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BANANA BACTERIAL WILT INCIDENCE IN UGANDA

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ABSTRACT

Among the main constraints in banana production in Uganda is the Banana Bacterial wilt (BBW) disease. The disease has spread widely but knowledge of its incidence at farmer level is lacking. Recommended disease management/control measures are mainly targeting farm level agronomic practices. This study aimed at establishing the knowledge gap to enhance their effectiveness. The objectives were to assess the role of the different clones in the spread and transmission of BBW and whether farmers were removing male buds from bananas as a control option for the disease. Data were collected on farmers' fields. Disease incidence was highest in Kayunga, Kamuli and Masindi followed by Mbale and Luwero and lowest in Mubende, Bushenyi and Ntungamo. In all districts, the most important clones were cooking bananas, kayinja and kivuvu. Results indicated that disease incidence was highest on Kayinja and lowest on cooking bananas. The sample size for the other clones was low for a conclusion to be drawn. The disease was first observed in Kayunga and Kamuli and as far back as 2000 but most of the farmers reported that they first observed the disease between 2003 and 2005. Most farmers reported that they were cutting off the male buds in a sporadic manner and when they were moderately old and using cutting tools. Farmers were reluctant to cut off male buds from Kayinja and Kivuvu. In conclusion, most farmers had heard about BBW though more sensitization needs to be done especially about the control measures.

Key Words: Debudding, *Musa* sp., *Xanthomonas*

RÉSUMÉ

Parmi les contraintes majeures dans la production de la banane en Ouganda sont la maladie le flétrissement bactérien de la banane (BBW). La maladie s'est largement répandue mais sa connaissance et son incidence à l'échelle des paysans sont très limitées. Les gestions recommandées de la maladie ciblehybrides à cause de leur tolérance plus élevée au stress abiotique. Les fermiers préféraient également une race terrienne locale 'Chitonga' grâce à son meilleur goût et la dureté du grain. Cependant les fermiers reconnaissaient qu'il manquait au Chitonga et aux hybrides le mécanisme de récupération du stress de sécheresse observable chez le sorgho ; ce qui les rendaient inaptes aux courtes saisons. La préférence de cultivars variait par localisation, avec les fermiers de la région de Mutasa, plus productivet plus faible à Mubende, Bushenyi et Ntugamo. Dans tous les districts les clones les plus importants étaient les bananes destinées a la cuisson : kayinja et kivuvu. Les résultats ont indiqué que l'incidence était la plus élevée sur kayinja et faible pour les bananas destinées à la cuisson. Les échantillons pour les autres clones étaient faibles pour tirer des bonnes conclusions. La maladie était d'abord observée à Kayunga et Kamuli vers l'an 2000, mais la plupart des fermiers ont signalé qu'ils ont observé la maladie entre 2003 et 2005. La plupart des paysans ont indiqué qu'ils coupaient les bourgeons de manière sporadique mais quand ils étaient modérément vieux en utilisant les outils à couper. Les fermiers étaient hésitants de couper les bourgeons males de kayinja et kivuvu. En conclusion, la plupart des paysans ont entendu du BBW même si plus de vulgarisation doivent être conduite particulièrement concernant le contrôle des mesures.

Mots Clés: De bourgeonnement, *Musa* sp., *Xanthomonas*

INTRODUCTION

The production of bananas in Uganda is threatened by the Banana Bacterial Wilt (BBW) caused by *Xanthomonas campestris* pv *musacerum* (Tushemereirwe *et al.*, 2001, 2003a). The disease (also locally called Kiwotoka) causes wilting of banana plants of all ages. The affected plants die prematurely. When affected at fruiting stage, the fruits rot and are not edible. The first symptom to be seen on the infected banana plant depends on the route of entrance of the pathogen. If pathogen entry is through the flower, wilting of the male bud will be the first symptom. From here the pathogen spreads downward to the fingers, to the leaves and through the stem to the roots (Tushemereirwe *et al.*, 2002). If the pathogen enters the plant elsewhere in the plant, wilting of the leaves will likely be the first visible symptom.

The disease was first reported in Mukono and Kayunga districts in 2001 (Tushemereirwe *et al.*, 2001) but has now spread to more than 30 districts. Although BBW distribution within these districts was at first localised and patchy, the disease is rapidly filling in the gaps (Bagamba *et al.*, 2006). The spread of this disease has been augmented through farmer exchange of planting materials and banana trade between the neighbouring districts and sub-counties (BBW Taskforce report, 2003). Reported entry of the disease into major banana growing and commercial supply districts will compound the problem as it is expected to reduce production and therefore limit commercial supplies to consumer markets, leading to increased banana prices. In addition, reduced production and sales will limit employment opportunities and lower farmers' incomes, thereby affecting the local district economies.

It is suspected that the disease is transmitted mainly through male flower buds by pollinating insects, bats and sunbirds (Yirgou and Bradbury, 1974; Tushemereirwe *et al.*, 2001). Not only are diseased buds often the first symptom to be observed but these are most commonly seen on ABB banana types, which are believed to be particularly susceptible to insect transmission in other banana bacterial wilt diseases (Buddenhagen and Elsasser, 1962; Yirgou and Bradbury, 1974; Tushemereirwe *et al.*, 2001). This suggests that, as with these other banana wilt diseases, insect vectored infection via male flower parts is the main mechanism driving the spread of the current epidemic (Tushemereirwe *et al.*, 2001). Other means of BBW transmission include: contaminated planting materials and cutting tools, browsing animals and water when it moves around infected soils (Yirgou and Bradbury, 1974; Tushemereirwe *et al.*, 2001).

Although the disease has been observed on both East African Highland bananas and exotic dessert and beer bananas, incidence varies by clone (Tushemereirwe *et al.*, 2003a). Based on information on other bacterial wilts of banana like Moko disease, it has been hypothesized that certain highly susceptible clones, like Kayinja and Kivuvu, facilitate the spread and transimission of BBW. Limited data collected so far suggest that disease incidence is, in fact, highest on these clones. In a study conducted in Lira district (Northern Uganda), field incidence per cultivar was highest on Kivuvu (73.5%) followed by Kayinja (30.4%) then cooking bananas (11.7%) and least in Sukari Ndiizi (2.8%) (Tushemereirwe *et al.*, 2003b). Farmers themselves have come to recognise that Kayinja and Kivuvu are usually the first banana types to become infected with BBW (Tushemereirwe *et al.*, 2003b; Bagamba *et al.*, 2006). Both clones are very important in Uganda's economy and food security. Kayinja is widely grown for beer (Bagamba *et al.*, 2001; Bagamba *et al.*, 2006). In some parts of the country, Kivuvu has been reported to be slowly replacing cooking bananas as a cooking banana because of its low production costs (Bagamba *et al.*, 2001). However more research needs to be carried out on the role of these clones in the transmission and spread of BBW.

The National Agricultural Research Organization (NARO), the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) and other stakeholders have embarked on awareness campaigns to raise farmers awareness about BBW, employ cultural methods in the control of BBW and in particular to break off the male buds immediately after flowering (as soon as the last cluster emerges) using a forked stick (BBW Taskforce, 2003) as the most important control measure for the disease. This management practice will reduce spread of the disease by insects, bats, sunbirds and other floral visitors

foraging for pollen and nectar (Tushemereirwe *et al.*, 2003a). Thus, timely removal of the male bud should interrupt the transmission cycle and prevent the spread of the disease, especially if this can be done in those types (Kayinja and Kivuvu) that are considered to be at greatest risk to infection via this route (Tushemereirwe *et al.*, 2003b).

Unfortunately, farmers are generally reluctant to cut off male buds especially on Kayinja and Kivuvu. This is the main challenge for controlling the disease in Uganda because Kayinja is widely grown for beer (Bagamba *et al.*, 2006) and in some parts of the country Kivuvu has been reported slowly replacing cooking bananas as a cooking banana because of its low production costs (Bagamba *et al.*, 2001). Farmers have advanced various reasons for not cutting off the male buds. Some reported that they wanted to use the male buds to identify affected bunches so that they do not harvest them for consumption. Some noted that it is in their tradition not to remove male buds from Kayinja because the practice reduces the quality of alcohol produced from such bunches. Others just found it tedious to go through Kayinja plots to remove the male buds (Bagamba *et al.*, 2006).

Thus a study was conducted to: (1) assess the role of the different clones in the spread and transmission of Banana Bacterial Wilt; and (2) determine whether farmers were following advertised recommendations of removing male buds from bananas as a control option for the disease.

MATERIALS AND METHODS

Study area description and selection criteria. The data for this study were collected from a multistage random sampling of rural banana households in Uganda. The sample domain was purposively selected to represent the major banana producing regions of Central, Eastern, Western and Southwestern Uganda. The sample was stratified according to disease incidences: (1) districts affected by disease for sometime (>2 years), (2) districts recently affected by the disease (<2 years), (3) districts at the frontline or close to disease outbreak and thus at high risk or already infected by the time of data collection (<1 year) and (4) areas not yet affected by disease and remote from disease front (low risk). Two districts were selected per region, Luwero and Kayunga for Central, Kamuli and Mbale for Eastern, Mubende and Masindi for Western and Bushenyi and Ntungamo for the Southwestern region.

Sample selection and research design approach. A multi-stage random sampling procedure was adopted in this study. At district level, two sub-counties were randomly selected from each of these two parishes. From each parish 3 villages were randomly selected from which 15 farmers were again randomly selected. The farmers were interviewed and additional data collected by visual observation on their farms.

Data collection. Data were collected at plant level by assessing banana bacterial wilt incidence on the first 30 mats by moving diagonally through the banana fields. The type of clones were also recorded. Information on when farmers recognised BBW on their farms and whether they were removing male buds from bananas to control BBW was obtained and verified by field observations.

Data analysis. Descriptive statistics were used to obtain means and frequencies using Stata Version 8.0 (Stata Corporation, 2003).

RESULTS AND DISCUSSION

Distribution of banana clones in the districts. According to our results, the cooking bananas were the most represented banana clone (>56%) in all the districts especially in the southwestern districts of Bushenyi and Ntungamo. Kayinja was second in importance especially in Luwero and in other districts like Mubende, Kamuli, Masindi and Kayunga (Table 1). The other banana clones were generally less represented (<6%) in all districts (Table 1). A similar trend was obseved from results in a countrywide survey conducted by Gold *et al.* (2002) in which, highland cooking bananas represented 76% of the total production while Kayinja contributed 8%, Ndiizi 7%, Kisubi 5%, Gros Michel 2% and plantain 2%. Kayinja is now widely grown for the production of banana

TABLE 1. Proportion (%) of banana clones by district: April 2005

Clone	Proportion of banana clones							
	Affected districts (>2 years)		Recently affected districts (<2 years)		Frontline districts (<1 year)		Low risk districts	
	Kayunga	Kamuli	Luwero	Mbale	Masindi	Mubende	Bushenyi	Ntungamo
Cooking bananas	80.0	60.1	56.5	84.5	65.3	76.7	96.5	92.8
Kayinja	11.0	13.4	33.4	2.6	11.4	14	<1	2.0
Kivuvu	2.6	6.3	3.3	2.8	11.7	1.9	-	<1
Ndiizi	3.1	16.2	5.1	4.1	4.7	3.6	2.2	3.8
Gros michel	1.4	2.2	1.0	6.0	2.9	<1	<1	1.1
Kisubi	<1	1.7	<1	<1	3.8	2.7	-	<1
Plantain	<1	-	<1	<1	<1	<1	<1	<1
FHIA 17	1.2	<1	<1	-	<1	<1	-	<1
Km5	<1	-	-	-	<1	-	-	-

beer (Bagamba *et al.*, 2001) because farmers believe they are more drought resistant than local brewing clones and can earn them income through marketing of value-added products such as banana wine and Waragi (Gold *et al.*, 2002). In some districts like Masindi, the importance of Kivuvu (Table 1) is worthy mentioning. It has been reported by Bagamba *et al.* (2002), that in some parts of the country, Kivuvu is slowly replacing other cooking varieties of bananas as because of its low production costs.

The role of the different clones in the spread and transmission of BBW. BBW has so far been reported in more than 30 districts. In our study, the most affected districts were Kayunga, Kamuli and Masindi followed by Mbale and Luwero (Table 2). Where the disease is widespread, Kayinja appeared most susceptible. Other susceptible clones were Kivuvu and Ndiizi though the numbers of mats sampled were generally lower than highland cooking bananas and Kayinja. Highland cooking bananas were less susceptible. The number of mats for Gros Michel, Kisubi, Plantain, FHIA 17 and Km5 was low and thus a conclusion on incidence on these cultivars could not be drawn (Table 2). The least affected districts were Mubende, Bushenyi and Ntungamo where disease incidence of less than 5% was observed. In these districts, Kayinja again appeared most susceptible. Farmers themselves recognised and reported that Kayinja and Kivuvu are usually the first types to become infected with BBW (Tushemereirwe *et al.*, 2003b; Bagamba *et al.*, 2006) and thus, the role of Kayinja in the transmission and spread of BBW should not be underestimated.

In similar studies conducted in Lira district by Tushemereirwe *et al.* (2003b), Kivuvu had the highest incidence (74%), followed by Kayinja (30%), cooking bananas (12%) with Ndizi having the lowest (3%). In other studies, incidences of 0.6-89% were reported on farms in Mukono, Kayunga, Jinja, Kamuli, Mbale, Sironko, Lira, Apach, Kaberamaido and Luwero districts (BBW Taskforce Report, 2003). From these results, the highest incidences were again observed on Kayinja and Kivuvu clones.

The low disease incidence in Mubende, Bushenyi and Ntungamo reflects the recent

TABLE 2. Incidence (%) of banana bacterial wilt by cultivar in sampled districts of Uganda: April 2005

Clone	Proportion of banana mats							
	Affected districts (>2 years)		Recently affected districts (<2 years)		Frontline districts (<1 year)		Low risk districts	
	Kayunga	Kamuli	Luwero	Mbale	Masindi	Mubende	Bushenyi	Ntungamo
Cooking bananas	24 (4,036)	27 (2,961)	18 (2,814)	12 (4,439)	21 (3,483)	<1 (3,801)	<1 (5,239)	<1 (4,593)
Kayinja	66 (554)	60 (658)	32 (1,664)	44 (135)	71 (607)	2 (694)	0 (41)	4 (100)
Kivuvu	73 (131)	68 (311)	51 (162)	31 (149)	76 (624)	1 (96)	-	0 (1)
Ndizi	51 (158)	64 (798)	26 (252)	43 (215)	69 (251)	1 (179)	0 (119)	4 (186)
Gros michel	19 (73)	25 (106)	16 (51)	23 (314)	27 (156)	0 (30)	0 (26)	0 (52)
Kisubi	50 (10)	57 (86)	10 (20)	100 (2)	23 (205)	0 (132)	-	0 (12)
Plantain	21 (14)	-	0 (16)	100 (2)	50 (4)	0 (17)	0 (5)	0 (3)
FHIA 17	29 (62)	0 (4)	0 (1)	-	0 (1)	0 (8)	-	0 (3)
Km5	17 (6)	-	-	-	0 (1)	-	-	-

*(n) = Number of banana mats

infection of these districts. In addition, Kayinja and Kivuvu that seem to be important in the transmission and spread of BBW (Tushemereirwe *et al.*, 2003b; Bagamba *et al.*, 2006) are minor clones in Bushenyi and Ntungamo (Table 1). The source of infection in Ntungamo district is still a puzzle, though the disease is likely to have come on infected planting material. However, in Bushenyi, the farmers who had the disease reported that they were mulching their fields with banana residues collected from a nearby banana trading/loading centre. Thus, there is a possibility that the bacterium was carried on bananas from infested neighbouring districts. The possibility of transmission through mulching materials from the trading/loading centre to farmers' fields therefore cannot be ruled out. For Mubende district, the source of infection is likely to have been from the neighbouring districts of Hoima and Wakiso that are already infested with the disease.

Although the distribution of the disease has been localised to areas specialised in growing the non-traditional banana types, the disease is rapidly filling in the gaps and rapidly moving towards the dominantly highland banana growing areas (i.e. the southern and western parts of the country). Reported entry of the disease into major banana growing and commercial supply districts will compound the problem as it is expected to reduce production and therefore limit commercial supplies to consumer markets, leading to increased banana prices.The challenge to all stakeholders (government, researchers, extension staff, non-governmental organazations, community-based organization and farmers) is to try to prevent the epidemic from moving south and westwards to these areas. Unfortunately, the disease has now been reported in some of the districts in the southern and southwestern Uganda.

Farmers usually are reluctant to remove male buds from Kayinja and Kivuvu clones and under such conditions the disease is likely to spread faster (Bagamba *et al.*, 2006). The greatest challenge in controlling the epidemic in Uganda is where Kayinja is widely grown for the production of banana beer (Bagamba *et al.*, 2002; Bagamba *et al.*, 2006) and in some parts of the country where Kivuvu has been reported slowly replacing cooking bananas as a cooking banana because of its low production costs (Bagamba *et*

al., 2002). As reported in earlier studies by Tushemereirwe *et al.* (2003b), our results revealed that the wilt incidence on cooking banana was lower than on Kayinja and Kivuvu. This might probably be because cooking banana stands are better managed (including farmer removal of the male buds) than in Kayinja and Kivuvu stands (Bagamba *et al.*, 2006). It may also mean that cooking bananas are not as susceptible to this disease.

Historical progress of the disease at district level. Our results show that BBW was first observed in Kamuli and Kayunga districts. The majority of the farmers in these districts reported that they first observed the disease in their banana fields between 2002 and 2004 though some farmers claim to have observed it as far back as 2000 (Table 3). We note that the disease was first reported in Mukono and Kayunga in 2001 though some farmers reported that they had noticed it as far back as 2000 (Tushemereirwe *et al.*, 2001). From Kayunga and Mukono, the disease probably spread to neighbouring districts including Kamuli and Luwero. In Luwero, Masindi, Mbale and Mubende the majority of farmers reported that they first noticed the disease between 2004 and 2005 (Table 3). Though the farmers in Masindi reported that they first observed the disease in 2004, the incidence in their fields was already very high on Kayinja and Kivuvu (Table 2) and it seems to be spreading very fast.

In the southwestern districts of Bushenyi and Ntungamo the farmers reported that they first observed the disease in 2005 (Table 3). It is of great concern that the disease has reached the southern and western regions of the country that are the major cooking banana producing areas in the country. Within the last 2 years, the disease has been spreading at a tremendous rate and of recent has been reported in more than 30 districts. Its spread has been augmented through exchange of planting materials from farmer-to-farmer or banana trade between the neighbouring districts and sub-counties (BBW Taskforce report, 2003). The epidemic will lead to reduced banana production and sales, thus, increased banana prices. This will limit employment opportunities and lower farmers' incomes, therefore impacting the local district economies.

TABLE 3. First reports of banana bacterial wilt by farmers at different times

Year of first attack	Proportion of farmers									
	Affected districts (>2 years)		Recently affected districts (<2 years)			Frontline districts (<1 year)			Low risk districts	
	Kayunga	Kamuli	Luwero	Mbale		Masindi	Mubende		Bushenyi	Ntungamo
2000	3	4	0	0		0	0		0	0
2001	12	6	3	0		1	0		0	0
2002	19	19	2	7		2	0		0	0
2003	27	39	14	18		8	0		0	0
2004	19	31	68	58		84	33		0	0
2005	21	2	14	18		5	67		100	100

Removal of male buds from the banana plants. Observations at advancing disease fronts in Uganda suggest that transmission to the male bud is, in fact, the primary means of spread. Not only are diseased buds often the first symptom to be observed but these are also most commonly seen on ABB banana types (Tushemereirwe *et al.*, 2003a), which are known to be particularly susceptible to insect transmission in other banana bacterial wilt diseases (Buddenhagen and Elsasser, 1962). Moreover, the discontinuous pattern of spread suggests that, as with other banana bacterial diseases, infection via male flowers by insects, bats and sunbirds is likely. Thus, timely removal of the male bud should interrupt the transmission cycle and prevent the spread of the disease, especially if this can be done in those types that are considered to be at greatest risk to infection via this route. Removal of male buds using a forked stick is one of the emphasised practices for controlling the disease (BBW Taskforce, 2003).

Most farmers in survey sites removed male flower buds, but many farmers did so only sporadically (Table 4). Surprisingly, the greatest adherence to systematic removal of male flower buds was in Bushenyi and Ntungamo district where disease incidence was low. By contrast, in more severely infected districts (e.g. Luwero and Kamuli), the majority of the farmers (>60%) reported that they were either not removing male flower buds or only doing so sporadically. Furthermore, the majority (>40%) of farmers in all districts were removing the male buds when they were moderately old (Table 4) and not likely to prevent disease transmission because by this time transmission is likely to have already taken place. Another concern was that almost all farmers (>80%) in all districts were using cutting tools such as machetes, ordinary and pruning knives to cut off the male buds (Table 5). This practice of using cutting tools is likely to aid the transmission of the disease from infected to non-infected plants (Yirgou and Bradbury, 1974; Tushemereirwe *et al.*, 2001). In addition, it was observed that in fields where monkeys were eating off the male buds, the disease incidence was generally low. Probably this was because the monkeys eat off the male buds before they open and thus interrupting the transmission cycle and preventing spread of the disease by insects.

TABLE 4. Removal of male buds practices in different districts: April 2005

Removal of male buds	Proportion of farmers							
	Affected districts (>2 years)		Recently affected districts (<2 years)		Frontline districts (<1 year)		Low risk districts	
	Kayunga	Kamuli	Luwero	Mbale	Masindi	Mubende	Bushenyi	Ntungamo
Farmer does not remove	9	31	32	33	15	20	0	0
Sporadic	48	57	45	51	58	44	30	37
Systematic	43	12	23	16	27	36	70	63
Stage of removal								
Early	41	18	26	3	23	17	33	20
Moderately old	40	61	46	62	47	60	58	55
Variable	20	21	28	35	20	23	9	25

TABLE 5. What is used to remove the male buds: April 2005

Tool used	Proportion of farmers							
	Affected districts (>2 years)		Recently affected districts (<2 years)		Frontline districts (<1 year)		Low risk districts	
	Kayunga	Kamuli	Luwero	Mbale	Masindi	Mubende	Bushenyi	Ntungamo
Cutting tools	90	92	95	90	84	92	100	99
Forked stick	10	8	5	10	16	8	0	1

Although farmers themselves have come to recognise that Kayinja and Kivuvu are usually the first clones to become infected (Bagamba *et al.*, 2006), it was observed that the farmers were generally reluctant to cut off male buds from these clones. This is the biggest challenge for controlling the disease in Uganda because Kayinja is widely grown for beer (Bagamba *et al.*, 2001; Bagamba *et al.*, 2006) and in some parts of the country it has been reported that Kivuvu is slowly replacing cooking bananas as a cooking banana because of its low production costs (Bagamba *et al.*, 2001). Farmers have advanced various reasons for not cutting off the male buds from these clones. Some reported that they wanted to use the male buds to identify affected bunches so that they do not harvest them for consumption. Some noted that it is in their tradition not to remove male buds from Kayinja because the practice reduces the quality of juice produce and therefore that of alcohol. Others just found it very hard to go through Kayinja plots to remove them (Bagamba *et al.*, 2006).

In addition to not cutting off the male buds from Kayinja, farmers frequently neglect or at best semi-cultivate Kayinja plots (Bagamba *et al.*, 2001; Bagamba *et al.*, 2006). Farmers cited lack of labour as the most limiting factors preventing them from maintaining their plots and from uprooting plants in infected plots. Others (especially in Luwero) reported that they maintain the Kayinja plots for the sake of obtaining leaves for cooking (Bagamba *et al.*, 2006). Under these circumstances, it is understandably difficult to persuade individual farmers to debud healthy plants or to cut down or destroy mats that have become diseased but may still produce the occasional usable bunch of fruit, let alone to remove plots of Kayinjas that are not yet affected (Eden-Green, 2004). This calls for further sensitization about the importance of removing male buds and the dangers non-removal of male buds poses in the spread of BBW.

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REFERENCES

Bagamba, F., Ssennyonga, J.W., Tushemereirwe, W.K., Katungi, E., Gold, C.S., Katwijukye, A.K. and Ragama, P. 2001. Analysis of banana production systems in Uganda: The case of Bamunanika sub-county in Luwero district, In: Banana Research Programme Report, Kampala, Uganda. 136pp.

Bagamba, F., Kikulwe, E., Tushemereirwe, W.K., Ngambeki, D., Muhangi, J., Kagezi, G., Ragama, P.E. and Eden-Green, S. 2006. Farmers' awareness of banana bacterial wilt and its control in Uganda. *African Crop Science Journal* 14:157-164.

BBW Taskforce Report. 2003. National Agricultural Research Organization (NARO). The National Research and development Action Plan for Control of Banana Bacterial Wilt (BBW): A Taskforce Report. October 2003. 50p.

Buddenhagen, I.W. and Elsasser, T.A. 1962. An insect spread bacterial wilt epiphytotic of bluggoe banana. *Nature* 194:164-165.

Eden-Green, S. 2004. How can the advance of banana xanthomonas wilt be halted? *Infomusa* 13:38-41

Gold, C.S., Kiggundu, A., Abera, A.M.K. and Karamura, D. 2002. Diversity, distribution and farmer preference of *Musa* cultivars in Uganda. *Experimental Agriculture* 38:39-50.

Stata Corporation. 2003. Stata Corporation: Stata Version 8.0. College Station, Texas.

Tushemereirwe, W. K., Kangire, A. Smith, J. Nakyanzi, M. Karyeija, R. Kataama, D. and Musiitwa, C. 2001. An out break of Banana bacterial wilt in Mukono and Kayunga districts: A new and devastating disease. NARO /KARI.

Tushemereirwe, W. K., Kangire, A. Smith, J. Nakyanzi, M. Karyeija, R. Kataama, D. and Musiitwa, C. 2002. An out break of Banana bacterial wilt in Mukono and Kayunga districts: A new and devastating disease. The first updated disease report. NARO /KARI.

Tushemereirwe, W. K., Kangire, A. Smith, J. Ssekiwoko, F., Nakyanzi, M., Kataama, D., Musiitwa, C. and Karyeija, R. 2003a. An out break of bacterial wilt on banana in Uganda. InfoMusa 12: 6-8.

Tushemereirwe, W. K., Ssekiwoko, F. and Ojeke, C. 2003b. An out break of Banana bacterial wilt in Lira. NBRP, KARI, 25p.

Yirgou, D. and Brudbury, J. F. 1974. A note on wilt of Banana caused by the Enset wilt organism, *Xanthomonas musacearuum*. East African Agricultural and Forestry Journal 40: 111-114.