THE EFFECTS OF BANANA XANTHOMONAS WILT (BXW) ON FOOD SECURITY AND THE PEOPLE'S LIVELIHOOD:
The Case of Nshamba and Rubale Divisions in Kagera Region, Tanzania

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<tbody>
<tr>
<td>AATF</td>
<td>African Agricultural Technology Foundation</td>
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<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
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<td>BARNESA</td>
<td>Banana Research Network for East and Southern Africa</td>
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<td>BFW</td>
<td>Banana Fusarium Wilt</td>
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<td>BXW</td>
<td>Banana Xanthomonas Wilt</td>
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<td>CDI</td>
<td>Centre for Development Initiatives</td>
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<td>EAHB</td>
<td>East African highland bananas</td>
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<td>ECSs</td>
<td>Embryogenic Cell Suspensions</td>
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<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
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<td>IGAs</td>
<td>Income Generating Activities</td>
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<td>IITA</td>
<td>International Institute of Tropical Agriculture</td>
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<td>Igabiro Training Institute of Agriculture</td>
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<td>KADETFU</td>
<td>Kagera Development and Credit Revolving Fund</td>
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<td>MAFC</td>
<td>Ministry of Agriculture, Food Security and Cooperatives</td>
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<td>MARDI</td>
<td>Maruku Agricultural Research and Development Institute</td>
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<tr>
<td>M &amp; E</td>
<td>Monitoring &amp; Evaluation</td>
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<td>MDGs</td>
<td>Millennium Development Goals</td>
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<td>NARL</td>
<td>National Agricultural Research Laboratories</td>
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<td>National Agriculture Research Organization</td>
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<tr>
<td>NGO</td>
<td>Non Governmental Organization</td>
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<td>NSGRP</td>
<td>National Strategy for Growth and Reduction of Poverty</td>
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<td>PLWHA</td>
<td>People Living With HIV/AIDS</td>
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<td>TDV</td>
<td>Tanzania Development Vision</td>
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<td>URT</td>
<td>United Republic of Tanzania</td>
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We are also indebted to the Regional and District Councils, Division authorities, community members including the respondents to this study, key informants and all the people that were consulted for revealing the information that was required by the study. They all deserve our admiration.

The Government of Tanzania also deserves acknowledgment for providing the encouraging working environment that enabled us to work for the betterment of her people and the community at large.

We finally wish to express our special gratitude and love to our families for their tolerance and encouragement during the whole period of this study.

Bukoba, August 2013

Yusto Paradius Muchuruza

Hance Richard Melchior
FOREWORD

Since late 2000s the majority of communities in Kagera region have been affected by Banana Xanthomonas Wilt (BXW), the banana disease known as “Mnyauko” which has consequently jeopardized assurance of food security and people’s livelihood at both family and community level. In recognition of its threat, last year (2012) the government authorities in Kagera region declared BXW a national disaster which needs immediate interventions. This study is the contribution to the initiatives of the region in trying to raise community awareness on the symptoms, mode of spread and effects of the disease to their livelihoods and sensitization on the measures to curb its spread.

In this regard, Kagera Development Trust Fund (KADETFU) and Centre for Development Initiatives (CDI) conducted this study whose goal was to assess the effects of BXW on food security and income to the community, including farmers in the Region. The study used a sample of Nshamba and Rubale divisions of Muleba and Bukoba Rural Districts respectively. I believe the observations from the sample reasonably reflect the situation and effects of BXW on both the food security and people’s livelihood.

I also believe that this study has been conducted at the right time when our country and the international community are trying to address BXW in a comprehensive way in order to control and possibly eradicate it. The study as well encourages the government to formulate policies and strategies to address the disease. I anticipate that the recommendations of the study will motivate the public and private agencies, Ministry of Agriculture, Food Security and Cooperatives (MAFC), international agencies as well as development partners to collaborate and join hands in curbing the disease for sustainable livelihoods in Kagera region and elsewhere in the country and the world at large.

It is also my hope that the contributions of the authors in this study will provide the essential additions to the debate and dialogue on BXW, as well as assist in creating new approaches of curbing BXW effects on food security and livelihoods of the communities and thus improving the living conditions of people. At the invitation of His Excellency President Kaguta Mseveni, in December 2011, I took a group of 140 farmers from Muleba to Uganda for an agricultural study tour to learn how our neighbors were coping with the challenge of BXW. We learnt a lot but above all that cultural practices must be followed strictly. I urge the readers of this book to adopt the recommendations and to recognize and take on their own responsibility in combating the disease. Finally no amount of external assistance shall help if we do not play our part.

I thank you all and congratulate the Authors who are responsible for the facts and views in this study.

Hon. Prof. Anna Kajumulo TIBAIJUKA  
Member of Parliament for Muleba South, Kagera region  
Minister for Lands, Housing and Human Settlements Development, United Republic of Tanzania  
Retired UN Under-Secretary General and Immediate former Executive Director, UN-HABITAT

Dar es Salaam; September 2013
ABSTRACT

Banana is the major staple food crop in Tanzania and in other countries of the East African Great Lakes region. Kagera Region is one of the most banana producing regions in Tanzania and banana production is the most important staple food for over two million people in the region. Banana crop is also the source of income for millions of people in this region. Despite the significance of banana in the region for food security and the farmers’ income and livelihoods, the crop has been mostly threatened by the Banana Xanthomonas wilt (BXW) which has lead to great losses of banana production in the region. BXW is currently the most destructive emergent disease in Tanzania which may cause up to 100% plantation loss if no management and control measures are employed.

The study generally aimed to assess the effects of the BXW on food security and income of the farmers in Nshamba and Rubale divisions of Muleba and Bukoba Rural Districts respectively in Kagera Region, Tanzania. Specifically the study intended to (a) identify economic activities performed by the people in the study area; (b) examine the farmers’ awareness of the BXW and its management and control measures in the study area; and (c) assess the effects of the BXW on food security and the income of rural community members. A cross-sectional research design was employed and both purposive and simple random techniques were used to select a sample of 360 farmers. As for data collection, the structured questionnaire was used. Both quantitative and qualitative methods of data analysis were employed. The quantitative data were analyzed by using the Statistical Product and Service Solutions (SPSS) (Version 16).

The majority of the respondents that were interviewed reported farming as their main activity. The study found that before the outbreak of BXW banana production was 356,545 bunches per annum; while after the outbreak of BXW the production has decreased to only 50,800 bunches (16.6%). This therefore implies that about 84% of banana production is lost per annum in the study area. It was also revealed that as production decreases, the price of banana bunches increases. The income from banana in the study area has dwindled from TZS. 801, 656,000/= to 307,034,248/= (38.3%) after the outbreak of BXW in the study area. This implies that TZS. 494,621,752 (61.7%) of the farmers’ income is lost annually in the Region. Therefore, immediate intervention measures should be taken to reduce the effects of the disease to the community in order to improve their livelihoods.

The study also found that the majority of the respondents (about 87%) are currently getting only one meal per day as compared to the previous years before the outbreak of BXW when they could afford to get three meals daily. This implies food insecurity for the majority of the farmer households; and immediate control measures are required to remedy the situation. The study concluded that banana production has declined significantly leading to food insecurity,
malnutrition and loss of income of the rural community members in the study area. The study recommends that the government should recruit extension officers in the study area and elsewhere in Kagera region in order to create awareness and sensitization to the farmers on the spread, management and control measures of the disease. The study also recommends that strategies developed and validated in Uganda should be replicated in the study area, Kagera Region as well as other regions of Tanzania for proper management and control of the BXW.

Moreover, the study recommends that the government should establish strategies to empower farmers and other key stakeholders with capacity, knowledge and skills needed to control the disease alongside the efforts of other state and non-state actors. The government and all actors in banana production areas should be advised to execute comprehensive strategies and enforce legislations pertaining to agricultural diseases control and management. The government should recruit more agricultural extension officers, and the farmers should be encouraged to use the management and control measures as recommended by experts and researchers.

Further studies are recommended to address the main causal factors that were established by the study, which include ignorance, negligence, mindset and poor knowledge. Strategies to combat BXW should be applied together with the efforts to address other cross cutting issues like gender inequality, HIV/AIDS and environmental problems. In addition, technical studies should be carried out to establish more scientific facts and additional measures that will be utilized to combat BXW in Tanzania and beyond. The study finally calls upon the international community to join the Tanzanian Government as stakeholders in research, technology transfer and knowledge dissemination in order to establish the causes, symptoms, effects, management and control of the disease.

**Key words: BXW, effects, food security, income, management and control**
CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information
Banana is the major staple food crop in the East African Great Lakes region. In Tanzania’s Kagera Region, banana is the most important staple food for over two million people (URT, 2006). Kagera Region has often been referred to as the “banana culture” or “banana land” (FAO - Rugalema and Mathieson, 2009). Kagera Region produces more than one-third of the total banana production in Tanzania, which was estimated to be 2.2 million tons in 2006. Banana dominates the diet of the Bahaya, the autochthonous people of Kagera Region. In this region, 70% of the households grow bananas and an estimated 2.3 million people depend to a large extent on bananas for their daily source of carbohydrates (URT, 2006). However, banana production is on the low input system, practiced in small holdings averaging 0.5 ha per farming household (Bosch and Shwagala, 1994). Bananas also provide a source of cash income for farmers as excess production when they are sold on the market. Bananas also have ecological functions such as protection of the soil against erosion and leaching.

1.1.1 Historical and cultural background of banana production in Kagera region
The history and culture of the banana based farming system in Kagera Region has been described by many experts including Rald and Rald, 1975; Rugalema, et al., 1994; Maruo, 2002; and FAO Rugalema and Mathieson, 2009). Banana farming differs from other forms of crop production. The Bantu people practiced slash and burn shifting cultivation and grew finger millet (Eleusine coracana), yams (Dioscorea sp) and Coleus (Coleus spp) for about two millennia.

In the 16th century the Nilo-Hamitic pastoralists arrived in contemporary Kagera Region from the lower Nile Valley and brought with them cattle. The two groups mixed and formed a new society, now called the Haya. The Haya exploited manure with careful management and built up a perennial culture of banana plants on highly weathered soils. At the end of the 19th century the rinderpest disease killed 90 percent of the cattle in the region and since then the number has continued to dwindle due to various epidemics. Nowadays, replenishment of fertility in banana fields depends mainly on grass brought in from the surrounding grasslands and only partly on manure (Mathieson and Steenhuijsen Piters, 1998). This situation, together with human population growth since the 1920s (Milne, 1938), has put pressure on farming and the region has been experiencing a decline in the degree of food security for over two decades.

According to Rugalema and Mathieson (2009), the Haya classify land use into two main categories: kibanja and rweya. The kibanja is the archetype of Bahaya rootedness and prosperity. This is an essential farm (area) where farmers grow banana, mixed with coffee (mainly Coffea canephora), maize (Zea mays), Phaseolus beans, and root and tuber crops. A farmer’s life is anchored in the kibanja, where he/she erects a family home. The kibanja also serves as a final
resting place for the deceased family members. A group of *kibanja* units comprises an aggregate of homesteads which form a village community (*ekyaro*). Milne (1938) described this aggregate as ‘an island of fertility in the sea of infertile grassland’.

*Rweya* is the savanna type grassland used mainly for grazing cattle. It also serves as a source of grass for mulching, thatching, carpeting and other essential uses. *Rweya* is also a site where crops such as cassava – *Manhot esculenta*, Bambara nuts – *Vigna subterranea* and yams – *Dioscorea sp*) are planted. Thus Rweya and Kibanja are interdependent and central to the livelihoods and food security of the Haya (FAO Rugalema and Mathieson, 2009).

The productivity of banana-based farming systems of Kagera Region has been deteriorating due to the increase in the occurrence of crop pests and diseases in recent years (Rugalema and Mathieson, 2009), and this has resulted into food insecurity in the region. In addition to that Moberg (1972) and Mathieson (2004) show that the other significant cause of declining productivity of banana-based farming systems is soil fertility decline, partly due to declined herd sizes which are the source of manure and partly due to decimation by various cattle diseases.

The types of banana grown in Kagera Region, in order of their importance include: East African highland bananas (AAA-EAHB), composed of cooking and brewing types; other brewing types (AB, ABB); other cooking types (ABB); dessert bananas (AAA, AAB); and plantains (AAB) (Karamura and Mgenzi, 2004). The farmers often grow bananas in highly complex cultivar mixtures.

**1.1.2 Morphology and reproduction of Banana in relation to BXW**

Bananas are large perennial herbs with an underground stem called a corm, which is the true stem of the banana plant. The corm produces aerial shoots which arise from the lateral buds which develop into eyes and later suckers. The continuous vegetative growth of suckers perpetuates the corm’s life and hence the perennial status of the banana plant. The aerial shoot is called a pseudostem and grows to the height of 2 to 8 m depending on the variety and the conditions. The pseudostem consists of large overlapping leaf bases which are tightly rolled round each other forming a cylindrical structure almost 48 cm in diameter. The roots are initiated from the corm and they range from 50 to 100 cm in length; occasionally sub-horizontal roots reach 3 m (Blomme and Ortiz, 2000). The corm also consists of the apical meristem from which the leaves and ultimately the flowers are initiated. On average, each plant produces 35 to 50 leaves in its growth cycle. When the banana plant has formed an average of 40 leaves (within 8 to 18 months), the terminal bud of the corm develops directly into the inflorescence which is carried up on a long smooth un-branched stem through the centre of the pseudostem emerging at the top in the centre of the leaf cluster. The inflorescence is a compound spike of female and male flowers arranged in groups. Each group consists of 2 rows of flowers, one above the other, closely appressed to each other, and the whole collection is covered by a large subtending bract. The bracts and their auxiliary groups of flowers are arranged spirally around the axis and the bracts closely overlap each other forming a tight conical inflorescence at the tip. The lower bracts of the axis enclose female flowers; the middle few bracts enclose neuter flowers whilst at
the tip of the inflorescence male flowers occur (Purseglove, 1972); and more importantly, \((M. \text{schizocarpa}, M. \text{acuminata} \text{ ssp. Banksii})\) and \((M. \text{acuminata} \text{ ssp. errans})\) hermaphrodite flowers are produced (Sharrock \textit{et al.} 2001).

The female inflorescences develop into fingers that constitute the bunch. Banana bunches possess 4 to 12 hands (clusters), each with at least 10 fingers. In wild bananas both male and female flowers produce abundant nectar and pollen whereas in cultivated bananas, many clones lack pollen. Banana pollen is tiny and sticky, being coated with waxes and proteins held in place by sculpture elements. The quantity of pollen is an important factor in enhancing the germination potential of pollen grains (Sharrock \textit{et al.} 2001). The female flowers have ovaries that develop first by parthenocarpy (without fertilization) to form pulp which is the edible part of the crop. Nevertheless, wild bananas exhibit cross pollination and ultimately fertilization to form seeds instead of pulp (non-parthenocarpic).

In the newly established banana plantation banana plants take up to 10 months to present bunches, provided agronomic and ecological factors are not limiting. The presented bunches take about 4 months to mature. Therefore from planting to harvesting, bananas take about 14 months. This period of almost 1 year is not enough to observe the disease basing on a single mother plant on the stool. The period of maturity of banana might be a little shorter or longer depending on the type and size of the planted suckers, environmental conditions and how the principles of banana farming have been followed. Sometimes two bunches are produced on the same stool in succession, whereby the daughter plant can present a bunch about 2 months following the harvesting of mother plant. Because of the nature of the disease, plant botany is very important as each part of the banana plant has something to reveal about the disease especially when it comes to identifying symptoms (epidemiology) (UNCST and PBS, 2007). Bananas are essential crops in Tanzania because they provide food security, income and livelihoods to millions of smallholder farmers.

Despite the importance of bananas to the livelihoods of the farmers in Tanzania, particularly in Kagera region, the crop is threatened by various production constraints such as biotic and abiotic factors (Ortiz \textit{et al.}, 2002). Biotic factors in general significantly reduce the yield of bananas in comparison to abiotic factors. The major biotic factors include banana weevils \((Cosmopolites sodidus)\), nematodes \((Rodopholus similis)\), black sigatoka disease \((Mycosphaerella fijiensis)\), fusarium wilt \((Fusarium oxysporum f.sp cubense)\) and the Banana Xanthomonas Wilt disease \((BXW)\) \((Xanthomonas campenstris pv.musacerum)\). Overall, the Banana Xanthomonas Wilt \((BXW)\) disease poses the most damaging threat to banana productivity. BXW has become a new threat and is currently rated the most serious constraint to banana production in Tanzania, particularly in Kagera Region.

The Banana Xanthomonas Wilt \((BXW)\) disease, caused by the bacterium \textit{Xanthomonas campesrtris pv. Musacearum}, jeopardizes the livelihoods of millions of farmers in East Africa (Tushemereirwe \textit{et al.}, 2004). It has threatened banana production in the Great Lakes region of Eastern Africa including Burundi, Rwanda, the Democratic Republic of Congo, Uganda, Kenya,
and Tanzania (Kalyebala et al., 2007). The disease was first reported about 40 years ago in Ethiopia on Ensete, which is closely related to banana (Yirgou et al., 1968). Outside Ethiopia, BXW was first reported in Uganda in 2001 and has now spread to almost all major banana producing districts of the country ((Tushemereirwe et al., 2004 and Tripathi et al., 2009). In Tanzania BXW was first recorded in January 2006 at Kabale village, Muleba District; the situation has since changed significantly and within one year it has spread to most parts of Kagera Region (Mgenzi et al., 2006). The disease has contributed to decreased household and national food security and income (Tushemereirwe et al. 2004; Tushemereirwe et al., 2003).

During the study done by Rugalema and Mathieson (2009) some farmers reported the outbreak of a new disease. Below is one of such testimonies (Box No.1):

“One day during the month of August 2005 my daughter reported a ripe bunch of bananas in the plantation. Surprisingly the reported bunch appeared mature just two months after it had flowered, which is abnormal. We harvested the bunch but found that the fingers were hard and blackish inside and emitted a very strong odour. We did not understand the kind of disease that had caused this problem, but thought that possibly the Cassava Mosaic Disease had started to affect Bananas. By September the disease had spread to about 20 other mats on the plantation”.

“I decided to report the disease to the village Government, but the village chairman asked me to report it to the extension staff. At that time there was no extension staff available as the officer responsible for our Ward had gone to Mwanza for further studies. Fortunately, an extension staff from an NGO (KADETFU) was visiting our village and I reported the case to him and he took the report to the District Office. In mid December 2005 I was visited by extension officers from the district headquarters who told me that the disease was Banana Xanthomonas Wilt” he added.

It was not until 26 January 2006 when I was visited by a group consisting of the District Commissioner, District extension officers and researchers, who ordered us to uproot the whole banana plantation. By then more than three-quarters of my plantation had been affected and the disease could be seen in neighboring plantations”. He concluded.

**Box No. 1: Testimony on the outbreak of BXW in Muleba District**

The disease has since spread throughout the major banana producing districts of Kagera region, causing losses of up to 100% in poorly managed banana plantations (Mgenzi et al., 2006). Yield losses are associated with early ripening and rotting of fruits even in the absence of apparent external symptoms of the disease, and wilting and death of the banana plants (FAO- Rugalema and Mathieson, 2009). Consequently, due to the BXW spread in most of the districts of Kagera region, several farmers have abandoned banana cultivation as the result of low production of banana. To rescue high loss of banana yield, appropriate BXW intervention measures need to be taken very soon in order to ensure food security, poverty reduction and sustainable livelihoods of the farmers (FAO - Rugalema and Mathieson, 2009).
1.2 Statement of the Problem

Banana Xanthomonas Wilt (BXW) is the most devastating disease affecting bananas in the entire Great lakes region of Africa. As pointed out earlier, it has contributed to decreased household and national food security and income (Tushemereirwe et al 2004; Tushemereirwe et al., 2003). In Tanzania, Kagera region in particular, BXW has negatively affected the livelihoods of the people by significantly contributing to food insecurity and decreasing the incomes of the smallholder farmers. The disease has already depleted several hundreds of acres of banana plantations mostly in Bukoba and Muleba districts. The most affected families include those headed by orphans and the elderly who have no other alternative means of survival. Data from the regional agricultural office show that the disease has affected 56,520 households from 389 villages in 100 wards (URT, 2012).

Reports from Bukoba Rural District Agricultural, Livestock and Co-operatives department show that more than 52 hectares of banana plantations capable of producing fruits valued at over Tsh.182 million per year were uprooted after the BXW outbreak. According to the Bukoba Rural District authorities, out of a total of 92 villages in the district, about 62 were affected, involving 39,000 infected banana plants, which were uprooted in 21 wards (BDC (R) annual report 2011). In addition to that, the reports show that since BXW broke out in 2006, the accumulated annual production loss of banana, if converted to the current compensation rates, is likely to amount to Tsh. 600m in Bukoba Rural District alone (Kaijage, J. “The citizen newspaper, 06.03.2011”).

In Muleba District, the authorities show that BXW has affected the district economy such that most families who depended on banana are no longer as wealthy as they used to be. “Almost 65% of the farmers in the district take one meal a day due to the loss of food (banana), while 35% who take more than one meal have other sources of income like businesses, and the district economy has dropped tremendously within a few years” (Kaijage, J. “The citizen newspaper, 06.03.2011”).

Culturally, the Haya people regard bananas as the best food and the banana plant as a blessed plant due to its more than 100 uses. The outbreak of BXW has changed this perception, causing desperation and disaster to the natives of this area. The dwindling income from banana production can no longer allow them to take their children to school, they cannot afford health care expenses and most importantly, food security at family level is not assured (FAO – Rugelema and Mathieson, 2009).

The effects of BXW are both extreme and rapid as compared to other diseases which have caused gradual losses over years. The economic impact of BXW is due to the death of the mother plant that would otherwise contribute to the ratoon plant production cycles (Tripathi et al., 2007). Moreover, the farms infected with X. campestris pv. musacearum cannot be replanted with bananas for at least 6 months due to the carryover of soil borne inoculum (Turyagyenda et al.,
BXW has similarities to other bacterial wilts of banana caused by *Rastonia solanacealum*, including moko, blood, and bugtok diseases (Thwaites *et al.*, 2000). Unfortunately, the control of diseases caused by these pathogens is very difficult (Eden-Green *et al.*, 2004).

The management and control measures of BXW, which include avoiding the introduction of foreign materials into the gardens; breaking off male flower buds immediately the last cluster on the bunch is formed; cutting down all infected plants and burying them; cleaning all cutting tools every after a cut in Jik or flame them; and M & E of control; have been identified in East African countries, yet very few farmers have adopted these management and control measures in their farms due to inadequate sensitization and awareness on BXW at the village level. This study, therefore, seeks to address the BXW problem in the study area, its socioeconomic related consequences and interventions that can be employed to rescue the livelihoods of the people who largely depend on bananas as a source of food and income (Karamura *et al.*, 2006 and Mgenzi *et al.*, 2006).

### 1.3 Objectives of the Study

#### 1.3.1 General objective

The general objective of the study was to assess the effects of BXW on food security, people’s income and other socio-economic aspects in Nshamba and Rubale Divisions.

#### 1.3.2 Specific objectives

- To identify economic activities performed by the people in the study area;
- To appraise the farmers’ awareness and knowledge on BXW and its management and control measures in the study area.
- To assess the magnitude of the effects caused by the disease so far and propose ways of addressing them.

#### 1.3.3 Research Questions

- What are the main economic activities that are performed by the people in the study area?
- How much is known by the people about BXW and its management and control measures?
- What is the magnitude of the effects of the disease and how can they be addressed?

### 1.4 Justification of the Study

BXW has threatened food security, income and livelihoods of the banana producing regions in the East African Great Lakes countries of Tanzania, Uganda, Kenya, Rwand Burundi and the Democratic Republic of Congo. The outbreak of BXW in the region has led to the need for
developing the regional strategy to control the disease (Karamura et al., 2006 as cited by FAO – Rugalema and Mathieson, 2009). The strategy is coordinated by the Banana Research Network for East and Southern Africa (BARNESA). The strategy envisages the involvement of international, regional, national and local level actors to develop, implement and coordinate research and extension interventions to support the prevention and control of BXW in order to enhance food security, income and livelihoods of the farmers in the region.

In addition, due to the importance of banana to food security, incomes and livelihoods of people, the government of Kagera region has declared the BXW to be the national disaster that needs to be addressed and called for remedial management and control measures soon because its economic impacts are significant (URT, 2012).

This study is an essential contribution to these efforts as envisaged by both the regional and local bodies. The findings of the study will enable the governments of Kagera region, Tanzania and the whole Great Lakes Region to deal with the disease effectively in order to improve banana production and thus enhance food security, income and livelihoods of the farmers and improve the economy of the small holder farmers and the respective nations at large. The study will also generate new knowledge and information which will be useful to development planners, local leaders, policy makers and practitioners interested in poverty reduction.

In addition, this study complies with Tanzania Development Vision (TDV) 2025, National Strategy for Growth and Reduction of Poverty (NSGRP) cluster 1, which emphasizes on promoting research activities on disease management and control as well as developing technical capacity for agricultural research and extension services in urban and rural areas (URT-NSGRPII, 2010).
CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Banana and its Importance in East Africa

Bananas belong to genus *Musa*, family *Musaceae* and order *Zingiberales*. Bananas are believed to have originated from South East Asia and Indochina (Simmonds, 1962) where the earliest domestication of bananas is also believed to have happened. From there, they were introduced to all tropical and subtropical regions of the world, gaining great importance as a food crop. It is suggested that edible bananas originated from two wild seed forming species, *Musa acuminata* Colla (2n = 2X= 22) and *Musa balbisiana* Colla (2n=22), and provide “A” and “B” genomes of bananas, respectively. Bananas were introduced into East Africa by the Arab traders on their journeys between India and East Africa, or could have reached East Africa via the west coast of Africa. It is believed that somatic mutations gave rise to the large variability in the East African highland banana (EAHB) cultivars, making East Africa the secondary center of diversity for this group.

Banana has many qualities that make it an essential crop in East Africa. Bananas are preferred to be consumed as fruits due to their progressive conversion of starch into sugars after harvest (Bagamba *et al*., 2006), while others like plantains are considered to be a carbohydrate staple. Depending on the juice yield, some fruit type cultivars are used to produce wine and gin. East African highland bananas are mainly produced as a starch staple that compete with other crops such as cereals (like maize and millet) and tubers (like sweet potatoes and cassava) (Bagamba *et al*., 2006). In addition to providing a reliable source of food, banana is an essential source of income with excess production sold in local markets.

In Africa, Tanzania ranks fourth in banana production and produces some 3.7 million tons per year from some 403,000 hectares. Kilimanjaro and Kagera are the most famous banana growing regions in the country, producing 1,383,800 and 1,150,000 tons respectively, in 1998. ([http://www.dailynews.co.tz/home/?n=15934](http://www.dailynews.co.tz/home/?n=15934)). Bananas are consumed as fruit, prepared by cooking, roasting or drying, used for production of banana juice and fermented for production of alcoholic beverage (beer, wine and gin) (Edmeades *et al*., 2006). Bananas are also a source of animal feeds (fresh pseudostems, male buds, banana peelings and by-products of fermentation), wrapping material for produce in storage, construction materials (thatch and binding ropes) and handicrafts (mats, baskets, hand bags, necklaces and decorations) (Karugaba and Kimaru, 1999). Banana leaves provide soil surface cover, reduce soil erosion on steep slopes, and are used as a principal source of mulch for maintaining and improving soil fertility (FAO – Rugalema and Mathieson, 2009). However, studies show that culturally, banana has more than 100 uses and benefits in Kagera Region.
2.2 Banana Production Hindrances

Bananas and plantains provide more than 25% of food energy requirement for more than 100 million people in Africa, 20 million of which are from East Africa alone (Robinson, 1996). In addition, banana is one of the most important cash crops contributing up to 22% of national agricultural revenue (Kalyebala et al., 2007). Banana is grown in almost all regions of Tanzania, from the coast to highland areas, and Tanzania ranks third in banana production in East and Central Africa (FAO, 2007). It is a staple food for about 15% of Tanzanians (Ngeze, 1994) and contributes to household income generation through sales on the domestic market.

Banana production is threatened by various biotic hindrances including pests such as banana weevil and nematodes and diseases (Ortiz et al., 2002). The significant diseases include Black Sigatoka, Fusarium wilt and Banana Xanthomonas Wilt (BXW) which cause yield losses of up to 90% in the farmers’ fields (Aritua et al., 2007). In 2006, the estimated loss of BXW was 295 million USD worth of banana output valued at farm gate (Kalyebara et al., 2006). This expected loss translates into around 200 USD of food and income per household. As reported previously (Tushemereirwe et al., 2006), all banana varieties so far screened are susceptible to BXW.

2.2.1 History of Banana Xanthomonas Wilt

Banana Xanthomonas Wilt (BXW) caused by the bacterium Xanthomonas campestris pv. musacearum jeopardizes the livelihoods of millions of farmers in East Africa (Tushemereirwe et al., 2004). BXW has threatened banana production in the Great Lakes region of East Africa including Burundi, Rwanda, the Democratic Republic of Congo, Uganda, Kenya, and Tanzania (Kalyebala et al., 2007). The disease was first reported about 40 years ago in Ethiopia on Ensete, which is closely related to banana (Yirgou et al., 1968). Outside Ethiopia, BXW was first reported in Uganda in 2001 and has now spread to almost all major banana producing districts of the region ((Tushemereirwe et al., 2004 and Tripathi et al., 2009). In Tanzania BXW was first recorded in January 2006 at Kabale village, Muleba District. The situation has since changed significantly, and within one year it has spread to most parts of Kagera Region (Mgenzi et al., 2006). The disease has contributed to decreased household and national food security and income (Tushemereirwe et al 2004; Tushemereirwe et al., 2003).

The disease has spread throughout the major banana producing districts of Kagera region, causing losses of up to 100% in poorly managed banana plantations (Mgenzi et al., 2006). Yield losses are associated with early ripening and rotting of fruits even in the absence of apparent external symptoms of the disease, and wilting and death of the banana plants (FAO- Rugalema and Mathieson, 2009). Several farmers have abandoned banana cultivation as a result of low production of banana due to the BXW spread in most of the districts of Kagera region. To rescue the situation of high losses of banana yield, BXW intervention measures need to be taken soon in
order to ensure food security, poverty reduction and sustainable livelihoods of the farmers (FAO - Rugalema and Mathieson, 2009).

2.3 Etiology of Banana Xanthomonas Wilt
Little is known about the etiology of BXW. It is reported that the pathogen enters the host through wounds on roots, pseudostems and leaves (Yirgou and Bradbury, 1968, 1974; Korobko et al., 1987). It is suspected that the bacterium enters the plant through the male buds as reported for the Moko disease (Korobko et al., 1987). According to Yigou and Bradbury (1974) long distance transmission of the disease is aided through contaminated farming tools such as pangas and pruning knives which transmit the bacteria through injuries on the roots and aerial parts, and movement of infected plant materials (suckers, bunches, leaves). The major transmitters of BXW are the insects as they move from one plant to another looking for nectar in flowers (Sekiwoko et al., 2006).

Xanthomonas campestris pv. musacearum (Xcv) attacks the vascular system of both banana and Ensete ventricosum (Enset) causing wilting and death of the plants. Xcm is motile, gram-negative rod shaped, possesses a single polar flagellum and produces typically yellow, convex, mucoid, slimy colonies on nutrient agar and other media (Yirgou and Bradbury, 1968, 1974; Tripathi et al., 2007). Phylogenetic relationships were evaluated for 20 isolates of the bacterium collected within a period of about four decades, between 1968 and 2005, from Ethiopia, Uganda, the Democratic Republic of Congo, Tanzania and Rwanda. Sequence analyses of the internally transcribed spacer (ITS) locus (Aritua et al., 2008) and the gyrase B (gyrB) gene revealed only limited (<2%) nucleotide divergence among the isolates (Aritua et al., 2008).

2.3.1. Banana Xanthomonas Wilt Disease symptoms
The affected banana plants develop symptoms characterized by a progressive yellowing and wilting of leaves, with fruits ripening prematurely and unevenly with internal brown discoloration. When stems are cut, a pocket of pale yellow bacterial ooze appears within 5-15 min (Yirgou and Bradbury, 1974 and Tushemereirwe et al., 2004). Yellow or brown streaks occur in vascular tissues of the infected plants. Other symptoms on the floral parts include wilting of bracts, shriveling and rotting of the male buds, and flower stalks turning yellow-brown (Yirgou and Bradbury, 1968; Tushemereirwe et al., 2004). Plant death commonly results from the infection.

2.4 Management of the Banana Xanthomonas Wilt
The management of diseases in tropical perennial crops such as bananas is a challenge due to continuous association of host and inoculum over a long period of time (Ploetz et al., 2007). The recommended measures for BXW management involve a mixture of approaches combining
exclusion, eradication, host resistance, and crop protection. Control of BXW and similar bacterial diseases of banana depends on the prevention of disease spread (containment), reduction of disease impact in affected farms (management), and rehabilitation of previously affected areas. In Uganda, BXW is mainly controlled by improved cultural practices in well organized banana production areas (Tushemereirwe et al., 2003). Cultural practices that have been used so far include the use of clean planting materials, clean tools which are sterilized in fire or diluted sodium hypochloride, de-budding by breaking the male buds with a forked stick, cutting and burying of the diseased plants, and crop rotation (Tushemereirwe et al., 2004 and FAO – Rugalema and Bijukya, 2009).

2.5 Genetic Engineering for Resistance to Bacterial Diseases in Plants

Genetic transformation approach has been used to control bacterial wilts in many crops (Huang et al., 2004 as cited by Namukwaya, 2011). The path system-specific plant resistance (R) genes that mediate resistance to bacterial, fungal, viral and nematode pathogens have been cloned from several plant species (Bent, 1996). Many of these R gene products share structural motifs, which indicate that disease resistance to diverse pathogens may operate through similar pathways. For example, the Bs2 resistance gene of pepper specifically recognizes and confers resistance to strains of *X. campestris* pv. *vesicatoria* (*Xcv*) (Wang et al., 1996) that contain the corresponding bacterial a virulence gene, *avr* Bs2 (Tai et al., 1999). Transgenic tomato plants expressing the pepper *Bs2* gene suppress the growth of *Xcv*. The *Xa1* gene in rice confers resistance to Japanese race 1 of *X. oryzae* pv. *oryzae*, the causal pathogen of bacterial blight (Yoshimura et al., 1998). Transgenic bananas expressing *Hrap* gene conferred resistance to BXW (Tripathi et al., 2010). *Sap1* is an amphipathic protein isolated from the sweet pepper, *Capsicum annum* (Lin et al., 1997). The use of *Sap1* has been shown to delay the hypersensitive response induced by *Pseudomonas syringae* pv. *syringae* in non-host plants through the release of the proteinaceous elicitor, harpins (Lin et al., 1997). Further analysis also showed that *Sap1* functioned in a dose-dependent manner by competitively inhibiting the interaction between harpins and its receptor on the plant cells and consequently suppressed bacterial growth. This transgene has showed enhanced hypersensitive response against various pathogens in many dicot and monocot crops (Tripathi et al., 2009).

2.6 Genetic Transformation of Banana

Biotechnological tools that are required for genetic transformation of banana have been reported (Sagi, 2000 as cited by Namukwaya, 2011). Various embryogenic cell suspensions (ECSs) technologies have also been reported (Strosse et al., 2006). Genetic transformation using direct gene transfer methods (Sagi et al., 1995) and Agrobacterium based gene transfer system are used routinely in different laboratories (Ganapathi et al., 2001; Khanna et al., 2004). Hence, biotechnology provides the most sufficient and precise techniques to introduce useful genes such as those for pest and disease resistance into locally available varieties without changing their preferred characteristics.
Genetic transformation of banana that commenced with the use of micro projectile bombardment is now regularly used (Becker et al., 2000). Afterward, Agrobacterium mediated transformation was reported (Ganapathi et al., 2001; Khanna et al., 2004). Agrobacterium mediated transformation system is more efficient than particle bombardment system in bananas as high transformation frequencies are obtained with higher frequencies of transgenic lines containing single transgene copy numbers (Tzafira and Citovsky, 2005). Many banana cultivars of variable genome types have been transformed so far (Sagi et al., 1995; May et al., 1995; Becker et al., 2000; Ganapathi et al., 2001; Tripathi et al., 2008; Arinaitwe et al., 2004). In recent years, ECSs of highland banana have been developed at the National Agricultural Research Laboratories (NARL) Kawanda, in Uganda. The transformation protocol of ECSs obtained was also developed, opening several avenues of genetic improvement of EAHB cultivars.

Therefore, this study acknowledges transformation of EAHB cultivars to be important for resistance to Banana Xanthomonas Wilt. However, this study basically promotes the developed and identified management and control intervention measures that are already disseminated and known to smallholder farmers in the study area as well as other areas.

2.7 Genetic Engineering for Banana Cultivars Resistant to BXW
Genetic engineering has become an imperative tool for crop improvement as it provides many significant opportunities for the improvement of existing selected cultivars and development of new cultivars. A main advantage of genetic engineering is that it allows breeders to rapidly develop new cultivars by the introduction of cloned genes into commercial cultivars (Tripathi et al., 2010).

More efforts have been put in place to find banana cultivars resistant to BXW in Great Lakes Regions particularly in Uganda. To verify this development, the International Institute of Tropical Agriculture (IITA) is currently collaborating with the National Agriculture Research Organization (NARO) in Uganda, and the African Agricultural Technology Foundation (AATF) for development and deployment of banana cultivars resistant to BXW in Africa. This became effective after IITA signing a tripartite agreement with NARO and AATF for developing BXW resistant transgenic bananas. With regard to this development, various hundreds of transgenic lines with pflp or hrap genes have been developed, using a protocol based on the Agrobacterium tumefaciens technology. Also these cultivars have been tested for disease resistance under laboratory conditions. The outcomes of this development are anticipated to be evaluated for effectiveness against BXW in fields (Tripathi et al., 2010).

This study therefore, recognizes the efforts that are underway to find genetic engineering solutions in controlling BXW. Since this genetic engineering technology has not yet been fully developed and disseminated to farmers, this study mainly recommends the farmers to use the identified and disseminated cultural practices technologies for management and control of BXW in their farms before the genetic engineering solutions to curb the disease become available to smallholder farmers who reside in the rural areas.
CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

This study was conducted in Kagera region, with the focus on Nshamba and Rubale Divisions which are situated in Muleba and Bukoba Rural Districts respectively. Kagera is one of the 26 regions of Tanzania. The region is located in the extreme North-Western corner of Tanzania. It lies just below the Equator between 1°00' and 2°45' south. Longitudinally it lies between 30°25' and 32°40' east of Greenwich. This includes a large part of the waters of Lake Victoria, with the land mass lying between 30°25' and 31°48' longitudes east. The region is divided into eight districts namely Biharamulo, Ngara, Muleba, Karagwe, Kyerwa, Bukoba Rural, Misenyi and Bukoba Urban. The districts are further sub-divided into Divisions Wards and Villages. It shares borders with Uganda to the North, Rwanda and Burundi to the West, Kigoma and Mwanza Regions to the South and Lake Victoria to the East.

Kagera region covers 40,838 km$^2$ of which 28,953 km$^2$ are islands and 11,885 km$^2$ are covered by the water bodies of Lakes Victoria, Ikimba and Burigi, and Kagera and Ngono rivers. The land area of Kagera is the 14$^{th}$ largest in the country and is approximately 3.2% of the total 883,527 km$^2$ land area of Tanzania mainland.

As far as climate is concerned, both Muleba and Bukoba Rural Districts receive two rainy seasons and two dry seasons annually. They get the rain of between 800 – 2000 mm per annum. The first and short rains fall between September and December, while the long rains fall between March and June. In a normal season the region expects a rainfall of about 2,250mm per annum. In the Lake Zone along Lake Victoria rainfall is between 1,400 – 2,000mm a year. The highland belt gets between 1,000 – 1,400 mm of rain per year while the Western zone gets between 600 – 1,000 mm of rain per year. The average temperature is 20°C with extremes of 15°C and 28°C. The roads are accessible throughout the year, though they are in bad condition during the rainy seasons (URT, 1998).

Muleba district is administratively divided into five divisions: Izigo, Muleba, Kamachumu, Nshamba and Kimwani; it has a total of 31 wards and 132 villages. It has the total population of 386,328 people of which 194,076 are females and 192,252 are males. Bukoba Rural District is divided into 4 divisions, 24 wards and 92 villages. Bukoba Rural District has the total population of 241,178 people out of which 119,288 and 121,890 are males and females respectively (URT, 2012).

According to the Government census of 2002 (URT, 2002), the total population of Nshamba division was 146,167 out of which 73,398 were females and 72,769 were males. The division has 11 Wards and 45 Villages. Rubale division has the total population of 74,455 out of which 33,786 and 40,669 are males and females respectively.
Agriculture is the main economic activity in Muleba and Bukoba Rural Districts. The main food crops grown in the areas include banana and beans; others include maize, cassava, sorghum, groundnuts, sweet potatoes, rice plant and yams. Cash crops include coffee, cotton, and tea.

3.2 Research Design
The study used Cross-sectional research that allows data to be collected at one point in time, gathering descriptive information while determining the relationships between variables. This statement is supported by IDRC (2003) as cited by John (2009) who points out that the method can be used for descriptive study and for determination of relationships between variables.

3.3 Population of the Study
The targeted population was the entire population of heads of the households or their representatives where the head of household was not around at the time of the study. It is from this population that the sample for the study was finally drawn.

3.4 Sample size and Sampling Procedure
The sample size of the study was 360 respondents. This sample size was drawn from the population of Muleba and Bukoba Rural Districts.

3.5 Sampling methodology
Both random and systematic sampling methodologies were employed to select the respondents. However, the respondents for the focus group discussion and the key informants were selected purposively.

3.6 Sampling procedure
Two districts were randomly selected from the list of all districts of Kagera region. Also from the two districts two divisions (one from each District) were randomly selected. Out of the selected divisions, four wards from each division were also randomly selected. The villages to be involved in the study were selected using multistage random sampling methodology. A list of villages found in each ward was listed from the records obtained from the District Agriculture offices from which eight villages (one village from each ward) were randomly selected.

From the above procedure the two selected divisions were Nshamba and Rubale, while the selected wards were Birabo, Kishanda, Buganguzi and Nshamba; Rubale, Izimbya, Butelankuzi and Kikomero of Nshamba and Rubale divisions respectively. Conversely, the eight selected villages were Rutenge, Kaburara, Buhanga and Kihumuro from Nshamba Division and Rubale, Irango, Kikomero and Izimbya from Rubale Division.
Lastly, forty five households were randomly selected from each village while one respondent was interviewed from each household. In all cases the respondents were heads of households except in a few cases where a family member had to represent the family head due to the absence of the substantive head.

3.5 Data Collection
3.5.1 Primary data
Primary data were collected by using questionnaires, interviews and focus group discussions (FGD). Questionnaires had both open-ended and closed-ended questions. The in depth-person approach was adopted during the questionnaire administration. Interviews were conducted to key informants, with a well structured checklist used to guide the discussion. The Focus Group Discussion was administered under the supervision of the researcher. In all cases the respondents were heads of households except in a few cases where a family member had to represent the family head due to the absence of the substantive head.

3.5.2 Secondary data
Secondary data were obtained from the reports in Muleba and Bukoba Rural District offices respectively. Journals and articles which have relevant information to this study were also consulted.
3.6  **Data Processing and Analysis**
Data from the respondents were verified, compiled, coded and summarized before being analyzed using the Statistical Package for Social Sciences (SPSS) Windows Software Version 16.0. Both quantitative and qualitative methods of data analysis were used. For quantitative data, descriptive and inferential statistics were applied. In descriptive statistics, frequencies percentages, mean, standard deviation, standard error and range were calculated. In inferential statistics, the t-test method was used to test whether there had been any significant difference in banana production per bunch, income earned by banana farmers and food security before and after the outbreak of BXW (p < 0.05). The criterion used for the t-test was that the findings of the study were considered to be significantly different if the p-value was less than 0.05.
CHAPTER FOUR

4.0 STUDY FINDINGS

4.1 Demographic and Socio-Economic Characteristics of the Respondents

The demographic and socio-economic aspects of the respondents examined in this study include sex, age, marital status, domicile, tribe, education level, economic occupation and crops grown. The results from the study (Table 1) show that the majority (79.5%) of the respondents were males while only 20.5% accounted were females. These results imply that most of the households in the study area are headed by males.

As for age, the findings of the study indicate that the majority of the respondents (45.5%) were between 41 and 60 years; 25% and 29.5% of the respondents were those aged between 21 and 40 years and 61 and above years respectively. These groups are considered to be more active and powerful in the society as supported by Singh et al., (2003) that in Tanzania the economically productive class ranges between the age group of 21-40 and 41 – 60 years respectively.

Furthermore, marriage was found to have great influence on family matters since household heads are forced to engage in agricultural activities in order to meet their family needs and necessities. The study findings (Table 1) show that the majority (96%) of the respondents that were interviewed were married while only 2.3% and 1.7% of the remaining respondents were single and/or widows respectively.

Conversely, the results (Table 1) show that about 99% of the respondents in the study area were from the Haya tribe while only about 1% of the respondents were from other tribes.

Education, which is a means of liberation from ignorance, a means of developing human skills and knowledge and a means of empowering the community to participate in certain activities, was found to be skewed to the low side. The results (Table 1) show that the majority (82%) of the respondents had attained primary education level, while those with secondary education and tertiary skills accounted for only 15% and 1.4% respectively. Those who had not attended any formal education were 1.6%. However, these findings imply that those who had gone to school at least could read and write, and hence they could adopt improved agricultural practices and new technologies. The study conducted by (Singh et al., 2003) contended that education status of the farmers is an important factor in the adoption of the new improved technologies.

Concerning the occupation of respondents, the study established that the majority (95.6%) of the respondents’ major occupation is farming. The rest are engaged in both farming and self
employment such as running their small businesses. Very few were found to combine formal employment and farming. These results indicate that most of the people in the study area had no other means of sustaining their livelihoods apart from farming. The findings comply with that of the government (URT, 2010), which states that agriculture is the source of food and provides employment opportunities to more than 90% of the Tanzanians.

On the type of farming methodology, the results found that all the respondents (100%) practice mixed farming, intercropping banana with cassava, beans, coffee, maize, yams and other perennial crops.

Table 1: Demographic and socio-economic characteristics of the respondents (N = 360) in Nshamba and Rubale Divisions

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>286</td>
<td>79.5</td>
</tr>
<tr>
<td>Female</td>
<td>74</td>
<td>20.5</td>
</tr>
<tr>
<td>Age of respondents</td>
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<td></td>
</tr>
<tr>
<td>21 – 40</td>
<td>90</td>
<td>25.0</td>
</tr>
<tr>
<td>41 – 60</td>
<td>164</td>
<td>45.5</td>
</tr>
<tr>
<td>61 and above years</td>
<td>106</td>
<td>29.5</td>
</tr>
<tr>
<td>Marital status</td>
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<td></td>
</tr>
<tr>
<td>Married</td>
<td>346</td>
<td>96.0</td>
</tr>
<tr>
<td>Single</td>
<td>8</td>
<td>2.3</td>
</tr>
<tr>
<td>Widow</td>
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<td>1.7</td>
</tr>
<tr>
<td>Tribe</td>
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<td></td>
</tr>
<tr>
<td>Haya</td>
<td>356</td>
<td>99.0</td>
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<tr>
<td>Other tribes</td>
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<td>1.0</td>
</tr>
<tr>
<td>Education level</td>
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<td></td>
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<tr>
<td>Primary education</td>
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<tr>
<td>Secondary education</td>
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<td>1.6</td>
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<tr>
<td>Main occupation</td>
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<tr>
<td>Farming</td>
<td>344</td>
<td>95.6</td>
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<td>Farming and Business</td>
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<td>3.8</td>
</tr>
<tr>
<td>Farming and Employed</td>
<td>2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

4.2 Economic Activities Performed by the Farmers in Nshamba and Rubale Divisions

4.2.1 Main cash and food crops produced in the area

The study aimed also to identify the main cash and food crops that are produced by the farmers in the study area. Traditionally, coffee used to be the cash crop and banana the food crop in Kagera Region. However, according to the respondents’ reports, this culture has changed in such
a way that both coffee and banana have become cash crops while banana is both a cash and food crop. This trend has changed due to the tremendous drop in the price of coffee in the world market that forced many farmers to engage mostly in banana farming as a cash crop instead. This study found that about 62% of the respondents produce coffee and 38% produce banana as the main cash crops. However, the findings indicate that the majority (about 87%) of the respondents still produce banana as their main food crop in the study area. Very few respondents produce maize, groundnuts and other crops as their main food crops. These results suggest that more efforts are needed to enhance banana production, including intervention efforts to reduce BXW which is the most threatening disease to banana production in Kagera Region and beyond.

Table 2: Main cash and food crops produced in Nshamba and Rubale Divisions (N = 360)

<table>
<thead>
<tr>
<th>Main Cash and Food Crops</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Cash Crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>223</td>
<td>62.0</td>
</tr>
<tr>
<td>Banana</td>
<td>137</td>
<td>38.0</td>
</tr>
<tr>
<td>Main Food Crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td>312</td>
<td>86.7</td>
</tr>
<tr>
<td>Other crops</td>
<td>48</td>
<td>13.3</td>
</tr>
</tbody>
</table>

4.2.2 Size of the banana farms (in hectares)

Land is one of the most important factors for smallholder farmers’ livelihoods. With enough land, farmers may have opportunities to grow a variety of food and cash crops which in turn increase food production and cash crops for sale. The average land size owned by farmers in the study area was 1.4 hectares. Furthermore the study results (Table 3) show that about 39.7% of the respondents owned one hectare. The rest about 29.2% of the respondents owned between two and three hectares and only 11.1% own more than three hectares of land. It was further that those with less than 1 hectare accounted for 20%. This implies that land is not a problem for most of the small holder farmers, but their productivity efforts in order to enhance poverty alleviation and food security are hampered by the spread of BXW.

Table 3: Size of banana farms (N = 360)

<table>
<thead>
<tr>
<th>Size of the farm</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 hectare</td>
<td>72</td>
<td>20.0</td>
</tr>
<tr>
<td>1 hectare</td>
<td>143</td>
<td>39.7</td>
</tr>
<tr>
<td>2-3 hectares</td>
<td>105</td>
<td>29.2</td>
</tr>
<tr>
<td>More than 3 hectares</td>
<td>40</td>
<td>11.1</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>100.0</td>
</tr>
</tbody>
</table>
4.3 Farmers Awareness of BXW, its Management and Control Measures

4.3.1 Knowledge on BXW in the study area

This study intended to investigate the extent to which the farmers were aware of BXW. The results (Table 4) show that the majority (about 85%) of the respondents who were interviewed in the study area were aware of the disease, but only 18% knew its symptoms and control measures. These findings signify that although most of the farmers are aware of the disease they lack knowledge on its symptoms, management and control.

Table 4: Knowledge on BXW in Nshamba and Rubale Divisions (N = 360)

<table>
<thead>
<tr>
<th>Aware of BXW</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>306</td>
<td>84.9</td>
</tr>
<tr>
<td>No</td>
<td>54</td>
<td>15.1</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>100.0</td>
</tr>
</tbody>
</table>

4.3.2 Infection of BXW in the farms

The study anticipated to discern to what extent the banana farms in the study area were affected by BXW. It was reported by the majority (67.8%) of the respondents that half of their farms have been affected by BXW while 23.6% of the respondents reported that the whole of their farms had actually been affected by the disease. 5.2% of the respondents affirmed that three quarters of their farms had been affected while only 2.2% and 1.2% said their farms were either not affected at all or they were affected by only a quarter, at most (Table 5). These findings are sounding an alarm for immediate intervention measures to be undertaken in the study area because most of the farms are reported to be affected by BXW and the trend seems to be worsening with time.

Table 5: The rate of infection of BXW in the respondents’ farms

<table>
<thead>
<tr>
<th>Infection of BXW</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole farm (100%)</td>
<td>85</td>
<td>23.6</td>
</tr>
<tr>
<td>Three quarter of farm (75%)</td>
<td>19</td>
<td>5.2</td>
</tr>
<tr>
<td>Half of farm (50%)</td>
<td>244</td>
<td>67.8</td>
</tr>
<tr>
<td>Quarter of farm (25%)</td>
<td>4</td>
<td>1.2</td>
</tr>
<tr>
<td>None or Never</td>
<td>8</td>
<td>2.2</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>100.0</td>
</tr>
</tbody>
</table>
4.3.3 The duration since BXW outbreak in the study area

This study also aimed to establish how long BXW has existed in the study area. As shown in Table 6 below, 79.1% of the respondents claimed that BXW had affected their farms for the past two to three years; while 19.8% reported the duration to be one year, and a negligible number (1.1) reported not to have been affected by the disease. These results imply that although the disease outbreak in Muleba District has been there since 2006 it had not reached some areas until recently. All in all, one thing that seems to be obvious is that the disease has existed for some time without adequate management and control measures, hence the need for immediate interventions.

Table 6: The duration (years) of BXW existence in the study area

<table>
<thead>
<tr>
<th>Years of BXW in the farms</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>71</td>
<td>19.8</td>
</tr>
<tr>
<td>2-3 years</td>
<td>285</td>
<td>79.1</td>
</tr>
<tr>
<td>None</td>
<td>4</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>100.0</td>
</tr>
</tbody>
</table>

4.3.4 Ownership of banana production implements

The study also intended to know whether the banana producers possess and actually use their own farm implements in their farms including hand hoes, bill hooks, dibblers and pangas. The results (Table 7) show that only 36.9% of the respondents own and use all of the above mentioned farm implements, while the majority (63.1%) own only a few of them and therefore borrow from each other. Since it is believed that the main source of BXW spread is sharing farm implements, these findings point to a very dangerous scenario that the spread of the disease in this area might be hastened by this habit. The results thus suggest that there is need to take immediate interventions of BXW management and control in order to reduce its pace of destruction through sensitization, awareness creation and enforcing bylaws and legislations pertaining to the management and control of crop diseases.

Table 7: Ownership of banana production implements

<table>
<thead>
<tr>
<th>Ownership of Banana production implements</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>133</td>
<td>36.9</td>
</tr>
<tr>
<td>No</td>
<td>227</td>
<td>63.1</td>
</tr>
<tr>
<td>Total</td>
<td>360</td>
<td>100.0</td>
</tr>
</tbody>
</table>
4.3.5 Farmers’ knowledge on the management and control of BXW

This study also intended to know whether the farmers in the study area are aware of the management and control of BXW in their banana farms. Specifically, the study aimed to assess the extent to which the farmers know how to use the implements while controlling the spread of BXW, whether they know any agricultural practices used in controlling the disease, and whether they receive any extension services on how to control the disease from Extension Officers. The findings of this study (Table 8) show that only 24.8% of the respondents know how to use the implements in controlling BXW. 35.4% reported knowing little and 39.8% of all the respondents said they do not know how to use the farm implements efficiently while controlling the spread of BXW. These findings imply that many farmers in Kagera Region either have little knowledge or have no knowledge at all regarding the use of farm implements in the management and control of the spread of BXW. These results are alarming and call for immediate interventions that include building capacities of farmers in using the implements in managing and controlling the spread of this deadly banana disease.

Additionally, it has been evidenced by this study (Table 8), that 23.6% of the respondents in the study area do know agricultural practices used in controlling BXW, while 31.4% know very little. Conversely, 45% of the respondents stated that they completely do not know these practices. Furthermore, the study results on the knowledge of management and control measures show that very few women have knowledge while most men are aware of the measures. This means that men are more likely to take action and adopt the measures than women. During group discussions with key informants in the local communities in Nshamba and Rubale divisions, it was discovered that one of the most important factors limiting constructive application of management and control measures is that men are mostly involved in sensitization and training programmes on BXW management but they do not pass on the information they acquire to their wives who are involved in managing banana plantations at household level on daily basis. This implies that women do not have an equal chance to acquire knowledge on BXW management, and thus strategies to eliminate this gender discrimination are essential. This was found by other researchers who have remarked that the incorrect application of the control package could be a reflection of inadequate knowledge on the disease and the practices by both men and women, which was also identified as a constraint to adoption (Bagamba et al., 2006).

Equally alarming, was the finding that extension services were not provided adequately as evidenced by 66.2% of the respondents who reported that they have never received any extension service on how to control BXW from these officers (Table 8). When they were asked if they know the reason behind this, almost all of them said that there is a shortage of extension workers and that even those who are available are subjected to poor working conditions.
Table 8: Farmers knowledge on the management and control of BXW (N = 360)

<table>
<thead>
<tr>
<th>Knowledge on the management &amp; control of BXW</th>
<th>Frequency</th>
<th>Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses of BXW controlling implements</td>
<td>Know 89 (F:29,M:60)</td>
<td>24.8</td>
</tr>
<tr>
<td></td>
<td>Know little 127(F:73,M:54)</td>
<td>35.4</td>
</tr>
<tr>
<td></td>
<td>Don’t know 144(F:86,M:58)</td>
<td>39.8</td>
</tr>
<tr>
<td>Agricultural practices used in controlling BXW</td>
<td>Know and practice BXW control 85</td>
<td>23.6</td>
</tr>
<tr>
<td></td>
<td>Know little 113</td>
<td>31.4</td>
</tr>
<tr>
<td></td>
<td>Don’t know BXW control practices 162</td>
<td>45.0</td>
</tr>
<tr>
<td>Advice from extension Officer</td>
<td>Receive extension services 122</td>
<td>33.8</td>
</tr>
<tr>
<td></td>
<td>Don’t receive extension services 238</td>
<td>66.2</td>
</tr>
</tbody>
</table>

4.3.6 Success stories on the management and control of BXW

The results of the study (Box No. 1) show that BXW can be managed and controlled if appropriate measures are taken immediately as soon as the farmers see the symptoms of the disease in their banana farms. The case study below is a telling example:

The Banana farm at Igabiro TIA has the size of 2.3 hectares. This farm is the vivid example which one can follow for BXW project intervention. Within this field, none of the bananas has been infected with BXW. The staff of ITIA informed the research team that they use different measures to manage and control the disease including avoiding using tools from outside their farms, breaking or removing the male buds using forked sticks immediately after the bunch has formed the last cluster (de-budding) since the male bud appears to be the primary infection site, taking action immediately to remove all infected plants once they show the symptoms, and cleaning all used tools using substances or fire flame. The staff maintained that BXW control technologies were promoted using a mix of top-down extension and participatory methods within the students and ITIA staff. “BXW can be managed and controlled if we are serious and take early intervention measures in a participatory manner,” said Mr. Thomas Niyegila, the Director of ITIA. The Director also cited an example of one farmer Mr. Theophil Rwakabale who is near ITIA, whose farm has no any infected plant due to proper management and control. Based on the great achievement of BXW management and control by ITIA, the visiting team learnt that BXW is possible to be managed and controlled in Kagera Region, starting with Rubale and Nshamba divisions of Bukoba and Muleba Districts respectively.

Box No. 1: Case study from ITIA on a successful management and control of BXW
The other vivid example of the successful farmers is Mr. Joseph Ntalala (63 years) from Buhanga village at Buganguzi ward in Nshamba division of Muleba District, his testimony of his success story is as described hereunder (Box No. 2):

“My farm has an average size of about 10 acres. It has not been affected so much by BXW due to early management and control measures. I remove any banana plant that shows the symptoms of the disease as soon as I see it. Other management and control measure that I take and use include: removal of male buds as soon as the bunch has formed the last cluster; cutting and

The flourishing farm at Igabiro Training Institute of Agriculture (ITIA)

Photo by: Muchuruza, Y.P. 2013

A bunch of banana at ITIA weighs between 150 – 200 Kilograms as a result of BXW management and control (ITIA Staff 2013).

Photo by: Muchuruza, Y.P. 2013
removal of all affected banana plants; clean all used tools using fire flame or some sterilizing substances like JIK; and avoiding sharing farm tools with my neighbors.”

These management and control methods of BXW mentioned by Mr. Joseph Ntalala have been supported by Tushemereirwe et al. (2006) and Mbaka et al. (2008) who cited that the cultural control packages of BXW include the use of clean planting materials, clean tools which are sterilized in fire or diluted sodium hypochloride, de-budding by breaking the male buds with a forked stick, cutting and burying of diseased plants, and crop rotation.

Mr. Joseph Ntalala further remarked: “…my farm produces more than 3,000 bunches of banana per annum and I sell each bunch of banana for the minimum price of TZS. 10,000/= leading to earning an income of TZS. 30,000,000/= per year”. “… To confirm that the BXW has not affected me so much, to date, I still get the same income from my banana farm” he concluded.

Box No. 2: Testimony of a successful farmer, Mr. Joseph Ntalala, in controlling BXW.

Based on the great achievement in controlling BXW made by Mr. Joseph Ntalala, it is quite possible that this disease can be controlled if appropriate measures are adopted.

Another vivid example of the success story is one of Mr. Jonathan Manase (74 years) who also confirmed that it is possible to control the disease (Box No. 3).

Mr. Jonathan Manase is one of the farmers who live in Kabilizi village of Rubale ward in Rubale division, Bukoba Rural District. He reported that he has been able to manage and control BXW in his farms due to immediate initiatives he takes as soon as the symptoms appear. “My farm does not have any banana plant with BXW. This is due to different measures that I use to manage and control the disease which include avoiding using tools from outside my farm and breaking or removing male buds using a forked stick immediately after the bunch has formed the last cluster (de-budding) as the male bud appears to be the primary infection site. Other measures include taking action immediately to remove all infected plants once they show symptoms, and cleaning all used tools using substances or fire flames. BXW can be managed and controlled if we are serious and take early intervention measures in a participatory manner” Mr. Manase insisted. He also affirmed that his farm produces 2,400 bunches of banana per annum, which he sells at the minimum price of 7,000/= each, leading to the total income of TZS. 16,800,000/= per annum.

Box No. 3: The success story from Mr. Manase on the management and control of BXW in Rubale Division.

Mr. Jonathan Manase’s great achievement provides enough evidence that there is a possibility of managing and controlling the disease in Kagera Region and beyond.

4.4 Effects of BXW on Food Security, Income and Other Cross Cutting Issues

The trend of banana production since the outbreak of BXW has declined tremendously as compared to the situation before the outbreak of the disease. The disease has negatively affected food security and household income. The income earned by the farmers after the plague of
BXW has also dwindled significantly. Additionally, it has been established by this study that the majority of the households that depended on bananas as their main food can now afford only one meal per day, compared to the past years when the households could take two to three meals per day. The results of this study show that banana production in the study area has fallen from 356,545 bunches before the outbreak of BXW to only 50,800 bunches (16.6%) per annum.

The t-test was performed to verify if there was any significant difference between bunches of banana produced per annum before and after the outbreak of BXW in the study area. The results (Table 10) show that there was a significant difference at (p = 0.000) between bunches of banana produced before and after the outbreak of BXW. These results imply that the outbreak of BXW has contributed significantly to the decline of banana production in the study area. The results thus suggest that there is a need to take early remedial measures to manage and control BXW in order to assure sustainable food security and the income of the rural community in Nshamba and Rubale Divisions of Muleba and Bukoba Rural Districts respectively.

4.4.1 BXW Effects on income
The outbreak of BXW has adversely affected the farmers’ income in the study area. The income has dwindled from TZS.801, 656,000/= before to 307,034,248/= (38.3%) after the outbreak of BXW. This implies a loss of TZS. 494,621,752 (61.7%) of the farmers’ income. Therefore, immediate intervention methods should be taken to reduce the effects of the disease to the community in order to improve their livelihoods.

Another, t-test was performed to verify if there was any significant difference between the income earned by the farmers before and after the eruption of BXW. It is evident that there is a significant difference at (p = 0.000) between the incomes earned by farmers before and after the outbreak of BXW (Table 10). These results confirm that the outbreak of BXW has contributed significantly to the decline of food security and household income in the Region.

Furthermore, it is apparent that most of the farmers who relied on agriculture as their source of food, income and livelihood are now facing problems as the disease has affected their main source of revenue. The effects of BXW has been vividly noted by one of the farmers who was strongly affected by the disease, Mr. Richard Mutongole of Kihumulo Village in Nshamba division who testified to what happened to him and his household during the focus group discussion as he demonstrates hereunder.

“My farm was a model in Banana Production. In every two months I could sell 200 bunches of banana at the maximum price of TZS. 20,000/= each. In this case every month I was getting TZS. 2,000,000/= amounting to the average of TZS. 24,000,000/= annually, while my investment was TZS. 10,000,000/= only per year. My banana markets were Mwanza, Shinyanga...
and Kahama. Formerly, I was running my shop for many years, but due to good income from banana farming, I decided to leave the shop to one of my sons and opt for farming activities which I thought were paying me better than the shop. I was comfortable working in my banana farms but now BXW has made me desperate and as a result I have returned to my shop business which I had left for many years. BXW has thrown my life into total confusion” Mr. Mutongole concluded.

**Box No. 4: Testimony of one of the farmers whose farms have been affected by BXW.**

Mr. Ignatio Batamuzi from Rutenge village in Nshamba Division, one of the farmers who have been badly affected by BXW, informed the study team that before the outbreak of BXW his banana farm could sustain the livelihood of his family abundantly. However, after the outbreak of this deadly disease his farm lost its productivity to the extent that he cannot even afford school fees for his children and the grand children. His testimony is reproduced in Box No. 5 below:

“After my retirement from teaching I decided to engage in farming activities, the occupation which gave me adequate earnings. Now about 90% of my banana farm which has 2,500 banana stools has been affected by the disease”. Before the outbreak of BXW, my banana farm was producing about 2,400 bunches of banana per annum, which I could sell at TZS. 10,000/= each earning the maximum income of TZS. 24,000,000/= per year. However, currently my banana farm produces only 120 bunches of banana per annum. As a result I cannot afford to pay school fees for my children and to pay for health service expenses” Mr. Batamuzi lamented.

“I have tried to apply all measures which I was told by extension officers but the situation remains the same and the disease continues to hit my banana farm”. Mr. Batamuzi concluded.

**Box No. 5: Testimony of one of the farmers whose farms was strongly hit by BXW.**

However, Mr. Batamuzi affirmed that he knows one of the farmers in Bugarama village near Igabiro farm, Mr. Theophilo Rwakabale, whose banana farm has been minimally affected due to the use of all recommended management and control measures of the disease. “I have even purchased some banana suckers for re-planting in my farm from him because I know they have no infections”, disclosed Mr. Batamuzi.

When asked why he did not succeed like Mr. Rwakabale, Mr. Batamuzi said “Theophilo Rwakabale attends his farm on a daily basis and sometimes more than once a day. He even knows how many banana plants he has in his farm; this is a big task which consumes a lot of time”, Mr. Batamuzi nodded. This testimony implies that some farmers do not take the disease control and management measures seriously as they think that the measures are tasking and labour intensive that take most of their time. Rugalema and Mathieson (2009) also had the same finding when they note: “The reliance on labour intensive disease control methods, though inevitable, must be carefully assessed given that not all households can marshal the required labour to uproot the diseased plants”. They also noted that shortage of labour, regardless of the cause, increases vulnerability to crop diseases not only among households with labour shortages but also to the rest of the households in the community.

On the other hand, most farmers are desperate and would not wish to continue investing in banana production. Another issue that was noticed by the study team from Mr. Batamuzi’s
testimony is that one of the reasons that contributed to significant effects of the disease in his farm was the use of only one method i.e. removing the affected bananas and ignoring other methods. To achieve the desired success, the control and management measures should be utilized together as a set. It has also been learnt that there are some farmers who do not want to change their mindset to adopt the recommended control and management measures and instead they continue upholding old farming practices, while some do not even believe that BXW can be controlled and managed. This again points to the need for more efforts in raising awareness and sensitizing the community.

Another moving testimony of the effects of BXW on the income of the households was presented by one Mr. Timothy Muchuruza Pesha (89) from Kikomero ward of Rubale division in Bukoba Rural District during the focus group discussion:

“My banana farm was an essential asset for my household’s food security and income before the outbreak of BXW. In short my banana farm was my livelihood. I was producing 200 bunches of banana every month, selling each bunch for the minimum price of TZS. 4,000/= per bunch. I was assured of getting TZS. 800,000/= per month and thus I had an assurance of earning TZS. 9,600,000/= per annum. The income that I earned from banana production could help to cater for my household expenses in terms of food, health services and education for my children. The remaining balance was my investment. However, currently the number of bunches produced per month has dropped significantly, leading to food insecurity and loss of income. This has led to failure to meet household living costs which largely require cash to purchase almost everything” summed up Mr. Muchuruza Pesha in despair.

Box No. 6: Testimony of one of the farmers whose farm has been affected by BXW in Kikomero ward, Rubale Division.

4.4.2 BXW Effects on Food security

Food security in the study area has been badly affected following the outbreak of BXW. The majority (53.8%) of the respondents that were interviewed, (Table 9), reported that their food situation was very bad, while 38.3% affirmed that their food situation was bad. This calls for immediate intervention by both the Government and the civil society to join hands in order to combat the disease, thereby improving food security and income generation for the rural communities in Tanzania.
Table 9: Food security in the study area (N = 360)

<table>
<thead>
<tr>
<th>Food situation and Number of Meals taken per day</th>
<th>Food Situation and Number of Meals taken per day before BXW</th>
<th>Food Situation and Number of Meals taken per day after BXW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent (%)</td>
</tr>
<tr>
<td>Good</td>
<td>360</td>
<td>100.0</td>
</tr>
<tr>
<td>Bad</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Very bad</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>One Meal</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Two Meals</td>
<td>70</td>
<td>19.4</td>
</tr>
<tr>
<td>Three Meals</td>
<td>290</td>
<td>80.6</td>
</tr>
</tbody>
</table>

As pointed out earlier, it has also been confirmed that the number of meals taken per day by the community members has fallen significantly following the outbreak of BXW in the study area, forcing the majority of the respondents (87.2%) to get only one meal per day as compared to the period before the outbreak when they could afford to get three meals daily (Table 10). This is a clear signal of food insecurity for the majority of farmer households. To remedy the situation, appropriate control measures must be adopted.

The t-test that was performed to verify if there was any significant difference between the number of meals taken per day by farmers before and after the outbreak of BXW in the study area verified the fear putting the score at \( p = 0.000 \) (Table 10) between the number of meals taken per day by farmers before and after the outbreak of BXW.

These results are contrary to the notion that the Bahaya and Banyambo people (natives of Muleba, Misene, Bukoba and Karagwe Districts respectively), who culturally regard banana as the blessed crop for its food production and other more than 100 uses. The outbreak of BXW has created food insecurity, the farmers have been made poor and the said 100 benefits have decreased significantly. As noted by FAO – Rugalema and Mathieson (2009) the dwindling income from banana production cannot allow them to take their children to school; they cannot afford health care expenses, and most importantly, food security at household level is not guaranteed. This once more calls for immediate management and control measures to fight against the BXW scourge.
Table 10: Paired Samples Test of bunches of banana production, income earned by farmers per annum and food security before and after the BXW outbreak

<table>
<thead>
<tr>
<th>Pairs compared</th>
<th>Mean</th>
<th>N</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunches of banana produced per annum before BXW by the respondent</td>
<td>0.794</td>
<td>360</td>
<td>11.514</td>
<td>0.000</td>
</tr>
<tr>
<td>Bunches of banana produced per annum after BXW by the respondent</td>
<td></td>
<td>360</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income earned per annum before BXW outbreak</td>
<td>1.274</td>
<td>360</td>
<td>20.961</td>
<td>0.000</td>
</tr>
<tr>
<td>Income earned per annum after BXW outbreak from the farm of the respondent</td>
<td></td>
<td>360</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of meals taken per day by the respondents before BXW</td>
<td>1.661</td>
<td>360</td>
<td>39.728</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of meals taken per day by the respondents after BXW</td>
<td></td>
<td>360</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4.3 BXW effects on the environment

The outbreak of Banana Xanthomonas Wilt (BXW) is believed to have severe effects on the environment. Due to income loses caused by this disease; most people tend to engage in other momentous income generating activities (IGAs) for their livelihood. A number of these undertakings are sometimes unfavourable to the environment.

On biodiversity for example, de-budding distresses ecological functions through removing banana flowers which are the main habitat of insects like bees, which are crucial in the process of transporting pollen from one plant to another. This idea is supported by the IITA Uganda (undated) which has made the following observation: “It has been feared that massive de-budding (removal of banana flowers) could destabilize the ecological niches of these insects and possibly lead to loss of biodiversity” [http://researchintouse.com/nrk/RIUinfo/PF/CPP18.htm](http://researchintouse.com/nrk/RIUinfo/PF/CPP18.htm)

Likewise, many farmers are forced to encroach on wetlands and rangelands looking for land where they could cultivate alternative crops. Such undertakings result into many negative effects like soil erosion and pollution to these fragile places due to, for example, spraying pesticides for pest control, leading to loss of biodiversity. In addition, some farmers burn forests and bushes in the process of clearing land for agriculture, producing heavy smoke that causes pollution.
In the same vein, it has been predicted by various researchers that some activities which the farmers have decided to turn to as a result of the effects of BXW are likely to cause climate change. Such activities, including timber and charcoal production, are more attractive to the farmers because they pay them more than banana production. Many timber factories have been established due to high demand of timber and wood. This scenario has caused tremendous tree felling, resulting into environmental destruction, a clear sign of climate change.

4.4.4 Link between BXW and HIV/AIDS

Another crosscutting issue that is linked to the BXW effects is the scourge of HIV/AIDS. There is an apparent link between the two, especially because BXW reduces food security and income to the entire community. Losses of food and income due to BXW mean more burden to the households caring for the People Living with HIV/AIDS (PLWHAs) as they require adequate food and nutrition in order to improve their health status that has been affected by the pandemic. Likewise, the people affected by HIV/AIDS do not have physical capacities to intervene BXW due to their health problems.

In addition to that, households with PLWHAs have less or no opportunity to manage and control BXW due to lack of time and labour to make proper follow up of the disease, which is labour intensive and time consuming. Thus, the efforts and strategies to combat BXW have to be taken in line with the efforts to combat HIV/AIDS.
CHAPTER FIVE

5.0 DISCUSSION OF THE FINDINGS

Banana Xanthomonas Wilt (BXW) has existed for too long without significant interventions to combat it, and it continues to spread significantly while threatening banana production in Kagera Region and beyond. The disease has affected the household income as well as the national economy in various ways. It has caused health deficiencies such as malnutrition, some families cannot afford paying for their children education, and peace and harmony at household level have disappeared in many families.

This study witnessed food insecurity in most of the households whereby many families have resorted to only one meal per day. The BXW has therefore affected the availability, affordability and stability of food at household level. It has affected academic performance, violated the right to food and health, affected the minds of most farmers and most seriously, many farmers have lost hope in banana farming while they have so far no any other alternative crop that has been diversified as a main food and cash crop in the place of bananas.

Nonetheless, it is evident that BXW is linked to most of crosscutting issues such as gender, HIV/AIDS and the environment. While the PLWHA need more food and income for their livelihood, efforts to combat environmental destruction are lessened by BXW which is affecting both food security and income. As if that is not enough, HIV/AIDS has reduced the manpower to combat BXW, resulting in a vicious circle with the effect that production is decreased and food insecurity and poverty are allowed to persist.

It has also been established that the small holder farmers’ awareness and knowledge on how to combat BXW are very low and sometimes nil. It has been proved by the study that very few farmers know the effects of BXW and its causes. Ignorance and negligence among the communities in this part of the country seem to play a big role in preventing the people from changing their mindset. Willingness to behavior change has been proved to be inadequate among the communities, thus leading to inefficiency in controlling the disease. This was also found by FAO - Rugalema and Mathieson (2009) who have remarked that: “Although various possible mechanisms for the spread of the disease were mentioned; it is obvious that quite a lot of farmers have no clear idea about the disease”. Similarly, Tushemereirwe and Opolot (2005) observed that there is presently low awareness of farmers in areas that are not yet heavily affected by the disease and even lower rate of farmers that know or apply preventive BXW control measures.

Gender is an important factor that contributes to the awareness in management and control of BXW. Well functioning and participatory gender roles can lead to the adoption of management and control technologies that have been identified by the experts. The study revealed that gender was not well observed in distributing roles at household level. The majority of males have more possibility of acquiring knowledge of BXW management and control technologies than women because they are more exposed to knowledge sources including TV and Radio programmes, newspapers and attending educative programmes; while women are mainly left to attending domestic chores such as caring for the family and working in the banana farms. However,
although men attend acquire important training and knowledge on curbing the disease, very few of them pass on the same knowledge to their wives. Such gender discrimination habits lead to low adoption of management and control measures at the household level.

Sharing farm implements has been established as one of the main ways of transmitting BXW by several studies. It has been found that many farms of smallholder farmers in East Africa have been affected by BXW due to lack of knowledge on the proper use of these tools, something that has been confirmed by this study as well. Biruma, et al. (2007) comments that; “Transmission from plant to plant within a field, is thought to be principally accomplished by flying insects and mechanically by contaminated tools used in pruning operations”. This was also confirmed during the focus group discussion, and the majority of the respondents attributed it to negligence because the tools are not expensive. “Income from the sale of one bunch of banana can buy more than one farm tool” one of the farmers commented. This is contrary to Sekiwoko et al. (2006) who found that these cultural practices of management and control of BXW have not been used effectively by farmers because they are expensive, labour intensive and time consuming. Perhaps this may be explained by the fact the cost of tools is not uniform in all areas and countries as the price of a tool in one area may differ from the other area depending on demand and supply of the commodity.

Inadequate extension services were also found to be among the causes for rapid spread of BXW in Tanzania and elsewhere in the banana production countries. Extension services are essential for the development and improvement of the banana subsector as the service providers carry out “early warning messages” to farmers, conduct close monitoring and supervisory services, and provide evidently supported onsite training to farmers that result in the change of the mindset and behavior. The majority of the farmers affirmed that they do not get adequate extension services on the management and control of the disease. Thus, the in absence of such services, the above said extension service benefits cannot be obtained because the farmers, especially smallholder ones, need to be supervised, reminded and encouraged to maintain what is needed for agricultural promotion and disease control.

One vivid example on inadequacy of extension services was when the disease first entered Tanzania through Kabale Village in Muleba district. Studies show that the government could not recognize the new banana disease until a Field Worker from KADETFU, (an NGO based in Kagera Region) visited that village on a monitoring routine, found the new disease and was the first to report the disease to the District government in Muleba. Moreover, human resources in terms of government extension workers are scarce and thinly spread, which means that there is little contact between farmers and extension workers as well as between extension workers and their principals at district level. As highlighted elsewhere in this report, this capacity problem is contributing to the endemic nature of this and a variety of other diseases (FAO-Rugalema and Mathieson: 2009). This argument on extension services is also supported by USAID (2011) which reports that improving agricultural productivity, profitability, and sustainability in the developing world depends on the ability of the rural people in those countries to adopt change and get innovative in their use of technologies, management systems, organizational arrangements, institutions, and environmental resources.
It is further argued in the USAID study that “expanding the people’s capacity to innovate depends on their access to knowledge and information services. Rural extension and advisory services meet the immediate needs of farmers and other rural people as they change their production and livelihood systems. As a whole, these efforts provide advice to farmers on problems or opportunities in agricultural production, marketing, conservation and family livelihood” (USAID, 2011).

It is evident that the disease has rapidly spread in Kagera region because the government and other responsible actors did not take immediate intervention measures to combat it. The disease was first reported in Kabale village in Muleba District since January 2006 (Mgenzi et al., 2006). However, as it has been revealed by this study, the disease has been spreading to other parts of Muleba and other districts for the past two to three years. This therefore implies that if the government and other stakeholders had taken immediate intervention measures, the disease would have not spread to the other parts of Kagera and beyond. The government should therefore establish early warning strategies in the country to combat plant disease epidemics in time and effectively.

The outbreak of BXW has caused a great loss in terms of banana production (84%) per annum. This tremendous decline of banana production has resulted into loss of households’ income and food security at the same time leading to the dwindling of the national economy. In the study area, more than 62% of the household income is lost per annum due to the outbreak of the disease. There is therefore a great need for establishing a community based approach that is an essential and appropriate modus operandi for curbing the spread of the disease. This kind of approach has to empower the community to manage and control pests and diseases, enabling the farmers to reverse the situation collectively. The approach, however, should be based on bringing into play all stakeholders (i.e. farmers, extension officers, NGOs, the Local Government, religious and traditional leaders, women and men, youth and elders) to exchange information and technologies with the mission of recognizing suitable approaches that can be effective for curbing the epidemic of BXW. This should also include other methodologies such as Farmers Field Schools that facilitate Community collective learning and action programmes which also smoothen the process of knowledge sharing and feedback systems. Similarly, a well functioning and appropriate management and control mechanism through which the government and other stakeholders’ efforts are coordinated should be established.

It was reported that during the study that the majority of the farmers had not adopted management and control measures of BXW as they are time consuming, requiring the farmers to spend much of their time in the farms with meager returns. This was coupled with the belief that BXW cannot be controlled. This kind of mindset can only be changed through capacity building, awareness and sensitization programmes. As for negligence and laxity among some farmers, existing bylaws and legislations must be enforced in all villages in order to task the farmers to adopt and abide by all pests and disease management and control measures.

Among the methods used to control the disease as reported by successful respondents was timely removal of male buds as soon as the last cluster of the bunch is formed in order to interrupt the transmission cycle. This is because male buds are important natural modes of disease spread.
This complies with Blomme et al. (2005a) finding who reported that “de-budding has to be done as soon as the last hand of the bunch is formed; this would prevent flower infection and result in bigger more evenly filled fruits”. In order to do this successfully, the farmers have to be encouraged to visit their farms on daily basis, which again touches on the tasking and time consuming issue, the mindset that has to be changed immediately. Other methods of disease management practices as mentioned by Blomme et al. (200b) include immediate rouging and burying of diseased plants, avoiding sharing of farm tools, sterilization of farm tools before and after use, and early removal of a pseudostem with floral infection which prevents the disease from moving down the plant and infecting the young developing suckers. In this case, intensive surveillance and reporting of the disease are necessary. All in all, it is essential to sensitize the farmers about the BXW in the awareness creation and sensitization campaigns at village level.
CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study has confirmed and therefore concludes with no doubt that; “Management and control of BXW is possible”. Provided remedial measures are implemented and existing legislations are enforced from the village level.

The study has conclusively established the effects of BXW are food insecurity and income losses at household as well as national level. These effects have been felt not only in the study area but also in Kagera region as a whole and beyond. According to the widely used definition, food security is a situation whereby all people, at all times, have physical, social and economic access to sufficient, safe, nutritious and culturally acceptable food for an active and healthy life (FAO – Rugalema, and Mathieson, 2009). Food security should cover all the four dimensions which are food availability, food access, food utilization and food stability. BXW has threatened not only these dimensions but also an additional and not usually mentioned fifth dimension of “food affordability”, which is linked to household “income”. During the focus group discussion, most of farmers affirmed that the disease has affected their income and food security in such a way that they no longer afford to cater for their family needs. This has culminated in having one meal per day, and failure to meet health and education expenses. The same has been confirmed by other researchers in various studies on the effects of BXW and other diverse forms of pests and plant diseases.

The study has further revealed that the majority of the farmers do not have knowledge on how to use management and control measures in their farms, thus causing great loss of banana production due to the disease spreading widely and in an uncontrolled manner. In addition, the results of the study have also revealed that in general disease cause banana production failure due to direct effects on the crop itself. The decline of banana production has directly led to shortage of food, resulting in food insecurity and malnutrition to the rural community members in the study area.

Economically, the effects of the disease have destabilized the households in terms of loss of income with dire consequences on their upkeep. Most households can no longer afford to meet their daily needs including crucial ones like food and medical expenditures and their children’s school fees. This has generally condemned them to poverty, effectively changing their lifestyles. As pointed out earlier, this kind of lifestyle is new in the study area as people used to believe that bananas are everything both culturally and economically. The outbreak of BXW has changed all this; causing food insecurity and economic instability as they have lost not only their staple food but also their main source of income.
6.2 Recommendations

In order to address the situation, the study recommends the following measures, which range from the household to the national, regional and international levels.

1. The government should establish strategies to empower the farmers and other key stakeholders with capacity, knowledge and skills needed to control the disease in line with the efforts of other state and non-state actors;

2. Efforts should be made by various actors to tackle the factors such as ignorance, negligence, mindset and lack of knowledge on the disease that were found to contribute to the spread of the disease and its effects as well as addressing cross cutting issues like gender inequality, HIV/AIDS and environmental degradation;

3. The government and all actors involved should execute comprehensive strategies and strengthen the enforcement of legislations pertaining to agricultural disease control and management including recruiting more extension officers and ensuring they are provided with a conducive working environment to enable them offer extension services effectively and efficiently;

4. International partners are called upon to join the government of Tanzania as well as other stakeholders in the efforts to transfer technology and disseminate knowledge on the causes, symptoms, effects, management and control of BXW.

5. Further technical studies are recommended to find out more scientific facts and additional measures to be utilized to combat BXW in Tanzania and beyond.
REFERENCES


banana genetic improvement and Innovations in the Lake Victoria Region of Uganda and Tanzania, pp 141-156.


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USAID (2011). Rural extension and advisory services meet the immediate needs of farmers and other rural people.
