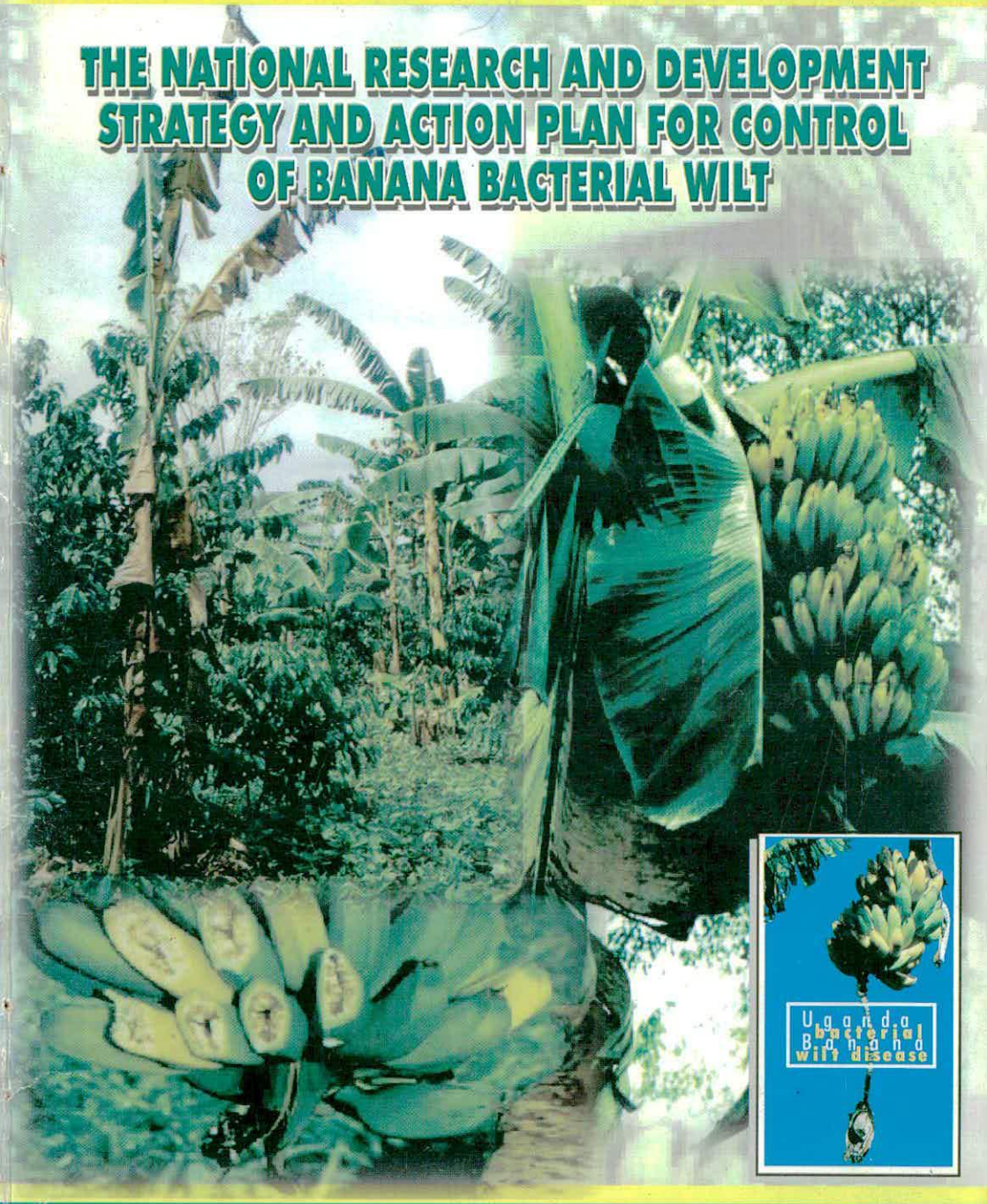
THE NATIONAL RESEARCH AND DEVELOPMENT STRATEGY AND ACTION PLAN FOR CONTROL OF BANANA BACTERIAL WILT



TASK REPORT

NOVEMBER 2003

Acknowledgements

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TABLE OF CONTENTS

Acknowledgements.....i

TABLE OF CONTENTS.....ii

List of Tables.....iv

LIST OF ABBREVIATION AND ACRONYMS.....iv

Appendices.....v

EXECUTIVE SUMMARY.....v

1. INTRODUCTION.....1

1.1. The banana: Importance and constraints.....1

1.2. Economic importance of Banana Bacterial Wilt Disease in Uganda.....2

1.3. Status of banana bacterial wilt disease in Uganda.....3

1.4. Government response 5

1.5. The Methodology adopted by the task force.....5

2. FINDINGS AND RECOMMENDATIONS FROM STAKEHOLDERS **6**

2.1. Findings..... 6

2.2. Recommendations.....7

3. LITERATURE REVIEW **8**

3.1. Disease history and etiology.....8

3.2. Host range.....9

3.3. Symptoms of banana wilt disease.....10

3.4. Spread mechanism 10

3.5. Control Measures 11

4. RESEARCH AND DEVELOPMENT ACTION PLAN FOR THE CONTROL OF BBW.....12

4.1. Introduction 12

4.2. Goal 12

4.3. Specific Objectives:.....13

4.4. Development of priorities and work plans.....13

5. OPPORTUNITIES AND RECOMMENDATIONS FOR CONTROL OF BBW.....20

5.1. Opportunities.....20

5.2. Recommendations.....21

5.3. Budget Estimates.....22

REFERENCES 25

List of Tables

Table 1. Summary of Research and Development Action Plan.....vi
Table 2. National Research and Development Action Plan On Banana Bacterial Wilt Disease 11
Table 3. Summary of Expected Outputs and budget estimates.....18
Table 4. Detailed budget estimates by activity.....19

Appendices

Annex 1. List of the Taskforce Members 22
Annex 2. Terms of reference 22
Annex 3. Logical Framework For Implementation Of Banana Bacterial Wilt Management Activities.....23
Annex 4. Banana Bacterial Wilt Project outputs based on NARO's Thematic areas..... 27

LIST OF ABBREVIATIONS AND ACRONYMS.

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BBW	Banana bacterial wilt
BT	Biotechnology
CABI	Commonwealth Agricultural Bureau International
CBOs	Community based organisations
CORI	Coffee Research Institute
DAO	District Agricultural Officer
DFID	Department for International Development of UK Eastern and Central Africa
FY	Financial year
GMOs	Genetically modified organisms

HORTEXA	Horticultural Exporters Association
IDRC	International Development Research Centre of Canada.
IITA	International Institute of Tropical Agriculture
INIBAP	International Network for Improvement of Banana and Plantain
KARI	Kawanda Agricultural Research Institute
LCs	Local Councils
LDUs	Local defence units
LGs	Local Governments
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MUK	Makerere University, Kampala
NAADS	National Agricultural Advisory Services
NAARI	Namulonge Agricultural and Animal production Research Institute
NARO	National Agricultural Research Organization
NBRP	National Banana Research Programme
NGOs	Non Governmental Organisations
NRI	Natural Resources International of UK
PMA	Program for modernization of agriculture
PRA	Participatory Rural Appraisal
PRAPACE	Regional Potato and Sweet Potato Improvement Network in
R & D	Research and Development
RDC	Resident District Commission
TOR	Terms of Reference
TV	Television
UNFE	Uganda National Farmers Federation
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

Following an outbreak of a banana bacterial wilt disease (BBW) caused by *Xanthomonas compestris pv. Musacearum* that was destructive and rapidly spreading in Mukono and Kayunga Districts, the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) constituted a Taskforce to formulate a strategy to eradicate or contain the disease. An action plan was formulated and efforts to contain the disease implemented focusing on the two districts. Later the disease was found to be more widespread than previously thought and a lot was unknown about it. A strategy integrating research and development was therefore needed to contain the disease. The Director General, NARO, on instructions from Minister of Ministry of Agriculture Animal Industry and Fisheries, constituted a new task force to formulate a long-term research and development strategy and action plan for control of the disease. The Taskforce was mandated to address a number of terms of references, which focused on reviewing the information on banana bacterial wilt, obtaining stakeholders' perspectives, identifying research and development options and policy requirements.

BBW is fast spreading and has so far been confirmed in Mukono, Kayunga, Lira, Kaberamaido, Sironko, Jinja, Kamuli, Luwero, Apac, Kumi, Mbale, Pallisa, Nakasongola, Masindi, Hoima, Iganga, Mayuge, Bugiri, Kampala, Kiboga and Wakiso districts. In affected plantations, disease incidence of up to 90% has been recorded. The affected plants die prematurely and when affected at fruiting stage, the fruits rot and cannot be eaten by both man and animals. The disease no doubt is a serious threat to both the food security and banana export market that is starting to pick up. The taskforce has therefore formulated a national strategy and action plan, which requires a well-coordinated national, regional and international effort to implement the research and development activities. The plan is based on the prioritized and budgeted expected outputs in the table below:

Table 1. Summary of Research and Development Action Plan

Expected Outputs (R &D Areas)	**Rank**	**Key players**	**Time Frame**	**Period**	**Total 5 yr budget:(000/=)**
Current status of BBW and priorities for banana for R for D established	1	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, donors	2004 - continuous	Short/Long term	1,728,326
Information on etiology and epidemilology of BBW generated	2	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, donors	2003-2009	Short/Long term	1,833,438
Appropriate technologies for control of BBW developed	2	NARO,MAAIF, MUK, IARCs, NGO, LGs, donors, farmers	2003-2010	Short/Long term	1,550,049
Appropriate Technologies and Information utilized to contain and control BBW	4	NARO,MAAIF, MUK, IARCs, NGO, LGs, donors, farmers, CBOs	2004-2010	Short/Long term	956,589
Capacity for R and D developed	4	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, NAADS, donors	2003-2010	Short/Long term	2,365,000
Impact of R and D determined	6	NARO, MAAIF, MUK, IARCs, NGO, GoU, LGs, donors	2004-2009	Short/Long term	786,112
Appropriated policies developed/improved	7	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, NAADS, donors	2003- continuous	Short/Long term	627,795
Alternative enterprises identified and promoted	8	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, NAADS, donors, UNIFE, HORTEXA	2004- continuous	Short/Long term	99,239
Coordination (10% of the budget					994,654.8
GRAND TOTAL					**10,941,203**

The following is recommended for effective implementation of this national strategy and action plan.

- Government should recognize the eminent threat posed by BBW to the banana industry and include it among its priority programmes.

The following is recommended for effective implementation of this national strategy and action plan.

- Government should recognize the eminent threat posed by BBW to the banana industry and include it among its priority programmes.
- MAAIF should institute strong steering and technical committees to spearhead implementation of the proposed research and development action plan.
- MAAIF should put in place a strong project on BBW, based on the National Network of Cassava workers (NANEC) model, to be coordinated from the National Banana Research Programme.
- MAAIF should strengthen the banana research and development team with additional trained manpower to facilitate more aggressive implementation of the proposed research and development action plan.
- On-going banana research and development activities should be reviewed to provide for integration of the proposed BBW activities and aggressive implementation of the proposed action plan.
- MAAIF should immediately source for funds for implementation of the action plan.
- MAAIF should put in place an aggressive sensitization programme, through Radio, TV and Newspaper.
- Central government should guide local governments to develop and enforce bye-laws to ensure compliance with the control measures.
- Farmer participatory implementation of activities should be strengthened to ensure their ownership of the programme and utilization of their experience.
- There is need to establish regional and international linkages and enhance complimentarity among government agencies, NGOs, IARCs (IITA, INIBAP) and donors to control BBW.

INTRODUCTION

1.1. The banana: Importance and constraints.

Globally banana is the fourth most important food crop after rice, wheat and maize. However, in Uganda it is the most important food crop as indicated by production output, acreage, consumption levels and priority ranking by stakeholders. Annual production is estimated at 9.5 million tonnes, accounting for 15% of total world banana/plantain output. Over 7 million people including 65% of the urban population depend on the crop as their staple. It is estimated that 75% of Ugandan farmers grow the crop on 1.5 million hectares, which accounts for over 38% of utilised arable land. The bananas produced are mainly consumed locally, with an estimated per capita consumption of over 200kg, the highest rate in the world.

Despite its importance, the crop is threatened by various constraints including: declining soil fertility, socioeconomic problems (marketing issues, crop management costs, post-harvest handling/utilization issues), pests (banana weevil, nematodes), diseases (black Sigatoka, Fusarium wilt and banana streak virus disease). Recently, the banana bacterial wilt BBW (commonly called Mukono disease) caused by *Xanthomonas campestris pv musacearum* has become a new threat to the banana and has been reported to devastatingly affect them in Mukono and Kayunga districts (Tushemereirwe *et al.*, 2001).

Presently at global level, bacterial wilts of bananas (moko and blood diseases) are ranked third most important disease after black Sigatoka and Fusarium wilt. Although black Sigatoka still remains a leading disease limiting banana production in Uganda, the observed outbreak

and spread of BBW presents a considerable threat to banana production. Moreover, the situation may be aggravated by the interactive effect between BBW and other pests and diseases prevalent in the country.

1.2. Economic importance of Banana Bacterial Wilt Disease in Uganda

At present, preliminary field studies conducted in Uganda reveal that most banana varieties are susceptible to BBW (Tushemereirwe *et al.*, 2001 and BBW task force, 2002). This devastating effect of BBW on banana in most districts in the country may contribute to decreased household and national food security; reduced incomes for banana farmers; increased relative food prices and cause Uganda to make difficult food policy decisions. This is because over 70% of farmers in Uganda rely on bananas as the main source of livelihood with banana consumption per capita ranging between 220 kg and 460kg (IITA, 1995). To this end, the spread of the disease has to be checked.

Moreover, the available statistics showed that, in the field where the disease was first observed, the incidence increased to over 70% in a period of one year. At this scale of spread, it implies that the disease has a potential to cause a substantial yield loss of the banana crop in Uganda.

Eden-Green (2003) reports that in Ntunda sub-county, Mukono district, a farmer who used to harvest 36 bunches per month before the BBW epidemic a year ago now gets no more than 3 bunches a month reflecting a yield loss of about 90%per annum in that farm. This loss

in terms of direct income and/or opportunity cost will result in an estimated value of Ug Shs. 0.8 m/year/farmer at Ug Shs. 2,000/bunch (Eden-Green, 2003).

He further observed that, in Budadiri in Sironko district, a farmer used to harvest 20 bunches per week before the BBW pandemic but with the disease outbreak after a year only 1 bunch per week is harvested. The estimated yield loss is 95% at a value of Ug Shs 0.9m per year. A similar trend in yield loss was obtained in Nsuube village, Jinja district by a farmer that experiences enormous food shortage and declining income due to BBW.

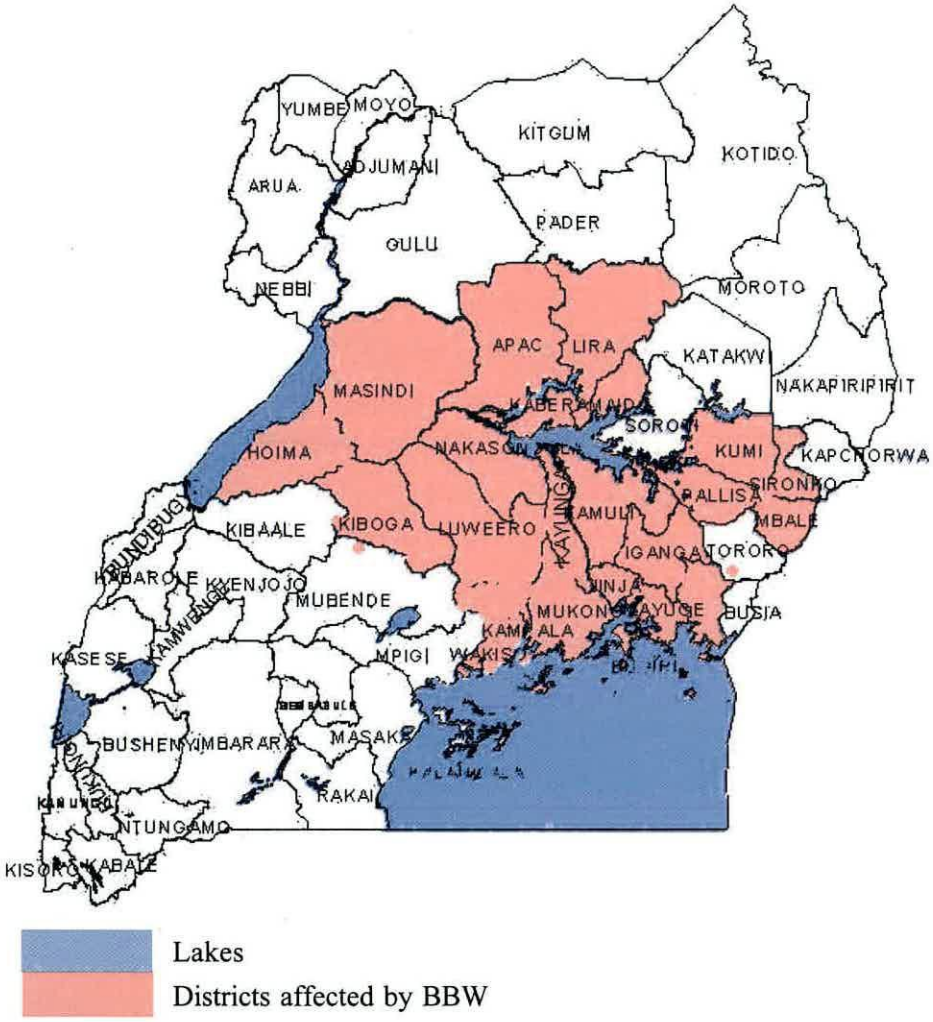
1.3. Status of banana bacterial wilt disease in Uganda

In Uganda BBW disease was first reported in 2001, on bananas in Mukono and Kayunga districts (Tushemereirwe *et al.*, 2001, 2002).

The disease causes wilting of banana plants of all ages and is easy to distinguish from other wilt diseases of the banana. Reddish brown staining in the banana fingers is the field confirmatory symptom of BBW that distinguishes it from all other wilts such as Fusarium wilt, known in Uganda (Tushemereirwe et al 2002).

Tushemereirwe *et al.* 2001 reported that in the affected fields, all banana varieties appeared to succumb. The disease has been confirmed in 21 districts of Uganda: Mukono, Kayunga, Lira, Kaberamaido, Sironko, Jinja, Kamuli, Luwero, Apac, Kumi, Mbale, Pallisa, Nakasongola, Masindi, Hoima, Iganga, Mayuge, Bugiri, Kampala, Kiboga and Wakiso districts. (Figure 1).

Figure 1. Distribution of Banana Bacterial Wilt in Uganda



1.4. Government response.

The Government initially responded to the outbreak of the disease by putting in place a taskforce (formed by The Minister of Agriculture, Animal Industry and Fisheries, MAAIF) to formulate an emergency action plan to contain the disease. An action plan was formulated and partial support for its implementation secured from the Government in June 2002. The plan emphasized cutting and burying infected banana stools, restricted movement of banana materials, decapitation of male buds, disinfection of tools and creation of awareness about the disease. A rapid appraisal survey and awareness campaign that followed revealed that the disease was more widespread than previously thought. The disease is now confirmed in Mukono, Kayunga, Lira, Kaberamaido, Sironko, Jinja, Kamuli, Luwero, Apac, Kumi, Mbale, Pallisa, Nakasongola, Masindi, Hoima, Iganga, Mayuge, Bugiri, Kampala, Kiboga and Wakiso with plantation incidence of up to 90%. It was realized that a lot was unknown about the disease and therefore, a strategy integrating research and development was needed to control the disease. NARO was requested by the Minister (MAAIF) to take lead in formulating a long-term research and development strategy for control of the disease. Consequently, the Director General, NARO constituted another multidisciplinary task force (Annex 1), including several members from the former task force, to address this concern in accordance with terms of reference (TOR) listed in Annex 2.

1.5. The Methodology adopted by the task force

The TF adopted the following methodology:

- Consultation with the first Taskforce (for emergency action plan)
- Discussion with different stakeholders (farmers, farmer groups and associations, local leaders and policy makers).

- Review literature from various sources including Ethiopia.
- Field visits to the affected areas.
- Regular brainstorming sessions among scientists.

2. FINDINGS AND RECOMMENDATIONS FROM STAKEHOLDERS

The task force team held consultations with various stakeholders and discussed their experiences and assembled opinions/ recommendations on how the disease can be managed. Consultations were held with farmers, community leaders, policy makers and researchers including: stakeholders from Mukono and Kayunga distticts, Uganda National Farmers Federation (UNFFE), National Agricultural Advisory Services (NAADS), Horticultural Exporters Association of Uganda (HORTEXA) and Dr. B. Lemaga (a scientist from Ethiopia). The following experiences and recommendations were obtained:

2.1. Findings

i. The disease was recognised as a threat and spreading fast with alarming damage on all banana varieties

ii. Some farmers had gone ahead to experiment control measures using indigenous technical knowledge such as application of wood ash.

iii. Initial interventions (rouging, quarantine and sensitization) led by MAAIF to control the disease were effective but expensive and the delivery method unsustainable.

iv. There is increased awareness of the disease

v. According to local leaders, government programmes are not participatory enough.

vi. The disease is mostly spread by farm tools, animals and planting materials

vii. Current research in Ethiopia has identified resistant/tolerant *Ensete* varieties, an experience which Ugandan scientists could benefit from.

viii. There is export market for apple bananas and Matooke in Europe with prices of US$ 1200 and 500 per tonne, respectively.

2.2. Recommendations

I. Local governments and community leaders be involved and facilitated for mobilization of farmers and other resources to control BBW preferably by adopting the Ministry of Health model against HIV/AIDS.

II. Sustained training and sensitization of farmers and other stakeholders on importance and control of BBW control.

III. Although control by cutting and burying of diseased plants was viewed as the most effective measure, most farmers preferred cutting without burying to reduce labour costs.

IV. Communities should be sensitized to cope with the disease and other epidemics by adopting alternative enterprises for food and income.

V. Banana traders recommended that the disease must be contained for them to continue with the highly paying banana business.

VI. Strengthen partnerships among various stakeholders (relevant ministries, local governments, institutions, NGOs and NAADS) and define roles to enhance efforts for control of BBW.

VII. Budget for the BBW control should be drawn and incorporated into the budgets of MAAIF and Local governments.

VIII. MAAIF and local governments should formulate and enforce bye-laws for control of BBW.

IX. NARO should intensify research to find varieties resistant/ tolerant to BBW

X. MAAIF should formulate a clear policy for overall control and containment of future pest and disease epidemics.

XI. Integrated pest Management (IPM) involving sanitation and control of nematodes, weevils and other soil pathogens that injure the plants is considered an effective strategy that has contained the disease in Ethiopia. It is suggested that this measure should be adopted by Ugandan farmers.

3. LITERATURE REVIEW

3.1. Disease history and etiology

The Banana bacterial wilt disease caused by *Xanthomonas campestris* pv *musacearum* was first reported in Ethiopia on Ensete (*Ensete ventricosum*), a family relative of the banana in 1968 (Yirgou and Bradbury, 1968 ;1974). It was later described on bananas in the Keffa,

Shoa and Sidamo, Harerge and Game-Goffa regions of Ethiopia, on cultivar Casse Hybrid (Yirgou and Bradbury, 1974), with incidence between 70 and 80% (Korobko *et al.*, 1987). In Ethiopia where this disease is considered important on ensete, banana cultivation is less extensive and therefore its destructive nature on the latter may be difficult to determine. In Uganda it was first reported in 2001 (Tushemereirwe *et al.*, 2001) and has since spread rapidly with plantation incidence of up to 70% and affecting both highland (Matooke bananas) and exotic (dessert/beer) bananas.

Little is known about the etiology of BBW. 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 also enters the plant through the male buds as reported for the Moko disease (Stover, 1972). This bacterium appears to attack the vascular system of both banana and *Ensete ventricosum* (Enset) causing wilting and death of the plants.

3.2. Host range

Little is known about alternative hosts of *X.* campestris pv *musacearum,* which affects bananas and *Ensete.* According to Wondimagegne *et al* (1987), the pathogen causes disease symptoms on hot pepper, tobacco, sesame, cabbage, wheat and barley and *Datura stramonium.* Although these crops are common in Uganda, their potential role as alternate hosts is not known. There is an urgent need to conduct pathogenicity-screening tests of a wide host range of common crops and weeds existing in the country.

3.3. Symptoms of banana wilt disease

According to Wondimagegne *et al.* (1987), the incubation period of the pathogen is 15 days. The first symptoms on the leaf is a dull green colour of the lamina, which gradually assumes a scalded appearance, becomes flaccid and folds back on its midrib, the two halves touching each other. The first leaf droops at the distal end, and the lamina gradually turns yellow, then brown and finally all leaves wither, and the plant rots (Yirgou and Bradbury, 1974). Cross sections of diseased petioles or pseudostems reveal yellowish droplets of bacterial oozing from vascular bundles (Korobko *et al.*, 1987), while the fruit ripens unevenly and prematurely with sections showing unique yellowish blotches in the flesh fingers and dark brown placental scars (Yirgou and Bradbury, 1974). While similar symptoms have also been described on affected bananas in Uganda (Tushemereirwe *et al.*, 2001), there is in addition a noted wilting of the male bud bracts and a characteristic bacterial oozing, proximal to the male bud.

3.4. Spread mechanism

The most important means of spread of the disease in enset in Ethiopia is through plant materials, contaminated cutting tools and browsing animals (Yirgou and Bradbury 1974; Wondimagegne *et al.*, 1987). Wondimagegne (1981) reported insect transmission in bananas. Yirgou and Bradbury (1974), emphasized that there is need to put measures in place so that Enset wilt does not escape and establish in other parts of the world where it could pose a serious problem on bananas.

3.5. Control Measures

In controlling a similar banana bacterial disease (Moko disease caused by *Ralstonia solanacearum),* Thwaites *et al* (2000) recommended *in situ* destruction of infected and neighbouring healthy plants and weeds within a buffer zone of 5-10m by injection with a systemic herbicide e.g. glyphosate. They further reported that eradication of Moko in Belize was achieved through cultural control with the cooperation of the public. This included sterilization of digging and cutting tools, clean planting materials in addition to destruction of diseased plants. Essentially, host plant resistance is the most reliable option for control of plant diseases and could be harnessed for BBW as adopted for Ensete wilt in Ethiopia (Thwaites *et al.*, 2000)

Some of the above cultural control measures based on rouging infected stools and disinfection of tools by flaming or with sodium hypochlorite (jik) were recommended in Uganda (Tushemereirwe *et al.,* 2001). In fields where massive cutting and burying of infected bananas was done incidence of the disease reduced to 3-8% and 1-28% in Mukono and Kayunga respectively. Experience gained from Mukono and Kayunga has indicated that it is important to sensitize and involve stakeholders in planning and implementation of control measures for BBW.

Based on available literature, there is insufficient knowledge to enable effective control of the disease. However, it is evident that cultural control measures have been effective in containing similar bacterial wilt epidemics in other countries. There is need to generate more information on the status of BBW and its etiology and epidemiology in Uganda. This will provide the basis for the development of appropriate technologies for effective control of the disease.

4. RESEARCH AND DEVELOPMENT ACTION PLAN FOR THE CONTROL OF BBW

4.1. Introduction

The banana production constraints described earlier (Section 1.1), are being addressed under a number of projects that constitute the current National Banana Research Programme of NARO. The action plan that follows (Table 2) specifically focuses on the priority research and development issues for the control of BBW. Its logical framework is presented in Annex 3.

The research and development action plan is designed and formulated to respond to the key requisites of the Plan for Modernisation of Agriculture (PMA) notably: increased income of affected subsistence farmers and their quality of life through increased productivity; improved household food security; provision of gainful employment as the farmers engage in banana production and promotion of environmentally friendly technologies. Furthermore, the plan is consistent with NARO's Research strategy and plan 2002-2005, for realignment of its research activities into specific thematic areas (Annex 4).

4.2. Goal

The National Research and Development Action Plan has been developed with the overall goal of improving and sustaining food security and incomes of banana producers and consumers through control of banana bacterial wilt.

4.3. Specific Objectives:

I. Establish the current status of banana bacterial wilt.

II. Generate information on etiology and epidemiology of BBW

III. Develop appropriate technologies for management of banana bacterial wilt disease.

IV. Use appropriate technologies and information to contain and control BBW.

V. Develop capacity for research and development for BBW control

VI. Develop and improve appropriate policies for management of pest and disease epidemics.

VII. Identify and promote alternative enterprises as a safety-first fallback option for farmers overwhelmed by BBW.

VIII. Assess and monitor impact of research and development on BBW

4.4. Development of priorities and work plans

In order to systematically and aggressively combat the devastating effect of BBW, there was need to rationalize use of limited resources. This required identification of research and development activity areas and prioritizing them. The key researchable areas were identified based on: current status of BBW, etiology and epidemiology and developing resistant/tolerant varieties. Development interventions identified include capacity building for control of BBW, dissemination of technologies and information, formulation of appropriate policies, alternative enterprises and impact assessment.

Priority setting of the research activities was conducted using the following criteria which was developed and adopted by the Taskforce.

I. Contribution to reducing the effects of BBW (30%)
II. Urgency of information/intervention (25%)
III. Chances of success by R &D agencies in obtaining information (20%)
IV. Time frame to accomplish the tasks (15%)
V. Resources needed (manpower, financial and physical) for the R&D activities (10%).

Each criterion above was given a specific weight (percentage) based on its relative importance in terms of controlling the disease. Indeed the percentages reflect the coefficients of the respondents in the task force, which resulted from the multiple regression analysis.

Based on the criteria, the researchable and development outputs and activities (within outputs) were scored by the TF members in a participatory manner. A scale ranging from 1 to 5, developed by the TF was used as follows: 1=Very low, 2= Low, 3= Medium, 4= High and 5 = Very high for each of the above listed criterion. The total score was then obtained for each output / activity which was then weighted according to importance of each of the criterion earlier developed. The total weighted scores for each of the outputs / or activities were then used to assign the ranks to outputs / or activities.

Table 2. National Research and Development Action Plan On Banana Bacterial Wilt Disease

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
1. Current status of BBW established		**4.20**	**1**				
Baseline information	Establish distribution, incidence and severity of BBW in Uganda	4.15	2	11 districts affected	NARO, MAAIF, IARCs, MUK, NGOs GoU and donors	2004	Short term
	Determine the economic importance of banana bacterial wilt	4.15	2	-.	NARO, MAAIF, MUK, IARCs GoU, LGs and donors	2004	Short term
	Establish coping mechanisms and ITK information	3.85	4	Cutting infected plants and use of wood ash.	NARO, MAAIF, MUK, IARCs, GoU, LGs and donors	2004	Short term
	Determine client needs and priorities for BBW control	3.75	7	-.	NARO, MAAIF, MUK, IARCs GoU, LGs and donors	2004	Short term
	Identify changes in banana based cropping systems	2.15	9	-.	NARO, MAAIF, MUK, IARCs GoU and donors	2004	Short term
Development of R & D agenda	Develop recommendations for setting Research and development priorities.	4.45	1	-.	MAAIF, NARO, IARCs, GoU and donors	2004	Short term
Monitoring	Monitor disease spread (Surveillance) and control new outbreaks	3.80	5	All districts being monitored	MAAIF and NARO GoU, LGs and donors	Continuous	Short/Long term
	Stakeholders workshops	3.80	5	-	MAAIF and NARO to convene	2004	Short term
	Identify gender implication of BBW & strategies for promoting gender contributions	3.50	8	-	NARO, MAAIF and MUK	2004	Short term
2. Information on Etiology and epidemiology of BBW generated		**4.00**	**2**				
Etiology and Pathogenesis	Determination of pathogen variability	3.85	2	-	NARO, MUK, IARCs, GoU and donors	2003-2006	Short term
	Develop inoculation techniques	4.05	1	Five techniques being evaluated	NARO, MUK, IARCs CABI,	2003-2004	Short term

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
					GoU, LGs and donors		
	Determine mode of penetration and disease development	2.65	8	-	-do-	2003-2009	Long term
	Determine factors affecting disease development	3.25	7	-	-do-	2003-2009	Long term
Epidemiology of BBW	Determine mode(s) and rate of transmission	3.80	3	Farm tools, plant materials confirmed	-do-	2003-2009	Long term
	Determine survival mechanisms of the pathogen	3.35	6	-		-do-	Long term
	Determine the pre-disposing factors and their influence on the disease development, severity and spread of the disease	3.45	5	-		-do-	Long term
	Determine alternative hosts	3.70	4	Canna-lily, wild banana confimed	-do-	-do-	Long term
3. Appropriate technologies for Management of BBW developed		**4.00**	**2**				
Cultural, chemical and biological control methods	Identify possible cultural, chemical and biological control measures	4.10	5	Sanitation measures under evaluation	NARO, MUK, IARCs CABI, Farmers, MAAIF, NAADS, LGs and donors	2003-2004	Short term
	Evaluate and refine possible control measures using farmer participatory methods	4.30	1	-	-do-	2004-2009	Medium term
	Determine the economic feasibility of the control measures	4.20	3	-	-do-	2006-2010	Long term
Resistant Varieties	Germplasm collection (local and introduced) and characterization	4.15	4	200 accessions already assembled	NARO, IARCs, CABI, INIBAP, Farmers, GoU, LGs and donors	2004-2008	Medium term
	Identify resistant/tolerant genotypes	3.65	6	-	Do	2010	Long term
	Screen the identified genotypes for pollen fertility	3.65	6	-	Do	2010	Long term
	Incorporation of resistance into desired	3.65	6	3 resistant genes		2004-2009	Long term

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
	Cultivars (conventional and molecular) that meet different market requirement			identified			
	Farmer participatory evaluation of selected resistant genotypes	4.30	1	-	NARO, MUK, IARCs, CABI, INIBAP, MAAIF, NAADS and Farmers	2007-2010	Long term
4.Appropriate Technologies and Information utilized to contain and control BBW		**3.95**	**4**				
Researchable area	**Activities**	**Total weighted score**	**Rank**	**Current status**	**Key players**	**Time frame**	
Technology and information dissemination	Characterize uptake pathways and evaluate different approaches of technology dissemination	3.15	3	2000 Posters and 5000 leaflets on emergency control of BBW widely disseminated	NARO, MUK CABI IARCs,Farmers MAAIF, NAADS NGOs GoU, LGs and donors	2004	Short term
	Identify technologies for dissemination	3.50	2	-		2004-2006	Medium term
	Promotion of appropriate technologies	3.75	1	- -	MAAIF, NARO, NAADS, MUK, private companies, GOU, LGs, CBOs, NGOs and Donor	2004--2010	Long term
	Contain and manage the Disease Adoption studies	3.75	1	Sanitation measures implemented in Kayunga and Mukono Districts	MAAIF, NARO,NAADS, MUK private companies, CBOs, NGOs and Donor	2004--2010	Long term
5. Capacity for R & D developed		**3.95**	**4**				
Capacity building	Train scientists in specialized skills for handling BBW Degrees (M.Sc. and Ph. D) Short courses (internal and external) Study visits Conferences and workshops	3.55	3	One M. Sc. student on training Funding for 1 PhD available	NARO, MUK and other universities, IARCs,Farmers MAAIF, NAADS Extension service providers, NGOs Private companies and GoU and donors	2004-2010	Long term

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
	Sensitise all stakeholders about the disease Training of trainers (Extension workers Local leaders Farmers)	4.10	1	Farmers in BBW affected areas sensitized. 90 extension workers trained		2003-2004	Short term
	Facilitate development and strengthening of grassroots farmers' institutions for management of BBW	3.55	3	-		2003-2005	Medium term
	Develop appropriate infrastructure for handling BBW	3.95	2	Biotech lab available			Medium term
6. Impact of R & D assessed and monitored		**3.55**	**6**				
Impact Assessment	Evaluate the potential impact of R for D interventions.	3.75	1	-	MAAIF, NARO MUK, IARCs	2004	Short term
	Assess Ex-post impact of interventions for BBW control	2.20	2	-	NARO, MAAIF with MUK, IARCs, NGOs	2009	Long term
7. Appropriate policies developed/ improved		**2.90**	**7**				
Policy Development	Review existing phytosanitary policy	2.65	4	-	MAAIF, NARO	2004	Short term
	Develop regulations, byelaws, and quarantine procedures in a participatory manner.	3.80	1	-	MAAIF, Grass root Institutions, LGs NARO	2004	Long term
	Develop a policy for mitigating effects of pests and diseases epidemics.	2.60	5	.-	MAAIF, NARO and Ministry for disaster preparedness	2004	Short term
Partnerships & linkages	Identify, develop and manage partnerships and linkages for	3.35	2	-	MAAIF, and NARO lead in	2004	Long term

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
	implementing relevant policies.				Collaboration with IARCs		
Monitoring & evaluation	Monitoring and evaluation for programs to implement the policies above	3.25	3	-	MAAIF, NARO, LGs and grass root institutions	Continuous	Short/Long term
8. Alternative enterprises identified and promoted		**2.45**	**8**				
Fall-back options	Identify suitable alternative food/cash crops in short/long run in a participatory manner	2.85	1	Cassava sunflower and vanilla identified for Mukono and Kayunga	MAAIF, NARO, farmers and private sector, MUK, IARCs	2005	Medium term
	Identify other suitable enterprises/technologies.	2.85	1	-	MAAIF, NARO, farmers and private sector, MUK, IARCs	2005	Medium term
Partnerships & linkages	Develop and manage partnership and linkages for promoting identified enterprises/technologies.	2.50	3	-	MAAIF, NARO, farmers and private sector, UNIFFE, HORTEXA, MUK, IARCs	2004	Short term
Gender mainstreaming	Identify gender implications of BBW and strategies for promoting gender contribution	2.40	4	-.	MAAIF, NARO, farmers and private sector back stopping MUK, IARCs	2004	Short term
Monitoring & evaluation	Monitoring and evaluation for promoting identified enterprises.	1.90	6	-.	MAAIF, NARO and grass root institutions	Continuous	Short/Long term
Dissemination	Promote identified enterprises/ technologies, food and cash crops	2.40	4	Cassava sunflower and vanilla planting materials distributed in Mukono and Kayunga	MAAIF, NARO and grass root institutions	2005	Medium term

5. OPPORTUNITIES AND RECOMMENDATIONS FOR CONTROL OF BBW

5.1. Opportunities

Despite the alarming threat presented by the BBW to the banana industry in Uganda, it is anticipated that with prompt and appropriate action by all banana sub-sector stakeholders the disease can be combated to save the country from eminent disaster. Consequently, the following opportunities need to be exploited.

- Many farmers treat banana as a high priority crop and allocate reasonable resources to its management, hence easy to develop partnerships, mobilize and sensitize them.
- Uganda has a fully-fledged and strong Banana Research team composed of national, regional and international scientists and good linkage to a consortium of donors to handle BBW Research and Development
- A minimum research and development programme has been initiated to address the problem of BBW and a number of donors and research collaborators have expressed interest in further financial support and technical back stopping, respectively.
- The current high demand for bananas in local and International niche markets, promises high returns to investments in R&D.
- Advanced research tools for accelerated research results (e.g, biotechnology) and a large reserve of plant genetic resources for utilization in genetic improvement of banana are available in Uganda and the region

5.2. Recommendations

The task force is of the view that the future of the banana industry in Uganda largely rests on the appropriate and timely implementation of the following strategies;

- Government should recognize the eminent threat posed by BBW to the banana industry and include it among its priority programmes.
- MAAIF should institute strong steering and technical committees to spearhead implementation of the proposed research and development action plan.
- MAAIF should put in place a strong project on BBW, based on the National Network of Cassava workers (NANEC) model, to be coordinated from the National Banana Research Programme.
- MAAIF should strengthen the banana research and development team with additional trained manpower to facilitate more aggressive implementation of the proposed research and development action plan.
- On-going banana research and development activities should be reviewed to provide for integration of the proposed BBW activities and aggressive implementation of the proposed action plan.
- MAAIF should immediately source for funds for implementation of the action plan.
- MAAIF should put in place an aggressive sensitization programme, through Radio, TV and Newspaper.
- Central government should guide local governments to develop and enforce bye-laws to ensure compliance with the control measures.

- Farmer participatory implementation of activities should be strengthened to ensure their ownership of the programme and utilization of their experience.
- There is need to establish regional and international linkages and enhance complimentarity among government agencies, NGOs, IARCs (IITA, INIBAP) and donors to control BBW.

5.3. Budget Estimates

The budgetary implications of the National Research and Development Action Plan on BBW are presented in table 3 (summarized according to activities) and table 4 (detailed estimates)

Table 3. Summary of Expected Outputs and budget estimates

Expected Outputs (R &D Areas)	RANK	BUDGET (UGSH)					
		YR1 ('000)	YR2 ('000)	YR3 ('000)	YR4 ('000)	YR5 ('000)	TOTAL ('000)
1: Current Status of Banana Bacterial Wilt and Priorities for Banana R for D, established	1	209,726	131,250	462,450	462,450	462,450	1,728,326
2: Information on the Etiology and Epidemiology of BBW generated	2	716,229	364,928.	262,338.	244,972	244,972	1,833,438
3:Technologies for Management of BBW Developed.	2	398,155	298,961	284,311	284,311	284,311	1,550,049
4:Appropriate Technologies utilized for control of BBW	4	229,839	178,313	173,813	187,313	187,313	956,589
5:Capacity Built	4	1,863,000	337,000	109,000	26,000	30,000	2,365,000
6: Determine Impact Of R For D.	6	178,664	176,906	147,514	147,514	135,514	786,112
7: Appropriate Policies Developed /Improved	7	159,780	161,070	123,900	95,555	87,490	627,795
8: Alternative Enterprises Identified and Promoted	8	21,582	21,582	12,000	28,038	16,038	99,239
Coordination (10% of the budget)		377,697.3	167,001	157,532.6	147,615.2	144,808.7	994,654.8
GRAND TOTAL		4,154,670	1,837,011	1,732,859	1,623,767	1,592,896	10,941,203

Table 4: Detailed budget estimates by activitiy

BUDGET FOR THE BBW ACTIVITIES						
ACTIVITIES	**YR1 ('000)**	**YR2 ('000)**	**YR3 ('000)**	**YR4 ('000)**	**YR5 ('000)**	**TOTAL ('000)**
ACTIVITIES	**YR1 ('000)**	**YR2 ('000)**	**YR3 ('000)**	**YR4 ('000)**	**YR5 ('000)**	**TOTAL ('000)**
OUTPUT 1: Establishing current status of Banana bacterial wilt and priorities for banana R for D						**211526**
1.1. Establish distribution, incidence and severity of BBW in Uganda	43715	0	0	0	0	43715
1.2. Determine the economic importance of banana bacterial wilt	25460	0	0	0	0	25460
1.3. Establish coping mechanisms and ITK information	0		0	0	0	0
1.4. Determine client needs and priorities for BBW control	0		0	0	0	0
1.5. Identify changes in banana based cropping systems	0		0	0	0	0
1.6. Develop recommendations for setting Research and development priorities.	1479	0	0	0	0	1479
1.7. Monitor disease spread and control of new outbreaks	131250	131250	462450	462450	462450	1649850
1.8. Stakeholders Workshop (3 days, 50 people)	7822	0	0	0	0	7822
Sub Total	**209,726**	**131,250**	**462,450**	**462,450**	**462,450**	**1,728,326**
OUTPUT 2: INFORMATION ON THE ETIOLOGY AND EPIDEMIOLOGY OF BBW GENERATED						**1833438**
2.1Collection of samples, Lab issolation & determination pathogen varieation	307917	80717	0	0	0	388634
2.2 Developing inoculation techniques	69853	25853	0	0	0	95706
2.3 Determine model of peeneration & diseas development	39053	39053	37803	29290	29290	174489
2.4 Determine factors affecting diseas development	34973	34973	39703	30850	30850	171349
2.5 Determine modes of transimission	34023	37173	37173	37173	37173	182715
2.6 Determine survial mechanisms of the pathogen	37881	37412	38912	38912	38912	192029
2.7 Determine the factors influencing disease incidence, serveity & spread	118275	41777	41277	41277	41277	283883
2.8 Detrmine machanisms of spread	36299	35515	35015	35015	35015	176859
2.9 Determine alternative hosts	37955	32455	32455	32455	32455	167775
Sub Total	**716,229**	**364,928**	**262,338**	**244,972**	**244,972**	**1,833,438**
OUTPUT 3: MANAGEMENT OF BBW						**1550049**
3. 1. APPROPRIATE CULTURAL AND BIOLOGICAL CONTROL MANAGEMENT	43374	41930	41930	41930	41930	211094
3.2 BREEDING FOR RESISTANCE	354781	257031	242381	242381	242381	1338955
Sub Total	**398,155**	**298,961**	**284,311**	**284,311**	**284,311**	**1,550,049**
OUTPUT 4: TECHNOLOGIES UTILIZED TO CONTROL BBW						**922065**
4.1 Identify and characterize uptake pathways	69548	35024	35024	35024	35024	209644
4.2 Identify technologies for dissemination	35024	35024	35024	35024	35024	175120
4.3 Promotion of techologies	125265	108265	103765	117265	117265	571825
Sub Total	**229,837**	**178,313**	**173,813**	**187,313**	**187,313**	**956,589**

Table 4: Detailed budget estimates by activitiy

ACTIVITIES	YR1 ('000)	YR2 ('000)	YR3 ('000)	YR4 ('000)	YR5 ('000)	TOTAL ('000)
OUTPUT 5: Capacity building						**2365000**
5.1 Specialised training	209000	137000	109000	26000	30000	511000
5.2. Sensitisation and training	684000	0	0	0	0	684000
5.3. Facilitate development and strengthening of grassroot farmer groups (at Sub-counties)	600000	200000	0	0	0	800000
5.4. Cross cutting expenses	370000	0	0	0	0	370000
						0
Sub Total	**1,863,000**	**337,000**	**109,000**	**26,000**	**30,000**	**2,365,000**
						0
OUTPUT 6: Appropriate policies developed /improved						**786112**
6.1 Review existing phytosanitary policy	40541	39441	36712	36712	36712	190118
6.2 Develop regulations, bye-laws, and quarantine procedures and approaches for implementation in a participatory manner	86256	86256	62982	62982	62982	361458
6.3 Develop a policy and strategy for mitigating effects of pests and diseases epidemics.	41101	41101	37712	37712	25712	183338
6.4 Identify partnerships and linkages for implementing relevant policies/strategies.	2416	1758	1758	1758	1758	9448
6.5. Monitoring and evaluation for programs to implement the policies/strategies	8350	8350	8350	8350	8350	41750
						0
Sub Total	**178,664**	**176,906**	**147,514**	**147,514**	**135,514**	**786,112**
OUTPUT 7: Alternative enterprises identified and promoted						**627795**
7.1 Identify suitable alternative food/cash crops in short/long run in a participatory manner	65160	41680	41680	41680	41680	231880
7.2 Identify other suitable enterprises/technologies in a participatory manner (Covered under 7.1)	0	0	0	0	0	0
7.3 Develop partnership and linkages for promoting identified enterprises/technologies.	3180	3180	3180	3180	3180	15900
7.4. Identify gender implications of BBW and strategies for promoting gender ontributions	18300	15900	15900	15900	15900	81900
7.5 Monitoring and evaluation for promoting identified enterprises.	10600	10600	10600	10600	10600	53000
7.6 Promote and disseminate identified enterprises/ technologies, food and cash crops	62540	89710	52540	24195	16130	245115
Sub Total	**159,780**	**161,070**	**123,900**	**95,555**	**87,490**	**627,795**
OUTPUT 8: Determine impact of R for D.						**99239**
8.1 Evaluate the potential impact of R for D interventions.	9582	9582	0	0	0	19164
8.2 Assess Ex-post impact of interventions for BBW control	12000	12000	12000	28038	16038	80075
						0
Sub Total	**21,582**	**21,582**	**12,000**	**28,038**	**16,038**	**99,239**
Total	**3,776,973**	**1,670,010**	**1,575,326**	**1,476,152**	**1,448,087**	**9,946,548**
9.0 Coordination (10% of budget)	**377,697**	**167,001**	**157,533**	**147,615**	**144,809**	**994,655**
						-
GRAND TOTAL	**4,154,670**	**1,837,011**	**1,732,859**	**1,623,767**	**1,592,896**	**10,941,203**

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Annex 1. List of the Taskforce Members

NAME	RESPONSIBILITY	SPECIALIZATION	INSTITUTION
Dr. F. Opio	Chairperson	Pathologist	D/NAARI
Dr. W. Tushemereirwe	Secretary	Pathologist	H/NBRP
Dr. M. Magunda	Member	Soil scientist	D/KARI
Dr. G. Hakiza	Member	Pathologist	SPRO/CORI
Dr. A. Kangire	Member	Pathologist	RO/CORI
Dr. A. Bua	Member	Socio-Economist	H/NCRP
Dr. R. Kalyebara	Member	Socio-Economist	NARO-NBRP
Prof. S. Kyamanywa	Member	Entomologist	H/CS Dpt/MU
Dr. T. Alicai	Member	Pathologist	RO/NCRP
Dr. M. Pillay	Member	Breeder	IITA
Dr. E. Karamura	Member	Entomologist	C/INIBAP
Mrs. D. Kataama	Member	Entomologist	DAO/Mukono
Mr. O. Okaasai	Member	Pathologist	AC/MAAIF
Mr. B. Byamugisha	Member	Economist	MAAIF
Mr. J. Kubirirba	Member	Pathologist	NBRP
Mr. F. Ssekiwoko	Member	Pathologist	NBRP
Mr. W. Serubombwe	Member	Pathologist	RO/ NCRP

Annex 2. Terms of reference

The task force was mandated to address the following terms of reference:

1. To review literature on banana wilt disease in Africa and elsewhere and document available knowledge on the economic importance, etiology, epidemiology and control of the disease including strategies for mitigating the economic and social impact of the disease.
2. To review existing reports and research proposals on banana wilt disease in Uganda.
3. To develop a National Research and Development Strategy and Plan indicating activities, priorities, key-players, time frame, and estimated costs.
4. To identify options and strategies for "fall-back" positions in case the control of the banana wilt disease is deemed to be uneconomic.
5. To present a written National Research and Development Action Plan to the Director General NARO.

Annex 3. Logical Framework For Implementation Of Banana Bacterial Wilt Management Activities

Narrative Summary	OVIs	Means of Verification	Assumptions
Goal Improving and sustaining food security and incomes of banana producers and consumers through control of banana bacterial wilt	Losses due to BBW reduced by 3% annually	Production statistics at various levels	
Purpose Control of BBW through adoption of appropriate technologies	At least 10% of farmers adopting appropriate technologies for control of BBW in at least 5 affected districts by 2005	Reports on adoption and impact	No emergence of other factors limiting banana production
OUTPUTS **1.** Current Status of Banana Bacterial Wilt established	Distribution, incidence, and severity of BBW in Uganda determined by June 2004 Social and Economic Impact of BBW (at farmer and national levels) determined for various beneficiary categories by Dec 2004 Farmers perceptions of BBW and their control strategies determined by June 2004 Stakeholder needs and priorities (including strategies for promoting gender contributions) identified by June 2004 Changes in banana based farming systems determined by June 2004	Technical Reports (survey reports, etc) Proceedings of stakeholder workshops	Favourable social & political environment prevailing
2. Information On The	Isolates of the BBW pathogen from all affected districts	Technical reports	Favourable social & political

Narrative Summary	OVIs	Means of Verification	Assumptions
Pathogen Etiology And Epidemiology Of The Disease Generated	characterized by end of 2006 Appropriate laboratory procedures (inoculation techniques, inoculum concentration etc) developed by June 2004 and refined by December 2004 Information on the rate, mechanisms and pattern of spread of BBW generated by 2007	Manuals	environment prevailing
Appropriate technologies for management of BBW developed	Possible cultural, chemical and biological control measures identified and at least three selected for evaluation by mid 2004 Three selected control measures evaluated by 2006 and the promising ones refined by 2009 Economic worthiness of at least three promising control measure determined by 2008 At least 250 local and foreign genotypes collected and characterized by 2008 Promising genotypes generated and evaluated on station for resistance to BBW by 2008 Promising genotypes with tolerance/ resistance to BBW identified and selected through farmer participatory methods by 2010	Technical reports Progress reports Inspection reports	Favourable social & political environment prevailing
3. BBW Controlled	At least one uptake pathway for each target site identified for promotion and dissemination of	Technical reports	Favourable social & political environment prevailing

Narrative Summary	OVIs	Means of Verification	Assumptions
	technologies on BBW by 2004 At least 3 appropriate technologies being promoted in at least 5 target districts by 2006 Mass multiplication and distribution of at least 2 technologies initiated by 2009 At least 5% of the farmers accessing at least one technology at 5 target sites	Progress reports Reports from extension service providers	
4. Capacities Developed at All Levels	At least three scientists trained and using specialised skills to address BBW by 2006; and at least 6 more by 2010 Laboratories equipped to handle BBW by December 2004 At least 2000 trainers (Key planners, policy makers, contact farmers and extension workers) from 10 districts trained annually At least 20% of farmers' institutions in affected districts facilitated and strengthened to handle BBW by the end of 2005	Staff assessment reports Reports from extension Meetings Inventory of equipment	Favourable social, economic & political environment prevailing
5. Appropriate Policies Developed/Improved	Phytosanitary policy developed by MAAIF by December 2005 Bye-law for control of BBW developed and being enforced in each affected district by 2004	Policy documents Proceedings of meetings	Favourable social, economic & political environment prevailing

Narrative Summary	OVIs	Means of Verification	Assumptions
	Policy for control of pest and disease epidemics developed and presented to parliament by MAAIF by 2006 Modalities for collaboration between partners in control of BBW developed by December 2004		
6. Alternative Enterprises Identified and Promoted	5% of target beneficiaries accessing or using identified enterprises annually.	Progress reports	Need for alternative enterprises exists Favourable social, economic & political environment prevailing
7. Impact of R & D for Management of BBW monitored and evaluated	Benefits of R&D for management of BBW and feed back from beneficiaries determined annually from 2004 Ex-ante impact of R & D determined by June 2004 Adoption study completed by 2013	Technical Reports	Favourable social, economic & political environment prevailing

TABLE OF CONTENTS

Acknowledgements.....i

TABLE OF CONTENTS.....ii

List of Tables.....iv

LIST OF ABBREVIATION AND ACRONYMS.....iv

Appendices.....v

EXECUTIVE SUMMARY.....v

1. INTRODUCTION.....1

1.1. The banana: Importance and constraints.....1

1.2. Economic importance of Banana Bacterial Wilt Disease in Uganda.....2

1.3. Status of banana bacterial wilt disease in Uganda.....3

1.4. Government response 5

1.5. The Methodology adopted by the task force.....5

2. FINDINGS AND RECOMMENDATIONS FROM STAKEHOLDERS **6**

2.1. Findings..... 6

2.2. Recommendations.....7

3. LITERATURE REVIEW **8**

3.1. Disease history and etiology.....8

3.2. Host range.....9

3.3. Symptoms of banana wilt disease.....10

3.4. Spread mechanism 10

3.5. Control Measures 11

Annex 4. Banana Bacterial Wilt Project outputs based on NARO's Thematic areas

Goal	Improving and sustaining food security and incomes of banana producers and consumers through control of banana bacterial wilt (BBW)					
Purpose	Control of BBW through adoption of appropriate technologies					
Thematic areas	People, their livelihood systems, demands and impact innovations understood	Innovation process and partnership enhanced	Integrated management of natural resources enhanced	Technological options that respond to demand and market opportunities generated and disseminated	Market requirements and enabling policies for technology development identified	
Outputs	Current status of banana bacterial wilt determined	Appropriate technologies for management of BBW developed	Appropriate technologies for management of BBW developed	Information on the pathogen Etiology and Epidemiology of the disease generated	Appropriate policies for management of pest and disease epidemics developed / improved	
	Alternative enterprises as safety-net fall back option for farmers overwhelmed by BBW identified and promoted	Appropriate Technologies and information disseminated		Appropriate technologies for management of BBW developed		
	Impact of R&D for management of BBW monitored and evaluated			Appropriate Technologies and information disseminated		

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The TF is highly indebted to the many individuals and institutions that provided valuable information at short notice. Our greatest gratitude goes to Hon. Dr. Kisamba Mugerwa, The Minister of Agriculture, Animal Industry and Fisheries for deeming it necessary to put in place this task force; Hon. Dr. Kibirige Sebunya, The Minister of State for Agriculture for his scientific input; Dr. W. Otim Nape, the Acting Director General of NARO, for the guidance and provision of an enabling environment. The farmers, local leaders and field extension workers in Mukono and Kayunga Districts and the other BBW affected areas who took time out of their busy schedules to discuss and show us banana fields devastated by the bacterial wilt disease and made valuable suggestions are highly acknowledged. The contributions from Uganda National Farmers Federation, National Agricultural Advisory Services, and Horticulture Exporters Association are appreciated. Finally, we would like to thank Dr B. Lemaga for providing his experience with Enset bacterial wilt in Ethiopia.

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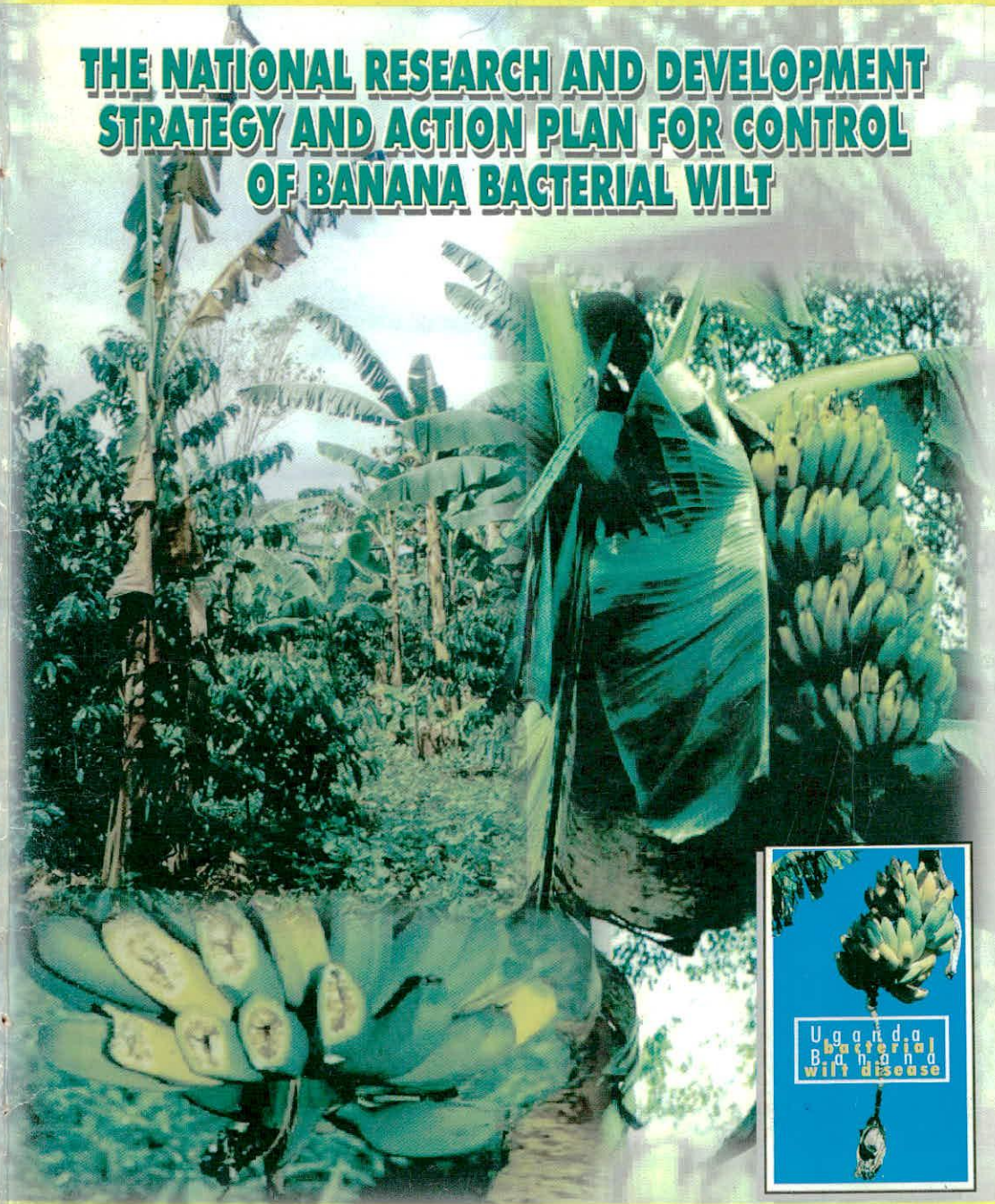
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FOR GOD AND MY COUNTRY

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THE NATIONAL RESEARCH AND DEVELOPMENT STRATEGY AND ACTION PLAN FOR CONTROL OF BANANA BACTERIAL WILT



TASK REPORT
NOVEMBER 2003

4. RESEARCH AND DEVELOPMENT ACTION PLAN FOR THE CONTROL OF BBW

4.1. Introduction

The banana production constraints described earlier (Section 1.1), are being addressed under a number of projects that constitute the current National Banana Research Programme of NARO. The action plan that follows (Table 2) specifically focuses on the priority research and development issues for the control of BBW. Its logical framework is presented in Annex 3.

The research and development action plan is designed and formulated to respond to the key requisites of the Plan for Modernisation of Agriculture (PMA) notably: increased income of affected subsistence farmers and their quality of life through increased productivity; improved household food security; provision of gainful employment as the farmers engage in banana production and promotion of environmentally friendly technologies. Furthermore, the plan is consistent with NARO's Research strategy and plan 2002-2005, for realignment of its research activities into specific thematic areas (Annex 4).

4.2. Goal

The National Research and Development Action Plan has been developed with the overall goal of improving and sustaining food security and incomes of banana producers and consumers through control of banana bacterial wilt.

4.3. Specific Objectives:

I. Establish the current status of banana bacterial wilt.

II. Generate information on etiology and epidemiology of BBW

III. Develop appropriate technologies for management of banana bacterial wilt disease.

IV. Use appropriate technologies and information to contain and control BBW.

V. Develop capacity for research and development for BBW control

VI. Develop and improve appropriate policies for management of pest and disease epidemics.

VII. Identify and promote alternative enterprises as a safety-first fallback option for farmers overwhelmed by BBW.

VIII. Assess and monitor impact of research and development on BBW

4.4. Development of priorities and work plans

In order to systematically and aggressively combat the devastating effect of BBW, there was need to rationalize use of limited resources. This required identification of research and development activity areas and prioritizing them. The key researchable areas were identified based on: current status of BBW, etiology and epidemiology and developing resistant/tolerant varieties. Development interventions identified include capacity building for control of BBW, dissemination of technologies and information, formulation of appropriate policies, alternative enterprises and impact assessment.

Priority setting of the research activities was conducted using the following criteria which was developed and adopted by the Taskforce.

I. Contribution to reducing the effects of BBW (30%)
II. Urgency of information/intervention (25%)
III. Chances of success by R &D agencies in obtaining information (20%)
IV. Time frame to accomplish the tasks (15%)
V. Resources needed (manpower, financial and physical) for the R&D activities (10%).

Each criterion above was given a specific weight (percentage) based on its relative importance in terms of controlling the disease. Indeed the percentages reflect the coefficients of the respondents in the task force, which resulted from the multiple regression analysis.

Based on the criteria, the researchable and development outputs and activities (within outputs) were scored by the TF members in a participatory manner. A scale ranging from 1 to 5, developed by the TF was used as follows: 1=Very low, 2= Low, 3= Medium, 4= High and 5 = Very high for each of the above listed criterion. The total score was then obtained for each output / activity which was then weighted according to importance of each of the criterion earlier developed. The total weighted scores for each of the outputs / or activities were then used to assign the ranks to outputs / or activities.

3.5. Control Measures

In controlling a similar banana bacterial disease (Moko disease caused by *Ralstonia solanacearum),* Thwaites *et al* (2000) recommended *in situ* destruction of infected and neighbouring healthy plants and weeds within a buffer zone of 5-10m by injection with a systemic herbicide e.g. glyphosate. They further reported that eradication of Moko in Belize was achieved through cultural control with the cooperation of the public. This included sterilization of digging and cutting tools, clean planting materials in addition to destruction of diseased plants. Essentially, host plant resistance is the most reliable option for control of plant diseases and could be harnessed for BBW as adopted for Ensete wilt in Ethiopia (Thwaites *et al.*, 2000)

Some of the above cultural control measures based on rouging infected stools and disinfection of tools by flaming or with sodium hypochlorite (jik) were recommended in Uganda (Tushemereirwe *et al.,* 2001). In fields where massive cutting and burying of infected bananas was done incidence of the disease reduced to 3-8% and 1-28% in Mukono and Kayunga respectively. Experience gained from Mukono and Kayunga has indicated that it is important to sensitize and involve stakeholders in planning and implementation of control measures for BBW.

Based on available literature, there is insufficient knowledge to enable effective control of the disease. However, it is evident that cultural control measures have been effective in containing similar bacterial wilt epidemics in other countries. There is need to generate more information on the status of BBW and its etiology and epidemiology in Uganda. This will provide the basis for the development of appropriate technologies for effective control of the disease.

3.3. Symptoms of banana wilt disease

According to Wondimagegne *et al.* (1987), the incubation period of the pathogen is 15 days. The first symptoms on the leaf is a dull green colour of the lamina, which gradually assumes a scalded appearance, becomes flaccid and folds back on its midrib, the two halves touching each other. The first leaf droops at the distal end, and the lamina gradually turns yellow, then brown and finally all leaves wither, and the plant rots (Yirgou and Bradbury, 1974). Cross sections of diseased petioles or pseudostems reveal yellowish droplets of bacterial oozing from vascular bundles (Korobko *et al.*, 1987), while the fruit ripens unevenly and prematurely with sections showing unique yellowish blotches in the flesh fingers and dark brown placental scars (Yirgou and Bradbury, 1974). While similar symptoms have also been described on affected bananas in Uganda (Tushemereirwe *et al.*, 2001), there is in addition a noted wilting of the male bud bracts and a characteristic bacterial oozing, proximal to the male bud.

3.4. Spread mechanism

The most important means of spread of the disease in enset in Ethiopia is through plant materials, contaminated cutting tools and browsing animals (Yirgou and Bradbury 1974; Wondimagegne *et al.,* 1987). Wondimagegne (1981) reported insect transmission in bananas. Yirgou and Bradbury (1974), emphasized that there is need to put measures in place so that Enset wilt does not escape and establish in other parts of the world where it could pose a serious problem on bananas.

Table 2. National Research and Development Action Plan On Banana Bacterial Wilt Disease

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
1. Current status of BBW established		**4.20**	**1**				
Baseline information	Establish distribution, incidence and severity of BBW in Uganda	4.15	2	11 districts affected	NARO, MAAIF, IARCs, MUK, NGOs GoU and donors	2004	Short term
	Determine the economic importance of banana bacterial wilt	4.15	2	-.	NARO, MAAIF, MUK, IARCs GoU, LGs and donors	2004	Short term
	Establish coping mechanisms and ITK information	3.85	4	Cutting infected plants and use of wood ash.	NARO, MAAIF, MUK, IARCs, GoU, LGs and donors	2004	Short term
	Determine client needs and priorities for BBW control	3.75	7	-.	NARO, MAAIF, MUK, IARCs GoU, LGs and donors	2004	Short term
	Identify changes in banana based cropping systems	2.15	9	-.	NARO, MAAIF, MUK, IARCs GoU and donors	2004	Short term
Development of R & D agenda	Develop recommendations for setting Research and development priorities.	4.45	1	-.	MAAIF, NARO, IARCs, GoU and donors	2004	Short term
Monitoring	Monitor disease spread (Surveillance) and control new outbreaks	3.80	5	All districts being monitored	MAAIF and NARO GoU, LGs and donors	Continuous	Short/Long term
	Stakeholders workshops	3.80	5	-	MAAIF and NARO to convene	2004	Short term
	Identify gender implication of BBW & strategies for promoting gender contributions	3.50	8	-	NARO, MAAIF and MUK	2004	Short term
2. Information on Etiology and epidemiology of BBW generated		**4.00**	**2**				
Etiology and Pathogenesis	Determination of pathogen variability	3.85	2	-	NARO, MUK, IARCs, GoU and donors	2003-2006	Short term
	Develop inoculation techniques	4.05	1	Five techniques being evaluated	NARO, MUK, IARCs CABI,	2003-2004	Short term

Shoa and Sidamo, Harerge and Game-Goffa regions of Ethiopia, on cultivar Casse Hybrid (Yirgou and Bradbury, 1974), with incidence between 70 and 80% (Korobko *et al.*, 1987). In Ethiopia where this disease is considered important on ensete, banana cultivation is less extensive and therefore its destructive nature on the latter may be difficult to determine. In Uganda it was first reported in 2001 (Tushemereirwe *et al.*, 2001) and has since spread rapidly with plantation incidence of up to 70% and affecting both highland (Matooke bananas) and exotic (dessert/beer) bananas.

Little is known about the etiology of BBW. 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 also enters the plant through the male buds as reported for the Moko disease (Stover, 1972). This bacterium appears to attack the vascular system of both banana and *Ensete ventricosum* (Enset) causing wilting and death of the plants.

3.2. Host range

Little is known about alternative hosts of *X.* campestris pv *musacearum,* which affects bananas and *Ensete*. According to Wondimagegne *et al* (1987), the pathogen causes disease symptoms on hot pepper, tobacco, sesame, cabbage, wheat and barley and *Datura stramonium.* Although these crops are common in Uganda, their potential role as alternate hosts is not known. There is an urgent need to conduct pathogenicity-screening tests of a wide host range of common crops and weeds existing in the country.

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
					GoU, LGs and donors		
	Determine mode of penetration and disease development	2.65	8	-	-do-	2003-2009	Long term
	Determine factors affecting disease development	3.25	7	-	-do-	2003-2009	Long term
Epidemiology of BBW	Determine mode(s) and rate of transmission	3.80	3	Farm tools, plant materials confirmed	-do-	2003-2009	Long term
	Determine survival mechanisms of the pathogen	3.35	6	-		-do-	Long term
	Determine the pre-disposing factors and their influence on the disease development, severity and spread of the disease	3.45	5	-		-do-	Long term
	Determine alternative hosts	3.70	4	Canna-lily, wild banana confirmed	-do-	-do-	Long term
3. Appropriate technologies for Management of BBW developed		**4.00**	**2**				
Cultural, chemical and biological control methods	Identify possible cultural, chemical and biological control measures	4.10	5	Sanitation measures under evaluation	NARO, MUK, IARCs CABI, Farmers, MAAIF, NAADS, LGs and donors	2003-2004	Short term
	Evaluate and refine possible control measures using farmer participatory methods	4.30	1	-	-do-	2004-2009	Medium term
	Determine the economic feasibility of the control measures	4.20	3	-	-do-	2006-2010	Long term
Resistant Varieties	Germplasm collection (local and introduced) and characterization	4.15	4	200 accessions already assembled	NARO, IARCs, CABI, INIBAP, Farmers, GoU, LGs and donors	2004-2008	Medium term
	Identify resistant/tolerant genotypes	3.65	6	-	Do	2010	Long term
	Screen the identified genotypes for pollen fertility	3.65	6	-	Do	2010	Long term
	Incorporation of resistance into desired	3.65	6	3 resistant genes		2004-2009	Long term

VI. Strengthen partnerships among various stakeholders (relevant ministries, local governments, institutions, NGOs and NAADS) and define roles to enhance efforts for control of BBW.

VII. Budget for the BBW control should be drawn and incorporated into the budgets of MAAIF and Local governments.

VIII. MAAIF and local governments should formulate and enforce bye-laws for control of BBW.

IX. NARO should intensify research to find varieties resistant/ tolerant to BBW

X. MAAIF should formulate a clear policy for overall control and containment of future pest and disease epidemics.

XI. Integrated pest Management (IPM) involving sanitation and control of nematodes, weevils and other soil pathogens that injure the plants is considered an effective strategy that has contained the disease in Ethiopia. It is suggested that this measure should be adopted by Ugandan farmers.

3. LITERATURE REVIEW

3.1. Disease history and etiology

The Banana bacterial wilt disease caused by *Xanthomonas campestris* pv *musacearum* was first reported in Ethiopia on Ensete (*Ensete ventricosum*), a family relative of the banana in 1968 (Yirgou and Bradbury, 1968 ;1974). It was later described on bananas in the Keffa,

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
	Cultivars (conventional and molecular) that meet different market requirement			identified			
	Farmer participatory evaluation of selected resistant genotypes	4.30	1	-	NARO, MUK, IARCs, CABI, INIBAP, MAAIF, NAADS and Farmers	2007-2010	Long term
4.Appropriate Technologies and Information utilized to contain and control BBW		**3.95**	**4**				
Researchable area	**Activities**	**Total weighted score**	**Rank**	**Current status**	**Key players**	**Time frame**	
Technology and information dissemination	Characterize uptake pathways and evaluate different approaches of technology dissemination	3.15	3	2000 Posters and 5000 leaflets on emergency control of BBW widely disseminated	NARO, MUK CABI IARCs,Farmers MAAIF, NAADS NGOs GoU, LGs and donors	2004	Short term
	Identify technologies for dissemination	3.50	2	-		2004-2006	Medium term
	Promotion of appropriate technologies	3.75	1	-	MAAIF, NARO, NAADS, MUK, private companies, GOU, LGs, CBOs, NGOs and Donor	2004--2010	Long term
	Contain and manage the Disease Adoption studies	3.75	1	Sanitation measures implemented in Kayunga and Mukono Districts	MAAIF, NARO,NAADS, MUK private companies, CBOs, NGOs and Donor	2004--2010	Long term
5. Capacity for R & D developed		**3.95**	**4**				
Capacity building	Train scientists in specialized skills for handling BBW Degrees (M.Sc. and Ph. D) Short courses (internal and external) Study visits Conferences and workshops	3.55	3	One M. Sc. student on training Funding for 1 PhD available	NARO, MUK and other universities, IARCs,Farmers MAAIF, NAADS Extension service providers, NGOs Private companies and GoU and donors	2004-2010	Long term

vi. The disease is mostly spread by farm tools, animals and planting materials

vii. Current research in Ethiopia has identified resistant/tolerant *Ensete* varieties, an experience which Ugandan scientists could benefit from.

viii. There is export market for apple bananas and Matooke in Europe with prices of US$ 1200 and 500 per tonne, respectively.

2.2. Recommendations

I. Local governments and community leaders be involved and facilitated for mobilization of farmers and other resources to control BBW preferably by adopting the Ministry of Health model against HIV/AIDS.

II. Sustained training and sensitization of farmers and other stakeholders on importance and control of BBW control.

III. Although control by cutting and burying of diseased plants was viewed as the most effective measure, most farmers preferred cutting without burying to reduce labour costs.

IV. Communities should be sensitized to cope with the disease and other epidemics by adopting alternative enterprises for food and income.

V. Banana traders recommended that the disease must be contained for them to continue with the highly paying banana business.

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
	Sensitise all stakeholders about the disease	4.10	1	Farmers in BBW affected areas sensitized.		2003-2004	Short term
	Training of trainers (Extension workers Local leaders Farmers)			90 extension workers trained			
	Facilitate development and strengthening of grassroots farmers' institutions for management of BBW	3.55	3	-		2003-2005	Medium term
	Develop appropriate infrastructure for handling BBW	3.95	2	Biotech lab available			Medium term
6. Impact of R & D assessed and monitored		**3.55**	**6**				
Impact Assessment	Evaluate the potential impact of R for D interventions.	3.75	1	-	MAAIF, NARO MUK, IARCs	2004	Short term
	Assess Ex-post impact of interventions for BBW control	2.20	2	-	NARO, MAAIF with MUK, IARCs, NGOs	2009	Long term
7. Appropriate policies developed/ improved		**2.90**	**7**				
Policy Development	Review existing phytosanitary policy	2.65	4	-	MAAIF, NARO	2004	Short term
	Develop regulations, byelaws, and quarantine procedures in a participatory manner.	3.80	1	-	MAAIF, Grass root Institutions, LGs NARO	2004	Long term
	Develop a policy for mitigating effects of pests and diseases epidemics.	2.60	5	-	MAAIF, NARO and Ministry for disaster preparedness	2004	Short term
Partnerships & linkages	Identify, develop and manage partnerships and linkages for	3.35	2	-	MAAIF, and NARO lead in	2004	Long term

- Review literature from various sources including Ethiopia.
- Field visits to the affected areas.
- Regular brainstorming sessions among scientists.

2. FINDINGS AND RECOMMENDATIONS FROM STAKEHOLDERS

The task force team held consultations with various stakeholders and discussed their experiences and assembled opinions/ recommendations on how the disease can be managed. Consultations were held with farmers, community leaders, policy makers and researchers including: stakeholders from Mukono and Kayunga distticts, Uganda National Farmers Federation (UNFFE), National Agricultural Advisory Services (NAADS), Horticultural Exporters Association of Uganda (HORTEXA) and Dr. B. Lemaga (a scientist from Ethiopia). The following experiences and recommendations were obtained:

2.1. Findings

i. The disease was recognised as a threat and spreading fast with alarming damage on all banana varieties

ii. Some farmers had gone ahead to experiment control measures using indigenous technical knowledge such as application of wood ash.

iii. Initial interventions (rouging, quarantine and sensitization) led by MAAIF to control the disease were effective but expensive and the delivery method unsustainable.

iv. There is increased awareness of the disease

v. According to local leaders, government programmes are not participatory enough.

Expected Outputs (R &D Areas)	Activities	Total weighted score	Rank	Current status	Key players	Time frame	Period
	implementing relevant policies.				Collaboration with IARCs		
Monitoring & evaluation	Monitoring and evaluation for programs to implement the policies above	3.25	3	-	MAAIF, NARO, LGs and grass root institutions	Continuous	Short/Long term
8. Alternative enterprises identified and promoted		**2.45**	**8**				
Fall-back options	Identify suitable alternative food/cash crops in short/long run in a participatory manner	2.85	1	Cassava sunflower and vanilla identified for Mukono and Kayunga	MAAIF, NARO, farmers and private sector, MUK, IARCs	2005	Medium term
	Identify other suitable enterprises/technologies.	2.85	1	-	MAAIF, NARO, farmers and private sector, MUK, IARCs	2005	Medium term
Partnerships & linkages	Develop and manage partnership and linkages for promoting identified enterprises/technologies.	2.50	3	-	MAAIF, NARO, farmers and private sector, UNIFFE, HORTEXA, MUK, IARCs	2004	Short term
Gender mainstreaming	Identify gender implications of BBW and strategies for promoting gender contribution	2.40	4	-.	MAAIF, NARO, farmers and private sector back stopping MUK, IARCs	2004	Short term
Monitoring & evaluation	Monitoring and evaluation for promoting identified enterprises.	1.90	6	-.	MAAIF, NARO and grass root institutions	Continuous	Short/Long term
Dissemination	Promote identified enterprises/ technologies, food and cash crops	2.40	4	Cassava sunflower and vanilla planting materials distributed in Mukono and Kayunga	MAAIF, NARO and grass root institutions	2005	Medium term

5. OPPORTUNITIES AND RECOMMENDATIONS FOR CONTROL OF BBW

5.1. Opportunities

Despite the alarming threat presented by the BBW to the banana industry in Uganda, it is anticipated that with prompt and appropriate action by all banana sub-sector stakeholders the disease can be combated to save the country from eminent disaster. Consequently, the following opportunities need to be exploited.

- Many farmers treat banana as a high priority crop and allocate reasonable resources to its management, hence easy to develop partnerships, mobilize and sensitize them.
- Uganda has a fully-fledged and strong Banana Research team composed of national, regional and international scientists and good linkage to a consortium of donors to handle BBW Research and Development
- A minimum research and development programme has been initiated to address the problem of BBW and a number of donors and research collaborators have expressed interest in further financial support and technical back stopping, respectively.
- The current high demand for bananas in local and International niche markets, promises high returns to investments in R&D.
- Advanced research tools for accelerated research results (e.g, biotechnology) and a large reserve of plant genetic resources for utilization in genetic improvement of banana are available in Uganda and the region

1.4. Government response.

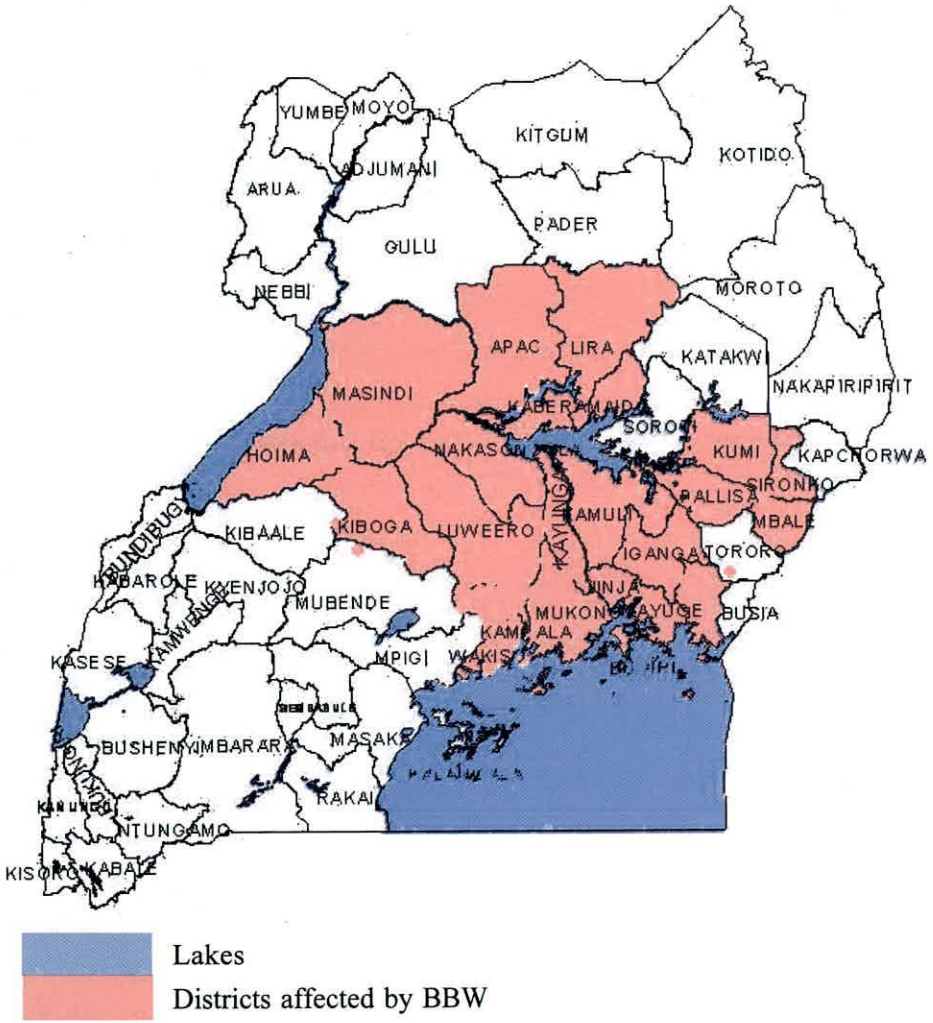
The Government initially responded to the outbreak of the disease by putting in place a taskforce (formed by The Minister of Agriculture, Animal Industry and Fisheries, MAAIF) to formulate an emergency action plan to contain the disease. An action plan was formulated and partial support for its implementation secured from the Government in June 2002. The plan emphasized cutting and burying infected banana stools, restricted movement of banana materials, decapitation of male buds, disinfection of tools and creation of awareness about the disease. A rapid appraisal survey and awareness campaign that followed revealed that the disease was more widespread than previously thought. The disease is now confirmed in Mukono, Kayunga, Lira, Kaberamaido, Sironko, Jinja, Kamuli, Luwero, Apac, Kumi, Mbale, Pallisa, Nakasongola, Masindi, Hoima, Iganga, Mayuge, Bugiri, Kampala, Kiboga and Wakiso with plantation incidence of up to 90%. It was realized that a lot was unknown about the disease and therefore, a strategy integrating research and development was needed to control the disease. NARO was requested by the Minister (MAAIF) to take lead in formulating a long-term research and development strategy for control of the disease. Consequently, the Director General, NARO constituted another multidisciplinary task force (Annex 1), including several members from the former task force, to address this concern in accordance with terms of reference (TOR) listed in Annex 2.

1.5. The Methodology adopted by the task force

The TF adopted the following methodology:

- Consultation with the first Taskforce (for emergency action plan)
- Discussion with different stakeholders (farmers, farmer groups and associations, local leaders and policy makers).

Figure 1. Distribution of Banana Bacterial Wilt in Uganda



5.2. Recommendations

The task force is of the view that the future of the banana industry in Uganda largely rests on the appropriate and timely implementation of the following strategies;

- Government should recognize the eminent threat posed by BBW to the banana industry and include it among its priority programmes.
- MAAIF should institute strong steering and technical committees to spearhead implementation of the proposed research and development action plan.
- MAAIF should put in place a strong project on BBW, based on the National Network of Cassava workers (NANEC) model, to be coordinated from the National Banana Research Programme.
- MAAIF should strengthen the banana research and development team with additional trained manpower to facilitate more aggressive implementation of the proposed research and development action plan.
- On-going banana research and development activities should be reviewed to provide for integration of the proposed BBW activities and aggressive implementation of the proposed action plan.
- MAAIF should immediately source for funds for implementation of the action plan.
- MAAIF should put in place an aggressive sensitization programme, through Radio, TV and Newspaper.
- Central government should guide local governments to develop and enforce bye-laws to ensure compliance with the control measures.

- Farmer participatory implementation of activities should be strengthened to ensure their ownership of the programme and utilization of their experience.
- There is need to establish regional and international linkages and enhance complimentarity among government agencies, NGOs, IARCs (IITA, INIBAP) and donors to control BBW.

5.3. Budget Estimates

The budgetary implications of the National Research and Development Action Plan on BBW are presented in table 3 (summarized according to activities) and table 4 (detailed estimates)

Table 3. Summary of Expected Outputs and budget estimates

Expected Outputs (R &D Areas)	RANK	BUDGET (UGSH)					
		YR1 ('000)	YR2 ('000)	YR3 ('000)	YR4 ('000)	YR5 ('000)	TOTAL ('000)
1: Current Status of Banana Bacterial Wilt and Priorities for Banana R for D, established	1	209,726	131,250	462,450	462,450	462,450	1,728,326
2: Information on the Etiology and Epidemiology of BBW generated	2	716,229	364,928.	262,338.	244,972	244,972	1,833,438
3:Technologies for Management of BBW Developed.	2	398,155	298,961	284,311	284,311	284,311	1,550,049
4:Appropriate Technologies utilized for control of BBW	4	229,839	178,313	173,813	187,313	187,313	956,589
5:Capacity Built	4	1,863,000	337,000	109,000	26,000	30,000	2,365,000
6: Determine Impact Of R For D.	6	178,664	176,906	147,514	147,514	135,514	786,112
7: Appropriate Policies Developed /Improved	7	159,780	161,070	123,900	95,555	87,490	627,795
8: Alternative Enterprises Identified and Promoted	8	21,582	21,582	12,000	28,038	16,038	99,239
Coordination (10% of the budget)		377,697.3	167,001	157,532.6	147,615.2	144,808.7	994,654.8
GRAND TOTAL		4,154,670	1,837,011	1,732,859	1,623,767	1,592,896	10,941,203

in terms of direct income and/or opportunity cost will result in an estimated value of Ug Shs. 0.8 m/year/farmer at Ug Shs. 2,000/bunch (Eden-Green, 2003).

He further observed that, in Budadiri in Sironko district, a farmer used to harvest 20 bunches per week before the BBW pandemic but with the disease outbreak after a year only 1 bunch per week is harvested. The estimated yield loss is 95% at a value of Ug Shs 0.9m per year. A similar trend in yield loss was obtained in Nsuube village, Jinja district by a farmer that experiences enormous food shortage and declining income due to BBW.

1.3. Status of banana bacterial wilt disease in Uganda

In Uganda BBW disease was first reported in 2001, on bananas in Mukono and Kayunga districts (Tushemereirwe *et al.*, 2001, 2002).

The disease causes wilting of banana plants of all ages and is easy to distinguish from other wilt diseases of the banana. Reddish brown staining in the banana fingers is the field confirmatory symptom of BBW that distinguishes it from all other wilts such as Fusarium wilt, known in Uganda (Tushemereirwe et al 2002).

Tushemereirwe *et al.* 2001 reported that in the affected fields, all banana varieties appeared to succumb. The disease has been confirmed in 21 districts of Uganda: Mukono, Kayunga, Lira, Kaberamaido, Sironko, Jinja, Kamuli, Luwero, Apac, Kumi, Mbale, Pallisa, Nakasongola, Masindi, Hoima, Iganga, Mayuge, Bugiri, Kampala, Kiboga and Wakiso districts. (Figure 1).

and spread of BBW presents a considerable threat to banana production. Moreover, the situation may be aggravated by the interactive effect between BBW and other pests and diseases prevalent in the country.

1.2. Economic importance of Banana Bacterial Wilt Disease in Uganda

At present, preliminary field studies conducted in Uganda reveal that most banana varieties are susceptible to BBW (Tushemereirwe *et al.*, 2001 and BBW task force, 2002). This devastating effect of BBW on banana in most districts in the country may contribute to decreased household and national food security; reduced incomes for banana farmers; increased relative food prices and cause Uganda to make difficult food policy decisions. This is because over 70% of farmers in Uganda rely on bananas as the main source of livelihood with banana consumption per capita ranging between 220 kg and 460kg (IITA, 1995). To this end, the spread of the disease has to be checked.

Moreover, the available statistics showed that, in the field where the disease was first observed, the incidence increased to over 70% in a period of one year. At this scale of spread, it implies that the disease has a potential to cause a substantial yield loss of the banana crop in Uganda.

Eden-Green (2003) reports that in Ntunda sub-county, Mukono district, a farmer who used to harvest 36 bunches per month before the BBW epidemic a year ago now gets no more than 3 bunches a month reflecting a yield loss of about 90%per annum in that farm. This loss

Table 4: Detailed budget estimates by activitiy

BUDGET FOR THE BBW ACTIVITIES							
ACTIVITIES	YR1 ('000)	YR2 ('000)	YR3 ('000)	YR4 ('000)	YR5 ('000)	TOTAL ('000)	
ACTIVITIES	YR1 ('000)	YR2 ('000)	YR3 ('000)	YR4 ('000)	YR5 ('000)	TOTAL ('000)	
OUTPUT 1: Establishing current status of Banana bacterial wilt and priorities for banana R for D							**211526**
1.1. Establish distribution, incidence and severity of BBW in Uganda	43715	0	0	0	0	0	43715
1.2. Determine the economic importance of banana bacterial wilt	25460	0	0	0	0	0	25460
1.3. Establish coping mechanisms and ITK information	0	0	0	0	0	0	0
1.4. Determine client needs and priorities for BBW control	0	0	0	0	0	0	0
1.5. Identify changes in banana based cropping systems	0	0	0	0	0	0	0
1.6. Develop recommendations for setting Research and development priorities	1479	0	0	0	0	0	1479
1.7. Monitor disease spread and control of new outbreaks	131250	131250	462450	462450	462450	462450	1649850
1.8. Stakeholders Workshop (3 days, 50 people)	7822	0	0	0	0	0	7822
Sub Total	**209,726**	**131,250**	**462,450**	**462,450**	**462,450**	**462,450**	**1,728,326**
OUTPUT 2: INFORMATION ON THE ETIOLOGY AND EPIDEMIOLOGY OF BBW GENERATED							**1833438**
2.1Collection of samples, Lab isolation & determination pathogen variation	307917	80717	0	0	0	0	388634
2.2 Developing inoculation techniques	69853	25853	0	37803	0	29290	95706
2.3 Determine model of penetration & discas development	39053	39053	39053	39703	30850	30850	174489
2.4 Determine factors affecting diseas development	34023	34973	34973	39703	30850	30850	171349
2.5 Determine modes of transmission	37881	37173	37173	37173	37173	37173	182715
2.6 Determine survial mechanisms of the pathogen	118275	37412	38912	38912	38912	38912	192029
2.7 Determine the factors influencing disease incidence, servity & spread		41777	41277	41277	41277	41277	283883
2.8 Determine machanisms of spread	36299	35515	35015	35015	35015	35015	176859
2.9 Determine alternative hosts	37955	32455	32455	32455	32455	32455	167775
Sub Total	**716,229**	**364,928**	**262,338**	**244,972**	**244,972**	**244,972**	**1,833,438**
OUTPUT 3: MANAGEMENT OF BBW							**1550049**
3. 1. APPROPRIATE CULTURAL AND BIOLOGICAL CONTROL MANAGEMENT	43374	41930	41930	41930	41930	41930	211094
3.2 BREEDING FOR RESISTANCE	354781	257031	242381	242381	242381	242381	1338955
Sub Total	**398,155**	**298,961**	**284,311**	**284,311**	**284,311**	**284,311**	**1,550,049**
OUTPUT 4: TECHNOLOGIES UTILIZED TO CONTROL BBW							**922065**
4.1 Identify and characterize uptake pathways	69548	35024	35024	35024	35024	35024	209644
4.2 Identify technologies for dissemination	35024	35024	35024	35024	35024	35024	175120
4.3 Promotion of technologies	125265	108265	103765	117265	117265	117265	571825
							0
Sub Total	**229,837**	**178,313**	**173,813**	**187,313**	**187,313**	**187,313**	**956,589**

INTRODUCTION

1.1. The banana: Importance and constraints.

Globally banana is the fourth most important food crop after rice, wheat and maize. However, in Uganda it is the most important food crop as indicated by production output, acreage, consumption levels and priority ranking by stakeholders. Annual production is estimated at 9.5 million tonnes, accounting for 15% of total world banana/plantain output. Over 7 million people including 65% of the urban population depend on the crop as their staple. It is estimated that 75% of Ugandan farmers grow the crop on 1.5 million hectares, which accounts for over 38% of utilised arable land. The bananas produced are mainly consumed locally, with an estimated per capita consumption of over 200kg, the highest rate in the world.

Despite its importance, the crop is threatened by various constraints including: declining soil fertility, socioeconomic problems (marketing issues, crop management costs, post-harvest handling/utilization issues), pests (banana weevil, nematodes), diseases (black Sigatoka, Fusarium wilt and banana streak virus disease). Recently, the banana bacterial wilt BBW (commonly called Mukono disease) caused by *Xanthomonas campestris pv musacearum* has become a new threat to the banana and has been reported to devastatingly affect them in Mukono and Kayunga districts (Tushemereirwe *et al.*, 2001).

Presently at global level, bacterial wilts of bananas (moko and blood diseases) are ranked third most important disease after black Sigatoka and Fusarium wilt. Although black Sigatoka still remains a leading disease limiting banana production in Uganda, the observed outbreak

Table 4: Detailed budget estimates by activitiy

ACTIVITIES	YR1 ('000)	YR2 ('000)	YR3 ('000)	YR4 ('000)	YR5 ('000)	TOTAL ('000)
OUTPUT 5: Capacity building						**2365000**
5.1 Specialised training	209000	137000	109000	26000	30000	511000
5.2. Sensitisation and training	684000	0	0	0	0	684000
5.3. Facilitate development and strengthening of grassroot farmer groups (at Sub-counties)	600000	200000	0	0	0	800000
5.4. Cross cutting expenses	370000	0	0	0	0	370000
Sub Total	**1,863,000**	**337,000**	**109,000**	**26,000**	**30,000**	**2,365,000**
						0
						0
OUTPUT 6: Appropriate policies developed /improved						**786112**
6.1 Review existing phytosanitary policy	40541	39441	36712	36712	36712	190118
6.2 Develop regulations, bye-laws, and quarantine procedures and approaches for implementation in a participatory manner	86256	86256	62982	62982	62982	361458
6.3 Develop a policy and strategy for mitigating effects of pests and diseases epidemics	41101	41101	37712	37712	25712	183338
6.4 Identify partnerships and linkages for implementing relevant policies/strategies.	2416	1758	1758	1758	1758	9448
6.5. Monitoring and evaluation for programs to implement the policies/strategies	8350	8350	8350	8350	8350	41750
Sub Total	**178,664**	**176,906**	**147,514**	**147,514**	**135,514**	**786,112**
						0
OUTPUT 7: Alternative enterprises identified and promoted						**627795**
7.1 Identify suitable alternative food/cash crops in short/long run in a participatory manner	65160	41680	41680	41680	41680	231880
7.2 Identify other suitable enterprises/technologies in a participatory manner (Covered under 7.1)	0	0	0	0	0	0
7.3 Develop partnership and linkages for promoting identified enterprises/technologies.	3180	3180	3180	3180	3180	15900
7.4. Identify gender implications of BBW and strategies for promoting gender contributions	18300	15900	15900	15900	15900	81900
7.5 Monitoring and evaluation for promoting identified enterprises.	10600	10600	10600	10600	10600	53000
7.6 Promote and disseminate identified enterprises/ technologies. food and cash crops	62540	89710	52540	24195	16130	245115
Sub Total	**159,780**	**161,070**	**123,900**	**95,555**	**87,490**	**627,795**
						99239
OUTPUT 8: Determine impact of R for D.						19164
8.1 Evaluate the potential impact of R for D interventions.	9582	9582	0	0	0	80075
8.2 Assess Ex-post impact of interventions for BBW control	12000	12000	12000	28038	16038	**0**
Sub Total	**21,582**	**21,582**	**12,000**	**28,038**	**16,038**	**99,239**
Total	**3,776,973**	**1,670,010**	**1,575,326**	**1,476,152**	**1,448,087**	**9,946,548**
9.0 Coordination (10% of budget)	**377,697**	**167,001**	**157,533**	**147,615**	**144,809**	**994,655**
GRAND TOTAL	**4,154,670**	**1,837,011**	**1,732,859**	**1,623,767**	**1,592,896**	**10,941,203**

The following is recommended for effective implementation of this national strategy and action plan.

- Government should recognize the eminent threat posed by BBW to the banana industry and include it among its priority programmes.
- MAAIF should institute strong steering and technical committees to spearhead implementation of the proposed research and development action plan.
- MAAIF should put in place a strong project on BBW, based on the National Network of Cassava workers (NANEC) model, to be coordinated from the National Banana Research Programme.
- MAAIF should strengthen the banana research and development team with additional trained manpower to facilitate more aggressive implementation of the proposed research and development action plan.
- On-going banana research and development activities should be reviewed to provide for integration of the proposed BBW activities and aggressive implementation of the proposed action plan.
- MAAIF should immediately source for funds for implementation of the action plan.
- MAAIF should put in place an aggressive sensitization programme, through Radio, TV and Newspaper.
- Central government should guide local governments to develop and enforce bye-laws to ensure compliance with the control measures.
- Farmer participatory implementation of activities should be strengthened to ensure their ownership of the programme and utilization of their experience.
- There is need to establish regional and international linkages and enhance complimentarity among government agencies, NGOs, IARCs (IITA, INIBAP) and donors to control BBW.

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Annex 1. List of the Taskforce Members

NAME	RESPONSIBILITY	SPECIALIZATION	INSTITUTION
Dr. F. Opio	Chairperson	Pathologist	D/NAARI
Dr. W. Tushemereirwe	Secretary	Pathologist	H/NBRP
Dr. M. Magunda	Member	Soil scientist	D/KARI
Dr. G. Hakiza	Member	Pathologist	SPRO/CORI
Dr. A. Kangire	Member	Pathologist	RO/CORI
Dr. A. Bua	Member	Socio-Economist	H/NCRP
Dr. R. Kalyebara	Member	Socio-Economist	NARO-NBRP
Prof. S. Kyamanywa	Member	Entomologist	H/CS Dpt/MU
Dr. T. Alicai	Member	Pathologist	RO/NCRP
Dr. M. Pillay	Member	Breeder	IITA
Dr. E. Karamura	Member	Entomologist	C/INIBAP
Mrs. D. Kataama	Member	Entomologist	DAO/Mukono
Mr. O. Okaasai	Member	Pathologist	AC/MAAIF
Mr. B. Byamugisha	Member	Economist	MAAIF
Mr. J. Kubiririba	Member	Pathologist	NBRP
Mr. F. Ssekiwoko	Member	Pathologist	NBRP
Mr. W. Serubombwe	Member	Pathologist	RO/ NCRP

Annex 2. Terms of reference

The task force was mandated to address the following terms of reference:

1. To review literature on banana wilt disease in Africa and elsewhere and document available knowledge on the economic importance, etiology, epidemiology and control of the disease including strategies for mitigating the economic and social impact of the disease.
2. To review existing reports and research proposals on banana wilt disease in Uganda.
3. To develop a National Research and Development Strategy and Plan indicating activities, priorities, key-players, time frame, and estimated costs.
4. To identify options and strategies for "fall-back" positions in case the control of the banana wilt disease is deemed to be uneconomic.
5. To present a written National Research and Development Action Plan to the Director General NARO.

Table 1. Summary of Research and Development Action Plan

Expected Outputs (R &D Areas)	**Rank**	**Key players**	**Time Frame**	**Period**	**Total 5 yr budget:(000/=)**
Current status of BBW and priorities for banana for R for D established	1	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, donors	2004 - continuous	Short/Long term	1,728,326
Information on etiology and epidemilology of BBW generated	2	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, donors	2003-2009	Short/Long term	1,833,438
Appropriate technologies for control of BBW developed	2	NARO,MAAIF, MUK, IARCs, NGO, LGs, donors, farmers	2003-2010	Short/Long term	1,550,049
Appropriate Technologies and Information utilized to contain and control BBW	4	NARO,MAAIF, MUK, IARCs, NGO, LGs, donors, farmers, CBOs	2004-2010	Short/Long term	956,589
Capacity for R and D developed	4	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, NAADS, donors	2003-2010	Short/Long term	2,365,000
Impact of R and D determined	6	NARO, MAAIF, MUK, IARCs, NGO, GoU, LGs, donors	2004-2009	Short/Long term	786,112
Appropriated policies developed/improved	7	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, NAADS, donors	2003-continuous	Short/Long term	627,795
Alternative enterprises identified and promoted	8	NARO,MAAIF, MUK, IARCs, NGO, GoU, LGs, NAADS, donors, UNIFE, HORTEXA	2004-continuous	Short/Long term	99,239
Coordination (10% of the budget					994,654.8
GRAND TOTAL					**10,941,203**

The following is recommended for effective implementation of this national strategy and action plan.

- Government should recognize the eminent threat posed by BBW to the banana industry and include it among its priority programmes.

Annex 3. Logical Framework For Implementation Of Banana Bacterial Wilt Management Activities

Narrative Summary	OVIs	Means of Verification	Assumptions
Goal Improving and sustaining food security and incomes of banana producers and consumers through control of banana bacterial wilt	Losses due to BBW reduced by 3% annually	Production statistics at various levels	
Purpose Control of BBW through adoption of appropriate technologies	At least 10% of farmers adopting appropriate technologies for control of BBW in at least 5 affected districts by 2005	Reports on adoption and impact	No emergence of other factors limiting banana production
OUTPUTS **1.** Current Status of Banana Bacterial Wilt established	Distribution, incidence, and severity of BBW in Uganda determined by June 2004 Social and Economic Impact of BBW (at farmer and national levels) determined for various beneficiary categories by Dec 2004 Farmers perceptions of BBW and their control strategies determined by June 2004 Stakeholder needs and priorities (including strategies for promoting gender contributions) identified by June 2004 Changes in banana based farming systems determined by June 2004	Technical Reports (survey reports, etc) Proceedings of stakeholder workshops	Favourable social & political environment prevailing
2. Information On The	Isolates of the BBW pathogen from all affected districts	Technical reports	Favourable social & political

EXECUTIVE SUMMARY

Following an outbreak of a banana bacterial wilt disease (BBW) caused by *Xanthomonas compestris pv. Musacearum* that was destructive and rapidly spreading in Mukono and Kayunga Districts, the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) constituted a Taskforce to formulate a strategy to eradicate or contain the disease. An action plan was formulated and efforts to contain the disease implemented focusing on the two districts. Later the disease was found to be more widespread than previously thought and a lot was unknown about it. A strategy integrating research and development was therefore needed to contain the disease. The Director General, NARO, on instructions from Minister of Ministry of Agriculture Animal Industry and Fisheries, constituted a new task force to formulate a long-term research and development strategy and action plan for control of the disease. The Taskforce was mandated to address a number of terms of references, which focused on reviewing the information on banana bacterial wilt, obtaining stakeholders' perspectives, identifying research and development options and policy requirements.

BBW is fast spreading and has so far been confirmed in Mukono, Kayunga, Lira, Kaberamaido, Sironko, Jinja, Kamuli, Luwero, Apac, Kumi, Mbale, Pallisa, Nakasongola, Masindi, Hoima, Iganga, Mayuge, Bugiri, Kampala, Kiboga and Wakiso districts. In affected plantations, disease incidence of up to 90% has been recorded. The affected plants die prematurely and when affected at fruiting stage, the fruits rot and cannot be eaten by both man and animals. The disease no doubt is a serious threat to both the food security and banana export market that is starting to pick up. The taskforce has therefore formulated a national strategy and action plan, which requires a well-coordinated national, regional and international effort to implement the research and development activities. The plan is based on the prioritized and budgeted expected outputs in the table below:

HORTEXA	Horticultural Exporters Association
IDRC	International Development Research Centre of Canada.
IITA	International Institute of Tropical Agriculture
INIBAP	International Network for Improvement of Banana and Plantain
KARI	Kawanda Agricultural Research Institute
LCs	Local Councils
LDUs	Local defence units
LGs	Local Governments
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MUK	Makerere University, Kampala
NAADS	National Agricultural Advisory Services
NAARI	Namulonge Agricultural and Animal production Research Institute
NARO	National Agricultural Research Organization
NBRP	National Banana Research Programme
NGOs	Non Governmental Organisations
NRI	Natural Resources International of UK
PMA	Program for modernization of agriculture
PRA	Participatory Rural Appraisal
PRAPACE	Regional Potato and Sweet Potato Improvement Network in
R & D	Research and Development
RDC	Resident District Commission
TOR	Terms of Reference
TV	Television
UNFE	Uganda National Farmers Federation
USAID	United States Agency for International Development

Narrative Summary	OVIs	Means of Verification	Assumptions
Pathogen Etiology And Epidemiology Of The Disease Generated	characterized by end of 2006	Manuals	environment prevailing
	Appropriate laboratory procedures (inoculation techniques, inoculum concentration etc) developed by June 2004 and refined by December 2004		
	Information on the rate, mechanisms and pattern of spread of BBW generated by 2007		
Appropriate technologies for management of BBW developed	Possible cultural, chemical and biological control measures identified and at least three selected for evaluation by mid 2004	Technical reports Progress reports	Favourable social & political environment prevailing
	Three selected control measures evaluated by 2006 and the promising ones refined by 2009	Inspection reports	
	Economic worthiness of at least three promising control measure determined by 2008		
	At least 250 local and foreign genotypes collected and characterized by 2008		
	Promising genotypes generated and evaluated on station for resistance to BBW by 2008		
	Promising genotypes with tolerance/ resistance to BBW identified and selected through farmer participatory methods by 2010		
3. BBW Controlled	At least one uptake pathway for each target site identified for promotion and dissemination of	Technical reports	Favourable social & political environment prevailing

List of Tables

Table 1. Summary of Research and Development Action Plan.....vi
Table 2. National Research and Development Action Plan On Banana Bacterial Wilt Disease 11
Table 3. Summary of Expected Outputs and budget estimates.....18
Table 4. Detailed budget estimates by activity.....19

Appendices

Annex 1. List of the Taskforce Members 22
Annex 2. Terms of reference 22
Annex 3. Logical Framework For Implementation Of Banana Bacterial Wilt Management Activities.....23
Annex 4. Banana Bacterial Wilt Project outputs based on NARO's Thematic areas..... 27

LIST OF ABBREVIATIONS AND ACRONYMS.

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BBW	Banana bacterial wilt
BT	Biotechnology
CABI	Commonwealth Agricultural Bureau International
CBOs	Community based organisations
CORI	Coffee Research Institute
DAO	District Agricultural Officer
DFID	Department for International Development of UK Eastern and Central Africa
FY	Financial year
GMOs	Genetically modified organisms

Narrative Summary	OVIs	Means of Verification	Assumptions
	technologies on BBW by 2004	Progress reports	
	At least 3 appropriate technologies being promoted in at least 5 target districts by 2006	Reports from extension service providers	
	Mass multiplication and distribution of at least 2 technologies initiated by 2009		
	At least 5% of the farmers accessing at least one technology at 5 target sites		
4. Capacities Developed at All Levels	At least three scientists trained and using specialised skills to address BBW by 2006; and at least 6 more by 2010	Staff assessment reports	Favourable social, economic & political environment prevailing
	Laboratories equipped to handle BBW by December 2004	Reports from extension	
	At least 2000 trainers (Key planners, policy makers, contact farmers and extension workers) from 10 districts trained annually	Meetings	
	At least 20% of farmers' institutions in affected districts facilitated and strengthened to handle BBW by the end of 2005	Inventory of equipment	
5. Appropriate Policies Developed/Improved	Phytosanitary policy developed by MAAIF by December 2005	Policy documents	Favourable social, economic & political environment prevailing
	Bye-law for control of BBW developed and being enforced in each affected district by 2004	Proceedings of meetings	

4. RESEARCH AND DEVELOPMENT ACTION PLAN FOR THE CONTROL OF BBW.....12

4.1. Introduction 12

4.2. Goal 12

4.3. Specific Objectives:.....13

4.4. Development of priorities and work plans.....13

5. OPPORTUNITIES AND RECOMMENDATIONS FOR CONTROL OF BBW.....20

5.1. Opportunities.....20

5.2. Recommendations.....21

5.3. Budget Estimates.....22

REFERENCES 25

Narrative Summary	OVIs	Means of Verification	Assumptions
	Policy for control of pest and disease epidemics developed and presented to parliament by MAAIF by 2006		
	Modalities for collaboration between partners in control of BBW developed by December 2004		
6. Alternative Enterprises Identified and Promoted	5% of target beneficiaries accessing or using identified enterprises annually.	Progress reports	Need for alternative enterprises exists
			Favourable social, economic & political environment prevailing
7. Impact of R & D for Management of BBW monitored and evaluated	Benefits of R&D for management of BBW and feed back from beneficiaries determined annually from 2004	Technical Reports	Favourable social, economic & political environment prevailing
	Ex-ante impact of R & D determined by June 2004		
	Adoption study completed by 2013		

Annex 4. Banana Bacterial Wilt Project outputs based on NARO's Thematic areas

Goal	Improving and sustaining food security and incomes of banana producers and consumers through control of banana bacterial wilt (BBW)				
Purpose	Control of BBW through adoption of appropriate technologies				
Thematic areas	People, their livelihood systems, demands and impact innovations understood	Innovation process and partnership enhanced	Integrated management of natural resources enhanced	Technological options that respond to demand and market opportunities generated and disseminated	Market requirements and enabling policies for technology development identified
Outputs	Current status of banana bacterial wilt determined Alternative enterprises as safety-net fall back option for farmers overwhelmed by BBW identified and promoted Impact of R&D for management of BBW monitored and evaluated	Appropriate technologies for management of BBW developed Appropriate Technologies and information disseminated	Appropriate technologies for management of BBW developed	Information on the pathogen Etiology and Epidemiology of the disease generated Appropriate technologies for management of BBW developed Appropriate Technologies and information disseminated	Appropriate policies for management of pest and disease epidemics developed / improved

TABLE OF CONTENTS

Acknowledgements.....i

TABLE OF CONTENTS.....ii

List of Tables.....iv

LIST OF ABBREVIATION AND ACRONYMS.....iv

Appendices.....v

EXECUTIVE SUMMARY.....v

1. INTRODUCTION.....1

1.1. The banana: Importance and constraints.....1

1.2. Economic importance of Banana Bacterial Wilt Disease in Uganda.....2

1.3. Status of banana bacterial wilt disease in Uganda.....3

1.4. Government response 5

1.5. The Methodology adopted by the task force.....5

2. FINDINGS AND RECOMMENDATIONS FROM STAKEHOLDERS 6

2.1. Findings..... 6

2.2. Recommendations.....7

3. LITERATURE REVIEW 8

3.1. Disease history and etiology.....8

3.2. Host range.....9

3.3. Symptoms of banana wilt disease.....10

3.4. Spread mechanism 10

3.5. Control Measures 11



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