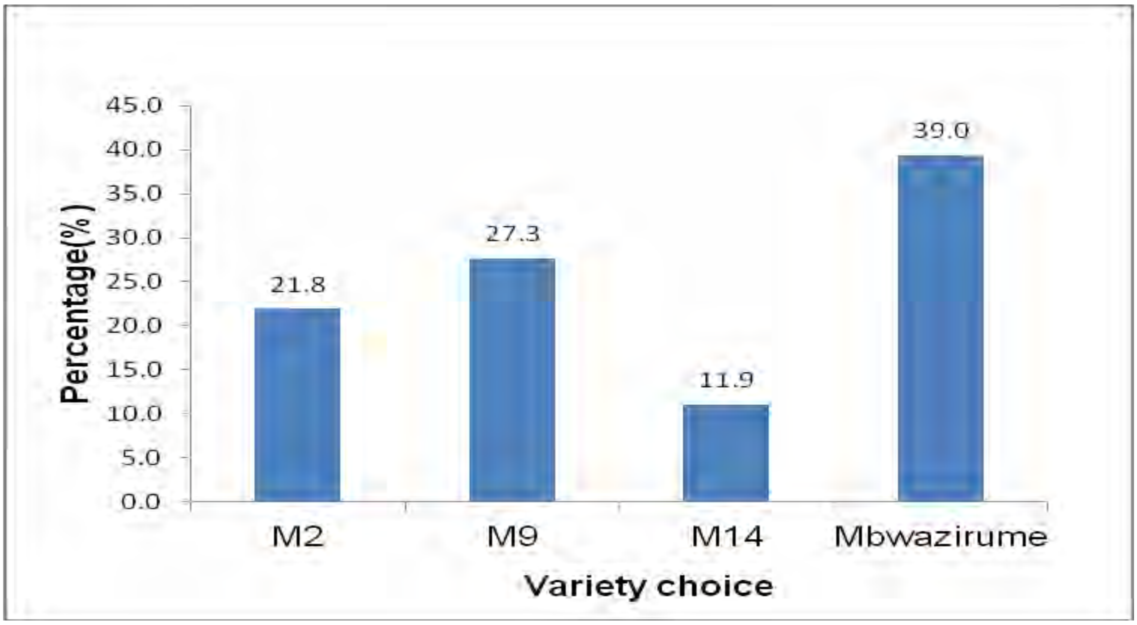

Figure 4.1 Farmer choice of hybrid bananas, Uganda, 2010/11
Source: See Table 3.1

Farmers were probed about their perceptions towards each of the hybrids in regard to preferences and choice made. Results show that farmers in all agro-ecological zones of Uganda have concerns regarding the hybrid banana varieties they would choose (Table 4.8). Judging by the percentage of responses related to a particular attribute as a measure of its relative importance, all the hybrid banana varieties were perceived to be better than the local variety with respect to agronomic characteristics, and pest and disease tolerance attributes, but inferior with respect to consumption characteristics compared to the reference variety. Specifically, farmers strongly agreed that Hybrid M9 has a high adaptation to drought, poor soils, and wind and is stable in terms of yield compared to the rest of the hybrids and a local check. This explains why farmers preferred Hybrid M9 as the best variety among the hybrid varieties despite its lower preference compared to the local variety (Table 4.8). Moreover, farmers strongly agreed that all the hybrids were better that a local check in terms of tolerance to pests and diseases like black Sigatoka, weevils and nematodes (Table 4.8). Mbwazirume is believed to be inferior in terms of bunch size compared to M9 and M2 but is better in terms of taste.

Table 4.8 Farmer perceptions of hybrid variety attributes in all agro-ecological regions of Uganda, 2010/11 (n=149)

Variety attributes	(%) M2		(%) M9		(%) M14		(%) Mbwazirume	
	Agree	Disagree	Agree	Disagree	Agree	Disagree	Agree	Disagree
High adaptation to drought	82.86	17.14	88.30	11.70	77.56	22.44	67.03	32.97
High adaptation to poor soils	75.31	24.69	78.99	21.01	67.53	32.47	58.06	41.94
High adaptation to wind	76.35	23.65	80.58	19.42	74.03	25.97	70.07	29.93
Stable in terms of Yield	81.36	18.64	84.44	15.56	74.34	25.66	75.46	24.54
Preferred to plant on own fields	63.52	36.48	64.79	35.21	56.38	43.62	66.79	33.21
Needs more labour	64.41	35.59	67.65	32.35	69.48	30.52	64.94	35.06
Usually requires higher rate of fertilizer application	39.13	60.87	41.35	58.65	39.33	60.67	48.47	51.53
Variety matures early	65.68	34.32	70.91	29.09	55.63	44.37	79.26	20.74
Resistance to black Sigatoka	82.74	17.26	87.45	12.55	82.78	17.22	57.25	42.75
Resistance to weevils	74.45	25.55	77.82	22.18	72.00	28.00	58.02	41.98
Resistance to nematodes	75.00	25.00	78.03	21.97	75.00	25.00	58.94	41.06
Longer storage life after harvest	70.14	29.86	70.27	29.73	59.71	40.29	59.46	40.54
Suitability to Matooke local food	61.21	38.79	67.29	32.71	62.42	37.58	84.85	15.15
Good bunch size	85.36	14.64	92.45	7.55	73.15	26.85	81.95	18.05
Good finger size	83.40	16.60	90.91	9.09	60.67	39.33	87.50	12.50
Good skin colour	85.53	14.47	88.36	11.64	73.33	26.67	91.58	8.42
Good inside colour when cooked	71.86	28.14	77.57	22.43	64.19	35.81	90.71	9.29
Good texture	72.73	27.27	78.23	21.77	64.43	35.57	88.15	11.85
Good taste	70.39	29.61	74.54	25.46	59.06	40.94	91.35	8.65

Notes: Farmer perceptions were captured using a five -point Likert scale:
1 = Strongly agree; 2 = Agree; 3 = Disagree; 4 = Don't Know
Source: See Table 3.1

The results show that many of the farmers have a preference for the Hybrid M9 due to its good bunch size, good finger size and longer storage capability after harvest compared with the rest of the hybrid banana varieties (Tables 4.8). Banana consumers in Uganda in most cases consider bunch characteristics when buying. This gives Hybrid M9 an advantage of being widely considered a variety to be produced for the market. In terms of the consumption qualities, many of the farmers regarded M9 to be better than the rest of the hybrids and close to the local variety. Considering supplementary input requirements, the majority of respondents disagreed that the hybrid banana varieties require higher rates of fertilizer application (Table 4.8). This result suggests that one would expect the majority of the resource poor farmers in Uganda, who lack the ability to purchase adequate amounts of fertilizers, to plant more of these hybrid banana varieties when they are less input-intensive.

4.4.6 The determinants of variety choice: multinomial results

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable (Table 4.9). The estimates do not represent actual magnitude of change or probabilities. Thus, the marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed (Table 4.10). Estimated coefficients for all the hybrid banana varieties are compared with Mbwazirume, a reference variety as the base category.

Table 4.9 Parameter estimates of the Multinomial Logit model explaining farmer choice and preferences for each hybrid banana variety, Uganda, 2010/11

Variables	M2	M9	M14
	Estimate(P level)	**Estimate(P level)**	**Estimate(P level)**
REduc	-0.014(0.79)	0.037(0.36)	0.093(0.11)
FHsize	-0.013(0.86)	0.034(0.60)	0.018(0.82)
HHAGE	0.007(0.64)	-0.0001(0.99)	0.019(0.18)
Gender	-0.606(0.17)	-0.375(0.32)	-0.414(0.36)
Labourforce	0.068(0.60)	0.079(0.42)	-0.110(0.44)
Tlarea	-0.026(0.08)*	-0.030(0.06)**	-0.015(0.47)
Hbrfood	1.142(0.07)*	2.677(0.01)**	0.808(0.21)
Taste	-2.417(0.00)**	-1.188(0.00)***	-1.834(0.00)***
Disease	0.064(0.87)	0.172(0.61)	0.014(0.97)
Good bunch	-0.470(0.26)	-0.177(0.62)	-1.111(0.01)***
Maturity	0.539(0.18)	0.039(0.91)	0.634(0.16)
Dcentral	-1.809(0.01)**	-0.012(0.98)	-0.237(0.71)
Dwest	-0.085(0.88)	-0.077(0.89)	-0.347(0.63)
Deast	-0.445(0.41)	0.026(0.96)	0.393(0.45)
IWealth	-0.670(0.06)**	-0.212(0.21)	-0.172(0.26)
Sought credit	0.158(0.72)	0.165(0.65)	-0.862(0.10)**
Extension	-0.466(0.27)	0.280(0.39)	-0.042(0.93)
Walking to road	0.003(0.05)**	0.001(0.56)	0.003(0.13)
Walking to market	-0.005(0.18)	-0.001(0.69)	-0.003(0.34)
Farming	0.758(0.11)	0.297(0.44)	0.529(0.32)
Plot slope	0.285(0.54)	0.488(0.22)	0.451(0.45)
SoilFertily	-0.345(0.32)	-0.283(0.34)	0.145(0.71)
Constant	0.314(0.84)	-3.310(0.07)**	-2.676(0.13)
Number of obs	305		
Pseudo likelihood	-321.748		
Wald chi2	148.16		
Prob > chi2	0.0000		
Pseudo R^2	0.176		

Notes: ***, **, * = significant at 1%, 5%, and 10% probability levels, respectively
Source: See Table 3.1

Table 4.10 Marginal effects from the Multinomial Logit model explaining farmer choice and preferences for each hybrid banana variety, Uganda, 2010/11

Variables	M2	M9	M14
	Marginal effect (P level)	**Marginal effect (P level)**	**Marginal effect (P level)**
REduc	-0.005(0.42)	0.005(0.46)	0.008(0.10)
FHsize	-0.003(0.69)	0.007(0.57)	0.001(0.89)
HHAGE	0.001(0.73)	-0.001(0.69)	0.002(014)
Gender	-0.057(0.31)	-0.036(0.61)	-0.018(0.65)
Labourforce	0.007(0.63)	0.016(0.37)	-0.014(0.28)
Tlarea	-0.002(0.28)	-0.005(0.12)	0.000(0.92)
Hbrfood	0.061(0.24)	0.276(0.00)**	0.019(0.69)
Taste	-0.231(0.00)***	-0.069(0.22)	-0.0936(0.01)**
Disease	0.001(0.98)	0.031(0.60)	-0.005(0.91)
Good bunch	-0.033(0.48)	0.019(0.76)	-0.1008(0.03)**
Maturity	0.057(0.25)	-0.033(0.59)	0.053(0.23)
Dcentral	-0.162(0.00)***	0.057(0.55)	-0.002(0.97)
Dwest	-0.003(0.97)	-0.003(0.98)	-0.027(0.60)
Deast	-0.059(0.28)	0.010(0.91)	0.045(0.37)
IWealth	-0.072(0.08)*	-0.011(0.74)	0.000(1.00)
Sought credit	0.025(0.63)	0.048(0.47)	-0.077(0.03)**
Extension	-0.070(0.17)	0.074(0.19)	-0.004(0.92)
Walking to road	0.0003(0.06)**	0.000(0.91)	0.000(0.21)
Walking to market	-0.001(0.22)	0.000(0.91)	0.000(0.48)
Farming	0.067(0.12)	0.019(0.78)	0.029(0.48)
Plot slope	0.009(0.86)	0.073(0.33)	0.024(0.66)
SoilFertily	-0.034(0.39)	-0.047(0.39)	0.027(0.40)

Notes: ***, **, * = significant at 1%, 5%, and 10% probability levels, respectively.
Source: See Table 3.1

The Chi-square test results indicate that the likelihood ratio statistics are highly statistically significant ($p<0.000$) suggesting that the MNL model has strong explanatory power. The model was tested for multi-collinearity using the variance inflation factors (VIF). The VIFs for all variables were less than 10 which indicate that multi-collinearity was not a problem.

The estimated coefficient for total land size (Tlarea) is negative and significant for the probability of farmer‟ choice of variety M2 and M9 (Table 4.9), implying that an increase in area of land will result in a lower probability (negative sign) of choosing M2 or M9 relative to Mbwazirume. A reduction in the land area will, therefore, increase the probability that M2 and M9 will be chosen, implying that farmers with small pieces of land are more likely to choose these two new hybrids relative to Mbwazirume. The marginal effects suggest that a unit increase in the size of land in acres is likely to decrease the farmers‟ likelihood of choice for hybrids M2 and M9 by 0.18% and 0.45%, respectively, relative to Mbwazirume (Table

4.10). The reason could be that farmers with small pieces of land are more likely to be motivated in searching for a new technology due to subsistence pressure, especially where household food insecurity is an important issue.

The estimated coefficient for taste is negative and statistically significant for all the hybrid banana varieties. These results suggest that farmers are less likely to choose all the hybrid banana varieties over Mbazirume for food taste. The marginal effects of the taste variable indicate that the probabilities of selecting hybrid banana varieties decreases by 23.05% for M2, 6.89% for M14 and 9.36% for M9, relative to Mbwazirume. This suggests that farmers consider the hybrid bananas as inferior to the local variety in terms of taste. One of the explanations could be that farmers prefer Mbwazirume because it may have other desirable attributes like soft food, good flavour and colour when cooked (Table 4.6). In a similar study of rice, Kshirsag et al. (2002) found that farmers indicated preference for retaining traditional varieties of rice for domestic consumption compared with the improved varieties.

The respondent farmers‟ perceptions about the role of hybrid banana to food security (Hbrfood) were positive for all hybrids and statistically significant for varieties M2 and M9 (Table 4.9). Similarly, the marginal effects suggest that the probabilities of choosing hybrid banana varieties for food security reasons increase in favour of M2 (6.13%) and M9 (27.60%) (Table 4.10). This could be due to the desirable attributes farmers associated with these hybrid bananas like large bunch size, tolerance to pests and diseases, and relatively good taste (Tables 4.6 and 4.7). According to Gold et al. (2002) farmers are more likely to select a variety with attributes that are considered important for provision of food security in subsistence production.

Farmer‟s perceptions of the resistance of hybrid varieties to pests and diseases, distance to the nearest market, education, importance of farming as a source of income to the household and plot slope showed positive relationships with variety choice as expected, but the estimated coefficients were not significant. None of the variables reflecting physical resources (for example, labour and family size), with the exception of accessibility to credit, was statistically significant. This is perhaps not surprising given that hybrid banana planting materials (suckers) can be relatively easily accessed through farmer to farmer exchange systems (Tushemereirwe et al., 2006). In many parts of the country, banana planting materials circulate among farmers and communities without the exchange of money.

A respondent being in the Central region (Dcentral) is negatively associated with the choice of all the hybrid banana varieties with a significant effect on M2 relative to Mbwazirume. Being in the Central region of Uganda decreases the likelihood of choosing hybrid M2 by 16.15% (Table 4.10).

4.5 Summary

The empirical results suggest that, among the hybrids, M9 was the most preferred variety followed by M2 and M14. However, many of the respondents (39.4%) chose Mbwazirume (a local variety) as their most preferred variety. The results also highlight the importance farmers attach to banana attributes: good taste, large bunch size, soft food and good flavour were the most desirable attributes that farmers considered for the hybrid banana varieties, particularly for M9 and M14. The study further revealed that total land size, taste and regional location, particularly in the Central region, were negatively associated with hybrid choice, while farmers" perception that hybrid bananas could reduce food insecurity were positively associated with probabilities of hybrid choice.

Farmers being the ultimate consumers of the invention of the agricultural research, such as a new hybrid banana variety, their knowledge of the production environment and variety and attribute preferences are critically important in influencing, not only the decision for the variety choice, but also the level of adoption. Hence, policy makers could prioritise farmers" involvement in varietal improvement and development programs so as to address their concerns and preferences. More details on the conclusions and policy implications of the empirical results of this chapter are contained in Chapter 6.

CHAPTER 5

DETERMINANTS OF CONSUMERS' WILLINGNESS TO PURCHASE THE PRODUCTS OF BANANA HYBRIDS IN UGANDA[5]

5.1 Introduction

Although the rates of poverty in Africa are declining, the continent is still the poorest region in the world (Hope, 2009, AfDB, 2012). By 2005, sub-Saharan Africa still had 51% and 73% of its total population living on only US$1.25 and US$2.00 per day, respectively (World Bank, 2008a, World Bank, 2014). Approximately 59% of the continent"s poor people live in rural areas and depend primarily on agriculture for food and livelihoods; agriculture representing the single largest economic activity on the continent. The bulk of Uganda"s population (85%) resides in rural areas and depends on agriculture for income and subsistence (Ssewanyana and Bategeka, 2007; Gollin and Rogerson, 2010) and yet the low levels of productivity in the sector have deepened in recent years (Nkonya et al., 2004). Moreover, the high population growth rate (approximately 3% per year), declining soil fertility and increases in urban migration have increased demand for food (Dorelien, 2008; Spilsbury et al., 2002). This has put pressure on land and other resources for food production in different farming systems. To satisfy the growing demand for food, there is need for improving productivity on existing farmland, among other things, by enhancing the yield level of food crops per unit area, through advancing science and technology (Edgerton, 2009). Therefore, an increase in banana productivity will play a very important role in food security and poverty alleviation. Banana production in Uganda has great yield potential to be tapped and there are many ways to raise banana yield of which improving soil conditions and breeding high-yielding varieties are the most important.

In Uganda, bananas occupy the largest cultivated area among staple food crops with more than 75% of all farmers growing bananas (NARO, 2001). The crop is mainly cultivated for subsistence purposes and it is increasingly becoming an important source of income for resource poor farmers (Karamura et al., 1998). In addition to being a source of income for

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[5] This chapter gave rise to the paper published as: Akankwasa K., G. F. Ortmann, E. Wale and W. K. Tushemereirwe. 2013. Determinants of consumers" willingness to purchase East African Highland cooking banana hybrids in Uganda. *African Journal of Agricultural Research* 8(9): 780-791.

poor farmers, it is the main staple food for urban consumers (Karamura et al., 1998; Asten et al., 2005). Despite its importance, the crop is currently facing major challenges due to soil exhaustion, pests and diseases (such as weevils, nematodes, and black Sigatoka), socio-economic constraints (such as high costs of production) and population pressure (Bagamba et al., 1998). This has culminated in the slowly declining banana supply as a result of declining yields. The declining yields could also be associated with the use of local varieties (Idrisa et al., 2010).

Recognising the importance of increasing banana productivity amidst all the above challenges, NBRP in Uganda has developed new hybrid banana varieties (M2, M9, M14, and M17). These are currently being evaluated in different agro-ecological regions with the local variety (Mbwazirume) as a control. Despite the introduction of the hybrid bananas among the farming communities since 2008, no research has so far been conducted to determine the factors (such as attribute preferences) that could influence consumers‟ purchasing decisions and their likelihood of purchasing these hybrid banana varieties.

Previous studies, for instance Kikulwe et al. (2011), investigated consumer willingness to purchase GM bananas and analysed the factors affecting consumers intentions to purchase GM bananas in Uganda. In addition, Edmeades (2007) and Edmeades and Smale (2006) investigated the determinants of the potential demand and supply for improved traits of banana varieties (e.g., GM bananas) in Uganda. These studies focused on the demand side examining revealed preferences. In the present study, the focus is on the supply side to determine the consumer‟s likely purchase of the improved (Matooke) hybrid bananas that have been developed through conventional breeding in Uganda, based on consumers‟ stated preferences. The crucial question that needs to be addressed before making commercialisation decisions is how end users, especially farmers and consumers, will react to the products of the newly developed hybrid bananas. The demand for hybrid bananas is likely to be better if, among others, varieties are developed to include producers‟ and consumers‟ preferred cooking traits. According to Quah and Tan (2010), the products must be evaluated to understand the critical sensory qualities that drive consumer acceptance and purchase decisions.

This chapter studies the effect of banana cooking qualities and consumption characteristics on purchase decisions for the newly developed hybrid banana varieties in Uganda. With many varieties being developed by breeding programmes of the National Banana Research Programme, it is important for farmers to select varieties most suitable for their conditions and likely to meet the demand for other end users and with better returns. According to David et al. (2002), farmers‟ adoption decisions are influenced by both production and consumption characteristics of crop varieties. Therefore, the knowledge of traits preferred by consumers is valuable for this important crop improvement programme and provides the market signals for producers. The study considered consumer and agronomic desired attributes in a consumer demand model and their effect on the likely purchase of the hybrid bananas when found on the market.

5.2 The research methodology

5.2.1 The conceptual Framework

The study analyses the likely consumer purchase of new hybrid banana varieties, borrowing from the theory of the consumer demand model (Lancaster, 1966) instead of the traditional theory of consumer demand. The fundamental idea behind this model is that consumers choose attributes of goods rather than the goods themselves. In the Lancaster approach, a consumer chooses a product that possesses a combination of attributes that maximises his/her utility. In other words, utility is provided by the attributes a good possesses and the good is as good as its attributes. The approach is based on the framework of random utility theory (Luce, 1959; McFadden, 1974; Rosen, 1974), which contends that consumers value goods based on their utility-generating attributes and product characteristics when making a purchase decision. The approach has been applied in related studies (Burton et al., 2001; Smale and DeGroote, 2003; Bonti-Ankomah and Yiridoe, 2006; Horna et al., 2007; Christensen et al., 2011; Veettil et al., 2011; Kikulwe et al., 2011).

Under normal circumstances, an individual consumer chooses the good that satisfies better his needs or expectations, or that provides him with a higher utility (McFadden, 1973). In reality, a consumer‟s choice in favour of a banana variety is made by comparing a bundle of (observable and unobservable) characteristics of the product (Bonti-Ankomah and Yiridoe, 2006). In this case, an individual consumer chooses between alternative hybrid banana varieties that contain a number of attributes at different levels while making his/her decisions based on the previous experience in banana consumption. The hybrid banana varieties are likely to be demanded for the utility they will provide, which, in turn, is a function of the characteristics of these hybrid banana varieties. Consumers are assumed to make their decisions by choosing the alternative that maximizes their perceived utility (Fernandez-Cornejo et al., 2005). Thus, a consumer is likely to buy a banana variety if the utility of purchase, Ui_1 is larger than the utility of not purchasing, Ui_0; that is, if $U^* = Ui_1 - Ui_0 > 0$.

5.2.2 The econometric model

In this study we apply a model that deals with the dichotomous dependent variable: willingness to purchase or not. Frequently used approaches in estimating such models include linear probability models (LPM), logit model and probit models (Gujarati, 2003). To evaluate farmers‟ likely purchase of a 30 kg hybrid banana variety when found on the market, logit models (Gujarati, 2003) were estimated for each variety. The model has been applied in similar studies in the past (Onyango et al., 2004; Gockowski and Ndoumbéb, 2004; Quah and Tan, 2010) and has been found to be efficient in explaining such dichotomous decision variables.

For simplicity, let Pi be the willingness to purchase or not purchase a specific banana variety and X be a vector of explanatory variables related to purchase. Vector X is assumed to be a function of various factors including consumer socioeconomic characteristics, sensory attributes, agronomic characteristics and the geographic location of the respondent. The likelihood purchase decision of a consumer is specified as;

$$Pi = f(X, \varepsilon) \qquad 1$$

Where ε is an error term with a logistic distribution. The conceptual model is given as:

$$ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{j=1}^{n} \beta_j X_{ji} + \varepsilon \qquad 2$$

The empirical model specifying the purchase of a banana variety is implicitly stated in equation 2 where $Pi = prop(y = 1)$ is the conditional probability that a consumer purchases a hybrid banana variety; $1 - Pi = prob(y = 0)$ is the conditional probability that a consumer does not purchase a variety; $Bj's$ are parameters to be estimated; $Xji's$ are the set of explanatory variables; and ε is the error term.

The following logit model is estimated per banana variety to analyse the effect of sensory characteristics, consumer characteristics, regional location and the agronomic attributes on consumers‟ likely purchase of a 30kg mature bunch of the banana variety and the price they would pay when found on the market; The mathematical model is defined as follows;

$$\mathrm{Ln}\left(\frac{P_i}{1-P_i}\right) = (\alpha 0 + \beta 1 * \text{gender} + \beta 2 * \text{educ} + \beta 3 * \text{age} + \beta 4 * \text{hhsize} + \beta 5 * \text{taste} + \beta 6 * \text{texture} + \beta 7 * \text{colour of food} + \beta 8 * Central + \beta 9 * Easten + \beta 10 * Western + \beta 11 * midwestern + \beta 12 * \text{logbunchweight} + \beta 13 * \text{acceptability} + \beta 14 * HHassets + \beta 15 * Flavour)\, \varepsilon_i \qquad 3$$

According to Drewnowski (1997) and Clark (1998), sensory parameters (in particular, taste, flavour, appearance and texture) determine food preferences and influence the product purchase decisions of the buyer. Previous studies (Dadzie and Orchard, 1997; Kikulwe et al., 2011) showed that colour of food, taste and texture and bunch size are some of the important attributes consumers consider for banana variety purchase decisions. In our study, these attributes have been measured by the importance that consumers attach to taste, flavour, texture, colour of the food and overall acceptability on a scale of 1 to 5, where 5 means the highest level of importance. We expect that positive perceptions for the good quality of the above attributes will have a positive effect on the likelihood of purchase decisions for the hybrid banana varieties. Consumers" purchasing behaviour may also be based on external factors such as socio-demographic profiles like gender, education and age (Phuah et al., 2011). The characteristics of the individual consumer have a bearing on how the individual decides food choice (Bower et al., 2003). These are hypothesised to affect the likely purchase of the banana varieties as they are important theoretical determinants of tastes and preferences. We also included regional location dummy that takes the value of 1 when the respondent is located in a given region and zero otherwise. According to Edmeades et al. (2005), farmers" selection among banana varieties depends on the regional location and whether the farmer is oriented towards subsistence or commercial production.

The study was conducted in four regions of Uganda (Mid-Western, Central, Western and Eastern) representing six major agro-ecological zones: Lake Albert crescent area, Lake Victoria crescent, Western highlands, Southern Highlands, South-East and Eastern agro-ecologic zones (Wortmann and Eledu, 1999). These are the regions where NBRP is evaluating the new hybrid banana varieties (namely, M2, M9, M14 and M17). While selecting the above regions and agro-ecological zones of the project, the Programme considered high disease/pest susceptibility as a major factor. This is mainly because the prime objective of hybrid banana development was to produce banana varieties resistant to black-Sigatoka, which has negatively affected banana production in these major areas.

The new varieties and Mbwazirume were introduced to farmers" fields. Mbwazirume was included so that farmers can have complete choice and make fully informed decisions by comparing the old variety with the new varieties. These varieties are being evaluated under farmer-managed conditions across all the above agro-ecologic zones in four regions of Uganda. The four banana hybrids were introduced to 312 farmers in 39 Districts covering all the above agro-ecological zones.

The study is based on primary data collected in two steps. The first step involved farmers who attended farmer field days that were conducted in 15 Districts of Uganda representing the Central region (Mityana, Wakiso, and Mukono), Eastern region (Butaleija, Jinja, Kaliro, Mayuge, Iganga, and Palisa), Mid-Western region (Bullisa and Masindi,) and Western region (Kyejojo and Mubende). The farmer field days were organised to evaluate the consumption traits of the new varieties and provide information on consumption characteristics and sensory tests for the hybrid bananas. The second step involved agronomic data, collected from the on-farm hybrid trials being hosted by the farmers. This captured, among other things, yield parameters, pseudo stem girth at base, 100 cm height, and the number of leaves on the plant (Weirengi et al., 2009).

One farmer field day was conducted in each of the above mentioned Districts at a host farmer"s plot. A minimum of 40 representative farmers were invited to field days in all regions of Uganda and participated as consumers. The field day activities involved consumer acceptability tests and a field tour of the hybrid banana plot. Participants included producer consumers (consumers that produce, consume and sell the surplus) and those who purely buy bananas from the markets. The experimental protocol consisted of a written survey, and taste evaluations of hybrid banana varieties, with Mbwazirume as a control. Participants were given a data sheet to collect data on consumers" personal and household characteristics that included age, gender, number of years spent in school, household size, and other characteristics.

At each site, all the varieties were harvested at maturity stage and cooked for evaluation. Participants were presented with cooked banana variety samples (presented in random order and coded with random numbers) and were asked to do visual and taste evaluations while filling out a two-page data sheet. Participants were asked to evaluate one sample at a time in the order of their appearance on the questionnaire, which was designed to avoid the effect of order of presentation. Participating consumers assessed and scored their perception for sensory parameters, namely flavour, taste, texture and colour of the food when cooked based on a five point Likert scale (5 = Excellent, 4 = Good, 3 = Fair, 2 = Bad, 1 = Very Bad) (Dadzie and Orchard, 1997). These were later collapsed into three categories (Bad, Fair, Good) at analytical level for meaningful interpretation.

This was followed by a field visit during which participants were allowed to do a visual inspection of the physical appearance like bunch size and other plant characteristics such as finger shape and the leaves for each variety. The aim of this field visit was for the participants to know the appearance of the varieties they had tested and make informed decisions as to whether they would purchase them when found on the market. The hypothesis was that the sensory and agronomic characteristics of a variety could have a greater impact on consumers" perception and influence their purchase decision when found on the market. A close-ended question was presented to participants assuming that they had gone to the market where there are many different cooking banana varieties on display to whether they would buy a 30kg bunch of each variety and how much they would pay (Carlsson et al., 2004). This question was used to create the dependent variable used in this study. A discrete (binary) variable was created which takes the value of 1 if the consumer would purchase a 30kg bunch of a specific hybrid banana and 0 otherwise.

5.3 The results and discussion

The majority of the participants (70%) were female. As women are the household members mainly involved in cooking, it is expected that they will inform the study on consumption and cooking attributes of the new banana varieties. The average age of the participants was 40.7 years, and had an education of about 8.7 years in school. On average, each participant represented a household of about 8.4 members. When asked about their intention to purchase hybrid banana varieties when found in the market, the majority indicated they would buy hybrid M9, M2, M14 and M17 (their propensity to buy in that decreasing order) (Table 5.1). The majority of the respondents were located in the Eastern region followed by the Central region, while the least were in the Mid-Western region of Uganda.

Table 5.1 Demographic characteristic of consumers that attended banana field days (n = 908), Uganda, 2010

Variable	Variable description	Mean	SD
Dependent variables			
M2buying	(1 if a respondent would purchase hybrid M2; 0 otherwise)	0.35	0.48
M9buying	(1 if a respondent would purchase hybrid M9; 0 otherwise)	0.43	0.50
M17buying	(1 if a respondent would purchase hybrid M17; 0 otherwise)	0.16	0.37
M14buying	(1 if a respondent would purchase hybrid M14; 0 otherwise)	0.25	0.43
Mbwazbuying	(1 if a respondent would purchase Mbwazirume; 0 otherwise)	0.42	0.49
Independent variables			
Gender	Gender(1=Male; 0=Female)	0.30	0.40
Educ	Respondent education in number of years of schooling	8.70	4.60
Age	Respondent age	40.7	13.50
Hhsize	Total number of household members	8.40	3.20
M9taste	If M9 taste (0=Bad 1=Fair 2=Good)	3.60	0.70
M9flavour	If M9 flavour (0=Bad 1=Fair 2=Good)	3.50	0.70
M9texture	If M9 texture (0=Bad 1=Fair 2=Good)	3.70	0.50
M9colourwhen cooked	If M9 colour (0=Bad 1=Fair 2=Good)	3.60	0.70
M9overall acceptability	If 0=not acceptable 1=Fairly acceptable 2= Acceptable)	3.60	0.70
M17taste	If M14 taste is (0=Bad 1=Fair 2=Good)	2.90	0.80
M17flavour	If M 17 flavour (0=Bad 1=Fair 2=Good)	2.90	0.80
M17texture	If M 17 texture (0=Bad 1=Fair 2=Good)	2.80	0.80
M17 colour whencooked	If M 17 colour (0=Bad 1=Fair 2=Good)	2.880	0.87
M17overall acceptability	If M17 0=Not acceptable 1=Fairly acceptable 2=Acceptable)	2.912	0.76
Mbwazirume Taste	If Mbwazirume Taste (0=Bad 1=Fair 2=Good)	3.75	0.57
Mbwazirume Flavour	If Mbwazirume Flavour (0=Bad 1=Fair 2=Good)	3.65	0.63
Mbwazirume Texture	If Mbwazirume Texture (0=Bad 1=Fair 2=Good)	3.80	0.48
Mbwazirume colour when cooked	If Mbwazirume colour (0=Bad 1=Fair 2=Good)	3.76	0.54
Mbwazirume overall acceptability	If (0=Not acceptable 1=Fairly acceptable 2=Acceptable)	3.72	0.61
M2taste	If M2 taste is (0=Bad 1=Fair 2=Good)	3.56	0.70
M2flavour	If M2 flavour is (0=Bad 1=Fair 2=Good)	3.48	0.72
M2texture	If M2 texture is (0=Bad 1=Fair 2=Good)	3.52	0.73
M2colour of the food when cooked	If M2 colour (0=Bad 1=Fair 2=Good)	3.53	0.74
M2overall acceptability	If m2 (0=Not acceptable 1=Fairly acceptable2=Acceptable)	3.60	0.69
M14taste	If M14 taste is (0=Bad 1=Fair 2=Good)	3.21	0.83

M14flavour	If M14 flavour is (0=Bad 1=Fair 2=Good)	3.12	0.84
M14texture	If M14 texture (0=Bad 1=Fair 2=Good)	3.02	0.83
M14colour of food when cooked	If M14 colour of the food when cooked is (0=Bad 1=Fair 2=Good)	3.00	0.87
M14overallacceptability	If M14 (0=Not acceptable 1=Fairly acceptable 2=Acceptable)	3.32	0.80
Central	Central region (1 if respondent resides in Central; 0 otherwise)	0.28	0.45
Eastern	Eastern region (1 if respondent resides in East ; 0 otherwise)	0.40	0.49
West	Western region (1 if respondent resides in West, 0 otherwise)	0.22	0.41
Mid-West	Mid-western (1 if respondent resides in Mid-west; 0 otherwise)	0.09	0.29
logbunchweightM9	Size of the banana bunch (Kg)	3.19	0.53
Logbunch	Size of the banana bunch (Kg)	2.72	0.52
HHassets	Value of the assets owned by the household (in Ugandan shillings)	726907.6	2240748

Source: See Table 3.1
Notes: The average exchange rate between February to Junes 2010 was US$ =UGX 2192.5.These were later collapsed into three categories as 0= Bad (1 and 2) 1= Fair (Fair) and 2=Good (4 and 5).

The presentation of the rest of the results is further split in two parts: First, the findings with respect to the participants‟ evaluation of the relevant hybrid banana varieties (with respect to sensory and agronomic attributes and the prices they would be willing to pay for the hybrid banana varieties) are presented. Second, the impact of the consumer characteristics and variety attributes (both sensory and agronomic) as determinants of consumers‟ purchase intention of the banana varieties are statistically analysed, the results presented and discussed.

5.3.1 Agronomic performance of the hybrid bananas in all regions of Uganda

The acceptability of a new banana hybrid by consumers is dependent on a combination of bunch attributes such as bunch weight (Kikulwe et al., 2011), number of hands, fingers and sensory attributes. Bananas are mainly sold as bunches and, to a lesser extent, as fingers (Odeke et al., 1999). The bunch attributes are dependent on agronomic attributes such as number of leaves and pseudo stem girth (Uazire et al., 2008).

Analysis of variance was performed to test whether there are significant differences in agronomic performance across varieties that seem to influence consumer preferences for the hybrid banana varieties (Table 5.2). The results suggest that hybrid banana varieties do not differ significantly (P > 0.05) between the pseudo stem (girth), girth 1 meter, hands, fingers, total number of leaves, the youngest leaf spotted and the bunch weight (Table 5.2). Variations were also observed in the plant girth across all the varieties (with the average girth at base of M9 (74.7cm), M17 (76.5cm), Mbwazirume (75.9cm), M2 (74.7cm), and M14 the smallest girth (67.1cm) (Table 5.2). Bigger pseudo stem (girth) reflects a healthy plant and increases the potential for production of heavier bunches with many clusters which attracts better prices in the market. According to Uazire et al. (2008) greater circumference of pseudostem increases the potential for production of heavier bunches. Considering the total number of leaves (Tl), all the hybrid banana varieties produced a higher total number of leaves than Mbwazirume (Table 5.2). The number of leaves produced by a plant and its functional leaf area are critical factors in determining the yield potential (Sheela and Nair, 2001; Uazire et al., 2008). The higher the number of youngest leaf spotted, the more the functional leaves on the plant and the lower the disease pressure. More functional leaves on the banana plant increase the production of heavier bunches that attract consumers and better prices in the market.

Table 5.2 Mean squares of analysis of variance of agronomic performance for hybrid bananas in all regions of Uganda, 2010

Variety type	Pseudo stem Girth at base	Girth 1 meter	Hands	Fingers	Total leaves	Youngest leaf spotted	Bunch weight
M2	74.68 (0.720)	54.93 0.571	9.25 (0.113)	8.04 (0.067)	7.10 (0.120)	6.01 (0.134)	25.84 (0.627)
M9	79.78 (0.452)	58.26 (0.358)	9.45 (0.071)	8.15 (0.041)	7.53 (0.075)	6.47 (0.084)	27.59 (0.393)
M14	67.09 (0.752)	49.37 (0.596)	8.48 (0.118)	8.24 (0.069)	5.95 (0.125)	5.06 (0.131)	22.52 (0.655)
M17	76.46 (1.065)	56.84 (0.845)	8.96 (0.166)	9.06 (0.097)	7.07 (0.178)	6.63 (0.199)	26.19 (0.928)
Mbwazirume	75.93 (0.671)	59.19 (0.533)	7.65 (0.105)	7.81 (0.062)	6.37 (0.112)	3.97 (0.125)	17.37 (0.586)
LSD (0.05)	3.30	2.4	0.5	0.2	0.5	0.6	1.7
CV (%)	17.77	18.99	23.72	15.15	32.23	43.99	48.05

Notes: Figures in parenthesis show the standard errors
Source: See Table 3.1

The results show that all four hybrid banana varieties produced significantly heavier bunches (M2 = 25.8kgs, M9 = 27.6 kgs, M14 = 22.5 kgs, and M17 = 26.2 kgs) than Mbwazirume

(17.4kgs) (Table 5.2). The increase in bunch weight for Hybrids M9 and M17 compared with the local variety may be attributed to increased number of leaves and pseudo stem girth at base (Table 5.2). According to Gold et al. (2002) bunch size largely determines marketability of a cultivar. In most cases, consumers consider bunch size, among other traits, when buying bananas from the market.

5.3.2 Evaluating the role of hybrid variety attributes to variety preferences

Product attributes are considered as evaluative criteria from which consumers form beliefs, develop attitudes and build up intentions to buy a product (Sabbe et al., 2009). Table 5.3 reports the participants" mean scores of the sensory attributes between the hybrid bananas and the local variety samples in terms of their visual and test evaluations. A higher score indicates a stronger preference for an attribute.

Table 5.3 Mean scores of the sensory attributes of different banana hybrids in Uganda, 2010

Cultivar type	Taste	Flavour	Texture	Colour of food	Overall acceptability
M2	3.84[b]	3.70[b]	3.77[b]	3.81[b]	3.52[b]
M9	3.75[b]	3.68[b]	3.77[b]	3.80[b]	3.63[b]
M14	3.12[c]	3.03[c]	2.87[c]	2.94[c]	3.43[b]
M17	2.76[d]	2.82[d]	2.66[d]	2.79[c]	2.64[c]
Mbwazirume	4.10[a]	3.99[a]	4.22[a]	4.15[a]	3.88[a]
LSD(0.05)	0.36	0.21	0.22	0.9	0.26

Notes: [a,b,c,d] Values followed by the same letter within a column are not significantly different at P=0.05 with respect to the least significant difference test.
Scale: 1 = Very Bad, 2 = Bad, 3 = Fair, 4 = Good, 5 = Excellent.
Source: see Table 3.1

Considering the sensory characteristics of the new hybrid banana varieties, there was no significant difference between Hybrid M9 and M2 (P>0.05) (Table 5.3). However, there were significant differences between M14, M17 and Mbwazirume. M17 was the least preferred variety with respect to all attributes. The local variety Mbwazirume was perceived to be better than all new varieties in all sensory attributes (Table 5. 3). In terms of colour of the food, Mbwazirume had the most preferred colour (Yellow), followed by M2 and M9. There was no significant difference between the colour of M14 and M17 although both were significantly inferior to Mbwazirume. According to Dadzie and Orchard (1997) and Nowakunda and Tushemereirwe (2004), the preferred colour of the cooked banana product is yellow, an attribute that was not observed in the hybrids M17 and M14. Considering consumers‟ overall acceptance, the trend was similar to the sensory attributes assessment. The results suggest that there was no significant difference ($P > 0.05$) in overall acceptability scores for hybrids M2, M9 and M14, implying that they were scored the same for acceptability.

5.3.3 Purchase intentions and participants' willingness to pay for hybrid bananas

The results from one way analysis of variance (ANOVA) of the prices consumers would be willing to pay for the hybrid banana varieties across regions show that participants would pay significantly higher prices for all the banana varieties in the Eastern region compared to other regions of Uganda (Table 5.4). This result could be attributed to the limited availability of cooking bananas in this region. Banana production in this region is predominantly subsistence and therefore banana varieties that would improve food security are considered most important.

Table 5.4 Average prices (in Uganda Shillings) for a 30kg bunch of hybrid bananas consumers are willing to pay in Uganda, 2010

Cultivar	Central (N=261)	Eastern (N=364)	Western (N=200)	Mid-Western (N=83)	Overall Mean (N=908)	F-statistic
M2	6115.0 (2768.6)	10098.7 (6069.2)	5311.0 (3534.3)	7705.3 (5260.1)	7832.5 (5275.9)	21.83***
M9	7082.3 (4299.2)	9537.7 (4552.8)	7696.2 (5293.6)	7314.3 (5363.4)	8465.9 (4871.7)	7.44**
M14	-	6867.5 (4751.4)	3225.8 (2015.9)	11236.8 (4571.5)	6695.0 (4819.1)	13.32***
M71	6833.3 (3336.7)	7887.5 (3300.1)	2773.7 (1725.9)	5812.5 (4550.8)	6343.2 (3699.6)	11.41***
Mbwazirume	7379.2 (4892.1)	10154.0 (4798.9)	7125.0 (4509.6)	6964.3 (4484.4)	8570.7 (4931.7)	12.33***

Notes: Figures in parenthesis show the standard deviations. The average exchange rate between February to August 2010 was US$ =UGX 2192.5
Source: See Table 3.1

The results show that hybrid M2 would fetch significantly higher prices in the Eastern region compared to the Mid-western region while consumers from the Western region would pay the least price for this hybrid. With respect to hybrid M9, participants in the Eastern region would pay a significantly higher price for this variety, followed by the Western region, with the Central region being the lowest (Table 5.4). Among all the hybrid varieties, the results show that consumers were willing to pay a significantly higher price for Hybrid M9 compared with Hybrid M17. This could be due to its desirable attributes like taste, flavour, texture and colour of the food for these two varieties (Table 5. 3). Also a comparison of willingness to buy values and the consumer" socioeconomic characteristics (Appendix 5.1) suggest that there were significant differences for all the characteristics with the exception of respondent gender and willingness to purchase M14.

5.3.4 Determinants of purchase intention

Table 5.5 shows the consumer buying intentions for the five banana varieties under study and the characteristics that made the hybrids appealing to the participants. The participants in the field days evaluated specific sensory attributes for each hybrid variety. Logit model analysis was then conducted taking the binary response variable (1 if a respondent would purchase a variety; 0 otherwise), to identify the impact of these evaluations on the purchase intentions for each of the hybrid banana varieties.

Table 5.5 Logit models of hybrid banana purchase decisions by farmers/consumers, Uganda, 2010

Variable	M2 Coefficient Estimate	M9 Coefficient Estimate	M14 Coefficient Estimate	M17 Coefficient Estimate	Mbwazirume Coefficient Estimate
Gender	-0.053 (0.270)	0.480 (0.306)	-0.071 (0.323)	-1.676*** (0.472)	-0.184 (0.299)
Age	0.009 (0.007)	0.028** (0.008)	0.014 (0.009)	0.031** (0.011)	0.004 (0.008)
HHsize	0.014 (0.034)	0.001** (0.036)	-0.062 (0.038)	-0.009 (0.052)	0.001*** (0.036)
Educ	0.350** (0.101)	0.017 (0.027)	0.117 (0.114)	0.541** (0.161)	0.441 (0.117)
HHAssets	6.56e-08 (4.52e-08)	2.45e-08 (5.13e-08)	-1.56e-07 (1.09e-07)	-1.41e-07 (2.11e-07)	-3.57e-08 (7.51e-08)
Taste	0.390* (0.207)	0.112 (0.231)	0.673** (0.222)	0.586** (0.281)	0.622** (0.196)
Flavour	0.536** (0.198)	0.459** (0.231)	-0.368 (0.239)	0.397 (0.384)	0.056 (0.215)
Texture	0.426** (0.180)	0.100 (0.090)	0.369 (0.270)	0.439 (0.312)	0.285 (0.228)
Colour	0.087 (0.109)	0.233 (0.169)	0.073 (0.220)	0.021 (0.178)	0.156 (0.220)
Acceptability	0.121 (0.080)	0.320** (0.104)	-0.123 (0.144)	0.464 0.178	0.129 (0.091)
Central region	-0.088 (0.550)	-0.349 (0.382)	-	-0.803 (0.643)	0.067 (0.471)
Eastern region	-0.650 (0.520)	0.380 (0.363)	2.657*** (0.585)	-0.236 (0.878)	-0.337 (0.350)
Western region	-1.208** (0.518)	-	-	-0.686 (0.497)	-
Mid-western region	-	-0.461 (0.235)	-	-	-0.742 (0.589)
Logbunch weight	-0.122 (0.092)	-0.120 (0.235)	-0.045 (0.290)	-0.011 (0.291)	0.265** (0.113)
Constant	-4.759*** (0.589)	-3.372*** (0.889)	-3.555** (1.098)	-4.608*** (0.696)	-4.274*** (0.386)
Number of observations	908	880	315	567	829
Wald chi2	237.52	463.42	78.05	166.43	331.12
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.5961	0.6049	0.3216	0.7089	0.6216
Log pseudo Likelihood	-238.2327	-239.57183	-147.643	-92.903613	-215.35727

Notes: ***, **, * = significant at 1%, 5%, and 10% probability levels, respectively. Standard errors are shown in parentheses.
Source: see Table 3.1

Consumer characteristics such as age, education, place of residence, income and gender, among others (Moser et al., 2011; Phuah et al., 2011), are important variables in explaining the likely consumer demand for the hybrid bananas in Uganda. The results show that respondent‟s age is statistically significant and positive for Hybrids M9 and M17. The age effect suggests that older consumers that participated in the field days were more likely to purchase M9 and M17 when found in the market (Table 5.5). This could perhaps be explained by the observation that older and more experienced consumers are better able to judge the variation in taste (Lyly et al., 2007) and are able to identify their preferred banana variety. The variable education is statistically significant and positive at the 5% level for hybrids M2 and M17 implying that consumers with higher education levels are more likely to purchase these varieties. Also, household size has a significant positive effect on the likely purchase for hybrid M9 among the hybrid varieties. The positive and significant sign for this variable suggests that the larger the household size, the more the likelihood for purchasing hybrid M9. A possible explanation could be that the hybrid is perceived to produce good bunch sizes that are likely to attract households with larger families for food security.

The study has demonstrated that different consumers will respond differently with respect to varietal attributes such as texture, taste, flavour and colour of the food. The taste attribute was found to be positively related to the likelihood of purchasing all the hybrid banana varieties with a significant effect on hybrids M2, M14 and M17. The importance of taste in food choice has been proven in other studies. According to Sabbe et al. (2009), the first impression of taste determines whether a consumer tries the consumption of a product for a second time or not. Taste was also found to be important in influencing consumers‟ willingness to use beverages and ready-to-eat frozen soups containing oat b-glucan in Finland, France and Sweden (Lyly et al., 2007).

Similarly, with the exception of hybrid M14, the coefficient for flavour was more important in explaining the likelihood of consumer‟s purchase for all the hybrid bananas and statistically significant for hybrids M2 and M9, implying that flavour is considered when making purchase decisions for these two varieties. This result suggests that the participants who attended field day evaluation activities indicated a more positive buying intention for hybrids M2 and M9 because of their preferred flavour. In a similar study, Moser et al. (2011) reported that organic and low environmental impact fruit and vegetables are commonly bought because they are thought to be superior in terms of flavour.

The variable for colour of the cooked food for the hybrid bananas suggests that consumers that participated in the evaluation field days were likely to purchase hybrid M9 because of its attractive colour when cooked. Colour is a very important sensory attribute of most foods because it influences the consumer's first judgment that determines the overall acceptability of foods (Sangketkit et al., 2000). In Uganda, most consumers prefer bananas with a yellow pulp colour when cooked. According to Dadzie and Orchard (1997), if the pulp colour is white, consumers feel that the fruit is immature and it may not be accepted. In terms of overall acceptability, hybrid M9 was significant and positive with consumer likelihood of purchase when found in the market. This could be because of its desirable attributes, particularly in flavour, colour of the food when cooked and the relatively heavy bunch size as manifested in the bunch weight (Table 5.3).

This study has demonstrated that the majority of consumers that participated in the field day activities are likely to purchase Hybrid M2 when found on the market because of its desired attributes: taste, flavour and texture. This indicates that there are good marketing possibilities for this hybrid when introduced to a wider consuming community. The regional location of the participants that attended the field days was found to reduce the likely purchase of the hybrid banana varieties, with participants located in the Western region not likely to purchase hybrid M2 when compared with those from the Mid-western region (Table 5.5). The marginal effect results indicate that the participants in the Central region are 10% less likely to purchase hybrid M2 compared with those from Mid-western region (Table 5.6). Moreover, consumers located in Eastern region of Uganda are more likely to purchase hybrid M9 compared with those located in Western region and significantly more likely to purchase hybrid M14 compared with those consumers in the Central and Western regions. The marginal analysis shows that consumers in Eastern region are more likely to purchase hybrid M9 by 8% compared with those in the Western region, and by 53% of M14 compared with those in the Western and Mid-Western regions of the country (Table 5.6).

Table 5.6 Marginal effects from the Logit models of hybrid banana purchase decisions by farmers/consumers, Uganda, 2010

Variable	M2 Dy/dx(Z)	M9 Dy/dx(Z)	M14 D y/dx(Z)	M17 y/dx(Z)	Mbwazirume Dy/dx(Z)
Gender	-0.005 (-0.20)	0.107 (1.53)	-0.018 (-0.22)	-0.057 (-3.44)	-0.035 (-0.63)
Age	0.001 (1.25)	0.006 (3.25)	0.004 (1.49)	0.002 (2.80)	0.001 (0.51)
HHsize	0.001 (0.39)	0.000 (0.02)	-0.015 (-1.63)	0.000 (-0.18)	0.000 (0.02)
Educ	0.035 (3.15)	0.004 (0.64)	0.029 (1.02)	0.027 (2.74)	0.084 (3.47)
HHAssets	6.65e-09 (1.45)	5.29e-09 (0.48)	-3.88e-08 (-1.43)	-7.15e-09 (-0.70)	-6.83e-09 (-0.48)
Taste	0.040 (1.97)	0.024 (0.48)	0.168 (3.03)	0.030 (2.04)	0.119 (3.12)
Flavour	0.054 (2.61)	0.099 (2.00)	-0.092 (-1.54)	0.020 (1.00)	0.011 (0.26)
Texture	0.043 (0.02)	0.022 (1.12)	0.092 (1.37)	0.022 (1.45)	0.055 (1.26)
Colour	0.009 (0.79)	0.050 (1.39)	0.018 (0.33)	0.001 (0.12)	0.030 (0.71)
Acceptability	0.012 (1.48)	0.069 (3.01)	-0.031 (-0.86)	0.023 (2.51)	0.025 (1.39)
Central region	-0.009 (-0.16)	-0.073 (-0.94)	-	-0.034 (-1.36)	0.013 (0.14)
Eastern region	-0.063 (-1.26)	0.083 (1.04)	0.528 (7.19)	-0.012 (-0.27)	-0.064 (-0.99)
Western region	-0.096 (-2.68)	-	-	-0.030 (-1.43)	-
Mid-western region	-	-0.092 (-0.96)	-	-	-0.121 (-1.57)
Logbunch weight	-0.012 (-1.32)	-0.026 (-0.51)	-0.011 (-0.15)	-0.001 (-0.04)	0.051 (2.27)

Notes: Z values are shown in parentheses
Source: See Table 3.1

5.4 Summary

Despite the introduction of hybrid banana varieties among the farming communities in different agro-ecological regions of Uganda, no study has attempted to investigate the effect of banana cooking desirable traits and consumption characteristics on the likelihood of consumers purchasing the hybrid bananas. Sensory evaluation showed that hybrid bananas differed significantly with regard to different sensory attributes. Attributes such as taste, flavour, texture, colour of the food when cooked and bunch weight are known to attract consumers. With respect to the prices, participants from the Eastern region would pay significantly higher prices for all the banana varieties compared to other regions of Uganda.

The results suggest that age, education, good taste, flavour and texture were the most important factors that are likely to positively influence the purchase of most of the hybrid banana varieties. In terms of overall acceptability, hybrid M9 scored significantly higher compared with other hybrid varieties.

The study suggests that consumer evaluation of the hybrid banana varieties based on their attributes can predict their acceptance on the market. Further studies could target investigating consumers‟ actual purchase behaviour for these varieties targeting regions where the project introduced them. More details on the conclusions and policy implications of the empirical results of this chapter are contained in Chapter 6. In brief, this chapter has studied the determinants of consumers‟ willingness to purchase banana hybrids in Uganda. The next chapter will be presenting the summary, conclusions and recommendations of the thesis.

CHAPTER 6

SUMMARY, CONCLUSIONS, RECOMMENDATIONS AND FUTURE RESEARCH DIRECTIONS

This chapter provides a brief summary of the purpose and methodology of the research, conclusions, policy implications and future research directions.

6.1 Recapping the purpose and methodology of the research

Banana and plantain (*Musa* spp.) is an important world food security crop for the livelihoods of millions of smallholders in tropical countries. East Africa is the largest producing and consuming region in Africa. More than 50% of Uganda"s 30 million people depend on bananas as their main source of livelihood. Household surveys indicate that areas where banana production is a main activity are rarely hit by famine and are relatively stable in terms of household incomes. The continuous production of bananas all year round offers a significant income generation advantage over traditional cash crops for many smallholder farmers who grow the bulk of the crop in East Africa. Above all, it is potentially a high yielder and the least labour demanding food crop to produce provided the plantation lasts more than five years to enable the farmer to recover the initial high cost of establishing the plantation.

Despite the crop"s importance for food security, its productivity in Uganda has been increasingly declining. The banana yields in Uganda are low (5-30 t/ha/year) and are declining further, compared to potential yield (70 t/ha/year). The leading factors responsible for the decline in productivity of the East African highland cooking bananas (*Musa genome group* AAA-EA) include: pests (banana weevil and nematodes), diseases (black Sigatoka, banana bacterial wilt), soil fertility decline, and socio-economic constraints (high costs of managing the crop, competition for labour with other enterprises, marketing difficulties and low genetic diversity, among others). This prompted NBRP to conduct a banana breeding programme in 1994. The programme developed new banana 'Matooke' hybrid varieties (M2, M9, M14, and M17). These varieties have been under evaluation in different agro-ecological regions of Uganda since 2008 with Mbwazirume (a traditional variety) as a local check.

The new hybrid banana varieties are being disseminated to the farming communities in Uganda. So far, no study has evaluated farmers‟ and consumers‟ acceptance of these new cooking banana hybrids. Specifically, no potential adoption study had been conducted with respect to farmers‟ preferences regarding varietal attributes and farmer specific characteristics that are likely to determine their adoption. Research was needed to determine the variety choice among the banana hybrids by the farming community and understanding of how consumers will perceive the hybrid banana varieties when found on the market, and their purchase intentions with respect to critical sensory and agronomic qualities. The demand for improved banana varieties is likely to increase if such varieties are designed to include end users‟ preferred traits. Also it was important to investigate farmer‟s perceptions of the hybrid banana varieties contributing to the smallholder households‟ livelihoods in terms of food security, household income and poverty reduction.

The study used primary data collected from a survey of 192 participating (host farmers of the demonstration plots) and 454 non-participating farmers (neighbours with no demonstration plots) and 908 consumers that participated in farmer field days to evaluate the hybrid banana varieties in 39 districts, located across six Agro-Ecologic Zones in the four administrative regions (Mid-Western, Central, Western and Eastern) of Uganda. The interviews were held between May and September 2010 using a pre-tested questionnaire.

The study examined the effects of farmers‟ preferences regarding varietal attributes, along with farm and farmer specific characteristics in the early stage adoption of hybrid banana varieties using factor analysis and a Zero Inflated Poisson (ZIP) regression model. Evaluating the socioeconomic and farmer perceptions that are likely to influence the up-take of the hybrid bananas remains critical to improve the long-term banana breeding strategy in Uganda. The study also analysed the effects of farmer characteristics, variety attributes and agro-ecological conditions on banana variety choice in Uganda, with the application of a multinomial logit model. This was meant to inform the determination of which variety to promote to the wider farming communities in Uganda.

Finally, this study also investigated the effect of banana cooking desirable traits and consumption characteristics on the likelihood of consumers‟ purchasing of the hybrid bananas. The analysis of variance and logit models were used to determine the consumption characteristics and sensory attributes that are most important in predicting the likelihood of consumers" purchasing of hybrid banana varieties.

6.2 Conclusions

The results showed that the hybrids are preferred to a traditional variety (Mbwazirume) based on better production characteristics (tolerance to Sigatoka, weevils, and nematodes, and good agronomic and yield attributes) but are regarded as inferior in terms of consumption characteristics (taste, flavour, skin colour, suitability as Matooke) compared to Mbwazirume. This suggests that adoption of these varieties will be determined mainly by production and agronomic attributes these varieties possess over the local varieties. The results further revealed that, with the exception of hybrid M14, all the Matooke hybrid bananas considered in this study scored above 3.0 (out of a maximum of 5.0) in terms of their cooking attributes, implying that they have acceptable cooking qualities. Hybrid M9 was closest to the reference variety with regard to all cooking quality traits. To this end, in case it is not feasible for breeders to holistically have a multi-attribute breeding approach for a particular hybrid variety, focussing on the improvement of consumption attributes could be an effective way forward. However, there is still a need for a breeding approach that simultaneously enhances the production as well as consumption attributes of varieties. This is likely to promote adoption of hybrid banana varieties.

The empirical results further suggest that, among the hybrids, M9 was the most preferred variety followed by M2 and M14 in terms of both production and consumption characteristics. However, many of the respondents (39.4%) chose Mbwazirume as their most preferred variety. The results of the study highlight the importance farmers attach to banana consumption attributes: good taste, large bunch size, soft food and good flavour. This suggests that farmers would particularly be looking for varieties with better taste and soft food for their household consumption needs. The study further revealed that total land size, taste and regional location, particularly in the Central region, were negatively associated with hybrid choice while farmers" perception that hybrid bananas could reduce food insecurity were positively associated with probabilities of hybrid choice. To this end, most of the farmers indicated they will grow these hybrids to provide them with food security at subsistence level.

The results from sensory evaluation showed that hybrid bananas differed significantly with regard to different sensory attributes. There was no significant difference between hybrids

M2 and M9 (P>0.05). However, there were significant differences between M14, M17 and Mbwazirume. M17 was the least preferred variety with respect to all attributes. The study findings show that participants from the Eastern region would pay significantly higher prices for all the banana varieties compared to other regions of Uganda. The results suggest that age, education, good taste and flavour were the most important factors that are likely to positively influence the purchase of most of the hybrid banana varieties. In terms of overall acceptability, hybrid M9 scored significantly higher compared to other hybrid varieties. The study results suggest that consumer evaluation of the hybrid banana varieties based on their desirable attributes can predict their acceptability on the market. This means that banana breeders should also focus on taste, flavour and colour because these features are regarded as important by consumers.

High yield, food security and income generation, resistance to diseases and pests, drought tolerance and the longevity of the hybrid plantations were the reasons given by banana farmers for their preference for new varieties. The study shows that 41% of the host farmers were having more than sufficient food supplies due to the hybrids, while 85% mentioned that their household food situation had substantially improved for the better over the past 3-5 years due to the hybrids suggesting that the hybrid banana varieties could be a source of food security to most of the rural farmers. The study shows that farmers were willing to pay for the planting materials with no significant differences in prices across varieties.

6.3 Recommendations and policy implications

The findings, demonstrate that among all the hybrid banana varieties considered, variety M9 is preferred as having a relatively good performance with respect to most required production and consumption traits. This suggests that M9 could be disseminated to a wider farming community, especially to larger family households, and to wealthier and younger farmers. This could be done through development of a farmer selection criteria targeting these categories of farmers. The production attributes of hybrid M9 are more likely to attract households with larger families to harvest more and achieve household food security. Also wealthier producers with larger farms are more willing to take risks and devote portions of the land to an untried variety compared with those with smaller areas. Furthermore, the younger farmers in most cases are greater risk takers compared to the older ones who have more attachment to heritage and tradition and may want Matooke to look and taste the way it has always been. Different approaches could be adopted in the dissemination of these varieties. One of them could be the participatory farmer led extension approach that involves the need to support farmer networking to reinforce individual learning, centered within a process which is facilitated by highly trained personnel (agricultural professionals - both researchers and extension workers), thus comprising an agricultural knowledge and information system. Another way could be the participation of multi-stakeholders approach. This strategy could be adopted on the understanding that diffusion of technologies is a social process and therefore, integrating different social networks (ie cultural leaders, local political leaders, community workers, and farmers), would enhance the dissemination of these hybrid banana varieties to many farmers.

The study also suggests that farmer access to extension services is likely to have a relatively large impact on the probability of adoption of hybrid banana varieties. This implies that coordination between researchers and extension agents should be strengthened and greater emphasis should be placed on more involvement of extension services in promoting hybrid bananas in the farming communities. This involvement could include effective provision of appropriate information concerning the hybrid bananas in order to increase knowledge and farmer awareness about the potential benefits of the hybrids. The study also demonstrated that the hybrid bananas, combining the desirable characteristics of pests and disease tolerance and yield and consumption attributes can be more successful in terms of adoption by farming communities in Uganda. These hybrid varieties could be disseminated by extension agencies, especially the National Agricultural Advisory Services (NAADS) and NGOs (such as World Vision and BUKADEF already involved in promoting banana production) targeting farmers in growing areas of the country which are currently prone to disease threats that have reduced banana production in Uganda.

The study has demonstrated that farmers have relevant knowledge that can be used in setting banana breeding priorities so that they can select varieties that potentially have traits of their preferences. Therefore, it is an opportunity for the banana breeding programmes to tap into this knowledge and translate it into their potential varietal improvement programmes. Farmers should be involved in the breeding process of new crop varieties through the participatory research methods. In this process, banana breeders will learn about farmers‟ preferences and take them into account when developing new varieties. Farmers will also learn about banana production from breeders and develop confidence in the new varieties since they will have participated in the evaluation process. This is likely to shorten the time required for evaluation and adoption of the preferred varieties.

The results have implications for the banana crop improvement programme underway in Uganda. Farmers, as the ultimate consumers of improved seeds, have a stock of knowledge about the production environment and their variety and attribute preferences that are critically important in influencing, not only the decision for the variety choice, but also the level of adoption. Hence, policy makers could prioritise farmers‟ involvement in varietal improvement and development programme so as to address their concerns and preferences.

The preference for hybrid M9 among the hybrids is a reflection of the desirable attributes associated with this variety. The implication for banana breeders could be that breeding efforts should consider attributes like bunch size, good taste, soft food, agronomic characteristics, and pest and disease tolerance while developing new varieties. The M9 variety could be promoted further on a wider scale for more farmers to benefit from it. The perception that new hybrid banana varieties could improve food security is a reflection of the production environment that farmers are facing, for which hybrid banana varieties could make significant contributions, especially when widely disseminated.

While disseminating the hybrid banana varieties, especially hybrids M2 and M9, farmers with relatively small pieces of land should be targeted for on-farm promotional activities to easily up-scale the potential adoption and impact of the hybrid technologies, especially in areas where household food security is more of an issue. The majority of farmers in Uganda are constrained by lack of access to improved and clean planting materials of desired quality. Efforts should be made to promote and make available planting materials to more farmers, particularly for the most preferred variety for better yields that can boost food security. This could be done through developing a seed production and dissemination mechanism (through public-private partnership) that enables access to seed by poor rural farming communities. There is a need for creating partnerships with private tissue culture laboratories in Uganda (such as Bio crops Ltd, Science Foundation for Livelihoods & Development (SCIFODE) Ltd and Agro-Genetic Technologies Ltd (AGT) to multiply the plantlets and then with the local government extension agencies (like NAADS) and NGOs (such as World Vision) that are already involved in promoting banana production for technical backstopping and for enhanced multiplication and dissemination of these varieties. NGOs, churches, schools, and donor agencies could partner with the researchers to champion further dissemination. A wider farming community, particularly in non-banana growing areas like the northern part of the country, could benefit from hybrid banana varieties. This could be done through establishing more demonstration plots in this region and engaging more farmers with start-up planting materials of these hybrids. In this regard, emphasis could be put on training the host farmers and farmer groups in seed multiplication (macropropagation) and quality control techniques, setting up sucker recovery and distribution process to reach wider farming communities. For instance, when a beneficiary receives 60 plants, let him/her give back 120 plants to the project to pass on to two more farmers and the process continues. Information about these hybrids that is not directly accessible to the end users, like consumption attributes, could be packaged in the form of posters and brochures to be distributed to end-users. The study shows that there is a need for improving hybrid M14, targeting its bunch sizes, fingers and taste.

6.4 Directions for future research

The hybrid bananas have only been with the farming communities in Uganda since 2008, and given that the study is based only on the second year of the project, future research has to elicit farmers‟ experience-based perceptions and explain the dynamics of adoption and/or dis-adoption. There is a need to monitor the adoption and dis-adoption of the studied hybrids as the programme progresses. Once the hybrids are released, the dynamics of actual adoption and dis-adoption need to be studied to inform all stakeholders in the banana industry, including researchers and policy makers. A panel data study could be useful to confirm the results of the current study to allow for the control of unobserved effects that remain relatively fixed over time at the household and community level.

In Chapter 5 of this study, the dependent variable in an empirical analysis was consumers‟ intention to purchase a hybrid banana variety when found on the market. Although this measure involved the actual varieties presented to consumers, it may have been difficult for the participants to evaluate their purchase intentions for the bananas that were not yet available on the market. Future studies could target investigating consumers‟ actual purchase behaviour for these varieties in the target regions. A market testing and promotional study could be done in some urban markets particularly those that handle the highest volumes of cooking bananas in the country, where these bananas could not have reached.

There is a need for further study to find out the relationship between hybrid banana sales, wealth creation and poverty reduction. To establish the cause and effect relationship, panel data could be used to control for unobserved effects that remain relatively fixed over time at the household and community level. Evaluations should also examine the impacts of these hybrids on income and food security status of different social groups. Monitoring and evaluating the impacts (on incomes and food security) of the hybrids would generate information relevant for future policy decisions to upscale the impacts and maximize the benefits.

Another study could target evaluating these banana hybrids for resistance to major pests and diseases like banana weevils, nematodes, Fusarium wilt, bacterial and viral diseases including *banana Xanthomonas wilt*, *Banana Streak virus* (BSV) and *Banana Bunchy Top Virus* (BBTV) that are commonly transmittable through planting materials. These evaluations could include introducing banana hybrids in formally non-banana growing agro-ecologies of Uganda, particularly northern Uganda and assess resistance/tolerance to nematodes, black Sigatoka and drought stress and other constraints.

There is also a need for further research to confirm the ability of these new hybrid banana varieties to withstand the current drought stress, their adaptability and stability in different agro-ecologies of Uganda. Drought is increasingly becoming an eminent challenge to banana production and productivity in some parts of the country like the central and northern regions. The majority of the farmers in these regions observe low yields during prolonged dry spells. There is a need to investigate the banana crop management technology requirements (sanitation, weed control, sucker management) for these particular hybrid varieties especially, and possible ways of disseminating this information to guide banana farmers, particularly targeting areas where banana production and productivity has declined.

Further research is also needed to establish an efficient seed system that will support the current existing dissemination methods for new varieties to smallholder farmers, targeting the poor rural farming communities in Uganda. A robust seed system that will enhance seed production and dissemination and access to seed by poor rural farming communities is needed. In collaboration with the banana breeders, there will be a need for more efforts aimed at improving hybrids M14 and M17 for both farmers‟ and consumers‟ satisfaction with respect to desirable production and consumption attributes. Another area could be identification of quality components for these hybrid banana varieties at post-harvest stage, especially for the fresh bananas destined to the local and export market.

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APPENDICES

Appendix 3.1 Factor Analysis of farmer perceptions of variety attributes on demand for the M17 banana variety, Uganda (n=149)

Variety attribute	**Factor Loadings for variety M17**			
	Factor 1 Sensory	**Factor 2** Biotic	**Factor 3** A biotic	**Factor 4** Agronomic
Tolerance to drought	-	0.43	-	0.52
Yield	-	-	0.67	-
Performance in good season	-	-	0.58	0.41
Early Maturity	-	-	0.42	0.52
Bunch size	-	-	0.79	-
Finger size	-	-	0.72	-
Sucker production	-	-	-	0.81
Plant height	-	-	-	0.40
Resistance to wind	-	0.37	-	-
Tolerance to poor soils	-	0.20	-	-
Resistance to black Sigatoka	-	0.78	-	-
Resistance to weevils	-	0.87	-	-
Resistance to nematodes	-	0.82	-	-
Taste	0.74	-	-	-
Texture(softness) when cooked	0.77	-	-	-
Color when cooked	0.80	-	-	-
Flavor	0.81	-	-	-
Longer storage capability after harvest	-	0.50	-	0.42
suitability to Matooke local food	0.64	0.46	-	-
Skin color	0.58	-	-	-
Easiness to peel	0.56	-	0.40	-
Exp. Var. (%)	0.20	0.15	0.13	0.09
Eigen values	7.01	2.50	1.67	1.35

Source: See Table 3.1
Notes: Farmers" perceptions on variety attributes are coded using a 5-point Likert scale, where 1= Very Poor, 2 = Poor, 3 = Fair, 4 = Good, and 5 = Very Good. Only attributes with absolute factor loadings >0.4 are included.

Appendix 3.2 Marginal effects from the ZIP regression results for early stage adoption of hybrid banana varieties in Uganda, 2008 - 2010 (N= 454)

Variable	M2 dy/dx	M9 dy/dx	M14 dy/dx	M17 dy/dx	Mbwazirume dy/dx
Educ	0.254	-0.014	0.050	0.075	0.158
HHsize	-0.128	0.534	0.182	0.024	0.121
Working	-0.394	-0.598	-0.191	-0.136	-0.076
Gender	0.715	2.255	0.337	-0.418	0.001
Age	0.160	-0.172	-0.045	0.048	2.686
Age^2	0.002	0.002	3.545	-0.001	-0.003
Farm size	0.019	0.020	-0.014	0.004	-0.022
Market	-0.011	0.015	-0.003	-0.006	-0.004
Extension	-1.851	4.261	-1.732	1.707	3.383
Population in labour force	-0.394	-0.598	-0.191	-0.136	-0.076
Sensory	-0.264	2.585	0.811	0.106	0.659
Biotic	-0.529	1.000	-6.878	0.074	-1.629
Abiotic	0.183	3.115	-.478	2.802	-
Agronomic	0.538	0.689	-0.123	-0.147	1.589

Source: See Table 3.1

Appendix 4.1 The structured matrix of canonical loadings of the independent variables on the canonical discriminant analysis of the hybrid banana varieties, Uganda, 2010/11

Variables	Structured matrix		
	Function 1	Function 2	Function 3
REduc	0.0206	0.1026	-0.3913*
FHsize	0.0818	0.2607*	0.0631
HHAGE	0.0502	-0.1011	-0.1851
Gender	-0.0956	-0.0073	-0.0125
Labourforce	0.0384	0.3016	0.2331*
Tlarea	-0.1208	-0.2090	0.0401
Hbrfood	0.1206	0.5819*	0.0468
Taste	-0.6982*	-0.1413	-0.0541
Disease	-0.0574	0.1113	-0.0642
Drought	-0.3351*	0.2022	0.1615
Good bunch	-0.2264	0.0760	0.2090*
Maturity	0.1514	-0.1020	-0.0111
Dcentral	-0.2777*	0.2326	-0.1945
Dwest	0.0948	-0.1450	0.4190
Deast	0.1023	0.0528	-0.3397*
IWealth	-0.1419	-0.0983	-0.1180
Sought credit	-0.1013	0.1534	0.2920*
Extension	-0.1225	0.3928*	-0.3014
Walking to road	0.1088	-0.0695	-0.2393
Walking to market	-0.0722	0.0974	-0.1120
Farming	0.0564	0.0606	-0.0628
Plot slope	0.0803	0.0709	-0.1241
SoilFertily	-0.0384	-0.1446	-0.2526
Canonical correlation	0.5197	0.2548	0.2278
P Value	0.0000	0.8328	0.7982
Variance accounted for (%)	0.7487	0.1405	0.1108

Source: See Table 3.1

Notes: The discriminant analysis determines if the hybrid banana varieties differed significantly on the independent variables. In this study, the discriminant analysis generated one statistically (P<.0000) significant function. This accounted for 74.87% of the explained between-group variance and has a canonical correlation of 0.52. Function 2 accounts for 14% of the explained between-group variance and has a canonical correlation of 0.25 and function 3 accounts for 11% of the explained between-group variance and has a canonical correlation of 0.23. With respect to function 1, Taste, Drought, and Central region are important and have a negative impact in variety choice for the new hybrid banana varieties. This is reflected in their higher loadings of above -20. Three variables have relatively high loadings on function 2, namely Hbrfood, Extension, and FHsize with loadings of 0.5819 0.3928 and 0.2607, respectively; they are positively important in allocation of respondents in this group. With respect to function 3, respondent education and farmer's location in the Eastern region would negatively be important while Labourforce, sought credit and Good bunch are positively important.

Appendix 4.2 The standardised canonical discriminant function coefficients of the hybrid banana varieties, Uganda, 2010/11

Variables	Canonical discriminant variate		
	Function 1	Function 2	Function 3
REduc	0.0490	0.1654	-0.4810
FHsize	-0.0380	0.2032	-0.1421
HHAGE	0.1339	-0.1450	-0.2099
Gender	-0.1390	-0.1295	-0.0398
Labourforce	0.0813	0.1769	0.3658
Tlarea	-0.1429	-0.3862	-0.0423
Hbrfood	0.1733	0.6289	-0.0032
Taste	-0.7628	-0.1396	-0.0707
Disease	-0.0045	0.1419	-0.0447
Drought	-0.4251	0.1812	0.1586
Good bunch	-0.1876	0.1303	0.3015
Maturity	0.1951	-0.1416	-0.0107
Dcentral	-0.3553	0.3539	-0.4421
Dwest	-0.0253	-0.0004	0.1356
Deast	-0.0612	0.0874	-0.4276
IWealth	-0.1725	-0.1054	-0.1238
Sought credit	-0.0510	0.2220	0.4210
Extension	-0.1407	0.3434	-0.2223
Walking to road	0.2177	-0.1189	-0.1811
Walking to market	-0.1457	0.0499	-0.0137
Farming	0.0564	0.0606	-0.0628
Plot slope	0.0803	0.0709	-0.1241
SoilFertily	-0.0384	-0.1446	-0.2526
Canonical correlation	0.5197	0.2548	0.2278
P Value	0.0000	0.8328	0.7982
Variance accounted for,%	0.7487	0.1405	0.1108

Source: See Table 3.1

Appendix 5.1 A comparison of willingness to buy values and consumers' socio-economic characteristics

Consumer Characteristics/Willingness to pay	Mean (Std. Error Mean)	t-test
Resgender - BuyM2	-.079 (.017)	-4.640***
Respage - BuyM2	20.006(.731)	27.378***
Education - BuyM2	3.573(.168)	21.273***
Hhsize - BuyM2	3.765(.148)	25.444***
Resgender - m9buying	-.165(.016)	-10.409***
Education - m9buying	3.487(.167)	20.866***
Respage - m9buying	19.921(.729)	27.340***
Hhsize - m9buying	3.680(.147)	25.096***
Resgender - buyingm14	.019(.018)	1.092
Education - buyingm14	3.671(.172)	21.405***
Respage - buyingm14	20.105(.734)	27.406***
Hhsize - m17buying	3.950(.154)	25.676***
Resgender - m17buying	.106(.017)	6.079***
Education - m17buying	3.758(.172)	21.830***
Respage - m17buying	20.192(.736)	27.445***
Education – BuyMbwaz	3.503(.166)	21.090***
Respage – BuyMbwaz	19.937(.730)	27.327***
Hhsize – BuyMbwaz	3.696(.147)	25.136***

Source: See Table 3.1
Notes: ***, **, * = Significant at 1, 5, and 10% probability levels, respectively. Standard errors are shown in parentheses.

Appendix 5.2 Household Questionnaire

The National Agricultural Research Organisation, Uganda through the National Banana Research Programme, jointly with the University of KwaZulu-Natal, South Africa are conducting a study on the ex-ante adoption and impact of hybrid bananas on smallholder farming systems in Uganda. They are requesting you to answer questions raised below as best as you can.

NATIONAL AGRICULTURAL RESEARCH ORGANISATION

The information captured in this questionnaire is strictly confidential and will be used for research purposes towards Mr Kenneth Akankwasa‟s PhD thesis.

RESPONDENT IDENTIFICATION:

Enumerator‟s Name ____ Date_________

Name of Respondent _____________________________Gender of respondent M/F_____________

Education of the respondent_______ (Number of years at school)
District___________________ Sub-county____________________________parish; _________________;

Village __________________

Region _________________________________,

PART 1. Basic household related information

1.1 How many people reside at your household___________(Household is a group of people who constantly live, cook and eat together)

Adult Males_______ Adult Females _______ Children (below 18 years of age) ________

1.2 Household (HH) member characteristics

Names of HH members (Begin with the HH Head)	Marital status 1=Married 2=Single 3=Divorced 4=Widowed 5=Married, more than one spouse	Relationship to the HH Head 1=Spouse 2=Child 3=Grandchild 4=Relative 5=Others (specify)	Age (years)	Formal Education (years)	Gender 1=male, 2=female	Area of residence 1=Urban 2=Rural	What is your main economic activity	Number of years of farming experience	Time allocated to farming per day (hrs)

Economic activity codes 1= Farming, 2=Housewife, 3=Commerce, 4=Transport, 5=brick-making,6=Hired farm worker, 7=Teacher, 8=Construction worker, 9=Others (specify)

PART 2: HOUSEHOLD RESOURCES

2.1 Land ownership, allocation and utilisation.

Parcel Number	**Area** (*acres*)	**Tenure**: 1=Mailo 2=Kibanja 3=Customary 4=Rented (hired-in) 5=Borrowed 6=Leased out 7=Other (specify)	**Land Use** (Acres)					
			Crops	Fallow	Settlement	Forested	Natural pasture	Others (specify)

2.2 How did you allocate your land during the last cropping season?

Food crops	Parcel number	Share crop area out of total crop area (%)	Amount produced in kg	Amount consumed at home in kg	Amount sold			Given away
					Qty in kg	Unit price (USh)	Income (USh)	Qty in kg
Banana								
Cash crops								

Codes for crops: 1= bananas; 2=coffee; 3= maize; 4=millet; 5=sorghum; 6=cassava; 7=sweet potato; 8=Irish potatoes; 9=beans; 10=ground nuts; 11=field peas;12=other (specify)

2.3 Farm equipment, implements and structures

Implement/ structure	Number owned at present	Number used but not owned	Means of access 1=Borrowed 2=Hired 3=Exchanged 4=Purchased 5=Others	Value of owned implements if sold today (in (UShs)	If hired, what is the rate for hire(UShs) /day	If hired (no. of days hired per season)
Tractor						
Tractor ploughs						
Animal plough						
Hoes						
Pangas						
Forked hoes						
Spades						
Wheel barrows						
Axes						
Sickle						
Chemical sprayer						
Grain mill						
Bicycle						
Motor cycle						
Pick – up/car						
Any other (specify)						

2.3 How much Labour (family and hired) did you use in banana production and in other crops?

Activity (specify code)	Parcel number			Other crops			
		Did you do this labour in Hybrid bananas over the past 12 months 1=yes 2=No	Did you do this labour in Traditional bananas over the past 12 months 1=yes 2=No				
	Plot number						
Land clearing	Men x days						
	Women x days						
	Children x days						
	Hours worked per day						
	Total cost(USh)						
Land preparation	Men x days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						
Planting	Men x days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						
De-	Men x						

suckering	days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						
Weeding	Men x days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						
Remove corms	Men x days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						
Others (specify)	Men x days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						
	Men x days						
	Women x days						
	Children x days						
	Hours per day						
	Total cost(USh)						

Other crop codes 1=Coffee 2=Maize 3=Millet 4=Cassava 5=Beans 6=Ground nuts 7=Sweet potatoes 8=Tomatoes 9=Cabbages 10=others (specify)

2.4 What were the expenses on variable inputs in Hybrid banana and Traditional banana production in the last 12 months?

Input	**IN HYBRID BANANA PRODUCTION USED** (Y or N)	Quantity used (specify units)	Total cost (UG sh)	**TRADITIONAL BANANAS PRODUCTION USED** (Y orN)	Quantity used (specify units)	Total cost (UG sh)
Household waste						
Fertilizer application						
Animal manure application						
Mulch application						
Coffee husks application						
Herbicide application						
Pesticide application						
Crop residue(maize residues)						
Compost manure						
Purchased seed						
Others(specify)						

2.5. Banana production and farm characteristics

2.5.1Tell us about the output you obtained from banana grown on this plot for the last six months

Plot no.	Banana variety	Total Number of mats	Small bunch size		Medium bunch size		Large bunch size	
			No	price per bunch	No	price per bunch	No	price per bunch
	Cooking bananas							
	Matooke mbidde							
	Dessert (Bogoya)							
	Kayinja							
	FHIAS							
	Other(specify)							

2.5.2 Tell us about the output you obtained from Hybrid bananas grown on this plot for the last six months

Banana variety	Total Number of mats	Small bunch size		Medium bunch size		Large bunch size	
		No	price per bunch	No	price per bunch	No	price per bunch
M2							
M9							
M14							
M17							
Mbwazirume							

2.6 Market access

Where do you sell your bananas	To whom do you sell your bananas? 1=Wholesalers 2=Retailers 3=Cooperative/association 4= Other (specify)			Amount (volume) per month	Transportation methods
At home					
Roadside					
Rural market					
Urban market					

2.7. Estimated time and distance it takes to go from your house to

	Distance	Time	Mode of transport 1 = by foot, 2 = by car, 3=motorcycle 4=bicycle 5=others
	(Km - Measure by car	(Minutes)	
Nearest tarmac road			
Major market for farm produce			
Health centre			
Extension office			
District office			

PART 3: FARMERS' PREFERENCES FOR HYBRID BANANA VARIETIES AND THEIR VARIETY CHOICE DECISIONS

3.1 (a) Have you ever grown improved banana varieties? 1=yes _____ 2=No ____

(b) If yes, are you still growing improved banana varieties? 1=yes _____2=No_____
(c) If no, why did you stop? _________________________

3.2 Are you participating in the Matooke Hybrid Banana on-farm Evaluation Project?
1= Yes ____ 2= No ____

(a) If yes, who selected you to participate in the project?
1= Selected by extension, 2=Invited by neighbour, 3=invited by myself, 4=Researchers, 5=others (specify)

(b) What was the criterion to be selected to participate in the project?
____
____
____
____

(c) If participating, would you continue participating in the project? 1=Yes ___ 2= No ___
(d) Give reasons for your answer____
____
_

(e) If No, specify reasons for not continuing to participate
____

3.3 (a) If not participating in the hybrid banana trials, do you grow bananas on your farm?
1=Yes ___ 2= No ____
(b) If yes, have you ever grown hybrid bananas on your farm? 1=Yes ____ 2= No ____
(c) If yes, what was the source of the banana planting materials? (i) Neighbour;
(ii) Extension workers; (iii) Kawanda Research; (IV) NAADs (v) Others (Specify)
____

(d) Which hybrid bananas are you growing 1=M2; 2=M9; 3=14; 4=M19; 5=Mbwazirume; Others (specify)
(e) Why did you choose this particular hybrid(s)? __________________________________

(f) Who influenced your decision whether to plant/ use hybrid bananas?
1= Extension; 2=Researchers; 3=Neighbours; 4=Self; 5=others (specify)
____

3.4 Assuming that the following Banana varieties were your ONLY choices, which one would you prefer to plant?

Variety	Rank in order of preference	Give reasons for the choice and your rating in the above question
M2		
M9		
M14		
M17		
Mbwzirume		

Codes for Reasons 1= Taste; 2 =tolerant to disease; 3=Tolerant to drought; 4=others (Specify)

3.5 Please rank your preferences regarding the selected banana varietal attributes on the following scale: 1= Very poor; 2=Poor; 3=Fair; 4= Good; 5=Very good

Attributes	Variety Name				
	M2	M9	M14	M17	MBwazirume
Production attributes					
Tolerance to drought					
Performance in good season					
Early maturity period					
Bunch size					
Finger size					
Sucker production					

Plant height					
Resistance to wind					
Tolerant to poor soils					
Resistant to sigantoka					
Resistant to weevils					
Resistant to nematodes					
Others(specify)					
Consumption attributes					
Taste					
Texture (softness) when cooked					
Colour when cooked					
Flavour					
Longer storage capability after harvest					
Others(Specify)					

3.6 Rate the following characteristics with respect to each of the following banana hybrid varieties, on the following scale: (1) Strongly agree; (2) Agree; (3) Disagree; (4) Don't Know

Variety attributes	**Variety Name**				
	M2	M9	M14	M17	Bwazirume
High adaptation to drought					
High adaptation to poor soils					
High adaptation to wind					
Stable in terms of yield					
Prefer to plant on owned fields, not on share cropped fields					
Needs more labour					
Usually fertiliser applied higher rate is required					
This variety needs better management					
Planted in fields that are nearer to house					
Fetches higher price					
Variety matures early					
Variety is disease resistant					
Early maturity period					
Good bunch size					
Good finger size					
Good skin colour					
Good inside colour when cooked					
Good texture					
Good flavour					
Good taste					
Easy to peel					
Others(Specify)					

3.7 In your opinion, describe what you would mean by the attributes

Attribute	Description	Reasons (where applicable)
Early maturity period		
Good bunch size		
Good finger size		
Good skin colour		
Good inside colour when cooked		
Good texture		
Good flavour		
Good taste		
Easy to peel		
Good sucker production		

3.8 What are the most important Desirable and Undesirable attributes of the hybrid banana varieties

Variety Type	Desirable attributes	Undesirable attributes
M2		
M9		
M14		
M17		
Mbwazirume		

PART 4: HYBRID BANANA UTILISATION

Variety name	Total number of bunches harvested/ month	Number consumed at home	Number given as gifts	Number stolen	Number sold	Price per bunch if sold (UShs /bunch)	Who buys[1]	Bunch weight *(in kg)*		
								Min	Max	In most cases
M2										
M9										
M14										
M17										
Mbwazirume										

[1] Who buys 1=Neighbour (local consumers); 2= Retailer traders; 3=Whole sellers; 4=others

4.1 If you are using hybrid banana varieties, do you expect to expand production in the next 3 years? 1=Yes _____2=No _______

Variety	Which of the varieties do you expect to expand production in the next 3 years 1 = increase production 2 =Decrease production 3 = No intention to change	Number of mats	Land size (acreage)	Quality of land (1)=good (2)=medium (3)=bad	Reasons for expansion of the variety
M2					
M9					
M14					
M17					
Mbwazirume					
Others (specify)					

4.2 Farmer Willingness to Pay for planting materials

Banana type	Would you buy planting materials if they were made available to you? 1= yes 2=No	If yes, how much would you pay for a Sucker (plant)?	How many of the Suckers (plants) would you need?
M2			
M9			
M14			
M17			

Mbwazirume			

4.3 Have you started giving out suckers of hybrid banana varieties (planting materials) to other

Farmers since establishing the evaluation plot? 1=yes ____2=No ____

4.4 If yes, how many suckers have you given out and who are the beneficiaries?

Variety Type	Number planted on own plot as expansion	Have you been selling suckers to other farmers 1=yes 2=no	Total Number of suckers given out			Taken by 1=Neighbour 2=People from far 3=Others (specify)
			Number Sold	Price per sucker if sold	Number given free	
M2						
M9						
M14						
M17						
Mbwazirume						

4.5 If you were to expand where would you plant new banana varieties?

Variety Name	Type of soils 1=Bad soils 2=Medium soils 3=Good soils	Reasons for the answer
M2		
M9		
M14		
M17		
Mbwazirume		

PART 5: HOUSEHOLD ASSET ENDOWMENTS

5.1 Livestock stocks

Do you have at home the following livestock and poultry? (Tick)	How many do you currently own	At what price would you sell it now?	Number sold in the last 12 months	Unit price (UShs)
Local cattle				
Improved cattle				

Exotic cattle				
Sheep				
Goats				
Local chicken				
Improved chicken				
Ducks				
Turkeys				
Pigs				
Others (specify)				

5.2 We would like to know if there have been any changes in the tenancy of the household possessions

Do you have at home the following household equipment	How many do you have currently	How long ago did you buy it (No. of Years)	How acquired[1]	If purchased, at what price did you purchase it?	At what price would you sell it now?
Bicycle					
Radio					
Chair/Table					
Car					
Mobile Phone					
Watch					
Sofa/Wooden chair					
Television					
Other(specify					

1=Purchase with own funds; 2=Purchase with loan; 3=Gift/Inherited; 4=Produced by self; 5=Borrowed; 6=Hired; 7=Exchanged; 6=others (specify)

5.3 Type of house

What is the mode of ownership of the main house?	What is the wall material of the main house?	What is the floor material of the main house?	What is the roofing material of the main house?	How many rooms does this house have in total, including bedrooms, dining room and livingroom? (Do not count the bathrooms, kitchen, hallways, garage or storage rooms)
1=Rented	1=Mud	1=Earth	1=Iron sheets	

2=Owned	2=Bricks	2=Cement	2=Grass or thatch	
3) Owned by relative	3=Stone	3=Wood	3=Banana fibre	
4) Other (specify	4=Iron sheet	4=Tiles	4=Tiles	
	5=Bricks 6=Others (specify)	5=Others(specify)	5= Other (specify	

5.4 Off- farm enterprises

Activity	Number of family Members involved	Amount of income received (UShs)/per month
Agricultural wages		
Non-agricultural wages		
Salaries		
Remittances		
Pensions		
Renting out land		
Renting out buildings		
Gifts		
Trading in crops		
Formal employment		
Casual labourer		
Brick-making		
Tailoring		
Trading in livestock		
Charcoal burning		
Other (specify)		

PART 6: ACCESS TO CREDIT

6.1 During the past 6 months, have you sought to obtain or used credit for farm production or for other purposes? (1=yes ___ 2= No ___)

6.2 If yes, please specify the purpose of Credit sought?

1=Input credit (mulch, manure, etc); 2= buying food;

3= paying school fees; 4= medical treatment; 5=others (specify)

6.3 For how long have you been using credit (years)? ___________________

6.4 How much credit did you obtain in the last two years_______________________?

6.5 What is the source of credit?

1=Money lender; 2=Cooperative; 3=Farmer group; 4=Financial institutions; 5=NGOs; 6=Neighbours; 7=Relatives; 8=Government programmes; 9=other (specify)
____

6.6.1 Was the credit received in time? 1=Yes ___ 2=No ___

6.6.2 If yes, how long did it take you to obtain the loan/credit?

Years________months _____weeks ______ days ________

6.7 How long did it take you to pay back the credit? _______________________

Loan

6.8 Were you able to pay back the credit? 1=Yes ____ 2=No ____

6.9 What was the form of payment? 1=Cash; 2=Grain; 3=others (specify)

Part 7: Extension

7.1 Have you ever been visited and advised by an agricultural officer? 1=yes ____2=No ___

7.2 If yes, indicate number of times in the last two years____________________

7.3 Do you receive any form of information on the farm? 1=Yes ____2=No ____

7.4 What type of information? 1= farming; 2= human health; 3=animal health; 4= marketing;

5=others_________________________________

7.5 Source of information: 1=extension; 2=farmer; 3=extension and farmer; 4=extension and

radio; 5=Farmer and radio; 6=Researcher; 7= others (specify) _____________________

7.6 How often do you get access to Banana growing support information?

a) Once a week; (b) Twice a week; (c) Once a month; d) Others (specify)

7.7 If not, why?
____
____
__

7.8. Do you get advice on Banana production and processing? 1=Yes ____2= No_____

7.9. If yes, explain the type of advice and from which organization.

Advice type	Source of advice/ Organization	How often?	Are you satisfied with the advice? (Yes/No)	If Yes, Explain	If No, Explain

Codes for Advice types: 1) planting material; 2) control of diseases and pests; 3) management; 4) marketing; 5) Others (specify_________________________________

7.10 Are you a member of the extension training group? 1=Yes ___2=.No ___

7.11 If No, what are your reasons for not being a member?

____

____

PART 8: FARMER GROUP OR ASSOCIATIONS

8.1 Are you a member of any farmer group or association? 1= Yes ____2=No ____

If yes, state the group ____

8.2 What are the activities of the farmer group or association? ________________

8.3 How long have you been a member? ____

8.4 Do you promote the production of bananas in the group/ association? 1=Yes____ 2=No ____

8.4.1 If yes, how? __________________________________

8.4.2. How best can these training programs be organized to benefit the farmers in your area?

a) Learning tours; b) Lectures; c) Field visits; d) Demonstrations;

e) Others (specify) ____

8.5 Does the group/ association have any influence on your banana variety choice decision?

1=Yes ____2=No ____

8.5.1 If yes, how? ____

8.6 What benefits do you obtain from the association/ group?

a) extension support; b) inputs such as improved seeds; c) exchange of labour; d) marketing; e) others (specify) ____

PART 9: FOOD CONSUMPTION EXPENDITURE IN THE PAST ONE MONTH

Type of food	In the past one month, did you buy or provide (including what you have grown or raised)?	**Source** 1=home produced 2=bought 3=given free 4=payment for labour 5=exchange 6=other (specify)	Quantity consumed (specify Unit measure)	Unit price (UShs)	Total cost (UShs)
Cereals					
Maize					
Sorghum					
Millet					
Rice					
Simsim					
Roots and tubers					
Sweet potato					
Potatoes					
Cassava					
Yams					
Legumes					
Beans					
Groundnuts					
Field peas					
Cow peas					
Bananas and plantains					
Matooke					
Mbidde					
Kayinja					
Sukalindizi					
Bogoya					
Other (specify) ____________________					
Confectionery					
Bread					
Cakes, biscuits and sweets					
Meat and meat products					
Meat					
Poultry					

Fish					
Milk					
Eggs					
Fruits and vegetables					
Oils and fats					
Beverages					
Soft drinks					
Juices					
Alcoholic drinks					
Beer (local)					
Beer (factory)					
Waragi (local)					
Uganda Waragi					
Cigarettes and tobacco					

9.1: Consumption of services and shelter (previous month)

Services	Source: 1=home produced 2=bought 3=given free 4=payment for labour 5=exchange 6=other (specify)	Quantity consumed (specify unit measure)	Unit price (UShs)	Total cost (UShs)
Education				
Medication				
Transport				
Shelter & clothing				
Energy and water				
Firewood				
Charcoal				
Paraffin				
Electricity				
Water				
Hygiene				
Soap				
Cleaning agents				
Rent				
Renting land				
Renting buildings				
Festivals and social expenses				
Wedding				
Social functions				
Gifts				
Loans to others				
House equipment				
Furniture				

PART 10: FOOD SECURITY AND OTHER BENEFITS FROM THE PROJECT

10.1 What is your household food situation with the hybrid bananas? (1) Has improved tremendously for the better; (2) has remained the same as before; (3) has declined slightly; (4) Has deteriorated tremendously; (5) Sell more food than it buys from the market; (6) Buy more food than it sells to the market (net buyers); (Tick as appropriate)

10.2 Have you experienced a problem of satisfying the food needs of your household in recent years? 1=Yes ____ 2=No ____

10.3 If yes, what would you consider as the principal reason (s) for your food shortage (Please rank)? 1= Not enough land; 2=Drought; 3= poor soils; 4= lack of fertilizers; 5= lack of planting materials; 6=Pests and diseases; 7=Lack of off-farm income; 8=others (specify) ____

10.4 What do you mostly do to survive when there is food shortage?
(Please Tick) 1=Bought food from the market; 2=Bought from other farmers in the village; 3=Borrowed or begged for that food; 4=Worked for that food; 6= Sold livestock and other assets to buy food; 7=Migration of household members to food secure areas; 8=Off-farm work and selling labour for different income-earning activities; 10=Reducing number of meals per day; 11=Seeking food aid; 13=Others (specify)

10.5 In times of plenty, how many meals do you have per day? ___________________

10.6 During lean periods how many meals do you have per day? _________________

10.7 Rate the food situation at your household before the hybrid banana project and now during the implementation of the project? 1=Remained the same; 2=Quantity of food has doubled;
3=Quantity of food has tripled; 4=Quantity of food has reduced by half.

10.8 Usually when there is good harvest of bananas how long does your harvest last?

Food supply Period	How many months does the harvest last	How many months of adequate food (banana) supply before the project
Before		
Project start		
Now		

10.9 If any change, what could be the cause?
____
____
_

10.10. In your opinion, do you think the hybrid Banana varieties could reduce your food insecurity problem? 1=Yes ____ 2=No ____

10.11Give a reason(s) for the above
____
____

PART 11: Likely impact and other benefits from the project

11.1When did you start growing the hybrid bananas? ________________________

11.2 Do you think your household has received any benefit from growing the bananas?
1=Yes ___
2=No ____

11.3 In which way is your household benefiting or likely to benenefit from the project?

Indicators of livelihood	1=Yes 2=No	Reason for change
Increased physical assets		
Increased food diversity		
Increased availability of food		
Increased stability of food supply		
Increased access to adequate food all the time		
Improved household income		
Improved health care		
Improved income for school fees		
Increased production of bananas		
Hiring of labour		
Social Obligations, e.g. giving to church)		
Increased Leisure		
social-capital through farmer groups - access to credit and other services (e.g. extension)		
Social networks		
Knowledge sharing		
Others(specify)		

11.4 For those hosting the trials, can you give any examples of the impact the hybrid bananas have had or likely to have on your family‟s livelihood?
____
____
________________________ ______________

11.5 Are there any impacts on the livelihood systems as a result of your participation in the hybrid Banana project?

11.6 What have been your household expectations of the hybrid banana project?
____
____

11.7 Rate the hybrid banana project in terms of meeting your household expectations: 1=consistently exceeded requirements; 2= consistently meeting and frequently exceeding the requirements; 3=fully is meeting my expectations; 4= often is not meeting some of my expectations; 5= Never met my expectations

11.8 Which expectations are not being fulfilled?
____
____

11.9 How could the project meet your expectations?

____

____

PART 12: Perception of the family's economic situation

12.1 Do you consider that the family‟s economic situation has changed or likely to change during or after hybrid banana project (mark with a tick)

	Better	Same	Worse
1=You consider that your current economic situation is __________ than two years ago			
2=You think that in 2 years your economic situation will be ________ than your current situation			

11.2 Fill in the table below to indicate the Banana plot physical characteristics

Plot No.	Slope: 1=Steep 2=Gentle 2=Flat	Soil depth: 1= Deep 2=Medium 3=Shallow	Soil moisture: 1=Very high 2=Medium 3=Low	Farmer perception of soil fertility" 1=High 2=medium 3=Low

11.3 What is your opinion about the hybrid bananas varieties project?____

____

____

Thank you for participating in this survey

Agronomic and Yield data sheet for Hybrid Banana varieties

District________________________ Farmer Name_________________________Sub County_______ ___________ Village______________
Qn: How many years does the banana plantation last in your area?________________
Qn : Do you think hybrid banana plantation is likely to stay logger compared to local bananas? 1=Yes 2= No If yes approximately how many years________________
Give reasons for the above answer:____
____

Cultivar	Plant_ no	Girth base	Girth_ 1m	Flower date	No hands	Fingers in lower row of the second lowest hand	Bunch development[1]	Harvest date	Bunch_ kg	TL	YLS
M2											
M2											
M2											
M2											
M2											
M2											
M2											
M2											
M2											
M2											
M9											
M9											
M9											
M9											
M9											
M9											
M9											
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M9											
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M17											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											
Mbwaz											

Bunch development stages

1=Flowering (flowers fresh to start of drying),

2=Early fruiting (flowers dried up to finger filling started but spaces still visible between fingers),

3= Late fruiting (finger filling continuing to lines on fingers start changing from angular to rounded) and (4) full maturity (ready for harvesting, finger lines more rounded than angular).

Appendix 5.3 Evaluating hybrid banana varieties for consumer acceptability

The National Banana Research Programme is evaluating some hybrid banana varieties for consumer acceptability. The programme is requesting you to receive this questionnaire and answer it as best as you can.

1 RESPONDENT IDENTIFICATION:

District____________________ Sub-county __________

Village (LC1) ______

Location variables (Region) _________________________________
Date_________

Name of Respondent ______________________________Gender of respondent M/F_____________ Age____________

Education of the respondent_______(Number of year at school) Number of Members in a household___________________

2 Farmer evaluation and perception of hybrid bananas varieties

Taste and evaluate the attributes indicated in the table per sample using the scale
1= Very poor 2=poor 3=Fair 4=Good 5= Very good

ATTRIBUTE	500	501	502	503	504
Taste					
Flavour					
Texture					
Colour					
Overall Acceptability[1]					

Acceptability[1] code: 5=Vary acceptable 4= Acceptable 3=Fairly acceptable 2= Not acceptable1= Not acceptable at all

3 Based on your own assessment of these hybrid bananas, would you be interested in buying them if priced within your budget?

Banana type	Would you be Interested in buying it if found on the market? 1= Yes 2=No 3=Not sure	If yes, How much would you pay for an average bunch of 30 kgs	If No, give reasons
500			
501			
502			
503			

504			

4 Planting material requirements

Variety	How many of the plants would you need	If Planting materials were on sale, how much would you be willing to pay for each of the varieties you have selected?
500		
501		
502		
503		
504		
Others (specify)		

5 What is your most preferred Banana variety Among these hybrid bananas varieties

Variety	Most preferred variety	What do you like most about it?