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Adverse impact of Banana Xanthomonas Wilt on farmers' livelihoods in Eastern and Central Africa

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Banana is a key crop in the livelihoods of many people in the Great Lakes region of East and Central Africa. For more than a decade now, the crop has been threatened by Banana Xanthomonas Wilt (BXW) which has spread throughout the region but at different rates. The disease attacks all banana cultivars and can cause up to 100% yield losses at farm level if effective control measures are not put in place. However, limited information on impact of BXW at regional level is available to guide interventions. Thus, this study assessed the impact of BXW on farmers' livelihoods in Kagera basin of Tanzania, Burundi and Rwanda. A total of 436 households (Tanzania 120, Burundi 208 and Rwanda 108) mostly from major banana-producing and BXW-affected districts were sampled and interviewed in a household survey. Thirty-three to seventy-five of the total banana mats per farm in the three countries were infected with BXW. Banana production losses caused by BXW were valued at US$ 10.2 million and US$ 2.95 million in Tanzania and Rwanda, respectively, banana sales by farmers dropped by 35% while bunch prices unpredictably doubled. Since banana is a key component of these farming communities, the banana production losses resulted in significant reduction in household food security and incomes. To cope with these challenges, most households are diversifying into other food crops such as maize, cassava and sweet potatoes. This poses a number of socio-economic and biological implications that require further investigation.

Key words: Banana Xanthomonas Wilt incidence, economic loss, food security.

INTRODUCTION

Banana is an important crop for the livelihoods of people in the Great Lakes region of East and Central Africa (ECA) including Burundi, Rwanda, eastern Democratic Republic of Congo (DR Congo), Uganda, western Kenya

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and north western Tanzania (Sharrock and Frison, 1999). In this region, annual per capita consumption of banana ranges from 400-600 kg, the highest in the world (Kalyebara et al., 2006). Currently, the livelihoods of banana farmers in these areas are threatened by Banana Xanthomonas Wilt (BXW) disease. The disease was first reported in the region in 2001 in Uganda and DR Congo (Tushemereirwe et al*.,* 2003), 2002 in Rwanda, 2005 in Tanzania and Kenya (Karamura et al*.,* 2005), and 2010 in Burundi (Niko et al*.,* 2011). Since the outbreak of the disease in ECA region, a number of efforts to elucidate both pathogenesis and epidemics have been undertaken in order to develop and fine tune management practices (Biruma et al., 2007; Karamura and Tinzaara, 2009).

All banana germplasm in ECA, including endemic highland cooking and brewing cultivars (AAA-EA), exotic brewing, dessert and roasting types (AB, AAA, AAB, ABB), and hybrids, are susceptible to the disease. Some ABB cultivars, for example, 'Pisang awak, are particularly susceptible to insect vector transmission and are believed to facilitate the rapid spread of the disease (Tushemereirwe et al., 2003). Some cultivars such as Dwarf Cavendish (AAA desert) which has persistent male bracts escape insect transmission. Unlike other diseases which cause gradually increasing losses over years, the impact of BXW is both extreme and rapid. The economic impact of BXW is due to death of the whole mat that would otherwise contribute to the ratoon plant production cycles. This disease has similarities to other bacterial wilts of banana, caused by *Ralstonia solanacearum* (Thwaites et al., 2000). Once these pathogens have become established, disease control is very difficult (Eden-Green, 2004).

In Uganda, at the height of epidemics (between 2001 and 2004), 33% of the total banana mats were infected with BXW in four heavily affected districts (Karamura et al., 2010). Total banana yield losses due to BXW infection were estimated at 10-17% per year during this period (Kalyebala et al., 2006). In DR Congo a study by Mwangi et al. (2006) estimated household income losses of about US$ 1500 per year. However, to the best of our knowledge, the few BXW socio-economic studies that have been done to date did not fully quantify the economic losses and BXW effects on household food security and incomes in the other EAC countries of Tanzania, Rwanda and Burundi which have been also greatly affected by BXW disease in banana production. Quantifying the economic losses due to BXW is critical for generating evidence to support policy advocacy for investment of resources by stakeholders (government, private sector, research and extension services) in managing the disease.

The overall objective of this study, therefore, was to assess the socio-economic impact of BXW disease on livelihoods of people of Burundi, Rwanda and Tanzania. Specifically, the study aimed at (i) assessing the spread of BXW disease, (ii) quantifying the economic loss due to BXW disease, and (iii) assessing the impact on household food security due to BXW disease in different banana farming communities.

METHODOLOGY

Household surveys between 2009 - 2011 was conducted in seven districts of Kagera region of Tanzania, sixteen provinces of Burundi and twelve districts of Rwanda for comparison between different communities. Selection of the sites was based on banana production potential, and incidence and intensity of BXW. A total of 120 households were purposely sampled in Kagera region, 208 households in Burundi and 108 households in Rwanda. A common structured household questionnaire was administered through face-to-face interviews. Data were collected on banana production constraints, number of banana plants (mats) affected by BXW, number of banana plants uprooted after being affected by BXW, banana production, consumption, banana sales before and after BXW attack, food security status and coping mechanism in relation to BXW and post-harvest products produced. Secondary data was obtained from local government offices in districts or provincial offices of each country. Data analysis was done using SPSS statistical software. Descriptive analysis of means, cross tabulations and variances were used to examine differences in various factors between BXW affected and unaffected farm households. The extrapolation method was used to compute the estimated banana economic losses resulting from BXW effect. Where applicable, a student's-test at 0.05 level of significance was performed to examine differences between variables such as before and after BXW outbreak, and between well and poorly managed banana farms.

RESULTS AND DISCUSSION

Ranking of BXW versus other banana production constraints

Farmers' ranking of banana production constraints in Burundi, Rwanda and Tanzania show that BXW disease was ranked first by most farmers (Figure 1). The importance of other banana constraints greatly varied between countries. Banana weevils (*Cosmopolites sordidus*), nematodes (including *Radopholus similis*, *Helicotylenchus multicinctus* and *Pratylenchus goodeyi*), Fusarium wilt (*Fusarium oxysporum cv cubence*) and Black Sigatoka (*Mycosphaerella fijiensis*) followed in that order for Tanzania.

In Rwanda, the second banana production constraint was Fusarium wilt followed by Black Sigatoka and Banana Bunchy Top Virus (BBTV) while in Burundi the second constraint was Fusarium wilt, BBTV, banana weevils and nematodes. The high ranking of BXW is probably due to the high yield losses the disease causes (up to 100 percent loss) if not controlled early enough (Karamura et al., 2010). This implies that for any banana intervention or investment, the control of BXW should be given first priority.

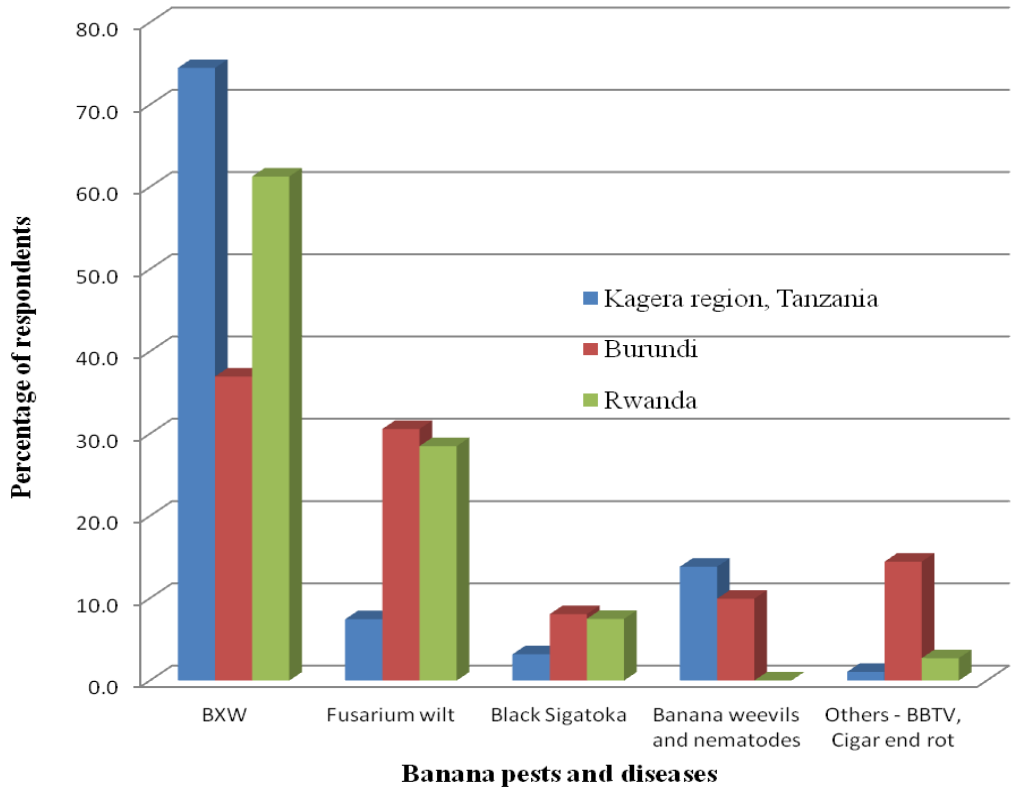

Figure 1. Farmers perceptions on importance of BXW compared with other banana pests and diseases.

BXW spread and banana management

The BXW spread was differently experienced between countries. In Kagera region of Tanzania, a total of 20,735 banana-growing households were reported by agricultural district departments to have farms infected with BXW disease in 2011. This was equivalent to 44% BXW incidence of the total villages found in that region (Table 1). About 30 banana mats per household were affected by BXW disease (Table 2). The highest number of affected farms was in Bukoba district (11,876) followed by Muleba district (6,035). However, Karagwe district had the highest percentage (73%) of villages affected by the disease. Biharamulo district was the only district that managed to control the disease after its outbreak in two wards in 2008.

BXW was first reported in Rwanda in 2005 (Reeder et al., 2007) in the district of Rubavu, Western Province, but farmers reported symptoms as having appeared in their fields in 2003. Percentage of banana fields with BXW was highest in Rutsiro (89%) and lowest in Gakenke, Kayonza and Ruhango (11%). The disease was not found in Kicukiro and in Ngoma. On average, the BXW incidence was highest in Rutsiro (35.9%) and lowest in Kayonza (1.1%). In Burundi, BXW disease was first confirmed in November 2010 in 11 of the 16 provinces of the country with a mean incidence of 25.5% of banana households. On average, 33% of the total banana mats per household were infected with BXW disease.

The incidence of BXW was slightly different between poorly and well managed fields. About 56 and 44% of poorly and well-managed farms, respectively were affected by BXW disease. However, the chances of BXW infection were not significantly different between well-managed and poorly-managed banana farms ($P < 0.05$). Likewise, the incidence of BXW was not significantly different between age categories of banana fields. About 80% of banana fields were more than 20 years old. This implies that farmers' knowledge on BXW spread mechanisms, symptoms and control options were almost the same between farmers with well and poorly managed fields as well as between farm age categories. Therefore, implementation of interventions to control the BXW disease should be equally imparted to all farmers with well and poor managed banana fields. The previous BXW awareness campaigns conducted through conventional extension approaches created good awareness to banana communities (Karamura and Tinzaara, 2009). In

Table 1. BXW incidences in Kagera region, June 2011.

District	Total number of villages	Villages affected with BXW (%)
Bukoba	92	68
Muleba	161	44
Missenyi	74	51
Karagwe	117	73
Biharamulo	74	0
Ngara	68	2
Total	586	44

Table 2. Number of banana mats affected by BXW disease per household in Kagera June 2011.

District	No. of mats affected by BXW	No. of households affected by BXW	Average number of banana mats affected by BXW per household
Bukoba	58,883	11,876	5
Muleba	67,200	6,035	11
Misenyi	10,920	650	17
Karagwe	460,086	2,134	217
Biharamulo	0	0	-
Ngara	17,776	80	222
Total	614,865	20,735	30

some cases, awareness on BXW management by farmers was high but adoption of control measures on affected farms was very low. For instance, in Tanzania and Rwanda where 92.5 and 60.8% of the farmers were knowledge-able on early de-budding of male flower by forked sticks, only 13 and 47% of them practiced the measures, respectively. This calls for strengthening jointly efforts and promotion of management technologies through partici-patory dissemination approaches accompanied by by-law enforcement of crop disease control by communities and local government authorities.

In Kagera, the proportion of BXW infected mats per household ranged from a single diseased mat to a whole banana field. The majority of farmers had proportion infection between 1 and 30% of their fields. Karagwe had the highest number of infected mats per household followed by Muleba, Bukoba, Ngara and then Missenyi. The average number of banana mats affected by BXW per household ranged from 5 to 222 with an overall average of 30 mats (Table 2). The difference could be attributed to differences in adoption rates of control measures among communities caused by differences in levels of awareness creation activities, importance of banana crop in the respective communities and level of by-law enforcement. Karagwe farmers were less aware of the disease symptoms, spread mechanisms and the recommended BXW control measures as compared to other districts. Farmers' knowledge on BXW management and awareness creation needs to be improved. The mechanisms of spread of BXW are mainly by insects such as bees, working tools, water runoff, grazing livestock and through planting effected planting materials (Karamura et al., 2005; Tushemereirwe et al., 2006). Therefore, based on the nature of the spread of the disease, community or participatory approaches should be emphasised in creating awareness of the disease and its management. Where creation of awareness on BXW and its control measures are done, then the application by farmers can be strengthened by the respective community organs or leadership.

Estimation of economic losses caused by BXW disease

Number of banana bunches harvested before and after BXW was significantly different in all countries ($P < 0.05$). Similarly, banana bunches per household sold and consumed before and after BXW were significantly different (Table 3). For instance, in Kagera region, there were enormous decline in banana products produced per month per household after BXW (Table 3). A decline was recorded in production of banana juice and beer by 62 and 64% after banana succumbed to BXW disease,

Table 3. Banana bunches harvested and products before and after BXW.

Products produced per household per month	Before BXW outbreak	After BXW outbreak	% Change (decline)
Banana juice (litres)	99.0*	37.2*	62
Banana beer (litres)	153.0*	54.7*	64
Number of bunches sold	9.4*	6.1*	35
Number of bunches consumed	11.0*	8.3*	25

*Significant at 0.05 level.

Table 4. Estimated banana economic loss caused by BXW in Kagera region in 2012.

District	No. of mats affected by BXW	Economic loss(TSh)	Economic loss(US$)
Bukoba	58,883	1,472,075,000	981,383
Muleba	67,200	1,680,000,000	1,120,000
Misenyi	10,920	273,000,000	182,000
Karagwe	460,086	11,502,150,000	7,668,100
Biharamulo	0	-	-
Ngara	17,776	444,400,000	296,267
Total	614,865	15,371,625,000	10,247,750

Assumption: One banana mat can produce 2.5 bunches per year and recovering period is 2 years.

respectively. Also, a dramatic decline in number of banana bunches sold and consumed per household was reduced by 35 and 25%, respectively (Table 3). In addition, banana price per bunch increased from an average of US$ 3.30 in 2007 before the BXW became a threat problem to US$ 4.80 during BXW peak in 2009, an equivalent increase of 46% of banana farm gate price.

BXW disease has negatively affected banana production and consequently the income accrued from banana sales dramatically dropped. It is estimated that a total banana economic loss of US$ 14.05 million was caused by BXW disease in the three countries of Tanzania, Rwanda and Burundi by 2012. The estimated monetary losses as a result of BXW infection in different districts of Kagera region are presented in Table 4. The total monetary loss due to BXW disease was about US$ 10.2 million (equivalent to 3 - 5% of the total banana value in Kagera region) excluding the recovery costs. Karagwe district had a huge loss accounting for over US$7.5 million. Similarly, at farm level in Burundi, harvest losses per household ranged from 65 to 99% in the BXW victim households in the three counties. Production losses of cooking banana which is a key to food security were 80%. Losses in beer and dessert types grown mainly for income ranged from 73 to 87%. In all the three countries, farmers cope with multiple strategies including increased cultivation of other crops such as maize, cassava and sweet potatoes and rearing animals.

In Rwanda, the BXW affected area of banana production in 2007 was estimated to be 433 ha of bananas with an economic loss of USD 638,675. In 2009, the estimated area affected by BXW was 2,000 hectares, that is, about five times more in period of two years which is equivalent to economic losses of US$ 2.95 million. Banana prices at farm gates dramatically increased by 33 to 100%. In Rwanda, price per bunch ranged from US$ 0.4 to US$ 4.00 before BXW, but they ranged from US$ 0.53 to US$ 8.00 during BXW peak period.

Banana fields in Burundi were affected by BXW much later as compared to the other two countries. In this country, it was estimated that on average, 33% of the total banana mats per household were infected by BXW since first reported in November 2010. In all areas, BXW rapidly reduced banana yields between 65 and 99%. The total banana economic loss caused by BXW outbreak in Burundi was estimated at US$ 0.9 million. About 8% of BXW affected households abandoned completely banana production.

Effect of BXW on household food security and dietary intake

Household food security was heavily affected by the outbreak of BXW in these countries. Usually, over 50% of the household diet comes from bananas (Table 5) in Kagera region. Likewise, banana contributes substantially to household diets in Rwanda with 32% of the households having banana contributing more than 50% to their diets (Table 5). The outbreak of BXW affected

Table 5. Contribution of bananas to household diet and coping mechanisms.

Criteria		Percentage	
		Tanzania (Kagera region)	Rwanda
(a) Contribution of banana to a household diet			
(0)	No contribution	8	10
(1)	less than 25%	14	32
(2)	between 26% and 50%	28	25
(3)	More than 50%	50	33
(b) Number of days in a week consume bananas either raw or cooked:			
(0)	We don't consume banana or plantain	8	-
(1)	< 2 days in a week	18	-
(2)	3-5 days in a week	53	-
(3)	Every day of the week	20	-
(c) Effect of outbreak of BXW to household diet:			
(0)	Not at all	30	50
(1)	Averagely	28	12
(2)	Affected very much	42	38

about 34 and 44% of the villages in Kagera in 2009 and 2011, respectively. About 70% of the interviewed farmers reported that there was a significant change in their dietary patterns due to the outbreak of BXW disease. Household food security was assessed as per measures developed by Webb et al. (2006) and Maxwell (1996).

About 42 and 38% of respondents reported that BXW affected household diet 'very much' in Tanzania and Rwanda, respectively (Table 5). The majority of households in Rwanda (46.1%) had two meals per day while 38.5% had three meals per day. One meal per day was reported by 14.4% of households and only 1% of households reported having four meals per day. For households having only one or two meals per day, the respondents reported either poor farm production (12%), lack of money (22%) or both reasons (66%). Lack of money has implications for access to food and also poor households are unable to access food not grown on their farm. The coping strategies of households whose banana farms were affected by BXW include eating substitute foods such as maize, root and tuber crops, and reduced number of meals and amount of food.

In the communities affected by BXW disease, the percentage of households who were not able to eat the food preferred in all months of the year increased from 14% before the BXW disease reference to 64% after affected by BXW. Thus, there was an increase in the occurrence of failing to get the food preferred by 50% for the households whose banana farms are affected by BXW (Table 6).

The results show that the percentage of households eating a smaller meal than desired increased from 16% before the BXW disease to 59% after banana farms were affected by BXW. The percentage of households who ate fewer meals in a day because there was not enough food increased from 20% before BXW to 50% after BXW infection with slight differences between countries (Table 6).

Farmers' coping mechanisms included consuming other foods such as maize and root and tuber crops (36%), reducing number and size of meals (10%) or both strategies (42%). Banana farmers reported increasing the cultivation of maize, root and tuber crops, and rearing of small ruminant animals. Although selling of household assets in order to buy food preferred was not recorded, in long run, households will be forced if BXW control measures are not adopted.

Conclusion and recommendations

People's livelihoods are at high risk due to outbreak of BXW disease. Up to June 2011, the BXW disease was still spreading in the region due to the fact that a number of farmers and their respective communities are not adhering to the BXW control measures. Banana yield losses caused by BXW disease was 3 - 5% of the total banana production up to 2012. BXW disease rapidly caused a decline in production of banana juice and beer by more than 62%. Amount of banana bunches sold and consumed per household dramatically declined by 35 and 25%, respectively. Banana prices at farm gate dramatically increased by 33 to 100% in all areas affected by BXW. This poses a big threat to the household food security, income and assets in long term if effective BXW control measures are not in place. Before the outbreak of BXW disease, about 50% of the household diet came from bananas. However, the outbreak of BXW disease

Table 6. Household food security status before, during and after affection of banana farms with BXW disease.

Criteria		Tanzania		Rwanda	
		Before BXW	BXW Peak	Before BXW	BXW Peak
1. Households not able to eat food preferred:					
(i)	Percentage	36.7	64.2	14	56.3
Frequency of happening:					
(i)	Rarely	47.7	24.6	71.4	35.4
(ii)	Often	52.3	75.4	28.6	64.6
Reasons for household members not able to eat food preferred:					
(i)	Lack of crop variety in farm	56.8	10.4		
(ii)	Lack of enough farm produce	11.5	44.1		
(iii)	Lack of money	9.0	2.6		
(iv)	All the above	22.7	42.8		
2. Households eating a smaller meal than needed amount:					
(i)	Percentage	15.8	47.5	20.0	58.9
(b) Frequency of happening:					
(i)	Rarely	68.1	38.9	63.4	37.4
(ii)	Often	31.9	61.1	36.4	62.8
3. Household members eating fewer meals in a day because there was no food:					
(i)	Households eaten fewer meals	20.0	44.2	29.2	50.0
(b) Frequency of happening:					
(i)	Rarely	41.5	26.5	56.0	23.8
(ii)	Sometimes	12.5	13.1	8.0	16.0
(iii)	Often	46.0	60.4	36.0	59.5

has affected the household dietary by 70%. As coping mechanisms, the food deficit caused by BXW effect is supplemented by other food crops such as maize, cassava and sweet potatoes, which has many implications in many socio-economic and biological aspects not investigated by this study. Therefore, sustainable joint efforts from all stakeholders are needed to rescue banana dependent families in the ECA region including by-law enforcement on BXW control measures by each community. In short-medium term, consumption of other foods as a coping strategy suggests that other crops should be promoted to mitigate the effects of BXW. However, clean banana planting material should also be availed to farmers who wish to replant banana after complete destruction of banana mats or entire fields.

Conflict of Interest

The authors did not declare any conflict of interest.

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