SOCIO-CULTURAL FACTORS INFLUENCING FARMER USE OF TISSUE CULTURE BANANA SEED IN CENTRAL UGANDA

BY

MULUGO LUCY
Bsc. (Hons) FORESTRY; MSc AGROFORESTRY (MAK)
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APRIL, 2021

DECLARATION

I, **Lucy Mulugo**, declare that the research reported in this dissertation titled *"Socio-cultural factors influencing farmer use of Tissue Culture banana seed in Central Uganda",* except where otherwise indicated, is my own original research, and to the best of my knowledge, it has never been submitted to any university or institution for any academic award whatsoever.

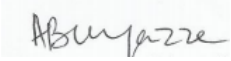
Signature: 

Date: 27th April, 2021

APPROVAL

This research dissertation has been submitted with the approval of the following supervisors:

Dr. Florence Birungi Kyazze,
Department of Extension and Innovation Studies,
School of Agricultural Sciences,
College of Agricultural and Environmental Sciences,
Makerere University

Signature: 

Date: 28th April, 2021

Prof. Paul Kibwika,
Department of Extension and Innovation Studies,
School of Agricultural Sciences,
College of Agricultural and Environmental Sciences,
Makerere University

Signature: 

Date: 28th April, 2021

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DEDICATION

In loving memory of my mother Jennipher Proscovia Frances Namwebya Mulugo (RIP).

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"Better is the end of a thing than the beginning thereof." Ecclesiastes 7:8a

"No matter how lengthy, irrespective of the hurdles and obstacles you meet; Victory is a must!" (Lucy Mulugo, 2018)

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LIST OF ABBREVIATIONS AND ACRONYMS

AGFI	Adjusted Goodness of Fit Index
AGRA	Alliance for a Green Revolution in Africa
AMOS	Analysis of Moment Structure
ASSP	Agriculture Sector Strategic Plan
AVE	Average Variance Extracted
BI	Bioversity International
BXW	Banana Xanthomonas Wilt
CAADP	Comprehensive Africa Agriculture Development Programme
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CGIAR	Consultative Group on International Agricultural Research
CR	Construct Reliability
DAAD	Deutscher Akademischer Austausch Dienst
EAHB	East African Highland Banana
EFA	Exploratory Factor Analysis
FAO	Food and Agriculture Organisation
FGDs	Focus Group Discussions
FHIA	*Fundación Hondureña de Investigación Agrícola* in Honduras (Honduras Foundation for Agricultural Research)
IDT	Innovation Diffusion Theory
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
KII	Key Informant Interview
KMO	Kaiser-Meyer-Olkin
LCs	Local Chairpersons
LTK	Local Technical Knowledge
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MM	Motivational Model
MPCU	Model of Personal Computer Utilization
NDP	National Development Plan
OLS	Ordinary Least Squares
PARI	PhD in Agricultural and Rural Innovation
PEAP	Poverty Eradication Action Plan
PFA	Prosperity for All
PMA	Plan for Modernization of Agriculture
RDS	Rural Development Strategy
RMSEA	Root Mean Square Error of Approximation
RTB	Roots Tubers and Banana
RUFORUM	Regional Universities Forum for Capacity Building in Agriculture
SCT	Social Cognitive Theory
SDG	Sustainable Development Goal
SEM	Structural Equation Modelling
SSA	Sub-Saharan Africa
TAM	Technology Acceptance Model
TC	Tissue Culture
TBD	Theory of Planned Behavior
TLI	Tucker-Lewis Index
TRA	Theory of Reasoned Action

UBOS	Uganda Bureau of Statistics
UGGDS	Uganda Green Growth Development Strategy
UNICEF	United Nations Children's Fund
UNDP	United Nations Development Program
UTAUT	Unified Theory of Acceptance and Use of Technology
WFP	World Food Program
WHO	World Health Organization

ABSTRACT

Banana, a major food and income security crop in Uganda is severely threatened by the Banana Xanthomonas Wilt (BXW) disease. Use of disease-free planting material such as tissue culture (TC) banana is a key intervention in control of the disease. Whereas TC banana seedlings have been promoted for more than a decade, the uptake is low (at only 7%). This has been attributed to economic factors, mainly the cost of seedlings but this does not take into account the socio-cultural issues around banana. Banana in Central Uganda and in the *Baganda* culture is not only a staple food, it also serves several cultural purposes. This study investigated how the biotechnology generated TC banana seed fits the socio-cultural context of the *Baganda* culture in Central Uganda. Specifically, the study; (i) established the socio-cultural fit of TC banana seed in Central Uganda; (ii) determined the influence of farmer perceptions on intentions to use the TC banana plantlets in Central Uganda and (iii) identified factors that influence uptake of TC banana seed among smallholder farmers in Central Uganda. A mixed methods research design was used employing both qualitative and quantitative data methods. Qualitative data were obtained from ten key informant and eight focus group discussions; and quantitative data were generated by two surveys one involving 174 and another 248 respondents from Mukono and Luweero districts. Results differentiate three major purposes of banana; as food, cultural artefact and medicine. Specific varieties are associated with each of those functions. However, the range of varieties supplied through TC technology are largely the commercial ones and do not meet the diverse socio-cultural functions of banana. The farmers therefore mix the TC banana plantlets and the local suckers in the same garden thereby facilitating cross-infection and defeating the intention of controlling BXW. The banana varieties supplied through TC are not the most preferred for home consumption though they yield big bunches good for the market. Farmers perceive TC banana to be genetically modified and they are therefore considered not fit for medicinal and cultural practices. Further, TC banana are considered unsustainable in the context of declining soil fertility and frequent droughts due to climate change. Growing TC banana requires new knowledge and management practices that farmers are not accustomed to. Farmer intentions to use TC planting materials is dependent on social influence ($\beta = 0.432$; $P< 0.01$) as the major predictor and farmer innovativeness ($\beta = 0.095$; $P< 0.05$) as a mediating factor. The findings also reveal that TC seed acceptability ($\beta= 0.74$; $P<0.01$), adaptability ($\beta= 0.69$; $P<0.01$) and availability for farmer ($\beta= 1.04$; $P<0.01$), farmer competences and socio-economic factors positively influence farmer uptake of banana TC seed. Uptake intensity is mainly influenced by TC seed acceptability ($\beta= 0.39$; $P<0.05$), accessibility ($\beta= 0.39$; $P<0.01$) and farmer competences. Use of the TC plantlets is still contentious among farmers and therefore mass sensitization and social influence through community opinion leaders, faith-based leaders and farmer groups is critical in influencing farmer perceptions to adopt TC banana. Promoting TC banana requires that the technology is accompanied with a package of information including among other things the soil fertility requirements, agronomic practices and disease management. To aid uptake, the promoters of TC banana will need a sound communication strategy that addresses the myths and perceptions on TC and widen the range of varieties supplied through TC to suit the diverse uses (beyond food) of banana and preferences in the *Baganda* culture.

CHAPTER 1: GENERAL INTRODUCTION

1.0 Introduction

Effective management of plant health to boost agricultural productivity is fundamental for food and income security amongst populations. Nonetheless, substantial amounts of crop produce worldwide are lost annually due to plant health problems, necessitating for agricultural technologies and innovations that can aid to curb the spread of plant pathogens. Surprisingly, uptake of such technological improvements in form of agricultural innovations that would otherwise contribute to food and income insecurity remain extremely low in Sub-Saharan Africa. While the current study provides insights on the socio-cultural environment that influences uptake of tissue culture banana seed in Uganda, this chapter describes the background of the study, statement of the problem, objectives, methodology and justification of the study. It concludes with an overview of the structure of the dissertation.

1.1 Background to the study

Worldwide, researchers and governments are working hard to improve agricultural productivity in developing countries through provision of quality seed (Coomes *et al.,* 2015; McGuire and Sperling, 2016). In Sub-Saharan Africa [SSA], the per capita food output has significantly declined contributing to food and income insecurity. This region has the highest proportion of undernourished people in the world, estimated to be 30% of the total population or 239 million people for the period 2010-2012 (FAO, 2013; Reynolds *et al.,* 2015; FAO, IFAD, UNICEF, WFP and WHO, 2019). Under such circumstances, 'seed' is an important entry point for the promotion of crop agricultural innovations/technologies for increased productivity, nutrition, as well as food and income security (McGuire and Sperling, 2016). Farmer seed sources have often been shown to carry pests and diseases that overtime lead to seed degeneration, compromising the seed quality and crop yield (Bentley *et al.,* 2018) and yet this remains the dominant source of seed especially for smallholder farmers. Organizations such as the Alliance for a Green Revolution in Africa (AGRA) have thus placed considerable emphasis on strengthening the seed sector and promoting the commercialization, distribution and uptake of improved seed/crop varieties (AGRA, 2013). Improving farmers' capabilities to access to seed/crop varieties in Africa, as well as supporting the informal seed sector is an integral component of the Comprehensive Africa Agriculture Development Programme

(CAADP). This demands that 'seed' is seen as a conduit through which new varieties and quality seed reach farmers.

In Uganda, agriculture is the most important sector with regard to food and income security (MAAIF, 2013). It supports the livelihoods of 73% of households, employs 36% of the population and 80% of the poorest population (UBOS, 2017). The sector contributes 23% of the country's Gross Domestic Product (World Bank, 2018). Agriculture in the country is dominated by smallholder farmers (80%) who farm ≤2 hectares and contribute 70% of the agricultural production. Most of the agricultural produce is consumed domestically. Despite its importance and growth in the recent years, the agricultural sector only meets 40% of its potential (WFP, 2017). Its productivity is impended by a number of factors that include pests and diseases, climatic change impacts, limited access by farmers to quality inputs, farmers' limited access to land and agricultural finance, decline in soil fertility and consequent low technology adoption (Ekesa *et al.,* 2015; Fiala and Apell, 2017).

Given the importance of agriculture in the country, a number of policies and strategic plans such as Poverty Eradication Action Plan (PEAP) with its component programs of Plan for Modernisation of Agriculture (PMA), Prosperity for All (PFA), Rural Development Strategy (RDS), National Development Plan (NDP), The National Agriculture Policy, The Agriculture Sector Strategic Plan (ASSP), Uganda Green Growth Development Strategy (UGGDS) and The Uganda Vision 2040 have been put in place by the government to guide the sector towards improved production, food and nutrition security and economic growth. These are geared towards uplifting the production of key production crops in the country for which banana is among.

1.2 Banana production and its importance

Banana (*Musa spp*.) is a staple and cash crop in the East African region with over 30 million people depending on the crop for food and income (Dotto *et al.,* 2019). The crop is of high nutrition content providing a good source of carbohydrates, vitamins (A, B_1, B_2, B_6, and C), minerals (potassium, iron, zinc, calcium, phosphorous, magnesium and selenium), polyphenols, resistant starch, and antioxidants (Hardisson *et al.,* 2001; Haslinda *et al.,* 2009). Banana is a major staple for more than a half of Uganda's population. With an estimated production of 10.5 million tonnes per annum, Uganda is currently the world's largest consumer of cooking bananas [matooke] (Kabahenda and Kapiriri, 2010). The average per capita annual

consumption of bananas in the country is estimated at close to 1 kg per person per day, the highest in the world (Edmeades *et al.,* 2015). The crop occupies the largest cultivated area (about 30 % of the cropland) on plots of less than 0.5ha (Ngambeki *et al.,* 2003; Edmeades *et al.,* 2015). Banana cultivation in the country is dominated by the locally evolved clones known as the East African Highland bananas (Gold *et al*., 2002), which include the harder green cooking bananas locally called "matooke". *Matooke* is the leading staple food with an annual production of over 6 million tonnes (Kilwinger *et al.,* 2019). The crop also provides a wide range of products (animal feeds, charcoal briskets, crafts, construction materials) which significantly contribute to food and income security of the populace and consequently to national development (Kikulwe *et al.,* 2018).

In spite of the importance of banana in the country, banana cultivation faces critical challenges that affect and even threaten its survival. Key among which is the Banana Xanthomonas Wilt (BXW) disease caused by the bacterium *Xanthomonas campestrisn pv. musacearum*. This disease has been a main reason for poor yields since its emergence in 2001 (Tushemereirwe *et al.,* 2004). BXW has continued to threaten banana production and can wipe out entire crop holdings where highly susceptible genotypes dominate the farming systems (Kubiriba *et al*., 2012). This therefore poses a serious threat to the country and to the livelihoods of the poor small-holder farmers who depend on banana. This disease was first reported in Mukono District, Central Uganda (Tushemereirwe *et al.,* 2004) and by 2005 it had rapidly spread to South Western Uganda, the major banana producing areas. Between 2002-2005, the disease caused a cumulative economic loss of 61.1 million dollars to the country, mainly incurred by the East African Highland Banana (EAHB) 'Matooke' (AAA-EAHB genome) and the 'Kayinja' beer banana (ABB genome) (Tushemereirwe *et al.,* 2009). The disease has also become of prominent importance in other banana producing countries in the Democratic Republic of Congo (Ndugo *et al*., 2006), Burundi (Anon., 2006), Tanzania (Mgenzi *et al.,* 2006), Rwanda (Reeder *et al.,* 2007) and Kenya (Mbaka *et al.,* 2007). The risk associated with *Xanthomonas campestrisn pv. Musacearum* in banana cultivation has as well been analyzed for countries in Eastern, Central and Southern parts of Africa (Smith *et al.,* 2008). The pathogen is gaining entry over long distances and across international boundaries. Trade and movement of banana fruit, the use of banana leaves for packaging and suckers as planting material are recognized as presenting a high risk of entry and spread of this disease (Smith *et al.,* 2008; Nakato *et al*., 2013).

1.3 Tissue culture as a seed system technology to control Banana Xanthomonas Wilt

The government of Uganda through the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) developed a BXW control package which comprised management practices, namely: (i) the chemical destruction of diseased mats using herbicides, (ii) continuous cutting of re-sprouts, (iii) uprooting or mechanical destruction of diseased mats, (iv) single diseased stem removal, (v) disposing of plant debris, (vi) optimum fallow period and break crops, (vii) improving soil fertility, (viii) the use of clean garden tools, (ix) the de-budding of the male flowers, (x) use of varieties that escape insect-mediated transmission, and (xi) the use of tissue culture (TC) banana as clean seed (Dubois *et al.*, 2013; Blomme *et al*., 2014).

The use of clean planting material[1] as part of the BXW control package is emphasized because once a seed system is contaminated (by pests & diseases), the best way to recuperate it is by introduction of 'new' and clean seed into the system (Thomas-Sharma *et al.*, 2016). The use of TC seed is a 'new' phenomenon to smallholder farmers (part of formal seed system[2]) as compared to the informal seed sources (informal seed system[3]) that they use. More than 90% of farmers in the banana farming systems in East and Central Africa rely on suckers from friends, neighbors, relatives or own fields to establish new gardens (Smith *et al*., 2008; Kilwinger *et al.*, 2019). This poses a high risk of transmitting pests and diseases across farms since the banana planting material they use is seldom certifiably disease free (Jogo *et al*., 2013). In support of this, several initiatives by the Government of Uganda, Research Institutes (Makerere University, Kawanda Agricultural Research Institute), CGIAR centers [International Institute of Tropical Agriculture (IITA), Bioversity International (BI)] and private institutions (Agro-Genetic Technologies Limited, Biocrops Uganda Limited) have promoted the use of TC as clean seed through the multiplication and distribution of free and at times sold TC planting material to farmers. A three-year project (January, 2008 to December, 2011) under IITA employed laboratory-based rapid multiplication techniques to produce disease-free plantlets that were hardened and multiplied in TC community nurseries established in Central Uganda. Additionally, a large number of farmers were trained on how to grow and manage TC banana seed, business and marketing and the establishment of farmer cooperatives linked to the TC community nurseries with the aim of improving livelihoods of the small-scale

[1] Banana planting materials are vegetatively propagated and alternately referred to as seed or suckers.
[2] A formal system is regulated by the public sector, usually by an inspection process known as 'certification' and controls variety release to ensure that available seed is of a recognized variety with a low incidence of disease (Bentley *et al*., 2018).
[3] An informal seed system is managed by the farmers, without the public sector (Thiele, 1999).

banana farmers. Nonetheless, the use of TC banana plantlets in the control of BXW is still low in the two main banana production (the 'Kayinja' beer banana ABB genome and the East African highland banana AAA-EAHB genome) systems in Uganda (Jogo *et al.,* 2013).

1.3.1 Seed systems and uptake of agricultural technologies

Worldwide, farmers have shown to accept technologies that are consistent or compatible with the central values of their socio-cultural systems (Rogers, 1995; Warren *et al.,* 2016). Indeed for any seed system technologies to be acceptable and effective, they must satisfy farmer economic benefits (Habtewold, 2018) as well align to the social cultural context in societies where they are introduced (Ozier-Lafontaine and Lesueur-Jannoyer, 2014; Palis, 2017). This social cultural context entails societal traditions, norms, values and practices that are essential in understanding farmer acceptance or rejection of agricultural innovations/technologies (Doss and Morris, 2001). Farmer traditions connote developed practices, symbols, ideas, and beliefs that represent farmers' shared experiences and meaning in societal life (Schwartz, 2012) whilst norms relate to the societal accepted ways of doing things, which are directly linked to culture. The societal culture[4] as such influences farmers' perceptions towards introduced technologies which may enable or impede farmer uptake of novel agricultural technologies (Palis, 2006).

While the above are essential to steer effective use of seed system technologies, it is imperative that seed security factors (seed availability, accessibility, acceptability and adaptability to local farming conditions) and farmer characteristics (competences, socio-economic and institutional factors) are given due consideration (Sperling *et al*., 2013; Bentlety *et al.,* 2018; Dessart *et al*., 2019). Focus on seed security factors stimulates farmer confidence in the uptake of technologies and is of utmost relevance in monitoring and correction of seed system interventions by; 1) identifying why such interventions fail (or may succeed) and 2) aiding more effective design of future interventions (Sperling *et al.,* 2013). Farmer competences are critical for farmer inspiration prior to acceptance and eventual uptake of seed-based technologies (Dessart *et al*., 2019). These relate to knowledge and skills about the application of novel agricultural innovations and their outcomes in terms of products, yield, potential benefits, risks and costs (Meijer *et al.,* 2015; Kuehne *et al.,* 2017; Ugochukwu and Phillips, 2018). Additionally, institutional factors such as membership to farmers' groups, access to credit and extension services and socio-economic factors (e.g. sex, age, education level, farm

[4] The culture of a society is the accepted way of doing things in that particular society, the way in which people live, their customs and traditions (Nisha, 2006).

size) have been found to play essential roles in farmers' uptake decisions of novel agricultural innovations (Doss, 2006; Kiyingi *et al.*, 2016; Higgins *et al*., 2017).

1.4 Research problem

Despite the promotion of tissue culture banana plantlets as a source of clean seed in the control of BXW, the uptake of these planting materials remains low, most especially in Central Uganda. Most farmers prefer to establish banana plantations using suckers that they obtain from friends, neighbors, relatives or from own fields (Smith *et al.*, 2008; Kilwinger *et al.*, 2019) that often serve as source of inoculum for BXW. Reports indicate that the uptake of TC seed is generally low, at less than 7% of the total banana planted in the country (Dubois *et al.*, 2013). Reluctance by farmers to take up the plantlets has to-date been explained using economic factors such as high cost of seedlings, higher labour and input requirements (Muyanga, 2009; Njau *et al.*, 2011; Kabunga *et al.*, 2012). Whereas these economic factors are important, they disconnect banana production from the socio-cultural context in which it is anchored. Moreover, studies (Akanle, 2012; Idang, 2015; Warren *et al.*, 2016) indicate socio-cultural values to be deeply engrained in societal norms, belief systems, behavioral patterns and way of life and as such inadvertently influence the uptake of agricultural technologies. Currently, limited attention has been directed towards situating the TC banana technology within the socio-cultural context of banana production. In addition, limited empirical research exists to explain the uptake of TC banana seed in terms of (i) cultural values on banana cultivation and their influence on farmer use of the TC banana plantlets, (ii) farmer perceptions on TC banana seed and their influence on intentions to use the TC plantlets, and; (iii) the determinants of uptake of TC banana planting materials among smallholder farmers. The present study therefore holistically examined socio-cultural antecedents and how they influence the uptake of TC banana plantlets in Central Uganda. The focus on social cultural aspects in the uptake of the TC banana seed provides insights on how approaches that integrate social cultural values can foster uptake of agricultural technologies.

1.5 Research objectives and questions

The overall objective of this study was to establish how socio-cultural factors influence use of TC banana seed among smallholder farmers in Central Uganda.

The specific objectives were to:

1. Establish the socio-cultural fit of TC banana seed in Central Uganda.

2. Determine the influence of farmer perceptions on intentions to use the TC banana plantlets in Central Uganda.
3. Identify factors that influence uptake of TC banana seed among smallholder farmers in Central Uganda.

From the above objectives, the following research questions were derived that guided the different studies reported in chapters 2 to 4;
1 a). What cultural values and practices relate to banana cultivation in Central Uganda?
1 b). How does TC banana seed fit in the cultural values and practices on banana cultivation in Central Uganda?
2 a). What shapes farmer perceptions to use TC banana seed?
2 b). How do perceptions influence farmer intentions to use TC banana seed in Central Uganda?
3. To what extent do seed security factors and farmer characteristics influence uptake of TC banana seed in Central Uganda?

1.6 Research methodology

This section describes the overall research approach expounding on the study scope, the study area, research design and data (sources, collection and analysis). Specifically, the study is divided into empirical chapters, each detailing the research methods and data analysis relevant to it.

1.6.1 Scope

This study examined socio-cultural factors and their influence on uptake of TC banana plantlets as a seed technology in the control of the BXW disease in Central Uganda. It uses the case of two villages that hosted community-based TC banana nurseries on assumption that farmer proximity to the seed enhances access to and hence uptake of the TC banana seed. Data from the two sites was combined for analysis because; 1) The two study sites are located in neighboring districts with similar characteristics (e.g. type of soils, rainfall pattern, crops grown); 2) the banana TC nurseries in the studies were established using a similar implementation style employing a demonstration garden besides them and 3) the means (for socio-economic variables such as age, formal education) of respondents in the two study villages were compared (using an independent sample t-test) and found to be statistically non-significant, a confirmation that the two study sites are homogenous. The unit of analysis for this study is an individual farmer.

1.6.2 Study area

The study was conducted in the Central region of Uganda where banana production has traditional roots. The crop has been grown for hundreds of years in this part of the country and the region has for long been the main source of banana seed (Lwandasa *et al.,* 2014; Kilwinger *et al.,* 2019). It is from the Central region that banana production has extended to other parts of the country. Majority of banana farmers in the region are smallholders and the crop is grown on an estimated mean plot size of 0.30 ha, the highest amongst all regions (UCA, 2010). Banana is the main staple food crop in Central Uganda and it is highly valued for its contribution to income from the ever-increasing demand for banana as food in neighboring towns and the city, Kampala (Kitanishi *et al.,* 2018).

Luweero and Mukono districts in the Central region of Uganda were purposively selected as study sites. Two villages, Nambi and Gonve in Luweero and Mukono districts respectively pioneered hosting TC nurseries. Farmers in these village have been extensively exposed to TC banana seed which has been promoted in these districts for more than a decade. Additionally, the two districts still experience high prevalence of BXW (Ocimati *et al.,* 2015) despite the intervention (Jogo *et al.,* 2013).

1.6.3 Research design

This study adopted pragmatism as a research paradigm to answer the overarching research question. A pragmatic approach was preferred for its suitability in embracing a plurality of methods, transcending positivism and constructivism philosophies (Creswell and Clark, 2011; Kaushik and Walsh, 2019). Specifically, empirical chapter two applied a qualitative research approach whilst chapters three and four applied quantitative approaches.

1.6.4 The research process

The study was carried out in four phases. Phase one of the study was a desktop review of relevant literature, including documents of the IITA project [titled "Banana tissue culture: community dissemination pathways for delivery of high-quality planting material to create markets for African farmers"] which was operated in Luweero and Mukono districts of Uganda. The purpose of literature review was to identify the project's intervention sites and contact persons, as well as background information on how project activities with TC nursery operators and TC banana growing farmers were implemented.

The second phase was a reconnaissance study to establish the current status of the project's intervention sites, from which study sites were to be selected. The intervention sites comprised TC nurseries and TC laboratories. The reconnaissance study entailed an exploratory visit to seven banana TC nurseries that had been established in the villages; Kikoma, Mpumudde, Nalwaana, Nambi and Namawojja in Luweero district and Gonve and Ntawo villages in Mukono district. Additionally, visits were made to three TC laboratories located in Central Uganda (Wakiso district) namely; Agro Genetic Technologies (AGT) laboratories, Makerere University TC laboratory and BIO-CROPS Uganda Limited laboratory where TC nursery operators and farmers obtain banana TC seed.

Phase three was largely a qualitative study aimed at in-depth understanding of the cultural values related to banana production in Central Uganda and how these can explain the current use of the TC seed evident in Central Uganda. This led to the quantitative studies in phases three and four of this study. Phase three specifically focused on farmers' perceptions and their influence on intentions to use the TC banana seed whilst phase four focused on TC seed uptake at farmer level and explored selected factors influencing uptake.

Data collection in phase three and four was implemented with the help of six (6) research assistants using semi structured interview tools. The study instruments were pilot tested in Gonve village, Mukono district on a sample of 20 respondents. This was done to check for consistency, sequence and flow of the questions. Results of the pilot testing were used to modify the study instruments before actual data collection.

1.6.5 Study population and sampling techniques

The study targeted banana farmers. Nambi and Gonve villages, respectively in Luweero and Mukono districts as study sites were purposively selected because the communities in these two villages pioneered in hosting TC nurseries and have been extensively exposed to TC banana seed which has been promoted in these districts for more than a decade.

Further, solely banana farmers in the selected villages were interviewed because the study focused on TC seed uptake and as such banana farmers were presumed to possess the information needed for the study. With the help of LC I chairpersons, names of all banana farmers in the selected villages were compiled to generate the sampling frame from which respondents were systematically sampled. The total size of the sampling frame was then used

to compute the sample size using Cochran (1977) and Krejcie and Morgan (1970) formulae as detailed in chapters 3 and 4 respectively of this dissertation.

1.6.6 Data collection methods and tools

a) Qualitative data collection

Focus Group Discussions (FGDs) and key informant interviews were used to collect qualitative data used in this study, specifically for the first objective.

i) Focus Group Discussions

Focus Group Discussions (FGDs) guided by a checklist (Appendix I) were conducted with banana farmers in the study communities. The size of the FGDs ranged from seven to nine participants with an average of eight participants. The FGDs were used to generate the cultural practices, beliefs and values about banana production. The discussions lasted between 2 to 3 hours. Farmers' impressions on differences between TC banana seed and banana suckers were also enlisted. Probing was done to clarify pertinent issues and to generate consensus from the farmers.

ii) Key Informant Interviews

Based on interactions in the focus group discussions, key informants were identified from the participants in FGDs. The key informants were selected based on their knowledge and experience in banana farming in the study communities. They were majorly followed up for clarification on cultural practices and rituals performed on specific banana varieties of cultural importance. Face-to-face interviews were conducted with key informants using a checklist (Appendix I) to aid probe and provide details for in-depth data. The qualitative data was collected between August, 2016 and February, 2017.

b) Quantitative data collection

A cross sectional survey was used to collect quantitative data, specifically for objectives two and three. Semi-structured questionnaires with both open-ended and close-ended questions (Appendices II and III) were developed prior to actual data collection. The survey targeted banana farmers in the study communities. One-on-one interviews were conducted with the help of six trained research assistants. The interviews solicited data on farmer socio-economic and demographic characteristics, perceptions on intentions to use TC seed and decision making for uptake of the TC plantlets. The quantitative data was collected between March, 2018 and May,

2018. Table 1 presents a summary of the primary data collection methods, tools used and type of data collected using each method.

Table 1: Overview of data collection methods and tools

Method	Tool	Number	Sampling strategy	Data collected
Focus group discussion with Banana farmers	FGD guide (Appendix I)	8 FGDs (64 banana farmers in total)	Purposive	-Focused on exploring the different banana varieties grown in the study area and their uses -Diverse cultural practices, traditions, norms and values about the banana varieties grown in the study area -Observed differences between TC banana seed and banana suckers
Key informants & in-depth interviews	Interview guide (Appendix I)	10 Key informants comprising banana farmers knowledgeable about cultural uses of banana varieties	Purposive	-Traditions and practices carried out on banana varieties that are of cultural importance
Survey	Semi-structured Questionnaire (Appendix II)	248 farmers (Second objective)	Systematic	-Farmer perceptions about TC banana seed in terms of; Perceived quality of the TC plantlets, Performance expectancy, Social influence, Farmer innovativeness & how these influence farmer intentions to use the TC banana plantlets
	Semi-structured Questionnaire (Appendix III)	174 farmers (Third objective)	Systematic	-Seed security factors e.g. Seed availability, seed acceptability, seed adaptability and seed accessibility -Farmer competences such as knowledge about TC and skill to grow and manage banana TC seed. -Demographic and socio-economic characteristics -Farm characteristics -Institutional factors such as membership to groups, access to information and extension services

1.6.7 Data analysis

Qualitative data collected using a digital recorder were translated from the local dialect (*Luganda*) used during the interviews and transcribed in English for analysis. Following Braun and Clarke (2006), *open codes* were assigned to the individual narratives which were grouped into *categories* and later constituted *themes* that guided the presentation and discussions of results.

Quantitative data for empirical chapter three were analyzed using Analysis of Moment Structure (AMOS) version 21 program to test a research model adapted from the Unified Theory of Acceptance and Use of Technologies (UTAUT) (Venkatesh *et al.*, 2003). Bootstrapping analysis was further used to assess mediation relationships of the research model and to determine effect sizes of prediction relationships. The STATA program (version 14) was used to generate descriptive and inferential statistics for results in chapter four. Frequencies, percentages and means were also generated for characterization of the banana farmers. A double hurdle model was used to determine the factors that influence adoption and intensity of use of TC banana planting materials at farmer level. Details of data analysis for each objective are presented in the respective empirical chapters. Table 2 presents a summary of the type of analysis per objective.

Table 2: Summary of data analysis methods and tools

Objective	Type of data	Methods and tools	Output
1. Establish the socio-cultural fit of TC banana seed in central Uganda.	Qualitative data (KIIs & FGDs)	• Thematic-content analysis as described by Braun and Clarke (2006).	• Emerging themes • Narrative and verbatim explanations
2. Determine the influence of farmer perceptions on intentions to use TC banana plantlets.	Quantitative data (Survey)	• Structural Equation Modelling (SEM) Using Analysis of Moment Structure (AMOS) ver. 21 program.	• Path co-efficients for relationships involving independent, mediating & dependent variables Effect sizes & evaluation of practical relevance
3. Identify factors that influence uptake of TC banana planting materials	Quantitative data (Survey)	Analyzed using STATA ver. 14 for descriptive and inferential statistics Principal component analysis Regressions analysis	• Frequencies, means • Double-hurdle model results for factors associated with use and intensity of TC banana seed.

1.7 Significance of the study

By exposition of socio-cultural factors influencing farmer use of TC banana planting materials, this study contributes to a number of agricultural policies and strategic plans of the government of Uganda which guide the agricultural sector towards improved production, food and nutrition security and economic growth. These policies and strategies entail the Poverty Eradication Action (PEAP) with its component programs of Plan for Modernisation of Agriculture (PMA), Prosperity for All (PFA), Rural Development Strategy (RDS), National Development Plan (NDP), The National Agriculture Policy, The Agriculture Sector Strategic Plan (ASSP) and Uganda Green Growth Development Strategy (UGGDS). This study further contributes to the overall goal of the Uganda Food and Nutrition Policy (2003) of promoting the nutritional status of the people of Uganda through multi-sectoral and coordinated interventions that focus on food security, improved nutrition and increased incomes.

Since current banana breeding efforts in the country are solely directed towards cooking banana types (Sanya *et al.*, 2020), findings from this study will guide TC seed producers (such as TC Laboratories and research institutions) and supporting institutions that help in breeding and propagating banana TC planting materials on other banana types of socio-cultural importance which is expected to result into increased uptake of the TC banana technology. Uptake of agricultural technologies for agricultural transformation leading to food security and economic growth is in tandem with Uganda's Vision 2040, the Comprehensive Africa Agriculture Development Programme (CAADP) and Sustainable Development Goal (SDG) two of zero hunger.

1.8 Conceptual and theoretical framework

The study aimed at explaining the current state of uptake of TC banana in the socio-cultural context of Central Uganda. Due to diversity of perspectives, this study is anchored in three theories. Integrated theories were adopted to build the conceptual framework (Figure 1) used to analyze socio-cultural factors influencing the uptake of TC banana seed in Central Uganda.

The Innovation Diffusion Theory (IDT) [Rogers, 1995], and the Schwartz Theory of Basic Human Values (Schwartz, 2012), are used to explain the interaction of banana TC seed as an agricultural innovation and cultural values on banana cultivation among the *Baganda* and how these impact on the uptake of the banana seed. The study draws three tenets from the IDT namely: (1) relative advantage; (2) compatibility; (3) complexity and a fourth attribute - degree

of risk articulated by White *et al.*, (2009). Tradition, security, hedonism, achievement and stimulation as constructs are borrowed from Schwartz Theory of Basic Human Values and used to explain the cultural influences on uptake of TC banana seed in context of the banana production system among the *Baganda* in Central Uganda.

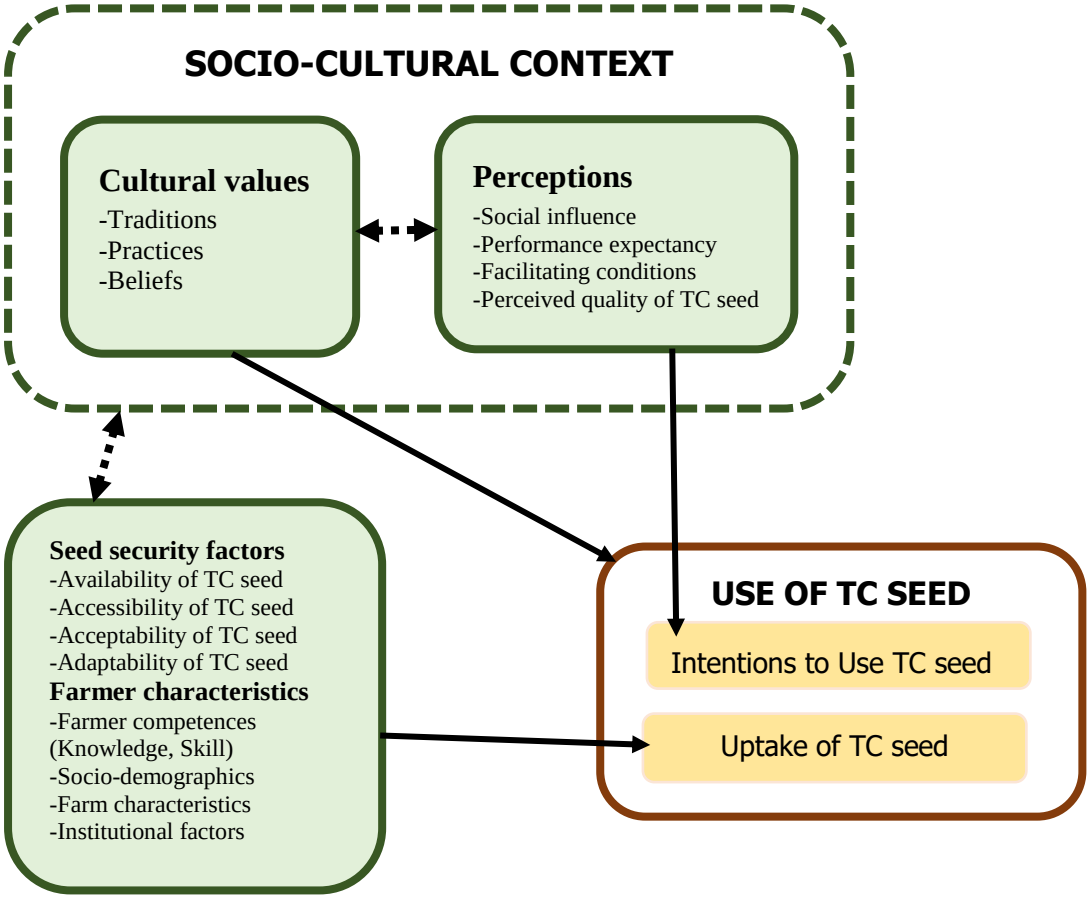

Figure 1: How the Socio-cultural context influences uptakes of TC seed

Based on the seed security framework (RTB, 2016; Sperling *et al.*, 2013; Sperling *et al.*, 2008), seed security factors such as seed availability, accessibility, acceptability and adaptability are important in explaining farmer use/nonuse of TC banana seed. These factors have been shown to be relevant in guiding seed systems interventions for uptake of newly introduced agricultural technologies (Bentley *et al.*, 2018; Andrade-Piedra *et al.*, 2016) and are incorporated as variables in this study. Similarly, farmer competences as relates with farmer knowledge about a newly introduced agricultural technology and farmer skills to use novel technologies have been found to be key in explaining the use or non-use of technologies by intended users

[Ugochukwu and Phillips (2018); Baartman and De Bruijn, (2011)]. Beyond farmer competences and seed security factors, there are socio-economic factors (sex, age, education level, and experience in banana farming), farm characteristics (farm size, land allocated to crops and banana) as well as institutional characteristics (membership to groups, access to agricultural information and access to extension services) that influence farmer decisions for uptake of banana TC seed (Kiyingi *et al.,* 2016; Higgins *et al*., 2017). These factors conjointly were hypothesized to positively affect farmer intentions to use the TC plantlets as a source of clean planting materials in the control of BXW.

In analyzing the role of farmer perceptions on TC banana planting materials, the study drew three constructs from the Unified Theory of Acceptance and Use of Technology [UTAUT] (Venkatesh *et al.,* 2003). These constructs include social influence, facilitating conditions and performance expectancy. Two additional variables: perceived quality of the TC seed (Andrade-Piedra *et al.,* 2016) and farmer innovativeness (Okumus *et al.,* (2018) were included and hypothesized to positively and significantly influence farmer intentions to use the TC banana seed. Social influence represents the degree to which a farmer perceives that relevant people believe that he or she should use a technology (El-Gayar *et al*., 2011), in this context the TC banana plantlets. If social influence as a construct is supportive in farmer use of TC banana planting materials, then a positive relationship between social influence and farmer intentions to use the TC plantlets is expected.

Performance expectancy on the other hand is contextualized as the extent to which a banana farmer believes that the use of TC as banana planting material enhances the performance and output from his or her banana plantation(s). As such, this variable is theoretically predicted to post a positive relationship with farmer intentions to use TC banana plantlets. Further, facilitating conditions describe the degree to which a farmer believes that organizational and technical infrastructure exist to support his or her use of TC banana seed. It is therefore assumed that facilitating conditions will influence uptake intentions for TC banana planting materials. The socio-cultural context pertinent to banana farming, seed security factors and farmer characteristics as conceptually visualized in Figure 1 are interrelated. Nonetheless, their relationship in the context of this study is not measured.

1.9 Ethics statement

Farmer participation in this study was voluntary and based on consent. Interviews were carried out in the local language by trained enumerators, who were supervised by the researcher. Prior

to starting each interview, the purpose of the study was explained to the respondents. Respondents were assured that the data collected would be treated confidentially, analyzed anonymously, and be used for research purposes only. Based on this, the interviewees were asked for their verbal informed consent to participate.

1.10 Organization of the dissertation

The dissertation is organized in five chapters. Chapter 1 gives a general introduction to the study highlighting the background of the study, statement of the problem, objectives, general research design and strategy, theoretical and conceptual framework as well as the significance of the study. Chapters 2-4 present the empirical findings for the study objectives and these are structured using the manuscript format. Specifically, chapter 2 examines the *Baganda* culture on banana cultivation and its influence on farmer use of TC banana planting materials in Central Uganda. The chapter uses the Innovation Diffusion Theory and Schwartz Theory of Basic Human Values to explain the interaction of TC banana seed as an agricultural innovation and cultural values on banana cultivation among the *Baganda* and how these impact on the uptake of the banana seed. Chapter 3 provides an analysis of farmer perceptions and attitudes on TC banana planting materials and how they predict farmer intentions to use the banana seed. The chapter uses the Unified Theory of Acceptance and Use of Technology to analyze the process. Chapter 4 investigates the determinants of uptake of Tc banana planting materials among smallholder banana farmers in Central Uganda. It analyses the factors influencing farmer use and intensity for uptake of TC banana seed using the Double-hurdle model. Finally, Chapter 5 summarizes the key empirical findings, conclusions and implications. It also presents recommendations for practice and policy as well as areas for further research.

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CHAPTER 2: THE CULTURE OF BANANA CULTIVATION AND ITS INFLUENCE ON FARMER USE OF TISSUE CULTURE BANANA SEED IN CENTRAL UGANDA[5]

Abstract

Several initiatives by the Government of Uganda, Research Institutes and CGIAR centers have promoted the use of banana tissue culture (TC) technology as a way of availing clean seed to reduce the spread of BXW but its uptake is still low. This has been attributed to economic factors, mainly the cost of seedlings but this does not take into account the socio-cultural issues around banana. Banana in Central Uganda and in the *Baganda* culture is not only a staple food, it also serves several cultural purposes. This study investigated how the biotechnology generated TC banana seed fits the socio-cultural context of the *Baganda* culture in Central Uganda. Data were collected using eight focus group discussions involving 64 banana farmers and ten key informant interviews and subjected to thematic content analysis. Results differentiate three major purposes of banana; as food, cultural artefact and medicine. Specific varieties are associated with each of those functions. However, the range of varieties supplied through TC technology are largely the commercial ones and do not meet the diverse socio-cultural functions of banana. The farmers therefore mix the TC banana plantlets and the local suckers in the same garden thereby facilitating cross-infection and defeating the intention of controlling BXW. The banana varieties supplied through TC are not the most preferred for home consumption though they yield big bunches good for the market. Farmers perceive TC banana to be genetically modified and therefore does not fit cultural functions and medicine. Further, TC banana plantlets are considered unsustainable in the context of declining soil fertility and frequent droughts due to climate change. Growing TC banana requires new knowledge and management practices that farmers are not accustomed to. Promoting TC banana to control BXW requires mass sensitization to address the myths and perceptions on the seed and a good communication strategy. A comprehensive information package for the TC banana planting materials including soil fertility requirements, agronomic practices and disease management is likely to enhance uptake of the TC seedlings.

Key words: Tissue culture; banana cultivation; cultural values; Banana Xanthomonas Wilt (BXW).

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2.0 Introduction

Use of Tissue Culture (TC) planting materials is one of the recommended practices for controlling Banana Xanthomonas Wilt (BXW) disease in Uganda. The disease can potentially decimate the entire crop where susceptible genotypes are grown (Kubiriba *et al.,* (2012) and has already severely affected banana production especially in central Uganda where banana is an important staple. It spreads mainly through vegetative propagation of infected suckers and to some extent through insects. In East and Central Africa, banana is conventionally planted as suckers obtained from own fields, or exchanged with other farmers (Smith *et al.,* 2008; Kilwinger *et al.,* 2019). Exchange of planting materials is a traditional practice embedded in cultural values and norms. This cultural practice however increases risk of spreading BXW. The control of BXW including use of TC planting materials is therefore not only a technical issue, it is also socio-cultural touching on deep cultural values, beliefs and practices (also see Karamura *et al.,* 2004).

Tissue culture generated seedlings are recommended for establishment of new banana plantations because they are free of BXW (Dubois *et al.,* 2013). The production of TC seed however has focused on varieties considered by researchers to be of higher value in terms of productivity. To the contrary, farmers particularly in central Uganda plant a wide range of varieties in the same plantation for the diverse uses of banana as a food, source of income and cultural artefact. Consequently, the uptake of TC seedlings remains low, at less than 7% of the total banana planted in the country (Dubois *et al.,* 2013) and in some cases, it is planted together with other locally acquired planting materials which serve as source of inoculum for BXW. The limited uptake of the TC seedlings has to-date been associated with economic factors such as high cost of seedlings, higher labour and input requirements for its establishment (Kabunga *et al.,* 2012). However, this only partly explains the phenomenon. It does not for example fully explain why commercially oriented farmers who also have more resources do not completely shift to TC seed. The cultural dimension of banana production in central Uganda has not been subject for investigation in as far as it influences uptake of TC seedlings. Values and cultural attachments to banana varieties construct a contextual setting around the banana production system that could further explain the cultural fit of TC banana seed. This study seeks to explain how cultural values and practices associated with different banana varieties may affect the effectiveness and uptake of TC banana seed as a strategy for control of BXW.

2.1 Theoretical Framework

The study is anchored in the Innovation Diffusion Theory (Rogers, 1995), and the Schwartz Theory of Basic Human Values (Schwartz, 2012), to explain the interaction of innovations and cultural values and how it impacts on adoption. Innovations refer to improved production techniques, novel ideas, processes, tools, practices or technologies [like TC banana seed] that facilitate sustainable agriculture (Barrientos-Fuentes and Berg, 2013).

The Innovation Diffusion Theory (IDT) explains the conditions under which new innovations are taken up and spread through a population (Rogers, 2010). IDT focuses on the interaction between the human and the innovation; and according to Blythe *et al.,* (2017), it enables unlocking processes through which innovations spread and the reasons for farmer decisions to take up an innovation or not. Rogers (1995), outlines five tenets that guide decisions on adoption of new innovations, namely: (1) relative advantage; (2) compatibility; (3) complexity; (4) triability and (5) observability. This study is perched on the first three tenets and a fourth attribute - degree of risk articulated by White *et al.,* (2009). But the farmer operates in a cultural context which influences their decisions. Schwarz theory of basic human values, therefore compliments IDT by examining the cultural values relevant to the innovation.

The tenet of *relative advantage* frames the TC seedlings as an alternative to banana suckers and guides exploration of how farmers compare the two with respect to control of BXW, and the trade-offs of shifting entirely to TC seedlings. Trade-offs here transcend economic benefits to encompass socio-cultural benefits users derive from taking up an innovation (Ssebaggala *et al.,* 2017). *Compatibility* helps to investigate how TC seedlings fit in the farmers' values, experiences and critical needs. Innovations that change the patterns of social interaction or trigger conflict with acceptable norms and values may not be easily taken up (Rogers, 2003; Warren *et al.,* 2016). Introduction of the TC seed could interfere with the social exchange and cultural embodiment of banana production among farmers.

Complexity helps to inquire into the ease of integrating the TC banana technology within existing knowledge, values, practices and culture. Innovations that are easy to understand and use are assumed to be taken up faster than those that require new skills and knowledge (Blythe *et al.,* 2017). The complexity of innovations is also associated with risk – the perceived risks of using TC seed for controlling BXW. Farmers' knowledge about the degree of risk is vital when introducing new technologies (White *et al.,* 2009; Warren *et al.,* 2016).

The IDT provides a framework to explain uptake of agricultural innovations but it is weak on unravelling cultural values embedded in farmers' practices. Schwartz (2012) provides insight into values that influence the use of innovations among divergent cultures; pointing out: tradition, security, hedonism, achievement, stimulation, power, conformity, self-direction, benevolence and universalism as key requisites for coordinated social interaction, survival and welfare. This study applies the first five of these elements (i.e. tradition, security, hedonism, achievement and stimulation) to explain the cultural influences on uptake of TC banana seed in the context of the *Baganda* culture and traditions of banana production. There are cultural practices, symbols, ideas, and beliefs associated with different banana varieties. Beyond controlling BXW, the planting seed supplied through TC have to be compatible with the traditions. S*ecurity* is derived from provision of basic individual and societal needs (Maslow, 1965; Schwartz, 2012), in this case focus is on food and income as necessities for societal welfare. Food also represents culture and can be used in different ways to foster harmony and stability of societies (Noack and Pouw, 2015). Cultural norms also define what foods are culturally acceptable (Ruel *et al.*, 1998) or consumed during specific events.

Achievement is endorsed by social approval and it varies across cultures for example meeting set goals and standards customarily defined (Schwartz, 2012), or bringing honour to one's family and/or society (Trumbull and Rothstein-Fisch, 2011). *Hedonism* is used to explain the satisfaction farmers derive from growing TC propagated banana. Lee (2011) argues that food in the cultural context is a kind of treatment with power that can bring joy and happiness, which evokes a sense of gratification. *Stimulation* as a value spirals from the societal need for diversity. A range of options is what thrills and creates excitement, promoting and fostering a positive and motivated attitude (Schwartz, 2012).

2.2 Methodology

2.2.1 Study area

The study was conducted in Luweero and Mukono districts in central Uganda where TC banana seed has been promoted for more than a decade. The two districts still experience high prevalence of BXW (Ocimati *et al.*, 2015) despite the intervention. To ease access, farmers were linked to TC laboratories that supplied the materials through farmer managed community-based TC nurseries. The study targeted villages that hosted these nurseries on assumption that proximity enhances access to and hence uptake of the TC banana plantlets. Two villages were

studied namely; Nambi village (Zirobwe Sub County) and Gonve village (Ntenjeru Sub County) Luwero and Mukono district respectively (Figure 2).

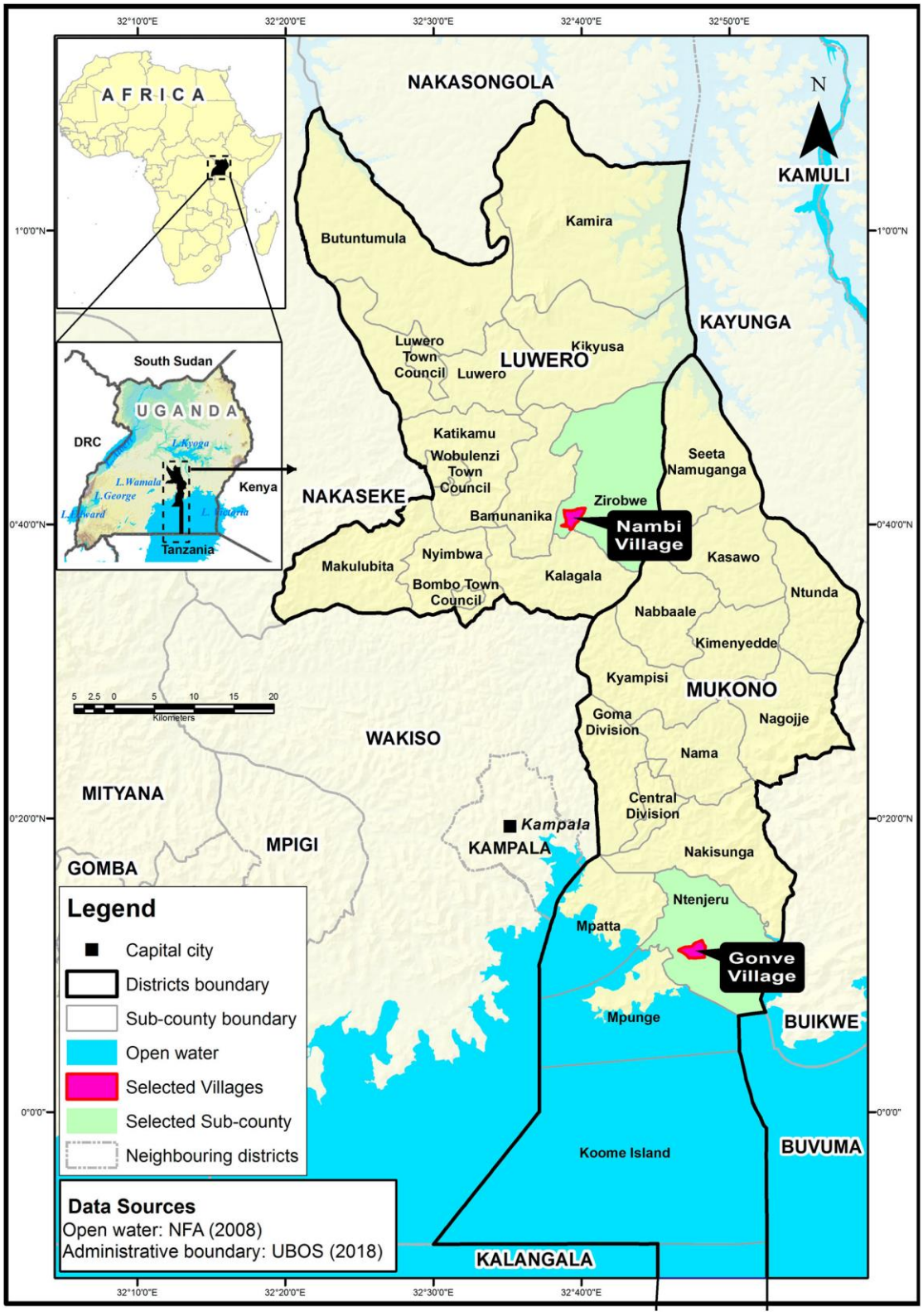

Figure 2: Location of study villages

2.2.2 Research Design and data collection

A qualitative mini-ethnographic case study design (Humphreys and Watson, 2009) was used. The mini-ethnography design was most suitable to understand the cultural values, traditions, beliefs and practices (Fusch *et al.*, 2017) associated with banana cultivation in the study communities, taking the two villages as cases. Qualitative interviews were conducted till data saturation as Fusch, (2013) encourages that the mini-ethnographic method enhances reaching saturation sooner.

Focus Group Discussions (FGDs) and key informants' interviews were used to collect data between August, 2016 and February, 2017. For community entry, village leaders (Chairpersons) assisted to identify farmers who had accessed TC banana seed. To obtain general understanding of the issues under investigation, FGDs were conducted with farmers purposively selected with the help of the village leaders basing on their knowledge and experience in banana production at the time. In each village, four FGDs were conducted with two FGDs separately constituting male farmers and female farmers (Table 3) for the reason that sex can determine the degree of involvement and freedom of expression (Braga, 2001). Each FGD comprised eight farmers, making a total of 32 participants from each village. The intention was to generate diverse cultural practices, beliefs and values from the perspectives of male and female farmers. Farmers were also questioned whether they observed any differences between TC seed and banana suckers.

Table 3: Proportion of focus group participants by location and sex

Location	Number of FGDs by sex		Participants	Number
	Male	Female		
Village: Nambi Luwero district	2	2	Male (16) and female (16) farmers	32
Village: Gonve Mukono district	2	2	Male (16) and female (16) farmers	32
Total	**4**	**4**		**64**

Based on the interactions in the FGDs, ten key informants (4 males and 6 females) were also purposively selected and followed up for clarification on some cultural practices and rituals performed on vital banana varieties of cultural importance. The interviews were recorded using

a digital recorder for accurate capture of the narratives. Photographs illustrating cultural practices were taken for visualization.

2.2.3 Data analysis

The local dialect (*Luganda*) used during the interview was translated into English and transcribed for analysis. Thematic-content analysis described by Braun and Clarke (2006) was used. The stages that were followed included (1) conducting the interviews and transcribing the data (2) familiarizing oneself with the data (3) generating initial codes (4) development and reviewing of themes, and (5) defining and naming the themes. Thematic network illustrations were produced to describe the relationships between and interrelatedness of the themes being developed (Figure 3).

2.3 Results and discussion

Three inter-related thematic strands on the uses of banana emerged, namely: Banana as food; Banana as a cultural artefact; and Banana as medicine (Figure 3). Each of the uses is associated with specific banana varieties. Documentation by Karamura *et al.*, (2012) and Hamilton *et al.*, (2016) was used to aid categorization (by clone sets, genomes and genome groups) of banana varieties found in the study communities.

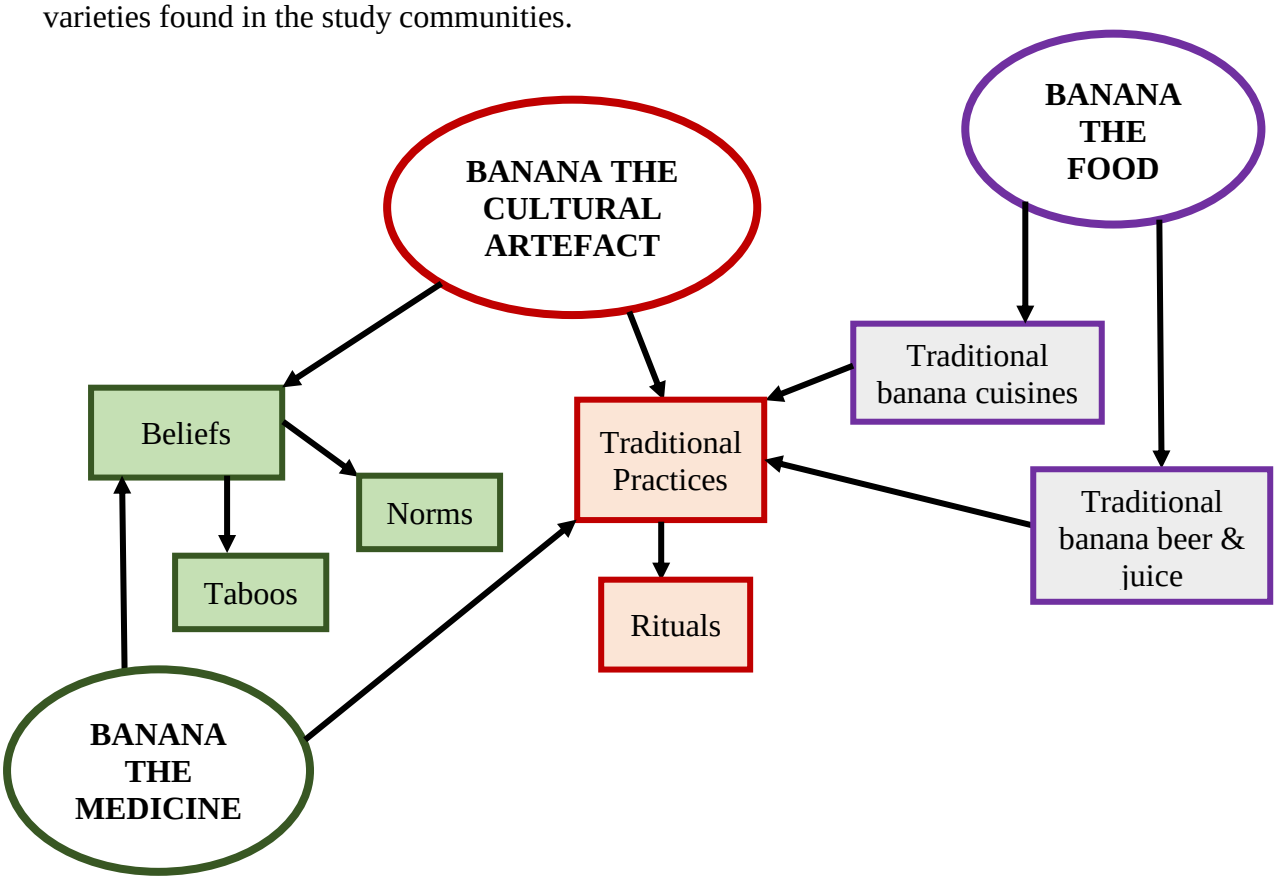

Figure 3: Thematic map of uses of bananas in *Baganda* culture

2.3.1 Banana varieties and their uses in the study area

Forty-five banana varieties were found to be grown by farmers in the two villages studied (Table 4). The diversity of varieties indicates the wide range of uses and preferences associated with specific banana varieties within a single farm. With regard to use, varieties are generally categorized as; cooking banana commonly known as *matooke*, dessert banana – eaten when ripe; brewing banana for making local beer known as *tonto* and roasting banana. Most of them belong to the East African Highland Genome Group (AAA-EA), which according to Karamura *et al.,* (2012) are grouped into five major clone sets namely; Musakala, Nakitembe, Mbidde, Nfuuka, and Nakabululu; each one with unique characteristic features. There is more diversity among the cooking type than the brewing or desert types. Varieties for brewing have high tannin content and astringent nature of fruits (Hamilton *et al.,* 2016). In addition to the economic use (food, or brewing) the varieties have multiple cultural uses that compel a single farmer to grow several varieties in the same plantation. Table 4 also indicates the varieties that were available through TC seed, representing a very small proportion of the range of varieties that a single farmer would normally have. This underscores *stimulation* as a value and means that other varieties have to be obtained through exchange of suckers, which are likely to be infected with BXW.

Table 4: Banana varieties grown in Gonve and Nambi communities in central Uganda

Banana varieties	Clone set	Genome	Genome Group	Major Use
Kisansa +	Musakala	East African Highland	AAA-EA	Cooking
Mpologoma +				
Mpologoma omukadde				
Musakala +				
*Muvubo**				
Namunwe				
*Mayovu**				
Mbwazirume	Nakitembe	East African Highland	AAA-EA	Cooking
Nakamali				
Nakitembe +				
Nalugolimo				
Nandigobe				
Nasalugiri-Soola mwana				
Wakirigga				
Nabununike				
Kibuzi +	Nakabululu	East African Highland	AAA-EA	Cooking
*Mukubyakonde**				
Nakabululu				
*Nakyetengu**				
Atwalirannyina	Nfuuka	East African Highland	AAA-EA	Cooking
Katwalo				
Lusumba				
Muziranyama				
Nabusa				
Nakabinyi				
*Nakawere**				
Nakinyika				
*Nambi**				
*Namwezi**				
Ndibwabalangira				
Nfuuka +				
*Siira**				
Kyesusa				
*Embidde enganda (Kabula & Nsowe)**	Mbidde	East African Highland	AAA-EA	Juice/Brewing
Improved Ndiizi +				Dessert
Bogoya		Gros Michel	AAA	Dessert
FHIA – 17 +		Tetraploid hybrids	AAAA	Cooking & Dessert
FHIA – 01 +		Tetraploid hybrids	AAAA	Cooking
FHIA 25 +		Tetraploid hybrids	AAAA	Juice/brewing
KM5(Kabana 5)+				Dessert
Gonja (Nakatansese & Manjaya) +		Plantain	AAB	Roasting
Kayinja		Pisang Awak	ABB	Brewing
Kisubi		Ney Poovan	AB	Brewing
Kivuuvu		Bluggoe	ABB	Dessert
Sukali Ndiizi		Kamaramasenge	AAB	Dessert

+ Varieties introduced under TC; * Nearly extinct and still desired banana varieties

2.3.2 Banana varieties as food

As food, bananas are consumed though in different forms; as *matooke*, roasted (plantain), dessert and juice/traditional beer. Among the cooking varieties, farmers may prefer specific ones for their own consumption while others are grown for the market (also see Bagamba *et al.,* 2006; Kitanishi *et al.,* 2018). Those for family consumptions may not be high yielding but are preferred for their taste, colour (yellowish) and texture (soft). Food in the cultural context wields power to bring joy and happiness to the consumer (Lee, 2011), hence aligning to hedonism. On the contrary, the *matooke* varieties introduced under TC (Mpologoma, FHIA-01 and FHIA-17) were reported to have an undesirable colour (whitish) when cooked, with no aroma and a 'flat' taste.

For some cultural events like traditional marriage ceremonies known as '*kwanjula*', specific varieties (*Nakitembe*) is used to prepare a special meal for the groom's family and or presented as gift to the bride's family. The same variety is also used for other cultural practices. Its stem and leaves are medicinal for treating menstrual pains and is also a herb for baby skin diseases (*ekyogero*). Out of the seven varieties that constitute the *Nakitembe* clone-set for example only one variety was supplied through TC. This constrains the diversity of varieties within a particular clone-set that is used for several cultural functions. Without giving due attention to the cultural importance, most of the varieties supplied through TC are the high yielding and of commercial value. The available TC planting materials do not provide varied farmers' consumption preferences and cultural uses of banana and hence fall short of stimulation as a cultural value. For example, one of the farmers in a FGD in Luweero District stated:

> "Not all cooking type varieties make good *matooke*. Some varieties are better and as a farmer who has a choice, I would prefer matooke from specific varieties like *Nakitembe, Mukubyakonde, Muziranyama* and *Nakawere* even though these may not be the best commercial varieties" (October, 2016).

Other cooking varieties have special cultural attachment. For example, the *Ndibwabalangira* literally by its name implies, it is best for the Royals – meaning it has attributes that are only deserving to the royals. Another variety, *Nakawere* by its name implies it is best for mothers that have just given birth, probably due to its nutritional value. *Atwalirannyina* implies that the variety is the best gift one can give to their mother because of its taste, large finger and bunch size. Banana varieties are symbolic of status in society and therefore focusing on only the commercial value (without cultural considerations) in selecting varieties promoted through TC

will only encourage growing of the local varieties infected with BXW alongside the TC varieties, which consequently defeats the control of BXW.

Traditional beer (*omwenge omuganda- tonto, akaliga, kwete, omusetulo* and *enguli)* is central and used at all cultural and social functions whether it is a celebration or funeral or other cultural ceremonies. Brewing banana varieties are also used to produce juice (*omubisi)*. None of the traditional varieties for brewing were supplied through TC, instead new hybrid varieties (FHIA-25 and KM5) which farmers are not accustomed to were provided. The scientific explanation was that the local brewing varieties were highly susceptible to BXW (Adikini *et al.,* 2013; Tripathi and Tripathi, 2009) but at the same time farmers claim the new varieties have low sugar content and do not make good quality beer. It is not possible for farmers to abandon such an important cultural value and will always plant their local varieties even though this practice favours cross-infection and spread of BXW.

Though in varying proportions, all farmers grow a wide range of varieties in the same plantation to meet both their economic and socio-cultural interests (Karamura *et al.,* 2012). Diversity is also desirable for food security and sustainability of the food system (Gold *et al*., 2002; Bioversity International, 2017). Nonetheless, it is difficult to maintain this diversity with TC due to high cost of propagation and yet some varieties may not be highly demanded to break-even in the TC business. In comparison of performance between TC seed and suckers, farmers had perceptions that tended to disadvantage the use of TC seed as outlined in figure 4.

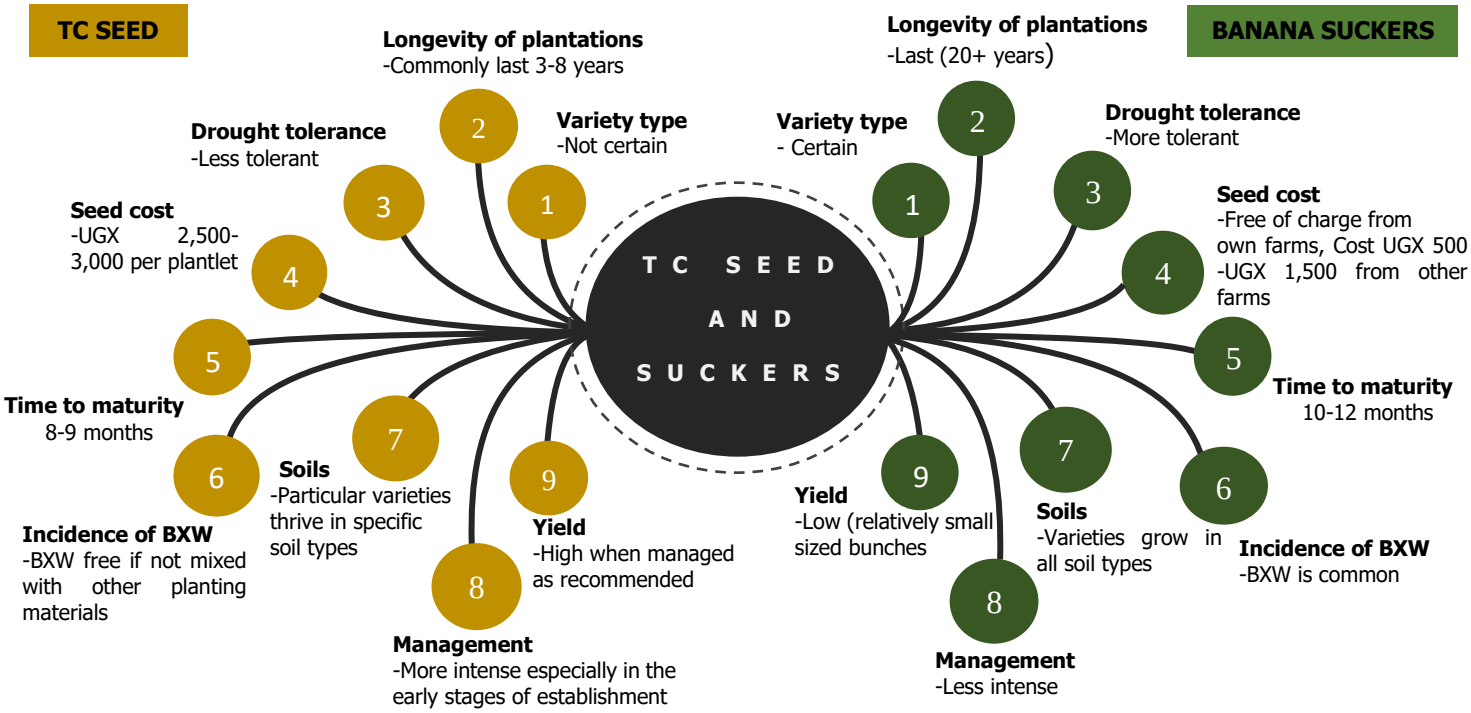

Figure 4: Farmers' comparison by performance of TC banana seed and suckers

From their own experience, farmers observed that some of the new varieties supplied through TC required intensive management including the use of fertilizers/manure, mulching and water availability. If managed the same way as the local varieties, they may yield even less than the local varieties. This increases the cost of management in addition to the high cost of seedlings. In this perspective, TC plantlets are considered to be of no relative advantage, complex to grow, and requiring change of practices which have to be accompanied by new information regarding the management. Some farmers who planted TC seed lamented about not being able to precisely identify the different seed varieties at time of planting, something that can hardly happen with suckers. It is possible that seedlings are mixed up in the nursery or mislabeled and bananas being a perennial crop, there is a long-term negative impact on the farmer if he/she plants a not intended variety. Complexity is not only at the farm but it is also mainstreamed in the entire seed system posing greater risk in case the farmer took the unintended variety.

Additionally, farmers indicated TC seed established plantations not to last long. In one farmer's words:

> "We got fifteen (15) free TC plantlets and a bag of manure each to establish a demo TC plantation. We were also encouraged to plant 10 local banana varieties alongside the TC plants for comparison. However, due to prolonged dry spells that we have experienced in the recent past, currently, all the TC plants wilted and dried but the 10 local varieties still exist". (FGD Mukono district, November, 2016).

This may be attributable to challenges in the tissue culture micro propagation process related to somaclonal variations (Damasco *et al.,* 1996), poor physiology (George, 1996) and the lack of soil micro biota. As established by Nowak (1998), these factors can render the performance of TC seed to be poor, especially under environmental stress. It is also argued that the survival of TC seed at establishment may be hampered by climatic distresses since plantlets are devoid of food reserves (Kavoo-Mwangi *et al.,* 2014). Besides, the performance of commercial varieties (large bunch and finger size) as is the case with newly introduced TC seed requires good soil fertility to sustain their production. Nevertheless, the soils in the central region have for various reasons considerably deteriorated in fertility (Zake *et al.,* 2000; Nyombi, 2013) a fact that can contribute to a shorter survival period of TC established plantations. In such aspects, there is lack of demonstrated relative advantage that TC seed has over suckers to meet farmers' needs in terms of food and income security which compromises *security* and *achievement* as cultural values.

2.3.3 Banana varieties as a cultural artefact

Different banana varieties were used in performance of some cultural practices. The banana in this case is not just a crop but also a cultural artefact. Propagation of TC planting materials would therefore have to consider the cultural use of the banana. Table 5 presents the cultural uses of banana in central Uganda.

Table 5: Banana varieties and their cultural practices in central Uganda

Variety	Cultural importance
Nakitembe	Disposal of placentas for newly borne baby girls
	Treating menstrual pains especially for adolescents
	Herbal baths for baby girls
	Celebrations of birth of twins
	Burial of deceased females (Mid rib of *Nakitembe* pseudo stems crushed and used to 'wash' the deceased's face. Of importance to pacify spirits of the dead).
	Marriage ceremonies -Leaves used in *matooke* preparation for in laws during introduction (*Kwanjula*) ceremonies. -Leaves important for herbal baths of brides before marriage. -Food used by brides after honey moon to prepare first meals for husbands.
Embidde enganda (Kabula & Nsowe)	Disposal of placentas of newly born baby boys.
	Burial of deceased males -Mid rib of pseudo stems crushed and used by relatives to 'wash' the deceased's face.
	Herbal bath '*Ekyogero'* for male babies.
	Marriage ceremonies -Leaves used for herbal baths of bride grooms.
Kayinja	Prevention of rains -A stick is pierced through a finger and placed at a fireplace ('*Ekyoto'*)
	Last funeral rites and burial ceremonies -Dry leaves *'essanja'* spread on bare ground whereon the casket is placed and the grieved sit. -Dry leaves used to make huts during last funeral rites where household members sleep.
Gonja	Cleansing ceremonies -The plant is lightly split from the pseudo stem and a household member made to go through it naked. S/he thereafter gets a herbal bath, marking the transfer of curses from the individual to the '*Gonja'* plant.

Most of these cultural practices are performed at household level, thereby compelling every household to posess specific varieties of cultural importance. Some of these varieties are considered of less importance by scientists and are not propagated through TC. A farmer in Nambi village emphasized:

"It is almost mandatory that in every household, each banana plantation will have varieties such as *Nakitembe*, *Embidde enganda* and even *Gonja*." (October, 2016).

There are several cultural practices related to child-birth ceremonies, marriage ceremonies, funerals and funeral rites. Even with the current modernization, it is common for women to give birth at home or within community. Traditionally, when a mother gives birth at home, the placentas are not thrown away as they are symbolic to the new-born child. For example, if a baby girl is borne, the placenta is wrapped in cloth by family and/or clan members and placed in a mat of *Nakitembe* variety (Plate 1). A different variety, *Embidde enganda* or *Kayinja* is used if it is a baby-boy. It is then covered with herbs preferably '*bombo' [Mormodica foetida Schum.]* and *'lweza' [Aerva lanata (L.) Juss. ex Schult*.] which are perceived to be important for peace and blessings upon the newborn.

Plate 1: A placenta wrapped in cloth and placed in shallow hole between two 'Nakitembe' pseudo stems.

The *Gonja* variety is used in cleansing ceremonies and celebrating peace and harmonious relationships in families or reuniting individuals and families. Literally translated, *Gonja*, means *'soften'* implying that when people share *Gonja* in a peace-making ceremony, the parties involved become tolerant to each other. For example, in case of disagreements between husband and wife, it is believed that when the wife serves her husband with roasted *Gonja* in the evening, such disagreements are resolved. The leaves of some varieties namely; *Kayinja*, *Ndiizi* and *Bogoya* are preferred for wrapping sauce (*luwombo*) or *matooke* before they are

steamed, a special way of cooking for distinguished guests such as in-laws (Plate 2 and 3). Such ways of food preparation are common for events that bring together people of various calibre such as marriage ceremonies and visits.

Plate 2: A-Smoked banana leaves, *'empombo'* with ground nut sauce: B- Ground nut sauce wrapped in *'empombo'* and tied with a banana fibre, traditionally referred to as *'luwumbo'* ready to be steamed.

Plate 3: A-Peeled cooking banana, '*matooke'* placed in banana leaves; B- *Matooke* wrapped in banana leaves and tied with banana fibre; C-*Matooke* covered with banana leaves in a saucepan ready to be steamed.

2.3.3.1 Beliefs associated with bananas

Societal beliefs associated with banana varieties (Table 6) guide farmers' use and cultural connections with the varieties that they grow. These relate to taboos and norms that are strongly beheld and adhered to, inevitably governing the banana cropping system as well as the farmers' way of life. For example, in one of the FGDs in Mukono district the TC nursery operator specified;

"Some time ago I had the Gonja variety among the TC planting materials and that season, my sales were very low. A community member advised that my sales were very low because of the bad luck associated with the Gonja

variety and he cautioned that I get rid of them. When I did as advised, my sales went higher the next season." (November, 2016).

This finding implies that some varieties such as *Gonja* are associated with bad luck and are not commonly grown in the region or where grown, caution is taken. For instance, it is believed that farmers have higher chances of experiencing lightning if they plant *Gonja* around their homesteads. As such, in homesteads where it is grown (most especially for use in performance of particular rituals), only a few mats are planted and precisely on the peripheries of plantations. Additionally, even buyers are keen not to carry *Gonja* among other bananas and to minimize on this effect, a finger of *Gonja* is placed under the vehicle wheel so that it is crushed prior to transportation. Unless going for burial, caution is taken by farmers not to consume *Gonja* or have anything to do with this variety as it is believed any anticipated success for the day will ultimately turn to failure. Such beliefs though scientifically not proven, inadvertently hinder the uptake and utilization of such varieties.

Similarly, some banana varieties are believed to 'transform' to other varieties when specific norms are evaded (Table 6). For example, *Nambi* is believed to change to *Nakitembe* when its banana leaves are used for cooking food. However, this is indicative of such varieties belonging to the *Nfuuka* clone set (characterized by high susceptibility to morphological change) (Karamura *et al.*, 2012) and not necessarily because particular norms have been evaded. Banana cultivars are known to present superficial expressions of morphological traits which are often not stable and some cultivars as well show different phenotypic expressions under different ecological conditions (also see Karamura and Karamura, 1994; Karamura, 1999). It is also believed by farmers in the study communities that the TC planting materials are 'hybrids' meaning that such a variety has been modified from its original form; implying that such varieties are not suitable to perform cultural functions and rituals. This points to farmers' perceived incompatibility of TC banana planting materials with their socio-cultural identity, which acts as a significant barrier to use of the technology in the study communities since *tradition* as a cultural value is compromised. To the contrary, TC established varieties are genetically similar with the original (local) varieties from whence they are cloned (Hrahsel and Thangjam, 2013). The hesitation to take on TC planting materials is therefore partly attributed to inadequate information and understanding of processes of TC propagation on the part of the farmers.

Table 6: Banana varieties and their associated beliefs in central Uganda

Variety	Associated beliefs
Nakabinyi	Banana bunches not fit to be given as gifts to in-laws since shape of male bud elongates in the semblance of a male human reproductive organ.
Mbwazirume	Believed to 'change' to *Nakitembe* (losing the reddish colour of the mid ribs of its banana leaves) if its leaves are used in food preparation.
Siira	Transforms to *Nfuuka* variety if leaves are used in food preparation.
Embidde enganda (Kabula & Nsowe)	Believed to be the 'husband' of a plantation. The first variety planted in the middle of a plantation.
Embidde (Kabula & Nsowe)& Kayinja	Considered 'male' varieties
Nfuuka	Changes to another variety if knife used to cut animal meat is used to cut the leaves.
Nakitembe Embidde enganda/Kayinja	Bestow blessings to infants when used for herbal baths.
Tissue culture banana varieties	Hybrids which have been modified from their original form

2.3.4 Banana as medicine

Some banana varieties are also used as medicine in the *Baganda* culture. Table 7 illustrates how some varieties are used to treat various ailments. For instance, epilepsy in infants is treated through a ritual where the infant is bathed from a *Mbidde* mat. Whereas neither fire nor hot water are used, the leaves of the *Mbidde* variety should appear 'burnt/scotched' after the ritual - a sign that the epileptic '*demon'* is gone and if it does not, the child is not healed and the procedure can be repeated. On the contrary, piles in males is treated by placing a patient up on the *Mbidde* variety pseudo stem (for females a *Nakitembe* pseudo stem is used) that has not flowered. S/he faces in the sun's direction and is gently lowered every morning and evening. It is believed that by the time the banana plant flowers, s/he will have healed.

Table 7: Medicinal uses of banana varieties in central Uganda

Variety	Disease/ailment
Embidde enganda (Kabula & Nsowe)	Diarrhea -Sap from suckers mixed with herbs and drank
	Treatment of umbilical cords in infants - Sap from suckers placed on the umbilical cords of infants
	Fractures in both humans and animals - Sap from suckers used to set and massage fractured bones
	Snake bites - Sap from sucker mixed with tree herbs and drank.
	Abscesses - Sap from sucker mixed with herbs, ant hill *'ekifulufu'* soil and concoction smeared on boils.
Gonja	Healing of umbilical cords in infants -A finger is burnt, resultant ash gently rubbed on umbilical cords of infants.
	Child birth - Mother in labour chews roots to hasten the child delivery process
	Colic in infants - A mother of twins (*Nalongo*) weaves a small rope from banana fibre that is tied around the waist of the infant
	Diarrhea in infants - Fibre tied around waist of sick infant till the condition stops.
	Mumps - Banana fibre tied around the child's chest
Kibuzi	Wounds and skin infections - Rachis cut into pieces, boiled and resultant liquid bathed or applied on wounds.
Nakamali	Impotence in men - Geotropic roots crushed, mixed with hot water and drank
Nakitembe, Embidde enganda & Kayinja	Skin diseases and epilepsy

Across the world, cultural systems recognize health and well-being of individuals as being complex, combining spiritual and physical dimensions (Bodeker, 1989; Willet, 1993; Fisher, 2011). It is believed that both dimensions have to be harmoniously developed for the total well-being of an individual. Nevertheless, as earlier mentioned, farmers have an attitude that TC materials have been genetically modified (or hybrids) and would not be trusted for potency of their medicinal properties. For this reason, farmers will continue to plant their local materials

even alongside the TC seed, and thereby sustaining the risk of BXW through cross-contamination.

2.4 Conclusion and implications

This chapter has illustrated how culture and traditions have influenced the limited uptake and effectiveness of TC banana planting materials as a strategy for controlling BXW in central Uganda and in the context of *Baganda* culture. Technologies such as TC need to be developed with multi-dimensional considerations including the cultural perspective, but results also paint the picture of how complex it is for the TC technology to meet the varied cultural needs and uses of banana. In the attempt to maintain a wide range of banana varieties for cultural practices, even the TC planting materials are cross-infected and therefore not effective in controlling BXW. It is as such imperative that a wide range of varieties through TC seed are provided which fit the socio-cultural context and satisfy the multiple functions of banana to foster uptake. Even so, TC seed producers (e.g. TC laboratories and TC nursery operators) ought to take caution whilst increasing seed supplies to break-even in their businesses. Only a few plantlets (one or two for a farmer) suffice for cultural purposes and as such not all varieties may be highly demanded.

Farmers' belief that TC seed is genetically modified points to the need for robust awareness creation in the study communities about the entire process and procedures for tissue culture micro propagation. Additionally, requisite practices and procedures related to TC seed establishment and management amongst which are factors such as soil fertility should be provided to farmers alongside TC materials. These are vital to sustain the high productive varieties mainly promoted through TC seed. This chapter provides clear insights that help to broaden explanations of socio-cultural factors that constrain use of newly introduced agricultural technologies. The results not only provide a 'reality check' but also highlight the importance of farmer engagement in the development and promotion of any agricultural-related innovation. Future efforts to control BXW would be beneficial if a location specific and holistic approach encompassing aspects of clean seed (but with cultural dimensions embedded therein) is taken into account. A systematic and scientific investigation concerning the medicinal values of some of the banana varieties to verify some of the claims made by the farmers is recommended.

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CHAPTER 3: THE INFLUENCE OF PERCEPTIONS ON FARMER INTENTIONS TO USE TISSUE CULTURE BANANA SEED IN CENTRAL UGANDA[6]

Abstract

Effective management of plant health is fundamental for food and income security to meet the growing demands of local and global markets. This however requires farmers' adequate access to quality seed void of pathogens. This chapter, anchored in the Unified Theory of Acceptance and Use of Technologies, unravels perceptions that influence farmers' intentions to use tissue culture banana plantlets in the control of Banana Xanthomonas Wilt. Data were collected from 248 systematically sampled banana farmers using a structured questionnaire and analyzed using structural equation modeling to examine hypothesized paths in the uptake of banana tissue culture planting materials. Results show that farmer perceptions on TC banana seed are shaped by a range of factors that include performance expectancy of the seed, social influence, facilitating conditions and seed quality. Findings also reveal that farmer intentions to use TC banana seed are dependent on two constructs; social influence ($\beta = 0.432$; $P < 0.01$) and farmer innovativeness ($\beta = 0.095$; $P < 0.05$). However social influence is the main predictor of intentions to use tissue culture banana planting materials. In particular, farmer innovativeness mediates facilitating conditions and social influence in predicting intentions to use tissue culture planting materials. Thus, this study reveals two factors that influence farmer intentions to use tissue culture planting materials; social influence and farmer innovativeness. The findings imply that social influence and farmer innovativeness are critical in disseminating novel agricultural technologies in Uganda and elsewhere.

Key words: Banana tissue culture, banana Xanthomonas wilt, central Uganda, use of agricultural technology

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3.0 Introduction

Good plant health is fundamental to ensure food and income security among smallholder farmers, so as to meet the demands of local and global markets (Danielsen et al. 2011). Likewise, effective plant healthcare is essential for producing healthy crops for both human and animal consumption (Karubanga, Matsiko, and Danielsen 2017), as well as for non-food purposes (Danielsen et al. 2012). However, substantial amounts of crop produce are lost every year due to plant health problems (Karubanga, Matsiko, and Danielsen 2017).

In sub-Saharan Africa, most of these losses are mainly due to pests and diseases associated with seed saved from previous harvests, that smallholder farmers rely on for planting material (McGuire and Sperling 2016). In rural farming communities the informal seed system[7] is usually preferred to the formal seed system.[8] Even when seed is available from the market, farmers often prefer using their own seed to save money and avert risks associated with the crops they grow (e.g. changes in weather, pests and erratic market prices). For example, in informal systems mostly in developing countries, the seed from vegetatively propagated crops such as banana is mainly produced locally. More than 90% of farmers in the banana farming systems in East and Central Africa rely on suckers sourced from friends, neighbors, relatives and/or their own fields to establish new banana gardens (Smith et al. 2008; Lwandasa et al. 2014). However, the banana planting material they use is seldom certifiably disease free, which poses a high risk of transmitting pests and diseases across farms (Jogo et al. 2013). Seed-borne pests and diseases[9] continue to be a serious threat to banana production, more so in areas where the planting material is of poor quality and/or scarce.

Banana Xanthomonas Wilt (BXW) caused by the bacterium *Xanthomonas campestrisn pv. musacearum* is a major threat to food and income security among smallholder farmers in Uganda, especially in the areas where banana is an important staple and cash crop. If uncontrolled, BXW can eventually cause an estimated production loss of the banana crop of about 53% over a 10-year period (Tripathi et al. 2009), equivalent to a reduction from 5.6 to 10.5 million metric tonnes per year (FAOSTAT, 2013). The disease can potentially decimate

[7] An informal seed system is managed by the farmers without the public sector involvement (Thiele, 1999).

[8] A formal seed system is regulated by the public sector, usually by an inspection process known as 'certification' and controls variety release to ensure that available seed is of a recognized variety with a low incidence of disease (RTB 2016).

[9] Nematodes, weevils, bacterial and fungal wilts (incl. BXW) and viral diseases.

the entire crop where highly susceptible cultivars are grown (Kubiriba et al. 2012). Between 2002-2005, it is estimated that the disease caused a total loss equivalent to 61.1 million dollars to Uganda, mainly associated with the East African Highland Banana (EAHB) 'Matooke' (AAA-EAHB genome group) and the 'Kayinja' beer banana (ABB genome group) (Tushemereirwe et al. 2009). To avert the situation, use of tissue culture (TC) banana (*Musa spp.*) planting materials is one of the strategies that has been promoted for controlling the BXW disease. Using TC banana seed is an effective method of providing pest and disease-free plants (Dubois et al. 2013), guaranteed by high standards in the production process. It is therefore argued that as a control measure in the spread of BXW, TC banana planting materials can be of high quality (Wambugu et al. 2000) and consequently of utmost relevance for boosting banana productivity since they aid in the establishment of clean banana plantations- void of BXW.

Campaign against BXW has since focused on encouraging farmers to adopt TC seedlings as a technology. However, the uptake of TC seedlings remains low (Jogo et al. 2013), at less than 7% of the total banana coverage in the country (Dubois et al. 2013). Several authors (Sall et al. 2000; Mcrobert and Rickards 2010; Meijer et al. 2015) cite the importance of perceptions in influencing adoption and scaling-up decisions for farmer uptake of agricultural technologies. Studies (Ali et al. 2016; Okumus et al. 2018) demonstrate higher innovativeness in individuals to be associated with positive beliefs and perceptions towards technology uptake. Similarly, farmer perceptions of the quality of proposed planting materials was showed to be of significance for farmer acceptance and eventual use of proposed technologies (Andrade-Piedra et al. 2016). Previous research assessing adoption of TC banana planting materials has mainly focused on economic factors such as high cost of seedlings, higher labor and input requirements (Muyanga 2009; Njau et al. 2011; Kabunga, Dubois, and Qaim 2012). Little attention has been paid to studying how farmers' perceptions towards TC banana seed affects their intentions to use the plantlets in the control of BXW. Specifically, two objectives are addressed in this study: first, to identify what shapes farmer perceptions to use TC banana seed; and second, to explore the extent to which farmer perceptions influence their intentions to use the TC banana seed.

3.1 Theoretical framework

This study uses the Unified Theory of Acceptance and Use of Technology (UTAUT) to examine the effect of perceptions on farmer intentions to use TC banana planting materials in Central Uganda. Recent applications of UTAUT for assessing uptake of a new technology such

as TC banana include: Wu, Tao, and Yang (2007); Maldonado et al. (2009); Islam and Grönlund (2011); and Taiwo and Downe, (2013). Specifically, UTAUT has been applied to examine rural farmers' adoption of agricultural information technology services (Wu 2012); farmers' uptake of solar water pump technology in Northern Pakistan (Zhou and Abdullah 2017), and farmers' acceptance of pressurized irrigation technology (Nejadrezaei et al. 2018).

UTAUT is one of the new models in the domain of technology acceptance and compared to other widely-used theories such as the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT) and Theory of Planned Behavior (TPB), it utilizes a more integrative approach, combining variables from existing theories as predictors of technology acceptance and usage (Nejadrezaei et al. 2018). The Unified Theory of Acceptance and Use of Technology integrates constructs across eight models that include: the Technology Acceptance Model (TAM) (Davis 1989), the Theory of Reasoned Action (TRA) (Fishbein and Ajzen 1975), the theory of Planned Behavior (TPB) (Ajzen 1991), the Combined TAM and TPB (Taylor and Todd 1995), the Innovation Diffusion Theory (IDT) (Rogers 2003), the Social Cognitive Theory (SCT) (Bandura 1989), the Motivational Model (MM) (Davis, Bagozzi, and Warshaw 1992), and the Model of PC Utilization (MPCU) (Thompson, Higgins, and Howell 1991). Consequently, it has a better predictive value than any one individual theory (San Martin and Herrero, 2012; Okumus et al. 2018).

In explaining intentions to use technologies, UTAUT uses the concepts of social influence, facilitating conditions, effort expectancy and performance expectancy. The promotion of TC banana seed amongst smallholder farmers for adoption mirrors this structural set of the UTAUT model in the sense that the focus is on farmers' acceptance of TC seed as a technology. UTAUT explains that people accept new ideas, such as using banana TC planting materials, following a series of complex mental processes in which intentions precede behavior (Venkatesh et al. 2003; Islam and Grönlund, 2011). However, the concept of effort expectancy which recounts the extent to which a farmer believes that using TC seed is free of effort was dropped in the analytical framework because it is a notion farmers in the current study communities are ardently aware of, having interfaced with this technology for over a decade now. Subsequently, farmer innovativeness and perceived quality of the technology are integrated as additional determinants of farmer acceptance and use of the TC banana technology. Previous studies have shown higher innovativeness in individuals to be associated with positive beliefs and perceptions towards technology uptake (Ali et al. 2016; Okumus et al. 2018). Similarly, farmer

perceptions of the quality of proposed planting materials has also been shown to be of significance for their acceptance and eventual use of proposed technologies (Andrade-Piedra et al. 2016). Thus, farmer innovativeness and perceived quality of the planting materials may be essential determinants of farmers' acceptance of the TC technology.

Previous research (Venkatesh, Thong, and Xu 2012; Ali et al. 2016; Okumus et al. 2018) showed that intentions to use a technology is the most significant predictor for uptake behavior and actual usage. Consequently, Ajzen (1991) assumes individuals' intentions capture the motivational aspects that affect their behavior and indicates any individual's willingness to develop an action. A common construct that explains intentions is social influence. For this study, s*ocial influence* is defined as *the degree to which a farmer perceives that relevant people believe that he or she should use a technology* (Taylor and Todd, 1995). El-Gayar, Moran, and Hawkes (2011) argue that social influence triggers individuals' behavioral intentions to use new technologies and various scholars (Abushanab and Pearson, 2007; Eckhardt, Laumer, and Weitzel 2009; Ali et al. 2016; Okumus et al. 2018) attest to this. Since banana cultivation is embedded in the cultural values of exchange of planting materials and traditional practices, the pressures created by social interactions and norms may motivate farmers in the uptake of TC as banana planting material in the control of BXW. In the context of this study, social influence is operationalized as *being persuaded (informed) by faith based organizations, members of the community and farmer groups to use TC planting materials in growing bananas*. It can thus be assumed that social influence on use of TC banana planting materials will influence farmer uptake intentions.

Facilitating conditions as a construct describes *the degree to which a farmer believes that organizational and technical infrastructure exist to support his or her use of TC as banana planting material*. A number of studies attest and confirm the effect of facilitating conditions on acceptance and usage of technologies (Venkatesh, Thong, and Xu 2012; Ali et al. 2016; Okumus et al. 2018). Increasing levels of facilitating conditions are expected to reduce levels of uncertainty or ambiguity with the TC banana technology (Al-Gahtani, Hubona, and Wang 2007). For instance, Alawadhi and Morris (2008) tested and confirmed the significant effect of facilitating conditions on students' use of e-government services. In another study, Lakhal, Khechine, and Pascot (2013) verified facilitating conditions as a significant determinant of students' intentions to use desktop video conferencing in a distance learning course. In the context of this study, 'facilitating conditions' are operationalized as *TC nurseries having*

demonstration gardens and the TC nursery operators being willing to provide information to intending users on how to plant and manage the TC planting materials. It can therefore be assumed that facilitating conditions will influence uptake intentions for TC banana planting materials. *Perceived seed quality* on the other hand is described as *the degree to which a farmer believes that TC planting materials are free of pests and diseases* (particularly BXW) *and are of high genetic purity* [Root Tuber and Banana (RTB) 2016]. Studies (Abay, Waters-Bayer, and Bjørnstad 2008; Kraft, de Jesús Luna-Ruíz, and Gepts 2010; Andrade-Piedra et al. 2016) attest and confirm the importance of seed quality in farmer acceptance and use of technologies. High perception levels of the quality of TC planting materials are expected to motivate farmers in their use of TC banana planting materials since their uncertainty/risk as a potential means of spreading BXW in farmers' banana farms is reduced. In the perspective of this research, seed quality is operationalized as *TC planting materials being perceived as pest and BXW free and void of mutants*. It is as such assumed that farmers' perceived quality of TC banana planting materials will influence their intentions to use this technology.

Performance expectancy is contextualized in this study as *the extent to which a banana farmer believes that the use of TC as banana planting material enhances the performance and output from his or her banana plantation(s)* (Compeau and Higgins, 1995). Previous studies have shown that intention to use a technology or system is significantly predicted by performance expectancy (Slade et al. 2015; Ali et al. 2016; Okumus et al. 2018). Biemans et al. (2005) revealed that performance expectancy is a high predictor of a nurse's behavioral intention to use medical teleconferencing applications. Similarly Fang, Li, and Liu (2008) showed that performance expectancy significantly predicts managers' intentions to engage in knowledge sharing using web2.0. We therefore presume that performance expectancy has a direct effect on TC technology uptake intentions. In light of this study, performance expectancy was operationalized as *TC planting materials yielding marketable large sized banana bunches and many suckers*. Thus, we further postulate that farmers' perceived performance expectancy of TC banana planting materials will positively influence uptake intentions of the TC banana technology.

Farmer innovativeness in the perspective of this study is *the degree to which a farmer is receptive to new agricultural related ideas and makes innovative decisions independently of the communicated experience of others* (Midgley and Dowling, 1978). Previous studies have discussed the influence of innovativeness on individuals' perceptions and behaviors and its role

in determining users' acceptance of technologies (Lu, et al. 2003; Lu, Yao, and Yu 2005; Yi et al. 2006; Turan, Tunç, and Zehir 2015). For instance, Okumus et al. 2018 showed individual innovativeness to be a significant predictor of restaurant customers' intentions to use smartphone diet apps while ordering food. Additionally, Liu, Li, and Carlsson (2010) revealed that innovativeness was a significant predictor of Chinese students' intentions to use mobile learning. In the field of self-service technologies, Chen (2008) also found that an individuals' innovativeness directly influenced intentions to purchase and use these technologies. For this study, farmer innovativeness was operationalized as *farmer willingness to creatively integrate the use of TC planting materials with their local knowledge and other available materials in the control and management of BXW*. We expect farmers' innovativeness to influence TC planting materials uptake intentions. Moreover, highly innovative farmers may have better perceptions of TC planting materials in terms of facilitating conditions, influencing their uptake intentions compared to less innovative farmers (Okumus et al. 2018). Likewise, San Martín and Herrero (2012) argued that individuals with higher innovativeness are less influenced by others' opinions about technological innovations. Thus, higher innovativeness may result in weaker social influence on adoption and uptake of the TC technology. Consequently, for highly innovative users, facilitating conditions and social influence may be less influential when adopting a technology.

Based on the descriptions above (summarized in figure 5), nine hypotheses were formulated:

H_1: Social influence has a positive and significant influence on farmer intentions to use TC banana seed.

H_2: Social influence has a positive and significant influence on farmer innovativeness in the use of TC banana seed.

H_3: Facilitating conditions have a positive and significant influence on farmer intentions to use TC banana seed.

H_4: Facilitating conditions have a positive and significant influence on farmer innovativeness to use TC banana seed.

H_5: Farmers' perceived quality of banana TC planting materials has a positive and significant influence on their intentions to use TC banana seed.

H_6: Performance expectancy has a positive and significant influence on farmer intentions to use TC banana seed.

H_7: Farmer innovativeness has a positive and significant influence on farmer intentions to use TC banana seed.

H_8: Social influence is mediated by farmer innovativeness in predicting farmer intentions to use TC banana seed.

H_9: Facilitating conditions is mediated by farmer innovativeness in predicting farmer intentions to use TC banana seed.

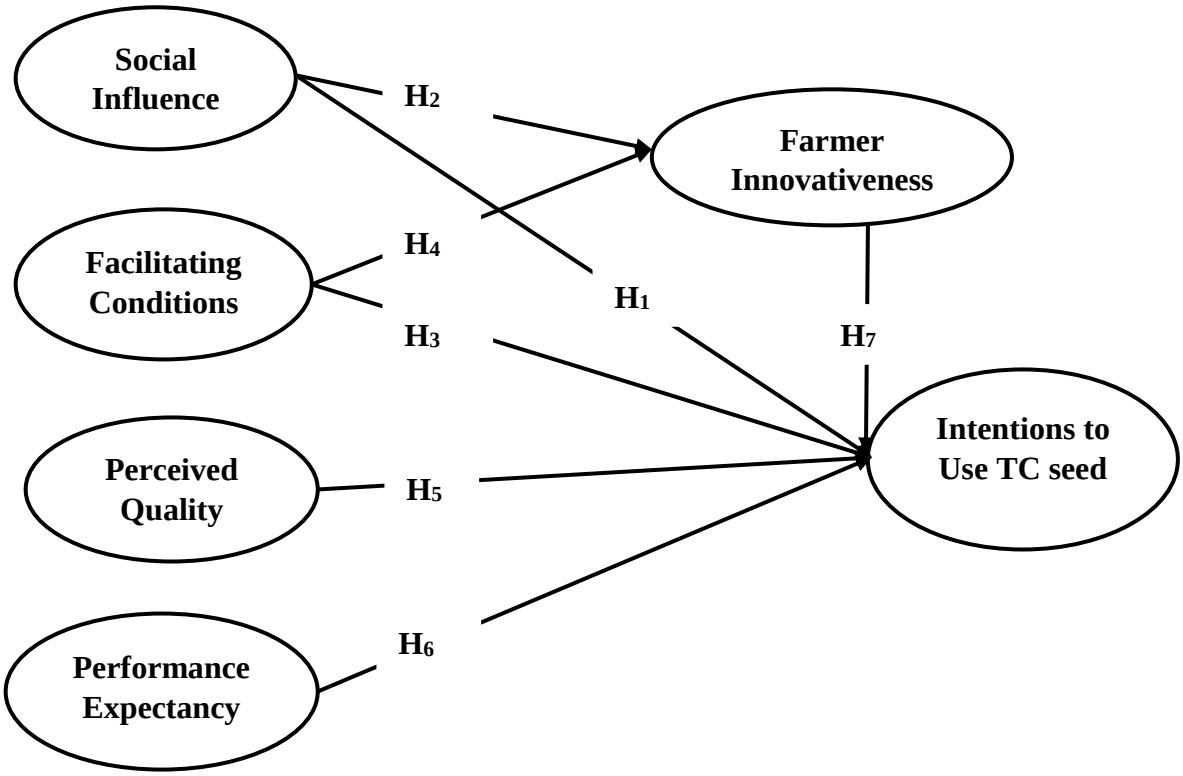


Figure 5: Summary of hypothesized relationships of farmer perceptions and their influence on intentions to use TC banana seed

3.2 Methodology

3.2.1 Research Design and sample collection

A cross-sectional survey was conducted between March, 2018 and May, 2018. A total of 248 banana farmers were systematically sampled from two farming communities (Gonve and Nambi) that hosted community-based banana TC nurseries in Luweero and Mukono districts respectively in central Uganda. Banana farmers were purposively targeted because the study focused on TC banana seed and these were the farmers that were presumed to possess the information needed for the study. Therefore, with the help of the village Local Chairpersons (LCs) names of all banana farmers in the selected communities were compiled to generate the sampling frame with a total of 1,060 banana farmers (Table 8). The total size of the sampling

frame was then used to compute the sample size using Cochran (1977) formula indicated below;

$$n_0 = \frac{z^2 pq}{e^2}$$

Where: n_0 is the sample size, z is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in the population, $q = 1 - p$ and e is the desired level of precision.

Since $n_0 / N > 0.05$, the correction factor is applied;

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$ (N is the population size)

Based on the formula, the computed sample size was 256 farmers. During the actual data collection, 248 banana farmers were successfully interviewed representing a response rate of 97% of the targeted 256.

Table 8: Number of farmers selected for the study

Location	Total number of farmers	Number of farmers selected
Village: Nambi Luwero district	500	122
Village: Gonve Mukono district	560	126
Total	**1060**	**248**

3.2.2 Data and data sources

To measure the constructs in this study, 21 statements were used. Social influence (SI) was measured with 3 items (e.g. "If I am informed about TC seed by a faith-based leader in my church/mosque, then I can use it as banana seed). Facilitating conditions (FC) was measured with 3 items (e.g. "The TC nursery operator provides information on how to plant TC seed), and perceived quality (PQ) had 3 items (e.g. "TC seed is BXW free") as proposed by RTB (2016). The performance expectancy (PE) variable had 4 items (e.g. "TC seed yields bunches with large banana fingers) as well as farmer innovativeness (FI) variable (e.g. "I apply wood ash around TC banana mats that have exhibited BXW symptoms to prevent further infection).

Finally, the dependent variable intention for uptake of TC technology (IU) had 4 items (e.g. Given chance, I intend to use TC seed when expanding my banana plantation) as adapted from Okumus *et al.* (2018). Each item was measured on a five-point rating scale with 1= least and 5 = highest.

3.2.3 Data analysis

Data were cleaned and transferred to the SPSS–AMOS version 23 for Structural Equation Modelling (SEM). Means, standard deviation and percentages for describing the sample characteristics were computed and descriptive statistics were generated for the six constructs.

Distinct from other methods of data analysis (e.g. Ordinary Least Squares (OLS), SEM is highly recommended for studying human behavior entailing complex inter-relationships between factors and behavior [MacCallum and Austin (2000)]. It is also credited for its ability to simultaneously estimate multiple cause–effect inter-relationships among independent, mediating and dependent variables (Mittal and Dhar 2015). The SEM process followed a three-step procedure entailing: (i) Exploratory Factor Analysis (EFA) for data reduction, (ii) Evaluation of the measurement model and (iii) Confirmatory Factor Analysis (CFA) for model fit and testing relationships. Specifically, EFA reduced the number of items for each construct to only those that exhibited the best fit while evaluation of the measurement model assessed the contribution of each item to the construct variance [measured using factor loadings and Average Variance Extracted (AVE)].

3.2.3.1 Assessment of assumptions for SEM analysis

Preceding path analysis, four assumptions of SEM were assessed namely: Normality, measurement validity, convergent validity, discriminant validity and multicollinearity. First, the normality of the data was examined. Skewness and kurtosis stretched from -1.89 to 1.25 and -0.57 to 5.04 respectively (Table 9). Following Kline's (2005) recommendations that the skewness and kurtosis indices should be within |3| and |10| respectively, the data in this study are regarded as normal.

Table 9: Descriptive statistics of the study constructs

Construct	Item	Mean	SD	Skewness	Kurtosis
SI	3	3.80	0.82	-1.34	2.65
FC	3	3.02	1.05	-0.57	-0.57
PQ	3	3.50	0.88	-0.64	0.03
PE	4	4.10	0.70	-1.20	3.40
FI	4	1.79	1.34	1.25	-0.15
IU	4	4.11	0.82	-1.89	5.04

SI-Social influence; FC-Facilitating conditions; PQ-Perceived Quality; PE-Performance Expectancy; FI-Farmer Innovativeness; IU-Intention for uptake of TC technology

Secondly, measurement validity was assessed using construct reliability (CR), instead of Cronbach's alpha because the latter understates reliability (Hair *et al.*, 2006). The precondition is that CR = 0.70 and above to satisfy measurement validity (Nunnally and Bernstein, 1994). Convergent validity, concerned with whether observable variables (items) share adequate variance in the construct/latent variable was assessed using two indicators; namely factor loadings and AVE. This study adopted the criteria of Hair et al. (1998) on assessing factor loadings. They specify that a minimum threshold value of 0.4 for a sample size of 200 is adequate for confirming convergent validity. The AVE minimum threshold value adopted for this study in assessing convergent validity was 0.5 as suggested by Segars (1977). Discriminant validity was assessed by comparing the values of correlates to square root of AVE values. The preconditions are that the correlates must be smaller than the square root of AVE to satisfy the condition of discriminant validity (Fornell and Larcker, 1981). Correlation analysis was also conducted to establish whether relationships between the constructs for the study existed prior to SEM analysis and to assess whether a risk of multicollinearity existed amongst the constructs.

Measurement validity, based on composite reliability (CR) values for all constructs, ranged from 0.70 to 0.99 (Table 10) which were all above the minimum threshold of 0.70. Accordingly, measurement validity was confirmed in this study. Similarly, convergent validity was confirmed, since all factor loading had values above 0.4 (Hair et al. 1998) and AVE values were also all above 0.5.

Table 10: Validity and reliability for constructs

Constructs	Items	Loadings (≥ .50)*	[a] AVE (≥ .50)*	[b] CR (≥ .70)*
Social Influence	If I am informed about TC seed by a faith based leader in my church/mosque, then I can use it as banana seed (SI_1)	0.917	0.854	0.990
	If I am informed about TC seed by a community leader in my village, then I can use it as banana seed (SI_2)	0.984		
	If I am informed about TC seed by one of the group members in a farmer group, then I can use it as banana seed (SI_3)	0.868		
Farmer Innovativeness	I use a concoction of organic pesticides (fermented human & animal urine, wood ash and red pepper) to control pests in TC seed (FI_2)	0.980	0.924	0.992
	I use organic fertilizer (concoction of fermented human & animal urine and wood ash) to increase the fertility of soils wherein I have planted TC seed (FI_3)	0.988		
	I spray inorganic pesticides unto TC seed to control pests that attack during earlier months (FI_4)	0.952		
	I apply wood ash around TC banana mats that have exhibited BXW symptoms to prevent further infection (FI_5)	0.923		
Facilitating Conditions	The TC nursery operator is welcoming and willingly provides information on how to plant TC seed (FC_4)	0.991	0.814	0.834
	The TC nursery operator is welcoming and willingly provides information on how to manage TC seed (FC_5)	0.985		
	The TC nursery has a TC banana demonstration garden (FC_12)	0.699		
Perceived Quality	TC seed is BXW free (PQ_1)	0.804	0.561	0.703
	TC seed is pest free (PQ_2)	0.935		
	TC seed has no mutants (PQ_4)	0.402		
Performance Expectancy	TC seed produces very many suckers (PE_1)	0.472	0.511	0.994
	TC seed yields large banana bunches (PE_2)	0.888		
	TC seed yields bunches with large banana fingers (PE_3)	0.884		
	Banana suckers from TC seed are highly marketable (PE_5)	0.500		
Intentions to use TC	Given chance, I intend to use TC seed when expanding my banana plantation(s) (IU_2)	0.935	0.824	0.998
	Given chance, I plan to use TC to gap fill (IU_3)	0.955		
	Given chance, I intend to use TC seed when I have no suckers (IU_4)	0.907		
	Given chance, I intend to use TC when establishing a commercial banana plantation. (IU_6)	0.829		

*Acceptable level of reliability or validity. [a] AVE is computed by adding the squared factor loadings divided by the number of factors of the underlying construct. [b] CR = $(\Sigma \lambda)^2/(\Sigma \lambda)^2 + (\Sigma\delta)$

Regarding discriminant validity, the values of correlates were less than the square root of values of AVE (Table 11). Since inter-construct variance was less than intra-construct variance, it meant that all constructs exhibited distinctness from each other. Accordingly, discriminant validity was confirmed. Correlate values (Table 11) ranged from weak to moderate (r = 0.034 to r = 0.538), implying the existence of relationships amongst the specified constructs. Additionally, the correlates were all below the minimum threshold value of 0.60 suggested by Hamilton (2006) which ruled out the risk of multicollinearity.

Table 11: Testing for multicollinearity and discriminant validity

Fornell and Larcker's (1981) procedure						
	1	2	3	4	5	6
1. Social Influence	.924					
2. Facilitating Conditions	.085	.902				
3. Perceived Quality	.054	.124	.749			
4. Performance Expectancy	.301**	.098	.538**	.715		
5. Farmer Innovativeness	.199**	.366**	.167**	.280**	.961	
6. Intent for Uptake	.502**	.034	.134*	.341**	.237**	.908

**P < .01, *P < .05

Diagonal in parentheses: Square root of average variance extracted from observed variables (items); *Off-diagonal*: Correlations between constructs

3.2.3.2 Structural model assessment

As recommended by Hair et al. (2006), a variety of indices; [the χ^2 statistic, the adjusted goodness of fit index (AGFI), the root mean square error of approximation (RMSEA), comparative fit index (CFI) and Tucker-Lewis index (TLI)] (Table 12), were used to test for model fit.

Table 12: Fit indices for the measurement model

Model fit index	**Baseline for Goodness of fit**	**References**
χ^2/df (deg. of freedom)	< 3	Kline (2005); Cheng (2007)
AGFI	> 0.8	Chau (1997); Cheng (2007)
RMSEA	< 0.08	MacCallum, Browne, and Sugawara (1996); Chen, Kwok, and Goodson (2008)
CFI	≥ 0.90	McDonald and Ho (2002); Cleveland, Laroche, and Papadopoulos (2009)
TLI	≥ 0.90	McDonald and Ho (2002); Loibl et al. (2009)

Further analysis was done using bootstrapping to assess mediation relationships as well as determining effect sizes of prediction relationships. A model-based bootstrapping simulation of up to two thousand repetitions was performed as suggested by Byrne (2010). Notably, Byrne

(2010) explained that this procedure is important for ascertaining that the overall fit is not inflated because of the small sample size relative to the degrees of freedom of the model. On effect sizes, Cohen (1988) reasoned that effects with values less than 0.1 are considered small, those with less than 0.3 medium and values with 0.5 or more are considered large. In this study, Cohen (1988) criterion of evaluating effect sizes was adopted to assess the extent of influence the independent variables had on the dependent variable.

3.3 Results

3.3.1 Socio-demographic characteristics

Results in Table 13 show that the sample of respondents comprised more females (55%) than males (45%). Most were married (67%) and were between the ages of 30 and 49 years (55%). Forty-six percent of the respondents earn between UGX 1,000,000 - 4,999,900 annually, with most of them (77%) having attained primary and secondary school education. The *Baganda* ethnic group is the most dominant (92%) in the study communities and most of the respondents (91%) belong to the Christian faith religion.

Table 13: Demographic characteristics of study participants

Item (n= 248)	%
Sex	
Male	45
Female	55
Age	
18-29 Years	14
30-39 Years	30
40-49 Years	25
50 and Over	31
Marital Status	
Married	67
Single	9
Widowed/Separated	16
Unmarried Living Together	8
Annual Income (UGX)	
< 1,000,000	10
1,000,000 - 4,999,900	46
5,000,000 – 9,999,900	26
10,000,000 – 14,999,900	13
>15,000,000	5
Education	
No Formal Education	11
Primary School Education	40
Secondary School Education	37
College/University Education	12
Religion	
Catholics	30
Protestant	45
Moslem	9
Born Again	11
Others (SDA, Traditional religion)	5
Ethnicity	
Baganda	92
Basoga	2
Bakiga	1
Other (Japadhola, Bagishu, Balulu, Banyakole, Banyarwanda)	5

3.3.2 Farmer perceptions on tissue culture banana seed

The results of farmer perceptions on the constructs used in this study are presented in Table 14. Findings show that farmers rated the construct of perceived intentions to use TC banana seed the highest (M= 4.11) while the least rated construct was farmer innovativeness (M= 1.79). Respondents scored performance expectancy of the TC seed the second highest (M= 4.10) and facilitating conditions (M= 3.02) was the second lowest rated.

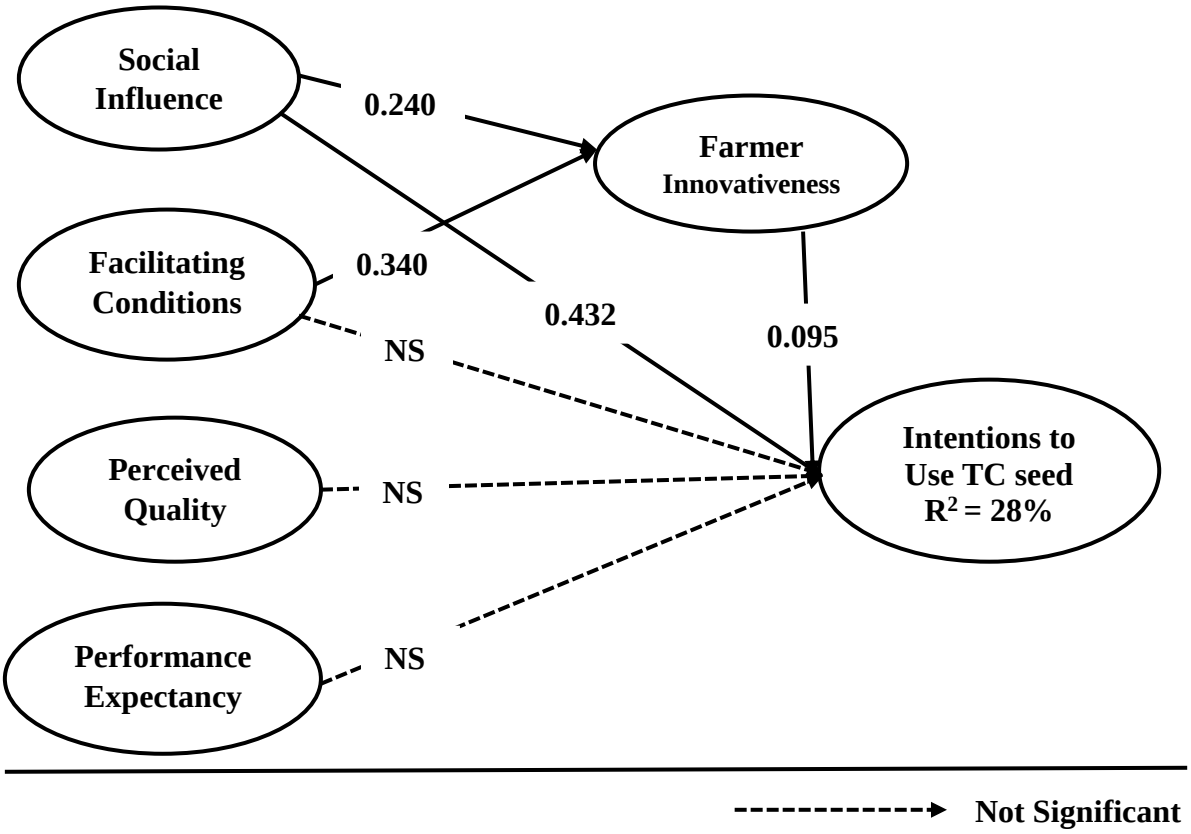
Table 14: Farmer perceptions on tissue culture banana seed (n = 248)

Construct	Item	Mean	Agg.mean
Perceived Quality	TC seed is BXW free	3.53	
	TC seed is pest free	3.62	
	TC seed is of desirable banana varieties	3.65	
	TC seed has no mutants	3.37	3.50
	Appropriateness of size	3.85	
	Food from TC seed is tasty	3.24	
	TC plantations are good for cultural purpose	2.52	
	TC plantations are drought tolerant	2.56	
Performance Expectancy			
	TC seed produces many suckers	3.69	
	TC seed yields big banana bunches	4.40	
	TC yield bunches with large fingers	4.29	
	Banana bunches from TC seed are highly marketable	3.98	4.10
	Banana suckers from TC seed are highly marketable	3.63	
	TC seed grows faster than suckers	3.88	
	Plantations established using TC seed last long	2.57	
Social Influence			
	Can use TC seed if informed by a faith based leader	3.73	
	Can use TC seed if informed by a community leader	3.79	
	Can use TC seed if informed by member of farmer group	3.88	3.80
	I should TC seed according to people of importance in my life	2.83	
Facilitating Conditions			
	TC seed sources are within reach	2.83	
	TC seed is certified	3.29	
	Information on how to grow & plant TC seed is available	3.15	
	Information on how to manage TC seed is available	3.14	
	Provision of trainings on how to plant & manage TC seed	3.13	3.02
	Provision of finances to purchase TC seed	2.58	
	Provision of land to plant TC seed	3.90	
	Provision of TC demo gardens	2.78	
Farmer Innovativeness			
	Intercropping TC seed with annual crops	1.72	
	Use organic pesticides to control pests on TC seed	1.82	
	Use organic fertilizers to increase soil fertility for TC seed	1.82	
	Use inorganic pesticides to control pests on TC seed	1.77	1.79
	Apply wood ash around TC banana mats to control BXW	1.74	
	First to explore new agric. info amongst my peers	2.88	
	Experiment with new agricultural information	3.42	
Intention to Use			
	Given chance, intend to use TC seed at initial establishment of plantation	3.88	
	Given chance, intend to expand my plantation using TC seed	4.02	
	Given chance, intend fill gaps in my plantation using TC seed	4.03	
	Given chance, intend to use TC seed when I have no suckers	4.12	4.11
	Given chance, intend to use TC seed when plantations exhibit BXW symptoms in community	4.13	
	Given chance, intend to use TC seed to establish commercial banana plantation	4.28	

For farmer perceived quality of the TC planting materials, appropriateness of size of the seed was rated highest (M= 3.85) while the item 'TC seed yields big banana bunches' for performance expectancy was scored highest (M= 4.40). The possibility of farmers using TC seed if informed by members of farmer groups was rated highest (M= 3.88) for social influence while provision of land to plant TC seed was scored highest (M= 3.90) for facilitating conditions.

3.3.3 Relationship between farmer perceptions and intentions to use TC seed

Figure 6 shows the results of the structural equation model predicting farmer intentions to use TC banana planting materials in the control of BXW. The overall goodness-of-fit of the illustrated model, as measured by the fit indices, indicated a good fit to the data. Furthermore, all independent and mediating variables explain 28% of the variance in intentions to use the TC banana technology (Figure 6). The R^2 value of 0.28 is higher than the 0.26 value that Cohen (1988) suggested would indicate a substantial model.



Model fit: χ^2/df = 2.349, AGFI= 0.826, RMSEA = 0.074, CFI = 0.954 and TLI = 0.950

Figure 6: Relationship between farmer perceptions and intentions to use TC seed

Results presented in Table 15 show that social influence (β = 0.432; t = 7.651; p< 0.01) had a positive and significant influence on farmers' intentions to use TC planting materials. This finding supports hypothesis H_1 implying that social influence is a significant predictor of farmer intentions to use banana TC planting materials. Furthermore, social influence (β = 0.240; t = 2.720; p< 0.01) and facilitating conditions (β = 0.340; t = 5.062; p< 0.01) indicated a positive and significant influence on farmer innovativeness, confirming hypotheses H_2 and H_4. Similarly, farmer innovativeness had a positive and significant influence on intentions to use

TC planting materials (β = 0.095; t = 2.396; p< 0.05), thus supporting hypothesis H_7 that farmer innovativeness significantly predicts farmer intentions to use banana TC planting materials.

Table 15: Path analysis results for testing hypotheses

Hypotheses	Standardized Estimates (β)	S.E	t-value	Decision
H_1: SI -- > IU	0.432	0.057	7.651**	Supported
H_2: SI -- > FI	0.240	0.088	2.720**	Supported
H_3: FC -- > IU	-0.044	0.042	-1.043	Not supported
H_4: FC -- > FI	0.340	0.067	5.062**	Supported
H_5: PQ -- > IU	0.031	0.054	0.574	Not supported
H_6: PE -- > IU	0.175	0.092	1.913	Not supported
H_7: FI -- > IU	0.095	0.040	2.396*	Supported

****P< 0.01, * P<0.05**

However, none of facilitating conditions (β = -0.044; t = -1.043; p>0.05), perceived quality of the TC planting materials (β = 0.031; t = 0.574; p>0.05) and performance expectancy (β = 0.175; t = 1.913; p>0.05) were significant predictors of farmer intentions to use TC planting materials. Hence hypotheses H_3, H_5 and H_6 were not supported in this study implying that facilitating conditions, perceived quality and performance expectancy are not perceived as important constructs in predicting farmer intentions to use TC banana planting materials.

3.3.4 Extent of influence of farmer perceptions on intentions to use TC banana seed

Bootstrapping results (Table 16) show that the indirect standardized effects for farmers' innovativeness (β = 0.025; 95% CI = 0.003 ~ 0.054) in mediating social influence to predict intention for uptake of TC planting materials was significant. Thus, the hypothesis (H_8) that farmer innovativeness mediates social influence in predicting intentions for uptake of TC was confirmed. Similarly, the indirect standardized effects for farmers' innovativeness (β = 0.046; 95% CI = 0.008 ~ 0.098) in mediating facilitating conditions to predict intention to use TC planting materials was significant. Likewise, hypothesis (H_9), that farmer innovativeness mediates facilitating conditions in predicting intentions to use TC, was confirmed.

Table 16: Boot strapping for mediation and effect sizes

Path	Standardized Effect sizes			Bias-corrected 95% CI	
	Direct	Indirect	Total	LL	UL
H_1: SI -- > FI	0.167	-	0.167	0.040	0.289
H_2: FC -- > FI	0.310	-	0.310	0.192	0.423
H_3: SI -- > IU	0.467	0.025	0.492	0.308	0.647
H_4: FC -- > IU	-0.062	0.046	-0.016	-0.159	0.133
H_5: PQ -- > IU	0.040	-	0.040	-0.126	0.203
H_6: PE -- > IU	0.141	-	0.141	-0.068	0.332
H_7: FI -- > IU	0.148	-	0.148	0.029	0.279
H_8: SI-- > FI -- > IU	-	0.025	0.025	0.003	0.054
H_9: FC-- > FI -- > IU	-	0.046	0.046	0.008	0.098

Results further show that social influence is the most dominant predictor of intentions to use TC planting materials with the largest total effect of 0.492. Additionally, this finding is statistically significant (β = 0.492; 95% CI = 0.308 ~ 0.647) and close to the large effect size criterion of Cohen (1988). The finding implies that social influence predicted about 49.2% of the variance in farmer willingness to use banana TC planting materials. Furthermore, facilitating conditions (β = -0.016; 95% CI = - 0.159 ~ 0.133), perceived quality of the TC planting materials (β = 0.040; 95% CI = -0.126 ~ 0.203), performance expectancy (β = 0.141; 95% CI = -0.068 ~ 0.332) and farmer innovativeness (β = 0.148; 95% CI = 0.029 ~ 0.279) respectively predict 1.6%, 4%, 14.1% and 14.8% of the variation in the farmers' intentions to use TC planting materials. Much as all these findings were significant, they fell short of meeting the medium size criterion of effect sizes as suggested by Cohen (1988).

The effect size in the relationship between facilitating conditions and farmer innovativeness (ß = 0.310; 95% CI = 0.192 ~ 0.423) was significant and fell within the criterion of medium size. This finding implies that facilitating conditions predicted about 31% of the variation in farmer innovativeness to use the TC planting materials in controlling BXW. On the other hand, the effect size in the relationship between social influence and farmer innovativeness (ß = 0.167; 95% CI = 0.040 ~ 0.289) was significant but it was only meeting small size criterion. This finding implies that facilitating conditions predicted about 16.7% of the variation in farmer innovativeness to use the TC planting materials in controlling BXW.

3.4 Discussion

Considering the importance of agricultural technology in the livelihoods of farmers it is necessary to have a deeper understanding of the factors that are likely to influence easy uptake of new technologies such as a TC banana seed. This study aimed at identifying and examining farmer perceptions that reportedly influence intentions to use TC banana planting materials, this technology being part of the strategy by the Government of Uganda to control the prevalence of BXW. Based on UTAUT, the study was set out to investigate hypotheses on factors that were presumed to influence farmers' adoption and use of TC banana planting materials including; social influence, facilitating conditions and performance. Owing to the relevance of individuals' innovativeness towards acceptance of new agricultural technologies and farmers' perceptions of the quality of proposed planting materials, this study also examined the role of farmer innovativeness and farmers' perceived quality of the planting materials and how these influence farmer intentions to use the TC technology.

The proposed model consists of explanatory variables from UTAUT, and is extended by two additional variables, viz; perceived quality and farmer innovativeness. Results showed that social influence and farmer innovativeness are significant predictors of uptake of banana TC technology and that social influence was the most important among all predictors for intentions to use the TC technology. Results point to the fact that farmers will have positive intentions to use TC as planting material if there is influence from a farmer's social circle or if a farmer is innovative and creatively integrates the use of TC planting materials with local knowledge and other available materials in the control and management of BXW. This is consistent with several previous studies (Eckhardt, Laumer, and Weitzel 2009; Amaroso and Lim, 2016; Okumus et al. 2018). The study findings further reveal that social influence and facilitating conditions influence farmer innovativeness. This indicates that a farmer's social circle and enabling conditions in the use of TC are essential in stimulating farmer innovativeness, an important predictor in TC planting materials uptake. This infers that social interactions and facilitating conditions are crucial in creating an enabling environment for farmers to be innovative.

Another important finding is the non-significant influence of facilitating conditions in predicting farmers' intentions for use of banana TC technology. This finding may be due to the fact that TC planting materials have been promoted for over a decade in the study area and even campaigns against BXW have mainly focused on encouraging farmers to use TC

seedlings. The TC nurseries were established in the study communities and as such, farmers are familiar with TC planting materials and facilitating conditions and this explains why TC may not be of relevance for them to consider in deciding whether to use them or not. Interestingly, the finding contrasts with previous literature supporting the significant effect of facilitating conditions on individuals' acceptance and uptake of technologies (Venkatesh et al. 2003; Alawadhi and Morris 2008; Eckhardt, Laumer, and Weitzel 2009; Lakhal, Khechine, and Pascot 2013; Ali *et al.*, 2016). For example, Alawadhi and Morris (2008) tested and confirmed the significant effect of facilitating conditions on students' use of e-government services and Lakhal, Khechine, and Pascot (2013) verified facilitating conditions as a significant determinant of students' intentions to use desktop video conferencing in a distance learning course.

Likewise, performance expectancy is not a significant predictor of farmer adoption of TC. This is perhaps explained by the fact that farmers have for the past decades interfaced with the TC technology and have observed its performance on their respective farmsteads. Thus, they are keenly aware of the benefits that they can derive from the technology and possibly rather than buy TC banana seed, they use suckers from their TC planted mats as planting material to expand or fill gaps in their banana plantations. These findings however contrast previous literature, supporting the significant effect of performance expectancy on intended users' acceptance and use of technologies (Biemans et al. 2005; Fang, Li, and Liu 2008; Eckhardt, Laumer, and Weitzel 2009; Ali et al. 2016; Okumus et al. 2018). For example, Biemans et al. (2005) examined nurses' behavioral intentions to use medical teleconferencing applications and their findings reveal that performance expectancy is a high predictor of behavioral intention. Similarly, empirical evidence from a study by Fang, Li, and Liu (2008) shows that performance expectancy significantly predicts managers' intentions to engage in knowledge sharing using web2.0.

Conversely, the perceived quality of TC planting materials was also found to be a non-significant predictor of farmer use of TC. This is probably because for the past decade, farmers in the study communities have intensively been sensitized and trained on the importance of TC as clean planting materials in attempts to control BXW. The finding implies that the farmers are undoubtedly aware of the quality of the TC planting materials, efforts that can be attributed to the role played by agricultural extension programs through the Government of Uganda (Barungi, Guloba, and Adong, 2015). Lastly, findings further reveal that the mediating role of

farmer innovativeness is significant in enhancing the potential of social influence and facilitating conditions in predicting the intentions of farmers to use the TC planting materials. This however means that farmers' innovativeness is a critical construct in intervening social influence and facilitating conditions if proper prediction for use of TC planting materials is to be made by the farmers (see also Turan, Tunç, and Zehir 2015).

3.5 Conclusion and implications

This chapter applied the UTAUT model to investigate perceptions influencing farmer use of TC banana seed as a strategy to control BXW. In attempts to achieve this overall objective, this study further used the constructs of farmer innovativeness and perceived quality of planting materials to extend the theoretical model of UTAUT. Results show that farmer perceptions on TC banana seed are shaped by a range of factors that include performance expectancy of the seed, social influence, facilitating conditions and seed quality. Findings have further revealed that farmer innovativeness is an important and critical factor in influencing the uptake of any agricultural technologies; in this case the TC banana planting materials. Farmer innovativeness also serves as a cardinal influence in mediating other technological-acceptance factors (i.e. social influence and facilitating conditions) for more meaningful and accurate prediction of farmers' intentions to use the quality banana plantlets for food and income security of smallholder farmers. Findings reveal critical factors and expand the UTAUT framework in the context of farmers' use of TC planting materials by proposing two additional constructs that are ideal in predicting the technological acceptance behavior among the farming communities - i.e., *farmer innovativeness* and *perceived quality* of TC planting materials. It can be concluded that these two are direct determinants of farmers' intentions to use agricultural technologies such as banana TC planting materials. This study provides strong empirical insights to propose and test a model for assessing technology-acceptance related factors that influence farmers' intentions to use promoted and approved agricultural technologies for enhancing rural livelihoods. This implies that the results provide a strong foundation for application in different contexts and theoretical assessments in other research fields.

Furthermore, this study offers practical implications in relation to banana farmers and supporting institutions (e.g. TC Laboratories and research institutions) that help in breeding and propagating TC banana seed. Concerning rural-based farmers, the research findings also suggest that social influence needs to be taken as the most significant predictor in assessing their intentions to use the new TC planting materials. This is a key implication for research and

other technology promoting institutions and extension efforts for the success of future related technologies meant for the marginalized rural farming communities.

Results recommend that new interventions such as the TC banana planting materials need to be promoted through locally institutionalized mechanisms such as faith-based leaders, political and community leaders and their respective members. Thus, fostering individual and group-based forms of interactive learning (e.g. through farmer groups, experimental gardens and extension) can as well act as systems for more enhanced encouragement purposely to trigger the acceptance and use of agricultural technologies such as the TC banana planting materials. However, it should be noted that this research was basically designed to investigate perceptions of farmers towards TC banana seed with limited attention on the actual measurement of farmer use of the TC planting materials in the study area. Therefore, this calls for future research efforts to focus on investigating the actual uptake of the TC banana technology in Uganda and elsewhere in the world. Additionally, prospective studies may also propose comparative models for TC technology users and non-users to establish the extent to which the intentions to use the technology differ among the two independent groups. The study sample was also limited to central Uganda and future studies should collect empirical data from other banana growing regions to ascertain whether use of technologies like TC banana planting materials are also influenced by different ecological zones and/or regions.

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CHAPTER 4: DETERMINANTS OF UPTAKE OF TISSUE CULTURE BANANA SEED BY SMALLHOLDER FARMERS IN CENTRAL UGANDA[10]

Abstract

Despite the development of Tissue Culture (TC) banana planting materials to curb the spread of diseases such as Banana xanthomonas wilt (BXW), farmer use of such quality planting material remains low. In this chapter, the Double-Hurdle model is utilized on cross-sectional data of 174 banana farmers sampled from Central Uganda to analyse the determinants for uptake of TC banana seed. Descriptive and inference statistics were also used to characterize and describe the sample. The findings reveal that only 33% of the farmers use tissue culture banana seed as planting material. Results also show that TC seed acceptability (β= 0.74; P<0.01), adaptability (β= 0.69; P<0.01) and availability for farmer use (β= 1.04; P<0.01) along with farmer competences and socio-economic factors positively influence farmer uptake of banana TC seed. For uptake intensity, the main positive drivers include TC seed acceptability (β= 0.39; P<0.05) and accessibility (β= 0.39; P<0.01) as well as farmer competences. This study demonstrates that seed security factors combine with farmer competences and socio-economic factors to influence farmer decisions on uptake of TC banana seed. Further, the study emphasizes the need for extra involvement of extension services and research institutions in the promotion of the TC planting materials in the banana farming communities. This involvement could include effective provision of appropriate information concerning the TC banana seed. It is recommended that TC banana seed developers and promoters focus attention on banana varieties that are acceptable and adaptable to the farmers' environmental conditions.

Key words: Seed security, tissue culture banana seed, uptake, banana farmers, central Uganda.

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4.0 Introduction

The per capita food output in Sub-Saharan Africa [SSA] has considerably declined and thus, contributing to increasing food and income insecurity (FAO, IFAD, UNICEF, WFP and WHO, 2019; Reynolds et al. 2015). At the center of the debate on food and income insecurity is the inability of the smallholder farmer to use quality seed void of pests and diseases (Kusena et al. 2017). Apparently in the SSA region, the seed system is characterized by the co-existence of the formal and informal seed supply. However, majority of the smallholder farmers depend on the informal seed supply (including home-saved seed from previous season harvests) for planting material (McGuire and Sperling 2016). For example, over 90% of banana farmers in East and Central Africa rely on suckers sourced from friends, neighbors, relatives and/or their own fields to either expand or establish new banana plantations (Kilwinger et al. 2019; Lwandasa et al. 2014). Nevertheless, the high prevalence pests and disease in the home-saved seed has necessitated the research and development practitioners to integrate the banana seed system into a more formal and quality assured seed supply (Dubois et al. 2013). It has been argued that an affordable and quality assured seed system that is embedded in the farmers' social cultural environment guarantees seed security (Almekinders et al. 2019). One such effort is the development of tissue culture planting materials which are always free of pests and diseases.

The development of banana tissue culture seed is a response strategy to addressing the dual challenge of: 1) supply of disease-free planting material; and 2) enhancing farm-level yields in banana production. First, banana is a major staple for more than a half of Uganda's population and it provides a wide range of products (animal feeds, charcoal briskets, crafts, construction materials) which significantly contribute to food and income security of the populace and consequently to national development (Kikulwe et al. 2018). Despite the value and benefits derived from banana, diseases such as Banana Xanthomonas Wilt (BXW) threaten its survival in the country. For example, between 2002-2005 it is estimated that the BXW caused a loss equivalent to 61.1 million dollars to the country, mainly associated with the East African Highland Banana (EAHB) 'Matooke' (AAA-EAHB genome) and the 'Kayinja' beer banana [ABB genome] (Tushemereirwe et al. 2009). As such, farmer use of quality banana material (e.g. tissue culture plantlets) is considered a vital component for the survival of bananas and boosting agricultural productivity in the country.

Tissue culture (TC) generated seed (also known as banana seedlings or banana planting material) is presumed to be free of BXW and are recommended for establishment of clean banana plantations (Dubois et al. 2013). However, the uptake of TC banana seedlings remains low (Jogo et al. 2013), at less than 7% of the total banana coverage in the country (Dubois et al. 2013). For instance, a study by Akankwasa et al. (2016) reveals two hundred and fifty mother gardens had been established in Uganda and 40,000 tissue cultured plantlets distributed to banana farmers. Results nonetheless indicate that merely 6% of the banana farmers are willing to use TC as banana seed. Existing studies (Murongo et al. 2018; Kabunga et al. 2012) have mainly focused on extrinsic (mainly socio-economic) factors to explain the low uptake of TC banana planting materials. However, studies that examine the role of seed security factors (seed availability, accessibility, acceptability and adaptability) in light of farmer characteristics (competence to use TC seed and socio-demographic characteristics) are still lacking necessitating further investigation.

Research applying the seed security framework is well established in root and tuber crops (Bentley et al. 2018; Andrade-Piedra et al. 2016). Further, studies on the farmer characteristics have been used to explain farmer behaviour in the uptake of agricultural technologies (Mulugo et al. 2019; Zhou and Abdullah, 2017; Meijer et al. 2015). Moreover, most of existing research is qualitative in nature depriving the research and development world an opportunity of understanding quantitative effects of factors affecting uptake of agricultural technologies such as TC banana seed. Similar research in the uptake of TC banana seed is still missing. Particularly, the knowledge gap is on how TC seed availability, accessibility, acceptability and adaptability combine with farmer characteristics to influence the uptake of TC banana seed. This study therefore explores the role of seed security factors and farmer characteristics in the uptake of TC banana planting materials. Results on seed security factors and farmer characteristics are important in designing interventions that ensure both uptake and sustainability of the banana crop in central Uganda.

4.1 Conceptual framework

The uptake of agricultural technologies like TC banana seed is a complex nonlinear process influenced by multiple factors. As such, the use of a single theory to analyze farmer decision-making in using tissue culture banana plantlets does not provide a holistic picture of the uptake process. A holistic framework which considers various factors in explaining farmer uptake of banana TC seed is what is needful. This study develops a conceptual framework (Figure 7) that

encompasses seed security factors and farmer characteristics to analyze uptake of the TC banana seed. Seed security factors and farmer characteristics as conceptually visualized in Figure 7 are interrelated. Nonetheless, their relationship in the context of this study is not measured.

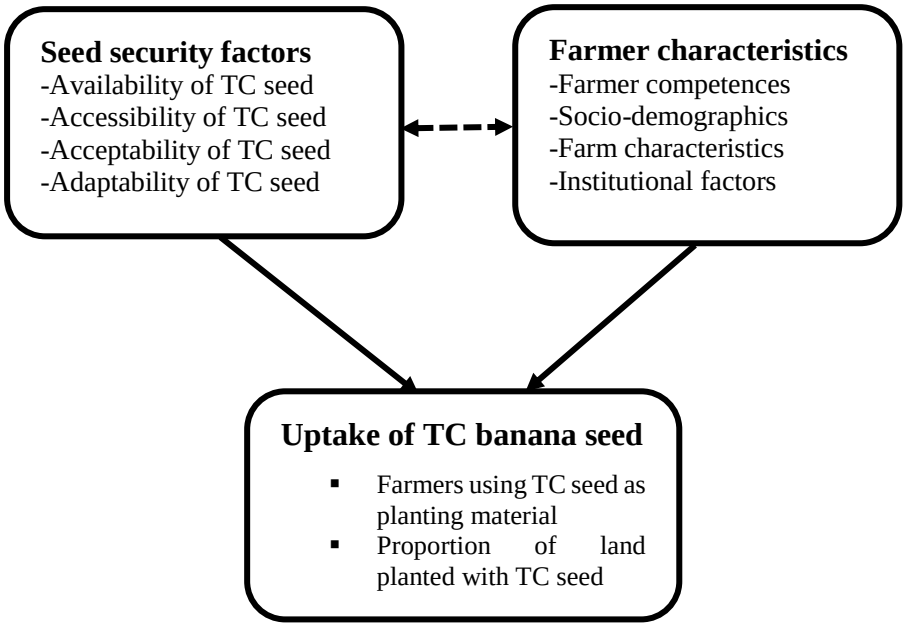

Figure 7: Seed security factors and farmer characteristics influencing uptake of TC banana seed

The seed security framework with foci on seed security factors explains that any given seed system for sustainable uptake of certified planting materials needs to address the following factors: seed availability, accessibility and quality [Root Tuber and Banana (RTB) 2016; Sperling et al. 2013; Sperling et al. 2008]. Notably, the quality dimension of the seed security framework emphasises health, acceptability and adaptability of seed. It has been argued that the focus of seed security factors stimulates farmer confidence in the uptake of technologies and is of utmost relevance in monitoring and correction of seed system interventions such as the TC banana seed; by identifying why such interventions fail (or may succeed) and aid in more effective design of future interventions (Sperling *et al.,* 2013). Studies on the seed security factors exist in potato (Kromann et al. 2016; Atieno and Schulte-Geldermann 2016), yam (Odu et al. 2016), cassava (Ospina 2016; Okechukwu and Lava 2016) banana and plantain (Kikulwe 2016; Jacobsen 2016) and sweet potato (Ogero et al. 2016; Nshimiyimana et al. 2016). These studies reiterate the relevance of seed security factors in guiding seed systems interventions for uptake of newly introduced technologies. Therefore, re-examining seed

security factors in combination with farmer characteristics is particularly important because unlike qualitative assessments by Kikulwe (2016) in East Africa and Jacobsen (2016) in Ghana [for both banana and plantain], no comprehensive quantitative research has been done to assess the role of these factors in the uptake of TC banana seed. It is hypothesized seed security factors to positively increase uptake of TC banana seed.

Seed availability relates to the assured supply of seed from existing and functional seed sources to farmers (RTB 2016). It is important that for seed to be considered available, it should be supplied in sufficient quantities and in time to meet farmers' needs (Bentley et al. 2018; RTB 2016). *Seed availability* in this study captures the elements of functional seed sources existence, seed availability in time and in sufficient quantities. These components are peculiar to the context of banana TC seed nurseries and supply in central Uganda. *Seed accessibility* as a parameter pertains to farmers' ease of acquiring TC banana planting material. In essence, this refers to whether farmers have financial capital to purchase the plantlets and the feasibility of transporting the banana planting materials from the TC sources to destined localities (RTB 2016). Provision of information pertaining to seed technologies has also been found to be key in aiding farmers to access seed (Bentley et al. 2018; Atieno and Schulte-Geldermann 2016; Kromann et al. 2016). *Seed accessibility* has been operationalised in this study to capture the elements of farmer provision with information on how to grow and manage TC plantlets and farmer affordability of the plantlets. *Seed acceptability* relates to provision of preferred and desirable seed varieties that are acceptable to meet farmers' tastes and preferences (Sperling et al. 2008; Remington et al. 2002). Farmers require banana varieties that they know, prefer and are confident to plant. In accordance, Mulugo et al. (forthcoming) attests to banana farmers in central Uganda having desirable banana varieties preferred basing on taste, aroma, colour and food texture. Similarly, Akankwasa et al. (2016) found that banana taste, flavour, texture and colour were key in determining consumers' likelihood of purchasing hybrid banana varieties in the four regions of Uganda. Thus, *seed acceptability* measures farmer satisfaction with banana varieties supplied through TC, appropriateness of the size of TC plantlets and taste of food from TC seed in this study.

Seed adaptability refers to farmer perceptions about TC seed's ability to perform well in newly introduced environments and farming conditions. Kilwinger et al. (2019) cite prolonged drought to be affecting banana productivity in central Uganda and Nyombi (2013) mentions soils in the same region to have considerably deteriorated in fertility. However, the focus of

previous studies has solely been on the role of these environmental factors on bananas generally- leaving out TC established plantations whose seed characteristically is fragile and sensitive to environmental conditions (Kavoo-Mwangi et al. 2014). Sinja et al. (2004) confirm that farmers will only take up a technology that is best adapted to their environment and as such relevant to their needs. It is as such imperative that TC planting materials are suited to adapt to the prevailing soil and environmental conditions in the study region. For this study, *seed adaptability* measures drought tolerance capabilities of TC established plantations and ability to survive for long in spite of drought spells and poor soil conditions.

Theories on competence development posit knowledge and skill to be important factors that determine individual capabilities (Eraut 1994; Kaslow et al. 2007). Competences consist of integrated pieces of knowledge and skills that can be used to perform a task successfully for instance, the uptake of TC plantlets (Baartman and de Bruijn 2011). Scholars (Baartman and de Bruijn 2011; Morrison et al. 2001) have shown skills to be interwoven with knowledge and viewed conjointly as doing or acting in practice. Therefore for the rest of this study, knowledge and skill were considered as one competence. Accordingly, Meijer et al. (2015) refer to knowledge as factual information and understanding of how a new agricultural technology works and what benefits the farmers can derive from it. Competence-based studies for instance, Ugochukwu and Phillips (2018), Kuehne et al. (2017) and Meijer et al. (2015), indicate that farmers' knowledge about the existence of a new technology extends to how to apply it and what the outcomes are in terms of products, yield, potential benefits, risks and costs. Such knowledge competences are important for acceptance and uptake of seed-based technologies. In this regard, *knowledge* is operationalized in this study to include elements of skill and technical knowledge that a farmer needs to grow TC seed as well as application of Local Technical Knowledge (LTK) on TC seed to control BXW. It is hypothesized that farmer knowledge enhances the uptake of TC banana planting materials.

Previous research (Akankwasa et al. 2016; Gibreel 2013; Barungi et al. 2013) show the importance of farmer characteristics (sex, age, education, farming experience, farm size, membership to farmer groups, accessibility to agricultural extension services) on farmer uptake of agricultural technologies, with their influence varying from one context to another. Thus, these factors are re-introduced in this study to evaluate whether they are critical in the uptake of TC banana seed. It is assumed that these factors in the presence of seed security factors could differently be influencing the uptake of TC banana seed.

4.3 Methodology

4.3.1 Study area

The study was conducted in Luweero and Mukono districts (Figure 8) in Central Uganda where TC banana planting materials have been promoted for more than a decade. The two districts experience high prevalence of BXW (Ocimati et al. 2015; Buregyeya et al. 2014) despite numerous interventions to curb the disease. To facilitate access to the TC materials, farmers in the two districts were linked to TC laboratories (whence they obtained TC plantlets) through farmer managed community-based TC nurseries. The study therefore targeted villages that hosted the community-based TC nurseries on assumption that proximity would enhance farmer access to TC planting materials.

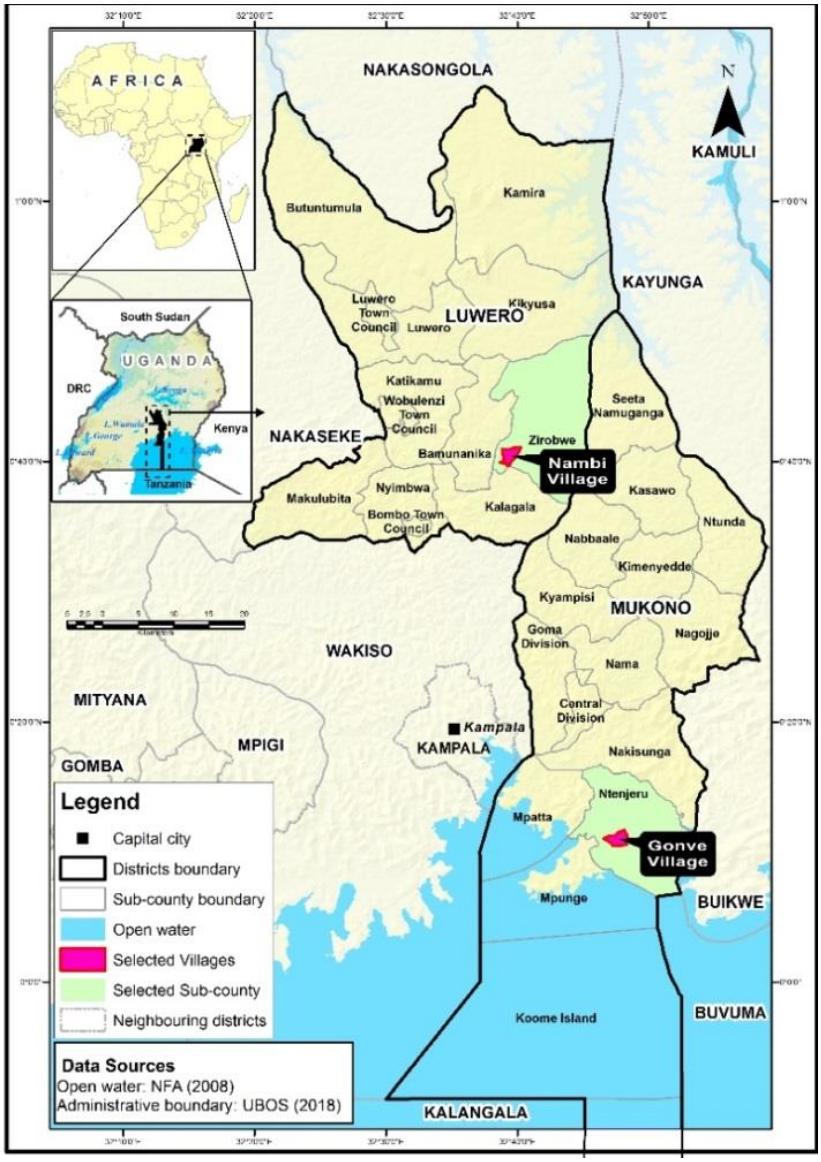

Figure 8: Map showing the study areas

4.3.2 Study design and sample selection

This study employed a cross sectional research design and data were obtained through a survey conducted in April and May 2018. This design was most appropriate because the study aimed at identifying factors that influence farmer uptake of TC banana seed. The unit of analysis is an individual banana farmer. A pre-tested semi structured questionnaire was administered to every respondent to generate data on variables of interest.

Two districts of Mukono and Luweero were purposively selected because they were linked to TC laboratories through farmer managed community-based TC nurseries. In each district, villages that hosted the community-based TC nurseries - Gonve and Nambi villages in Mukono and Luweero districts respectively were also purposively selected on assumption that proximity to TC nurseries enhances farmer access to TC banana planting materials. With the help of TC nursery operators and local council village chairpersons, names of banana farmers from the selected villages that had been trained by IITA between 2008- 2011 (comprising adopters and potential adopters of the TC banana technology) were compiled to generate the sampling frame with a total of 340 banana farmers (Table 17).

Table 17: Number of farmers selected for the study

Location	Total number of farmers listed	Number of farmers selected
Village: Nambi Luwero district	120	68
Village: Gonve Mukono district	220	106
Total	**340**	**174**

The total size of the sampling frame was then used to compute the sample size using Krejcie & Morgan (1970) formula indicated below;

$$S = X^2 Np\,(1-p)/d^2\,(N-1) + X^2\,p\,(1-p) \qquad (1)$$

Where;
S = required sample size
N = the population size
X^2 = a constant of value 3.841(the square of the z-value of 1.96 for 95% confidence interval)
p = the population proportion (assumed to be .50 since this would provide the maximum sample size).
d = the degree of accuracy expressed as a proportion (.05).

Substituting in the above equation (1) gave a sample size of 181. During the actual data collection, 174 banana farmers were successfully interviewed representing a response rate of 96.1% of the targeted 181 farmers.

4.3 Data collection

Primary data were collected from 174 banana farmers using a semi-structured questionnaire between April and May 2018. The questionnaire was pre-tested for reliability and suitability and then modified for clarity and sequencing of questions based on the pre-test experiences and results. The farmers were systematically sampled, the first farmer being randomly sampled from the list and subsequent farmers selected at intervals of two (2). Respondents were also drawn from each of the study villages as shown in the Table 17. Data were collected through face-to-face interviews with the selected banana farmers on seed security factors, farmer competences and farmer characteristics related to uptake of the TC banana seed.

4.3.1 Measures

To measure seed security factors, 12 statements in this study were used. Seed availability was measured with 4 items (e.g. 'TC seed availability in sufficient quantities'). Seed accessibility was measured with 3 items (e.g. 'Provision of information on how to plant TC seed'), seed acceptability had 3 items (e.g. 'TC banana seed is of desirable banana varieties') and seed adaptability had 2 items (e.g. TC banana seed thrive in all soil types). To measure farmer competences, 5 statements were used. Knowledge and skills were measured with 5 items (e.g. 'I have sufficient technical knowledge to grow TC banana seed). Each item was measured on a five-point rating scale with 1= least and 5 = highest.

In addition, the questionnaire had a component on social demographic characteristics of the farmers. These included age of the farmers in years, highest level of formal education in years of schooling, sex of the farmer, farm size in acres, experience in banana farming, access to agricultural extension services, membership to farmer groups, receipt of agricultural information, land apportioned for crop production and banana cultivation. The characteristics of the sample as well as competences and seed security factors are as summarized in Table 18 and Table 19 below.

Table 18: Description and summary statistics of respondent characteristics

Variable	Mean (SD)	Min	Max	Percentage (%)
Availability of banana TC seed	3.07 (1.166)	1	5	-
Accessibility of banana TC seed	2.94 (1.027)	1	5	-
Acceptability of TC banana seed	3.60 (0.946)	1	5	-
Adaptability of TC banana seed	2.74 (0.971)	1	5	-
Farmer Knowledge & skills to use TC seed	2.45 (1.365)	1	5	-
Age of farmer (years)	42.83 (13.63)	18	93	-
Sex (1 = male, 0 = female)	0.53 (0.50)	0	1	-
Formal education (years)	7.74 (3.45)	1	16	-
Banana farming experience (Years)	18.10 (13.10)	0	70	-
Farm size (acres)	4.27 (5.75)	0.50	69	-
Land allocated to crops (acres)	2.60 (2.41)	0.42	22.75	-
Land under banana cultivation (acres)	1.05 (1.08)	0.13	10	-
Banana TC Users (Yes = 1)	-	-	-	33.3
Access to extension services (Yes = 1)	-	-	-	38.5
Receipt of agricultural information (Yes = 1)	-	-	-	15.5
Membership to groups (Yes = 1)	-	-	-	39.7

Standard deviation (SD) in parenthesis

Table 19: Mean scores for competences and seed security factors

Variable	Item	Mean	Agg. mean
Knowledge & Skill	Sufficiency in technical knowledge to grow TC seed	3.00	
	Skilled to grow TC seed	2.95	
	Apply organic fertilizer to TC seed	2.14	2.39
	Apply organic pesticide to TC seed	2.13	
	Apply inorganic pesticide to TC seed	2.07	
	Apply LTK used in BXW management to TC seed	2.03	
Availability			
	Existence of TC seed sources	3.25	
	Availability of functional TC seed sources	3.13	3.07
	Availability of TC seed in sufficient quantities	3.03	
	Availability of TC seed in time	2.87	
Accessibility			
	Access information on how to grow/plant TC seed	3.32	
	Access information on how to manage TC seed	3.32	3.14
	Affordability of TC seed	2.78	
Acceptability			
	Farmer desirability of banana varieties supplied as TC seed	3.63	
	Appropriate of size of TC seed	3.92	3.60
	Acceptability of taste of food prepared from TC seed	3.25	
Adaptability			
	Drought tolerance capability of TC seed	2.64	
	Capability of TC seed established plantations to last long	2.48	2.74
	Ability of TC seed to thrive in all soil types	3.11	

4.4 Analytical Framework

Preceding regression analysis, principal component analysis (PCA) was carried out for data reduction and extraction of variables. Based on the criterion of eigenvalues being greater than 1 [Kaiser (1961)] in the PCA, underlying dimensions among the farmers' perceptions of the TC plantlets' attributes were generated. These included: seed availability, seed accessibility, seed acceptability, seed adaptability to environmental conditions, farmer knowledge and skills to use the TC banana seed (Tables 21).

This study assumes a banana farmer whose decision-making for uptake of banana TC seed is broken down into two stages. In the first stage, the banana farmer's decision criterion is either uptake of the banana TC seed or not. In the second stage, the farmer's decision is on how much of the TC seed to uptake (uptake intensity) which in this study is represented by the size of land allocated to the banana TC seed. Such a two-stage decision process on farmer uptake of banana TC seeds suits the double-hurdle model for data analysis as suggested by Cragg (1971). Cragg's double hurdle model is a two-stage regression in which the first stage is a probit model used to analyze factors influencing a binary decision on uptake of a technology. The second stage is a truncated model which analyses the factors that affect the intensity of uptake of the technology in question, in this case TC banana seed (Cragg 1971). In this study, farmer uptake of banana TC seed is hypothesized to be influenced by seed security factors and the farmers' characteristics which include the farmers' competences and socio-economic factors as shown in equation (2) below:

$$Y = \beta_0 + \beta_i [Seed\_Sec]_i + \beta_j [Farm\_Xtics]_j + \varepsilon \qquad (2)$$

Where Y represents farmer's decision-making for uptake of banana TC seed which in the first stage is a binary variable (if farmer uses TC seed = 1; otherwise =0) and in the second stage, Y equals the proportion of banana land allocated to TC seed cultivation (intensity). $[Seed\_Sec]$ is a vector of seed security factors which includes perceived seed acceptability, seed accessibility, seed adaptability and seed availability. $[Farm\_Xtics]$ comprises four components namely: 1) competences which include farmers' knowledge and skills to use TC seed; 2) socio-economic factors which include sex, age and education level of the farmers; 3) farm characteristics as identified from literature include farm size, land allocated to crop production and banana cultivation and; 4) institutional factors which comprise access to

extension services and membership to farmer groups. β_0 is the constant while β_i represent the various co-efficients of the seed security factors ranging 1 – 4. β_j are the co-efficients of farmer characteristics and ε is the error term. The a priori hypothesized signs of the co-efficients are as shown in Table 20 below.

Table 20: Apriori signs of explanatory variables used in the study

Variable	Apriori sign	Source
Availability of TC banana seed	(+)	Andrade-Piedra et al. 2016; Bentley et al. 2018.
Accessibility of TC banana seed	(+)	Andrade-Piedra et al. 2016; Bentley et al. 2018.
Acceptability of TC banana seed	(+)	Sperling et al. 2008; Remington et al. 2002.
Adaptability of TC banana seed	(+)	Sperling et al. 20 08; Remington et al. 2002.
Farmer Knowledge & skills to use TC seed	(+)	Ugochukwu and Phillips 2018; Kuehne et al. 2017; Meijer et al. 2015.
Sex	(+)	Ajewole (2010); Doss and Morris (2001); Adesina et al. (2000).
Age	(+/-)	Akankwasa et al. 2016; CIMMYT 1993.
Education	(+)	Akankwasa et al. 2016; Gibreel 2013.
Farm size	(+)	Barungi et al. 2013; Lunduka et al. 2012; Polson and Spencer 1991.
Land allocated to other crops	(-)	Doss 2006.
Group membership	(+)	Matata et al. 2010; Ajayi et al. 2003; Adesina et al. 2000.
Extension services	(+)	Matata et al. 2010; Sall et al. 2000; Polson and Spencer 1991.

4.5 Results and discussion

Results of the Kaiser-Meyer-Olkin (KMO) measure (0.858) and the Bartlett's test of sphericity (χ^2 = 3338.689; P<0.001) [Table 21] indicate sampling adequacy and suitability of the data for factor analysis (Leech et al. 2005). Principal component results show that five (5) extracted factors explained 76.1% of total variance in the principal components. Specifically, as presented in Table 21, the variance extracted ranged from 39.8% (for farmer knowledge and skill in use of TC banana seed) to 5.6% (TC seed adaptability). In addition, the factor loadings for the extracted variables ranged from 0. 508 to 0. 943 and thus, convergent validity was confirmed (Hair et al. 2006). Lastly, the chronbach alpha values (Table 21) range from 0. 600 to 0.992 signifying adequacy of internal consistency and thus, a confirmation of measurement validity (Taber 2018), in this study.

Table 21: Loadings of seed security factors and competences for uptake of TC banana seed (n=174)

Item description	Cronbach's alpha	Factor loadings*				
		Factor 1 Knowledge	**Factor 2** Availability	**Factor 3** Accessibility	**Factor 4** Acceptability	**Factor 5** Adaptability
Apply organic fertilizer to TC seed.	0.992	0.943				
Apply organic pesticide to TC seed		0.937				
Apply inorganic pesticide to TC seed		0.924				
Apply LTK used in BXW management to TC seed		0.902				
Sufficiency in technical knowledge to grow TC seed		0.605				
Skilled to grow TC seed		0.655				
Existence of TC seed sources	0.915		0.904			
Availability of functional TC seed sources			0.903			
Availability of TC seed in sufficient quantities			0.777			
Availability of TC seed in time			0.691			
Access to information on how to grow TC plantlets	0.839			0.851		
Access to information on how to manage TC plantlets				0.864		
Affordability of TC seed				0.666		
Farmer desirability of banana varieties supplied as TC seed	0.651				0.786	
Appropriateness of size of TC seed					0.664	
Acceptability of taste of food prepared from TC seed					0.681	
Drought tolerance capability of TC seed	0.600					0.725
Capability of TC seed established plantations to last long						0.744
Ability of TC seed to thrive in all soil types						0.508
Eigenvalues		7.563	2.777	1.568	1.497	1.061
% of variance explained		39.807	14.616	8.251	7.879	5.584

*Extraction Method: Principal Component Analysis and Rotation Method: Varimax with Kaiser Normalization. Only attributes with absolute factor loadings > 0.5 are included.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.858; Approx. Chi-square = 3338.689. Bartlett's Sphericity Test: df = 190; P < 0.001

4.5.1 Sample characteristics

Results show that about 53% of the sample respondents were females 47% males (Table 22). Ninety two percent (92%) of these respondents belong to the Baganda ethnic group. Overall, most of the respondents (75%) were married and about 11% were widowed. Only 11% of the sampled farmers reported that they were single and never been married while about 3% reported to have divorced or separated. The majority of the respondents (84%) reported farming (both crop and livestock) as their primary occupation.

Table 22: Distribution of sample characteristics of banana farmers sampled

Characteristics	Response	Percentage (n = 174)
Sex of respondent	Female	52.9
	Male	47.1
Ethnicity	Baganda	92.0
	Basoga	1.7
	Bakiga	1.1
	Other (Japadhola, Bagishu, Balulu, Banyakole, Banyarwanda)	5.2
Marital status	Married	75.3
	Widowed	10.9
	Divorced/ separated	2.9
	Single	10.9
Primary occupation of respondent	Farming (crops and livestock)	83.9
	Salaried employment	2.2
	Self-employed off-farm	8.1
	Casual laborer off-farm	5.8

Source: Survey data, 2018

Table 4.5.2 Characterization of the banana growing farmers

The surveyed banana growing farmers were categorized into two groups; of TC banana users and non-users (adopters and non-adopters respectively). The TC users consist of farmers that grow bananas using TC banana planting materials whilst the non-users consist of farmers who do not grow bananas using TC planting materials. Table 23 presents a summary of socio-economic and demographic statistics that characterize the TC banana users and non-users. The results show that the overall average age of the respondents was about 43. The TC users were significantly older (46 years on average) than the non-adopters (41 years). The average number of years of formal education of respondents was about eight (8) years. The total land size set aside by the sampled farmers for agricultural production was an average of 4.3 acres, with an average of about 1.1 acres (approximately 25%) allocated to banana production. Adopters of TC planting materials report significantly more land for agricultural production (about 6.4 acres) and allocated to banana production (1.4 acres) as compared to TC non-adopters that on average allocated 3 acres to agricultural productions and 0.9 acres to banana production respectively.

Table 23: Socio-economic and demographic characteristics of sampled banana growing farmers by TC banana users and TC banana non-users

Variable	Overall n = 174	TC Users n = 58	TC Non-Users n = 116	T-statistic
	Mean			
Age of farmer (years)	42.83	45.83	41.34	-2.069**
Formal education of farmer (years)	7.74	8.33	7.45	-1.592
Experience in banana farming (years)	18.05	20.48	16.83	-1.745*
Land allocated to agricultural production (acres)	4.27	6.36	3.22	-3.507***
Land allocated to banana (acres)	1.05	1.35	0.90	-3.345**
Annual income (UGX '000)	6, 352	9,414	4,821	-5.051***
	Proportion			χ^2 Stat.
Receipt of agricultural information in last 6 months (%)	38.50	46.55	34.48	0.123
Access to extension services (%)	60.92	62.07	60.34	0.826
Membership to groups (%)	39.66	53.44	32.76	0.009**

****, ** and * indicate statistical significance level at 1%, 5% and 10%, respectively.*

On average, annual income across all the respondents was about UGX 6,352,214 (US$ 1,717). The TC users report significantly more annual income (UGX 9,414,362 equivalent to US$ 2,544) compared to about UGX 4,821,141 (US$ 1,303) reported by TC non-users. This income was mentioned to be mainly derived from farming activities (both crop and livestock). On average, the farmers in the sample have 18 years' experience in banana farming, with TC users having more experience (21 years) compared to TC non-users (17 years). In addition, TC users report access to extension services and receipt of agricultural information related to TC planting materials more than the TC non-users. The findings also indicate that about 40% of the respondents belong to farmer groups with more TC users (53%) significantly belonging to farmer groups than TC non-users (33%).

4.5.1 Factors associated with the uptake decision for farmer use of TC banana seed

Results of first stage analysis (probit regression) are presented in Table 24. These results show that farmer perceived acceptability of the TC seed (β= 0.74; P<0.01) has a positive and significant influence on farmer decisions for uptake of the TC banana seed. Similarly, perceived TC seed adaptability (β= 0.69; P<0.01) and perceived availability (β= 1.04; P<0.01) have positive and significant influence on the uptake of the banana seed. In the category of seed security factors, it is only perceived accessibility that is not significant but still posting a positive influence on farmer use of TC banana seed.

Table 24: Factors that influence farmers' decisions regarding adoption of Tissue culture banana planting materials: results of the Probit Model

Variable	Coefficient	Robust Std. Error	P>z	Average Marginal Effects (dy/dx)
Seed security factors				
Perceived acceptability of TC seed	0.737	0.276	0.008**	0.062
Perceived accessibility of TC seed	0.302	0.229	0.187	0.025
Perceived adaptability of TC seed	0.688	0.263	0.009**	0.058
Perceived availability of TC seed	1.037	0.340	0.002**	0.087
Farmer characteristics				
Competence (knowledge & skill)	2.155	0.434	0.000***	0.180
Sex of farmer (1=male; 0=female)	-1.377	0.562	0.014*	-0.115
Age of farmer (years)	-0.088	0.297	0.767	-0.007
Education of farmer (years)	0.059	0.062	0.347	0.005
Group membership (1=yes; 0=No)	-0.496	0.551	0.369	-0.042
Access to extension services (1=yes; 0=No)	-0.344	0.525	0.513	-0.029
Land allocated to crops (acres)	0.341	0.154	0.027*	0.029
Experience in banana farming (years)	-0.013	0.025	0.624	-0.001
Constant	-1.016	1.158	0.381	
Number of observations	174			
Log likelihood ratio	-25.98			
Wald χ^2	169.56***			
Mean VIF	1.8			

**P< 0.05, **p < 0.01, ***p < 0.001*
Dependent variable: Uptake measured as a binary

The findings in this study are in conformity with theoretical prediction that seed security factors are associated with enhanced uptake of improved seed (Bentley et al. 2018; RTB 2016; Sperling et al. 2013). In terms of marginal effects, TC seed acceptability (0.062) implies that on average, a 1% increment in farmer acceptance of banana TC seed increases the probability

of farmer uptake of the banana seed by 6.2%. This could be explained by the fact that farmers normally prefer introduced seed varieties that are comparable to their local varieties in supply of desirable consumption attributes. Particularly for banana, food texture (soft), colour when cooked, flavor and taste are important attributes as discussed in chapter 2. Similar results are also reported by Akankwasa et al. (2016) for the case of Uganda. For farmer perceived adaptability of TC seed (marginal effect = 0.058), an additional increase in seed adaptability is associated with a probability of 5.8% improvement in uptake of the TC seed. Notably, the importance of TC seed adaptability to drought and poor soil fertility is emphasized (Kilwinger et al. 2019; Nyombi 2013). Lastly, the average marginal effect of TC seed availability (0.087) implies that an additional unit in TC seed nurseries is associated with a likelihood of 8.7% increase in farmer uptake of TC seed. Related studies like Okechukwu and Kumar (2016) on availing disease resistant varieties in Africa and Kromann et al. (2016) on provision of quality seed in Ecuador, have reported availability of quality seed in sufficient quantities and on time to increase farmer uptake of seed technologies.

On competences, farmer knowledge and skill to use TC seed (β= 2.16; P<0.001) has a positive and significant effect on farmer uptake of TC banana seed. This result is in conformity with theory prediction that farmer competences enhance uptake of the improved TC banana seed (Ugochukwu and Phillips 2018; Kuehne et al. 2017; Meijer et al. 2015). In terms of marginal effects, the result on farmer knowledge about TC seed (0.180) implies that on average, an increment in farmer skill and technical knowledge on how to grow TC seed increases the likelihood of farmer uptake of banana TC seed by 18 %. This finding validates the study by Atieno and Schulte-Geldermann (2016) on public-private partnerships in the multiplication of seed in Kenya. Specifically, knowledge sharing and training on new seed varieties by extension agents increase farmer uptake of a new seed technology. The result accentuates the importance of knowledge sharing and training [say through extension agents, research] on use of new seed technologies.

Contrary to most studies (Akankwasa et al. 2016; Awotide et al. 2014; Matata et al. 2010) the model estimates show that the sex of the farmer (β= -1.38; P<0.05) has a negative and significant effect on the uptake decision, indicating that women compared to men were more likely to use TC banana planting materials. The expected likelihood of male banana farmers using TC banana plantlets is reduced by 11.5%. This corroborates with findings of Akankwasa et al. (2013) who found the sex of a farmer to be negatively associated with early uptake of

M17 hybrid banana variety. A plausible explanation for women's interest in TC banana planting material could be attributed to the distinct role that women play in ensuring food security for their families (Sanya et al. 2020). Further, the land allocated to the production of crops (β= 0.34; P<0.05) has a positive influence on the likelihood of farmer uptake of the TC banana seed. The average marginal effect (0.029) denotes that increasing the land size allocated to other crops by one acre, increases the likelihood that farmers would try out the TC planting materials by 2.9%. This suggests that farmers with bigger land size allocated to the production of crops are more likely to try out the TC plantlets. A possible explanation for this finding could be that farmers with larger farms may be more willing to take risks and devote portions of their land to growing banana using TC plantlets, compared with those with smaller land areas. This is in line with most adoption studies (Barungi et al. 2013; Lunduka et al. 2012; Wubuneh and Sanders 2006) that established that farmers with larger farm sizes have more land to allocate to improved agricultural technologies.

4.5.2 Factors associated with intensity of farmer uptake of TC banana seed

Results of second stage analysis (truncated regression) are presented in Table 25. These results show that farmer perceived acceptability of the TC banana seed (β= 0.39; P<0.05) and farmer perceived accessibility of TC seed (β= 0.39; P<0.01) posit a positive and significant influence on farmer decisions to allocate more land to TC banana seed. For farmer perceived acceptability of the banana seed, the average marginal effect (0.018) indicates an increment in TC seed that is of desirable varieties to farmers improves the probability of a farmer expanding his/her plantation using the TC seed by 2%. Essentially, the result specifies that if farmers perceive that the varieties being promoted through TC match their preferred food attributes, then they are more likely to expand their banana plantations using such a seed technology. Previous studies, for example Akankwasa et al. 2016) attest to this finding.

Table 25: Factors that influence intensity of uptake of banana TC seed: results of the truncated regression model

Variable	Coefficient	Robust Std. Error	P>z	Average Marginal Effects (dy/dx)
Seed security factors				
Perceived acceptability of TC seed	0.390	0.179	0.029*	0.018
Perceived accessibility of TC seed	0.392	0.119	0.001**	0.058
Perceived adaptability of TC seed	0.019	0.084	0.822	0.003
Perceived availability of TC seed	0.049	0.086	0.566	0.007
Farmer characteristics				
Competences (Knowledge & skill)	1.461	0.197	0.000***	0.067
Sex of farmer (1=male; 0=female)	-0.874	0.347	0.012*	-0.040
Age of farmer (years)	-0.001	0.058	0.927	-0.001
Education of farmer (years)	0.010	0.020	0.623	0.002
Group membership (1=yes; 0=No)	-0.119	0.175	0.497	-0.018
Access to extension services (1=yes; 0=No)	0.166	0.440	0.706	0.008
Land allocated to crops (acres)	0.218	0.031	0.000***	0.032
Farm size (acres)	0.119	0.058	0.041*	0.006
Experience in banana farming (years)	0.003	0.008	0.678	0.678
Constant	-0.814	0.365	0.026	
Number of observations	58			
Log likelihood ratio	-34.39			
Wald χ^2	187.44***			
Mean VIF	1.88			

** P< 0.05, **p < 0.01, ***p < 0.001*
Dependent variable: Proportion of land planted with banana TC seed.

Similarly, farmer accessibility (marginal effect = 0.058) indicates that provision of farmers with fairly priced seed coupled by information on how to plant and grow the TC banana seed promotes farmer expansion of their plantations by 5.8%. This finding is in tandem with studies (Bentley et al. 2018; Kromann et al. 2016; Atieno and Schulte-Geldermann 2016) confirming seed accessibility in terms of affordability and awareness creation to be crucial for use and extent of uptake of introduced seed technologies.

On competences, farmer knowledge and skill to use TC seed (β= 1.46; P<0.001) postulates a positive and significant influence on farmer decisions to allocate more of their land to TC banana seed. The average marginal effect for farmer knowledge about TC seed (0.067) indicates that an increment in farmer skill and technical knowledge on how to grow TC seed proliferates the likelihood of farmers expanding their banana plantations using banana TC seed by 6.7%. The finding implies that farmers with skill and technical knowledge in growing TC seed coupled with the ability to apply local traditional knowledge in on-farm management of

TC seed are more likely to apportion more of their land to TC banana seed. The findings corroborate previous research about farmer knowledge on introduced agricultural technologies to influence uptake and extent of use of improved crop varieties (Ugochukwu and Phillips 2018; Kuehne et al. 2017; Atieno and Schulte-Geldermann 2016; Meijer et al. 2015).

Although not a significant predictor of uptake of TC banana planting materials, farm size (β= 0.12; $P<0.05$) has a positive influence on the intensity of uptake of TC banana planting materials. The average marginal effect (0.006) signifies that as farm size increases by one acre, the land farmers allocate to TC plantlets increases by 1%. A possible explanation for this finding could be that farmers with larger farms may be more willing to take risks and devote portions of their land to an introduced agricultural technology, compared with those with smaller land areas. Consequently Akankwasa et al. (2016) show that farmers with larger farms have more land to allocate to improved agricultural technologies.

4.6 Conclusion and implications

The study sought to establish the role of seed security factors and farmer characteristics in the uptake of TC banana seed among smallholder farmers. Results obtained in this study show that farmers' decisions for uptake of TC banana seed are positively and significantly influenced by seed security factors. In particular, the likelihood of uptake of banana TC seeds among smallholder farmers is improved by seed security factors of acceptability, adaptability and availability of TC seed. In addition, farmer characteristics related to competences (farmer knowledge and skill to use TC banana seed) as well as sex of the farmer enhance uptake of TC seed. For the intensity of uptake of the banana TC seed, important factors that positively and significantly impact farmer decisions are acceptability and accessibility of TC seed and competence to use TC seed. Other important factors include farm size and portion of land reserved for crop production.

This chapter contributes to theoretical development by applying the seed security framework to analyse farmer decisions on uptake of banana TC seeds. While combining the seed security framework with farmer characteristics, this study demonstrates that the seed security factors of acceptability, adaptability and availability are critical for farmer uptake of TC seed. From a practical perspective, the results suggest the importance of developers in the seed system in focusing at farmer desired crop attributes. For instance, seed system developers need to focus

attention on banana varieties that are acceptable and adaptable to farmers' environmental conditions.

Further, findings emphasize the need for more involvement of extension services and research institutions in the promotion of the TC planting materials in the banana farming communities. This involvement could include effective provision of appropriate information concerning the banana TC seed. It is recommended that seed security factors (acceptability, accessibility, adaptability and availability) and farmer characteristics entailing competences to use TC seed as variables need to be considered in evaluations for drivers of farmer uptake decisions for seed system technologies. Such variables can aid enrich the set of factors conventionally used in studies related to the uptake of agricultural seed technologies.

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CHAPTER 5: GENERAL DISCUSSION OF RESEARCH FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

Worldwide, researchers, policy makers, and development practitioners are working hard to improve agricultural technologies so as to boost agricultural productivity. In Sub Saharan Africa, the call for transformation of livelihoods is justified by the numerous challenges. The region has the highest proportion of undernourished people in the world, estimated to be 30% of the total population [or 239 million people for the period 2010-2012] (FAO, 2013). Agricultural research is therefore key to increase agricultural productivity for food and income security, nutrition and rural well-being (Coomes *et al.*, 2015). In Uganda, the National Agricultural Research System (NARS) has opened up frontiers to agricultural technologies as effective means for increasing crop productivity in the country. Nonetheless, the uptake of such improved technologies remains low (Kasirye, 2013). Thus far, empirical evidence to understand the underlying causes for the low uptake of agricultural technologies has put limited emphasis on the socio-cultural context in which new agricultural innovations are introduced.

Therefore, the goal of this study was to examine how social cultural antecedents influence the uptake of novel agricultural technologies such as the TC banana planting materials, introduced to help in the control of BXW in Uganda. Specifically, this study sought to (i) Establish the socio-cultural fit of TC banana seed in central Uganda; (ii) Determine the influence of farmer perceptions on intentions to use the TC banana plantlets in central Uganda and (iii) Assess the interaction of seed security factors (seed availability, accessibility, acceptability and adaptability) and farmer characteristics to influence uptake of TC banana seed in central Uganda. This chapter makes overall connection between the empirical chapters in order to draw general conclusions and recommendations.

5.2 Overview and general discussion of research findings

Findings from the study show that a diversity of banana varieties are grown in the study communities most importantly for; i) food, ii) cultural practices and iii) medicine. Results (chapter 2) highlight various bottlenecks and gaps that ultimately impact on the promotion and uptake of the TC banana planting materials. First, out of the forty-six banana varieties grown in the study communities, only twelve varieties were introduced as TC plantlets in the communities. This points to the fact that introduced varieties would only be integrated in the local varieties to meet the wider use of banana including cultural uses. Secondly, banana

varieties propagated through TC are mainly for commercial purposes, characterized by bigger bunches and fingers that are more attractive for the market. Whereas income is a primary goal for banana production, it is only one of the reasons farmers grow banana. The other varieties grown in the study communities serve to meet other specific cultural purposes and are commonly not propagated through TC because they are considered unattractive commercially. Therefore, this stresses the importance of TC seed developers to focus at farmers' desired attributes and multiple uses of the banana crop including the cultural elements.

Furthermore, farmers ostracized the taste of the food and juice from some of the varieties introduced under the TC banana technology. For example, the juice from varieties such as FHIA-25 and KM5 were mentioned to have a low sugar content compared to the local varieties. Similarly, the TC introduced *matooke* varieties (Mpologoma, FHIA-01 and FHIA-17) have an undesirable colour (whitish) when cooked, with no aroma and a 'flat' taste. Consequently, the uptake of such varieties for food, local beer and juice has been low. In this case, farmer tastes and preferences for banana cuisines and drinks ought to be put into consideration by seed system developers (e.g. TC Laboratories and research institutions) that help in breeding and propagating banana TC planting materials to focus attention on the farmers' preferred and acceptable banana attributes. Sperling *et al.,* (2008) and Remington *et al.,* (2002) stress the importance of provision of preferred and desirable seed varieties that are acceptable to meet farmers' tastes and food preferences for increased uptake of agricultural technologies.

The preferences for multiple functions of banana are linked to farmer beliefs and perceptions. Findings reveal farmer beliefs of the TC banana technology to be linked to its low uptake. For example, farmers perceived the TC plantlets to be hybrids. Inadvertently, the potency of the introduced seed technology to perform cultural functions and rituals as well as for medicinal purposes is questioned by the farmers. This glaringly points to farmers' perceived incompatibility of TC banana planting materials with their socio-cultural identity which acts as a barrier to its uptake in the banana farming communities. Warren *et al.,* (2016) emphasize the significance of introduced novel agricultural technologies to be compatible with the socio-cultural identity of farmers. None the less, the hesitation to take up the TC banana plantlets can also be partly attributable to inadequate information and understanding of processes of TC propagation on the part of the farmers.

With regard to farmer perceptions towards the TC banana planting materials, the findings reveal social influence and farmer innovativeness to be significant predictors of farmer

intentions to use the banana TC technology. In spite of promoting the plantlets as clean seed for disease (BXW) control, from the farmers' perspective- the quality of the seed is not important, albeit its performance with regard to banana productivity. Interestingly, findings show social influence to be the most important among all predictors for farmer intentions to use the TC plantlets. These findings accentuate the significance of role models in farmer uptake of the TC banana seed technology. Specifically, in this context faith based leaders, political and community leaders should be the front line promoters of the seed technology in the banana farming communities for its heightened uptake. Additionally, the findings reveal that farmers will have positive intentions to use TC as planting material if a farmer is innovative and creatively integrates the use of TC planting materials with local knowledge and other available materials in the control and management of BXW. Results further reveal that social influence and facilitating conditions influence farmer innovativeness, indicating the relevance of a farmer's social circle and enabling conditions in the uptake of TC as essential factors to stimulate farmer innovativeness. This infers that social interactions and facilitating conditions are crucial in creating an enabling environment for farmers to be innovative, a key predictor of farmer intentions to use the banana seed technology.

Farmer intentions to use agricultural technologies precede farmer uptake decisions. Findings demonstrated that the uptake of TC banana planting materials among farmers in the study communities is still low. Only 33% of the farmers use the TC banana plantlets as planting materials. Results show that farmers' decisions for uptake of banana TC seed are positively and significantly influenced by seed security factors. In particular, the likelihood of uptake of banana TC seed among smallholder farmers is improved by seed security factors of acceptability, adaptability and availability of the banana seed. This is mainly because farmers prefer introduced seed varieties that are comparable to their local varieties in supply of desirable consumption attributes. Particular for banana, food texture (soft), colour when cooked, flavor and taste are important attributes (Akankwasa *et al.*, 2016). In addition, the farmer characteristics and competences (such as farmer knowledge to use TC seed) enhance uptake of TC seed. On the contrary, women had more interest in TC banana seed as planting material compared to the men which can be attributed to women's distinct role of ensuring food security for their families.

For the intensity of uptake of the banana TC seed, important factors that positively and significantly impact farmer decisions are acceptability and accessibility of TC seed.

Additionally, farmer competence to use TC banana seed postulates a positive and significant influence on farmer decisions to allocate more of their land to the TC seed. Researchers (Ugochukwu and Phillips 2018; Kuehne *et al.,* 2017; Atieno and Schulte-Geldermann 2016) highlight the importance of farmers having essential knowledge and skills about introduced novel agricultural technologies to influence uptake and extent of use of improved crop varieties. Similarly, Obiero *et al.,* (2019) resonate the relevance of farmer knowledge and technical skills to use novel agricultural technologies as key indicators in predicting uptake of the novel technologies. Other than the technical knowledge for production of TC banana, farmer sensitization about the genetic aspect of TC banana is critical to aid demystify farmer beliefs that TC banana is genetically modified. Results further revealed that the probability of farmers apportioning more of their land to TC banana seed was largely influenced by farm size and portions of land reserved for crop production. As is often suggested in literature, farmers with larger farms are more likely to innovate and adopt agricultural technologies than those with smaller farms (Obiero *et al.,* 2019; Bosma *et al.,* 2012). These kinds of farmers are usually wealthier and less risk averse (Rapsomanikis, 2015). Findings from this study demonstrate that the uptake of TC banana planting materials is influenced by a combination of factors including cultural values, seed security factors, farmer competences, farmer and farm characteristics. The findings imply that the development of agricultural technologies and promotion processes should be customized to the specific socio-cultural context of farmer communities so as to achieve optimal impact.

5.3 General conclusions

It is evident from the research findings that the TC banana seed technology responds to the commercial needs of banana farmers and ignores the cultural uses of banana. Results emphasize that farmers' perspectives and goals for the banana crop differ significantly from those of researchers, government and other promoters of the TC banana technology. It is plausible that the TC banana varieties are largely selected and promoted basing on their productivity potential to suit market requirements as well quality aspects to curb the spread of banana diseases such as the Banana Xathomonas Wilt (BXW). The findings point to the introduction of the TC plantlets to be mainly researcher and government driven with the aim of curbing spread of banana diseases but '*blind'* to the farmers' cultural needs. Therefore, beyond introduction of the TC plantlets as quality seed void of pests and diseases, there is need for researchers to meet the socio-cultural considerations, needs and preferences of the banana farming communities. Consequently, the need for farmer involvement in the selection criteria

of varietal types to be promoted as TC seed is critical for enhanced uptake of the seed technology.

It is further noted that social influence and farmer innovativeness are significant predictors of farmer intentions to use the TC banana technology. Additionally, social influence is the most important among all predictors for farmer intentions to use the TC technology. This therefore infers that farmers will only have positive intentions to use the TC banana technology as planting material if there is influence from a farmer's social circle or if a farmer is innovative and creatively integrates the use of TC planting materials with local knowledge and other available materials in the control and management of BXW. As such, promotion of the TC seed technology through locally institutionalized mechanisms like faith-based leaders, political and community leaders and their respective members is key.

This study has demonstrated that farmers in central Uganda perceive seed security factors, farmer competences in terms of knowledge and skill to use introduced novel innovations to be important considerations in their decisions for uptake and to apportion more of their land to agricultural technologies. It is concluded that a combination of factors, including seed security, farmer competences, socio-economic, farmer and farm characteristics and institutional factors play a critical role in the uptake of TC banana plantlets. Therefore, adequate targeting of these essential antecedents in the development of agricultural technologies such as the TC banana seed is likely to enhance uptake.

5.4 General recommendations

The following recommendations are suggested based on key findings of the study.

From a practitioner's perspective, promoters of TC banana seed need to broaden the range of varieties supplied to match the diverse functions and uses of banana in the *Baganda* culture. Research institutions and TC banana laboratories should prioritize farmers' needs and preferences in relation to the socio-cultural uses of the banana crop. For instance, special attention should be paid to banana varieties that are acceptable and adaptable to farmers' environmental conditions. Such prioritization should be based on a clear understanding of farmers' preferred banana varieties and food attributes, tastes and preferences. As such, the researchers and other promoters of the seed technology should engage the farmers in a participatory way to properly understand their context, needs and preferences with regard to their choice of banana varieties.

This study has highlighted various factors including seed security factors (acceptability, accessibility, adaptability and availability), social influence and farmer competence (knowledge, skill and attitude) that enhance uptake of the TC banana seed technology. Therefore, a communication strategy that seeks to widely disseminate information about the TC planting materials is necessary. Such a communication strategy calls for more involvement of extension services and research institutions in the promotion of the TC planting materials in the banana farming communities. This involvement could include effective provision of appropriate information concerning the banana TC seed, albeit using role models (e.g. faith based leaders and the local leadership) in the communities since social influence plays a pivotal role in increasing uptake. This will be important for constant provision of information customized to the farmers' context, most especially to change their attitudes and misconceptions about the TC banana plantlets.

From a policy perspective, this study highlights the need for a communication strategy among the researchers, promoters of the TC banana technology and the banana farmers. This will be essential for the promotion of a levelled understanding through information and knowledge sharing. As such, policies, approaches and strategies that enhance these interactions that can create more space for smallholder farmers and other stakeholders to interact and share, need to be explored for improved uptake of the seed technology. This could be achieved by strengthening the existing private-public partnerships in technology development and promotion whilst facilitating establishment of individual and group-based forms of interactive learning (e.g. through farmer groups, experimental gardens and extension). By offering farmers with opportunities to access adequate information and useful linkages that are important for support and guidance in the uptake of TC plantlets, these structures can act as systems for enhanced encouragement purposely to trigger the acceptance and use of the TC banana planting materials.

Overall, the findings from this study and the above-mentioned recommendations point to the need for a change in the way newly introduced novel agricultural innovations are promoted. Therefore, a key output from this study is an integrated model highlighting key socio-cultural considerations for contemplation in farmer uptake of agricultural technologies (Figure 9). The proposed model aims at providing a holistic view of socio-cultural aspects that are of relevance in the enhancement of uptake and acceptance of agricultural innovations by intended users. Thus, the approach provides an all-inclusive framework on socio-cultural aspects for

agricultural technology uptake, using relevant theoretical frameworks. Basing on Schwartz theory of human values, it provides insights into cultural values that influence the use of innovations among divergent cultures which ultimately can lead to increased acceptance and use of novel agricultural technologies such as the TC banana planting materials. Further, using the Unified Theory of Acceptance and Use of Technologies (Venkatesh *et al.*, 2003) the framework postulates that for new technologies to be accepted by intended users, farmer perceptions and attitudes towards the technology are important. These pertain to; performance expectations of the technology, its perceived quality, social influence and the availability of facilitating conditions. Lastly, with specific inclination to the Multi-stakeholder framework for intervening in Root Tuber and Banana [RTB] crops (RTB, 2016), the proposed model specifies key technology attributes (availability, accessibility, acceptability and adaptability to farmer conditions) in combination with farmer competences (skills and knowledge about the technology), farmer and farm characteristics; and institutional factors to be integral points for increased uptake of novel agricultural innovations.

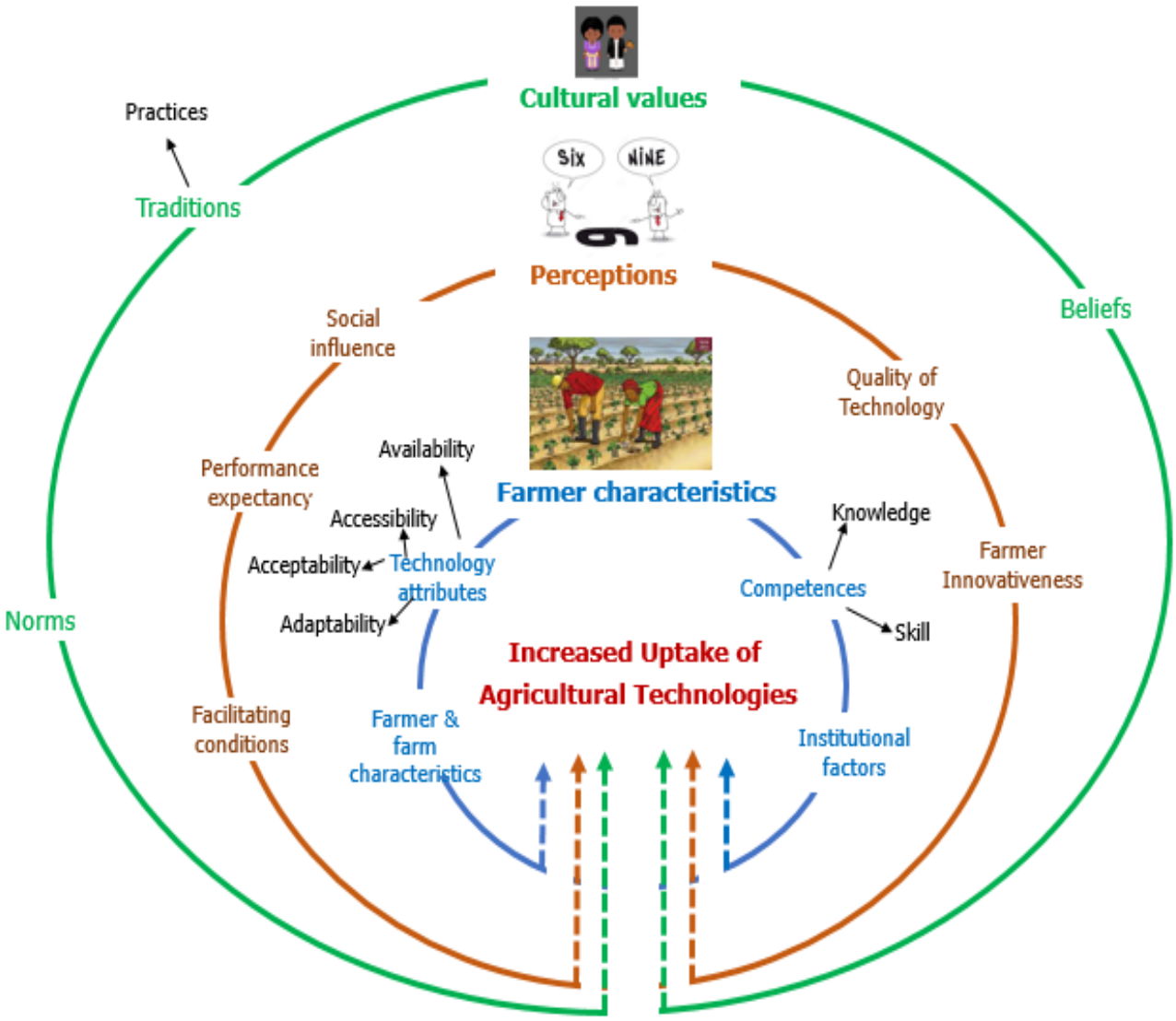

Figure 9: An Integrated framework of key socio-cultural considerations for contemplation in farmer uptake of agricultural technologies.

Contribution of the research

This research contributes to the existing literature by providing an integrated view of farmer uptake of agricultural technologies using a socio-cultural context. Most of the available frameworks focus on socio-economic factors influencing farmer uptake of agricultural innovations. This research has attempted to fill this research gap by generating a model which potentially can be applied to other technology uptake processes so as to address latent causes and limitations for low uptake of agricultural innovations.

Secondly, the research unravels cultural aspects of relevance in the enhancement of use & acceptance of agricultural innovations by intended users.

Thirdly, the research contributes to the existing body of knowledge by expanding the UTAUT framework in the context of farmers' use of TC planting materials. This study proposes two additional constructs that are ideal in predicting the technological acceptance behavior among the farming communities – i.e. farmer innovativeness and perceived quality of TC planting materials. The findings provide strong empirical insights to propose and test a model for assessing technology-acceptance related factors that influence farmers' intentions to use promoted and approved agricultural technologies for enhancing rural livelihoods. As such, results of this study provide a strong foundation for application in different contexts and theoretical assessments in other research fields.

Lastly, this research contributes to theoretical development by applying the seed security framework to analyze farmer decisions on uptake of banana TC seed, in combination with farmer competences, social influence and socio-economic factors.

5.6 Areas for further research

There is need for further studies that focus on an analysis of gendered socio-cultural preferences and needs in banana seed selection and development for the TC seed technology. Further research should also specifically seek to assess trait preferences for men and women farmers as a pre-requisite in the development of gender-responsive seed technologies.

Similar research in other agro-ecological zones is needed to understand uptake of the TC banana technology and to document experiences of men and women farmers with the TC banana plantlets. It is also necessary to identify factors that influence sustained use of the TC banana technology. Further, it is important that a systematic and scientific investigation concerning the medicinal values of some of the banana varieties be investigated to verify some of the claims made by the farmers.

Research on comparative models for TC banana technology users and non-users is important to establish the extent to which intentions to use the technology differ among the two independent groups. A similar study on socio-cultural aspects relating to banana production can be carried out in other major banana growing areas, most especially Western Uganda since it is an emerging major banana growing region.

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APPENDIX 1:

CHECKLIST FOR FOCUS GROUP DISCUSSIONS AND KEY INFORMANTS

District	
Sub county/Parish	
Village	
Name of the facilitator/interviewer	
Date of the interview	

Process:

i) Introduce yourself (name, organization/institution)

ii) Explain purpose of the discussion/interview

iii) Read out the content of the consent form and request for consent to; a.) Participate, b.) Take notes, c.) Photos, and d.) recordings

iv) Re-assure the respondent(s) of confidentiality for the information provided

v) Be observant to capture non-verbal expressions

A. Banana varieties grown in the community

A.1 What banana varieties are grown in your village? (Include those that no longer exist)

A.2 What are the special characteristics of the banana varieties grown in your village? (Include the desirable and undesirable traits)

A.3 Which banana varieties are of cultural importance in Qn. A.2 above? (For each banana variety mentioned, specify the cultural practice)

A.4 Why is the cultural practice important?

A.5 Who carries out the cultural practice?

A.6 How is the cultural importance carried out?

B. Farmer perceptions about TC banana seed

B.1 How do you perceive TC as banana seed?

B.2 Which banana varieties were introduced as TC banana seed?

B.3 What are your perceptions of the attributes of banana crop that were promoted by TC?

B.4 What are your tastes and preferences of the banana crop?

B.5 How do you manage TC seed on farm in comparison to local banana cultivars?

Thank you for taking the time to participate in this discussion.

APPENDIX 2:

SURVEY INSTRUMENT ON FARMER PERCEPTIONS ON TC BANANA SEED

District	
Sub county/Parish	
Village	
Name of the interviewer	
Date of the interview	
Questionnaire number	

SECTION A: Socio-Demographic Characteristics

Please circle or fill in as appropriate

1. Sex of the respondent_____

2. Age of respondent _____years

3. Respondent's marital status_____
   (1=married, monogamous; 2=married, polygamous; 3=cohabiting; 4=single; 5=widowed; 6=divorced; 7=separated; 8=child headed; 9=other (specify…….)

4. Educational level of the respondent _____
   1= No formal education
   2= Less than primary education
   3= Primary school education
   4= Secondary school education
   5= High school education
   6= College/University education
   7= Adult education
   8= Other (Please specify_____)

5. Annual income of the respondent _____

6. Religious affiliation of respondent_____

7. Ethnic group respondent belongs to _____

8. Annual income of the respondent (UGX)_____

SECTION B: Farmer perceptions on TC banana seed

On a scale of 1-5, how would you rate each of the constructs below on your perceptions of the TC banana seed?

2.1 Assessment on Performance Expectancy

	Variable	**Response**
1.	TC seed is BXW free *(Amalanga tegaba na kirwadde kya kiwotoka)*	
2.	TC seed is pest free *(Amalanga tegaba na biwuka (nga kayovu, ensilinganyi, amakovu e.t.c)*	
4.	TC seed is of desired banana varieties *(Amalanga gabera nebika ebye bitooke bye twagala)*	
5.	TC seed has no mutants *(Amalanga tegabera mu bika bye bitooke ebitategereka)*	
6.	TC seed is of right size *(Amalanga ga size nnungi)*	
7.	Food prepared from TC seed is tasty *Emeere eva mu bitooke bya'amalanga ewooma)*	
8.	TC seed/plantations are good for cultural purposes *(Amalanga oba ensuku eza amalanga bilungi okukozesa ku mikolo egye kinansi oba emikolo egyobuwangwa)*	
9.	TC seed/plantations are drought tolerant *(Amalanga oba ensuku eza amalanga bigumira embeera eyobudde eye kyeya)*	
10.	TC seed produces very many suckers *(Amalanga gazaala ensukusa nyingi)*	
11.	TC seed yields big banana bunches *(Amalanga gabala nenkoota eneene)*	
12.	TC seed yields bunches with big banana fingers *(Amalanga gabala enkota eze minwe emineene)*	
13.	Banana bunches from TC seed are highly marketable *(Amatooke agava mu malanga ga tunzi nnyo/galina akatale)*	
14.	Banana suckers from TC seed are highly marketable *(Ensukusa eziva mu malanga za tunzi nnyo/ galina akatale)*	
15.	TC seed grows faster compared to suckers under same management conditions *(Amalanga gakula mangu nnyo bwogeranganya ne'nsunkusa nga bisimbiddwa mu mbeera ezifanana)*	
16.	Plantations established using TC seed last longer than those established using suckers *(Ensuku ez'amalanga ziwangala okusinga eze'nsukusa)*	
17.	I can use suckers from TC seed to expand my banana plantations *(Nsobola okozesa amalanga okugaziya ensuku zange*)	

2.2 Assessment on Effort Expectancy

	Variable	Response
1.	TC seed sources exist *(Ebifo gyetujja amalanga we'biri)*	
2.	TC seed sources are functional *(Ebifo gyetujja amalanga bikola)*	
3.	TC seed is available in sufficient quantities *(Amalanga nsobola ogafuna mubunji bwemba ngetaze)*	
4.	TC seed is availed on time *(Amalanga nsobola ogafuna mu budde)*	
5.	TC seed is cheap to buy *(Amalanga ga bei laisi)*	
6.	TC seed is easy to transport *(Amalanga mangu otambuza)*	
7.	TC seed is easy to plant *(Amalanga mangu okusimba)*	
8.	TC seed is easy to manage *(Amalanga mangu okugalabirira)*	
9.	TC seed varieties perform well in different soil types *(Amalanga gadda bulungi mubika bye'ettaka ebyenjawulo)*	

2.3 Assessment on Social Influence

	Variable	Response
1.	If I am informed about TC seed by a faith based leader in my church/mosque, then I can use it as banana seed *(Ssinga omu kubakulembeze abeddini yange ambulira ku nnima ya'amalanga, nsobola okugalima)*	
2.	If I am informed about TC seed by a community leader in my village, then I can use it as banana seed *(Ssinga omu kubakulembeze abekyalo k yange ambulira ku nnima ya'amalanga, nsobola okugalima)*	
3.	If I am informed about TC seed by one of the group members in a farmer group, then I can use it as banana seed *(Ssinga omu kuba memba be'kibina kyobulimi kyendimu ambulira ku nnima ya'amalanga, nsobola okugalima)*	
4.	Using TC seed reflects my personality to other people/farmers *(Okozesa amalanga mu nnima yange kyoleka enkula/empisa/enneyisa yange eri abalala)*	
5.	According to people who are important to me, I should TC seed *(Okusinzira ku bantu abomugaso/abakulu jjendi, ntekwa okukozesa amalanga ng'ensigo ye'bitooke)*	

2.4 Assessment on Facilitating Conditions

	Variable	Response
1.	TC seed sources are within reach *(Ebifo mwetujja amalanga byangu okutukibwako)*	
2.	TC seed sources are certified *(Ebifo mwetujja amalanga bikirizabwa mu matteka okutusa/okuguza ku balimi amalanga)*	
3.	There isn't counterfeit TC seed on the market *(Tewaliwo malanga gga biccupuli mu katale)*	
4.	The TC nursery operator is welcoming and willingly provides information on how to grow/plant TC seed. *(Alabirira nursery atwaniriza bulungi era otusomesa ku nnima ya malanga)*	
5.	The TC nursery operator is welcoming and willingly provides information on how to manage TC seed. *(Alabirira nursery atwaniriza bulungi era otusomesa ku ndalabirira ya malanga)*	
6.	Trainings on the growing and management of TC seed are/were held in my community. *(Emisomo ku nnima ne'ndalibirira eya malanga gyiberawo/gyaberawo ku kyalo kyaffe)*	
7.	I have the finances to purchase TC banana seed *(Nnina ensimbi ezetagisa okugula amalanga)*	
8.	I have the land to plant TC seed *(Nnina ettaka kwensobola okulimira amalanga)*	
9.	I have sufficient technical knowledge to grow TC seed *(Nnina okumanya okumala kunima y'amalanga)*	
10.	I have enough skill to grow TC seed *(Nnina obukuggu obumala okulima amalanga)*	
11.	The TC nursery organises trainings on TC planting and management. *(Nursery ettekateka emisomo ku nnima ne'ndabilirira ya'malanga)*	
12.	The TC nursery has a TC banana demonstration garden. *(Nursery erina ennimiro ya demo eyigiriza ennima ya'malanga)*	
13.	I have enough passion for TC seed to grow it *(Nnina obwaggazzi obumala okulima amalanga)*	

2.5 Assessment on Farmer Innovativeness

	Variable	Response
1.	I intercrop TC seed with annual food crops *(Ntobeka ebirime ebirala mwaka na'malanga)*	
2.	I use a concocted organic pesticide (fermented human & animal urine, wood ash and red pepper) to control pests in TC seed *(Nkozesa omusulo ogwabantu ne'ebisolo ebimaze wiiki bbiri , kamulali n'evvu okuttangira ebiwuka bya'matooke obutakosa malanga)*	
3.	I use an organic fertiliser (concoction of fermented human & animal urine, wood ash and pepper) to increase the fertility of soils wherein I have planted TC seed. *(Nkozesa omusulo ogwabantu ne'ebisolo ebimaze weeks bbiri , kamulali n'evvu okwongera obujjimu mu ttaka mwesimbye malanga)*	
4.	I spray inorganic pesticides unto TC seed to control pests that attack it in its earlier months. *(Nfuyiira amalanga okuggatangira ebiwuka ebigakosa mu myezi ejjisoka)*	
5.	I apply wood ash around TC banana mats that have exhibited BXW symptoms to prevent further infection *(Nkozesa evvu ku bitooke ebibeera bisiggadewo ku bikolo ebibadde ne'kirwadde kya kiwotoka okuttangira obulwadde obuta sassana)*	
6.	Among my peers, I am usually the first to explore new agricultural technologies *(Mu banange, nze ntera okusoka okugezesa ennima empya eziba zizze)*	
7.	I like to experiment with new agricultural technologies. *(Njagala nnyo okugezesa ennima empya eziba zizze)*	
8.	If I heard about a new agricultural technology, I would look for ways to experiment with it. *(Ssinga mpulira ku nnima empya, mbera nnonyereza bwemba nsobola okujigezesa)*	

2.6 Assessment on Intention to Use TC banana seed

	Variable	Response
1.	Given chance, I intend to use TC seed at initial establishment of a plantation. *(Singa mpebwa omukisa, nsubira okukozesa amalanga nga ntandika olusuku)*	
2.	Given chance, I intend to use TC when expanding my banana plantation(s). *(Singa mpebwa omukisa, nsubira okukozesa amalanga nga ngaziiya olusuku/ensuku zange)*	
3.	Given chance, I plan to use TC seed to gap fill *(Singa mpebwa omukisa, ntekateka okukozesa amalanga okujuza amabanga mulusuku/nsuku zange)*	
4.	Given chance, I intend to use TC seed when I have no suckers. *(Singa mpebwa omukisa, nsubira okukozesa amalanga nga sirina nsukusa)*	
5.	Given chance, I intend to use TC seed when on-farm plantations in my community exhibit symptoms of BXW infection. *(Singa mpebwa omukisa, nsubira okukozesa amalanga nga ensuku ku kyalo zirina obubonero bwe'kirwadde kya kiwotoka)*	
6.	Given chance, I intend to use TC seed when establishing a commercial banana plantation. *(Singa mpebwa omukisa, nsubira okozesa amalanga nga ntandiika olusuuku lwa business)*	

Thank you for your time!

APPENDIX 3:

SURVEY INSTRUMENT FOR BANANA FARMERS

Questionnaire number_____ Farmer ID_____
Name of the Enumerator_____ Date: -------- / -------- / --------
-
Checked by _____ Entered by _____

Location of farmer surveyed

District	
Sub county	
Parish	
Village	

Section 1: Details of demographic and socio-economic characteristics of respondent

Please circle or fill in as appropriate

1. Respondent's information

1.1. Sex of respondent	1=Female; 0=Male
1.2. Respondent's marital status	1=married, monogamous; 2=married, polygamous; 3=cohabiting; 4=single; 5=widowed; 6=divorced; 7=separated; 8=child headed; 9=other (specify……)
1.3. Education level of the respondent (Number of years spent in formal schooling)	_____*(1= No formal education; 2= Less than primary education; 3= Primary school education; 4= Secondary school education; 5= High school education; 6= College/University education; 7= Adult education; 8= Other (specify_____)*
1.4. Respondent's age	
1.5. Religious affiliation of respondent	
1.6. Ethnicity	

2. Type of main house *please circle*

Walls	**Floor**	**Roof**
1= Brick	1= Tiles	1= Iron sheets
2= Concrete blocks	2= Cement	2= Grass or thatch
3= Mud and wattle	3= Mud	3= Tiles

3 Respondent's income

3.1 What is your main source of income? (**see code A**)

_____

3.2 What is your alternative(s) sources of income? (**see code A**)

Code A

0. *None; 1. Farming; 2. Salaried employment; 3. Self-employed off-farm (retail Shop); 4. Self-employed off-farm (Boda boda); 5. Self-employed off-farm (tailoring); 6. Self-employed off-farm (market vendor); 7. Casual laborer on-farm; 8. Casual laborer off-farm; 9. Student/Pupil; 10. Household chores; 11. Handcraft; 12. Brewing; 13. Rentals; 14. Produce trade; 15. Bee keeping; 16. Builder; 17. Other_____ (specify)*

3.3 Please fill in the table below information about ***respondent's income sources*** and rate according to importance

Income source (refer to Codes below)	**Rate the source on a scale of 1-3, where** *1= Most important, 2=Important, and 3= Least important)*
1)	
2)	
3)	

***Codes: 1**= Production and sale of crops, **2**= Production and sale of livestock and livestock products, **3**=Salary, **4**= Casual labour wages, **5**= Trading in agricultural produce, **6**=Trading in non-agricultural products, **7**= Remittances, **8**= Fishing, **9**= Boda-boda/taxi, **10**= Brewing, **11**=Brick Laying, **12**=Other (specify)_____*

3.4 In the table below, give details of total annual income from **major crops** produced *besides banana by* the respondents

Crop (At least four major crops)	**Who mainly earns income from this crop in respondents HH** *1=Male, 2=Female, 3=Both*	**Frequency of income from crop** *1=Monthly, 2=seasonally 3=Annually*	**Average amount per *Month/season***	**Total Annual Income** *(Computed by data collector)*

3.5 In the table below, give details of total annual income from specific livestock type owned by the respondent

Livestock Type (& poultry where applicable)	**Who mainly earns income from this Livestock in respondent's HH** *1=Male, 2=Female, 3=Both*	**Frequency of income** *1=Monthly, 2=seasonally 3=Annually*	**Average amount per *Month/season***	**Total Annual Income** *(Computed by data collector)*

3.6 In the table below, give details of total annual income from non-farm activities by the respondent

Non-Farm activities	**Who mainly earns income from this activity in respondent's HH** *1=Male, 2=Female, 3=Both*	**Frequency of income** *1=Daily, 2=Weekly, 3=Monthly, 4=Annually*	**Average amount per** *Day/Week/ Month/Year*	**Total Annual Income** *(Computed by data collector)*
1.				
2.				
3.				
4.				

3.7 What is your total annual earnings from remittances (If any)? _____

3.8 What is your annual income (UGX)_____ *(to be computed)*

4. Access, ownership and control of durable goods

		Available	**How many?**	**Access/use**	**Ownership**	**Control of usage**
	Good	(1=yes,0=no) if no, skip columns to right		1. Woman 2. Man 3. Both 4. Other	1. Woman 2. Man 3. Both 4. Other	1. Woman 2. Man 3. Both 4. Other
4.1.	Radio					
4.2	Mobile phone					
4.3	Bicycle					
4.4	Motorcycle					
4.5	Motor vehicle					
4.6	TV					
4.7	Sewing machine/tools					
4.8	Hoe/Axe/Machete/plough					
4.9	Animal drawn cart					

5. Land access and utilization

How much land (acres) in total does the respondent have access to for agricultural production (including rented-in, rented-out, sharecropped in, borrowed land, fallowed land etc) and how it is allocated?

Variable	**Total Acreage *(in Acres)***
5.1 Total land accessed	
5.2 ***Owned*** (inherited/bought) by the farmer of the total land	
5.3 Area under ***crops***	
5.4 Area under ***banana crop***	
5.5 Area under tissue culture ***banana crop***	

5.6 Farmer access to agricultural land

5.6.1. Plot number	5.6.2. Plot size in acres	5.6.3. Does the plot belong to your family? *1=Yes, 2=No, it is Rented, 3=No, it is Borrowed 4=No, it is share cropped, 5=Other (specify)_____*	5.6.4. Who owns the land? *1=Male HHH, 2=Female HHH, 3=Spouse of HHH 4=parents to HHH/spouse, 5= grandparents 6= sibling to HHH/spouse 7=Other (Specify) _____*	5.6.5. Who mostly works on this land? *1= Male HHH, 2=Female HHH, 3=Spouse of HHH, 4= male child, 5=female child, 6=All children, 7= Whole family, 8=Parent /sibling to the HHH/Spouse, 9=hired labourers, 10= both HHH & spouse 11=Other (specify)._____*	5.6.6. Who decides what to do on the land? *1= Male HHH 2=Female HHH, 3=Spouse of HHH, 4=parents to HHH/spouse, 5= grandparents to HHH/spouse, 6= sibling to HHH/spouse 7= both HHH & spouse 8=Other (Specify) _____*
1					
2					
3					
4					
5					

5.7 Major crops grown

List and rank the five major crops grown by the farmer

Crop	Rate on 5 point scale **Importance for Income** *(1=most important)*		Rate on 5 point scale importance for **Food security** *(1=most important)*	
1.				
2.				
3.				
4.				
5.				

***Codes**: 1 = Bananas, 2 =Coffee, 3= Beans, 4= Cassava, 5= Maize, 6= Sweet potatoes, 7=Tomatoes, 8=Leafy Vegetables (Nakati, Bugga, Ddodo, Jobyo…), 9=Cabbage, 10=Irish potato, 11=ground nuts, 12=Other (Specify)_____*

Section 2: Banana Production

2.1 For how long have you grown banana? _____(years)

2.2 Number of banana fields _____

2.3 Size, kind of banana field, distance from tarmac road and source of planting materials

2.3.1 Banana field	2.3.2. Size of field (acres)	2.3.3. Kind of plantation *1= Cooking bananas 2= Brewing bananas 3= Desert bananas 4= Mixed cooking, brewing & desert bananas 5= Plantain 6= others (Specify_____)*	2.3.4. Average yields (Bunches per month)	2.3.5 Average weight in Kg (use the most common bunches harvested) ***(see note below)***	2.3.6 Ownership *1= man 2= woman 3= both*	2.3.7 Distance from tarmac (km)	2.3.8 Source of planting materials *1=Own plantation; 2= neighbors farms sourced at free of cost 3= neighbors farms on payment; 4= NARO 5= TC nursery/laboratory 6=NGOs 7=Government/extension 8=others, specify*
Plot 1							
Plot 2							
Plot 3							
Plot 4							
Plot 5							

Note: for estimation of weight in kg, let the farmer compare bunches with jerry cans of water; 5L=5kg, 10L=10kg, 15L=15kg, 20L=20kg

2.3.9 What are the most important features you look for when obtaining suckers from the sources named above?

Source as mentioned above in 2.3.8	**Features *(Specify up to 4 features per source)*** *1=Sucker size and appearance 2=Mother plant size and appearance 3=varietal characteristics 4=Description from trusted source e.g. seller or neighbor 5=Risk of pest or disease 6= Other specify_____*	**For each source, rank** the features in order of importance from 1 upwards [1 being the most important feature]

2.4 Varieties grown and their acreage

2.4.1 What are the ***five (5) most important local banana varieties*** grown by the farmer? Place in the table below details of varieties and acreage planted with each of the varieties

Name of Local Banana variety *(Use Codes)*	**Rank**	**Total number of mats**	**Acreage for all *local banana varieties* (Record in Acres)**

Codes: *1=Kisansa, 2=Nakitembe, 3= Musakala, 4= Mbwazirume, 5=Muvubo, 6=Mpologoma, 7=Bogoya, 8=Nfuuka, 9= Nakabululu, 10=Kibuzi, 11=Muzira Nyama, 12=Nakawere, 13=Others (Specify* _____

2.4.2 Has the respondent ever heard about ***tissue culture banana planting materials*** *(TCs are sometimes referred to as amalanga)*_____

1=Yes, 2=No

2.4.3 If yes, in which ***year*** did your farmer first get to know about the TC banana planting materials? ____

2.4.4 ***How (source of info.)*** did the farmer first get to know about TC banana planting materials?

1=Research Institute, 2=NGO, 3=Fellow farmer, 4=Extension, 5=Local leader, 6=Community leader, 7=TC Nursery operator, 8=other (specify) _____

2.4.5 Has the farmer ever grown TC banana planting materials on their farm? _____

1=Yes, 2=No, (If No, ***ask why not and then skip to Qn. 8.6.9***

_____

_____

2.4.6 If yes, Please fill in the table below the varieties grown using TC banana planting materials by the respondent and the acreage planted for each of the varieties

varieties grown using TC banana planting materials *(use* *codes A)*	**Rank in order of preference**	**Year first planted**	***Source* of first planting materials** *(use codes B)*	**Quantity first planted** *(suckers/ plantlets)*	**Still growing variety** *(1=yes, 2=No)*	**If yes, Current Total number of mats**	**Current Acreage for all TC established varieties** (In Acres)
1)							
2)							
3)							
4)							

Codes A: *1= Kisansa 2=Mpologoma, 3=Musakala, 4=Nakitembe, 5=Kibuzi, 6=Nfuuka, 7= FHIA (mainly juice), 8=FHIA 17 (both food &dessert) 9=Improved Ndiizi (Kawanda tombaddala) , 10=Kabana, 11=Others (Specify)*_____

Codes for source B: *1=TC Nursery, 2=Research Institute, 3=NGO, 4=Fellow farmer, 5=Extension, 6=Local leader, 7=NAADS, 8= Community leader, 9=other (specify)_____*

2.5 Did you buy the **TC banana planting material**? _____

Yes = 1 *No = 0*

8.6.1 If yes, what was the cost of each plantlet (specify unit)? _____

2.5.1 What would be your price limit for buying TC banana planting material and why?

Price Limit *(specify unit)* _____

Reason_____
_____
_____
_____
_____

2.5.2 Was the variety(ies) you bought what you had sought for?

Yes = 1 *No = 0*

2.5.3 Did you have the variety(ies) on your farm before?

Yes = 1 *No = 0*

2.5.4 What is the ***size (in acres)*** of the main plot on which TC banana varieties are planted? -------

2.5.5 What is the ***distance (walking minutes)*** to the main plot where TC banana varieties are grown? _____

2.5.6 Give main reason why TC banana varieties are planted on this plot? _____

1=TC varieties received by the person, 2=Main decision maker for land allocation, 3=main decision maker in what to grow, 4=Sole responsibility for food consumption, 5=Other specify_____

2.5.7 What factors facilitate and or inhibit use of TC by the respondent?

Issue	**Response**
a.) What were the ***enabling factors*** for you to start growing TC banana varieties?	1. _____ 2. _____
b.) Which factors ***motivate*** you to continue growing TCs?	1. _____ 2. _____
c.) List main ***challenge***, ***limiting*** or ***constraining factor*** to growing TC banana varieties?	1. _____ 2. _____

2.5.8 Areas of TC banana varieties that need further improvement by research

Variety Name	**Aspects that require further improvement by research**		
	1st most important aspect	***2nd most important aspect***	***3rd most important aspect***

_____
_____
____
_____
___

2.5.9 What is the number of TC banana plantlets you have bought over the years?

Number of TC plantlets bought in							
Other Specify _____	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**

2.5.10 Do you manage TC seed/crop on farm the same way as local banana cultivars?

Yes = 1 *No = 0*

8.6.12.1 If not, how differently do you manage the plantlets?

_____
_____
_____
_____

2.5.11 How do TC plantlets perform on-farm compared to local banana suckers and why? *(To score using a scale of 1-10)*

Score _____

Reason_____
_____

Section 3: Assessment on seed security factors and farmer competences on the use of TC banana seed

On a scale of 1-5, how would you rate each of the constructs below on your perceptions of the TC banana seed?

3.1 Assessment on Seed Acceptability

	Variable	**Response**
1.	TC seed is of desirable banana varieties *(Amalanga gabera nebika ebye bitooke bye twagala)*	
2.	TC seed is of right size *(Amalanga ga size nnungi)*	
3.	Food prepared from TC seed is tasty *Emeere eva mu bitooke bya'amalanga ewooma)*	
4.	TC seed/plantations are good for cultural purposes *(Amalanga oba ensuku eza amalanga bilungi okukozesa ku mikolo egye kinansi oba emikolo egyobuwangwa)*	

3.2 Assessment on Seed Availability

	Variable	**Response**
1.	TC seed sources exist *(Ebifo gyetujja amalanga we'biri)*	
2.	TC seed sources are functional *(Ebifo gyetujja amalanga bikola)*	
3.	TC seed is available in sufficient quantities *(Amalanga nsobola ogafuna mubunji bwemba ngetaze)*	
4.	TC seed is availed on time *(Amalanga nsobola ogafuna mu budde)*	

3.3 Assessment on Seed Accessibility

	Variable	**Response**
1.	I have the finances to purchase TC banana seed *(Nnina ensimbi ezetagisa okugula amalanga)*	
2.	I have access to information on how to grow/plant TC seed. *(Nnina okusomesebwa oba entegera ku nnima ya malanga)*	
3.	I have access to information on how to manage TC seed. *(Nnina okusomesebwa oba entegera ku ndalabirira ya malanga)*	
4.	TC seed sources are within reach *(Ebifo mwetujja amalanga byangu okutukibwako)*	
5.	TC seed is easy to transport *(Amalanga mangu otambuza)*	

3.4 Assessment on Seed Adaptability

	Variable	Response
1.	TC seed/plantations are drought tolerant *(Amalanga oba ensuku eza amalanga bigumira embeera eyobudde eye kyeya)*	
2.	Plantations established using TC seed last longer than those established using suckers *(Ensuku ez'amalanga ziwangala okusinga eze'nsukusa)*	
3.	TC seed varieties perform well in different soil types *(Amalanga gadda bulungi mubika bye'ettaka ebyenjawulo)*	

3.5 Assessment on Farmer competences to use banana seed

	Variable	Response
1.	I have sufficient technical knowledge to grow TC seed *(Nnina okumanya okumala kunima y'amalanga)*	
2.	I have enough skill to grow TC seed *(Nnina obukuggu obumala okulima amalanga)*	
3.	I use a concocted organic pesticide (fermented human & animal urine, wood ash and red pepper) to control pests in TC seed *(Nkozesa omusulo ogwabantu ne'ebisolo ebimaze wiiki bbiri , kamulali n'evvu okuttangira ebiwuka bya'matooke obutakosa malanga)*	
4.	I use an organic fertiliser (concoction of fermented human & animal urine, wood ash and pepper) to increase the fertility of soils wherein I have planted TC seed. *(Nkozesa omusulo ogwabantu ne'ebisolo ebimaze weeks bbiri , kamulali n'evvu okwongera obujjimu mu ttaka mwesimbye malanga)*	
5.	I spray inorganic pesticides unto TC seed to control pests that attack it in its earlier months. *(Nfuyiira amalanga okuggatangira ebiwuka ebigakosa mu myezi ejjisoka)*	
6.	I apply wood ash around TC banana mats that have exhibited BXW symptoms to prevent further infection *(Nkozesa evvu ku bitooke ebibeera bisiggadewo ku bikolo ebibadde ne'kirwadde kya kiwotoka okuttangira obulwadde obuta sassana)*	

Section 4 Institutional interventions or services in place

Please fill in the table below the different services/interventions available in your area and how you access them

4.1 Institutions /service	4.2 Is this service/intervention available in your area? 1=*Yes* *0=No*	4.3 Do you have access to this service? 1=Yes 0=No	4.4 Distance from your home to the nearest point of access to this service (**in walking hours**)	4.5 Did you participate or accessed services from this institution in the last 6 months? *1=Yes; 0=No*	4.6 Number of times you have been in contact with the institution that provides this service in the last year?	4.7 Who is responsible for facilitating access to service/intervention? *1=the community;* *2. NAADS; 3=NGOs;* *4=private sector; 5=FAO;* *6=Research Organizations;* *7=Others (specify)*
Traditional extension services						
Development agencies (NGOs and private sector) working on BXW						
Farmer field schools (Farmer groups not only addressing wilt but other banana problems)						
Community (bye-laws, action plans, BXW control committees)						
Trainings on BXW management (includes meetings on BXW, field days, demonstrations on BXW, other formal and informal trainings)						
Nurseries for banana planting materials						
Banana product markets						
Agricultural input markets						
Tarmac road						
Business Centre or town						
Credit facilities/banks						

4.8 Which of the institutions above have been the *most important contributors* to your use/uptake of tissue culture banana planting materials? Please, give reasons why

Contribution	**Institution (Use codes)**	**Main Reason why**
Highest contributor		
Second highest contributor		
Least contributor		

1=the community; 2. NAADS; 3=NGOs; 4=private sector; 5=Extension; 6=Research Organizations; 7=Others (specify) _____

4.9 What kind of Extension and advisory related advice on TC planting materials has the respondent received in the past 5years?

4.9.1 Extension advice related to …….	**4.9.2 Did you receive any advice related to …….** *1= Yes , 2= No*	**4.9.3 Main Source of advice***(use codes A below)*	**4.9.4 Main Channels used to receive the advice** *(Use codes B below)*	**4.9.5 Adequacy of the service received** 1=Very Satisfactory 2=Fairly satisfactory 3 = Not at all satisfactory
Sources of TC planting materials				
Disease & pest control/management				
How to plant TC seed(Agronomy)				
How to manage TC crop in the field (management)				
Harvest related information				
Others (specify) _____				

Codes A for sources of Advice: *1= Fellow farmers 2=Research 3= Community leaders, 4= Local Leaders 5=Traders 6= Input dealers 7=Farmers' groups/assoc. 8=Gov't extension agent 9= Opinion leaders 10=NAADS, 11=Others (Specify _____*

Codes B for channels used*: 1= One-on-one meeting 2= Group meeting 3= Trainings 4= Radio 5= Television 6=Printed material 7= Mobile phone 8= Videos 9= Exposure/exchange visits 10= Demonstration plots 11=Others (Specify _____*

4.10 Which channel among those used influenced most your choice of TC planting materials? _____

4.11 Why was this the most influential? _____

4.12 Which is your most preferred channel for receiving information about banana production? (***Circle only one most important)*** _____

Codes: *1=One-on-one meeting 2= Group meeting 3= Trainings 4= Radio 5= Television 6=Printed material 7= Mobile phone 8= Videos 9= Exposure/exchange visits 10= Demonstration plots*

4.13 If you had a question about TC planting materials, what would be the FIRST thing you would do to get information ***(Please, circle only one)*** _____

1) Ask someone I know (for example: friend, relative, neighbour, acquaintance)
2) Check media sources (for example radio, TV, newspapers, magazines, internet)
3) Approach an extension, organisation or group (for extension officer, CBO, NGO, Research Institute)

Section5: Memberships in organizations/groups/associations by farmer

5.1 Does the respondent belong to any community organization, association/ group *(including cooperatives, farmers groups, SACCOs, women's associations, youth groups, self-help mutual support groups, input/ marketing groups)?* Circle response

_____

1=Yes, 2=No, (if **No, proceed to 6.0)**

5.2 In which year did you first gain membership in any organizations/groups/associations?

_____

5.3 Please, fill in the Specify information about the type of groups and main activities in table below

Name of the group /organization/ association *(Multiple groups allowed)*	Type of group *(Refer to codes A below)*	No. of years spent in this group	Main activity *(refer to codes B below) Multiple options allowed)*	Does the group participate in any banana related activities? *1= Yes, 2=No*	If the group participates in banana related activities, what specifically does it do *(refer to codes C below) (Multiple options allowed)*

Codes A for type of organization/association/group: *1= Women only group 2= Men only 3= Youth only group 4= Mixed (men, women, youth) 5= Men and Women only*

Codes B for main activity or purpose of the group: *1=Self-help activities such as labour mobilization, 2=Income generation, 3= Group access to inputs and extension, 4=Mobilizing savings and credit, 5=Group marketing of produce 6=Promotion of improved farming practices, 7=Access to credit, 8=others (specify)* ----------

Codes C for specific banana related activities: *1= Accessing technologies/free planting materials, 2=Sharing information on banana, 3= Training on banana, 4=Group marketing of banana 5=others (specify)*_____

5.4 Has your membership to group/association/organisation contributed to your use of tissue culture banana planting materials? _____

Scale: 1=strongly disagree, 2=Disagree, 3=No comment/ neutral, 4=Agree, 5=strongly agree

6 Innovations and changes in farmer's system

6.1 List the major changes and/or innovations that have occurred in ***farming practices*** due to introduction of tissue culture banana planting materials

_____

_____

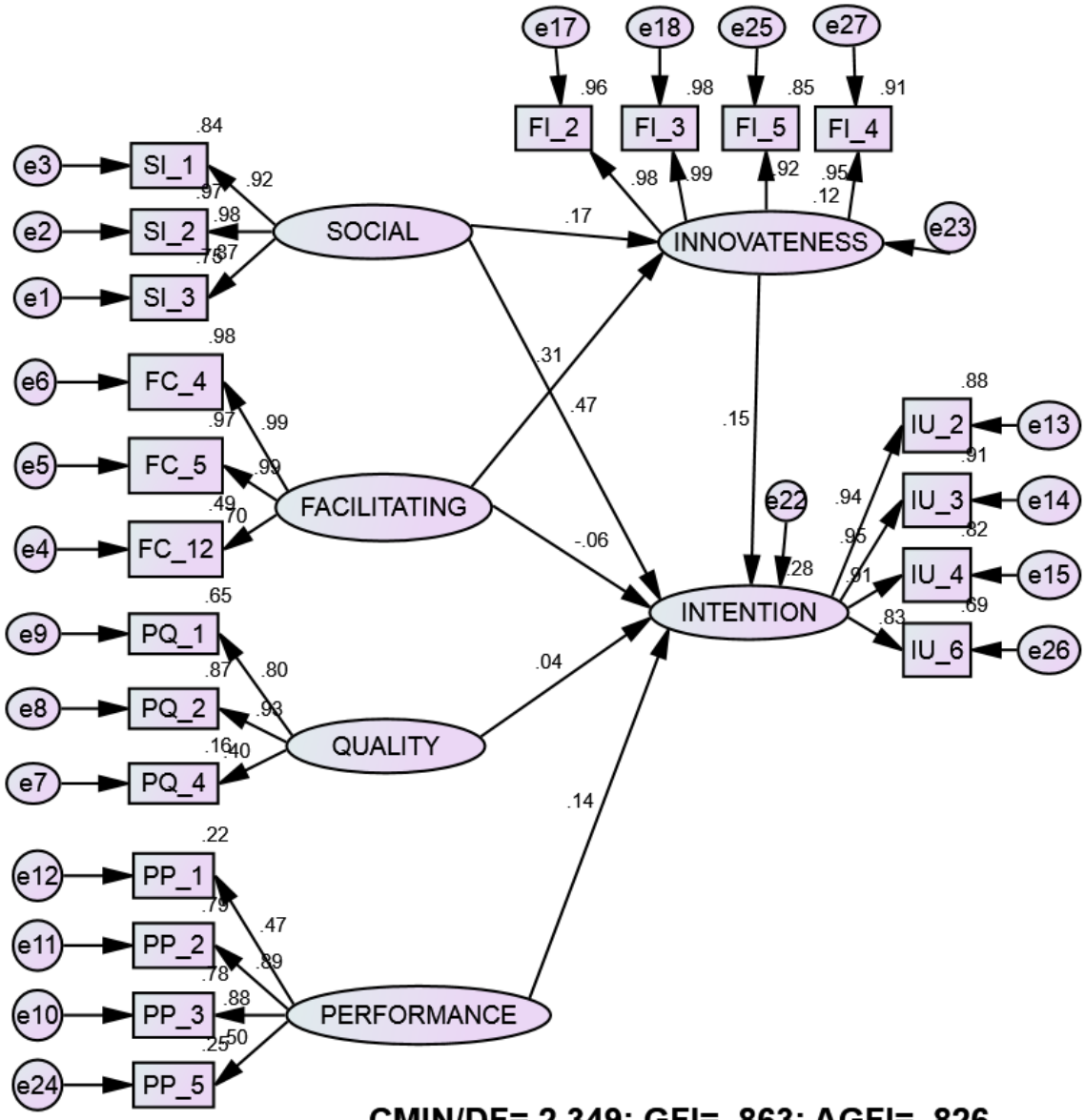
6.2 What is the overall most significant ***change*** that has occurred as a result of the ***introduction*** and ***uptake*** of tissue culture banana planting material? (*Allow the farmer to freely mention as you rank the most important three*)

Variable	**Rank (1=most important, 3=less important)**
1. Increased physical assets	
2. Increased food diversity	
3. Increased availability of food	
4. Increased stability of food supply	
5. Increased access to adequate food all the time	
6. Improved income	
7. Increased saving from banana production	
8. Increased number of banana products sold	
9. Increased production of bananas	
10. Hiring of labour	
11. Increase in livestock production	
12. Social networks	
13. Knowledge sharing	
14. Others(specify)	

Thank you for your time

APPENDIX IV

MEASUREMENT MODEL FOR FARMER PERCEPTIONS ON BANANA TISSUE CULTURE PLANTING MATERIALS



CMIN/DF= 2.349; GFI= .863; AGFI= .826
TLI= .950; CFI= .954; RMSEA= .074