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16 Distribution, Incidence and Farmer Knowledge of Banana Xanthomonas Wilt in Rwanda

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Abstract

Banana Xanthomonas wilt was reported in Rwanda in 2005. The present study was conducted to determine the distribution and incidence of the disease and farmer knowledge of disease symptoms, modes of spread and control. A survey was conducted in Rwanda in 2009–2010 in 12 major banana-growing districts of the country. One hundred and eight banana growers were interviewed using a structured questionnaire. Farmers were asked about knowledge of disease symptoms, spread, control and use of control methods. They were also asked about their sources of information on Xanthomonas wilt. Direct field observations were made of the distribution and incidence of the disease as well. The proportion of fields with Xanthomonas wilt was highest in Rutsiro (89%) and lowest in Kayonza and Ruhango (11%). The disease was not found in Gakenke, Kicukiro or Ngoma. Within-farm incidence was highest in Rutsiro (average 36%) and lowest in Kayonza (1%). The awareness of disease symptoms ranged from 53% (discoloured fruit pulp) to 84% (wilting leaves). For modes of spread, the highest proportion of farmers (73%) was aware of the role of contaminated tools while the least known mode was spread via soil and water (24%). Some 72% of famers were aware of uprooting plants as a control measure. There were large differences between awareness and use of tool disinfection and destruction of infected plants as control measures. There is a need to develop user-friendly methods of disease control. The creation of awareness in newly affected and Xanthomonas wilt-free areas is advocated. Participatory approaches are encouraged as they may reduce the gap between knowledge and adoption of control measures.

16.1 Introduction

Banana Xanthomonas wilt caused by *Xathomonas campestris* pv. *musacearum* is characterized by several symptoms: wilting leaves; yellow ooze from severed pseudostems, fingers and other plant parts; premature ripening; discoloration of fruit pulp; and rotting of

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male buds (Smith *et al*., 2008). Recently, Aritua *et al*., (2008) suggested reclassification of the pathogen as *X. vasicola* pv. *musacearum*. The disease causes plant death and total loss of yield as the infected fruit cannot be consumed by humans or livestock. It is transmitted through infected plant material, contaminated tools, insects visiting male buds and animals coming into contact with infected material, as well as via soil and water (Tinzaara *et al*., 2006; Biruma *et al*., 2007). Methods recommended for management of the disease are the destruction of infected plant material, early disbudding (removal of the male bud), disinfection of tools and quarantine (Muhangi *et al*., 2006; Biruma *et al*., 2007).

Xanthomonas wilt first existed only in Ethiopia on enset (*Ensete ventricosum*) and banana (*Musa* spp.) (Yirgou and Bradbury, 1968, 1974). The disease currently affects banana in several countries of eastern, central and southern Africa. Banana Xanthomonas wilt 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 2002.

When Xanthomonas wilt was reported in Rwanda, a National Task Force was set up to combat it and this drew up a management strategy with a focus on raising awareness (through meetings, mass media, posters and pamphlets), eradication of infected plants through community work ('umuganda') as well as individual initiatives, training and local quarantine. Further interventions included a campaign to eradicate infected plants by uprooting, training of trainers and the formation of task forces at district, sector and cellule levels (administrative divisions in order of decreasing size). In spite of these efforts, Xanthomonas wilt has continued to spread.

The status of Xanthomonas wilt in different areas of Rwanda ranges from contained outbreaks to endemic. Furthermore, resurgence has occurred in some of the areas where the disease was thought to have been contained. There is, therefore, a need to determine the current status of the disease. Moreover, control interventions depend on the status of the disease, differing in endemic, front-line, threatened or disease-free areas (Smith *et al*., 2008). Levels of awareness of Xanthomonas wilt among farmers are key in the implementation of disease management programmes (Bagamba *et al*., 2006).

The present study had the specific objectives of establishing and updating information on: (i) distribution and incidence of Xanthomonas wilt in Rwanda; (ii) farmers' knowledge of disease symptoms and mechanisms of spread; (iii) knowledge and use of control methods by farmers.

16.2 Methods

A survey was conducted to determine disease status in areas where the disease has been reported, to assess disease advance in reportedly free areas and to investigate farmer knowledge of the disease. The survey was carried out in districts where Xanthomonas wilt has been reported (existing or contained) and in those where it has not been reported, and was conducted from December 2009 to January 2010. Twelve districts were surveyed (Plate 14). Three sectors were randomly selected and surveyed in each district, with the exception of Kicukiro District, in which the sole sector where banana is grown (Masaka) was selected. Three fields were randomly selected in each sector, from at least two different cellules. In Kicukiro District, however, sites were selected from six different cellules of one sector (Masaka). The criterion used for site selection was a banana field having at least 20 mats (stools). Distance between fields was at least 5 km. In total, 108 farmers, nine from each district, were interviewed using a structured questionnaire. Questions addressed to farmers included knowledge of disease symptoms, spread and control, and use of control methods. Direct field observations were also made of the incidence of Xanthomonas wilt. Twenty stools selected along two diagonals (ten stools on each diagonal) were observed for absence or presence of symptoms of Xanthomonas wilt. Stools were scored as '0' when symptom free and '1' when they presented symptoms of the disease.

The farms that were investigated were spatially located using handheld global positioning system (GPS) units with at least 3 m accuracy. Incidence of banana Xanthomonas

wilt (BXW) was determined by calculating the proportion of affected mats among those selected. Incidence data were joined to GPS coordinates plotted and mapped using ArcGIS (Version 9.3). Symbols of proportional size were used for illustrating the spatial patterns of wilt incidence at farm level. Data were analysed using the Statistical Analysis System (SAS, Version 9.1). Descriptive statistics (percentages of respondents) were calculated to determine the proportions of farmers having knowledge of a given subject (different symptoms, methods of spread and control) or using a particular technique to control Xanthomonas wilt. Fisher's Exact Test was used to determine whether there was an effect of awareness of symptoms (know or do not know) on the correct estimation of disease incidence within the field (correct or incorrect).

16.3 Results and Discussion

16.3.1 Status of Xanthomonas wilt on farms

The districts of Rutsiro, Rubavu, Nyamasheke, Musanze and Karongi had the highest proportions of sites/farms infected with Xanthomonas wilt (Fig. 16.1). None of them has received as much attention to disease management as Rubavu. Banana Xanthomonas wilt arrived in Rutsiro in 2007, but limited interventions in terms of disease control have been made there. The other three districts (Nyamasheke, Musanze and Karongi) have newer infections. Rulindo had a low incidence of the disease, although it was the second district where it was reported. This may be attributed to the fact that the district is not a major banana-growing area. Gakenke, Kicukiro and Ngoma districts were free of Xanthomonas wilt.

Some 37% of respondents indicated that they had Xanthomonas wilt on their farms at the time of the survey, and 63% said that it was absent from their farms. The survey observations indicated that 33% of the farms had mats with symptoms of Xanthomonas wilt. These incidences underline the importance that the disease has assumed over the last 5 years.

Disease incidences of 10–40% were found in 51% of the farms, and incidences of 40–70% were found on 16% of farms. The highest mean within-farm Xanthomonas wilt incidences were observed in the districts of Rutsiro, Rubavu and Nyamasheke (Table 16.1; Plate 15). These levels are high and suggest large potential economic losses. Kalyebara *et al*. (2006) estimated annual losses of US$200/household if Xanthomonas wilt was not controlled in Uganda, where incidence varied from 10% to 71%. Further studies are required to determine the economic losses

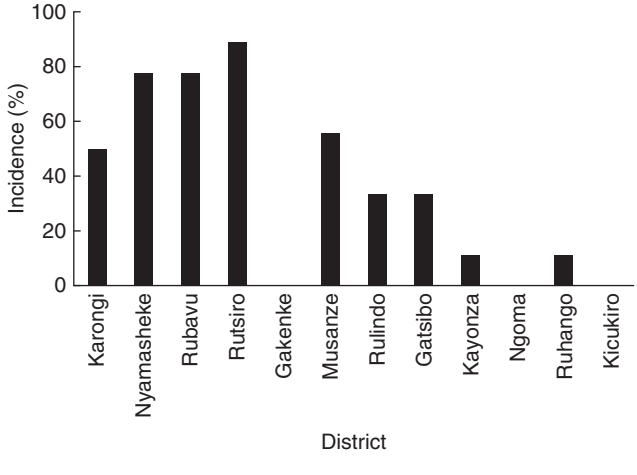

Fig. 16.1. Proportion of sites/farms with Xanthomonas wilt infection in different districts of Rwanda surveyed in 2009–2010.

Table 16.1. Proportion of plants (mean ± SE) infected by Xanthomonas wilt within farms/sites (n = 9) in Rwanda, 2009–2010. Means followed by the same letter are not significantly different at P = 0.05.

District	% infected plants
Gakenke	0.0 ± 0.0b
Gatsibo	3.9 ± 2.9b
Karongi	7.8 ± 3.3b
Kayonza	1.1 ± 1.1b
Kicukiro	0.0 ± 0.0b
Musanze	11.8 ± 5.8bc
Ngoma	0.0 ± 0.0b
Nyamasheke	16.2 ± 4.8ac
Rubavu	26.1 ± 8.2ac
Ruhango	3.9 ± 3.3b
Rulindo	12.0 ± 7.7ac
Rutsiro	35.9 ± 8.6a

Table 16.2. Incidence of Xanthomonas wilt within fields reported by farmers and observed by interviewers on farms with the disease in Rwanda, 2009–2010.

	Proportion (%) of plants with symptoms	
Incidence range (%)	Farmer estimates (n = 42)	Interviewer observations (n = 37)
<10	47.6	27.0
10–40	23.8	51.4
40–70	7.1	16.2
>70	21.4	5.4

due to Xanthomonas wilt in Rwanda. Some 60% of respondents indicated that Xanthomonas wilt was increasing on their farms, while 36% thought that it was decreasing; only 4% thought that it was constant.

Banana Xanthomonas wilt incidence within fields, as estimated by farmers and as observed by interviewers, differed (Table 16.2). Farmers tended to overestimate extreme incidence levels (<10% and >70%) and underestimate moderate levels (10–70%). However, the farmers' ability to accurately determine incidence levels was not related to whether they were able to recognize disease symptoms in terms of discoloration of fruit pulp (χ^2 = 0.89; P = 0.61), wilting leaves (all farmers who had Xanthomonas wilt knew), yellow ooze from stems (χ^2= 0.21; P = 1.00), premature fruit ripening (χ^2 = 0.87; P = 1.00) or rotting of the fruit (χ^2 = 0.07; P = 1.00).

16.3.2 Awareness of Xanthomonas wilt symptoms

Some 97% of respondents had heard of Xanthomonas wilt before the survey; only 3% had not, and having heard of Xanthomonas wilt was independent of district (Fisher's exact test $P \leq 0.85$). Awareness of Xanthomonas wilt symptoms was high (Table 16.3). Most farmers were aware of wilting leaves (84%), premature ripening (71%) and yellow ooze from cut plant parts (67%) as symptoms of Xanthomonas wilt. Discoloration of fruit pulp and rotting of the male bud were less well known as symptoms, and significantly so compared with the previously mentioned three symptoms, although at least half of the respondents were aware of these other two symptoms. Knowledge of all Xanthomonas wilt symptoms except for rotting of male buds was influenced by district. In general, awareness of the different symptoms varied by district, with knowledge of one symptom not automatically implying knowledge of other symptoms. Notably low levels of knowledge were noted in the districts of Gakenke (25% for discoloration of pulp, premature ripening and rotting of male bud to 63% for wilting leaves), Ngoma (22% for pulp discoloration to 67% for wilting leaves) and Ruhango (25% for all symptoms).

16.3.3 Awareness of modes of spread

Farmers were most aware of contaminated tools, insects, infected planting material and infected plant parts as means of spread of Xanthomonas wilt (Table 16.4). Awareness of disease spread by water and soil, domestic animals and flying animals was significantly lower (P = 0.05), while knowledge of spread by infected plant parts was moderate. Low levels of awareness for these modes of spread were not influenced by district

Table 16.3. Awareness of farmers of the symptoms of Xanthomonas wilt in the 12 districts of Rwanda surveyed in 2009–2010. Means followed by the same letter are not significantly different at $P = 0.05$.

Symptom	Proportion (%, mean ± SE) of respondents aware of symptoms	No. respondents
Wilting leaves	83.2 ± 6.7a	88
Premature ripening	70.4 ± 8.0ab	74
Yellow ooze	66.3 ± 7.4ab	70
Rotting male bud	55.0 ± 6.2b	57
Discoloration of fruit pulp	53.9 ± 9.3b	55

Table 16.4. Awareness of farmers of the mode of spread of Xanthomonas wilt in the 12 districts of Rwanda surveyed in 2009–2010. Means followed by the same letter (a, b) are not significantly different at $P = 0.05$.

Mode of spread	Proportion (%, mean ± SE) of respondents aware of mode of spread	No. respondents
Contaminated tools	71.7 ± 7.9a	74
Insects	63.7 ± 6.5a	64
Infected planting material	61.2 ± 7.2a	62
Infected plant parts	55.1 ± 6.8ab	56
Flying animals	37.8 ± 6.3b	38
Cattle and goats	26.8 ± 5.8b	27
Water and soil	23.4 ± 6.7b	24

(i.e. they were low regardless of district). Awareness of contaminated tools as a means of disease spread was uniformly high across districts. In contrast, awareness of infected planting material as means of Xanthomonas wilt spread was strongly influenced by district. Several districts had low levels of awareness of various means of disease spread compared with others: Gakenke, 0% for transmission by water and soil or cattle and goats, up to 29% for transmission by insects or tools; Ngoma, 0% for transmission by cattle and goats, up to 33% for transmission by tools or infected planting material; and Ruhango, 13% for transmission by water and soil or cattle and goats, up to 38% for transmission by tools.

These levels of awareness are higher than those reported by Bagamba *et al*. (2006) in Uganda. In their study, the highest levels of awareness of means of disease transmission were 39% for flying insects, followed by 27% for contaminated tools; the lowest levels of awareness were for flying and walking animals (2%), soil (3%) and water (4%).

16.3.4 Awareness and use of control methods of Xanthomonas wilt

The awareness of different methods of Xanthomonas wilt control varied among farmers (Table 16.5). Awareness of the destruction of plants by uprooting, removal of male buds, cutting or burying plants and tool disinfection as control measures was very high. The removal of male buds, while a method of Xanthomonas wilt control, is also a common agronomic practice among banana growers. However, in Uganda, farmers do not commonly remove male buds of beer bananas (AAA-EA), and this has facilitated spread of Xanthomonas wilt (Bagamba *et al*., 2006; Kagezi *et al*., 2006). Farmers in Uganda cite reduction of beer quality and labour requirements as reasons for not removing male buds from beer bananas, although in Rwanda, levels of awareness of the removal of male buds for wilt control and the practice of this method were similar.

Table 16.5. Awareness of farmers of methods for control of Xanthomonas wilt and their use in the 12 districts of Rwanda surveyed in 2009–2010. Means followed by letters a–c in a column or x, y in a row are not significantly different at $P = 0.05$.

	Proportion (%, mean ± SE) and number of respondents			
Method of control	% aware of control method	No. respondents	% currently using control method	No. respondents
Uprooting plants	70.4 ± 8.9ax	68	37.1 ± 9.2aby	32
Removal of male buds	68.2 ± 8.8ax	66	55.2 ± 7.3ax	48
Cutting plants	63.5 ± 7.5ax	59	17.9 ± 6.6bcy	27
Burying plants	63.2 ± 9.2ax	62	31.0 ± 9.1aby	28
Tool disinfection	56.8 ± 7.6abx	58	30.2 ± 5.5by	24
Use of pruning knife	34.6 ± 7.3bx	31	30.1 ± 6.5bx	31
Use of forked stick	23.5 ± 6.9bcx	23	15.5 ± 4.9bcx	31
Use of clean planting material	20.9 ± 4.5bcx	18	12.9 ± 3.5cx	8
Breaking with hand	10.2 ± 3.0cx	9	7.4 ± 3.4cx	5
Burning plants	8.8 ± 3.7cx	8	0.0dy	0
Quarantine	8.1 ± 3.1cx	7	6.6 ± 2.9cx	1

Early removal of male buds is recommended for Xanthomonas wilt control as a means of preventing insect transmission. Use of a pruning knife to do this is not recommended as sap on the knife can easily contaminate healthy plants if disinfection is not carried out. Therefore, removal of male buds using a (forked) stick or breaking by hand is recommended. In this study, use of a pruning knife was practised by 30% of the farmers. These observations demonstrate the importance of communicating clear messages to farmers. Moreover, as Muhangi *et al*. (2006) pointed out, farmers may not readily relate modes of spread (for example through contaminated tools) to methods of control.

Levels of current usage of control methods were generally less than levels of awareness of the methods. The use of tool disinfection, destruction of infected plants by cutting, uprooting, burying and burning were significantly ($P = 0.05$) lower than the levels of awareness (Table 16.5). For tool disinfection or destruction of infected plants, only about half of the respondents who were aware of the method actually used it. Tool disinfection using fire is not user friendly (i.e. convenient) and household bleach (sodium hypochlorite) is not affordable for most farmers. Muhangi *et al*. (2006) also observed low levels of use of bleach for tool disinfection in Uganda. The destruction of infected plants is labour intensive, and lack of labour was cited by farmers in Uganda as a major reason for not carrying out Xanthomonas wilt control practices (Muhangi *et al*., 2006). For the other methods of Xanthomonas wilt control (removal of male buds, use of a pruning knife or forked stick, use of clean planting material, breaking by hand and quarantine), the proportion of respondents aware of the method was not significantly different from those who were using it.

16.4 Conclusion

Banana Xanthomonas wilt has spread widely in Rwanda. Farmers' awareness of disease symptoms, modes of spread and control was appreciable. However, launching awareness campaigns to enhance these levels would be beneficial. There was often a discrepancy between awareness of control methods and actual practice, especially for tool disinfection and the destruction of infected plants, and there is a need to develop more user-friendly methods. Moreover, future studies should investigate the factors that influence the adoption of Xanthomonas wilt control

technologies. While awareness of Xanthomonas wilt symptoms, spread and control was high, there is a need to increase awareness in newly infected and disease-free areas. Previous methods of disseminating information pertaining to Xanthomonas wilt were top-down. Participatory approaches would enhance training and dissemination of control technologies and decrease the gap between knowledge and use.

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