



# RTB

## Working paper

### **The Culture of Banana Cultivation: an exploratory study of a local banana seed system in Central Uganda**

Fleur Kilwinger, Anne Rietveld, Conny Almekinders

S E P T E M B E R 2 0 1 7





## RTB Research Report

**Correct citation:** Kilwinger, F., A. Rietveld, C. Almekinders, 2017. The Culture of Banana Cultivation: an exploratory study of a local banana seed system in Central Uganda. CGIAR Research program on Roots, Tubers and Bananas (RTB) RTB Research Report.

## Published by the CGIAR Research Program on Roots, Tubers and Bananas

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### Contact:

RTB Program Management Unit  
International Potato Center (CIP)  
Apartado 1558, Lima 12, Peru  
[rtb@cgiar.org](mailto:rtb@cgiar.org) • [www.rtb.cgiar.org](http://www.rtb.cgiar.org)

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# Abstract

Banana is one of the most important staple crops in Central Uganda. In central Uganda most of the banana varieties cultivated belong to the East African Highland Bananas (EAHB) which include food (Matooke) and beer (Mbidde) varieties. The production of banana in Central Uganda has declined over the last years due to soil exhaustion, pest pressure and socio-economic constraints. Besides that new pests and diseases have entered the country in recent years. One of those diseases is Banana Xantomonas Wilt (BXW) which can destroy entire banana plantations. Farmers obtain new planting material mainly “informal” from their own farms or from fellow farmers. This contributes to built-up and rapid spread of diseases. Tissue Culture (TC) banana plantlets have been promoted and distributed to combat these negative effects of the current type of acquisition of planting material. Despite efforts the adoption of improved banana varieties and TC banana plantlets remains low under small-holder famers in Central Africa. The aim of this research is to get a better understanding of the current banana seed system in order to make future interventions, aiming to improve the seed system, better suited to farmers’ needs. The focus of the research has been on the use of banana variety and the selection, sources and availability of planting material. The study was conducted in Mukono district of Uganda where smallholder banana farmers are common. In these regions the use of TC banana plantlets has been promoted by the governments National Agricultural Advisory Services (NAADS) and the International Institute of Tropical Agriculture (IITA). During the study the role of TC banana plantlets in the banana seed system has been addressed. To understand how new diseases affect the seed system the effects of BXW on seed sourcing practices among farmers were also examined.

Farmers in the study area were found to use a great diversity of banana varieties belonging to EAHB and other clone sets. The emphasis of all farmers was on the cultivation of cooking varieties. The cultivation of beer varieties was popular in the area but the farmers told that due to BXW all the plantations with beer bananas got destroyed. Each of the varieties grown had perceived strengths and weaknesses and cultivar diversity therefore brought security to the household. Preferred variety characteristics differed if the purpose of the variety was commercial or for home consumption.

The rate in which existing banana mats were replaced with new planting material differed among farmers. Uprooting of mats is labor intensive and therefore more difficult for elderly and women. Less resourceful households can thus experience more difficulties keeping the plantation vital by replacement of banana mats. Combatting diseases on the farm can for the similar reason be more difficult among those households. According to the farmers uprooting and destroying infected mats is the most successful measure to get rid of BXW on the farm. Physically weaker farmers who do not have the opportunity to hire labor nor have family or friends to rely on are thus more vulnerable to these kind of diseases.

New planting material was mainly acquired on-farm. The extent to which planting material can be assessed and evaluated was described as the key difference between on and off-farm sourcing. While selecting planting material on-farm, farmers evaluate the mat, mother plant and sucker itself. When farmers source off-farm the source-farmer often uproots planting material him/herself and gives it to the receiving farmer. In that case the farmers are not sure about the varieties, the condition of the farm, the presence of diseases and the condition of the mat and mother plant the sucker was subtracted from. This made off-farm sucker sourcing less popular among farmers. Another difference between on and off-farm sucker sourcing was the preferred size of the suckers. on-farm smaller suckers were preferred than off-farm.

Farmers in the study area mainly got familiar with the TC banana plantlets due to the programs of NAADS and IITA. All farmers making use of TC plantlets considered them profitable regardless of the higher inputs required. The reason why some farmers were not that fond of the TC's was not only because relatively high costs but also because the varieties of the plantlets can only be identified after maturity. Stories of farmers getting the wrong variety were roaming around which made the farmers hesitant to buy them. TC plantlets were often associated with the varieties Mpologoma and Kisansa which made it difficult to understand which perceived benefits and weaknesses were to be attributed to the technology and which to the variety. Farmers using TC on a large scale usually cultivated less varieties and did not share planting material that frequently. Nursery owners tell their clients to not uproot suckers from TC but rather de-sucker their mats by destroying the suckers. This would keep the mat more vital. Farmers are advised they should return to the nursery every 3 years to get new TC plantlets instead of multiply the material by themselves. TC plantlets are often used by wealthier farmers cultivating on a relatively large scale. These are also the types of farmers which provide a source of planting material for other farmers having shortages. This change in sharing behavior could thus pose a potential risk for farmers who are often short in planting material in case they cannot use these farmers as a source anymore.

# Acknowledgments

I want to thank Bioversity International and Wageningen University for giving me the opportunity to perform this research. First I would like to thank my supervisor Conny Almekinders from Wageningen University for introducing me to the social science and guiding me through my first interdisciplinary research. Besides that I want to thank her for helping me improving my (sometimes funny) English. I also want to thank my other supervisor from Wageningen University Jeroen Groot. As my supervisor from the department of plant sciences he always gave me valuable feedback, especially to improve the natural science part of my thesis. I want to thank Anne Rietveld my supervisor from Bioversity International for guiding me through the (sometimes challenging) fieldwork in Uganda. Besides Anne's guidance, the fieldwork became successful thanks to my field assistants Winnie Candiru, who is specialized in gender research, and Francis Karyango, who is working for NARO and is very knowledgeable of banana cultivation. It was a pleasure to work with you guys. I want to thank Charles Staver (bioversity International), who is also very knowledgeable of banana cultivation, for his valuable inputs to improve my research proposal. This also counts for Aman Omondi and Enoch Kikulwe (Bioversity International) for their feedback which really helped me improve my research proposal. I also want to thank Lucy Mulugo, who is currently working on her PhD about a similar topic, for all her inputs. I hope our researches can complement each other, to better understand the banana seed system in Uganda. Last but not least, I want to thank the farmers for always being welcome, giving us some of their time and sharing their knowledge with us.

# Abbreviations

FGD	Focus Group Discussion
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organization
TC	Tissue Culture
AGT	Agro Genetic Technologies
EAHB	East African Highland Bananas
NPAE	New Page Agricultural Enterprises
BXW	Banana Xantomonas Wilt
IFE	Ideal Farm Enterprises
IITA	International Institute for Tropical Agriculture
FHIA	Honduran Agricultural Research Foundation
UPDF	Ugandan People Defense Force
PMA	Plan of Modernization of Agriculture
OWC	Operation Wealth Creation
CBF	Community Based Facilitator
PCC	Parish Coordinating Committee
VFF	Village Farmer Forum

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# CHAPTER 1. INTRODUCTION

East African highland banana (EAHB) is the most important staple crop in the eastern Great Lake regions of Africa. In Uganda highland cooking bananas, locally referred to as Matooke, have been cultivated for ages being one of the most important food crops and are therefore deeply rooted the countries culture. In the past years the production of banana has declined in Central Uganda due to soil exhaustion, pest pressure and socio-economic constraints. Nevertheless the demand for bananas on urban market has increased but is mainly supplied from south-western regions (Bagama et al., 1999). Banana cultivation in the central region is characterized by low input - low output smallholder farming in contrast to western Uganda where banana cultivation is more commercialized. In case of bananas the vast majority of these smallholder farmers provide their own planting material (Staver et al., 2010). Such a system is referred to as a local, farmer, traditional or informal seed system. (Almekinders & Louwaars 2002). Farmers dynamically manage agricultural biodiversity in informal seed systems by collecting, testing and sourcing “seeds”, which is here understood as propagules such as true seeds, tubers, vines, rhizomes etc. (Delêtre et al., 2011). Bananas and plantains are clonally propagated which results in low levels of variation within populations (see chapter 1.2 for more information on banana morphology and growth). Suckers are hardly genetically different from the mother and variation only exists due to mutations and the chimerical nature of the crop. On a similar mat several suckers may appear which are phenotypic (and possible genotypic), not all identical (Pillay & Tenkouano, 2011). Among those suckers new planting material is selected by the farmer. During this selection farmers have to make decisions about the variety, the appearance of the sucker and the presence of pests and diseases (Staver et al., 2010). This selection pressure by farmers over the years has led to new varieties or landraces which are well suited to agro-ecological and socio-economic properties of the farmers (Pillay & Tenkouano, 2011). Since farmers are the ones managing the farms and selecting the planting material they are the ones responsible for the quality of the material.

Not all farmers have similar access to resources and inputs, manage their farm in the same way and have mats of the same varieties on their farm which leads to exchange of planting material among households. The exchange of planting material gives farmers access to planting material of higher quality, allows farmers to obtain planting material timely, helps to maintain a higher diversity of varieties in the area and buffers possible losses. (Staver et al., 2010). Besides that it gives the farmer access to new planting material often for a low price or even for free. In this way farmers form a source of genetic diversity and conserve varieties *in situ* (Delêtre et al., 2011). The great lake region in Africa is in fact known as a secondary center of banana diversity (Smale & Tushemereirwe, 2007). Unfortunately this way of acquisition of planting material knows negative side-effects. The clonal propagation method does not include a step of true seed set in which most pests and diseases are usually removed. This results in a built up of pests and diseases. When planting material is exchanged by farmers these pests and diseases can easily be transferred among farms (Jacobsen 2016 ; Staver et al, 2010 ; Dubois et al., 2006 ; Andrade-Piedra et al., 2016). The informal seed system has been providing farmers with healthy, viable seeds of desired varieties for a long time but new challenges for the system have arisen the last couple of decades such as intensification of land use, changes in market demands,

environmental changes and newly introduced pest and diseases. One of those new diseases is Banana Xantomonas Wilt (BXW) which has been reported in Uganda since 2000 and is capable of wiping out entire plantations, especially when susceptible genotypes are grown intensively. Low soil fertility and BXW are considered as the biggest production constraints in Eastern Africa (Basengere & Rutegeya 2014). The formal, conventional or modern seed system addresses these types of challenges by the development, production and distribution of improved varieties using scientific knowledge of genetics, crop productivity and pest and diseases. Introduction of improved varieties transforms seed from a mainly on-farm input to an off-farm input.

Banana has been largely neglected regarding breeding programs for improved varieties (Pillay & Tenkouano, 2011). Due to its clonal propagation banana is less interesting for the private industry since farmers can multiply the crop themselves after once purchasing an improved variety. Besides that breeding techniques for banana are difficult which makes it also less attractive for commercial companies to put effort in the crop. Despite all challenges the formal seed system could still play a role providing farmers of quality and clean planting material by selection of superior mother plants and tissue culture (TC) multiplication (Staver et al., 2010). TC banana plantlets have been introduced in several countries in the great lake regions via various research programs but are still not widely adopted among farmers (Dubois et al., 2006; Mbaka et al., 2008; Indimuli, 2013; Kikulwe, 2016; Wambunga et al., n.d.). TC banana plantlets have several benefits over traditional planting material such as cleanness, a higher yield, earlier and more vigorous sucker production, higher uniformity and are available in large quantities at the right time (Dubois et al., 2006). However these properties are not necessarily all considered as most beneficial by farmers. Uniformity of the planting material for example might not be considered by all farmers as positive. For example when crops are grown for home consumption heterogeneity instead of uniformity in the time of harvest can be preferred for food-security reasons.

Agro-ecological and socio-economic properties among smallholder farmers are often highly variable in space and time resulting in a great diversity of varieties used among farmers. Genetic diversity is essential for smallholder farmers since crops often have multiple purposes and farmers need to be able to cope with changing environments and markets. Formal systems have difficulties meeting these needs since usually a limited number of varieties is brought on the market which suits the most common agro-ecological and socio-economical properties (Almekinders & Louwaars, 2002 ; Almekinders et al., 2007). In case of TC planting material all varieties can be produced as long as the mother material is available. Nevertheless other challenges are still present. The production of a large number of varieties which are demanded only in small quantities can be economically challenging. Besides that the distribution of the plantlets in the right varieties, the right quantities and at the right time can be complicated since smallholder farmers often live in remote and inaccessible areas. Furthermore the demand can vary between years since demand for planting material depends on yields in foregoing productions and the availability of cash in the household (Almekinders & Louwaars, 2002).

Other factors that can further complicate the adoption of TC planting material are higher input requirements, differences in required management practices, poor accessibility and cash needed for the acquisition of the material. Formal and informal seed systems are often poorly connected and linkage of the systems has been proposed to address these challenges as they can complement each other's weaknesses. Formal and informal systems usually have a small link in which landraces are used by the formal sector to create improved varieties and those improved varieties find their way to the farmers. To better connect the formal and informal seed system farmers and their knowledge could be used for the development, production and distribution of new technologies and varieties. This requires a deep understanding of the informal seed system as well as a better understanding of farmers' wishes and needs of planting material.

The aim of this research is to get more insights in the banana seed system and evaluate the methodologies that have been developed for this purpose. Due to bananas unique propagation method the methodologies used to clarify a seed system had to be adapted. In contrast to most other crops bananas are clonally propagated and the "seeds" are bulky and cannot be stored which complicates large scale distribution of planting material. The emphasis of the research has been on the selection, sourcing and availability of planting material. While assessing the selection practices of new planting material close attention has been paid to farmers' perception of quality. Doing so the opinions of both male and female farmers have been taken into account and possible differences were identified. In indigenous cultures women often play an important role in seed selection and possess important knowledge of seeds and varieties. Women are a source of knowledge with regard to different types of utilization of crops such as taste, cooking quality and processing, crafts, and medicine which are often unaddressed in the development of new technologies and varieties. Similarly men might have other specific interest which makes it important to address both the opinions of man and woman (Almekinders & Louwaars 2002 ; Karamura et al., 2004). The exchange of planting material has several benefits for farmers as described before. However, little is understood about the rules which guide the movement of seeds among and within farms. To clarify the movement of planting material, the sourcing behavior of farmers was examined. Because banana does not know a typical harvest season, planting season or period of time in which planting material is collected the availability of the planting material was addressed as well.

The study was conducted in the Mukono district of Uganda where smallholder banana farmers are common. In these regions the use of TC banana plantlets have been promoted by the governments National Agricultural Advisory Services (NAADS) and the International Institute of Tropical Agriculture (IITA) via training to farmers, establishment of TC nurseries, establishment of demo plantations and distribution of the plantlets (Kikulwe, 2016). During the research the role of TC banana plantlets in the banana seed system, the type of farmers which use TC plantlets, the channels via which farmers obtained the plantlets, motivations of farmers behind the use of TC, the type of varieties used and the dynamics of the exchange of suckers originating from the material were addressed. To understand how new diseases affect the informal and the formal seed system the effects of BXW on seed sourcing practices among farmers were also examined.

## CHAPTER 1.1 BANANA MORPHOLOGY AND GROWTH

Bananas have the looks of a tree but are actually herbaceous perennial plants. Bananas belong to the herbs because they do not pose a woody stem. The part of the plant that looks like the trunk is not the actual stem but is called the pseudo stem formed by tightly packed overlapping leaf sheets. The rhizome is the banana's actual stem. This belowground structure produces the shoots and the roots and is in literature referred to as the corm (fig 1.1). The crop is perennial because the belowground parts survive from season to season by developing new, clonal, above ground parts. The term mat is used to designate all plants that are connected to the same belowground part. Primary roots are produced by the rhizome and usually appear from the central cylinder in clusters of three or four roots (fig 1.2). Rhizomes are characterized by horizontal growth and emerging suckers do grow slightly horizontal before they emerge above the soil surface. Because of this horizontal growth, although minimal, the term corm is actually incorrect (Robinson, 1996) but due to the frequent use of this term in literature the belowground part will be referred to as corm hereafter.

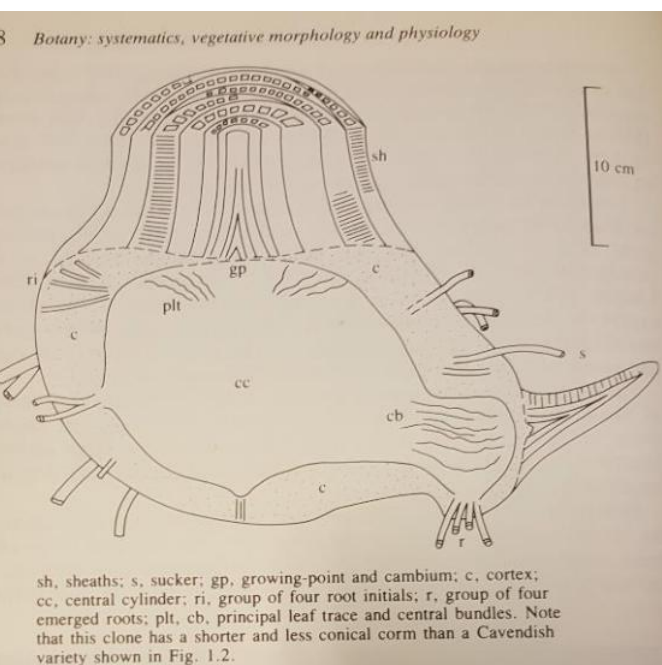


Fig.1.1. Morphology of the corm of a banana plant.

Source: Stover & Simmonds, 1987

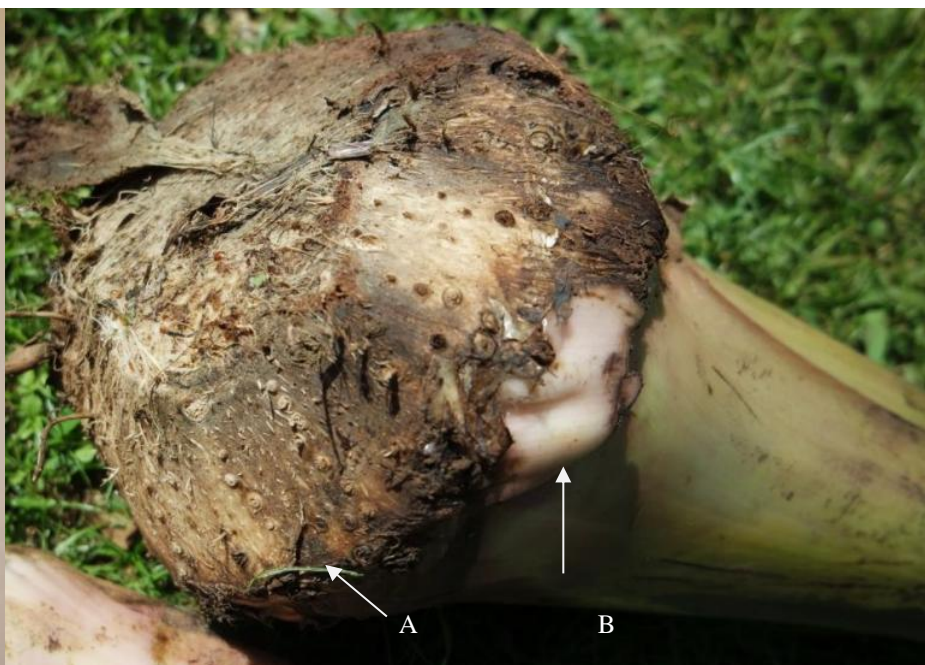


Fig.1.2. Picture of a peeled banana corm .Places where roots emerged from the corm can be seen (A) and one of the buds (B).

The meristem is a flattened dome located in the upper part of the corm which produces new leaves in spiral succession. New leaves emerge from the center of the pseudo stem as a rolled cylinder one at a time. When the youngest leaf is still rolled it is called a cigar leaf. During the production of leaves a vegetative bud is produced 180° opposite of the leaf. Not all of the formed buds develop into suckers (Stover & Simmonds, 1987). When a sucker appears just above the soil surface it is called a peeper. A full grown sucker bearing foliar leaves is called a maiden sucker. The number of suckers produced varies among varieties and is influenced by environmental circumstances. After all leaves of a banana plant are produced the meristem is transformed into an inflorescence. The time it takes for a banana plant to produce an inflorescence is referred to as flowering

time. The inflorescence is supported by the true stem or floral stem which is produced in the meristem and grows through the whole pseudo stem. The stalk supporting the inflorescence is called peduncle and, regarding bananas, refers to the stalk between the leaf crown and the first hand of fruits. The further stalk supporting the female and male flowers which ends with the male bud is called rachis (figure 1.3). First the female flowers appear first aligned in rows which develop into seedless fruits. Each cluster of fruits is called a hand by analogy each individual fruit a finger. All hands together form the bunch (figure 1.4). The time it takes from flowering until a ripened bunch has formed is referred to as maturity time. Maturity time, the number of hands that form on each bunch and the size of the fingers depend on genotype and environmental conditions. While the female flowers are developing into fruits the inflorescence elongates and produces male flowers out of the male bud. Between the female and male flowers a third type of flowers called neutral flowers might be present (Promusa, 2016).

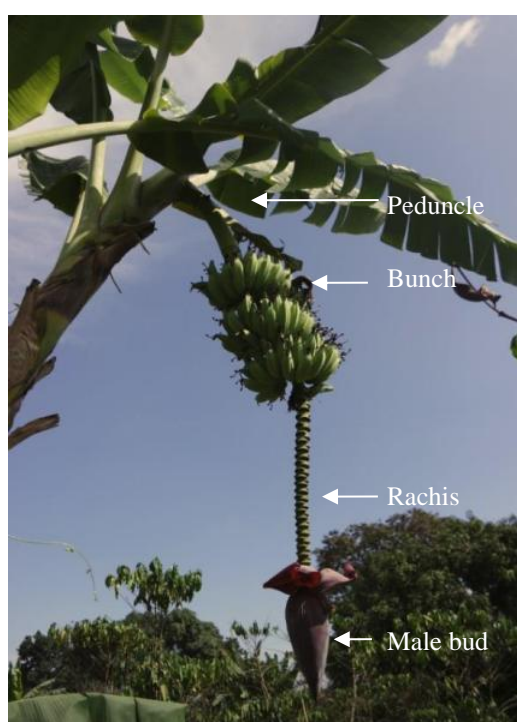


Fig.1.3. Morphology of the inflorescence of banana.

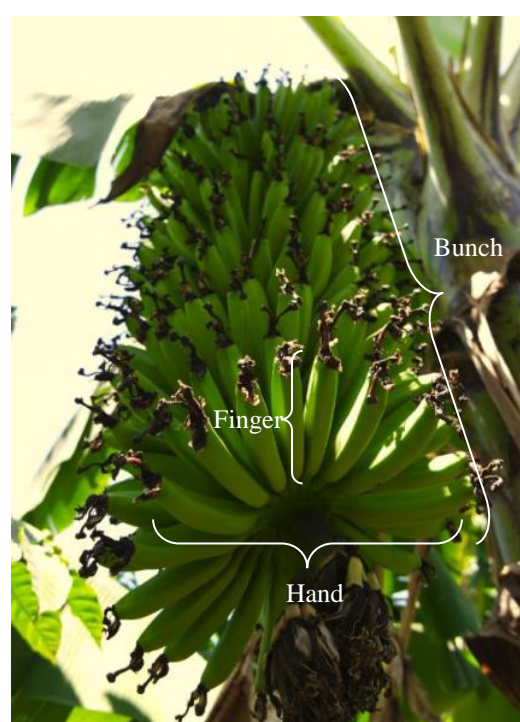


Fig.1.4. Morphology of the bunch of a banana

When the bunch is ready for harvest the pseudo stem is cut down since each stem is only capable of producing one bunch. The sucker selected as successor produces the following bunch. The oldest plant on the mat, producing the upcoming bunch, is called the mother plant. Its successor is called the daughter or the follower. The suckers that emerged even later are called the grandchildren (figure 1.6). Depending on variety and management more than one mother plant, daughters and grandchildren can appear on a mat. Suckers that are in a good condition and which are not needed in the succession on the mat can be uprooted and transplanted to multiply the number of mats. Suckers are connected by the corm to the mother plant. A strong connection between mother and sucker results in a “sword sucker” which is characterized by a strong cone shaped stem and spear shaped leaves. When the mother and sucker have a poor connection a “water sucker” appears which is characterized by a weak stem and broad leaves (promusa, 2016; Robinson 1996).

## CHAPTER 1.2 BANANA MULTIPLICATION METHODS

As described in the previous chapter bananas produce clonal plants, the suckers, which can be separated from the mat and transplanted. This natural regeneration process is the traditional way of banana multiplication and still commonly practiced in many banana producing areas such as Central Africa. Suckers are detached from the mat and can be transplanted completely, but are usually “peeled” or “pared” before transplanting (figure 1.5). Hereby the roots are cut from the corm and the pseudo stem is cut below the leaves. In this way possible pests or diseases attached to the roots, such as nematodes, are removed and infection of the corm by weevils can be identified (Lwandasa et al., 2014). When the sucker has germinated it grows out to an adult banana plant which starts producing suckers itself.



Fig.1.5. The process of peeling or paring suckers. From left to right: A sucker is uprooted with its corm and roots attached, the roots are cut off and the corm is peeled. The sucker is planted and starts germinating.

All plants which are connected to the same corm are referred to as a mat. The sucker which has been uprooted and planted is called the “plant crop” and is the first cycle. The sucker following up after the plant crop has been harvested is called the “ratoon”. The sucker following thereafter is called the first ratoon, the one thereafter second ratoon and so on.

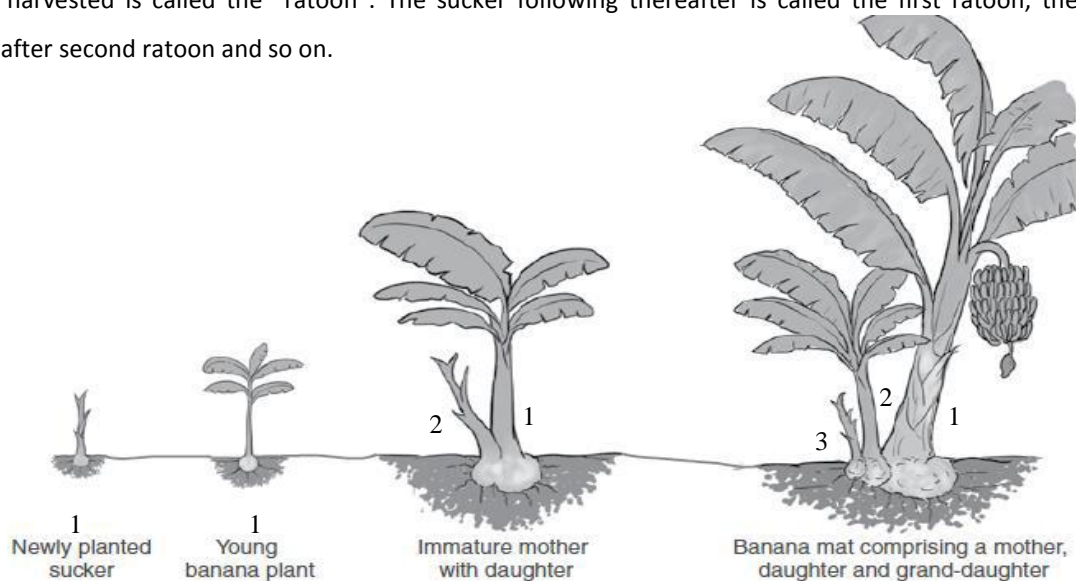


Fig.1.6. Establishment of a banana mat. 1: The sucker which is uprooted and replanted is called the “crop plant”. It will start developing suckers of its own which makes it the mother plant to these suckers. 2: The sucker which follows after the mother plant has been harvested is called the ratoon, follower or daughter. 3: The sucker which follows thereafter is referred to as first ratoon or grandchild. All plants attached to the same corm together form a “mat”. (source image: Wairegi et al., 2016)

The corm of the uprooted sucker can also be chopped into “bits” and out of each bit containing a bud a new banana plantlet can germinate. The corm as a whole can also be used for multiplication using a technique called macro-propagation. The principle of this technique is to activate lateral buds by destruction of apical dominance (Jacobsen, 2010). Using this technique corms which are at least 12-25 cm in diameter are stripped from the leaf sheaths. While carefully removing the leaf sheaths one by one the buds opposite to each leaf are left intact. With a knife a cross is cut in the center of the peeled corm to destroy the meristem which breaks apical dominance and allows the axillary buds to sprout. After peeling the corms are placed in wet sawdust in a humidity chamber. The appearing shoots can be transferred to nursery bags and transplanted into the field after reaching an appropriate height.

Bananas can also be propagated in vitro and the banana plantlets resulting from this technology are called tissue culture (TC bananas). This technique, also referred to as micropropagation, requires suckers as initial material. Clean suckers should be uprooted and tested on pests and diseases and cleaned when needed. The corms of the suckers should be pared down and disinfected; thereafter shoot tips can be extracted. The shoot tips are then individually transferred to a growth and rooting medium. The shoot tips each give rise to 3 -20 new shoot tips which again can be cultured and multiplied. The tiny plantlets emerging in the medium are transplanted into trays and set-out in hardening nurseries for a period of about 6 weeks. Afterwards the plantlets are transplanted again into larger bags to get adapted to field conditions. After another period of about 6 weeks the plantlets can be transplanted to the field (Jacobsen, 2010).

## CHAPTER 1.3 METHODS

### 1.3.1 RESEARCH AREA

Uganda is a land locked country that lies astride the equator. Due to Uganda's location between the drier East African savannas and the moist West African rain forest in combination with a high range of altitudes the country has diverse ecological zones. (NEMA, 2016). The general climate of the country is characterized by moderate temperatures and a high humidity throughout the year. In Uganda two rainy seasons are known of which one starts in March and ends in May which are locally called the April rains and one starting in October and ending in December which are called the November rains. The research was conducted in the Mukono district of Uganda which is situated in central Uganda above the Victoria Lake at the east side of the capital city Kampala. Data was collected between October and December 2016 in several villages of the sub counties Ntenjeru and Nakisunga (figure 1.7).

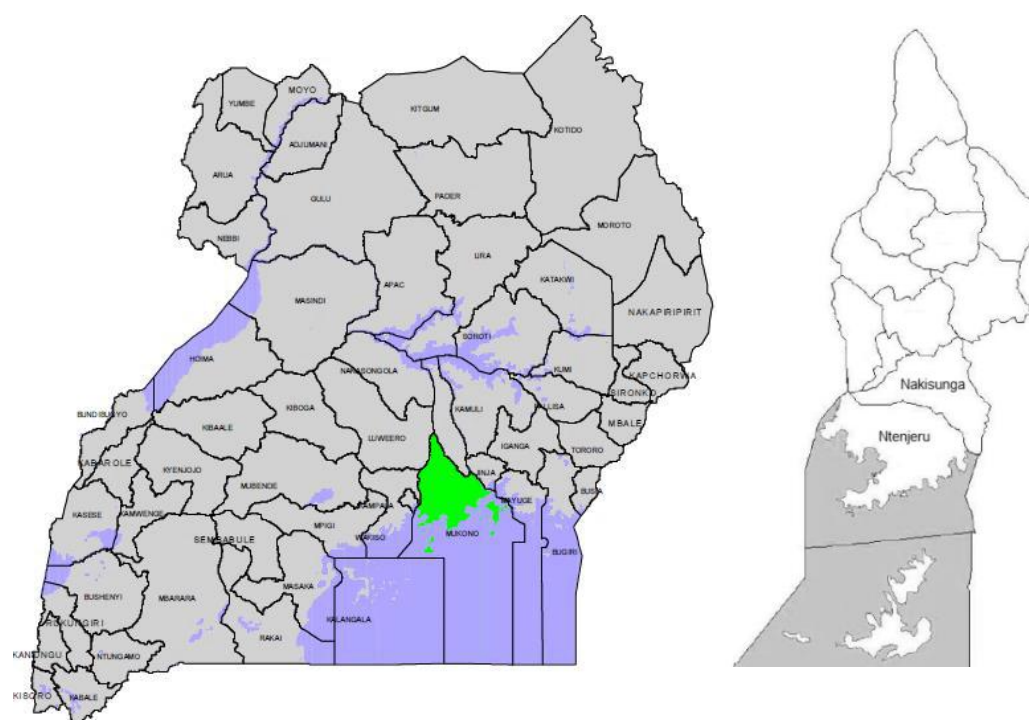


Fig.1.7. Left: A map of Uganda showing Mukono district in green. Right: A map of Mukono district showing the sub-counties Nakisunga and Ntenjeru were data collection took place. Source: Mukono 5 Year District Development Plan 2010-2015

### 1.3.2 FOUR SQUARE ANALYSIS TO UNDERSTAND BANANA DIVERSITY AND USAGE

Farmers in these regions of Uganda are known to use a great diversity of banana varieties on their farm. To get familiar with the varieties that are used in the area, their abundance, original source, desirable traits and undesirable traits, Focus Group Discussions (FGD) were organized. The FGDs were carried out with 4 groups namely; old female farmers, young female farmers, old male farmers and young male farmers. In each group between 6 and 8 farmers were participating. The motivation behind the division in groups and the number of participants per group was to make all farmers comfortable to speak. Results of all four focus group discussions were later combined since the aim was to create an overall image of banana diversity and use in the study area. However, remarkable differences between groups were noted. All participants of the FGD lived in Gonvé village situated in the Ntenjeru sub county. Farmers were mobilized by a well-known lady in the village. The method that was used was adapted from the four-square-analysis developed by Bioversity International (Grum et al., 2008).

### 1.3.3 ON FARM INTERVIEWS

To understand the current dynamics of seed sourcing and seed replacement 23 farms were visited situated in 5 villages located in the sub county Ntenjeru. The choice of the villages was based on information we received of a youth councilor involved in agriculture living in the area. The initial idea was to ask the chairman of each village for a list of banana cultivating farmers in the area and pick a random sample among those. However, in none of the villages any form of registration of farmers was present. The farmers were therefore selected by the research team itself while making sure to differentiate among wealth, gender, age, farm size and other socio-economic characteristics of a household.

Semi-structured interviews were carried out while visiting the farm. Both male and female farmers were interviewed in male as well as female headed households. The interview consisted out of 6 parts. In the first part background information about the farmers and their household was asked. This information was later used to categorize farmers concerning wealth, age, gender, farm scale and age of the banana plantation. Farmers with an age between 0 and 30 were classified as young farmers, farmers with an age between 31 and 50 were classified as middle aged farmers and farmers with an age above 50 were classified as old farmers. Characteristics of the assets of the household including type of house, the number of livestock and area of landholding were used to make a classification in wealth (table 1.1).

Table 1.1 Classification of farmers according to their assets in housing, livestock and landholding.

Asset	Poor	medium	rich
Roof type	Grass – iron	Iron	Iron - roof tiles
Walls	Mud – brick	Brick	Brick - plaster
Floor	Earth – cement	Cement	Cement/elevated cement/tiles
Number of cows	<1	1-5	>5
Number of pigs	<2	2-10	>10
Number of goats	<4	4-15	>15
Number of poultry	<5	5-20	>20
Area of landholding	<1.5 ha	1.5-5 ha	>5 ha

The area of landholding which the household used for cultivation of bananas was used to classify farmers as large scale, medium scale and small scale banana farmers. Households that cultivated less than 1 acre with bananas were classified as small scale farmers, households that cultivated between 1 and 2 acres with bananas were classified as middle scale farms and households that cultivated more than 2 acres with bananas were classified as large scale farms. The number of mats grown on each banana farm was estimated using plant densities described in a banana-coffee intercrop guide and the plant density recommended by NAADS was used when bananas were grown in monoculture. When intercropped with coffee the number of banana trees on 1 acre was estimated at 250 and when planted in monoculture at 450 mats/acre (Wairegi et al., 2016). Special cases in land tenure, which is further elaborated on in chapter 3.1.4, sometimes complicated the classification of farmers regarding wealth and farm size. The distinction between wealth and farm size was made because for example not all rich farmer are necessarily large scale banana farmers. Rich farmers can use their land and other resources for other purposes instead of mainly banana cultivation. Further a classification was made for the age of the banana plantations. Farmers were asked about the age of their banana plantation and in case it was inherited were asked if they newly planted the area ore continued to multiply from the old plot (table 1.2).

Table 1.2. Classification of farmers concerning farm scale, age, gender and wealth. Categories and the number of farmers classified in each category are presented.

	n	Gender		Average age respondent	Average farm size	Estimated number of mats	Average year of establishment
		Man	Female				
General	23			47	1.58	401	1996
Gender							
Male respondents	13			45	2.12	229	1995
Female respondents	10			48	0.88	533	1998
Male headed households	16			44	1.81	455	1996
Female headed households	7			48	0.92	246	1999
Age							
Old farmers	11	6	5	58	1.68	420	1985
Middle aged farmers	7	4	3	44	1.89	488	2003
Young farmers	5	3	2	27	0.90	235	2012
Wealth							
Rich households	7	6	1	50	2.57	650	1996
Medium wealthy households	11	6	5	47	1.07	267	1997
Poor households	5	1	4	43	1.30	345	1996
Farm size							
Large scale banana farms	5	5	0	47	3.50	875	1995
Medium scale banana farms	9	6	3	53	1.64	410	1994
Small scale banana farms	9	2	7	41	0.44	128	2000

In part two of the interview information was asked about the farm such as a short history, ownership, input use, management, and use of varieties. This information was gathered about each plot the farmer used for banana cultivation. Included in this part the farmers were asked to draw a schematic layout of their farm and explain us their motivation behind the planting pattern of bananas. A walk around the farm to visit the banana mats was included in part two. During this walk a sample of four banana mats of four varieties was taken to ask specific questions about the mat. Varieties were chosen based on their abundance in the study area according to the results of the four square method. Out of each square a variety was picket if present on the farm. Of this variety the farmer were asked about the lifespan, the maturity time and which sources they would use if they had to obtain 1,10,100 or 1000 suckers of this variety. Per variety four mats were sampled including

the oldest mat the youngest mat and mats that were planted in-between if present. Of these mats the age, source and type of transaction were asked. Additionally of each mat was asked why they decided to plant it, who in the household decided to plant it, who managed it, and who could keep the revenues of the produce. In some cases four mats of the same variety were not present on the farm. In that case the farmer was asked why he did not have more mats of this variety on his farm.

The questions in part three concerned the replacement dynamics of banana mats. Farmers were first asked about their initial source of planting material for establishing the banana plot, how many suckers they planted last season, where they sourced the planting material, and how many suckers they provided to another farmer. In case a farmer provided a fellow farmer with suckers they were asked about the relationship with that fellow farmer and which type of transaction was used. Afterwards the farmers were asked how they decide which mats have to be replaced and how they decide which type of planting material will be used to replace mat. During part four of the interview farmers were asked what they considered as quality planting material regarding traits among and within varieties, the criteria used while selecting a sucker and the number of suckers available on farm that meet these criteria. Farmers were asked about their source of preference and why they preferred this source. This information generated during part four was further used to establish a method to get a deeper understanding about quality planting material according to farmers (chapter 1.4.5). In part five farmers were asked if they made use of TC banana plantlets and their motivations to use or not use this type of planting material. In part six farmers were asked about the incidence of BXW on their farm, how they recognize the disease, which measures they use to control the disease and how the disease changed their seed sourcing behavior.

### 1.3.4 NETWORK ANALYSIS

To better understand the role of TC banana plantlets in the entire banana seed system, a network analysis was carried out. Key informant interviews were held with TC banana producing laboratories and with TC banana nurseries and NAADS employees and volunteers. The key informant were held to understand which types of farmers were buyers at the nurseries, how beneficiaries of TC banana plantlets are targeted, which types of varieties were given out, in which quantities and at which price.

After each interview, the nursery owners/operators, NAADS employees and the laboratory operators were asked about their clients. The nursery owners were asked for client lists to pick a random sample but those turned out to be absent at all nurseries. However, all of the nursery owners did know or remember some of their clients of which they had contact details. In a similar way the NAADS beneficiaries were selected for a follow up interview. The laboratory was not asked for client lists since the time they were operating was too short and their direct farmer clients were too far located from the study area.

After the collection of contact details of nursery clients and NAADS beneficiaries the farmers were visited for an interview about their TC banana plantlets. Those farmers who directly obtained material from the nurseries, laboratory or NAADS are referred to as 'first generation farmers'. In the first part the same questions as were used in the method of the on farm interviews were used to classify farmers concerning wealth, farm size and

age. Some additional questions about the social activities of the participant and the household were asked such as participation in farmers groups, other social groups and politics. In the second part of the interview the farmers were asked when, how, why and where they obtained TC planting material. This part of the interview was slightly different for nursery/laboratory clients and NAADS beneficiaries. The NAADS beneficiaries were asked some additional questions about the application procedure, previous trainings and special conditions under which they received the TC plantlets. In part three farmers were asked about their opinion about the management and performance of the TC plantlets. Due to time constraints this part was left out for most farmers accept questions about the profitability of TC banana plantlets compared to suckers and their opinion about the future role of TC banana in the banana seed system. In part four farmers were asked if they provided fellow farmers with suckers originating from TC material in order to trace how TC material spreads along farms. In case the farmers shared the material, they were asked with how many farmers they shared, what type of material they shared with the farmers, which type of transaction was involved, the type of relationship and whether the farmers lived in the same community or not. Contact details about the receiving farmer, referred to as 'second generation farmers', were asked in order to use "snowball sampling". If it was possible to get in touch with the second generation farmer the farm was visited and the similar questions were asked. In case a second generation farmer shared planting material with another farmer the receiving farmer is referred to as a 'third generation farmer'.

In some cases a first generation farmer obtained planting material from multiple sources. For that reason still two farmers that obtained TC plantlets directly from the laboratory were interviewed. For the same reason a second or third generation farmer could also be a first generation farmer. In total 26 interviews were made with first generation farmers of which 12 were NAADS beneficiaries, 12 were nursery clients and two laboratory client. The actual number of first generation farmers was only 17 because most farmers were among the NAADS beneficiaries but also became nursery or laboratory clients.

### 1.3.5 QUALITY PLANTING MATERIAL

During part four of the on farm interviews (chapter 1.3.4) farmers were asked about the criteria they take in account while selecting a sucker. These results were used to give us the first insights in the sucker selection practices and criteria among farmers. To get more in depth insights about this process of sucker selection a choice experiment was conducted. The method that was used was adapted from a study regarding potato seed quality (Urrea-Hernandez et al., 2015). In this study the means-end-theory developed by Reynolds and Gutman was used to identify farmers' preferences of potato planting material (Reynolds & Gutman, 1988). In our choice experiment farmers were presented with eight triplets of suckers. Among each triplet of suckers the farmers had to choose the one they preferred to plant. In two batches the suckers were from the same variety originating from the same source. In another two batches the suckers were from the same variety but originated from a different source. In another two batches the suckers were from a different variety but originated from the same source and in two batches the suckers were from a different variety and originated from different sources. In total six varieties were used based on the results of the four square analysis since two of the varieties originated from square one, two varieties from square two and two varieties from square

four. No varieties originating from square tree were used (chapter 2.1). Of the two suckers classified in the same square each time one of the varieties was a traditional variety and the other one was an introduced or improved variety (table 1.3).

Table 1.3. The varieties used in the choice experiments. Of each variety is given in which square they were classified during the FGD's using the four square analysis, the origin and the characteristics. The origin and characteristics are also based on the results of the four square method.

Square	Variety	Origin	Characteristics of the variety
1	Nakitembe	Indigenous	Nakitembe is the most common variety in the study area and was grown by all farmers that participated. It is an important food variety. The variety withstands most climate conditions, gives tasty food and is used in rituals. The bunch size given is average.
1	Mpologoma	Improved/introduced	Mpologoma is becoming a very popular variety because of its big bunches and high marked value/demand. For own consumption Mpologoma is not favoured by most farmers because of its taste. Besides that the variety is very sensitive for climate conditions and has a relative short lifespan.
2	Muvubo	Indigenous	Muvubo is a relatively popular food variety. It gives big fingers and has a good bunch size.
2	FHIA food	Improved/introduced	FHIA is known to give very big bunches but the taste is not appreciated by most farmers. It can be invasive to other varieties. Most farmers have a few mats for food security. It is less affected by BXW. The variety is part of a line of hybrids which are all called FHIA.
4	Nakabululu	Indigenous	Nakabululu is an indigenous variety which gives tasty bunches and withstands weather conditions. Because of the small bunch not a lot of farmers grow the variety.
4	Tombadala	Improved/introduced	Tombadala grows well without inputs and is very invasive. Despite the fact that it always gives bunches farmers do not like it because it has a bad taste and no marked value. Most likely it was taken from Congo by NARO. Most farmers have a mat for food security and because they cannot easily get rid of it once planted.

The suckers were sourced from 3 different farms. The initial idea was to source the suckers from a well-known commercial farmer, a market oriented farmer and a small-scale/home consumption farmer. These classifications among farmers are also made by the National Agricultural Advisory Services (NAADS). The idea behind these sources was to find out to which extend farmers value the source of the sucker and if they would prefer to source from a commercial farmer who has likely more inputs to use for the cultivation of his bananas compared to a home consumption farmer. While collecting the suckers it turned out to be impossible to source the suckers from a small-scale/home consumption farmer because they did not have the required suckers available. In total five small-scale farmers were asked if they could sell us some suckers and all replied that they were not available and if available they would face serious problems in the coming planting seasons if they would uproot them. Eventually we ended up with the following sources:

- a. A commercial farmer who is known in the area for the sales of suckers and TC plantlets. The farmer is the owner Mpekke Nursery Bed (chapter 1.4.4).
- b. A market oriented farmer who is known in the area and lived within the community.
- c. A market oriented farmer who is known in the area and lived outside the community.

In the study conducted by Urrea-Hernandez et al (2016) among the sources used were a research institute and a local market. Due to logistic constraints and the absence of a sucker market these types of sources could not be used in this research.

After deciding on the source and the varieties the suckers were collected on the farms. We told the farmers we came to buy suckers with no further instructions. In this way we made sure the farmers would just uproot the kind of suckers they would normally uproot when a fellow farmer comes to buy suckers. We paid the prices the farmers usually sell their suckers for. This gave us some extra insights in the prices of suckers from different varieties and different sources. After collection of the planting material the suckers were coded according to the triplets that were made (table 1.4).

Table 1.4. The varieties and sources of the suckers used in each batch of planting material. In total 8 batches of planting material were used consisting out of 3 suckers.

Set	Sucker 1		Sucker 2		Sucker 3	
	Source	Variety	Source	Variety	Source	Variety
1	a	Muvubo	a	Muvubo	a	Muvubo
2	c	Nakitembe	c	Nakitembe	c	Nakitembe
3	a	Nakabululu	c	Tombadala	a	Nakitembe
4	a	Tombadala	c	Nakitembe	a	Muvubo
5	c	Mpologoma	c	Mpologoma	b	Mpologoma
6	c	FHIA cooking	c	FHIA cooking	b	FHIA cooking
7	c	Mpologoma	c	FHIA cooking	b	Nakitembe
8	c	Nakabululu	c	Nakitembe	b	Muvubo

To every participating farmer each triplet of planting material was presented individually. First the farmers were asked to distinguish between the suckers. One of the suckers they had to place aside when they thought this sucker was most different from the other two suckers. During the first step farmers made distinctions between the particular characteristics of the suckers. Next the farmers were asked which sucker, based on which criteria, they would prefer to plant. This first part of selection was based on plant specific characteristics or traits such as size, color or number of buds, which will further be referred to as quality cues. There were no limitations to the number of quality cues a farmer could name while motivating his choice. Those quality cues named by the farmers were listed and afterwards the farmers were asked what these cues indicated for him or her such as higher yield or better taste which will be further referred to as quality attributes. Those quality attributes were again listed of each quality attribute was probed what this meant for the farmer personally. Examples of personal values are achievement and security. This technique of probing to come from a specific quality cue to a personal value is called “laddering” (Reynolds & Gutman, 1988).

After the farmer selected a sucker and the laddering was completed the farmer was given an extra option. Before each farmer started with the experiment he was given 4000 UGX of fake money. Farmers were informed on forehand they had to choose a sucker out of triplets of planting material eight times. If a farmer wanted to know, of which varieties all suckers of a triplet belonged, he could pay 500 UGX. The farmer could also choose to get to know the source of all sucker in a triplets and again had to pay 500 UGX. In case the farmer wanted to know both the variety and the source they had to pay 700 UGX. Because the farmers did not have enough money to get to know the variety and the source of the suckers of all eight triplets we could understand what

was most important for them to know, the source or the variety. In case the farmer wanted to know both he would end up with a shortage of money. After revelation of the variety and or source the farmer could change his choice of sucker. In case the farmer picked another sucker farmers were asked why.

The farmers were mobilized by a well-known lady in from the village since no list of farmers to pick a random sample was available. This lady knew which persons in the area were cultivating bananas and we asked her to differentiate among gender, wealth and farm size.

### 1.3.6 DATA ANALYSIS

One of the goals of this research was to test methodologies which can be used to get a better insight in the banana seed system. Several questionnaires have been used to see what kinds of responses are given by the farmers and to understand these responses. For this reason answers were scored and where possible averages per social group were calculated. In this way ranges and patterns among the answers could be identified. Since the sample sizes for each questionnaire were rather small no statistical analyses have been carried out. The output was discussed based on scores and averages and with these new insights follow up studies can be carried out with refined questions and larger sample sizes. Besides that the sample size of some questions of the farm interviews were smaller since a few questions were added after pilot interviews with five farmers.

## CHAPTER 2. BANANA DIVERSITY AND USE

### CHAPTER 2.1 DIVERSITY OF BANANAS USED IN THE AREA

In the four Focus Group Discussions (FGD's) a total 30 different banana varieties were named by the farmers (table 2.1). Most of the varieties belonged to the East African Highland Bananas (EAHB), also known as *Musa* AAA-EA or Lujugira-Mutika. EAHB consist of five major clone sets of beer and cooking bananas namely; Mbidde (beer clone set), Musakala, Nakitembe, Nfuuka and Nakabululu (cooking clone sets) (Karamura, 1998). EAHB are characterized by green glossy stems with a purple to pinkish base which is mottled with black or brown (figure 2.1). Other types of bananas which were cultivated by the farmers belonged to other *Musa* AAA groups, the *Musa* ABB group, the plantains (AAB), the apple bananas (AAB) and to hybrid lines (FHIA). A classification of the bananas was made according to the banana cultivar guide developed by Bioversity International (Karamura et al., 2012) and is included in appendix 1. Each of the varieties were placed in one of the 4 squares by each group in accordance to their abundance in the study area. Not all groups classified the varieties in the same square. In these cases the variety was placed in the square that was referred to most frequently. Only 2 varieties were placed in square 3 by the group of young women farmers: Mpologoma and Kisansa. However, because the other three groups placed these varieties in square 1, no variety was placed in the category "few farmers – large area". Mpologoma and Kisansa are relatively new in the area and give a high yield compared to indigenous varieties and are increasingly popular. Cooking and Dessert varieties were placed in square 1, 2 and 4. Beer bananas were only placed in the square of few farmers, small area. Cultivation of beer bananas was describes as abundant in the area but has decreased in recent years. According to the farmers beer bananas are highly susceptible for BXW and entire plots have been whipped out by the disease. Farmers are now more careful planting the varieties in large quantities. Dessert varieties were also described as highly susceptible for BXW but are still grown in larger numbers compared to beer bananas. Most varieties are grown by few farmers in relatively small areas; those varieties are mainly indigenous varieties. In the category of "grown by many farmers, large area" half of the varieties are newly introduced in the area.



Fig.2.1. East African Highland Bananas (EAHB) are characterized by a glossy stem of which the color can vary from green to pinkish, purplish or reddish. The stem is mottled with brown or black. Color of the stem, the color of the mottle and the pattern of the mottle of adult banana plants are characteristics used by the farmers to determine variety. The pictures show different stem colors and patterns encountered during the field work

Table 2.1. Banana varieties grown by farmers in the study area and their abundance, type and year of introduction in the area (using the four square analysis, Grum et al, 2008 ). \* Varieties with an \* are recognised by farmers as improved varieties.

Square 1. Many farmers – Large area			Square 2. Many farmers – Small area		
Local variety name	Type of banana	Year of introduction	Local variety name	Type of banana	Year of introduction
Bogoya	Dessert	Indigenous	FHIA*	All	1998
Tombadala	Dessert	2006	Kibuzi black	Cooking	Indigenous
Kibuzi	Cooking	Indigenous	Kivuvu	Cooking	Indigenous
Kisansa	Cooking	1970	Musakala	Cooking	Indigenous
Mpologoma	Cooking	2000	Muvubo	Cooking	Indigenous
Nakitembe	Cooking	Indigenous	Ndiizi	Dessert	Indigenous

Square 3. Few farmers – Large area			Square 4. Few farmers – Small area		
Local variety name	Type of banana	Year of introduction	Local variety name	Type of banana	Year of introduction
			AGT	Cooking	2004
			Bogoya red	Dessert	Indigenous
			Gonja	Roasting	Indigenous
			Kayinja	Beer	1970
			Kisubi	Beer	Indigenous
			Luwaata	Cooking	Indigenous
			Lwandungu	Cooking	2011
			Mbidde	Beer	Indigenous
			Mwazirume	Cooking	Indigenous
			Nakabululu	Cooking	Indigenous
			Nakawere	Cooking	Indigenous
			Nakytengu	Cooking	Indigenous
			Nambi	Cooking	Indigenous
			Namwezi	Cooking	Indigenous
			Nandigobe	Cooking	Indigenous
			Nsalwagiri	Cooking	Indigenous
			Nfuuka	Cooking	Indigenous
			Ndiizi Mfungu*	Dessert	1998

## CHAPTER 2.2 USE AND CULTURAL VALUE OF THE BANANA VARIETIES

Bananas are used for multiple purposes. Farmers differentiate between three types of bananas. The first and most important type is the cooking or food bananas which are used as staple crop. The bananas are peeled when the fingers are not yet completely ripe and then steamed or cooked. After cooking the bananas are mashed to make “matooke”. Farmers indicate that “how well the fruit can be mashed” as an important trait of a variety. The second group are the beer bananas which are used to make juice and brew beer. The third type are the dessert varieties which are used as fruit or to make pancakes. Gonja can be classified as a dessert banana but is often referred to as a roasting type banana and includes various sub-varieties. It occurs among more varieties that what is called a variety refers to a group of sub-varieties which are slightly different. Nakitembe for example is the name of a whole clone set, the name of a variety, and knows several sub varieties such as Nakitembe-Nakawere, Nakitembe-Omumyufu and Nakitembe-Omusoga (Karamura et al., 2012).

Bananas have more purposes than food alone. The pseudo stem of the banana can be used as animal fodder or as mulch. Fibers coming from the pseudo stem are used to make fire for cooking and serve as string. The leaves of the bananas are used to steam food, for mulching, for packing or to craft baskets and mats. Especially the use as wrapping for the steaming of food was important to the farmers (figure 2.2). Not all varieties give

good leaves for steaming bananas: farmers indicate Bogoya and Ndiizi as good varieties for this purpose as they color the matooke yellow and gives it a nice aroma. Leaves of Mpologoma for example are said to give the bananas a blackish color. Some varieties such Gonja and Mbidde also have medicinal use. Gonja is used to hasten healing of navels of new-born babies and Mbidde to prevent vomiting among the children.



Fig.2.2. Bananas are prepared to be steamed: the fingers are peeled and tightly packet within banana leaves. Fibers of the pseudo stem are used to make the fire for steaming.

Bananas play an important cultural role as they are associated with a lot of traditions and rituals. Nakitembe is among the most popular indigenous varieties and is used in rituals when a girl is born (the placenta is buried by a mat of Nakitembe) and when a wife loses her husband. Mbidde on the other hand is used for rituals for a boys. The cultivation of banana itself also knows traditions. One female farmer told us she had a close relationship with her banana farm and carried out several practices to keep it that way:

*“Because the banana plantation knows me, I am the only one uprooting suckers from my plantation because I do not want to make it angree. Whenever I want to uproot suckers I first inform my plantation I am going to take some of her children away. I do so by cutting off the tops of a few suckers the night before I want to uproot. It is a kind of ‘death announcement’ I make to the plantation for taking the children away. Because the plantation gives me a lot I have also have to return something to my plantation. If I harvest a bunch I take out the dried leaves of the bud. I place these into the part of the pseudo stem that is left behind. Now the plantation knows I care about her”.*

Several of such practices have been mentioned by the farmers throughout the fieldwork. For example the plantation has to be informed when its owner dies; if a bunch is taken from the farm one of the fingers has to be broken and trown back; when the bunch is taken by a bicycle or motorcycle, the driver has to drive over the finger and the remaining sheets of the flowers have to be removed from the bunch otherwise they will bring the farmer bad luck.

# CHAPTER 3. BANANA CULTIVATION & SEED SOURCING

## CHAPTER 3.1 GENERAL ASPECTS OF BANANA CULTIVATION

### 3.1.1 PRODUCTIVITY

The farmers in the study area typically intercropped bananas with coffee, cocoa and beans. Only in rare cases bananas were mono cropped and if so, the farmer was usually a large scale or commercial farmer. Large trees providing shade for the banana trees can be found on many of the farms. The areas on the farms cultivated with bananas varied from 0.25 to 6 acres per farm. The average size of the banana cultivated area was 1.58 acres which corresponds with an estimated number of 401 banana mats (chapter 1.4.3). The age of the banana plantations varied between 2 and 54 years, with an average age of 20 years. Production of bananas bunches remains fairly stable over the year with peaks in harvest in the months (Wairegi et al., 2016). On average farmers harvested 25 bunches in the month September 2016 of which 10 were used for home consumption and 15 to sell on local markets (table 3.1). Bananas were usually not sold by the farmers themselves but sold to local traders who bring the bunches to local markets. When using the estimated number of mats this would mean that averagely on 5% of the banana mats bunch could be harvested in the month September. September is not one of the months included in the rainy season and usually has a lower production compared to months in the rainy season. The largest difference in productivity was seen between very young farms and very old farms. On young farms from 10% of the mats a bunch could be harvested and on old farms on 3% of the banana mats.

Table 3.1. Productivity in terms of harvested bunches in the month of September 2016. The number of bunches used for home consumption and used to sell given for farmers classified according to various socio-economic properties (n=23). (Source: On farm interviews)

	Average size banana plantation	Average number of mats	Number of bunches consumed	Number of bunches sold	Share of bunches sold	Number of bunches harvested/acre	% of mats giving a bunch
General	1.6	401	10	15	54%	27	5%
Old farmers	1.7	420	9	8	43%	13	4%
Middle aged farmers	1.9	488	11	24	66%	32	6%
Young farmers	0.9	235	8	16	63%	50	10%
Rich households	2.6	650	14	16	53%	27	5%
Medium wealth households	1.1	267	9	18	57%	31	7%
Poor households	1.3	345	5	7	51%	16	3%
Large scale banana farmers	3.5	875	10	25	71%	12	3%
Medium scale banana farmers	1.6	410	13	13	47%	17	5%
Small scale banana farmers	0.5	128	6	11	53%	45	8%
Very old plantations	1.9	463	9	9	42%	10	3%
Old plantations	1.2	300	6	9	53%	23	5%
Medium aged plantations	3.0	750	11	22	60%	13	4%
Young plantations	1.5	375	12	15	53%	25	7%
Very young plantations	0.6	180	11	21	65%	59	10%

Younger banana farms had a higher productivity and a higher share of bunches sold on the market. The age of a farm can influence the productivity because the soil becomes depleted after many years of cultivation, especially without proper fertilization (Bekunda, 1999). The number of bunches produced/acre on very old farms (established before 1987) was 10 compared to 59 on very young (established after 2011) farms. In particular when the young farm was newly established on an area previously covered in bush instead of an area previously used for cultivation by another farmer the productivity was high. Most of the banana farms classified as young or very young were owned by young or middle aged farmers. Positive correlation between the age of the farmer and the age of the banana plantations was found ( $P=0.003$ ). There was one main exception regarding this correlation; one older farmer established his banana plantation in 2007 after participating in a NAADS program whereby he obtained TC banana plantlets. The correlation between age of the farmer and age of the plantation could explain why the productivity among young farmers was higher compared to old farmers. Besides that, the old farmers said several times during the field work that they skipped certain management practices due to a lack of energy. Thus besides younger farmers owning a younger farm, it is plausible that young farmers are more energetic which might help them to manage the bananas more intensively compared to old farmers. Correlation between banana production and the age of the farmer, age of the banana plantation, family size and labor force used has been reported in literature (Mamuye, 2016).

Young starting farmers usually do not yet own a large plantation, which might explain why small scale farmers have a higher productivity per acre as large scale farmers. The average plantation size of young farmers was 0.9 acres compared to 1.7 acres of old farmers. The largest farmer who was cultivating 6 acres with bananas was among the lowest producers with 6 bunches per acre. The reason behind this low production might be theft as he explained: *"I do not plant new bananas mats far from the homestead anymore. There were so many thieves stealing my banana bunches on those remote fields that I stopped placing new banana mats there"*. The highest producing farmer with 120 bunches an acre was a young male farmer who obtained a new plot of a quarter acre on a steep hill at a riparian zone (the zone around a river or stream which has unique properties and is usually very fertile). The farmer with the second highest productivity of 60 bunches an acre was a young female who was illegally cropping in a previous forest area which was also characterized by a highly fertile soil according to the farmer.

Rich and medium wealthy households had a higher productivity compared to poor households. In contrast the share of bananas used for market purposes compared to the share used for home consumption was not higher among wealthier households. The explanation might be that the family size of rich households was slightly larger with averagely 8 members compared to poor households with averagely 6 members. Another explanation could be the social responsibility of wealthier households in the community. The farmers told it is tradition to give away banana bunches at social matters such as a wedding or a birth celebration (figure 3.1). One farmer explained his father gives away a lot of banana bunches as this is expected of him being among the richest farmers in the area.



Fig.3.1. Preparations are being made for a wedding the next day. Each member of the community is supposed to contribute to the food.

### 3.1.2 DIVERSITY

Farmers grow between 4 and 16 varieties on their farms with an average of 10 varieties per farm. Among each social group the average number of banana varieties grown was between 9 and 11 varieties (table 3.2). This indicates that the diversity holders in the area do not belong to a particular socio-economic group.

Table 3.2 Number of banana varieties cultivated by farmers classified according to various socio-economic properties (n=23). (Method: Free listing ; Source: On farm interviews)

	Wealth class of household			Size of banana farm			Sex of farmer		Age of farmer		
	Rich	Medium	Poor	Large	Medium	Small	Male	Female	Old	Middle	Young
Average number of cultivated banana varieties	9	10	10	11	9	9	9	10	9	11	9

The cooking variety Nakitembe was grown by all farmers that were interviewed. Varieties grown by more than five farmers were classified as common varieties, varieties grown by a number of farmers between two and five were classified as less common varieties and varieties grown by only one farmer were classified as rare varieties (table 3.3). Classification was not based on the same categories as the four-square analysis since that is a qualitative approach instead of quantitative. Because not all varieties encountered during the field work were described in the four-square analysis a new classification had to be made. With the exception of a few varieties the results were comparable with the results of the four-square method (chapter 2.1). Among the common varieties are cooking, beer and dessert bananas as well as Gonja which is mainly used for roasting. Mats of beer, dessert and roasting varieties are usually present in lower numbers on the farm than cooking varieties. The percentage of beer bananas cultivated out of the total number was averagely around 2% and the percentage of dessert banana around 10%. The remaining 88% of the bananas mats cultivated are cooking type bananas.

Table 3.3 Varieties grown in the study area and the number of farmers growing them (n=23) Varieties grown by more than 5 farmers are classified as common varieties, varieties grown by a number of farmers between 2 and 5 are classified as less common varieties and varieties grown by only 1 farmer are classified as rare varieties. (Method: Free listing; Source: On farm interviews)

Common varieties			Less common varieties			Rare varieties		
Variety	Grown by <i>n</i> farmers	Type*	Variety	Grown by <i>n</i> farmers	Type	Variety	Grown by <i>n</i> farmers	Type
Nakitembe	23	C	Kisubi	5	B	Kabula	1	C
Kibuzi	16	C	Namwezi	5	C	Katwalo	1	C
Bogoya	15	D	Bogoya red	3	D	Mbiolde kabula	1	C
Ndiizi	15	D	Luwaata	3	C	Nabusa	1	C
FHIA	14	D/C/B	Mbwazirume	3	C	Nakyatengu	1	C
Mpologoma	14	C	Nakabululu	3	C	Siira white	1	C
Muvubo	14	C	Lusumba	2	C	Sita kange	1	C
Kainja	11	B	Nakawere	2	C	Tayasama	1	C
Musakala	11	C	Nambi	2	C	Njwebuzito	1	C
Kisansa	10	C	Nandigobe	2	C	Ntika	1	C
Tombadala	8	D	Nfuuka	2	C	Muvakonde	1	C
Gonja	7	R	Nabomba	2	C	Mabumba	1	C
Kivivu	7	C						
Ndyabalangira	7	C						

\* Type of banana variety. C = Cooking banana variety, D = Dessert banana variety, B = Beer or juice banana variety, R = Roasting banana variety.

The cultivation of banana among the participants was characterized by low inputs. Banana was mostly grown on the home plot because it is the most important food crop for the household which is easy to have close to the homestead. Inputs that are commonly used are different types of organic fertilizers, pesticides and herbicides. Artificial fertilizers and other chemicals were rarely used. Most of the organic fertilizers used originate from animals on the own farm. Four out of the 23 farmers mentioned to sometimes use off-farm sources to obtain fertilizers but those fertilizers were still organic fertilizers. The amount of inputs used for bananas in the close and remote fields was much less than on the home plot (table 3.4) which is typical for African smallholder farming (Tittonell et al., 2005).

The main reasons among farmers to not use inputs on remote fields were difficulties in the transport of and the risk of harvestable products getting stolen which would result in a loss of the harvest and of the inputs used. Some farmers even mentioned a difference in resource distribution on the home plot due to “lazy children that not spread the manure equally but most of it close to home” and “kitchen residues that are easier dropped close by”.

Table 3.4. Inputs used by farmers for the cultivation of banana on the home plot, close fields and remote fields. The number of farmers is given per type of field since not all farmers possessed multiple plots. (Method: Free listing; Source: On farm interviews).

Type of input	Inputs used by farmers on the home plot (n=23)	Inputs used by farmers of close fields (n=10)	Inputs used by farmers on remote fields (n=6)
Cow dung	18	5	1
Pig manure	2	1	-
Poultry manure	8	1	-
Goat droppings	7	1	1
Coffee husks	5	1	-
Herbicides	4	-	-
Insecticides	8	2	-
Foliar fertilizer	1	-	-
Artificial fertilizer	-	-	-

### 3.1.3 GENDER

Both male and female farmers were involved in the cultivation of bananas (management, decision making, sales and earnings). In total, 13 male and 10 female farmers were interviewed. Seven of the interviewed female farmers were head of the household. The remaining 16 households were male headed. In all the female headed households the female was involved in the management, the decisions making regarding banana cultivation and the sale and revenues of banana produce (table 3.5). All of the interviewed male farmers in the male headed households were married. Among these females living in male headed households nine were involved in the management of the banana mats and the decision making. In three cases solely the wife was involved and in six cases both man and wife were involved. In nine households the wives were also involved in the sales in the revenues of the banana produce. In four households solely the wife was involved in the sales and revenues and in five households both man and wife were involved. In three households were both man and wife were involved in management and sales all decisions regarding banana cultivation were made in consultation. In the remaining three households the man and wife had separate plots were they each made their own decisions and kept their own revenues (box 1). There were no big differences in the type of bananas found on plots managed by only males or females except the cultivation of beer banana varieties which is usually done on the plots managed by the male farmers (The number of these type of plots managed only by male farmers and cultivated with beer bananas seemed to be reduced the last couple of years due to BXW). In case solely the wife was in charge over management, decision making, sales and revenues in a male headed household there was in all cases another income source that generated more income for the household in which the man was involved, such as coffee growing or a small business.

Table 3.5. Allocation of roles regarding banana cultivation among male and female farmers in male and female headed households. (Source: On farm interviews).

	Involved management	in	Makes decisions about planting material	Involved in sales of banana products	Gains revenues of banana products
Female headed households (n=7)					
Female only	7		7	7	7
Male headed households (n=16)					
Male only	7		7	7	7
Female only	3		3	4	4
Both male and female	6		6	5	5

## Box 1: Competition between man and wife both managing a banana plot



Most of the time wife and husband cooperate in a household to cultivate their bananas but not in all cases they come to consensus about the right way to manage a plantation. In one case the husband and wife split up their plantation after getting tired of their arguments. They made their own little competition in banana cultivation. The wife manages her plantation traditionally using indigenous varieties and applying manure in gutters to let it stream downwards the hill (left picture). The man manages his part in a more modern way using TC plantlets and introduced/improved varieties. To fertilize his bananas he applies chicken droppings mixed with coffee husks at the base of the mats (right picture). Since the couple newly established their banana plots there is no indication on the outcome yet.

### 3.1.4 LAND TENURE

Not in all households the land used for banana cultivation was actually owned by the household. Some special issues regarding land tenure were encountered during the research. For example when the household head is polygamous, when the household head is not the actual owner of the land or when the household head has passed away and the land is entitled to his family. These special cases in land tenure sometimes complicated the classification of households among wealth classes and farm size. Someone can be classified as a farmer belonging to a rich household without having actual access to their assets on paper and others can be classified as poor while they have access to more assets as they have on paper.

## CHAPTER 3.2 PLANTING PATTERN AND REPLACEMENT OF BANANA MATS

### 3.2.1 PLANTING PATTERN OF BANANA VARIETIES ON THE FARM

The placement of different banana varieties on the farm follows a particular pattern in the study area. A mixed variety pattern can typically be found for cooking banana varieties. Most of the farmers said the mixture of varieties is tradition and they learned to plant this way from their parents. One of the farmers explained that the mix of varieties also happens when new planting material is acquired:

*“When I source for new planting material I usually go to several farms such as my mothers’ and my grandmothers’. After the suckers are uprooted and transported to my place I cannot identify any longer which sucker belongs to which variety; this results in a mixed pattern of varieties. Suckers of different varieties of cooking banana cannot be identified. I do know which suckers belong to dessert and roasting varieties because they have a pale pseudo stem”.*

The dessert varieties Bogoya and Ndiizi are usually placed in remote fields or on the boundaries of the plantation. Farmers have several motivations for this: The varieties are often placed on remote fields or away from other varieties because farmers experience them as invasive varieties. They do not like to be grown together with other varieties and destroy mats of other varieties that are near. One reason given for this by the farmers is the tall growth of the varieties, when their canopies close they easily over-shade shorter banana varieties. Another motivation to place the varieties on plots located further away is their susceptibility to diseases such as BXW and are therefore kept away from other mats. Bogoya and Ndiizi are also varieties which need less management and inputs compared to other bananas and are therefore easier to place on remote fields. Besides that it is part of the tradition to place Bogoya and Ndiizi on the boundaries of the plantation as well as the roasting variety Gonja. When the varieties are placed at the border of the farm they help the household to protect their farm from thieves and “nighty dancers” (box 2). In some villages it is the tradition to place a Mbidde variety (beer banana) in the middle of the plantation as being “the man” of the plantation.



#### Box 2: The spell of Gonja

Several farmers told about varieties such as Gonja that are placed at the borders of the plantation and serve as guard for thieves. One morning during breakfast we saw a video that was placed online by a local news station. The movie shows a man in a banana plantation making funny noises. The man was trying to steal a bunch of banana but got bewitched. With the banana bunch in his hand he was unable to move and leave the plantation because he saw snakes surrounding him (picture). Besides thieves Gonja also protects to “nighty dancers”. Those are people in the village who during the night start to dance naked on the plantation.

### 3.2.2 REPLACEMENT OF BANANA MATS

Most farmers replaced a banana mat when a mat goes down in productivity or when a gap is created by a mat that died. Farmers gave several reasons why a mat could go down in productivity such as exhaustion, infection and position on the farm. An exhausted mat was defined by the farmers as a mat going down in production due to its age which they noticed by smaller bunches. One farmer explained that the bunch given by the first plant on a mat is usually quite small, the second bunch is the biggest and from there on the bunch size slowly declines again. There were 14 farmers who said to uproot exhausted mats to replace it. After how many years a mat is exhausted depends on variety, management and environmental circumstances. Several farmers responded that: *“Under the right conditions and when properly managed a banana mat can exist forever”*. Farmers were urged to give an estimation about the average lifespan of different varieties. The responses among farmers differed greatly but there emerged a pattern of long living and shorter living varieties. The average lifespan estimated by farmers differed between 5 years for the varieties Nandigobe and Mpologoma and 83 years for the variety Bogoya (table 3.6). Also within varieties the answers were variable. For example one farmer estimated the average lifespan of Kibuzi at 10 years and another farmer said a mat of Kibuzi could grow older than a 100 years. One of the farmers explained that soil selectiveness has a great influence on the lifespan of bananas:

*“Bananas are very soil selective, that is why in each area different varieties are preferred. Also on my own farm I take soil type in account. By trial and error I get to understand my soil and know which varieties perform well in which parts of my farm.”*

Table 3.6. Highest, lowest and average estimated lifespan per variety (n=64). Number of observations is given per variety since number of observations was not equal for all varieties. (Source: *On farm interviews*).

variety	n	Abundancy <sup>1</sup>	Type <sup>2</sup>	Lowest estimated lifespan	Highest estimated lifespan	Average lifespan
Nandigobe	1	LC	C	5	5	5
Mpologoma	3	C	C	2	8	5
Nakitenyu	2	R	C	4	7	6
Muvubo	4	C	C	4	10	6
Kibuzi	7	C	C	4	10	6
Luwaata	2	LC	C	6	8	7
Tayasamba	1	R	C	7	7	7
Nabomba	2	LC	C	5	10	8
Ndiwa warangira	2	C	C	6	10	8
Lusumba	2	LC	C	8	10	9
Musakala	4	C	C	6	17	10
Nfuuka	1	LC	C	10	10	10
Sita kange	1	R	C	10	10	10
Kainja	1	C	B	10	10	10
Nabusa	1	R	C	10	10	10
Gonja	3	C	R	10	10	10
Nambi	1	LC	C	10	10	10
Nakitembe	9	C	C	5	20	10
Kisansa	4	C	C	8	17	11
Nakabululu	2	LC	C	13	20	17
Ndiizi	1	C	D	20	20	20
Mwazirume	1	LC	C	20	20	20
Kisubi	3	LC	B	10	100	47
Namwezi	1	LC	C	50	50	50
Tombadala	1	C	D	50	50	50
Bogoya	4	C	D	50	100	83
Average				13	21	17

<sup>1</sup> Abundancy according to the classification based on the data of the on-farm interviews. C = Common varieties, LC = Less common varieties, R = Rare varieties.

<sup>2</sup> C = Cooking variety, B = Beer variety, D = Dessert variety and R = Roasting variety.

Five other farmers mentioned soil selectiveness of varieties as a reason for replacement of a banana mat. If a mat does not perform well those farmers uproot the mat and replace it with another variety to see if it performs better. The positioning of the variety on the farm is therefore an important factor of productivity. Another reason why a mat can go down in productivity is infection with pests and diseases. Four farmers said to uproot infected mats and place a new one close to the place of the diseased mat but not on the exact same place to avoid reinfection.

As mentioned, mats can also die off which does not necessarily mean they were also going down in productivity. Sudden events such as toppling over by wind can cause a mat to die while the productivity was still fine. Farmers named four main reasons for mats to die. First the mat can be at the end of its lifespan. Some farmers do not replace mats when they become exhausted but wait for the mat to die off. Second abiotic damage can cause the mat to go extinct such as wind, drought or excess sunshine. Also infection by pests and diseases can make a mat go extinct. In some cases an infected mat can die before the farmer managed to remove the mat. Lastly the farmers named continuity of the mat as a reason why they died off. If insufficient suckers are produced by a mat it will eventually go extinct as there is no follower after harvest of the last bunch. When mats die off they leave “gaps” in the plantation that have to be filled. Eleven farmers said that gaps in the plantation are their main motivation plant new suckers (table 3.7). Mats usually die off randomly on the farm because of the mixed pattern of varieties on most farms. As one of the farmers explained:

*“After a very windy day I might find 3 mats that were toppled over by the strong winds belonging to a variety which has a more shallow root system. Because of the mixed pattern I will find these toppled over mats scattered over the plantation and not all in the same area”.*

The mixed pattern thus makes it very uncommon that large areas of banana mats show a reduction in productivity or die off at the same time. Therefore, farmers make the distinction between “gap filling” which they consider as the fill up of created gaps and “planting” which they consider as the planting of a new area. Gaps are also created by a phenomenon which is indicated as the movement of the banana mats. Every time a sucker appears, it appears some distance from the mother plant. When the mother plant is cut down for harvest, usually the oldest sucker or “daughter” will follow up on the mother plant. The remaining part of the mother plant is removed or left to rot depending on the management of the farmer. The actual place of the mat has now been moved several inches. When this process repeats itself, the mat can have moved even a couple of meters according to the farmers. Two farmers said they actually use this phenomenon to “move” the mat in a desired direction. As one of them explained:

*“By putting manure a few inches away from the mat on the side of the direction I want the mat to move the chance is higher a new and strong sucker will appear on that side. Suckers that appear in the undesired direction I destroy. In this way I can guide my mats over the plantation and I can create a gap at the place I desire”.*

Table 3.7. Motivations of farmers to replace a banana mat and the number of farmers giving each motivation (n=23). (Method: Free listing ; Source: On farm interviews)

Motivations behind the replacement of banana mats	n
I replace mats when they get exhausted which I notice due to a decreased production/decline in bunch size.	14
If I see a gap in a plantation due to a mat that died or due to movement I plant a new sucker.	11
I replace mats that do not perform well in a certain area of my plantation, bananas are very soil selective.	5
I replace mats that are infected by pests or diseases.	4
I replace a sucker that did not germinate or does not grow vigorous with a new one.	2
I replant an entire area when it goes exhausted.	1

The variation in decline in productivity and death of mats is also what keeps the mixed pattern in place. One farmer explained: *“I just leave the older mats standing there until they die off, and because they do not die all at the same time I end up with a mixed pattern”*. Another farmer explained:

*“If you would plant an acre of Nakitembe the general lifespan could be 10 years when managed well. But not all mats will go extinct at the same time: some may never even germinate, others may die after a few years due to a disease or climate factors and some may even grow older than the 10 years”*.

Only one of the 23 farmers said to replace entire areas instead of filling gaps. This farmer was a middle aged farmer who used the land of a rich man living in Kampala. The farmer had access to 45 acres for cultivation and received planting material and inputs from the owner of the land. He explained:

*“I wait for an area to go extinct and then I clear and replant the entire area. It does not make sense for me to fill gaps because the older mats will compete with the young ones. After uprooting all the old mats I leave a fallow period to let the roots rot away and diseases attached to those roots will then disappear and can no longer infect the roots of the young plants. If I would plant the young ones between older mats they will get infected with diseases and start to compete for resources”*.

### 3.2.3 CHOICE OF VARIETIES TO FILL GAPS

When farmers start gap filling they have to decide which varieties they will use for replacement. Most farmers gave as motivation for their choice of variety the bunch size given by the variety. Also the lifespan and resistance to weather conditions, especially resistance to sunshine, were important. Resistance to weather conditions was mentioned by more farmers as being important than resistance to pests and diseases. Not only variety dependent but also farm dependent motivations were given, such as the performance of a variety in the soil type on the farm, how well the variety suited among the surrounding mats of the gap and the abundance of other varieties (table 3.8). One of the farmers explained that the purpose for which the variety is grown is also important. She explained:

*“If I want to plant a new variety which is meant for home consumption, the taste and the lifespan of the variety is most important. If I grow the variety for market purposes the bunch size is the most important trait”*.

Some farmers said the replacement of varieties was simply determined by sucker availability because they can only plant what is available. As described in chapter 1.2, sucker availability is determined by variety and environmental circumstances.

Table 3.8. Motivations of farmers behind the choice of varieties used for replacement and the number of farmers giving each motivation (n=23). (*Method: Free listing ; Source: On farm interviews*)

Motivation behind the choice of replaced varieties	n
It depends on the bunch size given by the variety.	11
It depends on the lifespan of the variety.	8
It depends on the performance of the variety on my farm and how well it suits my soil type.	7
It depends on the resistance of the variety to weather conditions such as sunshine and wind.	7
It depends on the availability of suckers of each variety which ones can be planted.	6
It depends on the market demand of a variety.	5
It depends on the abundance of the other varieties on my farm; I try to keep my varieties in balance.	4
It depends on the tastiness of the variety.	4
It depends on the purpose for which I grow the variety.	3
It depends on the resistance of the variety to diseases such as weevils.	3
It depends on the varieties surrounding the gap I want to fill, varieties should not compete.	2

### 3.2.4 SUCKER PLANTING AND REPLACEMENT RATES

Farmers were asked about the number of suckers and the varieties they planted last season, which was the period of the April rains of 2016. Some farmers told us they were unable to plant any suckers during the season due to the drought. Sucker availability increases when the rains come. Due to climate change farmers had difficulties predicting the start of the rains. March till May and October till December used to be the rainy season and good for planting but the last years this was different; farmers said they cannot count on the rains anymore the way they did back in the time. Most of the farmers said suckers are best sourced and planted at the beginning of the rainy season because they need modest rain after they are planted to properly germinate. Since the rain has become unpredictable farmers started sourcing and planting after 3 or 4 heavy rains. Farmers explained that if a sucker is planted at the beginning of the rainy season when the rain is modest it has time to develop roots before the heavy rains start. If a sucker is planted during the heavy rains and it has not yet developed roots the corm is likely to rot away. That suckers can best be planted directly after uprooting was confirmed by all farmers. Due to this unpredictability of the rains there was a lot of variation in the time the farmers last planted a sucker. Some of the farmers planted suckers outside the rainy seasons (table 3.9). Four farmers had not planted at all in 2016. The farmers which were unable to plant during the April rains of 2016 belonged to all socio-economic classes defined.

Table 3.9. Month and year in which the farmers last time planted suckers (n=23). The number of farmers planting in each month is presented. (Source: *On farm interviews*)

Date	Number of farmers who last planted in a specific month
April 2015	1
July 2015	1
August 2015	1
November 2015	1
March 2016	1
April 2016	6
May 2016	1
September 2016	2
October 2016	6
November 2016	3
Total	23

Because not all farmers were able to plant during the last season (being the April rains of 2016), we asked the farmers about the number of suckers they planted most recently and of which variety. The farmers who did plant during the last planting season, which were the April rains of 2016, were asked the same questions (table 3.10).

The average number of suckers planted during the last time farmers planted suckers was 19 and the average number of suckers planted during the April rains was 25. The average number of suckers planted per acre was 14 during the last time suckers were planted and 17 during the April rains. In absolute terms men planted more suckers both during the last planting and during the April rains than women but when calculated per acre the differences were minimal. Middle aged farmers planted the most suckers during the last time they planted and during the April rains as well in absolute terms as per acre. During the last time planted the older farmers planted the lowest number of suckers per acre. During the April rains the differences between age classes were minimal. Farmers belonging to medium wealthy households planted most suckers during the last time they planted and during the April rains. The absolute number of suckers planted and the number of suckers planted per acre was highest among medium wealthy households followed by rich households. Poor households planted the lowest number of suckers. In absolute terms large scale banana farmers planted most suckers followed by medium scale banana farmers. Small scale banana farmers planted the smallest number of suckers. Nevertheless, when the number of suckers per acre was calculated small scale banana farmers planted the highest number of suckers and large scale banana farmers planted the lowest number of suckers during the last time they planted. Also during the April rains the number of suckers planted was lowest among large scale banana farmers.

Table 3.10. The average number of suckers planted by farmers during the actual last time they planted and during the last planting season which are the April rains of 2016 (n=22\*). (Source: On farm interviews)

Category	n	Farm size (acres)	Number of suckers planted during last planting	Number of suckers planted during last planting/acre	Number of suckers planted during April rains 2016	Number of suckers planted during April rains 2016/acre
General	22	1.6	19	14	25	17
Male farmers	12	2.1	23	11	36	18
Female farmers	10	0.9	15	17	13	15
Male headed households	16	1.8	21	11	57	32
Female headed households	7	0.9	14	15	16	18
Old farmers	10	1.7	8	5	21	14
Middle aged farmers	7	1.9	34	18	36	19
Young farmers	5	0.9	15	17	17	19
Rich households	7	2.6	18	7	34	13
Medium wealthy households	11	1.7	26	24	47	28
Poor households	4	0.5	7	14	1	2
Large scale banana farms	4	3.5	37	9	40	11
Medium scale banana farms	9	1.7	17	10	40	24
Small scale banana farms	9	0.5	14	33	9	20

\* The sample size was for these data was smaller since one of the farmers was excluded due to a special case in land tenure.

In total farmers replanted suckers of 14 different varieties. The suckers were of all types of varieties except beer bananas. Abundant as well as less abundant varieties were replanted (table 3.3). Suckers of the cooking banana varieties Nakitembe and Mpologoma were replanted by most farmers. The number of suckers planted per variety was not remembered by most famers (figure 3.2).

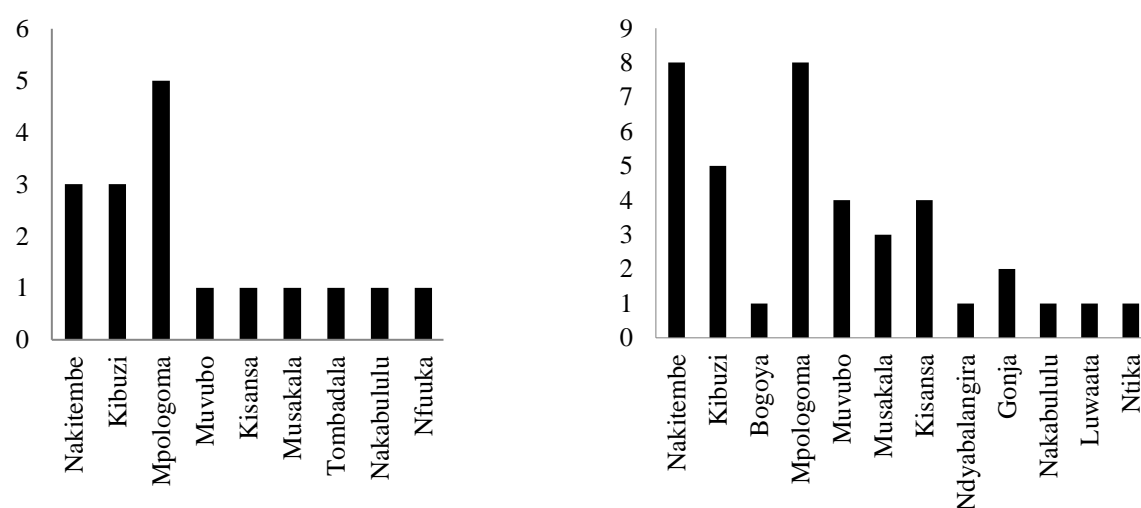


Fig.3.2. Varieties and the number of farmers who planted them during the last time they planted (left) and the last planting season (right) (April rains of 2016). Varieties are places in order of abundance in the study area with the most abundant variety on the left and the less abundant variety on the right.

## CHAPTER 3.3 SELECTION OF PLANTING MATERIAL

### 3.3.1 SELECTION OF PLANTING MATERIAL AMONG VARIETIES

The criteria considered by farmers while selecting planting material are plant traits depending on variety or plant traits which differ within a variety, i.e. representing variation between suckers. Farmers were asked to name five variety dependent plant traits most important to them and rank them in order of importance. Farmers were free to list all plant traits but sometimes did not mention a total five plant traits but less. In total the farmers named 13 characteristics (table 3.11). Bunch size or yield, the lifespan and the varieties reputation as being good performing in the area were named by farmers as most important characteristics of a variety.

Table 3.11. Ranking of the characteristics of a variety taken into account by farmers while selecting new planting material (n=23).  
(Method: Free ranking ; Source, On farm interviews)

Rank	Score	Characteristics of a variety taken into account while selecting new planting material
1	3.13	The bunch size given by the variety
2	1.22	The lifespan of the variety
3	0.78	The reputation of the variety as being good performing in the area
4	0.70	The resistance of the variety to pests and diseases
5	0.43	The condition of the suckers given by the mats of the variety
6	0.35	The resistance of the variety to climate conditions
7	0.35	The abundancy of the variety in the area: I rather replant rare varieties
8	0.30	The marketability of the variety
9	0.26	The suitability of the variety for the type of soil.
10	0.26	The required management needed for the variety is minimal
11	0.22	The taste of the fruit given by the variety
12	0.13	The maturity time of the variety
13	0.09	The abundancy of the varieties on my own farm. I balance my varieties to keep them in equal number on my farm

### 3.3.2 SELECTION OF PLANTING MATERIAL WITHIN VARIETIES

Besides the variety specific traits farmers take into consideration while selecting planting material, also within varieties certain sucker characteristics are preferred above others. Farmers were asked how they decided which suckers to uproot for replanting. All farmers said that the selection of suckers was similar for all varieties and there were no specific characteristics they took in consideration for a particular variety. Farmers looked at several traits of the entire mat, the mother plant and the sucker itself (table 3.12).

Table 3.12. Characteristics taken into account while selecting a sucker and the number of farmers naming each characteristic (n=23). (Method: Free listing ; Source: On farm interviews)(Characteristics are elaborated on in Appendix 2)

Category	Characteristic	n
Mat	Generation or continuity of the mat (mother, child, grandchild, orphan)	5
	Age of the mat	2
	Place on the mat where sucker appears	1
	Distance between the sucker and the mother plant	1
	Total number of suckers on the mat	1
	Corm of mat above soil surface or not	1
Mother plant	Bunch size given by mother plant	6
	Weevil infection mother plant	5
	Health of mother plant	4
	Diameter pseudo stem mother plant	2
	Size of fingers mother plant	1
Sucker	Leaf shape & size	14
	Shape of the pseudo stem	13
	Size of the sucker	9
	Weevils in corm/stem	9
	Colour of the leaves	6
	Health of the sucker	5
	Colour pseudo stem	4
	Position of leafs along the pseudo stem	2
	Number of leaves	2
	"Ash" on the base of the leaves	1
	Cigar leaf coming up vertically	1
	Reddish colour base of leaves	1
	Depth of roots	1
	Colour corm sucker after uprooting	1
	Age of the sucker	1

The traits that were taken in account by most farmers were the leaf shape and size of the sucker, the shape of the sucker's pseudo stem and the size of the sucker. Farmers explained that leaf shape and size are important in relationship to age of the sucker. If a sucker is still young and already has big broad leaves it is called a water sucker (around 70cm). A thin stem at the base is another characteristic of a water sucker. The three most named characteristics relate to the distinction between sword and water suckers, which therefore can be considered as the main criteria among farmers. Water suckers were not liked by the farmers; they refer to it as "something is wrong inside". One of the farmers said: *"They are like a 4 year old boy with a beard, if you would see a boy like that you just know something is wrong inside"*. What that "something" exactly was turned out to be difficult to tell for most farmers. Most of them said they could just feel it, like they know when their children are sick. Some said it was some disease inside and for others it indicated the sucker was infected by weevils.

However, a water sucker is not necessarily infected by weevils or other diseases nor is a sword sucker free of them. Infections of weevils in the corms of sword suckers were regularly observed during the field work. The

scientific explanation for the appearance of a sword or water sucker is the attachment to the mother plant (Robinson, 1996). Young suckers almost entirely depend on the reserves of the mother corm. The connection of the sucker's corm to the corm of the mother plant is essential for the sucker to receive nutrition. A strong connection between a sucker and the mother corm results in a sucker with a strong base. Due to the strong connection a sword sucker is provided with enough nutrition from the mother and it can grow vigorous without the need for leaves of its own. Water suckers on the other hand have a small surface area to which their corm is connected to the mother corm. Because it receives less nutrition it cannot grow as vigorous as a sword sucker which results in a weak and thin stem usually more pale of color. The development of broad leaves in a young stage helps the water sucker to obtain its own energy. Water suckers usually develop slower and are more at risk during drought until they have developed a proper root system of their own. Nevertheless it does not mean the sucker is infected or they can never give a good bunch since a sword and water suckers of the same mat are genetically identical. Due to this disadvantage of a slower development it is advisable to use sword suckers instead of water suckers. Despite, in case a farmer has no other option due to a lack of sword suckers on their own farm and insufficient money to buy them, a water sucker can still be used.

The size of the sucker was also named by many farmers as important and the preferred size differed among farmers. Some farmers preferred sword suckers (suckers which did not yet develop foliage leaves) because they are easy to uproot and the mat is not damaged that much by uprooting the sucker. Other farmers preferred to use maiden suckers (suckers which developed foliage leaves but at the right age in contrast to water suckers which develop them too young) because they grow with more vigor and because a lot of water is stored inside the sucker. An earlier study showed that farmers in Uganda prefer maiden suckers (Lwandasa et al, 2014). During this research we found that the preferred sucker size varies among farmers.

The mat trait most frequently mentioned by farmers was the generation or continuity of the mat. This regard the growth cycles of a mat. Each plant emerging on a mat bearing a bunch is a cycle. Farmers want as many cycles as possible on each mat. Farmers explained that to keep a mat "vital" the right number of suckers should be left. If too many suckers are uprooted the mat is weakened and might even die off due to a lack of successors. If too many suckers remain they use too much of the mat's energy and the mat might become exhausted. For that reason, a mat sometimes has to be "de-suckered" (Robinson & Nel, 1990). In order to not damage the corm the excess suckers are destroyed above-ground (by cutting them or by piercing them with a stick) instead of uprooted. The right number of suckers to be left on the mat depends on the type of management and the variety. Most farmers explained they treat their mats as being a family. As explained in chapter 1.2, the mother plant is the oldest plant on the mat bearing a bunch earliest. The sucker that comes after that in age is called the daughter and the suckers following thereafter in age are the grandchildren. According to the farmers it is best to leave the mother plant, the follower and at least two or three suckers on a mat. Some varieties can have a mat with several mother plants which bare a bunch around the same time. In that case for each mother plant a follower and two or three smaller suckers need to be maintained. This means that the best suckers can actually not be uprooted and need to be left on the mat in order to keep it vital. One of the farmers also explained the importance of the presence of the mother plant:

*“It is important to see if a sucker still gets nourishment from the mother plant. In some cases the mother plant gets extinct premature due to wind or other damage. In that case a sucker is called an orphan. Due to the lack of nourishment of the mother the sucker will not grow as vigorous”.*

The influence of the mother plant in sucker production has been described in literature. When the leaf canopy of a mother plant is removed at the right moment this can double the dry mass and leaf production of the sucker six months later. In contrast, when the connection of the mother plant and the sucker is damaged a reduction in sucker growth was observed. (Eckstein & Robinson 1999). The most important characteristic regarding the mother plant was the bunch size given by the mother. An elaborated list with explanations of the farmers regarding each trait presented in table 3.12 can be viewed in Appendix 2.

## CHAPTER 3.4 SEED SOURCING PRACTICES

### 3.4.1 ESTABLISHMENT OF THE BANANA PLANTATION AT THE HOME PLOT

When farmers establish a banana plantation most of them obtain their initial planting material from relatives, friends or neighbours. A new farm is usually established after marriage when a new plot is bought or when a farmer is given a plot by its parents. Therefore the farmers might sometimes start with a plot which is already cultivated with bananas or other crops. In case bananas are already present the farmer can choose to replant the area with new planting material acquired off-farm or to multiply from the bananas present on the plot. Combinations whereby the farmer multiplies and sources off-farm for new planting material but also multiplies the material on the plot are possible (table 3.13).

Among the interviewed farmers 11 inherited their home plot from family members or were given a plot by their parents after marriage. Another 11 farmers bought their first plot. Ten of the plots were covered in bush before the banana plantation was established by the farmers. The home plots of the other 12 farmers were already cultivated and nine of them were cultivated with bananas. Two farmers decided to only multiply from the banana mats present on the plot. Six farmers multiplied but additionally sourced off-farm for new planting material and the remaining 15 farmers completely sourced off-farm to establish their banana plantation. The farmers' initial source of planting material was usually located within the village. Only four farmers said they sourced outside their village.

Table 3.13. The age, terms of acquisition and the type of planting of the home plot of the farmers (n=23). (Source: On farm interviews).

Age of the plot			Terms of acquisition		Type of planting		
Category	Classification	n	Category	n	Category	n	
Very old plantations	< 1987	5	Inherited or given by parents	11	Gap filled	2	
Old plantations	1987 – 1996	5	Bought	11	Gap filled/newly planted	6	
Medium aged plantations	1997 – 2006	4	Other	1	Newly planted	15	
Young plantations	2007 – 2011	4					
Very young plantations	> 2012	5					

The farmers explained that when the first mats are established and provide a sufficient number of suckers they usually switch from mainly sourcing off-farm to mainly sourcing on-farm. For most farmers the acquisition of planting material is a process that can even take several years were they get a small number of suckers each

time from a neighbour, relative or friend in combination with multiplication of the own mats. Especially when relatives do not have enough suckers to give out for the establishment of a plantation at once the process can take long. When the first area on the farm is cultivated with banana and a new area is to be planted the farmers usually start sourcing from their own earlier established mats, and only if suckers are not sufficient continue with sourcing a lot off-farm.

Because the initial planting material is mainly sourced from friends and relatives it would be plausible that planting material acquired by female farmers comes from a source located further away than material acquainted by male farmers as the female farmers usually move to the village of the man heaving family in other areas (Delêtre et al., 2011). However, among the male and female farmers we interviewed we found no difference; most farmers had their source of planting material within the village. In other areas where it is tradition to give away planting material to the newlywed couple there may be a difference. For example the one female who got her material outside the district acquired planting material from her family when she married. In the community she originated from, this tradition of giving away planting material during marriage was common.

### 3.4.2 MAIN SOURCES OF PLANTING MATERIAL

We tried to sample 16 banana mats on each farm (4 mats of 4 varieties each, for sampling procedure and variety choice, see chapter 1.4.3), not always these 16 mats were available. In total 279 mats were sampled. The source of these mats was with 89% mainly inside the community. With 68.5% the majority of the mats originated from planting material acquired on-farm through multiplication or because they were present on the plot at time of inheritance or when given by the family. The remaining 31.5% of the mats were sourced off-farm from several sources. Off-farm sources included family, friends, neighbours and others (figure 3.3). Out of the 88 off-farm acquired mats 70% was a gift. The other 30% involved a monetary transaction. Only of one of the sampled mats was obtained in exchanged for another sucker.

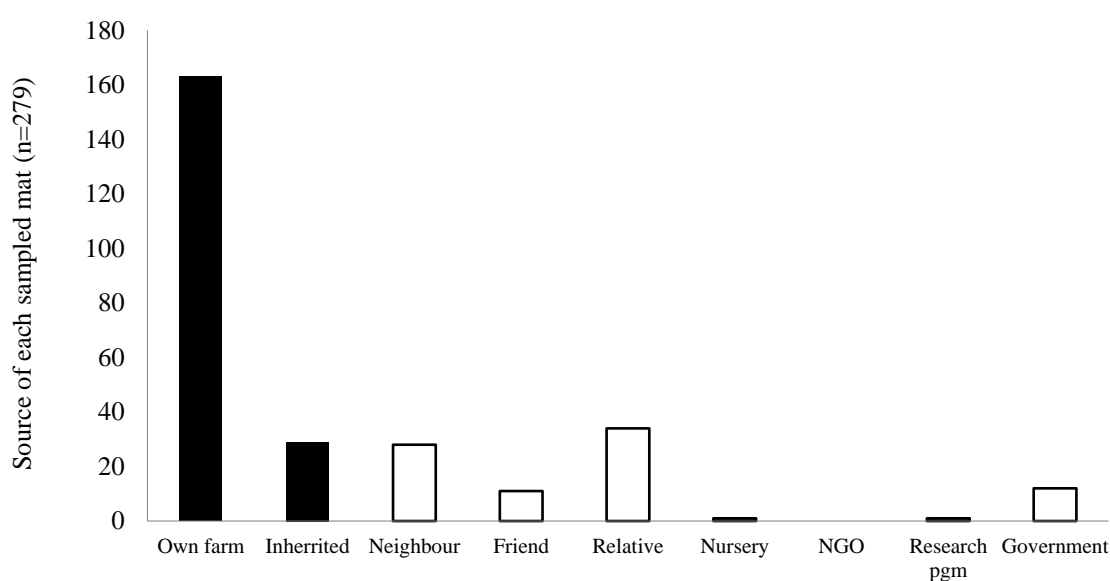


Fig.3.3. Source of each sampled mat (n=279). Black bars are on-farm sources and white bars are off-farm sources. (Source: On farm interviews)

### 3.4.3 OFF-FARM SUCKER SOURCING

Farmers said the main difference between on- and off-farm sucker sourcing is the payment which is usually involved in off-farm sucker sourcing. For that reasons farmers preferred to source on-farm, and if needed, to source at relatives or friends. When sourcing at the farms of relatives and friends, farmers usually do not charged and are still given a choice in the suckers to take. It is also possible to source free suckers at neighbours or acquaintances but most farmers mentioned to not have choice among suckers in that case. The lack of choice among sucker was the main argument for most farmers to not source off-farm. One of the farmers said:

*“That person will just uproot what he has available and give you the peeled suckers. In that case you have no idea about the varieties you get, the condition of the mother plant, the presence of pests and diseases and the condition of the farm itself. For the continuity farmers need the best suckers on their plantation so they will never uproot the best suckers for you”.*

The criteria mentioned by most farmers while deciding on an off-farm source is the presence of pests and diseases on that farm (table 3.14). Two farmers pointed out in particular that they check if a farm is free of BXW (for a review how farmers evaluate the presence of BXW on a farm, see chapter 6.1). The way a farmer manages his farm and the condition of the farm in relation with this management is a criteria important to most farmers. Also the performance in terms of bunch sizes given by the mats on the farm was said to represent an attraction to ask for a sucker of such a mat. The types of varieties that a source-farmer grows and the way these varieties perform on the farm of the suck-sourcing-farmer was also mentioned to be taken into consideration. One farmer explained that if he sees a good performing banana variety but grown in a different soil type than present on his own plantation, it would not necessarily be an attractive variety for him. Also named by the farmers was the reputation of the source-farmer: some farmers are known to possess good varieties and manage their farms well. One farmer mentioned the age of the plantation being important to her while selecting an off-farm source. She preferred to source from a farm of which the mats yielded about three bunches (meaning it went through 3 growth cycles) which she considered as a young plantation.

Table 3.14. Criteria of farmers when deciding on an off-farm source and number of farmers naming each criteria (n=23). (Method: free listing ; Source: On farm interviews)

What do you take into consideration when deciding on an off-farm source	n
The presence of pests and diseases on the farm	15
The way a the farm in managed and if the farm is in a good condition	9
The bunch sizes on the banana mats on the farm	8
The types of varieties that are grown on the farm and how they would perform on my own farm	4
The reputation of the farmer	4
The age of the plantation	1

All farmers said that on-farm sucker sourcing had their preference because no transaction was involved, the farmers had a free choice which suckers to uproot and they were sure about the condition of their own farm. The main reasons tempting the farmers to source off-farm were a nice appearing farm meaning it is free of diseases and gives big bunches, a variety the farmer not yet possesses and a lack of suckers on the own farm.

### 3.4.4 SUCKER AVAILABILITY AND EXCHANGE

Farmers were asked about the number of suckers available on their farm which they considered as suckers good for planting according to their own criteria which they mentioned earlier (see chapter 3.3.2). The number of actual available suckers on-farm (at the moment of interviewing) varied from 5 to 300 suckers. On average, the farmers had 78 suckers available on their farm of which they needed 53 suckers for their gap filling and mat replacement (table 3.15). The sample size for these data was smaller since the pilot interview for the first five farmers did not include the questions on which the data is based.

Table 3.15. Average number of available suckers at the time of interviewing farmers considered as “good” for planting, the number of suckers needed on-farm and the percentage of suckers that could be provided to fellow farmers. (n=17\*) (Source: On farm interviews)

	n	Average number of available suckers	Average number of available suckers per acre	Average number of suckers needed on own farm	Percentage of suckers needed on the own farm.
General	17	78	76	53	70%
Male farmers	10	48	29	38	76%
Female farmers	7	93	108	43	58%
Old farmers	6	72	34	67	87%
Middle aged farmers	7	93	49	57	71%
Young farmers	4	63	71	23	43%
Rich households	5	88	31	81	80%
Medium households	7	64	51	40	67%
Poor households	5	89	69	42	65%
Large scale farmers	5	100	29	88	76%
Medium scale farmers	6	96	61	59	82%
Small scale farmers	5	43	102	43	53%
Very old plantations	4	70	38	69	85%
Old plantations	2	40	33	30	73%
Middle aged plantations	4	138	46	80	68%
Young plantations	2	50	33	30	60%
Very young plantation	5	64	107	36	62%

\* The sample size was for these data was smaller since the pilot interview for the first five farmers did not include the questions on which the data is based.

Because of the different sizes of the farms, we calculated the number of available suckers per acre: the variation in number of available suckers still differed between 5 and 280 suckers per acre. Several factors can explain this big difference. One factor is the type of varieties grown on farm since the number of suckers produced by a mat is variety dependent. Furthermore, the amount of rainfall the farm received influences (chapter 3.2), the condition of the farm such as soil fertility (a higher number of suckers is produced in fertile soils), the ability of the farmers to use fertilizers and the criteria of the farmers which sucker is considered a “good” sucker for replanting (some farmers had more strict criteria then others). One of the female farmers who only had 5 suckers available and was classified as a poor farmer said:

*“It does not make sense for me to have very strict criteria for the suckers I use for replanting. The number of suckers I have available on my farm is that low that none of them would go through the right criteria. I have no other option than just to uproot the suckers I have available. I do not even take leaf shape into consideration and also plant water suckers. I only look at diseases because a diseased sucker will die anyway”.*

Averagely farmers were able to give out 30% of the available suckers. Seven farmers said they were not able to provide any suckers at all because they needed all available suckers for their own planting next season. Some of them even mentioned to have a shortage of suckers for the coming season. Those farmers not able to share at all were belonging to all classes of wealth, gender age and farm size.

Among the farmers that said they were able to share the female farmers said to have more suckers available on their farm and were able to provide a larger share of the available suckers to fellow farmers. Young farmers had less suckers available compared to old and middle aged farmers but were able to give out a larger share. Old farmers needed the largest share of available suckers on their own farm. Regarding wealth classes the rich farmers needed the largest share of suckers on their own farm. Small scale farmers had less suckers available on their farm but were able to provide more compared to middle and large scale farmers. Farmers owning a middle aged plantation had the highest number of suckers available. The number of suckers available per acre on the other hand was highest on very young farms. Farmers owning a very old plantation needed the largest share of planting material on their own farm and farmers owning a young or very young plantation needed the smallest share. Possibly young farms are more productive in suckering compared to older farms (Robinson, 1996). As explained previously younger farmers were more likely to own a young farm which might explain why young farmers were able to provide a larger share of their suckers to a fellow farmer. Besides that young farmers usually own a smaller plantation which could explain why small scale farmers needed a smaller share of suckers on their own plantation. Since the rate of sucker production partly depends on soil fertility it is possible that young plantations provide more suckers because they are usually more fertile compared to old plantations.

### 3.4.5 SELLING OR GIVING

Of the seven farmers that needed all planting material on their own farm there were five farmers that said they were unable to share or sell any sucker at all this planting season. One of the farmers said he could still give suckers to a relative or friends if they would ask. If a stranger would come, he would sell some suckers for 500 UGX (≈0.15 \$) each. His reason to still share with friends and family if they would come to ask for them was because he might experience a situation in which he would be short of planting material himself. In that case he could rely on his friends and family if he had been sharing previously. The other remaining farmer who needed all suckers on his own farm, said he was able to sell some if a fellow farmer would pay 1000 UGX per sucker (≈0.30 \$). Even to friends and family he was not able to give out suckers for free because he needed them himself. The 10 farmers who had suckers available for others all said they would give them away for free to friends and family except one lady who was establishing a commercial banana farm and only sold suckers for 2000 UGX (≈0.60 \$). The other farmers said they would charge an unknown fellow farmer 500-1000 UGX

per sucker. Two of the farmers said they would sell suckers, were unable to give a price since they determined the price on sucker availability and variety, one of them said:

*“It depends on the variety they want to take. If a stranger comes for Tombadala, he can take all the suckers he wants; it would even be a blessing to get rid of them, if he comes for other varieties I would charge him depending on the variety.”*

Mpologoma was named as such a variety of which suckers would be sold for a higher price. Only one farmer said he would also give suckers for free to fellow farmers he does not know (table 3.16). He said *“I would charge them 300 UGX for a sucker, but what would I do with 300 UGX? I rather have a good relationship with my fellow farmers instead of having 300 UGX”*. Farmers also mentioned the number of suckers a fellow farmer wants to acquire as being of importance determining the price. If a farmer comes for just a few suckers they would more easily give them away for free than when a farmer wants a large amount of suckers.

Table 3.16. Terms under which farmers would provide a fellow farmer they know and a fellow farmer they do not know with suckers (n=17\*). (Source: On farm interviews).

		Known fellow farmers	Unknown fellow farmers
Farmers who needed all suckers (n=7)	Not provide	5	5
	Charge	1	2
	Give for free	1	0
Farmer who had suckers available (n=10)	Not provide	0	1
	Charge	1	8
	Give for free	9	1

\* The sample size was for these data was smaller since the pilot interview for the first five farmers did not include the questions on which the data is based.

Eight farmers actually provided fellow farmers with suckers last planting season, being the April rains of 2016 (Table 3.17). There was no difference in the number of farmers who provided suckers in terms of gender, farm size and wealth. Middle aged and young farmers provided suckers to fellow farmers more often than older farmers did, only one farmer who provided suckers belonged to the group of old farmers. The number suckers provided by each farmer varied between 3 and 200. The 200 suckers were given out to several farmers by one of the richer, large scale farmer. He mentioned he was known around among farmers as a source for suckers. Every season he would provide a handful of farmers with suckers. The average number of suckers exchanged last season per farmer was 49 and the average number per acre 31. All suckers were provided to farmers within the same community. Some farmers shared their suckers with more than one farmer. Suckers were provided six times to friends, four times to relatives and once with a neighbour. In all cases the suckers were provided for free except the suckers provided to the neighbour which were sold for 1000UGX (≈0.30\$) each. Remarkable is that the only farmer who said not to have suckers available and who would charge even his family and friends if they would come to ask for them (table 3.16) shared suckers without charge with his grandchildren. He said: *“When the spirit of kindness hits me I can give out some suckers”*.

Table 3.17. Number of farmers who provided fellow farmers with suckers last planting season (April rains of 2016), the average number of suckers they provided and the average farm size given for each social group (n=8). (Source: *On farm interviews*)

	Number of farmers that shared suckers	Average size of banana cultivated area	Average number of suckers shared	Average number of sucker shared per acre
General	8	1.6	49	31
Male farmers	4	2.1	79	38
Female farmers	4	0.9	20	22
Old farmers	1	1.7	12	7
Middle aged farmers	4	1.9	79	42
Young farmers	3	0.9	22	25
Rich households	3	2.6	80	31
Medium households	2	1.1	55	50
Poor households	3	1.3	15	12
Large scale farmers	3	3.5	80	23
Medium scale	2	1.7	44	28
Small scale farmers	3	0.5	23	58
Very old plantations	1	1.9	8	4
Old plantations	0	1.2	0	0
Middle aged plantations	2	3.0	106	35
Young plantations	1	1.5	27	18
Very young plantations	4	0.6	36	60

The main difference in sucker providing farmers was found in the age of the plantation. Farmers owning a middle-aged to very young banana plantation shared more often than farmers owning an old or very old banana plantation. Also the absolute number of suckers provided and the number of suckers provided per acre was higher among farmers owning a middle-aged to very young plantation.

The lack of suckers available on-farm was the main motivation not to share for the nine farmers who did not provide fellow farmers with suckers. Their explanation for the shortage of suckers was the drought farmers experienced. Two farmers said they did not provide suckers because nobody came to ask them. One of the farmers also mentioned he is still establishing his initial plot so he is rather sourcing off-farm himself instead of giving out.

### 3.4.6 ACQUIRING SMALL AND LARGER NUMBERS OF SUCKERS

Of each varieties of the banana mat samples on the farms (chapter 1.4.3) the farmer was asked where (s)he would go if he or she wanted to obtain 1,10,100 or a 1000 pieces of new planting material for this variety. This would give some indication about the availability of suckers in the area and in which amounts farmers are able to obtain suckers (table 3.18).

Table 3.18 Sources were farmers (n=23) would obtain 1,10,100,1000 suckers of the same variety as the sampled mat (n=89). (Source: *On farm interviews*)

	1	%	10	%	100	%	1000	%
I would obtain them on my own farm	87	98%	59	66%	7	8%	0	0%
I would obtain them from fellow farmers within the community	1	1%	14	16%	33	37%	12	13%
I would obtain them from fellow farmers outside the community	0	0%	0	0%	3	3%	0	0%
I would obtain them from a nursery	0	0%	0	0%	4	4%	9	9%
I would not be able to obtain them	1	1%	16	18%	42	47%	68	78%

If farmers had to source one sucker most of them would source them on their own farm. In two cases a farmer said not to be able to obtain even one sucker on farm. In one case a sucker could be obtained within the community and in one case new planting material could not be obtained at all. The lady owning the variety said she had only one mat in the community, without any suckers and she had no money to obtain planting material off-farm. She was afraid if her mat would die she would lose the variety.

Also if farmers had to obtain 10 pieces of planting material they would mostly source on farm. In 14 cases the farmers would source off-farm but within the community and in 16 cases the farmers said they were not able to obtain 10 pieces of planting material at all. When farmers were not able to obtain the material at all this was usually because the variety was less common or scarce and because the farmer did not make use of off-farm sources. Five farmers said they would not source off-farm at all and said therefore they were unable to obtain the planting material in large quantities. They said that if they wanted the planting material they would multiply and get the material little by little. The reason most farmers gave for not sourcing off-farm was a lack of trust in the management of the other farmers. One of the farmers said:

*“I got my planting material from one of NAADS programs. They gave me and other farmers each 450 tissue culture plantlets in 2007. Since then I have been able to multiply the material and you can see how far I have extended my banana plantation. The other farmers do not have anything left of the material due to their poor management. I would not source from these farmers, I am able to multiply my own planting material”.*

In case farmers had to obtain 100 pieces of planting material most of the time the farmers said they were unable to obtain the material. Most farmers were not able to obtain 100 suckers of a single variety on their own farm. If farmers were able to obtain the material most of them said they would obtain them on the farm from a fellow farmer within the community. Three farmers said they would have to source outside the community and four farmers said they would make use of TC plantlets from a nursery to obtain planting material in a large quantity.

Also a 1000 suckers were not obtainable for most farmers. Farmers saw different challenges in obtaining such amounts, they would not be able to find, transport or pay for such quantities. None of the farmers said they were able to obtain them on their own farm. Also within the community the number of farmer that would be able to obtain them was low. None of the farmers said they would source them from fellow farmers outside the community mainly since they were not used to source outside the community because they did not know a lot of fellow-farmers that well or because the suckers were difficult to transport. Three farmers said they would make use of a nursery to obtain 1000 suckers/(pieces of planting material). The reason why a lot of farmers would not make use of a nursery although the numbers are available was because they did never make use of TC material or because they were unable to pay for such a large amount of plantlets.

## CHAPTER 3.5 THE USE OF TISSUE CULTURE BANANA PLANTLETS

About half of the farmers (12 of 23) said they had made use of tissue culture (TC) banana plantlets. The main reasons given by farmers to make use of TC plantlets were because they could obtain them for free from NAADS or from their farmers group. Six of the farmers who used TC received the plantlets as part of a NAADS program, five of them bought the plantlets at a nursery and one farmer received the plantlets from an extension officer. Big bunches, short period to flowering, cleanness, marketability, availability in large quantities and generation of a high income were other reasons given by farmer to use TC plantlets (table 3.20). One farmer explained she obtained the plantlets because she wanted to become a commercial farmer:

*“I was listening to the radio and I heard a lady pricing TC banana plantlets. While listening to this lady I realized we shared the same dream which is becoming a commercial banana farmer. I decided to send someone who lived in that area to visit her plantation to see how it performs. This person confirmed her plantation was doing that well and therefore I decided to order plantlets for a value of 40.000 UGX (≈ 11.00 \$)”*

The main reasons given by farmers to not make use of TC were that they never felt the need to get them or because they heard from fellow farmers that TC banana plantlets are not drought resistant. Some farmers also heard that TC material does not have a long lifespan. Two farmers told us of a problem which they said to be an important reason for farmers to hesitate to adopt using TC bananas:

*“TC plantlets of all varieties look the same when they are young and the variety can therefore not be identified until they reach the stage of flowering. I heard stories of several farmers who ordered plantlets of a certain variety but received others. I think in the laboratory or at the nursery they just mix the varieties they have to get rid of among the ordered varieties. I want to know which varieties I plant and I would never obtain this material if I cannot be sure about the varieties”.*

Farmers also said to not have access to TC plantlets because they did not know where to buy them or because they were not part of a farmers group. One of the farmers was unaware of nurseries selling TC material and thought she could only obtain those plantlets via NAADS. There was only one farmer who was not familiar the TC technology at all. She said she heard farmers speaking of banana plantlets which look like a common weed in the area but she never saw one of those herself.

Table 3.20. Reasons given by farmers to make use or not make use of TC banana plantlets (n=23) and the number of times the reason was mentioned. (Method: free listing ; Source: On farm interviews)

Reasons of farmers to make use of TC banana plantlets (n=12)	n	Reasons of farmers not to use TC banana plantlets (n=11)	n
I made use of TC material because I could obtain it for free from NAADS or in farmer trainings	6	I never made use of TC material because I never felt the need to use those plantlets	5
I made use of TC material because it gives a big bunch	5	I never made use of TC material because I heard TC plantlets are not drought resistant	5
I made use of TC material because it reaches the stage of flowering early	3	I never made use of TC material because I do not know where I can obtain TC plantlets	2
I made use of TC material because TC plantlets are mainly disease free	2	I never make use of TC material because I cannot identify of which varieties these plantlets are	2
I made use of TC material because bunches of TC material are marketable	1	I never made use of TC material because I heard that TC plantlets have a short lifespan	2
I made use of TC material because I want to become a commercial farmer	1	I never made use of TC material because they do not have the varieties I desire	1
I made use of TC material because the material is available in the quantities I desire	1	I never made use of TC material because I am not in a farmers group so I have no access to these plantlets	1
I made use of TC because I was told TC generates a high income	1	I never made use of TC plantlets because there are a lot of rules regarding their management	1
		I never made use of TC material because I do not know what TC plantlets are	1

None of the farmers who used TC planting material was classified as a poor farmer. All farmers living in rich households and about half of the medium wealthy households once used TC planting material. The number of middle aged farmers who used TC was low compared to the old and young farmers. There was no big difference in gender and size of the banana plantation regarding the use of TC planting material (table 3.21).

Table 3.21 Number of farmers making use of TC banana plantlets among different social groups (n=23). (Source: On farm interviews)

	n	Number of farmers made use of TC	% of farmers made use of TC
Total	23	12	52%
Male farmers	13	7	54%
Female farmers	10	5	50%
Old farmers	11	7	64%
Middle aged farmers	7	2	29%
Young farmers	5	3	60%
Rich households	7	7	100%
Medium households	11	5	45%
Poor households	4	0	0%
Large scale farmers	5	3	60%
Medium scale	9	5	56%
Small scale farmers	9	4	44%

Nine different varieties of TC plantlets were used. One farmer did not know which varieties he obtained even after the plantlets matured. One farmer did not know TC banana plantlets are available of different varieties and thought TC was a variety itself. Most of the farmers made use of TC plantlets of the varieties Mpologoma, Kibuzi and Nakitembe (figure 3.4). Three farmers said they received exactly the varieties they ordered, and four

farmers said they had no choice which varieties to obtain because they were given by NAADS. One farmer explained that in her village they were given a choice at first during the NAADS distribution of TC plantlets but she did not receive the varieties she thought she would receive:

*The suppliers of the sub-county were crooks. They said they were giving out Mpologoma and Kisansa but most of it turned out to be Kibusi and Nakitembe and some other varieties I not remember. There were more rounds of distribution. I was in the second root of distribution but everybody already knew from the first root of distribution that Mpologoma and Kisansa were among them and that they give very big bunches. Everybody wanted to get those varieties in the second round but there was in fact not even one Mpologoma and Kisansa plantlet among them; the mat of Mpologoma I have in my garden I bought from a fellow farmer”.*

Of the nursery clients there were two farmers who said they did not make an order for a certain variety but just for TC plantlets. Two of the nursery clients said they received partly the varieties they ordered because the nursery did not have sufficient plantlets in stock but the farmer was aware of that at the moment of getting them.

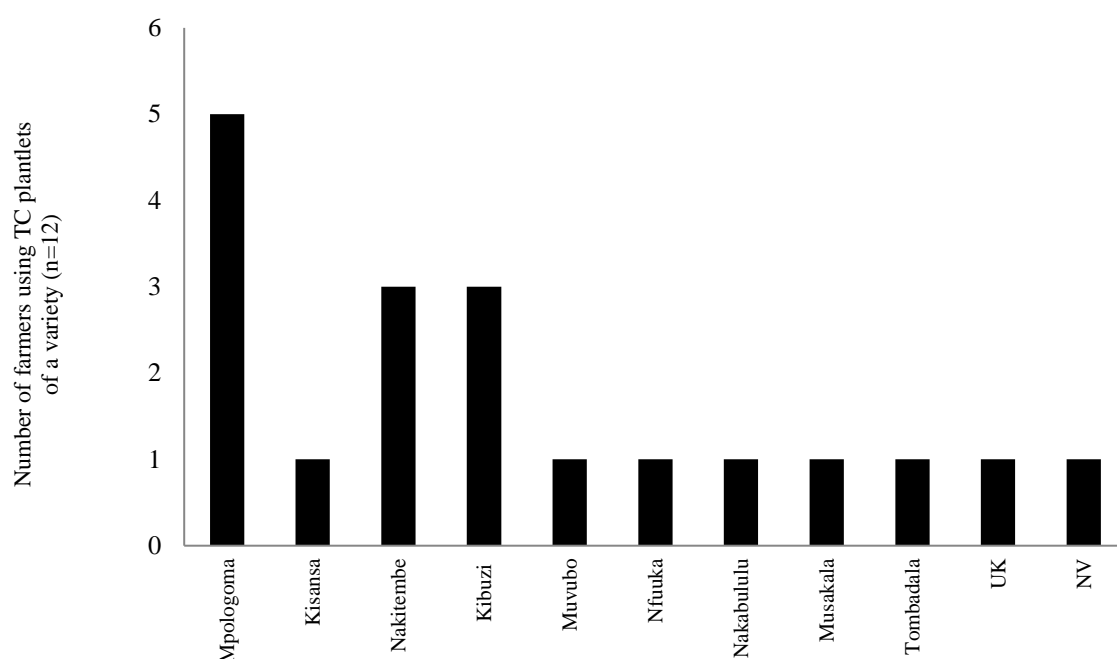


Fig.3.4. Varieties of which farmers obtained TC banana plantlets (n=12). (Source: On farm interviews)

One of the main advantages of TC planting material according to literature is the cleanness of the material. Diseases can easily be transported from farm-to-farm with the exchange of infected planting material. The use of TC plantlets could thus reduce the spread of pests and diseases (Dubois et al., 2006). Only two farmers who used the TCs said they did so because the plantlets are free of pests and diseases. On the other hand, 21 farmers said they would benefit from a source to obtain clean planting material. Two farmers said they would not need a source to obtain clean planting material because they would not be able to pay for the material at

all. Besides that they heard TC material dies easily and she would rather buy and plant suckers instead. All farmers who saw the advantages in clean planting material said that such a source, for example a nursery, should be within the community to be easy accessible for them since most farmers did not have any transportation options. The price farmers said they were willing to pay for a TC plantlet varied from 0 to 2000 UGX. Most farmers said they were willing to pay 500-1000 UGX which is around 0.15-0.30 \$ (table 3.22). The price of TC plantlets at nurseries during the field work was between 2500 – 3000 UGX (≈0.70-0.85 \$).

Table 3.22. Price farmers said they were willing to pay for one TC banana plantlet in Ugandan Shillings (UGX) and US Dollars (USD) (n=21). (Source: On farm interviews)

Price farmers were willing to pay for a TC banana plantlet				n
0	UGX	0	USD	1
500	UGX	0.14	USD	6
1000	UGX	0.28	USD	8
1500	UGX	0.42	USD	3
2000	UGX	0.56	USD	1

## CHAPTER 4. BANANA SUCKER QUALITY

During the on farm interviews the farmers were asked about the process of sucker selection. We asked this question on their own farm and the farmers were able to physically show us the traits they take into consideration while selecting a sucker. Several traits came up regarding the whole mat the sucker is subtracted from, the mother plant to which the sucker is attached and the sucker itself (chapter 3.3.2). Farmers said the main difference in the process of sucker selection on- and off-farm was the opportunity to select suckers yourself. On-farm, farmers have a free choice in sucker selection in contrast to off-farm, where suckers are often uprooted by the owner of the farm. During this choice experiment off-farm sucker sourcing was mimicked to understand how farmers select suckers which are already uprooted and how important is for them to know the variety and the origin of the sucker. As described in chapter 1.4.5 farmers were presented with eight triplets of suckers, among which they had to choose the sucker they preferred (figure 4.1).



Figure 4.1. The 8 sets of planting material, each consisting of 3 suckers which were presented to the farmers. The number given to each sucker is written below.

The sucker preferred for planting differed among farmers. None of the suckers was chosen by all farmers (table 4.1). In total five suckers were not picked by any of the farmers. The varieties and sources of the suckers were not known to the farmers at this point of the experiment.

Table 4.1. Number of farmers preferring a sucker out of 3 suckers presented. Each farmer was presented by 8 sets of suckers. Sources and varieties of the suckers are not known to the farmers. (Source: *perception of quality*)

	1th Sucker	First choice by n farmers	2th Sucker	First choice by n farmers	3th Sucker	First choice by n farmers
Set 1	Sucker 1	0	Sucker 2	6	Sucker 3	2
Set 2	Sucker 4	1	Sucker 5	5	Sucker 6	2
Set 3	Sucker 7	2	Sucker 8	2	Sucker 9	4
Set 4	Sucker 10	0	Sucker 11	7	Sucker 12	1
Set 5	Sucker 13	4	Sucker 14	0	Sucker 15	4
Set 6	Sucker 16	2	Sucker 17	1	Sucker 18	4
Set 7	Sucker 19	5	Sucker 20	0	Sucker 21	3
Set 8	Sucker 22	0	Sucker 23	4	Sucker 24	4

## CHAPTER 4.1 QUALITY CUES, ATTRIBUTES AND PERSONAL VALUES

First the farmers were asked to list the specific plant traits (hereafter referred to as quality cues) on which they based their choice of sucker. The quality cues 'size of the base' and 'size' were named most frequently by the farmers. Larger suckers with a thicker base were mostly preferred over smaller suckers. During the on farm interviews the farmers were also asked to point out preferred suckers but in that case most often smaller suckers (60-70 cm) were preferred. Farmers explained they preferred smaller suckers because large suckers cost a lot of energy to uproot and the mat is more damaged while uprooting large suckers compared to small suckers. Apparently, if the sucker is already uprooted from a fellow farmer's farm, large sucker sizes (maiden suckers) are preferred over smaller suckers (sword suckers). Absence of black spots in the corm was the third most important quality cue named by the farmers. In total the farmers named 11 quality cues on which they based their choice of sucker (table 4.2).

Table 4.2. Frequency of different quality cues mentioned by farmers while variety and source of the sucker were unknown to the farmers (n=8). (Source: *Perception of quality*).

Quality cue	Named by n farmers	Frequency	Relative frequency
Size of the base	8	37	0.25
Size of the sucker	8	36	0.25
Black spots in corm or at the stem base	8	27	0.18
Colour of pseudo stem	8	24	0.16
Leaf sheets at the base/ridges	4	7	0.05
Colour of the base of the pseudo stem	2	6	0.04
Placement of the roots	1	3	0.02
New buds	2	2	0.01
Germination signs (inner leaves coming up)	1	2	0.01
Indication of new roots	1	1	0.01
Compactness pseudo stem	1	1	0.01
Total		146	1.00

After the farmers had listed all the quality cues on which they based their choice they were asked what these cues indicated for them or what the *associated benefits* are (hereafter referred to as attributes). The most frequently named attribute was the generation of a higher income followed by a high survival rate and a less frequent need for replanting. In total the farmers named 31 attributes related to the 11 quality cues (table 4.3).

Table 4.3. Frequency of different quality attributes mentioned by farmers while variety and source of the sucker were unknown to the farmers (n=8). (Source: *Perception of quality*).

Quality attribute	Named by <i>n</i> farmers	Frequency	Relative frequency
Higher income	8	47	0.18
High survival rate	8	27	0.11
Less frequent replanting needed	8	24	0.09
Time saving	6	13	0.05
Higher yield	7	13	0.05
Big bunch size	7	12	0.05
Less labour/management needed	5	10	0.04
High market demand	5	9	0.04
Age of mat/plantation sucker was subtracted from	4	9	0.04
No weevil infection	8	8	0.03
Maturation fast	7	8	0.03
Vigorous growth	5	8	0.03
Quick income	5	7	0.03
High rate of suckering	5	7	0.03
Fast germination	3	7	0.03
Type of variety	6	6	0.02
Quick food	4	6	0.02
Less pesticides needed	4	6	0.02
Less risk of disease transfer	5	6	0.02
Drought resistance	4	4	0.02
Origin nutritious place	2	4	0.02
Food reserves	1	2	0.01
Resistance to pests and diseases	1	2	0.01
Looks nice	1	2	0.01
Less manure needed	1	2	0.01
Less off-farm sourcing needed	1	2	0.01
Easy to transport	1	1	0.00
Sustain livestock	1	1	0.00
Soil quality	1	1	0.00
Distance between sucker and mother plant	1	1	0.00
Be able to give an share	1	1	0.00
Total		255	1.00

After the farmers named the quality attributes associated with each quality cues they were asked about the importance of those attributes to the farmers personally (hereafter referred to as personal values). The ability to pay for the children's school fees was the most frequently named personal value among the farmers. Food securities and meeting responsibility were named thereafter as most important. In total the farmers named 17 personal values associated with the quality attributes (table 4.4).

Table 4.4. Frequency of different personal values mentioned by farmers while variety and source of the sucker were unknown to the farmers (n=8). (Source: *Perception of quality*).

Personal value	Named by <i>n</i> farmers	Frequency	Relative frequency
Be able to pay school fees for the children	7	42	0.37
Food security for the household	8	16	0.14
Meet responsibilities	2	11	0.10
Sustain the family	5	10	0.09
Have time for other activities in the household	4	7	0.06
Saves energy	2	5	0.04
Security for the household	3	5	0.04
Less risk destroyed plantation	2	4	0.04
Healthy family	2	3	0.03
Meet direct needs	1	2	0.02
Become respected	1	2	0.02
Satisfaction	2	2	0.02
Have more family time	1	1	0.01
Expect reciprocity	1	1	0.01
Good relationship fellow farmers	1	1	0.01
Independence	1	1	0.01
Pleasure	1	1	0.01
Total		114	1.00

How each cue, attribute and personal value is connected is schematically presented in diagrams which can be found in appendix 3. One example for the diagram made for the quality cue 'size of the base' is presented in figure 4.2. The diagrams were made by mapping each ladder constructed by a farmer and adding a value to each time a similar ladder was made. The most important and interesting connections are here described:

- Size of the base was the quality cue most frequently named by the farmers. Several benefits have been attributed to this quality cue. The size of the base mainly gave an indication to the farmers about the chances of survival, the rate of suckering and the bunch size that will be produced once the plant is mature (figure 4.2). Suckers with a broader base are expected to have a higher survival rate. When the survival rate is higher farmers less frequently need to replant. This saves the farmers time and labour, and leads to a higher yield and income. The related personal benefits for most farmers were food security, money for school fees and more energy and time for other activities in the household.

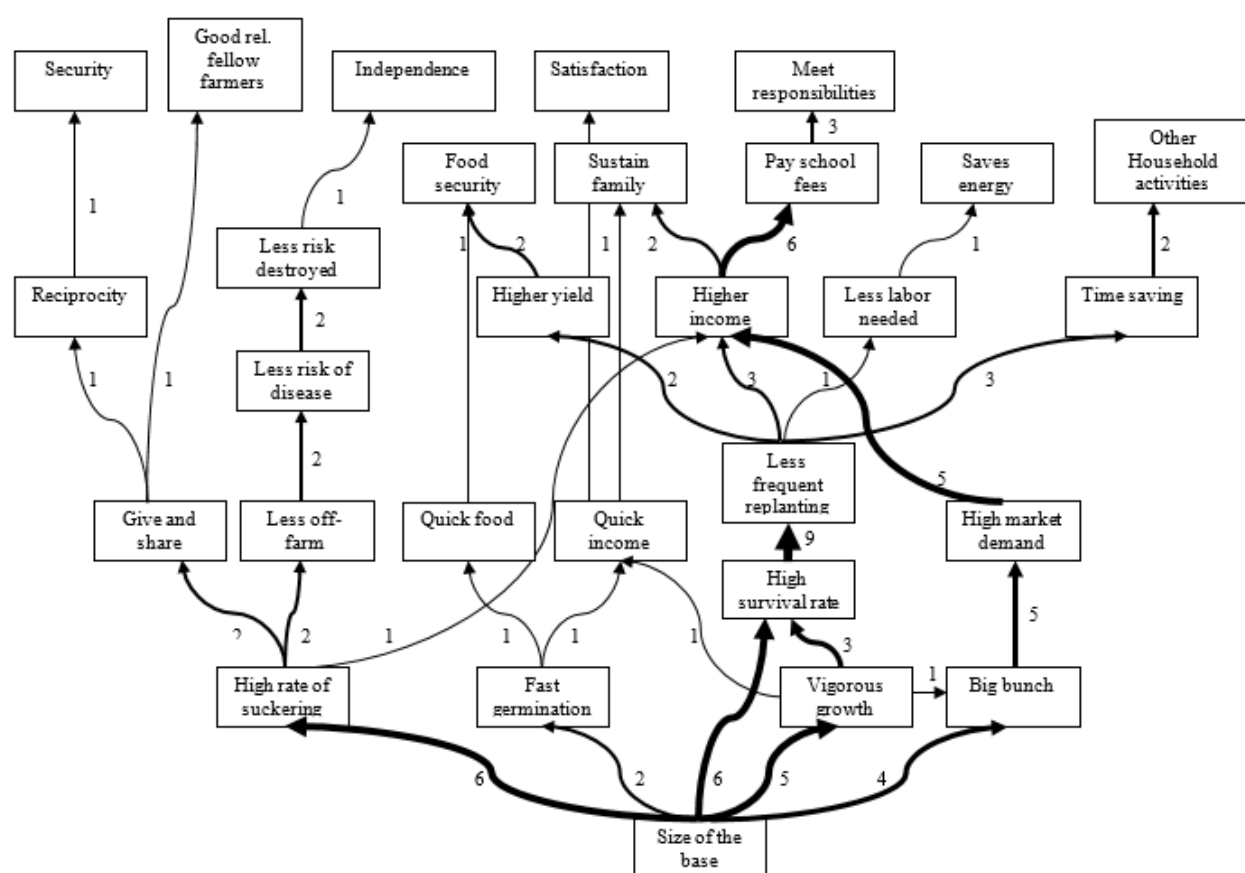


Figure 4.2. Diagram of the quality cue big base, the attributes related to the quality cues and the personal values.

- The colour of the stem and the base had two main related attributes. First, black mottle on the stem indicates for the farmers that the sucker belongs to a cooking variety. Cooking varieties are preferred because they are easier sold on the market and because they secure the household of sufficient food. For some farmers the intensity/darkness of the black mottle as well as a darker more purplish base meant that the sucker was subtracted from a nutritious place. This indicated that the sucker will grow vigorously, will give big bunches and that less manure is needed.
- The farmers explained they did not prefer suckers where ridges are present at the base (figure 4.3). According to the farmers this indicates that the sucker grew partly above the soil surface and probably was subtracted from a very old mat and therefore had a lower survival rate. Ridges were not preferred by any of the farmers. Nevertheless regarding the presence of leaf sheets, which also indicates that the sucker is subtracted from an older mat, the responses among farmers differed. Some farmers did not mind if a sucker was subtracted from a somewhat older mat because this also meant the mat had been able to survive some years and probably had built up some resistance to pests and diseases. Other farmers preferred suckers without ridges or leaf sheets because it meant that the sucker came from a young mat and would therefore grow vigorous. Similar to ridges and leaf sheets the placement of the roots also indicated for some farmers if the sucker was subtracted from an old or young mat. If the roots were only present at the bottom of the sucker and not at the sides this would mean it was subtracted from an older mat.



Figure 4.3. Ridges and old leaf sheets at the base of a sucker. A) Sucker with ridges at the base, this indicates the sucker grew above the soil surface and was subtracted from a very old mat. B) Sucker where old leaf sheets were present, this indicates the sucker was subtracted from an older mat. C) sucker with no ridges and no old leaf sheets, this indicates that the sucker is subtracted from a young mat.

- The expected rate of suckering was an important quality attribute to most farmers and several cues were named that would lead to a high suckering rate namely; a big base, presence of new buds and size of the sucker. A high rate of suckering was preferred because less sourcing off-farm would be needed. When sourcing is done less off-farm the risk of disease transfer also becomes smaller. Having more suckers available on-farm also made the farmers feel more independent and secure. Furthermore the farmers would be able to give and share more suckers which leads to a better relationship with fellow farmers and secured the farmers because they could expect suckers in return when they had a shortage themselves.

## CHAPTER 4.2 INFLUENCE OF VARIETY ON SUCKER SELECTION

After making their choice of sucker the farmers were asked if they wanted to know the variety or source of the suckers. In total the farmers asked the researcher to reveal the variety of a set of suckers 48 times. Farmers changed their preferred sucker 13 times after revelation of the variety. Nakitembe was the variety most preferred by farmers followed by Mpologoma and Muvubo. Mpologoma is in contrast to Nakitembe and Muvubo a non-traditional variety which was introduced into the area. Some farmers did only prefer traditional varieties and others were very fond of the variety Mpologoma due to the big bunches it gives. One of the farmers who picked the sucker of Mpologoma when the varieties were still unknown was very happy after the revelation of the varieties; she started to laugh and said she was very proud of herself being able to pick the sucker of Mpologoma. She said she was a 100% sure she wanted to sustain her choice of sucker. The least preferred varieties were Tombadala and FHIA, both improved and/or introduced varieties (table 4.5). In one of the sets of planting material, three suckers of FHIA were present. After the varieties of this set were revealed four farmers said they would not even take one of the suckers because they did not like the variety. Having a bad taste was the most frequently named reason why farmers did not like FHIA.

Table 4.5 Number of times a variety was preferred by a farmer (n=8) (Source: *Perception of quality*)

Variety	Nakitembe	Mpologoma	Muvubo	Nakabululu	Tombadala	FHIA
Number of times preferred by farmer	21	11	9	2	1	1

In general 22 quality attributes associated with variety were named by the farmers as motivation to sustain or change their choice of sucker (table 4.6). The quality attributes most named were taste, bunch size and marketability of the bunches.

Table 4.6. Frequency of different quality attributes mentioned by farmers after revelation of variety (n=8). (Source: *Perception of quality*).

Quality cue	frequency	relative frequency
Taste	21	0.16
Bunch size	19	0.14
Marketability bunches	14	0.10
Maturity time	13	0.10
Lifespan	11	0.08
Rate of suckering	10	0.07
Finger size	9	0.07
Drought resistance	8	0.06
Invasiveness	4	0.03
New variety	4	0.03
Number of bunches given/mat	3	0.02
Weevil resistance	3	0.02
Bunch type	3	0.02
Disease resistance	2	0.01
Marketability suckers	2	0.01
Management requirements	2	0.01
Soil selectiveness	1	0.01
Number of hands	1	0.01
Input requirements	1	0.01
Flowering time	1	0.01
Cultural value of variety	1	0.01
Status given by variety	1	0.01
total	134	1.00

Not all farmers changed to the same sucker after revelation of the varieties. For example in set 4 one farmer chose the sucker of Nakitembe initially and changed to Muvubo in contrast to another farmer who initially choose Muvubo but changed to Nakitembe. Similarly a specific cue named a positive by a farmer was not necessarily also experienced as a positive cue by another farmer. For example, a low rate of suckering of the variety Muvubo was considered as negative by one farmer because it did not provided him enough seed supply but positive by another farmer because it required less management as de-suckering is not needed. It also depended on variety if a cue was considered positive or negative. A high rate of suckering was experienced as positive for Nakitembe because it provides a source of new planting material. In contrast, it was experienced as negative in Tombadala because the rate of suckering is that high, the variety becomes invasive and farmers can hardly get rid of it. Because of its low market demand, replanting of suckers of Tombadala is rarely done. Therefore all excess suckers are useless and need to be destroyed. A more elaborate list of positive and negative traits of each variety can be found in appendix 4.

Farmers did also base their choice of variety on the type of varieties that were already present on their farm. Some farmers preferred varieties they already had because they had similar flowering and maturity times. Therefore they would bare bunches at the same time generating a high income at one point. For the same reason farmers liked varieties that gave multiple bunches on one mat at the same time. In contrast, other farmers said they would rather obtain a rare variety to increase the diversity of varieties on their farm. All varieties have a different time to flowering and a different maturity time. This would ensure the farmer that a bunch would be present at all times instead of a lot of bunches at once. In that way the household would be secured of food. Farmers also diversified their plantation with varieties to spread risks. If only one variety would be present on the farm and it would be affected they would lose all their mats.

## CHAPTER 4.3 INFLUENCE OF SOURCE ON SUCKER SELECTION

Only seven times the farmers asked the researcher to reveal the source of the suckers. None of the farmers changed their choice of sucker in after revelation of the sources of the suckers. To know the origin of the suckers was not that important to all farmers. Some farmers said off-farm sucker sourcing was common in their area and therefore they rather knew the variety instead of the source. To some farmers source was important, but since all sources were located in the community and were considered “good” sources there was no more need to get to know the sources behind each set. Farmers made several remarks on the sources such as: *“I know the owner of the plantation manages his farm well”* and *“I know that farmer, he just replanted a piece of his plantation, so I know the suckers come from young mats”*. Possibly source would have been more interesting to farmers if a formal source such as NAADS or NARO was added to the experiment. One of the farmers said:

*“I was very curious about the sources at first because one of you said he is working for NARO. NARO usually gives out interesting new varieties. Now I know all sources are farmers within the community I am not so interested anymore in the sources”.*

# CHAPTER 5. NETWORK ANALYSIS ON TISSUE CULTURE BANANA PLANTLETS

As described in the introduction, tissue culture banana plantlets (TC's) have been promoted via several programs to combat disease spread via planting material. In the study area TC bananas can be obtained by the farmers from 3 sources namely; via the National Agricultural Advisory Services (NAADS), from a TC nursery or directly from a TC producing laboratory. Key informant interviews were held with laboratory owners/operators, nursery owners/operators, and NAADS staff or volunteers to better understand the network of TC bananas as described in chapter 1.4.4. These interviews also were the starting point for a network analysis. Nursery owners/operators were asked for a client list and NAADS staff was asked if they knew any previous NAADS beneficiaries: these listings were used as the starting point for a network analysis. Such a network analysis is meant to show how TC planting material reaches the farmers, which type of farmers have access to the planting material and if suckers originating from TC material are shared with fellow farmers. In the next chapters the 3 sources for TC planting material will be described with the focus on; the number of plantlets produced/distributed/sold, the varieties of the TC plantlets produced/distributed/sold, the targeting of farmers, the type of farmers that buy TC and the promotion of TC plantlets by the organization/company.

## CHAPTER 5.1 PRODUCTION AND DISTRIBUTION OF TC BANANA PLANTLETS IN TC LABORATORIES

Mukono district is supplied with TC banana plantlets produced in five different laboratories. Two laboratories are part public sector institutions. The College of Agriculture and Environmental Sciences at Makerere University has a functional laboratory where TC banana plantlets are produced. The National Agricultural Research Organization (NARO) also has a research base where TC banana plantlets are produced. No farmers receiving TC plantlets from those research institutes have been encountered during the research. The remaining 3 laboratories are commercial and have as main objective the production and distribution of plantlets instead of research. The biggest among them is Agro Genetic Technologies (AGT) with an annual production over 8 million plantlets (Dubois et al., 2016). AGT supplies multiple districts in Uganda and even exports to bordering countries. All tissue culture nurseries identified in the study area were supplied by AGT laboratories. BIO-CROPS is a smaller laboratory situated in Kampala but was supplying none of the nurseries or farmer involved in this study. New Page Agriculture Enterprise (NPAE) is the youngest among the laboratories and is only operational since 2014. NPAE was supplying one of the nurseries in the study area. Due to time constraints only the NPAE laboratory could be visited for an interview. The laboratories supply two types of plantlets to farmers and nurseries. The first type concerns very young plantlets which first have to be further hardened in a protected environment like a nursery bed. The second type concerns “ready-to-plant” plantlets which are sufficiently developed to be directly transplanted to the field.

### 5.1.1 NEW PAGE AGRICULTURE ENTERPRISE

The owner of New Agriculture Enterprise established the TC laboratory in 2014 together with his wife. In the beginning of 2014 he conceived the idea to start a laboratory when he noticed farmers experienced shortages in suckers. The owner of the laboratory has no special background in agriculture himself but is supported by a staff member of Makerere University for technical assistance. The laboratory owner and his wife had an empty house, located in Jinja, which they transformed into a laboratory after buying the required equipment. At the moment the laboratory is exclusively producing banana plantlets but they are planning to produce sweet and Irish potato plantlets in the future. The laboratory owner explains:

*“BXW and other diseases are currently threatening banana production in Uganda which creates the need for clean planting material. At the moment there is only one prominent TC banana laboratory, the AGT laboratory, and there are 2 or 3 other starting laboratories. Banana is a prominent cash crop and in Uganda, we see the gap in the market which we are trying to fill.”*

At the moment the laboratory produces eight different varieties and is starting with the ninth. Which varieties are multiply and in which quantities is determined by the farmers. Previously to the operation of the laboratory a market research was carried out in cooperation with Makerere University. The laboratory owner explains they have close contact with their customers and therefore they know which varieties are desired. Besides that they move around a lot in the area and closely monitor what the farmers are currently growing:

*“The abundance of each variety is typical for each area and it differs locally which varieties farmers prefer to grow. Mpologoma is for example preferred in areas with sufficient rain, Kibuzi in areas where bananas are grown for export and the high demand for Nakitembe is due to its higher disease resistance.”*

In which amounts the laboratory produces each variety is not only driven by demand but also by the laboratory conditions. Some varieties respond better to the environment in the laboratory and can therefore be produced in a higher rate. What causes this difference is still being investigated. Mpologoma and Kisansa are the varieties that are currently needed in greater numbers. The laboratory owner advises farmers in dryer areas to grow Kisansa and farmers in areas which are well rain fed to grow Mpologoma. Both varieties give big bunches but Mpologoma is not drought resistant and Kisansa has a longer maturity time. The demand for Kibuzi Nfuuka and Atwalira is lower because they perform better in other areas which supplying are not yet supplied by the laboratory. TC banana plantlets are promoted by the laboratory on agricultural shows, social media and by personal approach. The clients of the laboratory are mainly located outside Jinja district. In Jinja, he explains, farmers have a problem with land tenure as most people do not own a large area of land and there is no space for farmers to expand. The TC technology is most interesting for farmers that plant to go commercial. The material is clean, high yielding, available in large quantities, uniform and less bulky to transport compared to suckers. However, the laboratory does not only target to supply commercial farmers but also small scale farmers because of the need for clean planting material due to diseases such as BXW.

The starting material the laboratory uses to create TC plantlets comes from NARO and a farm established by the government. These sources are used because they are known to the laboratory owner and they can be trusted. The laboratory currently tries to establish their own mother garden so a farmer can come over and pick the mats of which (s)he wants TC plantlets produced. The laboratory thinks in this way problems with “wrong or different varieties” can be overcome. The NPAE laboratory has faced problems with mix up of varieties:

*“One time a nursery owner came with an order. The varieties he ordered were not available in the right quantities at our laboratory. When I told him the right varieties were not in stock he decided to take FHIA, which is cheaper, to fill up his order and meet his target. In this way distributors can spoil our name because plantlets cannot be identified until the plants are mature. The farmer will never be able to tell were in the process the plantlets were mixed. Because varieties cannot be identified the problem of mix up can be in the whole chain of distribution. They can be mixed in the laboratory, among the NAADS distributors, in the nurseries and by the middleman”.*

One of the future objectives of the laboratory is to start supplying NAADS. At the moment the laboratory is not supplying for NAADS because the suppliers are already on contract. The laboratory plans to work with them in the future when new contracts are being made. The laboratory owner thinks a partnership with NAADS will be beneficial because it will give them more security how many plantlets need to be produced. At the moment the laboratory has difficulties to predict what needs to be in stock:

*“This year we produced around 20.000 plantlets and we have a capacity of 100.000 plantlets. Due to the unpredictability of the rain, and because the technology is new to most farmers, we have not been able to produce to full capacity.”*

The biggest challenge for the laboratory is the unfamiliarity of farmers with the technology; the technology is not on the market that long, a lot of farmers do not even know that the plantlets exist and a large share of the ones that do know, do not know the benefits and the amount of money that can be made TC. Besides that the laboratory owner explains that previous interventions complicate the adoption of TC bananas.

*“The improvement of banana production started with the FHIA line. FHIA was distributed among farmers but people hated it and that is why they now fear new technologies. They expect you to come again with those improved varieties but with the TC technology traditional varieties are just multiplied.”*



Figure 5.1. Pictures taken during the visit at NPAAE in December 2016. From left to right: shoot tips are placed at a rooting medium, new shoot tips appear which are again transplanted to a rooting medium, the young plantlets are transplanted and brought to a hardening nursery, when the plantlets are large enough they are placed in larger bags to get adapted to field conditions.

## CHAPTER 5.2 DISTRIBUTION OF TC BANANA PLANTLETS BY THE NATIONAL AGRICULTURAL ADVISORY SERVICES (NAADS)

NAADS has been involved in the distribution of TC plantlets (Kikulwe, 2016). In this chapter first some background information about NAADS is given. Furthermore it is described how NAADS distributed TC plantlets and how farmers were targeted.

### 5.2.1 BACKGROUND INFORMATION OF THE NATIONAL AGRICULTURAL SERVICES

The National Agricultural Advisory Services (NAADS) became functional in 2001 as part of the Plan of Modernization of Agriculture (PMA) of the government of Uganda. The PMA has been implemented to reduce poverty by implementing multi-sectoral interventions which enable the people to improve their livelihoods in a sustainable manner (Diaz, n.d.). NAADS was implemented as an advisory service which would not just deliver messages and inputs to the farmers but would engage them in critical thinking about their farming activities. From the beginning NAADS was to be a bottom-up organization as in the PMA is stated “The work programs and activities of the advisors will be determined by the farmers themselves. The advisors will therefore effectively become de facto employees to farmers, rendering advisory services to help famers make better decisions on their farm” (Diaz, n.d.). The NAADS program knew two phases and has entered a “third” phase in 2014, which is slightly different than the original plan. Locally the new phase of NAADS is referred to as “an army takeover”. The new program of NAADS was indeed to be carried out partly by the army (Uganda People’s

Defense Forces-UPDF). At the 9<sup>th</sup> of June 2014 President Museveni of Uganda announced he would scrap NAADS coordinators and deploy soldiers in every district to monitor the programs of NAADS. The president accused NAADS coordinators of failing programs that should have improved household incomes through agriculture (Wesaka, 2014). Over 300 UPDF soldiers completed an introduction course in agriculture at the Makerere University (figure 5.2) (Rwakakamba & Lukwago, 2014). NAADS writes on its website:

*“Operation Wealth Creation (OWC) is an initiative by H.E the President of the Republic of Uganda aimed at engaging the UPDF in improving household incomes by providing support in the coordination of NAADS activities at community level. This was in recognition of the role of the UPDF in spearheading the liberation struggle. As a result therefore, the NAADS staff in District Local Governments was relieved of their duties to pave way for a single spine mode of extension approach to be implemented directly under the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).”*



Figure 5.2. UPDF Officers who underwent induction training course in agriculture at Makerere University. Source image: Rwakakamba & Lukwago, 2014.

### 5.2.2 STRUCTURE AND FUNCTIONING

During a key informant interview with a local youth councilor the structure of NAADS before the army takeover was given (figure 5.4). The youth councilor also told some details about the functioning of NAADS:

*“During phase I of NAADS it was difficult for individual farmers to benefit because demonstrations and materials were given to farmers within a farmers group. During phase II individual farmers were also targeted by trying to make them create, and subscribe to, farmers groups. Another difference that was made in NAADS phase II was the classification of farmers as home consumption, market oriented and commercial farmers. For each of the three types of farmers a budget was reserved which could be used*

to acquaint materials. For commercial farmers this budget was 1.600.000 UGX and for food security farmers 100.000 UGX. Of these investments, the farmers had to pay back 75%. Of the different types of farmers, commercial and market oriented farmers were most interested in TC banana plantlets. For home consumption farmers the TC bananas were not so attractive because they were not familiar with them and they did not like the taste that much. After farmers made their request for the type of planting material they wanted to receive, all the requests were given to the NAADS coordinator. The team at the sub-county would meet with the suppliers who had the opportunity to promote themselves to the procurement committee as suitable supplier. The procurement committee made their choice among the suppliers. When the materials were delivered by the suppliers it was thereafter distributed among the farmers. This whole procedure has changed now. Operation Wealth Creation stimulates the growth of coffee, cocoa and citrus fruits because they believe these will get people out of poverty. I have been the only one getting TC banana plantlets this year in this area, because I am the councilor and I am still volunteering for NAADS currently. When material needs to be distributed I help mobilizing famers. Besides that my place is available to put the planting material because otherwise the plantlets do not reach the farmers. My place used to be a distribution place but still, it does not always work to distribute the plantlets. As you can see I have a lot of young cocoa plantlets lying over there which were not taken by farmers (figure 5.3). They do not have the land for such big trees over here. I know the demand for TC banana plantlets is there because we distributed a lot before the NAADS reorganization, but they have not been distributing them this year.”



Figure 5.3. Bags filled with young cocoa plants which were not taken by the farmers.

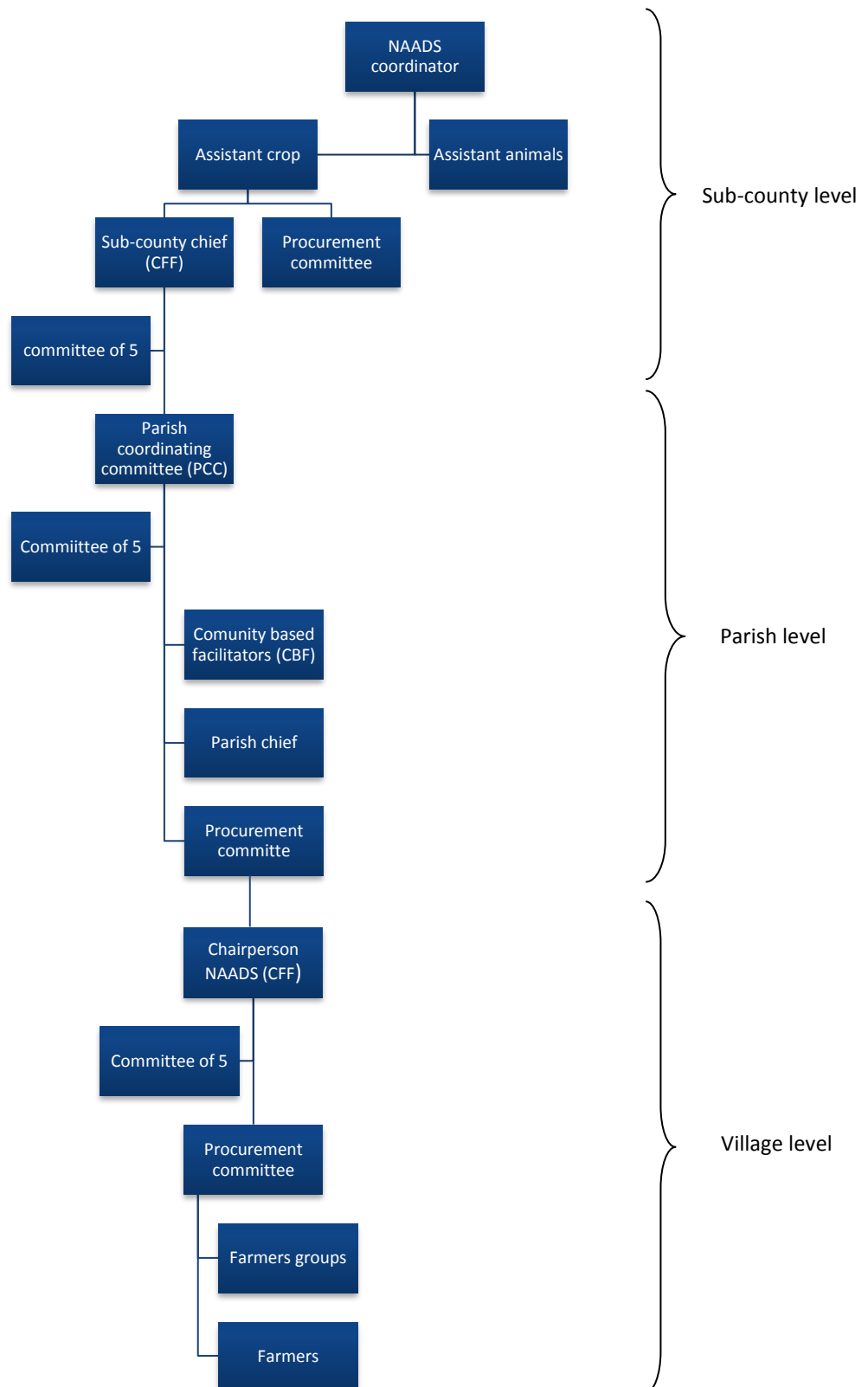


Figure 5.4. The structure of NAADS, before reorganization, from the sub county level to the village level.  
(Based on interview local youth councilor)

### 5.2.3 DISTRIBUTION OF TC BANANA PLANTLETS BY NAADS

To understand the targeting of beneficiaries receiving TC banana plantlets, key informant interviews were held with people of different positions in NAADS namely; a member of the Parish Coordinating Comity (PCC), a community based facilitator (CBF) and a member of the Village Farmer Forum (VFF). Despite those interviews the picture remained quite blurry and stories were contradicting. This might be explained by a different procedure used in each parish<sup>1</sup>, but since the interviews were held with people who had been working in the same sub-county one would expect some more similarities in procedure. What remained most unclear was the decision making which farmers would receive planting material and which farmers would not. During none of the key informant interviews we got a clear explanation. Nevertheless, what was confirmed during all three interviews was that farmers had to put in a request for TC bananas if they wanted to receive them, that the farmers/farms would be evaluated to see if they were able to sustain the plantlets and that the farmers had to attend trainings about TC maintenance in advance. The number of plantlets a farmer could receive depended on the farm type (200-400 for commercial/marked oriented and 40-60 for home consumption). Besides that, each farmer was supposed to receive TC planting material only once and thereafter had to multiply using this material. Farmers were encouraged to share the suckers originating from the TC material with fellow farmers. Furthermore during all interviews it was confirmed that; the procedure had changed after NAADS reorganization, that no TC plantlets were distributed afterwards and all of them said they currently had no active role in the NAADS program.

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<sup>1</sup> Regions in Uganda are divided into districts, which are divided into sub-counties, which are divided into parishes, which are divided into villages.

## CHAPTER 5.3 TISSUE CULTURE BANANA NURSERIES

The operators of three nurseries were interviewed: Alinyikira nursery bed, Mpekke nursery and Ideal Farm enterprises. The operators of all tree nurseries said that TC banana plantlets were mainly distributed on behalf of NAADS. Since NAADS is not distributing TC banana plantlets anymore in the area since the reorganization, the sales of two of the nurseries dropped drastically. The other nursery which has been mainly supplying directly to farmers instead of on behalf of NAADS had an increase in the number of plantlets sold.

## CHAPTER 5.4 NETWORK ANALYSIS OF TC BANANA PLANTLETS

To understand how TC material spreads among farmers, interviews were held with NAADS beneficiaries, nursery clients and laboratory clients. As described in the method of the network analysis 26 first generation farmers were identified of which 12 were NAADS beneficiaries and 14 nursery/laboratory clients. Some farmers were both a NAADS beneficiary and a nursery/laboratory client; two NAADS beneficiaries received TC plantlets twice and 9 farmers were both NAADS beneficiary and nursery/laboratory client. In case a farmer received TC plantlets from both sources they were interviewed about both sources. Therefore the actual number of first generation farmers was only 17.

Out of the 17 first generation farmers 14 said to have provided other farmers with planting material originating from TC. These 14 farmers said to have provided a total of 119 farmers with planting material. In two cases not suckers were given to a fellow farmer but a part of the TC plantlets was given. Out of these 119 farmers the number of second generation farmers we could actually follow up was 16. Those 16 second generation farmers said to have shared with 12 farmer in total of which 2 could be followed up. The reason why we were unable to follow up on the second generation farmers differed. In most cases the farmers could not remember who they provided with seeds or the farmer did not want to give out contact details of recipients to strangers

Both among the NAADS beneficiaries and nursery/laboratory clients there were more male farmers as female farmers. Among the recipients of suckers or a share of the TC's there was no difference in gender. Among the NAADS beneficiaries were more old and middle aged farmers as young farmers. Among the nursery/laboratory clients and recipients the middle aged farmers were the largest group. Most of the NAADS beneficiaries belonged to rich or medium wealthy households. Most of the nursery/laboratory clients belonged to rich households and recipients were among each class of wealth. The distribution among wealth classes seemed to be more equal among the NAADS beneficiaries compared to the nursery/laboratory clients of which most were classified as rich farmers. Still the proportion of rich farmers among the NAADS beneficiaries was highest. The higher proportion of rich farmers among the nursery clients is plausible since the price of TC planting material is considered as high in the research area (chapter 3.5). NAADS beneficiaries and nursery/laboratory clients had all farm sizes. Medium scale banana farmers were the largest groups among the NAADS beneficiaries, nursery/laboratory clients and recipients. None of the recipients was a large scale farmer (Table 5.6).

Table 5.6. Socio-economic properties of the NAADS beneficiaries, nursery/laboratory clients who made use of TC banana and of the recipients of planting material originating from TC material (n=44). (Source: Network analysis).

	NAADS beneficiaries (n=12)	Nursery/laboratory clients (n=14)	Recipients (n=18)
Male farmers	8	10	9
Female farmers	4	4	9
Male headed households	9	11	14
Female headed household	3	3	4
Old farmers	6	4	2
Middle aged farmers	5	9	10
Young farmers	1	1	6
Rich households	6	10	5
Medium wealthy households	4	3	5
Poor households	2	1	8
Large scale banana farms	3	4	0
Medium scale banana farms	7	8	12
Small scale banana farms	2	2	6

### 5.4.1 FIRST GENERATION FARMERS

Farmers had several motives to obtain TC banana plantlets. In total 19 reasons were given by the farmers. Among the NAADS beneficiaries the most important reason was because NAADS was distributing them followed by high yield and because the plantlets were promoted in a research program or by the government. The main reason for nursery or laboratory clients to acquire the plantlets was because of high yield, the high income which can be generated with TC material and because the plantlets reach the stage of flowering early (table 5.7).

Table 5.7. Motivations of NAADS beneficiaries and nursery/laboratory clients to make use of TC banana plantlets (n=26). (Method: free listing ; source: Network analysis)

Motivations given by the farmers to make use of TC banana plantlets (n=19)	NAADS beneficiary (n=12)	Nursery or laboratory clients (n=14)	Total (n=26)
TC plantlets give a high yield	6	6	12
TC planting material generates a high income	3	4	7
TC planting material was promoted by the government or in trainings	5	2	7
NAADS was distributing TC plantlets	7	0	7
TC plantlets reach the state of flowering early/grow fast	2	4	6
I saw a farm with TC planting material that was performing very well	3	1	4
TC plantlets have a high survival rate	0	3	3
TC plantlets are free of diseases	0	3	3
I was expanding my area	0	3	3
There were not enough suckers available for planting	2	1	3
TC plantlets are easier to transport than suckers	0	2	2
TC plantlets are available in the varieties and quantities you wish	1	1	2
TC planting material was recommended by a friend	0	2	2
There was food scarcity	2	0	2
The number of TC plantlets NAADS was giving out was insufficient so I had to add on with TC plantlets form a nursery	0	1	1
I do not know how to produce TC plantlets myself	0	1	1
To combat BXW I obtained TC plantlets	1	0	1
I wanted new, young planting material	0	1	1

The 10 farmers which obtained TC plantlets from NAADS and a nursery/laboratory all obtained TC plantlets first via NAADS and afterwards went to a nursery or laboratory. The material which they provided to a fellow farmer also originated from the NAADS material in all cases. The main motivation behind this was the time of acquisition. The time between both acquisitions differed between two and 15 years and was averagely six years. The NAADS material was obtained by most farmers between 2008 and 2010 and the nursery/laboratory material between 2015 and 2016 (table 5.8). Most farmers said they were not able to share the material they obtained from the nursery because it was still young and did not yet give any suckers or because they first had to multiply the material themselves.

Table 5.8. Year of acquaintance of TC banana plantlets among farmers who received material from NAADS as well as from a nursery or laboratory (n=10). (Source: *Network analysis*)

Farmer	Year of acquaintance NAADS material	Year of acquaintance Nursery/lab material	Difference in years
1	2008	2015	7
3	2008	2015	7
4	2010	2016	6
5	2008 & 2010	2016	6
6	2013	2015	2
7	2008	2011	3
8	2010	2015	5
9	2001	2016	15
10	2010	2010	0
average	2009	2014	6

Large scale farmers received a higher number of TC plantlets via the NAADS program compared to medium and small scale banana farmers (table 5.9). This is in line with the information given in the key informant interviews in chapter 5.2 where is described that NAADS made a division among households in its second phase. Households were classified by NAADS as home consumption farmers, market oriented farmers and commercial farmers. Commercial farmers who had at least one acre of land available could obtain 450 plantlets in total which is sufficient for 1 ace of land if the ideal plant density given by NAADS is used. Market oriented farmers could obtain between 20 and 25 plantlets from NAADS according to the farmers.

The highest number of plantlets obtained by nursery clients was higher compared to the number given out by NAADS. Also the average number of plantlets obtained was higher among nursery/laboratory clients compared to NAADS beneficiaries.

Table 5.9. Number of TC plantlets obtained among NAADS beneficiaries and Nursery clients per wealth class and farm size (n=26). (Source: *Network analysis*).

	NAADS beneficiaries (n=12)			Nursery/laboratory clients (n=14)		
Highest number of TC plantlets obtained per farmer			400			600
Lowest number of TC plantlets obtained per farmer			5			20
Average number of TC plantlets obtained per farmer			89			141
Average number of plantlets obtained per social class	n	Average plantation size	Number of TC plantlets	n	Average plantation size	Number of TC plantlets
Rich households	6	4.8	122	10	3.5	177
Medium wealthy households	4	1.4	63	3	1.7	60
Poor households	2	1.0	23	1	0.5	30
Large scale banana farmers	3	8.0	300	4	6.6	223
Medium scale banana farmers	7	1.6	25	8	1.7	116
Small scale banana farmers	2	0.5	25	2	0.5	80

Farmers using TC's had their main focus on the cultivation of cooking varieties. Averagely 93.6% of the cultivated bananas were food varieties, 0.3% beer varieties and 6.1% dessert varieties. TC plantlets of 13 different varieties were acquired by the farmers of which 10 were cooking varieties. The diversity of varieties was mainly given out via the NAADS program as all 13 varieties were distributed by NAADS. At the nurseries and laboratories on the other hand only five different varieties were obtained (table 5.10). The results show that Mpologoma and Kisansa are the most popular varieties to obtain TC's from. The high numbers for the varieties Mpologoma and Kisansa are mainly caused by the orders of two large scale/commercial farmers that obtained a total of 450 plantlets. The reason why among the nursery/laboratory clients Mpologoma was not the most popular variety can be explained by one incident. One of the farmers told he placed an order of 500 TC plantlets of the variety Mpologoma at Alinyikira nursery bed but received only 100. Of the remaining plantlets 400 were of the variety Kisansa which has led to the high number of Kisansa plantlets. We asked the farmer if he was angry he received so many plantlets of the wrong variety and he replied: *"I am not angry and I would even purchase plantlets there again. I understand Ugandans have to be creative."*

Table 5.10. Number of TC plantlets obtained among NAADS beneficiaries (n=12) and nursery/laboratory clients (n=14) in total and averagely per farmer. (Source: Network analysis)

Variety	NAADS beneficiaries (n=12)			Nursery clients (n=14)		
	n	Total number of plantlets per variety	Average number of plantlets per farmer	n	Total number of plantlets per variety	Average number of plantlets per farmer
Mpologoma	7	659	94	14	720	51
Kisansa	4	152	38	7	850	121
Kibuzi	1	25	25	3	260	87
Nakitembe	5	83	17	4	110	28
Unknown*	5	79	16	1	40	40
Mwazirume	1	25	25	-	-	-
Musakala	1	25	25	-	-	-
Gonja	1	25	25	-	-	-
Mbidde	1	25	25	-	-	-
Bogoya	1	25	25	-	-	-
Nfuuka	2	10	5	-	-	-
Nandigobe	1	5	5	-	-	-
Nabomba	1	9	9	-	-	-
FHIA	1	5	5	-	-	-

\* In some cases farmers were unable to identify the variety they had obtained.

The farmers were asked about their main motivations behind the varieties they obtained. The reasons varied between NAADS beneficiaries and nursery/laboratory clients (table 5.11). When we asked the NAADS beneficiaries about their motivations most of them replied they did not receive the varieties they ordered. In total 16 farmers replied to have received the wrong varieties. 13 of these complaints were among the NAADS beneficiaries and 3 among the nursery/laboratory clients. Most of the time when a wrong variety was received the farmers actually placed an order for plantlets of the variety Mpologoma.

The top 3 explanations for variety choice among nursery/laboratory clients were high yield, a high market price and early maturity/fast growth. The high yield and market price are more variety dependent than technology dependent. TC is often associated with the varieties Mpologoma and Kisansa which have a high yield compared to traditional varieties. Bunch size is therefore more likely a benefit of the variety instead of the technology itself. Fast growth (or time to flowering) on the other hand is partly variety dependent and partly technology

dependent. TC plantlets earlier reach the stage of flowering than suckers because suckers are damaged when cleaned before planting and have to re-grow their root system. This gives TC plantlets a head start over suckers. Maturity time on the other hand, which is the time between flowering and a harvestable bunch, is variety dependent. Mpologoma has a shorter maturity time compared to Kisansa which makes it generally more popular and is why it is given the nickname “Money Maker” by farmers. One of the farmers called it a variety for teenagers. *“It gives you fast money but does not last for long”* which refers to its short lifespan.

Table 5.11. Explanation for varieties of the TC plantlets that were obtained by NAADS beneficiaries and nursery/laboratory clients.  
(Source: Network analysis)

Main explanations behind varieties obtained by NAADS beneficiaries (n=14)	Main explanations behind varieties obtained by nursery/laboratory clients (n=14)
I did not receive the varieties I ordered	The variety is high yielding/gives a big bunch
I had no choice which varieties to obtain	The bunch of this variety fetches a high market price
The variety is high yielding/gives a big bunch	The variety is early maturing/fast growing

### Acquisition of TC banana plantlets by NAADS beneficiaries

Most farmers were informed NAADS was distributing TC’s in farmer trainings and had to apply before they could obtain the plantlets. Stories of application procedures differed among the farmers regarding the details. The general line however is that farmers were informed they could apply for plantlets and had to fill in an application form on which they had to note down the quantity which they wanted to receive. After inspection to make sure the farmer could maintain the plantlets and had his farm prepared, the farmers were informed when and where they could obtain the planting material. This procedure was the case for home consumption or market oriented farmers. However not all farmers did receive what they ordered as one farmer explained:

*“I did apply for TC plantlets once and I was informed I could get them at the nursery. When I came there the nursery operator told me they were out of stock. I had already dug the holes and the season was coming to an end. I decided to ask one of my farm group mates for suckers since she was supposed to share them; she already received twice from NAADS”.*

In all cases the plantlets were obtained without a monetary transaction. There were certain terms and conditions under which the farmers could obtain the material. First of all the land had to be prepared, which means holes had to be dug, to make sure the suckers were planted and not sold. Second the farmer had to prove he or she was able to maintain the plantlets by showing they could apply some manure and water. In case manure was present the farmers could obtain 30 plantlets and in case manure was not present the farmers could obtain 25 plantlets and a bag of manure. Thirdly the farmers had to share suckers originating from the TC planting material with fellow members of their farm group who did not receive plantlets. This condition given by NAADS might also be an explanation why the number of farmers that actually could be followed up was low. Some farmers thought we came on behalf of NAADS to check if the farmers really shared suckers (box 5).



### Box 3: Sharing suckers?

As part of the NAADS program, farmers receiving TC planting material are supposed to share suckers with farmers who not directly benefited. One lady farmer told us she had shared suckers originating from TC planting material, but that the receiving farmers were not at home and were even out of the village. She wanted to call them but she said she couldn't since she had no battery. When we left we saw her making a phone call in the bushes, she came after us and told one of them just got back home. When we visited him, he named the exact quantities and varieties the lady told us she shared with him. According to the man the suckers were given to him in 2008. However, the lady told us she received the TC banana plantlets from NAADS in 2012, which makes it impossible she shared suckers of that material in 2008. Possibly she thought we were agents of NAADS who came to check if beneficiaries indeed shared their material with non-beneficiaries.

The application procedure for commercial farmers differed from the application procedure for home consumption and market oriented farmers. First of all the maximum amount of plantlets which could be obtained was 450 instead of 30. Farmers said they could apply if they had at least 1 acre of land available for banana cultivation. They could put in their request at the sub-county. After all the requests were gathered, a team of the sub-county would come to inspect the farm to see if the land was available, there was sufficient manure and there was a water source nearby which could be used to water the plants. According to the farmers in each parish there could be one commercial farmer receiving the plantlets. When the farmers were chosen they received a form on which they could place their order for the varieties and quantities. Three of the farmers received TC plantlets from NAADS in large quantities. One of them said he was supposed to co-fund the plantlets and had to pay 50.000UGX to obtain the plantlets. After he had been able to make money out of the plantlets he was supposed to return the value of the plantlets to NAADS. The value of the plantlets was 750.000 UGX but he said NAADS never came to him to collect this money. Another commercial farmer told he was not supposed to co-fund but had to return the value of the plantlets (2.000.000 UGX) after he made his profits. He did return the money to the bank account of their farmers group in order to make other farmers benefit from the money now. The conditions to have the farm prepared and to be able to provide sufficient inputs also applied for commercial farmers. Commercial farmers were not supposed to share suckers with fellow farmers in contrast to the home consumption and market oriented farmers. All of the commercial farmers said their farm was serving as demonstration garden for NAADS as well.

#### **Acquisition of TC banana plantlets by nursery/laboratory clients.**

All of the nursery and laboratory clients said they paid cash for the TC plantlets and prices differed from 1000 to 3000 UGX. Variability in prices was mainly due to time of acquisition. Plantlets increased in price around 2015 from 2500 to 3000 UGX. The plantlets that were obtained for 1000 UGX came from the laboratory. Most farmers knew they could obtain TC plantlets from the nursery because they were previous NAADS beneficiaries and the nursery supplied them previously. Six farmers said they knew about the nursery because the nursery owner/operator is a friend and two farmers said they knew due to promotion of the nursery. In case the farmers obtained the plantlets from the laboratory they said they were informed by a friend they could sometimes obtain plantlets from there in case the laboratory had excess plantlets.

## 5.4.2 SECOND AND THIRD GENERATION FARMERS

Second generation farmers of all wealth classes were provided with planting material by first generation NAADS and nursery/laboratory clients, who also originated from all wealth classes (figure 5.11). As described earlier, in case a farmer obtain TC plantlets from NAADS and a nursery/laboratory in all cases it was the material originating from NAADS which was shared. In all cases material was shared with fellow farmers the provider and recipient lived within the same community.

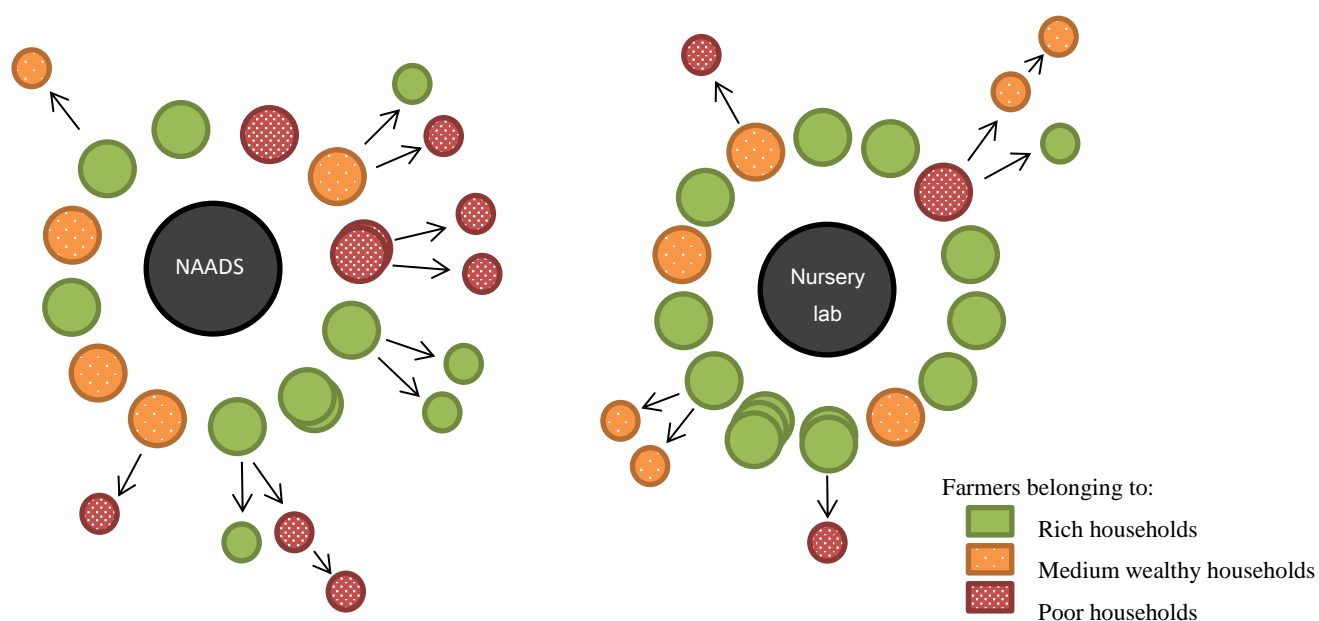


Figure 5.11 First generation NAADS beneficiaries (left) and nursery/laboratory client (right) and the second and third generation farmers they shared planting material with. Each circle represents a farmer. When multiple circles are placed at the same spot this means the farmer obtained plantlets multiple times. (source: Network analysis)

Planting material was most of the time provided to friends followed by relatives and neighbours. Material was never provided to farmers who were just acquaintances (table 5.12). Most of the time planting material was given for free. Three times the planting material was exchanged, twice for other planting material and once in exchange for transport of the plantlets. Four times the planting material was paid for, three times among friends and once among neighbours. The average quantity of suckers was higher in case they were paid for compared to when they were given or exchanged. The total number of transactions was higher than the number of recipients (18) because in some cases a part of the material was given and a part of the material was paid for. Especially transactions of large numbers of suckers were partly paid and partly given. Farmers explained it is custom to give some free suckers in case a fellow farmer buys a large quantity of suckers. Remarkable is that planting material was only provided twice to farm group mates considering that sharing of suckers within the farmers group was one of the conditions given by NAADS to receive TC planting material.

Table 5.12. Social relationships and type of transaction used for each time suckers originating from TC planting material were provided to a fellow farmer. (Source: Network analysis)

	Relatives (n=6)			Friends (n=11)			Farm group mates (n=2)			Neighbours (n=6)			Acquaintances (n=0)		
	n	#	Av#	n	#	Av#	n	#	AV#	n	#	AV#	n	#	AV#
Gift	4	30	8	8	144	18	1	12	12	4	46	12	0	-	-
In exchange	1	5	5	0	-	-	1	25	25	1	10	10	0	-	-
Monetary	0	-	-	3	120	40	0	-	-	1	20	20	0	-	-

# total number of suckers shared per social relationship and transaction type. Av# Average number of suckers shared per social relationship and transaction type.

Most of the second and third generation farmers did ask for the suckers or plantlets themselves. Only in two cases the plantlets were given to the recipient without him or her asking for them. One farmer gave a motivation why he decided to give suckers from the material to fellow farmers without them asking for it:

*“From five different varieties, of which most I did not yet possess on my farm, I obtained one TC plantlet each. When the mats started to give suckers I decided to give some to a friend. In case I am not able to keep the mat alive at my own farm my friend still has the variety on his farm. When needed, I can ask a sucker in return. In this way I secure myself from losing varieties.”*

Motivations among recipients to ask for suckers originating from the TC planting material differed and in total 14 motivations were given. The main reasons among farmers to ask for suckers originating from TC material were the high yield and the big bunches, because they saw a very productive farm and because they were unable to obtain plantlets directly from NAADS themselves (table 5.13).

Table 5.13. Motivations given by farmers to ask for planting material originating of TC banana plantlets (n=18). (Method: Free listing ; Source: Network analysis)

Motivation	n
TC material gives a high yield/big bunch	9
I saw a farm with TC material which was very productive so I decided to ask for suckers	8
I could not obtain TC plantlets directly from NAADS myself	6
Because TC material generates a high income	5
Because I saw a mat giving very big bunches so I asked for a sucker	4
I was curious how this material performs	3
I had the right to receive suckers form the TC material according to the NAADS program	2
TC material was promoted in farmer trainings and by the government so I wanted to try it	1
For food security	1
Because of the early maturity time of TC material	1
I wanted to obtain a new variety	1
I had a shortage of suckers on my own farm	1
I was establishing a new area for banana cultivation	1
The material is disease resistant	1
Total	44

The reorganisation of NAADS seems to have its consequences for agricultural extension in Uganda in general as well as on the banana seed system. Through training and distribution TC banana plantlets have been promoted by NAADS among all types of banana farmers. Most farmers interviewed in the network analysis got familiar with and got access to TC banana plantlets due to the NAADS programs. Since the reorganisation of NAADS, no distribution of TC banana plantlets took place according to the key informants and farmers. Nevertheless we encountered one female farmer during the network analysis who confirmed NAADS was still distributing TC banana plantlets around the end of 2016:

*"I not only received suckers originating of TC material but I also used them myself once. My brother bought 200 and gave me 20 of them. They were of the varieties Mpologoma and Kisansa. He did not buy them at a nursery. My brother is an army official (UPDF) and bought them "through the backdoor" for 1500 UGX each. It might be possible those plantlets were meant for distribution. My brother is not part of the NAADS program himself but some of his friends are, which is why he got access to those plantlets."*

## CHAPTER 5.5 PROFITABILITY AND THE FUTURE ROLE OF TC BANANA IN THE BANANA SEED SYSTEM

Farmers were asked about the specific inputs they needed to maintain the TC banana plantlets. 13 of the first generation farmers said TC plantlets needed more inputs and 11 of the second generation farmers said the suckers originating from TC material needed more input (table 5.14). Most of the farmers said the plantlets needed more fertilizers followed by labour, pesticides and water. According to the farmers who said TC's require more labour this labour includes; application of more inputs, weeding and putting sticks to support the bunches. Especially for the variety Mpologoma it seems necessary to place wooden sticks to support the bunch weight (figure 5.12). Mpologoma is not drought tolerant and without a sufficient amount of rain the stem easily breaks, especially when a heavy bunch is present. Another symptom of drought stress in Mpologoma is a bunch which appears directly from the pseudo stem. To prevent this Mpologoma needs to be watered in periods of drought the farmers explained (figure 5.13).

Table 5.14. Inputs needed in a higher amount for TC banana plantlets compared to traditional suckers according to the first generation farmers (n=17) and inputs needed in a higher amount for suckers originating from TC compared to traditional suckers according to the second and third generation farmers (n=18). (*Method: checklist; Source: Network analysis*).

Input	Higher input requirement for TC banana plantlets compared to traditional suckers according to <i>n</i> farmers	Higher input requirement for TC suckers compared to traditional suckers according to <i>n</i> farmers
Fertilizer	10	8
Labour	6	4
Pesticides	3	6
Water	5	1
No additional inputs needed	2	3



Figure 5.12 The pseudo stem of varieties which are not drought resistant, such as Mpologoma, easily break during periods of drought, especially when a heavy bunch is present (left). To prevent this, farmers support pseudo stems bearing big bunches with wooden sticks (right).



Figure 5.13. A symptom of the variety Mpologoma when experiencing drought, is a bunch which comes out directly of the pseudo stem with absence of a proper peduncle (left). Besides that the rachis easily breaks causing a large part of the bunch to be lost (right).

Despite most farmers said they needed more inputs for TC planting material they still said it was profitable. All farmers said their material has been profitable if they compared the inputs with the outputs, except for seven farmers who had not yet harvested from their TC material. Most farmers said TC material was more profitable due to the big bunches it gave followed by the higher output for each input, the early flowering, the better management that is given to TC material, the number of bunches given and the high survival rate respectively (table 5.15). Five farmers mentioned the profits were only temporary because of the short lifespan of TC material.

Table 5.15. Reasons given by farmers (n=27) why TC banana plantlets and their suckers are profitable. (Method: Free listing; Source: Network analysis)

Motivation	n
Bunches originating from TC plantlets are bigger	20
For each unit of input, I receive more output	5
The plantlets reach the stage of flowering earlier	4
The plantlets are more profitable because I managed them well (because I bought them at a high price a manage better)	3
The TC plantlets always give sufficient food	3
Profit of TC plantlets is higher when you plant the varieties Mpologoma and Kisansa	2
The plantlets have a higher survival rate than suckers	1
Total	38

It was difficult to determine if the reasons for a high profit were really to be attributed to the TC technology or if they are more likely to be variety dependent. TC technology is among farmers often associated with the varieties Mpologoma and Kisansa which already harvest big bunches as a variety characteristic. The highest quantity of plantlets was obtained by the farmers of the varieties Mpologoma and Kisansa. If farmers compare bunches of TC Mpologoma and Kisansa with bunches of local varieties it is logic that bunches of TC's are bigger. Only a few farmers cultivated local varieties grown from TC's and traditional suckers. Those famers said the main benefit of TC's was the early time to flowering and that bunches were not specifically a lot bigger. The early time to flowering can be explained by the fact that suckers are damaged when they are peeled/pared. All the roots are cut off from the sucker and need to regrow. TC's in contrast have already (although small) a developed root system. The sucker thus has a slow start compared to TC's. Farmers said: *"It is incredible, those plantlets are so small but when you plant them they grow very fast and with a lot of vigor. They catch up with a sucker very fast"*. This early time of flowering thus seems really a benefit of the technology and not the variety. Nevertheless, when suckers of the TC's are taken this benefit is probably lost.

All first generation farmers said they would like to make use of TC banana plantlets again. Also the second and third generation farmers who received suckers originating from TC said they would like to make use of TC plantlets, except for 2 farmers. Those farmers would not buy TC's because they hear a lot of these plantlets get stolen. When we asked the farmers who would like to use TC's why they did not go to a nursery yet to buy them, most replied that the plantlets are too expensive for them. Others said they did not know where they could obtain TC plantlets.

The farmers were asked what the role of TC banana plantlets should be in the entire banana seed system, according to them. All of the farmers thought the TC banana plantlets should at least be part of the future banana seed system. 21 farmers thought TC planting material should be an addition to traditional planting

material and 12 farmers thought it would be best if TC plantlets would replace traditional planting material entirely. All of the farmers who thought it would be best to replace suckers for TC plantlets entirely were male farmers of which most were classified as young and middle aged. The farmers were asked if they did not see any risks if TC planting material would take over the banana seed system. They replied they did only see the benefits such as a higher profit. They were not afraid to loose certain varieties because they knew TC plantlets could be made in all varieties or they did not care about low performing varieties. The other farmers said they noticed a higher profit could be made with TC planting material but they also saw the benefits of suckers over TC plantlets, which is why they said it could best be a mix. According to those farmers TC material could best be used to generate an income and traditional planting material to secure the household of sufficient food. Farmers said the traditional planting material needs less care, is long-lasting and is better adapted to agro-ecological properties on the farm. Also the taste of traditional planting material is better according to some of the farmers.

# CHAPTER 6. BXW AND ITS EFFECTS ON THE BANANA SEED SYSTEM

## CHAPTER 6.1 INCIDENCE AND RECOGNITION OF BXW

Of the 23 interviewed farmers, 22 said they had incidence of BXW on their farm. The time they discovered BXW on their farm for the first time varied between 2000 and 2016. Several symptoms to recognize a banana plant infected with BXW were named by the farmers. BXW (table 6.1) Immature yellowing of the leaves was named by most farmers followed by immature ripening of the bunch and the wilting and breaking of the leaves after they yellowed.

Table 6.1. Symptoms which were named by farmers (n=23) for the recognition of BXW (Source: *On farm interviews*)

Symptom	n
Leaves start yellowing while their immature	22
The bunch ripens while it's still immature and fingers ripen unequally	13
The leaves start wilting after they yellowed	9
The leaves break after they wilted	9
There are black spots present in the fingers when you break them	5
The male bud starts to wilt	4
Yellowish sap comes out of the pseudo stem when it is cut	3
The growth of the bunch stagnates	3
There are yellow spots present in the fingers when you break them	2
The pseudo stem starts rotting and smells like animals	2
Black spots are present in the corm when you peel it	2
The bunch becomes light green	1
An ash like substance surrounds the infected plants	1



Figure 6.1. Fingers of a banana plant which is not infected with BXW (left) and a plant which is infected with BXW (right). When infected yellow or black spots appear in the fingers.



Figure 6.2. A bunch of a banana plant which is not infected by BXW (left) and a bunch of a banana plant which is infected with BXW (right). Infection with BXW causes the fingers to ripen immature and unequally.

Symptoms that are named in literature are the ripening and wilting of immature leaves (figure 6.3), a creamy to yellowish bacterial ooze coming from the pseudo stem when cut (figure 6.3), wilting of the male bud, unequal and premature ripening of the fingers and black or yellow spots in the fingers (figure 6.1 & 6.1) (Promusa, 2016). Four additional symptoms were named by the farmers which were: a stagnated growth of the bunch, the colour of the bunch becoming pale green, black spots in the corm when peeled and an ash like substance surrounding the plant. The farmers who said they recognized BXW by stagnated growth of the bunch and a pale colour of the bunch said those were early signs of recognition before the other symptoms start showing. Black spots seem to be a symptom of banana weevils and not of BXW.

The process of yellowing and wilting of the leaves was described by most farmers to start from the youngest middle leaf and spread to the older leaves. Fewer farmers said the yellowing started with the oldest leaves and then spread to the youngest leaves. One farmer said he had seen both patterns according to him the difference was caused by the place of the infection: *“if infection comes via the corm, the leaves start yellowing from the outside, if the infection comes via the male bud, the leaves start yellowing from the inside.”*

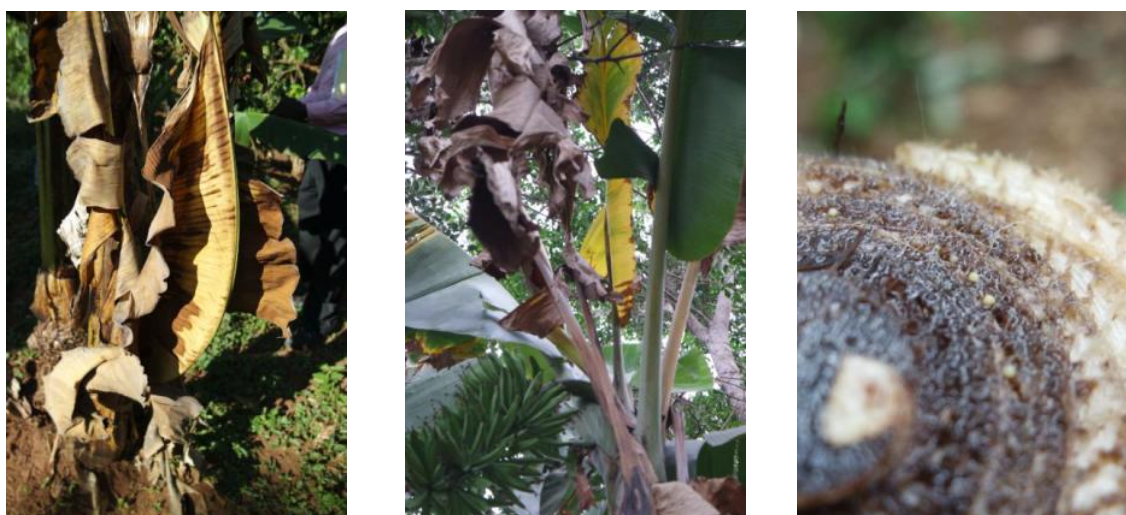


Figure 6.3. Yellowing and wilting of premature leaves (left & middle) and yellowish bacterial ooze coming from the pseudo stem of a banana plant infected with BXW (right).

## CHAPTER 6.2 VARIATION IN SUSCEPTIBILITY AMONG VARIETIES

None of the varieties in the study area was resistant for BXW according to the farmers. Although all can be affected they said there is a difference among varieties in susceptibility: some varieties were hardly ever seen infected with BXW while other varieties were almost wiped out due to the disease. The variety most named by farmers as being highly susceptible was Kivuvu. Kivuvu is an indigenous variety which is used as food and to make juice. Kayinja, which is also used to produce juice, was named by most farmers as highly susceptible as well. Ndiizi and Bogoya, both abundant dessert varieties were also pointed out as highly susceptible by most farmers. Varieties that were said to be less susceptible compared to others were Tombadala, Bogoya red, Nabomba, Luwaata, Kibuzi and FHIA (table 6.2). Remarkable is that the normal Bogoya, which is the local name for the variety Gran Michel, is pointed out as highly susceptible whereas Bogoya red is pointed out as being less susceptible. Three farmers had the variety on their farm and all said they have never seen Bogoya red getting infected with BXW, even though mats of normal Bogoya did get infected on their farms (figure 6.4). A more elaborate list off the varieties and their susceptibility to BXW can be found in Appendix 1.

Table 6.2. Varieties which were pointed out by farmers as highly susceptible to BXW and less susceptible to BXW (n=23). (Source: On farm interviews)

Highly susceptible varieties			Less susceptible varieties		
Variety	Type of variety	n	variety	Type of variety	N
Kivuvu	Beer	14	Bogoya red	Dessert	3
Kayinja	Beer	13	Tombadala	Dessert	2
Ndiizi	Dessert	13	Nabomba	Food	1
Bogoya	Dessert	11	Luwaata	Food	1
Kisansa	Food	1	FHIA	All	1
Kibuzi	Food	1	Kibuzi	Food	1
Namwezi	Food	1			
Mpologoma	Food	1			
Nakitembe	Food	1			



Figure 6.4. Sucker (left) and bunch (right) of a mat of Bogoya red. This variety is less susceptible to BXW in contrast to its green brother who is pointed out as highly susceptible.

The varieties which were classified as highly susceptible by most farmers do not belong to the bananas of the AAA-EAHB clone sets. This might indicate that susceptibility is genetically determined. The structure of the flower seems to influence disease transfer by insects. Besides that, the leaves of the varieties pointed out as highly susceptible are frequently cut and used for cooking. They are said to give the cooked bananas a yellow colour and a nice aroma. Frequently cutting of leaves, which can infect the tools, might also explain why the disease is easier transferred among these varieties. The cultivation of the variety Kayinja seemed to have dropped most drastically due to BXW. Farmers explained that, especially for men, Kayinja was an important variety which was used to brew beer. Before BXW came, gardens solely planted with bananas of the variety Kayinja and managed mainly by men, were common in the study area. This is supported by Gold who wrote in 2002:

*“At the national level, Kayinja was the most abundant cultivar and represented 8% of total production. In many areas of central Uganda, where production of cooking bananas declined over the last 20 years, farmers are replacing cooking bananas with Kayinja. Kayinja is used for brewing and is grown mainly in single cultivar stands that often are large and separated from the home garden. Farmer preferences at some sites shifted to Kayinja, which is believed to be more drought tolerant than the local brewing clones and which can earn them a ready income through the marketing of value-added products such as banana wine and Waragi.”*

The fact that Kayinja, in contrast to most other varieties was cultivated in a monoculture instead of a mixture might also have contributed to the rapid spread of the disease among this variety. During the fieldwork none of these single-cultivar-Kayinja plantations was seen. Some farmers told that their fathers, and in some cases the farmers themselves, had such plantations but they were destroyed by BXW. Kayinja was now classified as a variety grown by few farmers on a small area during the four square method. Now BXW was disappearing some farmers were carefully starting to grow Kayinja for beer production again. It was not possible to buy

banana beer in the study area during the field work. Banana beer used to be important in the culture of the farmers in the study area, which is confirmed by Karamura (2004) who wrote:

*“Local banana beer is important in the socio-economic set up of the farming communities in Great Lakes region of Africa. In rural areas it is common to find community based labour/activities being exchanged for local beer. In addition to exchange for labour needs, local banana beer plays a major role in social gatherings.”*

## CHAPTER 6.3 CHANGES IN SEED SOURCING AND PLANTING PATTERN IN RESPONSE TO BXW

Most farmers did not change their seed sourcing practices in response to BXW. Four farmers said to still source off-farm but make a more comprehensive inspection on the farm they want to take suckers from to make sure there are no signs of BXW. Two farmers said to still make use of off-farm sources but they started paying for the material in order to be allowed to pick the suckers themselves. Nine farmers said they were only sourcing on-farm before they noticed BXW and continued to source on-farm from non-infected mats. Seven farmers said they sourced less off-farm in response to BXW to make sure infection was not transmitted to their own farm. One farmer mentioned to have even increased her off-farm sourcing because her own farm got infected that heavily, she could not make use of her own planting material anymore. There was only one farmer who said he started making use of formal sources for planting material which was in this case a TC nursery (table 6.3).

Tabel 6.3. Changes in the seed sourcing practices by interviewed farmers (n=23) in response to the outbreak of BXW. (*Methodology: Free listing; Source: On farm interviews*)

Response	n
I did not change my seed sourcing practices in response to BXW because I was and still am only sourcing on-farm	9
I started sourcing less off-farm to prevent my farm from getting infected with BXW	7
I did not change my seed sourcing practices in response to BXW, I continue to source off-farm when needed.	4
I still source off-farm when needed but I started paying for the suckers to make sure I can pick none-infected suckers myself	2
I started sourcing from a formal seed source such as a nursery when I have a shortage in suckers on my own farm	1
I started sourcing off-farm because my own farm got infected by BXW and I could not take my own suckers anymore	1
Total	24

## CHAPTER 6.4 MEASURES FOR CONTROL, SOURCE OF INFORMATION AND SUCCESSFULNESS OF THE METHODS

No true curative measures exist to control BXW (Biruma et al., 2007). Nevertheless, there are measure to prevent the farm gets infected by BXW and there are measures to control the disease after the farm has been infected. The measure to prevent the farm gets infected by BXW include: improved soil fertility, the use of clean garden tools, the use of varieties that escape insect mediated transmission and de-budding of male

flowers (Blomme et al., 2014). A change in seed sourcing practices can also prevent the farm gets infected by BXW. The measures to control and get rid of BXW include: uprooting and mechanical destruction of mats, uprooting and chemical destruction of mats, continuously cutting of re-sprouts, single diseased stem removal, disposal of plant debris and a fallow period (Blomme et al., 2014). Farmers were asked measures they carried out purposively for the prevention or the reduction of BXW.

The measures reduce spread of BXW used by most farmers were de-budding, the use of clean garden tools and a change in seed sourcing practices respectively (table 6.4). De-budding was practiced by 14 farmers with a stick and by 4 farmers with tools. De-budding with a stick is recommended to prevent the disease from spreading via tools (Blomme et al., 2014). All of the 13 farmers who said they disinfected their tools said they did so with fire and one farmer said he used bleach additionally after he used his tools on an infected plant. None of the farmers said they increased their soil fertility for the purpose of BXW, there were even two farmers who said they made less use of fertilizers because they saw an increase of the spread of BXW when they used more fertilizers. Also none of the farmers said to make use of varieties that escape insect mediated transmission although there were three farmers who said they were planting more suckers of the FHIA variety because these are less susceptible but they did not know if this was due to less insect transmission. One of the farmers said: *“Only FHIA gets less affected by BXW but I cannot plant too many suckers of FHIA because there is no good market for it. Therefore I only have 6 mats of FHIA.”* Farmers obtained their knowledge from various sources such as the radio, in farmer trainings, from fellow farmers, from their relatives as being a cultural practice and on their own initiative (table 6.4). De-budding was part of culture in some villages and some farmers said they did it with a double purpose because the bunch size increases when the male bud is removed at the right time.

Table 6.4. Measures to prevent the spread of BXW carried out by farmers and the sources were they got to learn these practices (n=23).  
( Method: Checklist to which additional practices could be added ; Source: On farm interviews)

Measures to reduce disease spread		Source				
	n	Radio	Farmer trainings	Fellow farmers	Cultural practice	Own initiative
De-budding of male flowers	18	2	6	6	4	-
Use of clean garden tools	13	4	7	5	-	-
Change in seed source practices	11	-	-	-	-	11
Varieties that escape insect-mediated transmission	0	-	-	-	-	-
Improve soil fertility	0	-	-	-	-	-
Total		6	13	11	4	11

Single diseased stem removal and uprooting or mechanical destruction of mats were the most practiced measures regarding the removal of sources of inoculum (table 6.5). Not all farmers thought that single disease stem removal was successful as some farmers described the disease spread further to the other stems, whereas others say the mat remained healthy after removal of the diseased stem. BXW is a non-systemic disease which means that it depends how far the disease has spread throughout the mat if removal of only the stem which shows symptoms is sufficient (Biruma et al., 2007). This makes it plausible that the answers on the effect of diseased stem removal varied. All farmers who uprooted and mechanically destructed their mats said the method was successful. Another popular measurement, which is not acknowledged in literature, was the

application of urine (sometimes in combination with ash) on the diseased mats. Most farmers learned about the measure from fellow farmers and some from radio and farmers trainings. All farmers considered the method successful.

None of the farmers destructed their mats chemically. Few farmers continuously cut the re-sprouts of diseased mats and the two farmers who did said the method was not success because all the new suckers that came up were infected. Two of the farmers said they burned their plant debris. All other farmers said they used plant debris for mulching or as animal fodder. Having a fallow period was practiced by only one farmer and he said this was not successful. None of the other farmers used fallow periods and some even said it was not necessary; they planted suckers sometimes at the place a diseased mat was removed and the sucker came up healthy. How BXW survives in the soil is not yet entirely clear (Biruma et al., 2007). There were also three farmers which used a curative measure which was not earlier described. They sprayed the mats with Rocket, an insecticide used against weevils, to cure mats from BXW and to prevent it.

Table 6.5. Measures for inoculum removal practiced by farmers to cure BXW on their farm, and the sources were they got to learn these practices (n=23). (Method: Checklist to which additional practices could be added ; Source: On farm interviews)

Measure to remove sources of inoculum		Source				
	n	Radio	Farmer trainings	Fellow farmers	Cultural practice	Own initiative
Single diseased stem removal	10	1	3	5	2	-
Application of urine on diseased mats	10	2	2	6	-	-
Uprooting or mechanical destruction of mats	8	3	3	4	-	-
Application of insecticide 'Rocket' on diseased mats	3	-	-	3	-	-
Disposure of plant debris	2	-	-	2	-	-
Continuous cutting of re-sprouts	2	1	1	-	-	-
Fallow period	1	-	-	1	-	-
Chemical destruction of mats	0	-	-	-	-	-
Total		7	9	21	2	0

All farmers practiced at least one measure to prevent and combat BXW. All farmers had access to some source of information how to handle the disease. None of the farmers was currently facing big problems with BXW although it was still present at some farms. Most methods were described as functional by the farmers. To cure BXW uprooting and destruction of the mat was most successful according to the farmers. The farms where BXW was still present were mainly female headed households. Uprooting of an entire mat can be a tiring practice. At one of the farms belonging to a female headed household an infected mat was discovered during the fieldwork. The farmer was informed but one month later the diseased mat was still there, we asked the lady why she did not uproot the mat and she explained: *"I am tired of uprooting, this disease returns to my farm anyway. I do not have the energy anymore to uproot a mat"*. One of the older men came with a similar complaint that uprooting of diseased mats was very exhausting (figure 6.5). When we asked him what he considered to be the most successful practice he started laughing:

*"I would say that uprooting the entire mat is most successful, but if you have seen a mat of Bogoya you understand that I am not really looking forward to uprooting that. I even need to hire workers for that because I am not able to do it myself, which costs me money. I do try to remove the diseased stems but at some places new sprouts just come up infected."*



Figure 6.5. A mat of Bogoya can grow several meters in diameter. Both pictures show a mat of Bogoya , all stems within the white arrows belong to a single mat. Uprooting of those mats when they are infected is very labor intensive for farmers.

## CHAPTER 7. DISCUSSION & CONCLUSIONS

Smallholder farmers grow a mixture of banana varieties on their farm, which is typical for smallholder banana farmers in Central Uganda (Gold et al., 2002b; Karamura et al., 2004). Farmers grow banana varieties in mixtures because it is part of their culture and is taught by their parents. Farmers often inherited plantations on which a cultivar mixture was already present. The farmers named 30 banana varieties that were grown in the area belonging to all five major clone sets of the East African Highland Bananas (EAHB). Next to EAHB, banana varieties belonging to other sub-groups such as Gonja, Ndiizi and Kayinja were also grown. Cultivar diversity on farm ranged from 4 to 16 varieties. On average the farmers grew about 10 different varieties on their farm. There was no difference among socio-economic properties regarding cultivar diversity, indicating that the diversity holders in the area are distributed among all types of households. Since all varieties have perceived strengths and weaknesses this diversity brings security to the household. Besides that, the banana types cultivated have different end uses which are not only culinary but also cultural or practical. These results are in line with previous research conducted in Uganda (Gold et al., 2002b). The emphasis of all farmers was on the cultivation of cooking varieties. Roasting, Beer and Dessert varieties were cultivated among most households but were lower in abundance on the farm. The cooking variety Nakitembe was the most popular variety and was grown by all participating farmers. Nakitembe was preferred by farmers due to its resistance to biotic and abiotic threats, nice aroma and taste of the fruit and cultural value. Another variety gaining popularity among farmers is Mpologoma. This variety was not yet described as an important variety by Gold et al. (2002b) but is now the talk of the day among farmers. Due to its large bunches Mpologoma is referred to as the giant lion (Mpologoma means lion in Luganda language) and money maker. That the variety in 2002 was not yet described as a prominent variety indicates that farmers are continuously assessing and evaluating varieties and when necessary shift to the cultivation of more beneficial varieties. Nevertheless, although some varieties are preferred over others, farmers rarely turn to the cultivation of a single variety but rather keep the farm diverse. Some varieties, usually the ones that yield smaller bunches or have a long maturity time, were grown by few farmer. These farmers still kept the varieties on their farm out of pride for the rich diversity in bananas which they believed should not be lost; out of cultural beliefs; because the fruit is very tasty, or for food security reasons. The culture surrounding banana cultivation thus conserves banana diversity. Preferred varieties were by most farmers placed close to the home where they receive extra inputs such as kitchen waste increasing their performance. Varieties that do not thrive well in mixture, for example very short or very tall varieties, are placed at the boundaries. Some species such as Gonja and Bogoya were describes as invasive because of their tall growth which inhibits other varieties. Differences in management requirement and cultural beliefs were other reasons why these varieties were placed at the boundary. Farm composition is thus an important characteristic of banana cultivation in Central Uganda.

## CHAPTER 7.1 SELECTION OF VARIETIES

The selection of varieties differs locally as well as individually among farmers. In areas more commercially oriented, bunch size and maturity time are key selection criteria. In areas where banana is cultivated to a large extent for home consumption; taste and longevity are more important characteristics (Gold et al., 2002a). Farmer explained that while selecting a variety they take in consideration for which purpose the variety is grown; to be sold or for home consumption. Also among farmers beneficial characteristics differed and in total 22 positive variety traits were named. New varieties developed by the formal sector often do not take farmers' opinions in consideration until final stages of testing which leads to mismatches and poor adoption (Gold et al., 2002a; Almekinders & Louwaars, 2002; Almekinders et al., 2007; Urrea-Hernandez et al., 2016). In case of bananas in Central Uganda, varieties developed by the formal sector were indeed not very appreciated. FHIA varieties for example has a high yield and resistance to disease but do not possess other traits that are desired by farmers. Despite most farmers grew FHIA, the majority did not like it because of its poor taste and solely grew it in low numbers for security reasons. Not only the general beliefs of farmers' preferences, which are high yield, fast growth, uniformity and disease resistance (which are indeed preferred), but also the details of what varieties should possess are of great importance if varieties are to be created that are successfully adopted. These details often differ locally but also differ among social groups and individuals, which emphasizes the importance of variety diversity, and thus also the need of diverse improved varieties. The methods used to understand farmers' preferences are also of importance. While asking farmers to rank important traits, all farmers first replied with bunch size. While asking them to actually select a good sucker, none of the farmers selected the suckers of FHIA, which is the variety producing the largest bunch. Using a different method than ranking, taste came up as the most important variety trait since all farmers rejected suckers of FHIA because of its poor taste and low market value. Besides the fact that farmer opinions should be taken into closer consideration while developing improved varieties, also the methodologies used to do so should be carefully selected.

## CHAPTER 7.2 REPLACEMENT DYNAMICS

Although depending on a lot of factors, such as soil type, management and position on the farm, farmers gave an estimation of the lifespans of cultivated varieties which differed from 2 – 100 years. Farmers regularly responded that with the right type of management and inputs a banana mat can live forever. Still, some varieties are more likely to get affected by biotic or abiotic factors, which results in lower average lifespans. The mixed pattern, the diversity of varieties and the differences in lifespan result in a unique type of management especially concerning planting. It does not occur very often that a large part of a banana plantation has to be replaced at once; rather, gaps are formed at the plantations, which have to be filled with new planting material. Farmers therefore know two types of planting: "Gap-filling" which is filling up these gaps and "real planting" which means a larger area is newly planted or replaced at once. The replacement management of mats differed among farmers. Some farmers replaced a mat when they saw it declining in productivity and therefore replaced relatively frequent. Other farmers just waited until a mat would die off and only then replaced it. The movement of mats is also an important phenomena which creates gaps in the

plantations. Farmers intentionally guide the mats on their plantation to prevent them from coming too close to each other.

Uprooting a mat to replace it demands quite some energy from the farmer. Especially for farmers with less physical strength such as elderly and woman the replacement of mats is an exhausting task. Besides that, it is a time consuming task and single women running a household do often not have this time available. When there is no opportunity to hire a laborer in these household, nor are there friends or family to rely on, replacement of mats is likely to happen less frequently on their farms. Replacement of mats, when they show a decline in productivity or when diseased, keeps the plantation fresh and vital (Robinson 1996; Mamuye, 2016). Having sufficient social or financial capital in the household for labor can thus increase the vitality and productivity of the banana plantations. Negative correlation between age of the farmer and banana productivity has been reported previously in literature but could not be shown in this study (Mamuye, 2016; Ebiowei et al., 2014). What this study showed was that during the April rains planting season in 2016 farmers belonging to female headed households planted fewer suckers than farmers belonging to male headed households. Also old farmers planted slightly less suckers. The lowest number of suckers was planted by farmers belonging to poor households. That fewer new suckers are planted indicated that less mats are replaced. Besides that, a lower number of suckers planted can also be a result of less availability of, and access to, new planting material.

## CHAPTER 7.3 SEED SOURCING PRACTICES

Farmers acquired new planting material mainly on-farm. Off-farm sources were used less frequently. If off-farm sources were used the farmers preferred to source from friends and family because planting material can often be obtained free of charge. The farmers explained that the evaluation of planting material is important, especially to prevent disease transfer. When farmers select planting material on-farm they do not only assess the suckers themselves but they take a close look at the mother plant and the entire mat. When farmers source off-farm from a close relative or friend they often get the chance to select the suckers themselves. In that case the farmers can assess the farm, the mat, the mother plant and the sucker itself. When farmers source from a fellow farmer they are less familiar with, they are usually not given this opportunity. The source-farmer uproots the suckers him/herself, and sometimes even peels them, before giving them to the receiving farmer. In this case the farmers are not sure about the varieties, do not know if there were any diseases on the farm and do not know the condition of the mat and mother plant the sucker was subtracted from. The extensiveness in assessment and selection of the planting material was described by the farmers as the key difference in on- and off-farm sucker sourcing. Additionally, the farmers explained that the best suckers can never be given out by a source-farmer. In order to secure that a vital follower will appear on a mat, a sufficient amount of vigorous suckers has to be kept on the mat (Robinson & Nel, 1990). The best suckers can thus not be uprooted otherwise the farmer risks his existing mats will die. This combined made off-farm sourcing less popular among farmers. Nevertheless, if farmers were willing to pay for the suckers they often did get the opportunity to select suckers themselves from the source-farmers farm. A payment was also involved most of the times when large quantities of planting material were obtained. Farmers generally turned to off-farm sourcing when they had a

shortage of planting material, when they saw a farmer cultivating a variety which they not yet possessed, when they saw a good-looking farm which is well-managed and when they saw a mat bearing big bunches. Reciprocity was a reason often named by the farmers to provide a fellow farmer with planting material. The likelihood of receiving a sucker in return when the farmers have a shortage in planting material themselves thus influences if a farmer will share planting material or not. Hence, similarly to replacement management, the access to planting material of proper quality depends on the social and financial capital of the household.

## CHAPTER 7.4 AVAILABILITY OF PLANTING MATERIAL

The availability of planting material differed enormously among households ranging from 5 to 280 suckers per acre. Sucker production is determined by several factors such as variety, abiotic factors such as season and soil type, biotic factors such as weevil infection and management (Robinson & Nel., 1990; Rukazambuga et al., 1998; Eckstein & Robinson, 1999; Bhende et al., 2015). The availability of suckers is not only determined by the number of suckers produced on a mat but also by the number of suckers that can actually be subtracted from the mat. As previously described a sufficient amount of suckers should be left on the mat for its continuity. In addition some suckers are considered to be too low of quality and rather should be destroyed as uprooted. The number of suckers minus the suckers for continuity and the unsuitable suckers gives the actual number of suckers that can be uprooted and used for replanting or sharing. The number of suckers considered suitable for planting, available per acre, was highest among young farmers, small-scale banana farmers and farmers owning a very young plantation. It is plausible that these results all relate to each other since young farmers usually own a young banana plantation which is not yet that large. According to the farmers sucker production usually declines when the plantation and mats get older. Secondly, as previously described younger farmers are more energetic and therefore can put more effort in the management of the bananas which is beneficial for sucker production. Old farmers and farmer owning an old plantation also provided less suckers to fellow farmers, which can be explained by the lower sucker availability. Most farmers explained they currently face a problem regarding availability of banana suckers. Due to climate changes resulting in prolonged droughts the number of available suckers has decreased.

## CHAPTER 7.5 QUALITY OF BANANA SUCKERS

When farmers receive suckers from fellow farmers they often cannot assess the whole farm, mat and mother plant. Uprooted suckers received from fellow farmers are evaluated differently than suckers on-farm still attached to the mat. Regarding suckers of EAHB, the variety of peeled suckers can usually not be identified as they look too much alike. Both on- and off-farm the most important distinction between suckers that was made regarded sword and water suckers. All farmers preferred sword suckers over water suckers. The size of the sucker (length), the size of the base of the sucker (the diameter) and black spots in the corm, which are the signs of weevil (*Cosmopolites sordidus*) galleries, were the individual plant traits most important to farmers. Large suckers with broad bases, which are traits of maiden suckers, were favored by most farmers. A previous research in Uganda similarly pointed out that farmers prefer maiden suckers over sword suckers because they establish faster and are more disease resistant (Lwandasa et al., 2014). Interesting is, that while asking farmers

to point out suitable suckers for planting on-farm, the majority pointed at sword suckers and not maiden suckers. This is possibly due to damage done to mats when maiden suckers are uprooted. Due to their large size also a large part of the mats corm has to be removed which damages the mat. Additionally a large open wound is left which is vulnerable for infection with pests and diseases. For example, weevils are attracted to cut rhizomes, making detached suckers but also the wounds created while uprooting, especially susceptible to attack (Gold et al., 2002c). On-farm, farmers are apparently more careful uprooting large suckers but when the sucker is already uprooted from a fellow farmer's farm, they prefer the larger suckers. Besides that, uprooting maiden suckers requires more energy as uprooting sword suckers. Next to size, all farmers evaluated the suckers for black holes in the corm and stem base which are symptoms of weevil infection. Weevils are considered a major pest and pose a large threat to banana production, especially EAHB are designated as highly susceptible (Gold et al 2002c). Farmers thus very carefully assess planting material to make sure weevils are not transferred to their plantation.

## CHAPTER 7.6 BXW AND ITS EFFECT ON THE BANANA SEED SYSTEM

Where Gold and colleagues described in 2002 that cultivation of food variety was declining and that cultivation of beer varieties was increasing in Central Uganda, we saw a decline in cultivation of beer varieties. Beer banana used to be cultivated in monocultures on separated fields mainly by men. The cultivation of beer banana had important social and economic value in the study area (Gold 2002b). In line with the results Gold documented, the farmers confirmed that single variety plots with beer bananas were common in the area. Farmers told the cultivation of beer bananas seriously reduced due to BXW. Besides that there is currently a better market for cooking varieties compared to beer varieties.

Beer and dessert bananas are more susceptible to BXW as compared to food varieties. Beer and dessert varieties belong to different clone sets than the EAHB which could be an explanation for the higher susceptibility of those varieties. Because of differences in flower morphology, ABB and AAB types of banana are more susceptible for infection via inflorescence as compared to AAA-EAHB bananas (Biruma et al., 2007; Karamura et al., 2010; Blomme et al., 2014) Another explanation why the disease was more common among those varieties might be the use of the banana leaves for cooking and packaging. For cooking, the leaves of those varieties are preferred since they give the food an appealing yellow color and nice aroma. Cutting of leaves from several plants with the same tools can contribute to a rapid spread of the disease when one of the plants was infected (Brandt et al., 2007). In addition to those explanations the varieties are not typically grown in the mixture but are rather grown on the borders of the plantation or in monocultures. This could also have contributed to the fact that BXW spread more rapidly among those varieties. It is plausible that all three explanations are true and reinforce each other. Currently farmers in the study area did not face large problems regarding BXW. After the Kayinja plantations have been destroyed the disease remained quiet, although still roaming around. This could be because highly susceptible varieties are currently less abundant but, besides that all farmers were in the meantime informed about management practices to combat BXW. Farmers

obtained the information from several sources such as the radio, from extension officers in farmer trainings and fellow farmers. The most successful measure to control BXW according to the farmers was to uproot an infected mat and destroy it. However, this measure was not practiced by all farmers because uprooting of mats is a very tiring practice. Especially since the mats of highly susceptible varieties are rather large. Thus for farmers who have less physical strength such as elderly and women, the disease poses a higher risk. It has been estimated that a single farmer can uproot two banana mats a day (Mwangi, 2007). Single diseased stem removal has been proposed as a less rigorous control measure. Since BXW is a non-systemic disease, removal of only infected parts can be successful (Blomme et al., 2014). Nevertheless, the measure does not always have to be successful if the disease already spread to other parts of the plants which do not yet show symptoms and are thus not removed. Some farmers indeed reported the method very successful while others in contrast said the mat became sick again.

## CHAPTER 7.7 THE USE OF TISSUE CULTURE BANANA PLANTLETS

To combat BXW TC banana plantlets have been introduced and promoted in the area around 2008 coordinated by IITA (Kikulwe, 2016). Farmers could obtain TC from three sources; the nursery, directly from the lab and via NAADS programs. Most farmers got familiar with TC plantlets through the NAADS programs. Nurseries were mainly thriving on the orders from NAADS. Since the reorganization of NAADS around 2015 the sales of most nurseries have dropped drastically. The operator of Alinyikira Nursery Bed estimated the nursery sold around 100.000 plantlets less on a yearly base under the new NAADS program. Ideal Farm Enterprises sells even 270.000 less plantlets on a yearly base which is around 90% of the total sales. The clients of nurseries were mainly better-off farmers in contrast to the NAADS beneficiaries who belonged to all wealth classes. Farmers now refer to TC as “something for the rich”. This suggests that the previous NAADS programs were successful in providing better access to TC plantlets for less wealthy farmers, although the actual procedure of targeting farmers remained unclear during this research. The richer farmers who were recurrent buyers of TC plantlets and cultivated them in larger quantities said they were given advice by the nursery regarding exchange of planting material. The nursery owners told them to not uproot suckers from the mats for own use or to provide to fellow farmers, but to destroy the suckers. This would keep the mats more vigorous. Some farmers indeed changed to this practice and never uprooted suckers but instead returned to the nursery for new plantlets every 3 years. The use of TC could thus change the sharing behavior of farmers. Better-off farmers, who have to opportunity use more inputs and put effort in banana cultivation, often serve as source-farmers providing suckers to farmers who have a shortage. If these farmers stop with the exchange of planting material this could pose a potential threat to farmers who regularly have to source off-farm to acquire sufficient planting material. Also the number of varieties cultivated was lower among TC users. As part of the NAADS program TC plantlets of 11 different varieties were distributed, but when farmers bought TC themselves at a nursery or lab the number of different varieties obtained was only four.

Farmers often associated TC plantlets with the varieties Mpologoma and Kisansa. This made it difficult to understand the benefits farmers perceived while using TC since most of the named benefits were rather variety dependent than technology dependent. The most important benefit named that can be attributed to the technology was the fast growth of the plantlets. Although small at the moment of purchase, farmers said these plantlets easily catch up with a sucker when transplanted and flower about a month earlier. The fact that suckers are customarily planted after they are peeled, and thus first need to develop a new root system, gives TC plantlets a head start. However, these advantages do not extend to the ratoon crop (Drew & Smith, 1990). Most farmers were positive about the TC technology yet there were some farmers who said they were not fond of the plantlets. The relatively high costs of TC plantlets are often described as the main reason why farmers poorly adopt the TC technology (Indimuli, 2013). Indeed, the majority of the farmers considered the price of the TC's as high and some said this was the main reason to not use them. Nevertheless this was not the only major constraint among the farmers; farmers were skeptical toward the technology due to the fact that varieties of young plantlets cannot be identified. Only after the plantlets are fully grown the varieties can be identified, it is very demotivating for farmers to discover the wrong variety was obtained after putting effort to grow the plantlets until maturity. Farmers heard rumors about other farmers who received wrong plantlets or experienced it themselves. Other reasons why some farmers did not like TC plantlets were the taste which they did not like and a shorter lifespan. Similar to the perceived benefits it was not clear if those dislikes were variety or technology dependent. TC is just another way of multiplying banana but the material is genetically identical to the mother plant whereupon taste of the plantlets should also be equal to the taste of the mother plant when grown under similar circumstances. A reason for this undesired taste could be that varieties differ locally. Selection pressure of farmers is an ongoing process: it could thus be possible that Nakitembe in one region is slightly different than Nakitembe in another region. In addition, the names given to varieties vary among regions which can cause differences in the expectancies of a certain variety.

All farmers using TC said the plantlets were profitable regardless of the higher input requirements. Especially young men using TC banana saw an important role for the technology in the future. According to them the TC plantlets could replace the entire sucker seed system since they were way more profitable. They did not fear any loss of varieties when the use of TC would increase. That low yielding varieties could disappear was not a problem to them because they did not want to grow them anyway and if other farmers wanted to grow them the TC technology could provide them. Women and older farmers envisioned a less rigorous future role for the TC technology. They said the technology was a valuable addition to banana cultivation since it is very profitable. However, to secure their household of food they would keep 50% of their plantations traditional with a high diversity of varieties.

# REFERENCES

- Almekinders, C.J.M. & Louwaars, N. P. (2002) The importance of the farmers' seed systems in a functional national seed sector. *Journal of New Seeds*, 4(1-2), 15-33.
- Almekinders, C.J.M., Thiele G., Danial D.L. (2007) Can cultivars from participatory plant breeding improve seed provision to small-scale farmers? *Euphyca* 153:363-372 doi:10.1007/s10681-006-9201-9
- Andrade-Piedra J., Bentley J.W., Almekinders C., Jacobsen K., Walsh S. & Thiele G. (2016) Case Studies of Root, Tuber and Banana Seed Systems.
- (Author unknown) Mukono 5 Year District Development Plan 2010-2015
- Bagamba F., Ssenyonga J.W., Tushemereirwe W.K., Gold C.S. (1999) Performance and profitability of the banana sub-sector in Uganda farming systems. *Bananas and food security* ISBN: 2-910810-36-4.
- Basengere E.B. & Rutega B.D. (2014). Banana seed systems and practices in eastern DR Congo. *Seed Systems, Science and Policy in East and Central Africa*.
- Bekunda M. (1999) Farmers' responses to soil fertility decline in banana-based cropping systems of Uganda.
- Bhende S. (2015) Sucker production in banana. *Journal of Tropical Agriculture*.
- Blomme G., Jacobsen K., Ocimati W., Beed F., Ntamwira J., Sivirihauma C., Ssekiwoko F., Nakato V., Kubiriba J., Tripathi L., Tinzaara W., mbolela F., Lutete L., Karamura E. Fine-tuning banana *Xanthomonas* wilt control options over the past decade in East and Central Africa. *Eur J Plant Pathol* (2014) 139:271–287 doi:10.1007/s10658-014-0402-0
- Brandt S.A., Spring A., Hiebsch C., McCabe J.T., Tabogie E., Wolde., Michael G., Yntiso G., Shigeta M., Tesfaye S. (1997). *The Tree Against Hunger: Ensete-based Agricultural Systems in Ethiopia*. American Association for the Advancement of Science, Washington, DC, USA. p. 56.
- Delêtre M., McKeyc D.B., Hodkinsona T.R. (2011) Marriage exchanges, seed exchanges and the dynamic of manioc diversity. [www.pnas.org/cgi/doi/10.1073/pnas.1106259108](http://www.pnas.org/cgi/doi/10.1073/pnas.1106259108) vol. 185
- Diaz. J.M. (n.d.) Empowering Rural Producer Organisations within the World Bank Initiatives: A Capitalisation Study Uganda Country Case Study
- Drew R.A., Smith M.K. (1990) Field evaluation of tissue-cultured bananas in south-eastern Queensland *Australian Joirrnal of Experimental Agriculture*. 1990,30,569-74
- Dubois T., Coyne D., Kahangi E., Turoop L. & Nsubuga E.W.N. (2006) Endophyte-enhanced banana tissue culture: technology transfer through public-private partnerships in Kenya and Uganda. *ATDF Journal* Vol 3.
- Ebiowei K.P., Eugene O.C., Jackson N.N. (2014). Socio-economic determinants and productivity in banana and plantain production. *Global Journal of Biology, Agriculture and Health Sciences*.
- Eckstein K., Robinson J.C. (1999) The influence of the mother plant on sucker growth, development and photosynthesis in banana (*Musa* AAA; Dwarf Cavendish). *The Journal of Horticultural Science and Biotechnology*. ISSN: 1462-0316 (Print) 2380-4084 (Online) Journal homepage: <http://www.tandfonline.com/loi/thsb20>
- Gold C.S., Kiggunda A., Karamura D.A. Abera A.M. (2002)a. Selection criteria of *Musa* cultivars through a farmer participatory appraisal survey in Uganda. *Expl Agric*. volume 38, pp. 29-38 doi:10.1017/S0014479702000133
- Gold C.S., Kiggundu, A., Karamura, D.A., Abera, A.M. (2002)b. Diversity, distribution and selection criteria of *Musa* germplasm in Uganda. In: Picq, C., Fouré, E., Frison, E. (Eds.), *Bananas and food security*. International Symposium, Douala, Cameroon, 10-14 November 1998, INIBAP, Montpellier, France, pp. 163-179

- Gold C.S. Pinese B., Peña J.E. (2002)c. Pests of banana. ©CAB *International* 2002. *Tropical Fruit Pests and Pollinators*
- Grum, M., Gyasi, E.A., Osei, C. & Kranjac-Berisavljevic, G. (2008) Evaluation of best practices for landrace conservation: Farmer evaluation. Bioversity International, Rome, Italy. 20 pp.
- Indimuli L. (2013) Factors Influencing the Discontinuance in Adoption of Tissue Culture Banana Technology: A Study of Smallholder Farmers in Maragwa District. Institute for Development Studies, University of Nairobi.
- Jacobsen K.S. (n.d.) Review of seed systems for bananas and plantains (*Musa* spp.)
- Karamura, D. A. (1998). Numerical Taxonomic Studies of the East African Highland Bananas (*Musa* ± AAA-East Africa) in Uganda. Ph.D. thesis. University of Reading, U.K.
- Karamura, D., B. Mgenzi, E. Karamura, and S. Sharrock. (2004) Exploiting indigenous knowledge for the management and maintenance of *Musa* biodiversity on farm. *African Crop Science Journal* 12: 67-74.
- Karamura E., Kayobyo G., Tushemereirwe W., Benin S., Blomme G., Eden Green S., Markham R. (2010) Assessing the Impacts of Banana Bacterial Wilt Disease on Banana (*Musa* spp.) Productivity and Livelihoods of Ugandan Farm Households.
- Karamura D.A., Karamura E.B. and Tinzaara W. (2012) Banana cultivar names, synonyms and their usage in Eastern Africa, Bioversity International, Uganda.
- Kikulwe E. (2016) Banana tissue culture: community nurseries for African farmers in: Andrade-Piedra J., Bentley J.W., Almekinders C., Jacobsen K., Walsh S. & Thiele G. (2016) Case Studies of Root, Tuber and Banana Seed Systems.
- KWDT (2017) <http://www.katosi.org/>. Reviewed at 16th of June 2017.
- Lwandasa H., Kagezi G.H., Akol A.M., Mulumba J.W., Nankaya R., Fadda C., Jarvis D.I. (2014) Assessment of farmers' knowledge and preferences for planting materials to fill-gaps in banana plantations in southwestern Uganda. *Uganda Journal of Agricultural Sciences*, 15 (2): 165 - 178 ISSN 1026-0919
- Mamuye N. (2016) Statistical Analysis of Factor Affecting Banana Production in GamoGofa District, Southern Ethiopia. *Engineering and Applied Sciences*. Vol. 1, No. 1, 2016, pp. 5-12. doi: 10.11648/j.eas.20160101.12
- Mbaka J.N., Mwangi M. & Mwangi M.N. (2008) Banana Farming as a Business: The Role of Tissue Cultured Planting Materials in Kenya *Journal of Applied Biosciences*. Vol. 9(1): 354 – 361. ISSN 1997 – 5902: [www.biosciences.elewa.org](http://www.biosciences.elewa.org)
- Mwangi, M. (2007). Removing infected banana mats to contain *Xanthomonas* wilt: Experiences in Uganda, Rwanda and the Democratic Republic of Congo. A brief prepared for the Crop Crisis Control Project. IITA-C3P, Kampala, Uganda, 13p.
- National Environment Management Authority (NEMA) (2016). National Biodiversity Strategy and Action Plan II of the Republic of Uganda (2015-2025) ISBN:978-9970-88109-3
- Pillay M. & Tenkouano A. (2011) Banana breeding: Progress and Challenges. ISBN:9781439800171
- Promusa (2016). [www.promusa.org](http://www.promusa.org) < <http://www.promusa.org/Morphology+of+banana+plant> >. Reviewed at: 4<sup>th</sup> of February 2016)
- Reynolds T.J., Gutman J. (1988) Laddering theory, method, analysis and interpretation. *Journal of advertising research*.
- Robinson J.C. & Nel D.J. (1986) The influence of planting date, sucker selection and density on yield and crop-timing of bananas (cultivar 'Williams') in the Eastern Transvaal. *Scientia Horticulturae*, 29:347--358 347

- Robinson J.C. & Nel D.J. (1990) Competitive inhibition of yield potential in a 'Williams' banana plantation due to excessive sucker growth. *Scientia Horticulturae*, 43:225-236 225
- Robinson J.C. (1996) Bananas and plantains. ISBN 0-85198-985-3
- Rakazambunga N.D.T.M., Gold C.S., Gowen S.R. (1998) Yield loss in East African highland banana (*Musa* spp., AAA-EA group) caused by the banana weevil, *Cosmopolites sordidus* Germar International Institute of Tropical Agriculture, PO Box 7878, Kampala, Uganda [https://doi.org/10.1016/S0261-2194\(98\)00056-8](https://doi.org/10.1016/S0261-2194(98)00056-8)
- Rwakakamba M. & Lukwago D. (2014) The changing face of NAADS and what the entry of Uganda People's Defense Forces will mean for Uganda's agriculture. Public Policy Issue Paper No:004/2014
- Smale M., Tushemereirwe W.K. (2007) An Economic Assessment of Banana Genetic Improvement and Innovation in the Lake Victoria Region of Uganda and Tanzania. IFPRI Research Report. DOI: 10.2499/9780896291645RR155
- Staver C., Bergh van den I., Karamura E., Blomme G., Lescot T. (2010) Targeting Actions to Improve the Quality of Farmer Planting Material in Bananas and Plantains – Building a National Priority-setting Framework. Tree and Forestry Science and Biotechnology.
- Stover R. H. & Simmonds N. W., (1987) Bananas 3th edition. ISBN 0-582-46357-2
- Tittonell P., Vanlauwe B., Leffelaar P.A., Shepherd K.D., Giller K.E. (2005) Exploring diversity in soil fertility management of smallholder farms in western Kenya II. Within-farm variability in resource allocation, nutrient flows and soil fertility status. *Agriculture, Ecosystems and Environment* 110 (2005) 166–184
- Urrea-Hernandez C., Almekinders C.J.M., van Dam Y.K. (2016) Understanding perceptions of potato seed quality among small scale farmers in Peruvian highlands *Wageningen Journal of Life Sciences* 76 (2016) 21–28
- Wairegi L.W.I., van Asten P.J.A., Giller K.E. & Fairhurst T. (2016) Banana–coffee system cropping guide. Africa Soil Health Consortium, Nairobi.
- Wambugu W.F., Karembu M., Njuguna M. and Wanyangu S.W. (n.d.) Biotechnology to benefit small-scale banana producers in Kenya.
- Wesaka A., (2014) Man sues Museveni over army takeover of NAADS programme. Daily monitor.

## Appendix 1 Classification of varieties used in the study area and their susceptibility to BXW

Table A13. Local name, sub group, clone set, abundance and type of each variety grown by the farmers in the study area. (Source: four-square analysis and on farm interviews)

Local name	Sub group	Clone set	Genetic makeup	Method	Abundance <sup>1</sup>	type	Susceptibility BXW <sup>2</sup>
Bogoya	Musa AAA	Gros Michel	AAA	FGD	1	dessert	HS
Bogoya red	Musa AAA	Gros Michel	AAA	FGD	4	dessert	LS
Gonja	Plantain		AAB	FGD	4	roasting	S
Kibuzi	EAHB	Nakabululu	AAA	FGD	1	cooking	S
Kibuzi black	EAHB	Nakabululu	AAA	FGD	2	cooking	S
Nakabululu	EAHB	Nakabululu	AAA	FGD	4	cooking	S
Nakyatengu	EAHB	Nakabululu	AAA	FGD	4	cooking	S
Mukubakkonde	EAHB	Nakabululu	AAA	OFI	R	cooking	S
Kisansa	EAHB	Musakala	AAA	FGD	1	cooking	MS
Musakala	EAHB	Musakala	AAA	FGD	2	cooking	MS
Muvubo/Tayasame	EAHB	Musakala	AAA	FGD	2	cooking	S
Mpologoma	EAHB	Musakala	AAA	FGD	1	cooking	S
Nakitembe	EAHB	Nakitembe	AAA	FGD	1	cooking	MS
Nakitembe-nakawere	EAHB	Nakitembe	AAA	FGD	4	cooking	MS
Mbwazirume	EAHB	Nakitembe	AAA	FGD	4	cooking	S
Nandigobe	EAHB	Nakitembe	AAA	FGD	4	cooking	S
Nfuuka/Ntika	EAHB	Nfuuka	AAA	FGD	4	cooking	S
Nambi/Sitakange	EAHB	Nfuuka	AAA	FGD	4	cooking	S
Namwezi	EAHB	Nfuuka	AAA	FGD	4	cooking	MS
Ndyabalangira	EAHB	Nfuuka	AAA	OFI	C	cooking	S
Lusumba	EAHB	Nfuuka	AAA	OFI	LC	cooking	S
Katwalo	EAHB	Nfuuka	AAA	OFI	R	cooking	S
Nabusa	EAHB	Nfuuka	AAA	OFI	R	cooking	S
siira white	EAHB	Nfuuka	AAA	OFI	R	cooking	S
Mbidde	EAHB	Mbidde	AAA	FGD	4	beer	S
Kabula	EAHB	Mbidde	AAA	OFI	R	beer	S
Kisubi	Ney Poovan		AB	FGD	4	beer	HS
Ndiizi	Ney Poovan		AB	FGD	2	dessert	HS
Kayinja	Musa ABB	bluggoe	ABB	FGD	4	beer	HS
Kivuvu	Musa ABB	bluggoe	ABB	FGD	2	cooking	HS
FHIA 01	Hybrid		AAAB	FGD	2		LS
FHIA 02	Hybrid		AAAA	FGD	2		LS
FHIA 03	Hybrid		AABB	FGD	2		LS
FHIA 17	Hybrid		AAAA	FGD	2		LS
FHIA 21	Hybrid			FGD	2		LS
FHIA 23	Hybrid		AAAA	FGD	2		LS
FHIA 24	Hybrid		AAA	FGD	2		LS
Unclassified varieties					Abundance <sup>1</sup>	Type	Susceptibility BXW <sup>2</sup>
Tombadala					1	dessert	LS
Luwaata					4	cooking	S
Lwadungu					4	cooking	S
Nasalwagiri					4	cooking	S
AGT					4	cooking	S
Nabomba					LC	cooking	S
Njwebuzito					R	cooking	S
Mabumba					R	cooking	S

<sup>1</sup> Abundance of the varieties is classified according to the squares when the variety was named during the FGD's and according to abundance classes when named during the on farm interviews. 1 = Many farmer, large area; 2 = Many farmers, small area; 4 = Few farmers, small area; C = Common; LC = Less common; R = Rare.

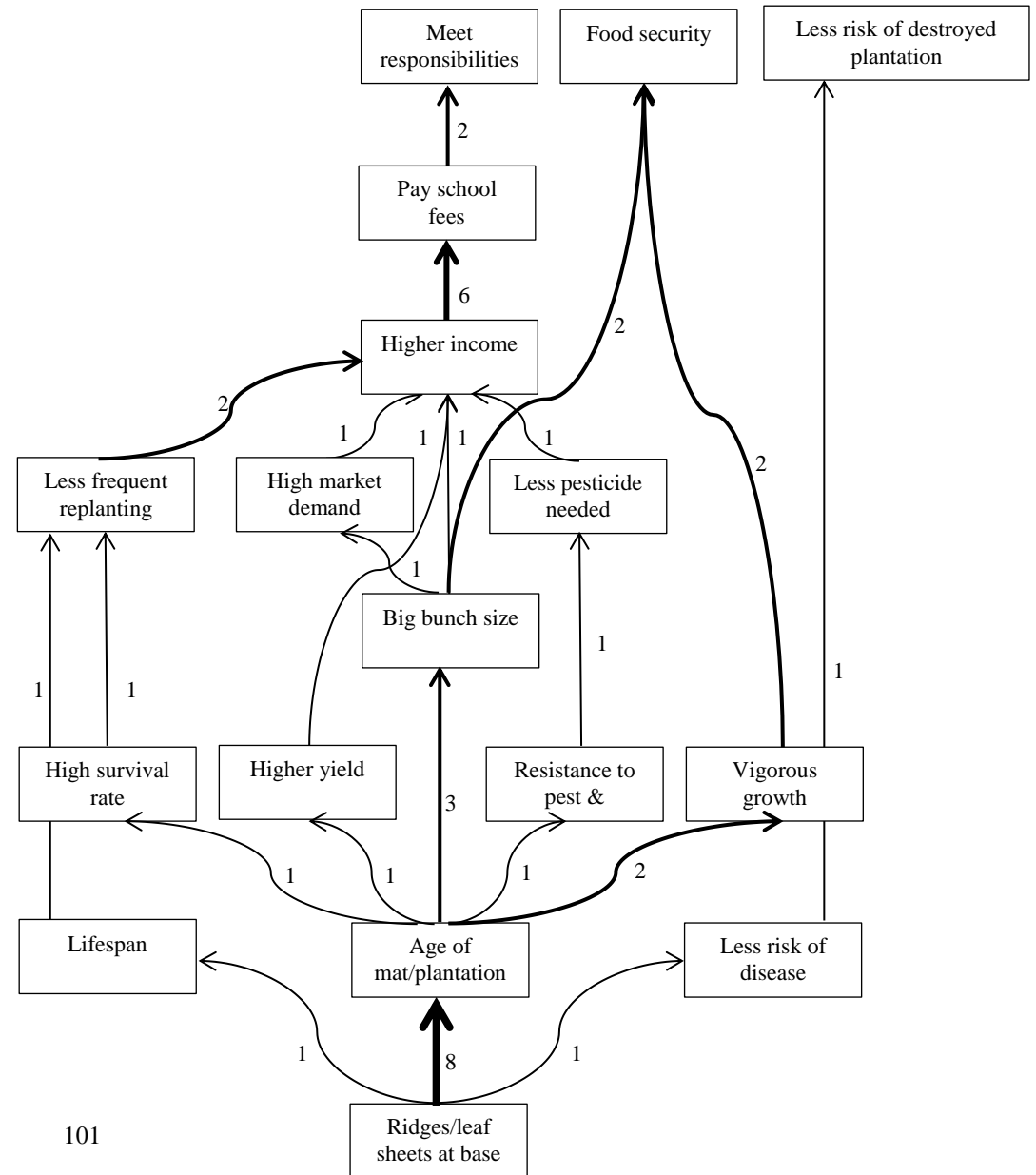
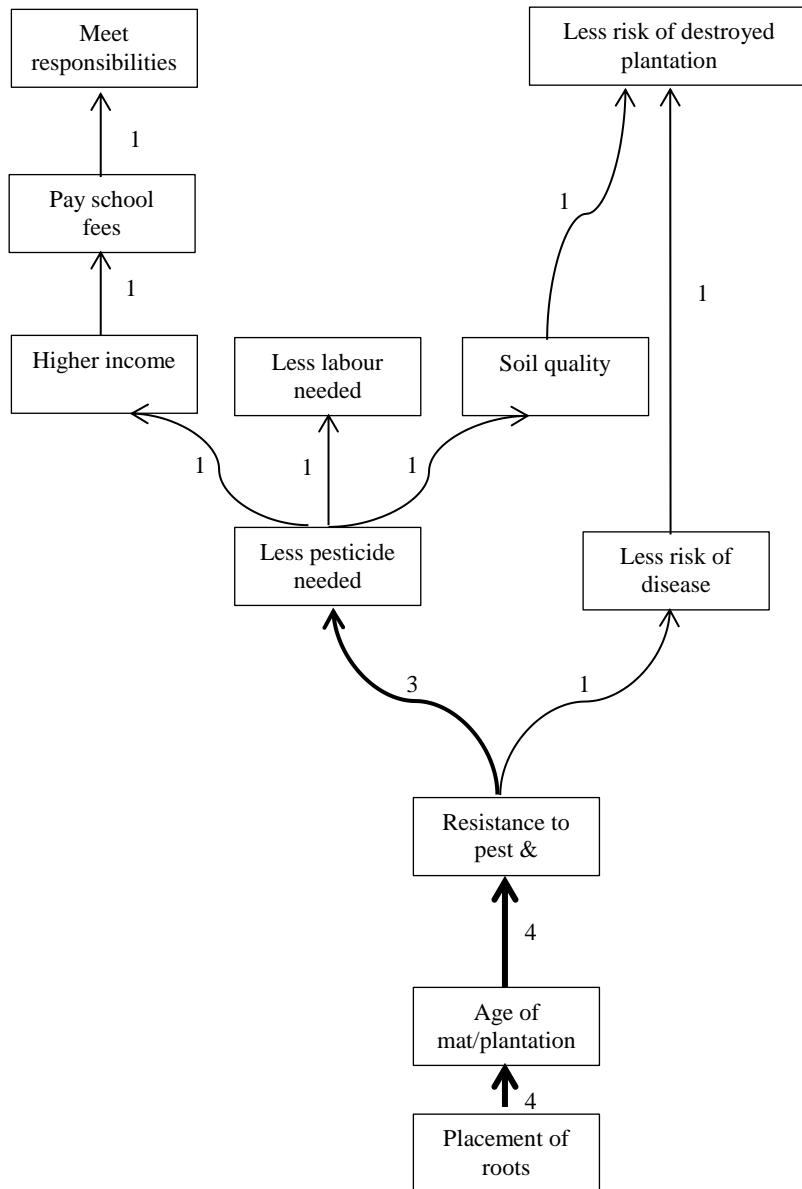
<sup>2</sup> Susceptibility of varieties to BXW was classified by the farmers as: HS = Highly susceptible; MS = More susceptible; S = Susceptible; LS = Less susceptible.

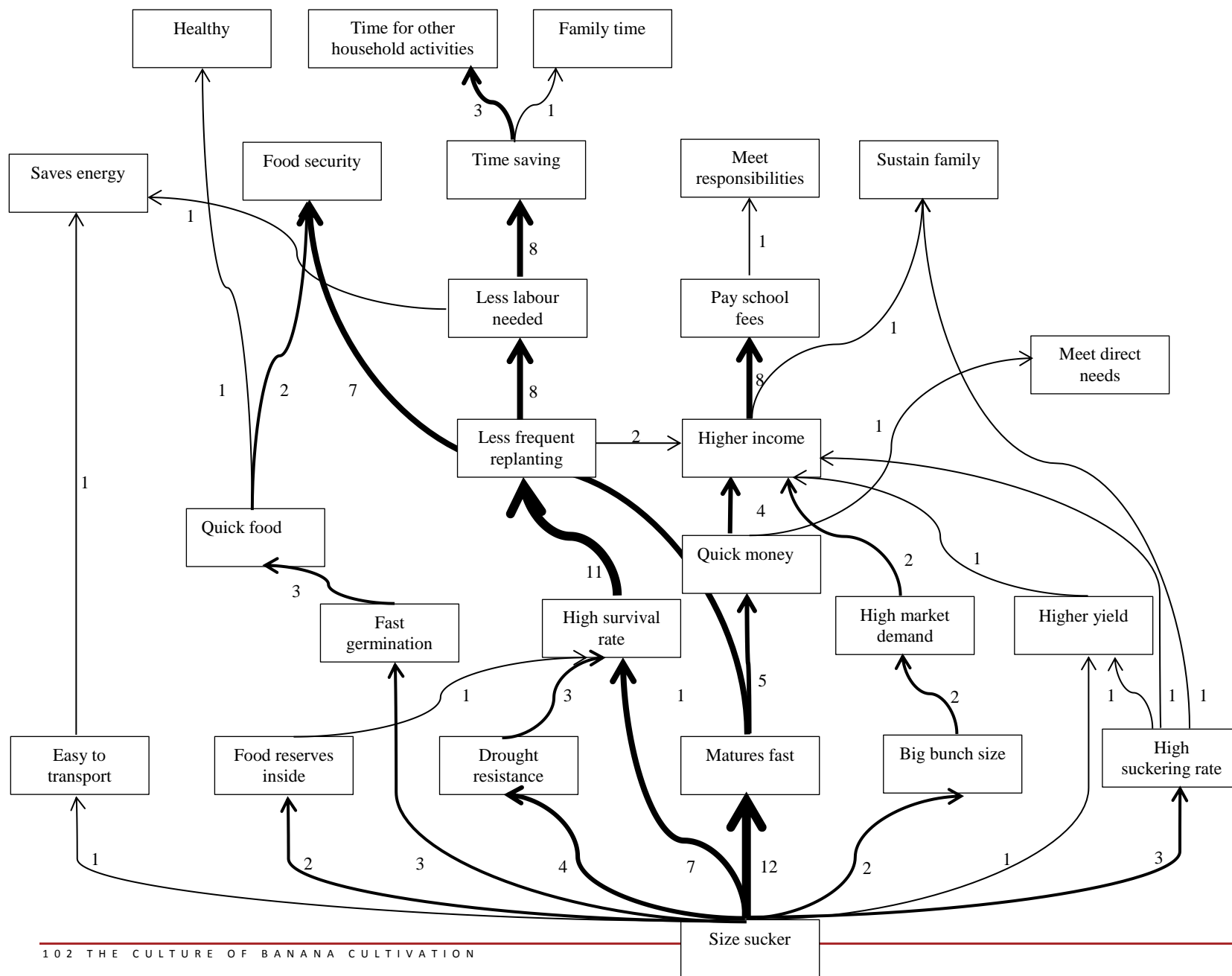
## Appendix 2 Characteristics for sucker quality

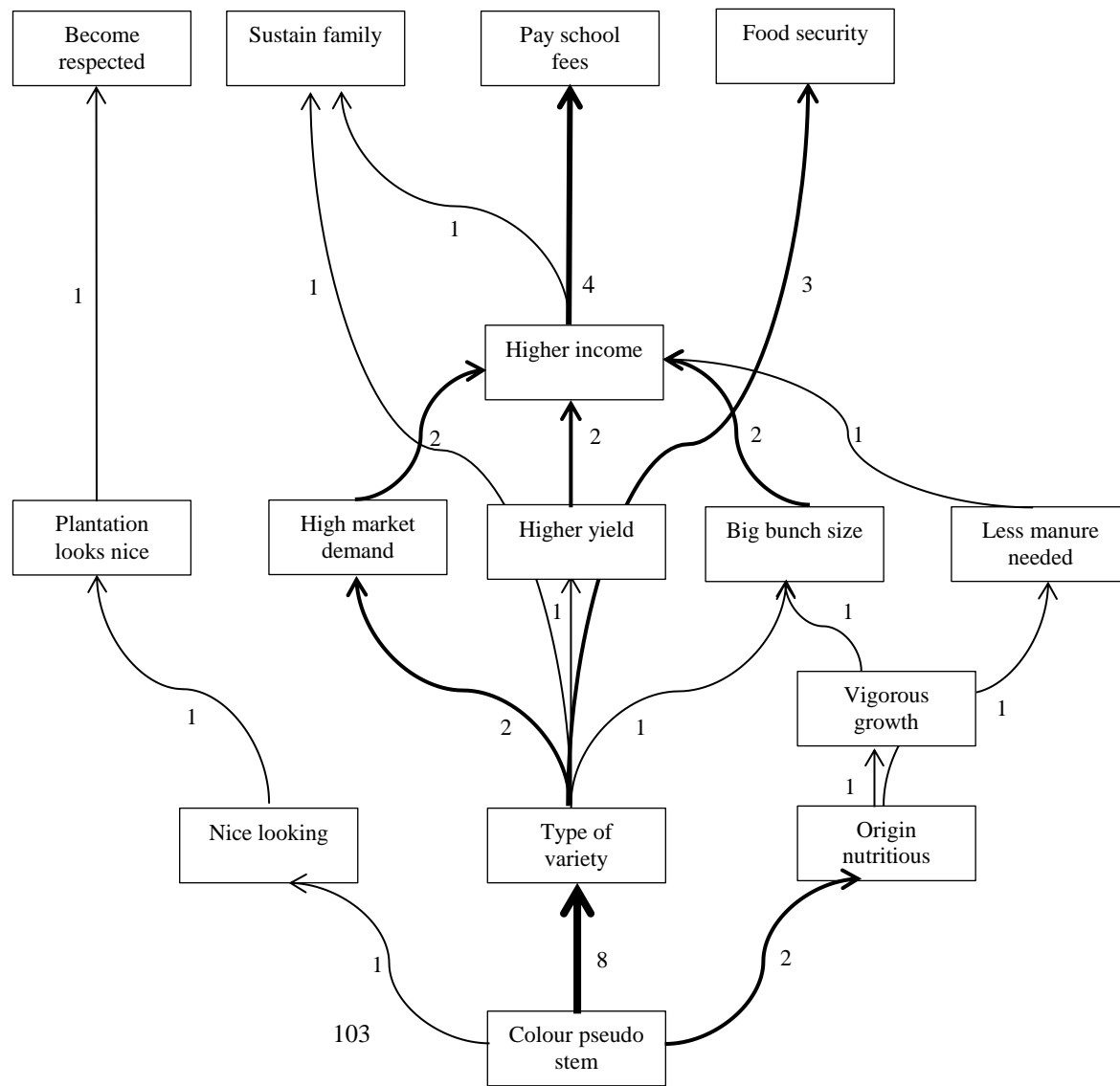
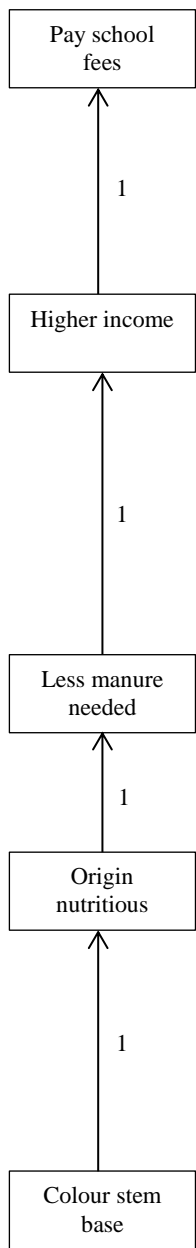
Table A13. Characteristics named by farmers to determine sucker quality ( <i>Method: Free listing ; Source: On farm interviews</i> )		
Category	Quality cue	Explanation
Mat	Distance of sucker to mother plant	The distance from the mother plant where the sucker comes up is important. A sucker should not be taken when it comes up too close to the mother plant (less than 1cm) because the corm of the mother plant can be too much damaged during uprooting. The sucker should also not come up too far from the mother plant because then it does not receive proper nutrition from the mother plant. Usually suckers that come up far from the mother plant are “water suckers” which are not preferred by farmers.
Mat	Place on the mat where the sucker comes up	Farmers usually decide which direction a mat should move. Suckers that come up in the desired direction are therefore better left on the mat. Suckers that come up between 2 mother plants are defined as bad suckers.
Mat	Age of the mat	At a certain age a mat can become exhausted, suckers can better not be taken from an exhausted mat because they perform less and the chance the sucker is already infected with weevils is higher. When a mat becomes exhausted depends on several factors such as variety, management and soil type.
Mat	Generation	Most farmers describe a mat of bananas as a family. The oldest stem on the mat is called the mother plant the stem following in age is called the daughter or the follower. The sucker coming after that is the grandchild. Depending on the variety a mat can have more than 1 mother plants on a single mat and have several daughters and suckers. It is advisable to let the mother, the follower and at least 1 sucker on the mat. In this way the farmers secure that the mat will live on the next season. Besides that it is also important if a sucker still gets nourishment from the mother plant. In some cases the mother plant gets extinct premature due to wind or other damage. In that case a sucker is called an orphan.
Mat	Number of suckers on the mat	If too many suckers are removed from the mat the mat is likely to go extinct. On the other hand too many suckers on a mat might remove too many nutrients from the main plant. Excess suckers are therefore to be removed for transplanting or just destroyed if no suckers are needed.
Mat	Corm of the mat above soil surface	If the corm of a mat or sucker is visible above the soil surface this usually indicates weevils which cause the corm to come up.
Mother plant	Size of the bunch given by the mother plant	If a mother plant gives a big bunch it is a good plant to take a sucker from because it is likely the children will also give big bunches. This was no hard rule for all farmers because some farmers mentioned that a mat can give a small bunch in a certain area but if a sucker from that mat is transplanted in another area better suited it might still give a big bunch.
Mother plant	Size of the fingers on the bunch given by the mother plant	Besides the size of the bunch itself also the size of the fingers is important. They have to be long and thick to fill the bunch well and make it compact. This trait is also likely to be given to sucker originating from that plant.
Mother plant	Diameter of the pseudo stem of the mother plant	A big diameter of the pseudo stem indicates that a big bunch will come out and that it has enough nutrition. It also means the stem will be strong enough to bare a big bunch without breaking.
Mother plant	Weevil infections in the corm and stem	The mother plant should be free of weevil infections because if the mother is infected with weevils the sucker is likely also to be infected. The presence of weevil tunnels in the base of the stem can tell the farmer if the mother plant is infected or not.
Mother plant	Health	The mother plant should also be free of other pests and diseases and should look vital. If the plant is not vital or infected the sucker is likely also to be infected.
Sucker	Weevil infections in the corm and stem	The stem and the corm of the sucker itself should be free of weevils. If the stem is free of weevils can be seen at the outside on the presence of weevil tunnels. To see if the corm is free of weevils the corm of the sucker is usually peeled. If weevil tunnels appear to be present in the corm they can be cut off and the corm can be bathed in an insecticide.
Sucker	Leaf shape and size in relation to age	The shape and the size of the leaves is important in relation to the age of the sucker. When the sucker is still young the leaves should be narrow, oblong and small. If the leaves of the sucker are too broad at a young age it tells the farmer something is wrong inside the sucker.
Sucker	Size of the sucker	Every farmer has a particular size of sucker which he prefers to plant. Some farmers preferred suckers smaller than 30 cm whereas others preferred suckers over 1,5 meters. Uprooting a large sucker requires more effort but increases the survival rate.
Sucker	Shape of the pseudo stem	The shape of the pseudo stem of a sword sucker is conical in contrast to the stem of a water sucker which is straight.

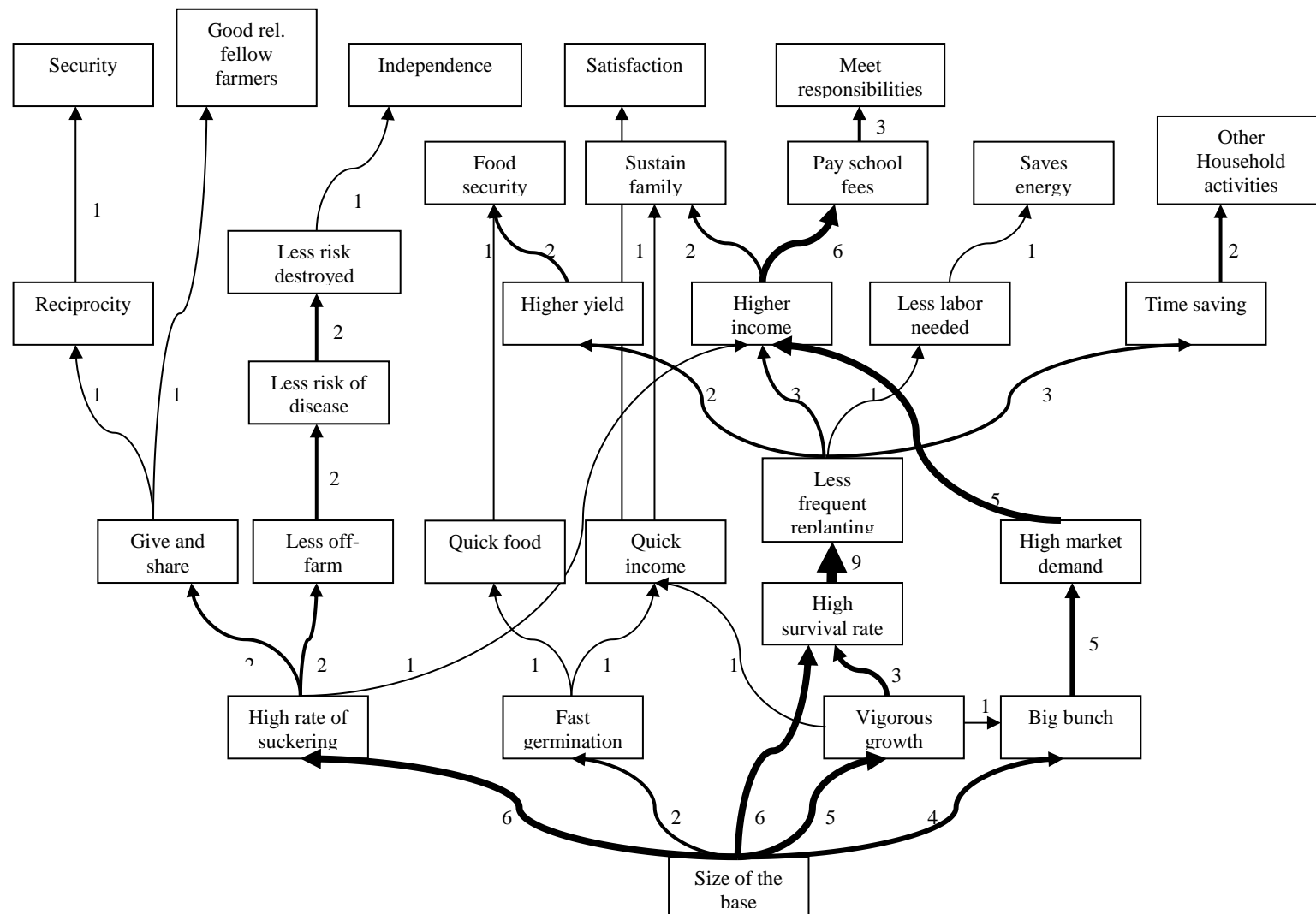
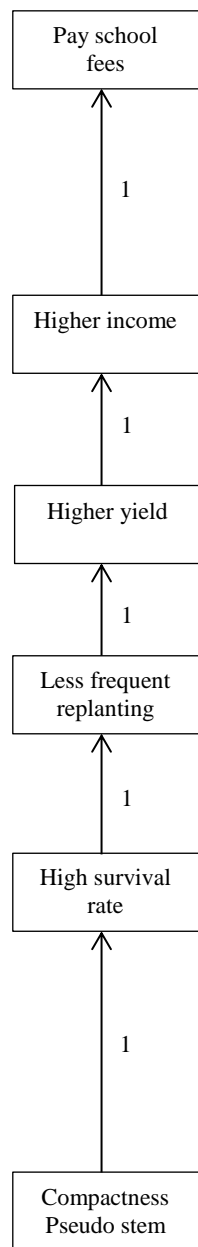
Sucker	Colour of the pseudo stem	For food varieties the pseudo stem should be dark of colour and not show brown colouring which indicates the sucker suffers from drought or disease.
Sucker	Arrangement of the leaves along the pseudo stem / length of the internodes	The length of the internodes should be a few centimetres. If leaves appear all at the same point it is not a good sucker.
Sucker	Appearance of the cigar leaf	A new leave called the cigar leaf should appear from the middle. This indicates the sucker is still vital and produces new leaves.
Sucker	Reddish colour at the base of the leaves	Some varieties such as Kisansa show a red colouration at the base of the leaves of the sucker. If this colouration is present the sucker is healthy.
Sucker	Presence of “ash” on the base of the leaves.	Certain varieties produce “ash” on the base of the leaves. If this ash is present the sucker is healthy.
Sucker	Colour of the leaves	The leaves of the sucker should be dark green. Yellow or brown parts indicate a disease or drought.
Sucker	Number of leaves	Some farmers count the number of leaves that the sucker has formed. The sucker is only planted after a certain number of leaves appeared. This number differed among farmers. A banana produces a bunch after a fixed number of leaves has appeared, counting the leaves therefore gives the farmers an indication about time to flowering.
Sucker	Depth of the roots	The roots of the sucker should not be too deep.
Sucker	Corm above or below soil surface	When the corm of the sucker comes above the soil surface this indicates it is infected with weevils.
Sucker	Colour of the corm after peeling the sucker	When the sucker is uprooted the corm is peeled to see if it is infected. When the corm is cut the sap that comes out should be clear. If the corm shows strange colourations such as bright orange the corm is infected.
Sucker	Age of the sucker	The age of the sucker is important to know for the farmers because they observe the stem and the size of the leaves in relation to age. If a sucker shows broad leaves at a young age it is not a good sucker.
Sucker	Health of the sucker	The sucker has to look healthy to the farmer. They just see if it's healthy or not the way they see if their children are.
Variety	Lifespan of the variety	Suckers are preferred of a variety that has a long lifespan.

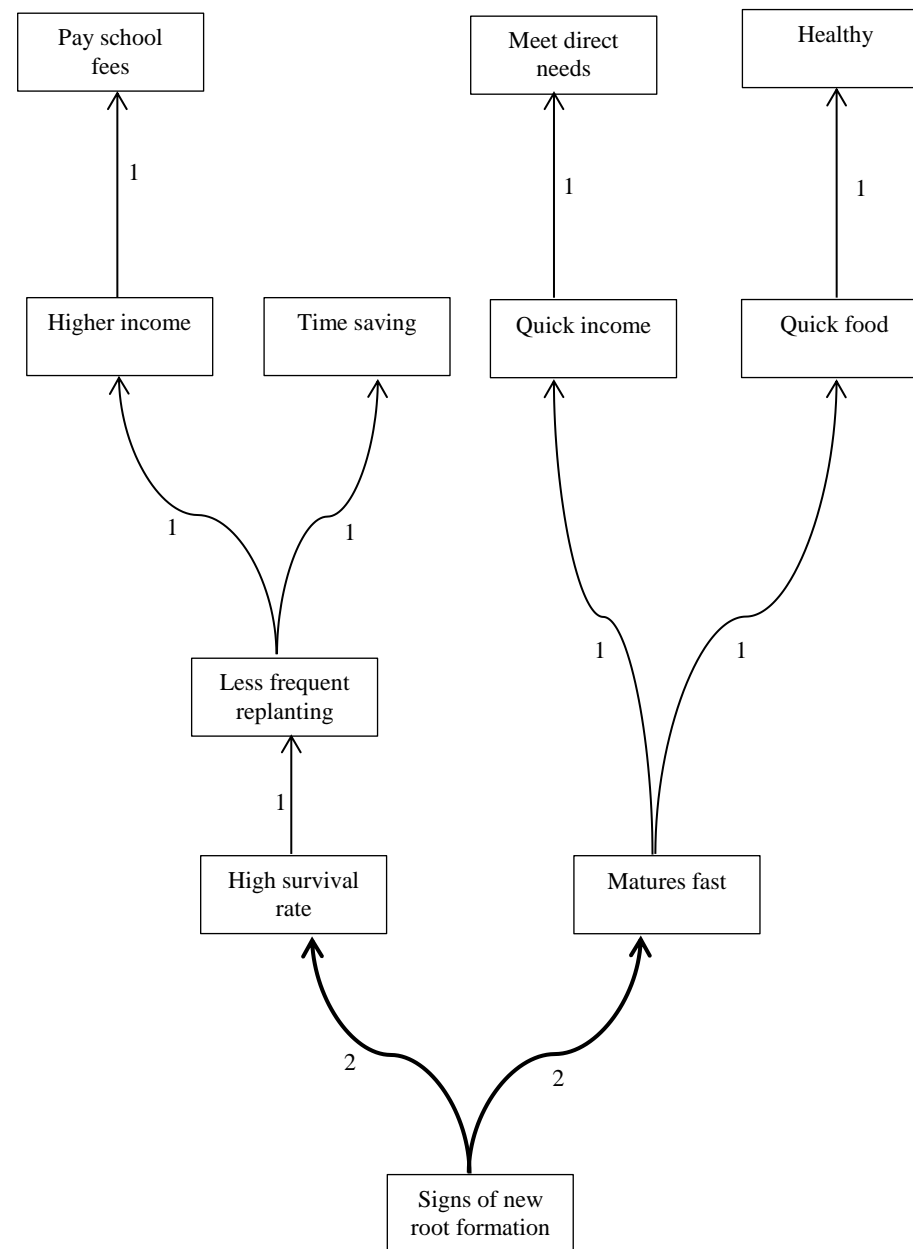
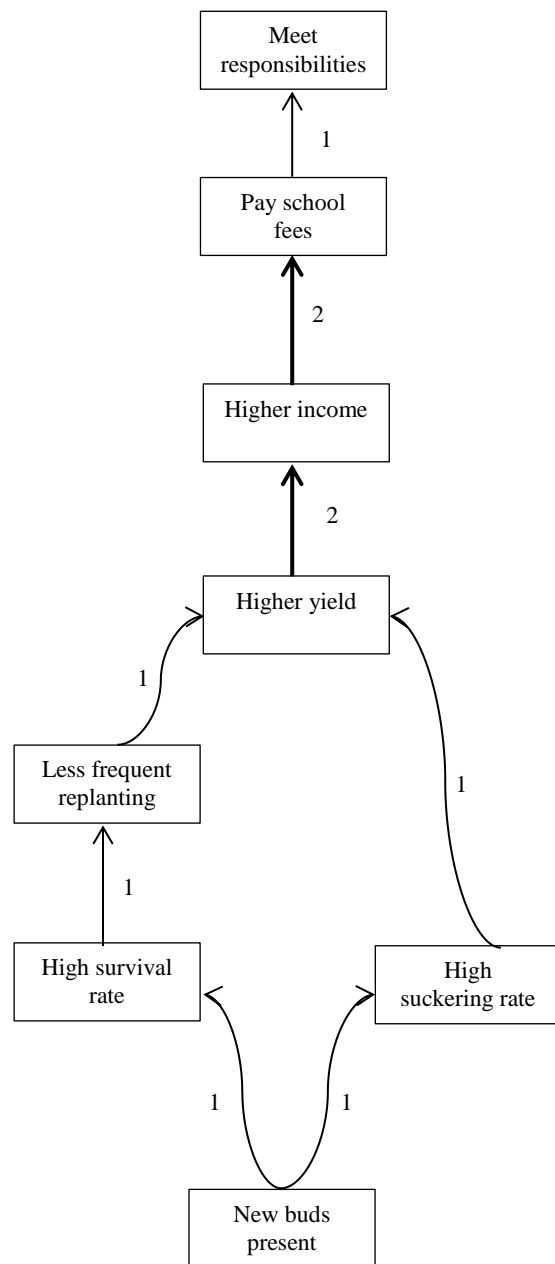
### Appendix 3 Diagrams of sucker quality

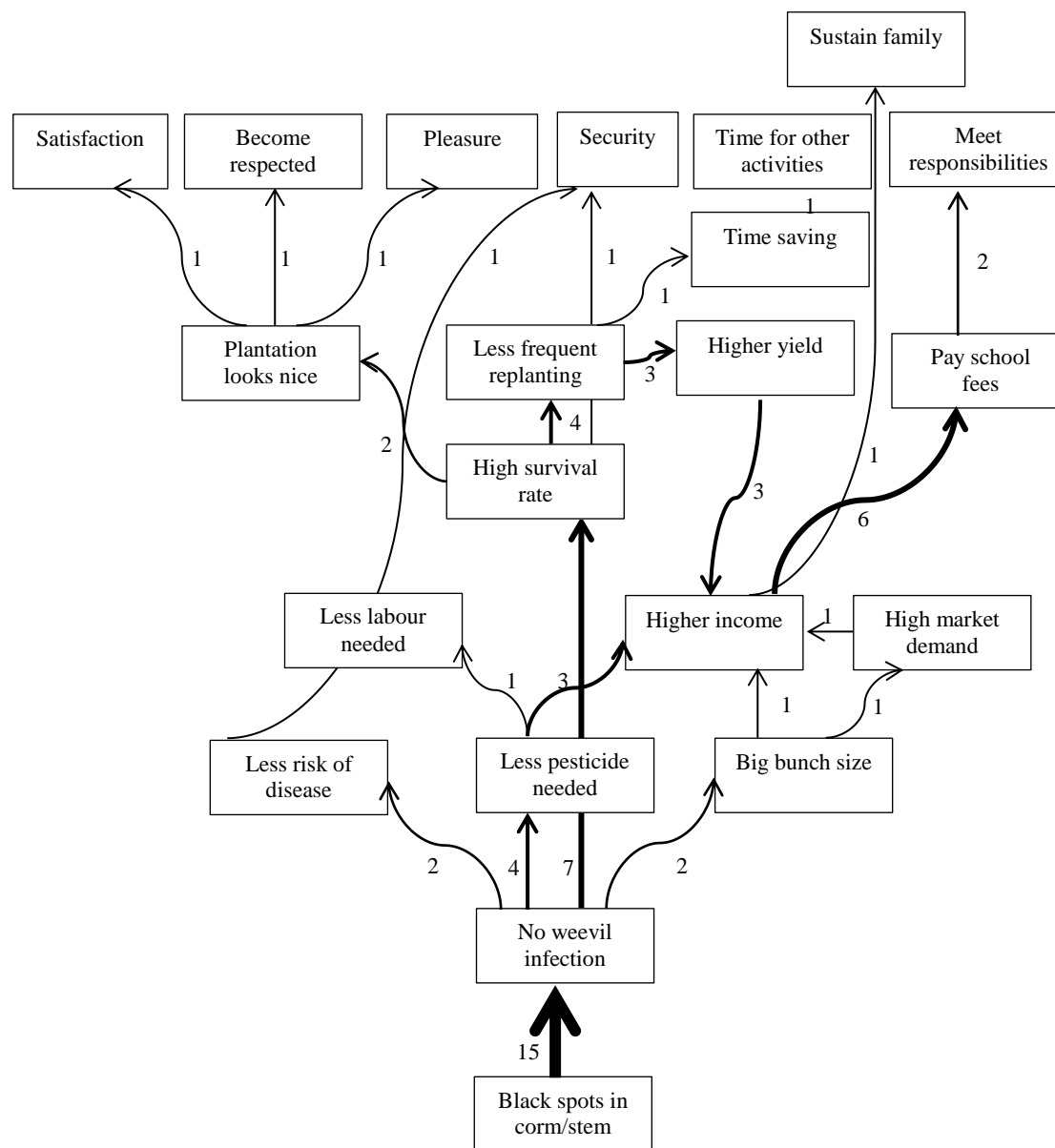
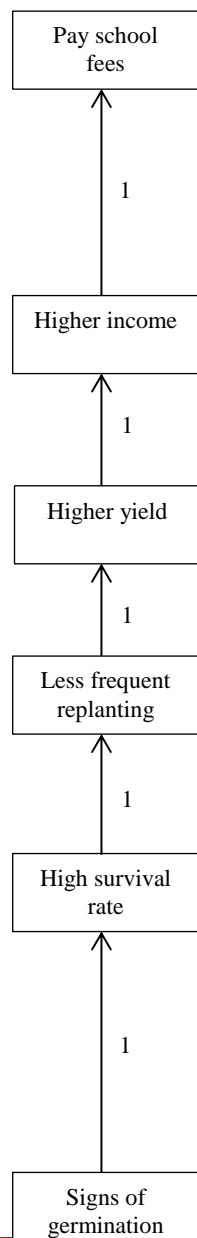














## Appendix 4 Positive and negative variety traits

Table A14. Variety traits considered as positive and negative by the farmers. Numbers under the + signs indicate how many farmers consider a trait positive and numbers under the – sign indicate how many farmers consider the trait as negative. (Source: *Perception of quality*)

Variety		Muvubo		Nakitembe		Nakabululu		Tombadala		Mpolgoma		FHIA	
		+	-	+	-	+	-	+	-	+	-	+	-
Bunch size	large	7								9		1	
	small					2							
Finger size	large	8											
	small					1							
Lifespan	long	3		4		2						1	
	short									1			
Number of bunches/mat	high	1		2									
	low												
taste	good	3		5		2				2			
	bad							2			1		6
rate of suckering	high			6				1					
	low	1	1								1		
drought resistance	high			5		1							
	low		1								1		
maturity time	long					1	1						
	short			8						3			
resistance to weevils	high			1									
	low		2										
soil selectiveness	high												
	low			1									
market demand	high	1		1						1			
	low					2		1					8
disease resistance	high					1				1			
	low												
bunch type	packet			1		1							
	loose						1						
invasiveness	high							3					1
	low												
number of hands	high												
	low		1										
market demand for suckers	high									1			
	low					1							
required management	high										1		
	low					1							
required inputs	high										1		
	low												
period to flowering	long												
	short			1									
New variety		1		2						1			
Variety has cultural value						1							
Variety on the farm gives status										1			



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