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Full Length Research Paper

Farmers' awareness and application of banana *Xanthomonas* wilt control options: The case of Uganda and Kenya

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Banana is a key staple and cash crop in east and central Africa. However, the recent outbreak of Banana *Xanthomonas* wilt (BXW) has threatened farmers whose livelihoods depend on the crop. Since 2002, stakeholders embarked on campaigns to sensitize farmers on the disease and its management. This study evaluated the effectiveness of these efforts by examining farmers' awareness of the disease, control options and their application in Uganda and Kenya. Data on BXW distribution and incidence, farmers' awareness of symptoms, mechanisms of spread and control options of the disease and banana production were collected through household surveys conducted in 2010. The results indicated that most farmers (> 90%) were aware of the disease and its symptoms and more than 50% were aware of the recommended control measures. Farmers obtained information on the disease from multiple sources but farmer-to-farmer interaction was the main source suggesting the key role rural social networks play in managing the disease. Not all affected farmers were able to apply control measures due to cost of intervention, lack of labour and inputs. The study recommends strengthening of linkages among stakeholders for better coordination of efforts and participatory development and promotion of farmer-oriented interventions that address farmer constraints.

Key words: Banana (*Musa* spp), Xanthomonas wilt, awareness, control measures, households.

INTRODUCTION

Banana (*Musa* spp) is an important crop in east and central Africa. Apart from being a key staple food in the region, the crop is an important source of income for resource poor farmers (Karamura et al., 1998). Despite its importance, the crop has been quickly losing ground as a dependable crop due to several biotic and abiotic constraints. Until the beginning of the century, the main biotic threats (weevils, nematodes, fungal and viral diseases) were managed using cultural methods. In this way farmers suffered reduced productivity but maintained reasonable levels of food and income security. However, following the arrival of banana Xanthomonas wilt (BXW) (caused by *Xanthomonas campestris* pv. *musacearum*) in the region, entire crop holdings were wiped out in some areas where highly susceptible genotypes were dominating the farming systems. Up to the 1960s, the wilt was known only in Ethiopia, occurring in both bananas and enset. In 2001, the disease was reported in central Uganda (Tushemereirwe et al., 2001) and in north Kivu Province of DR Congo in 2003 (Ndungo et al., 2006) and in Rwanda in 2005 (ISAR, 2007). Between 2002 and 2006, the disease spread to the major banana growing regions of Uganda, western Kenya, and other countries in Central Africa, where it reportedly caused 80 to 100% crop loss, especially in beer bananas (ABB genome) in Uganda and DR Congo (Ndungo et al., 2006). Such losses drastically affected food security and incomes for the poor and vulnerable farmers.

All banana cultivars in eastern Africa, including endemic

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highland cooking and brewing cultivars (AAA-EA), exotic brewing, dessert and roasting types (AB, AAA, AAB, ABB), and hybrids, are susceptible to the disease. No cultivars with BXW resistance have so far been identified. Some cultivars, e.g. Pisang awak (ABB) are particularly susceptible to insect vector transmission and are believed to facilitate the spread of BXW (Tushemereirwe et al., 2003). The first symptoms of floral infection by BXW include discoloration at the tip of the flower and withering of the flower bracts. This is followed by drying of the rachis, premature drying and rotting of bunches and eventually wilting and death of the whole plant. In the vegetative phase, the symptoms include yellowing, wilting and eventually death of the whole plant. When the banana pseudostem is cut, yellow ooze in the real stem confirms presence of the disease. This discoloration is diagnostic and is observable even where other symptoms are not yet manifest.

As a result of the severity of the disease, regional stakeholders developed a management strategy in 2005 (Karamura et al., 2006) based on what was known about the mode of spread of other similar bacterial wilt diseases of banana (e.g. Moko and Blood diseases). Removal of male buds is instrumental in preventing possible insect and/or bat transmission of the disease. Destruction and disposal of infected plants, disinfecting tools used in the plantation, avoiding using planting materials from infected areas, replacing bananas with other crops and quarantine measures are the other recommended practices. These cultural practices, if adhered to, should slow but may not completely prevent the spread of BXW (Karamura et al., 2008). Since 2002, intensive campaigns were mounted across the region to create awareness on the disease and educate farmers about its diagnosis, prevention and recommended control practices through posters, brochures, newspaper inserts, calendars, radio and several other participatory development communication approaches. However, little is known about the effectiveness of these efforts in raising farmers' awareness of the disease, control options and their application and how these may be influenced by farmers' agro-ecological and socio-economic context.

The objective of this study, therefore, was to assess farmer-level awareness of BXW, its effect on production, control options and their application in the main banana cropping systems using data from Uganda and Kenya. The results of this study should generate insights that will inform policy-makers and stakeholders in the banana sector on possible interventions for managing BXW and reduce its impacts on food security and incomes of poor farmers.

METHODOLOGY

This study was carried out in Uganda and Kenya. In Uganda, the study targeted the two main banana cropping systems: the 'Kayinja' beer banana (ABB genome) and the East African highland banana (EAHB) 'Matooke' (AAA-EAHB) based systems. The AAA-EAHB types are produced by farm households mainly for food security purposes, while the ABB types are largely market-oriented. The Kayinja system is located mainly in central Uganda, and is usually a mix of bananas and other crops (e.g. coffee, cassava and trees) while the EAHB based system is mainly found in the south western parts of Uganda, on relatively fertile soils and with low banana pest pressure. The EAHB system is more intensively managed (with frequent pruning, weeding, de-budding) than the Kayinja system. Accordingly, BXW transmission in the EAHB system is mainly through farm tools while in the Kayinja system, insects are the main mechanism of transmission.

In Kenya, one district from the western part of the country (Ugunja division, Siaya district) where the disease is prevalent and banana is a key crop for farm households was selected. In this area, the banana production system is dominated by dessert bananas including Kivuvu (ABB genome), Sukari Ndiizi (AB genome), Cavendish (AAA genome) but also has significant Kayinja and EAHB bananas (Mbaka et al., 2009). In general, management of banana fields is less intensive in Kenya than in Uganda. In both countries, household surveys were conducted in May to September, 2010 to collect data using a structured questionnaire. A similar questionnaire was used in both countries, although minor adaptations were made to capture contextual differences. The questionnaire solicited data on household socio-economic characteristics, BXW distribution and incidence; farmers' awareness of disease symptoms, mechanisms of spread and control measures, banana production, coping mechanisms and livelihoods strategies. In Uganda, a multi-stage stratified random sampling design was used to select households for the survey. The two main banana systems described earlier were the sampling units for the first stage.

A total of ten districts were purposively selected to represent the two banana systems in the country, six for the EAHB system (Isingiro, Mbarara, Masaka, Bushenyi, Ibanda and Ntungamo) and four from the Kayinja system (Kiboga, Mityana, Mubende and Mpigi). Occurrence of the disease and period since the disease was first observed were also considered in selecting the districts for the survey. Within each of the selected districts, communities were mobilized to control BXW using three main extension approaches: 1) farmer field schools, 2) community-based extension and 3) traditional top-down extension approach. For example, there were over twenty communities who were mobilized using farmer field schools in each of the cropping systems, three of which were randomly selected for this study. Likewise, three communities were randomly selected among those who were mobilized using community and traditional approaches in each district. Households in each of the selected communities were then stratified according to the banana marketing strategy they use: group versus individual. To take into account farm size, the households were further stratified according to farm size into large (>2 acres) and small farms (<2 acres) and twenty households were randomly selected in each stratum. The final sample of households interviewed in Uganda consisted of 350 households.

In Kenya, the cropping systems and technology transfer approaches used for mobilizing farmers for BXW control were more or less similar across the country and hence one district was selected for the survey. A total of 52 households were randomly sampled from six locations in the district. Descriptive frequencies were used to analyse farmers' awareness, sources of information, application of BXW control measures and coping strategies in the two study countries. Comparative statistics (means, frequencies and cross tabulations) with statistical tests for significance were used in examining differences in various factors across sites and cropping systems (t-tests and chi-square tests). The impact of disease on banana production and sales was first analyzed by comparing the significance of the difference in mean banana production and sales before and at the peak of the disease using a paired t-test statistic.

In order to obtain robust estimates of the impact of the disease on banana production and sales, a combination of propensity score matching (PSM) and difference-in-difference or double difference (DID) approaches was applied. PSM is used to match affected households (the treated group) with non-affected households (the control group), based on similarity in observable socio-economic characteristics (Barker, 1999). This controls for selection bias arising from differences in observable characteristics between the two groups. Bias due to unobservable time-invariant characteristics (e.g. ability of farmers, inherent quality of natural resources) or common trends affecting both groups equally (e.g. prices, weather) was addressed by using the DID approach (Barker, 1999; Smale et al., 2008; Davis and Nkonya, 2008). Combining the two nets out, both observable and unobservable factors that affect the outcome variable and in principle produces impact estimates that are more plausible than those based on a single difference (either overtime, as is the case with the paired t-test statistic highlighted earlier or between groups) (Nkonya and Davis, 2008). Because the sample size for Kenya was very small, the impact analysis using PSM and DID was only done for Uganda.

RESULTS AND DISCUSSION

Socio-economic characteristics and importance of banana in the study countries

The demographic characteristics of the interviewed households in the two countries are summarized in Table 1. Age of household head averaged in the forties in both countries was not significantly different between the two sites. Similarly, the average education level of household head for the two countries was not significantly different with most of the household heads not having gone beyond primary education. However, while there was no significant difference in the number of years living in the area between the two study countries, households in Uganda had significantly more farming experience than those in Kenya. Results on the importance of bananas in farming systems in the two countries are presented in Table 2. The results show that mean farm size per household was significantly higher in Uganda than in Kenya. In both countries, banana was an important food and income crop.

However, the crop was more important in Uganda than in Kenya, as evidenced by the fact that more than 70% of the interviewed households in Uganda grew banana as the main crop compared to only 10% in Kenya. Accordingly, households in Uganda allocated a significantly higher proportion of their farmland to banana production, invested a higher proportion of their income in banana production and consumed banana products more frequently than their Kenyan counterparts. In Uganda, the percentage of households growing banana as the main crop and the proportions of farmland under banana and household monthly income from banana were significantly higher in the EAHB system than in the Kayinja system. This confirms the special position of East African highland cooking 'Matooke' bananas in the livelihoods (food security and income purposes) of rural households in the country. The difference in importance of banana for farmers in the two systems may influence their decision to invest in BXW control.

Farmer awareness and application of BXW control measures

In both countries, more than 70% of the interviewed farmers had their farms affected by BXW. All interviewed households were aware of the disease and its symptoms. In line with findings from previous studies (Ngambeki et al., 2006; Bagamba et al., 2006; Muhangi et al., 2006) this study found that the three main recommended BXW control measures of removing male buds with a forked stick; destroying infected plant material (through different approaches of cutting of pseudo stem of affected plants; cutting down and bury whole mat of diseased plants); and disinfecting cutting tools were widely known and applied by farmers in Uganda (Table 3). Destroying affected plants through cutting of affected pseudo stem; cutting and dig down whole mat of affected plants and removal of male buds with cutting tools were the most widely known and practiced control measures in Kenya. Contrary to the results in Uganda, removal of male buds with forked stick and disinfecting of farm tools were known and practiced by very few farmers in Kenya. The limited application of removal of male buds with forked stick by farmers supports an earlier finding by Mbaka et al. (2009) that few farmers in western Kenya carry out this practice and do it not with the intention to control BXW, but to use the male bud as a stopper for water containers.

Although the use of cutting tools in de-budding is discouraged by researchers and extension practitioners, a significant number of farmers in both countries were still using cutting tools for de-budding (29 and 39% in Uganda and Kenya, respectively). This demonstrates that a significant number of farmers were still not aware of the potential danger posed by cutting tools in transmitting the disease both in-field and across fields. Future awareness campaigns need to emphasise on enhancing farmer understanding of the rationale behind different practices and the motive behind discouraging certain practices such as the use of cutting tools. In both countries, putting restrictions on movement of plant material (including suckers) to contain the spread of disease to disease-free areas was less practiced. More than 90% of the farmers in both countries used suckers from their own fields or from neighbors, thereby increasing the chances of spreading the disease across farms through planting material. With the exception of a few practices, more farmers under the EAHB system were applying BXW control measures than under Kayinja system (table 4), as the former is more important to the farmers' livelihoods and therefore farmers are more willing to invest in disease control in that system than in the latter.

A comparison of the percentage of households aware

Table 1. Socio-economic characteristics of interviewed households in Uganda and Kenya.

Socioeconomic characteristics	Uganda (n=350)			Kenya (n=52)	Statistical tests for significance	
	EAHB system (n=172)	Kayinja system (n=178)	Sample (n=350)	Dessert system (n=52)	t-values (comparison of EAHB and Kayinja)	t-values (comparison of Uganda and Kenya)
Age of household head (years)	44	47	46	48	2.02**	1.15
Education of household head (years)	6	8	7	7	4.55**	1.31
Years living in area	28	29	28	29	0.25	0.19
Years in farming	23	25	24	19	1.25	2.21**
					χ^2 values	
Gender of household head (%) : Male	49	53	51	65	0.48	1.33
Female	51	47	49	35		

** Significant at 5%.

of the different control measures with those applying them shows that in both countries, not all of those who knew the control measures were actually applying them. For instance, in Uganda 82% were aware of the removal of male buds using a forked stick as a control measure but only 67% were practicing this control measure. The same trend can be observed for the other control measures and also for Kenya. The worst case scenario is where farmers were not practicing any control measure despite their farms being infected with the disease and knowing the control options. However, in Uganda only 3% of affected households did not apply any control measure (26% in Kenya), suggesting that the majority of farmers believed the disease could be successfully controlled. Limited application of practices that farmers were aware of was attributed to several constraints (Table 5), including high cost of application (e.g. disinfecting of farm tools), lack of labour (e.g. cutting down and burying whole mat of affected plant) and ineffectiveness of control measures. Concerns raised by some farmers about ineffectiveness of some control measures in controlling the disease (e.g. debudding with forked stick) could be due to incorrect application of such control measures.

For instance, a study by Muhangi et al. (2006) in Uganda found that farmers who de-bud using a forked stick or cutting tools did it late (normally when fingers have turned upwards). In their study, they argued that such incorrect application of the control measure could explain the claims by farmers that removal of male buds is ineffective in controlling the disease. These findings suggest the need to go beyond just creating awareness of existing control measures but also equip farmers with skills on correct application of these measures. Most farmers were aware of more than one control measure and those controlling the disease were mostly applying combinations of control measures (Table 3). That explains why the percentage of farmers aware or applying the different practices add up to more than 100%. Whilst most farmers were applying more than one control measure, few were deploying the full package of control measures (using removal of male buds with fork stick, destroying infected plant material and disinfecting tools simultaneously) and as a result few farmers were able to eradicate the disease from their farms. The main sources of information on BXW control measures are presented in Table 6. The results show that farmers obtained information on BXW control measures from multiple sources. In both countries, friends/neighbours and extension were the main sources of information for farmers.

However, the fact that friends/neighbours played a key role in disseminating BXW information, demonstrates the importance of social networks (such as farmer associations, farmer field schools and community-based extension approaches) in raising awareness and improving adoption of BXW control measures. An interesting contrast between the two countries is that while researchers played some role in disseminating information in Uganda, they played no role in Kenya. There is evidence that community-based organizations, such as schools, churches and

Table 2. Comparative analysis of the importance of banana in farming systems in the two countries.

Parameter	Uganda (n =350)			Kenya (n=52)	Statistical tests for significance	
	EAHB system (n=172)	Kayinja System (n=178)	Sample (n=350)	Dessert system (n=52)	t-values (comparison of EAHB and Kayinja)	t-values (comparison of Uganda and Kenya)
Farm size (acres)	6	9	8	4	1.49	1.43*
Mean farm size under banana (acres)	2	2	2	0.5	1.21	5.12***
Proportion of farm size allocated to banana (%)	63	31	49	14	11.72***	7.85***
Proportion of monthly household income from banana (%)	43	17	29	27	7.06***	0.14
Proportion of household income invested in banana production (%)	15	14	12	9	0.24	1.22***
Mean number of times banana products are consumed per week per household	9	10	7	0.3	0.55	10.89***
					χ^2 values	
Grow banana as (%): Main crop	91	56	73	10	57.23***	101.14***
Secondary crop	9	44	27	90		
Grow banana as (%): Food only	16	31	24	10	18.29***	49.86***
Cash only	1	3	2	2		
Both	83	66	74	89		

*, **, *** Significant at 10, 5 and 1% respectively.

market places also played a role in disseminating information on the disease in both countries, albeit small. The fact that farmers received information from multiple sources, raises concerns about the possibility of farmers receiving conflicting messages from different sources.

In their study on BXW in Uganda, Bagamba et al. (2006) reported that farmers raised concerns over receiving different information from different sources. The implication of this finding is that there is need for better coordination and strengthening of linkages among stakeholders (researchers, extension, farmers, media, non-governmental organisations and community-based organisations) and build synergies in fighting against the disease.

Impact of BXW on farm production, income and household coping strategies

Impact on banana production and sales

To ascertain the impact of BXW on banana production and incomes at household level, farmers were asked to provide estimates of their banana harvest and sales levels per month (a monthly time step was thought to be shorter and easier recall period for farmers than a year) before and at the peak of BXW. The impact of the disease on banana production and sales was first analyzed by testing the significance of the mean monthly banana harvest and sales per household before and at the peak of BXW attack in each country using a paired t-test. The results, which are presented in Table 7, show that in both countries banana harvest and sales levels fell drastically at the peak of BXW attack. In Uganda, average monthly banana harvest levels per

Table 3. Farmer awareness and application of BXW control measures in Uganda and Kenya.

Practice	Uganda (n=350)		Kenya (n=52)	
	Percentage of households aware	Percentage of households currently applying	Percentage of households aware	Percentage of households currently applying
Cut down affected pseudo stem of affected plant	74	65	57	41
Cut down and dig up the whole mat of affected plants	59	41	45	39
Bury plant remains	49	32	6	2
Burn plant remains	23	8	4	-
Heap affected plant remains and leave on ground	35	29	10	6
Left on ground but not heaped or buried	13	11	6	4
Remove male buds of affected plant with fork stick	82	67	12	8
Remove male buds with cutting tools	41	29	45	39
After cutting, clean tools (JIK/fire)	77	64	4	4
Treat with concoction	21	16	8	6
Do not sell or move any fruits, leaves, or suckers outside a disease area	18	14	4	-

Table 4. Proportion of farmers (%) applying control measures by banana cropping system.

Practice	Uganda (n=350)			Kenya (n=52)
	Kayinja system (n=178)	EAHB system (n=172)	χ^2	Dessert system
Cut down affected pseudo stem of affected plant	80	53	37.31***	41
Cut down and dig up the whole mat of affected plant	30	53	14.31***	39
Bury plant remains	7	58	88.62***	2
Burn plant remains	11	5	5.4**	-
Heap affected plant remains and leave on ground	36	22	9.32***	6
Left on ground but not heaped or buried	2	6	11.21***	4
Remove male buds of affected plant with fork stick	65	69	2.31	8
Remove male buds with cutting tools	25	35	4.29**	39
After cutting, clean tools (JIK/fire)	58	70	6.67**	4
Do not sell or move any fruits, leaves, or suckers outside a disease area	11	20	5.27**	-

household dropped by 57%, while sales fell by 67% at the peak of BXW infection. Similarly, in Kenya, farmers experienced an average of 77% reduction in pre-infection banana harvest levels while sales fell by 80%. Comparing the production impacts in the two countries, we observe that the

Table 5. Farmer constraints to application of different BXW control measures (% of farmers reporting) in Uganda.

Practice	Practice application constraints (% of farmers)			
	Expensive	Lack of labour (or technology is labour intensive)	Technology does not work (ineffective in controlling BXW)	Spreads BXW
Cut down affected pseudo stem of affected plant	17	17	11	-
Cut down and dig up the whole mat of affected plants	15	31	2	-
Bury plant remains	20	22	10	-
Burn plant remains	17	29	14	-
Heap affected plant remains and leave on ground	12	16	12	-
Left on ground but not heaped or buried	-	18	9	
Remove male buds of affected plant with fork stick	2	17	9	
Remove male buds with cutting tools	-	5	-	16
After cutting, clean tools (JIK/fire)	33	13	13	-
Treat with concoction	10	17	2	
Do not sell or move any fruits, leaves, or suckers outside a disease area		7	7.	
Destroy all infected plants until disease has gone away	-	11	-	-

disease had more severe effects on banana production in Kenya than in Uganda presumably because farmers in Kenya had less farming experience (Table 1) and accordingly possessed less experience in managing agricultural risks associated with pests and diseases than their Ugandan counterparts. This result could also be attributed to the fact that farmers in Kenya put less effort and invest less resources in managing the disease, as banana is grown largely as a secondary crop. Also, as results in Table 3 show, de-budding with cutting tools still had wider application among farmers in Kenya (with only 4% farmers disinfecting the used cutting tools) which could have exacerbated the disease and associated impacts.

The results obtained from DID impact analysis (Table8) show that during the period before BXW, affected households harvested significantly more than the non-affected households. However, at the peak of BXW, affected households suffered a significantly higher percentage reduction in average harvest (63%), although their harvest levels remained slightly higher than those of non-affected households. Even though there is a general downward trend in banana harvest during the two periods for both groups (presumably due to other factors), it is clear that the disease had large impacts on affected households. The difference-in-difference estimate is -22.66, which shows that average banana harvest among affected households was 22.66% lower than that of their non-affected counterparts. This is a sign of increasing difference between the two groups. The same trend is observed for banana sales. The reduction in banana production and sales due to disease infection adversely affect household food security and income. In turn, the loss in banana income adversely affects other household livelihood aspects into which income from banana is invested, such as home care (school fees, health) and investments into household infrastructure and productive assets.

The study also analysed the change in banana harvest and sales levels before and at peak of BXW by years, since the disease was observed in the two countries and the results are presented in Table 9. In Uganda, the number of years since the disease was observed on farm ranged from 0 to 9, with an average of 4.5 years and therefore the study compared percentage change in harvest and sales below and above this average. The disease was a recent phenomenon on most farms in Kenya, with the number of years since the disease was observed on farm ranging from 0 to 3 years with an average of 1.3 and we similarly compared the percentage change below and above this average. The results show that in both countries, banana harvest and sales reductions were much more severe on farms that had been

Table 6. Farmer sources of information (% of farmers) on BXW control measures known in Uganda and Kenya.

Practice	Uganda (n=350)					Kenya (n=52)				
	Friends/ neighbors	Radio/ TV	Extension	School/ church	Researcher	Friends/ neighbors	Radio/ TV	Extension	School/ church	Traders/ market place
Cut down affected pseudo stem of affected plant	36	28	40	1	8	27	6	17	2	2
Cut down and dig up the whole mat of affected plant	24	20	35	-	5	23	2	19	4	4
Bury plant remains	17	11	28	-	4	-	-	-	-	-
Burn plant remains	11	9	11	-	3	-	-	-	-	-
Heap affected plant remains and leave on ground	14	11	20	1	4		2	2	-	-
Left on ground but not heaped or buried	5	3	7	-	1	4	-	4	-	2
Remove male buds of affected plant with fork stick	33	26	48	1	9	2	-	2	-	-
Remove male buds with cutting tools	13	9	19	-	2	21	2	13	4	4
After cutting, clean tools (JIK/fire)	28	22	46	1	9	2	-	2	-	-
Do not sell or move any fruits, leaves, or suckers outside a disease area	5	3	7	-	2	-	-	-	-	-

Table 7. Comparison of banana harvest and sales before and after BXW attack among affected households in Uganda and Kenya.

Parameter	Uganda (n=350)				Kenya (n=52)			
	Before BXW	At peak of BXW	t-test statistic	Percentage change (%)	Before BXW	At peak of BXW	t-test statistic	Percentage change (%)
Mean banana harvested per month (bunches/household)	78.44	30.50	8.82***	-57.13	31.71	7.36	2.61**	-76.82
Mean banana sold per month (bunches/household)	59.53	17.13	7.07***	-67.37	23.91	4.77	2.39**	-79.57

, * Significant at 5 and 1% respectively.

affected by the disease for a much longer time than those recently affected.

In order to assess the potential recovery from application of control measures, this study compared banana harvest levels at the peak of disease and in the current period (the period the survey was conducted). The results show evidence of production recovery from the disease through application of control measures. In both countries, farmers applying control measures recovered more than 50% of their production losses, and those applying the full package of control measures recorded close to 80% production recovery. However, as highlighted earlier, few farmers (14 and 0% in Uganda and Kenya, respectively) were applying the full package of control methods.

Farmer strategies to cope with BXW

Besides applying control measures to reduce their losses, farmers are also using various coping strategies to 'live with the disease'. Such strategies represent a response by way of altering livelihood strategies to deal with the disease. These strategies range from those related to disease management, processing and marketing and consumption. Affected house-holds in both countries coped with the disease using multiple strategies (Table 10). However, the most widely used strategy was switching from banana to other crops. For instance, in Uganda, a previous work

Table 8. DID estimate of the effect of BXW using matched sample for Uganda.

Parameter	BXW infection status	Before BXW (B)	At the peak of BXW (A)	Current period (C)	Difference between periods (A-B)
Banana harvested (bunches/month)	Affected households	80.89	30.32	47.31	-50.57
	Non-affected household	56.77	28.86	34.51	-27.91
	Difference between groups	24.12	1.46	12.80	-22.66
Banana sales (bunches/month)	Affected households	61.30	17.80	26.73	-43.5
	Non-affected households	33.13	13.92	14.56	-19.21
	Difference between groups	28.17	3.88	12.17	-24.29

Table 9. Percentage change in banana harvest and sales before and after BXW by years since disease has been observed for Uganda and Kenya.

Parameter	Uganda (n=350)			Kenya (n=52)		
	< 4.5 years since BXW was first observed on farm	4.5 to 9 years since BXW was first observed on farm	t-test statistic	<1.3 years since BXW was first observed on farm	> 1.3 since BXW was first observed on farm	t-test statistic
Banana harvest per month (bunches/household)	-58.81	-73.66	3.46**	-51.53	-63.89	0.60
Banana sales per month (bunches/household)	-64.56	-79.54	2.53**	-48.70	-86.94	2.16*

*, **, Significant at 10 and 5% respectively.

by Karamura (2006) showed that acreage under banana declined, as affected farmers moved to crops that were considered safer than banana, with maize and cassava being the main crops increasing in acreage. Accordingly, the change in crop production system is accompanied with re-allocation of farm resources such as labour, equipment and other farm inputs. Other disease management strategies used to cope with the disease include raring livestock, use of concoctions, fallowing of banana fields and abandoning infected fields completely.

The results in Table 10 further show that most farmers in Kenya coped with the disease mainly through disease management strategies (growing other crops, rearing livestock, use of concoctions, fallowing and field abandonment) and less farmers used strategies related to adjusting their marketing and consumption decisions. In contrast, a significant proportion of farmers in Uganda coped with the disease through changing their consumption patterns by reducing the number of banana-based meals taken (31%) or consuming more of other food products (26%). This result supports evidence shown by Karamura (2006) that affected households have reduced consumption of banana products and consumption of other food types such as *posho* (maize meal) has increased (in line with increased importance and production of maize as stated earlier). These results illustrate that BXW has had profound effects on the livelihoods of banana-dependent communities by causing significant production and income losses and changing cropping and consumption patterns and processing and marketing decisions of affected communities.

CONCLUSIONS AND POLICY IMPLICATIONS

The importance of bananas as a food security crop in central and east Africa is increasingly threatened by BXW. A lot of progress has been made in raising farmers' awareness of the disease and available control options following its outbreak in the region. Friends/neighbours, researchers, extension, media and non-governmental organizations (NGOs) and community-based organizations (CBOs) played a key role in disseminating information on the disease and its management to farmers. Farmer-to-farmer interaction has been by far the most widely used dissemination channel for information on the disease and control options, reflecting the importance of rural social networks in raising awareness and enhancing adoption of improved banana management technologies. This draws policy makers' and development agents' attention to exploit these social networks through participatory approaches, such as farmer groups, farmer

Table 10. Percentage of farmers using different BXW coping strategies in Uganda and Kenya.

Coping strategies	Uganda (n=350)	Kenya (n=52)
Disease management		
Growing other crops	32	28.3
Raring livestock	8.3	7.5
Use of concoctions	9.7	13.2
Cut down entire field and rest for some time (fallowing)	8.9	18.9
Abandoning the infected field completely	11.1	15.1
Processing and marketing		
Use other raw materials to make beer	0.9	1.9
Making cassava and potato chips or other products (instead of banana crisps)	1.4	11.3
Stop selling banana products	12.6	7.5
Selling other crop products	-	9.4
Consumption		
Purchasing of banana from the market	11.1	3.8
Reduction of number of banana-based meals	31.4	9.4
Consumption of other food types	26.3	13.2

field schools and community extension groups for more effective farmer learning and adoption of BXW control measures. In addition, the multiplicity of the information sources suggest the need to strengthen linkages and synergies among all stakeholders (farmers, researchers, extension, farmers, media and NGOs, CBOs, policy-makers, NARS) to ensure that farmers do not receive conflicting messages from different sources and foster better coordination and complimentarity of efforts in managing the disease.

The results of this study showed that costs of control measures, lack of labour (or convenience of application) and effectiveness of control measure are key constraints to farmer application of control measures. While a more rigorous analysis of the factors influencing farmers' decisions on adoption of BXW control measures will be presented in a follow up paper, these preliminary results already suggest the need to strengthen farmer-researcher-extension linkages and adoption of a participatory farmer-oriented (demand-driven) technology development approach, to take into account indigenous knowledge and match technologies to farmer's socio-economic circumstances. This ensures that effective technologies are developed and are readily adopted by farmers. Furthermore, there is need to go beyond awareness raising and educate farmers on the correct application of the recommended control measures, something that can be addressed through stronger researcher-extension-farmer linkages and more effective farmer-to-farmer knowledge sharing and experiential learning through group approaches such as farmer field schools.

Finally, our study also showed that BXW has led to significant production and income losses among banana-dependent farmers, threatening their food security and incomes. The disease has caused far-reaching impacts on their livelihoods by inducing changes in farm production systems and consumption patterns and spill-over effects of the income losses on other downstream non-farm household livelihood aspects that depend on farm incomes. However, the study demonstrated that in the short term, farmers are able to recover their production through application of the recommended cultural control practices. That being the case though, given the evidence that the disease is resurging in some areas where it had been successfully controlled, developing cultivars with resistance to the disease seems to be the most effective long-term solution to the epidemic.

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REFERENCES

Bagamba F, Kikulwe E, Tushemereirwe WK, Ngambeki D, Muhangi J, Kagezi GH, Ramaga PE, Eden-Green S (2006). Awareness of banana bacterial wilt in Uganda: farmers' perspective. Afr. Crop Sci. J., 14(2): 157-164.

Barker J (1999). Evaluating the Poverty Impact of Projects: A Handbook for practitioners. LCSPR/PRMPO. The World Bank.

Davis K, Nkonya E (2008). Developing a methodology for assessing the impact of farmer field schools in East Africa. Proceedings of the 24th Annual Meeting of the Association for International Agricultural and Extension Education (AIAEE), 93–99. College Station, Texas. Association for International Agricultural and Extension Education.

ISAR (2007). Sustainable agricultural productivity for improved food security and livelihoods, proceedings of the national conference on agricultural research outputs. 25-27 March, 2007. Serena Hotel, Kigali, Rwanda.

Karamura E, Frison E, Karamura DA, Sharrock S (1998). Banana production systems in eastern and southern Africa In: Picq C, Foure E and Frison E (eds) (1998). Bananas and food security. INIBAP, Montpellier, pp. 401-412.

Karamura EB (2006). Assessing the Impact of the Banana Bacterial Wilt, *Xanthomonas campestris* pv. *musacearum* (BXW) on Household Livelihoods in East Africa: Final technical Report Project R8437 (ZA0661) to DFID. Crop Protection Programme.

Karamura EB, Osiru M, Blomme G, Lusty C, Picq C (eds). 2006. Developing a regional Strategy to address the outbreak of Banana *Xanthomonas* wilt in East and Central Africa. Proceedings of the Banana *Xanthomonas* wilt regional preparedness and strategy development workshop held in Kampala, Uganda. 14-18 February 2005. INIBAP, Montipellier, France.

Karamura EB, Turyagyenda FL, Tinzaara W, Blomme G, Ssekiwoko F, Eden-Green SJ, Molina A, Markham R (2008). *Xanthomonas* wilt of bananas in East and Central Africa: Diagnostic and Management Guide. Bioversity International, Uganda.

Mbaka JN, Nakato VG, Auma J, Odero B (2009). Status of banana Xanthomonas wilt in western Kenya and factors enhancing its spread. Afr. Crop Sci. Confer. Proc., 9: 673-676.

Muhangi J, Nankinga C, Tushemereirwe WK, Rutherford M, Ragama P, Nowakunda K, Abeyasekera S (2006). Impact of awareness campaigns for banana bacterial wilt control in Uganda. Afr. Crop Sci. J., 14 (2): 175-183.

Ndungo V, Eden-Green S, Blomme G, Crozier J, Smith JJ (2006). Presence of banana xanthomonas wilt (*Xanthomonas campestris* pv. *Musacearum*) in the Democratic Republic of Congo (DRC). Plant Pathol., 55: 294.

Ngambeki DS, Tushemereirwe WK, Okaasai O (2006). Awareness of banana bacterial wilt control in Uganda: community leaders perspective. Afr. Crop Sci. J., 14(2): 165-173.

Nkonya E, Davis K (2008). The statistical challenges of attributing impacts of demand driven advisory service programs and farmer field schools in Africa. Paper presented at the workshop on: Rethinking Impact: understanding the complexity of Poverty and Change, Colombia, March 26-29, 2008.

Smale M, Diakite L, Sidibe A, Grum M, Jones H (2008). An econometric analysis of the impact of farmer participation in diversity field fora in Mali. Unpublished manuscript, International Food Policy Research Institute, Washington D.C.

Tushemereirwe WK, Kangire A, Smith J, Nakyanzi M, Kataama D, Musiitwa, C (2001). An outbreak of banana bacterial wilt in Mukono district: A new and devastating disease. National Banana Programme. Kawanda Agricultural Research Organisation.

Tushemereirwe WK, Kangire A, Smith J, Ssekiwoko F, Nakyanzi M, Kataama D, Musiitwa C (2003). An outbreak of banana bacterial wilt in Uganda. Infomusa, 12: 6-8.