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Strategies for rehabilitation of banana fields infested with *Xanthomonas campestris* pv. *musacrearum*

Kubiriba Jerome[1*], Muthomi James[2], Ndungo Vigheri[3], Kwach Johnson[4], Erima Rockefeller[1], Rwomushana Ivan[5], Tushemereirwe Wilberforce[1] and Opio Fina[5]

1. National Agricultural Laboratories Research Institute, P. O. Box: 7084, Kampala, Uganda.
2. University of Nairobi, P. O. Box: 30197, Nairobi, Kenya.
3. Catholic University of Graben, Beni, Butembo, DR Congo.
4. Kenya Agricultural Research Institute, P. O. Box: 57811-00100, Nairobi, Kenya.
5. Association for strengthening Agricultural Research in East and Central Africa, P. O. Box: 765, Entebbe, Uganda.

Abstract: *Xanthomonas campestris* pv.*musacrearum* causes Banana wilt disease (BXW disease) which occurs at different epidemic phases in East and Central Africa (ECA). In the endemic areas, there are many banana fields with over 80% BXW disease incidence. This study aimed at rehabilitating banana fields heavily infected with BXW disease in Uganda, Kenya and DR. Congo. Farmer managed trials were established in BXW disease hotspots in western Kenya and DR. Congo, while in Uganda, similar trials were established at community level i.e. clusters of at least 200 heavily infected banana fields. The control options evaluated included single stem removal, suspension of pruning in affected fields, male bud removal and disinfection of tools with fire or Sodium hypochlorite. Data was collected on the proportion of affected fields (BXW disease prevalence), BXW disease incidence and the number of banana bunches sold at 3-month intervals. BXW disease incidence was reduced by over 80% in 11 months in Kenya and DR. Congo, resulting in yield recovery by up to 70% within one year. In Uganda, the proportion of farmers that effectively controlled BXW disease increased 5% to 60% within a year in some hotspots. Consequently banana sales recovered up to 30% in some hotspots. This study demonstrates that it is possible to effectively control BXW disease within 12 months in previously severely infected fields in various areas of ECA.

Keywords: *BXW disease incidence and prevalence, control options, yield and sales recovery*

Introduction

Many communities of the east and central Africa have traditionally depended on a perennial banana cropping system for food and income (Karamura *et al*., 2006). Different ecological zones in east and Central Africa are characterised by various banana cropping systems named after the dominating cultivars. e. g. Pisang awak or East African highland banana cropping systems in Central and South Western Uganda respectively. Following the outbreak of banana *Xanthomonas* wilt (BXW disease) (*Xanthomonas campestris* pv. *musacearum*) in the region, entire crop holdings were wiped out in some areas (Kalyebara *et al*., 2006; Smith *et al.*, 2008). Even where there was partial infection of the fields, affected bunches were of no economic value (Ndungo *et al.*, 2005). During the last 10 years, banana farming communities in the region have been struggling to control BXW disease resulting in drastic reduction

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[*] **Corresponding author**, e-mail: jkubiriba@kari.go.ug
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of disease and achieving production recovery in parts of South West Uganda, Lake Victoria zone of Tanzania, and Northern Rwanda (Murekezi *et al*., 2009; Mgenzi *et al.,* 2009; Kubiriba *et al.,* 2012). The disease has nevertheless continued to spread to many other banana-growing areas in the region (Mbaka *et al.,* 2008; Niko *et al.,* 2011). Possible reasons for this continued spread include user-unfriendliness of some control recommendations, unreported resurgence and lack of coherent institutional frameworks for organising and mobilising stakeholder partnerships for BXW disease control (Karamura *et al.,* 2006). Additionally, many farmers in endemic areas abandon BXW disease control because they are overwhelmed by the devastation and rapid spread of BXW disease (Tushemereirwe *et al.,* 2006).

Management of BXW disease strategies are effective in BXW disease control if they block insect vectored spread; cutting tool mediated spread and reduce inoculums load from affected banana plantations. Early removal of male bud using forked stick eliminates inflorescences that attract insects to banana plants (Tinzaara *et al.,* 2006). BXW disease spread through cutting tools can be managed by sterilizing tools with fire or JIK (Commercial Sodium hypochloride (Reckit Becktisner) or suspending use of cutting tools for at least 3 months (Tushemereirwe *et al.,* 2006). Reduction of inocula is through uprooting all the plants in affected fields, using herbicides to kill infected plants and single stem removal (Okurut *et al.,* 2006). Single stem removal involves removal of only infected plants from an infected banana stool at the base, leaving other uninfected plants on the same mat. This minimizes the risk of the bacteria moving down the plant and spreading to other plants on the mat (Ssekiwoko *et al.,* 2006). Single stem removal is preferred to destruction of the whole mat because the latter is labour intensive (Bagamba *et al.,* 2006).

It is therefore necessary to address some of these issues to be able to improve BXW disease control and halt its spread in the region. We undertook to validate recommended options of BXW disease control where they have not been used to demonstrate their efficacy for rehabilitating heavily BXW disease -affected banana fields.

Materials and Methods

Farm level trial in Kenya

Field experiments were carried out over a 12-month period in a BXW disease hot spot in Ugunja in western Kenya where a banana field with over 80% BXW disease infection was selected. The disease management method adopted consisted of single stem removal by uprooting, cutting infected plants at the base, injecting infected plants with herbicide and uprooting infected mats. Plots with mats affected by BXW disease where no management option practice was applied comprised the control. Herbicide was applied by injecting 20 ml of Glyphosate (Roundup®) solution at the base of the infected banana stem. Each plot had six banana mats, with at least eight plants. The treatments were laid out in a randomized complete block design with five replicates (blocks). Farm implements used in uprooting or cutting the plants were sterilized by wiping with 2% (v/v) JIK (sodium hypochlorite). Other recommended agronomic practices like male bud removal and weed control were applied uniformly on all the plots, except the control. Data was recorded on the number of plants with BXW disease symptoms and weight of bunches harvested from each plot. Data on weight of the harvested bunches was recorded monthly for a period of 12 months. The data was subjected to analysis of variance and mean separation using the Least Significant difference at 5%.

Farm level trials in DR Congo

The farmer managed field trials were carried out at three sites (Kirea, Kalunguta and Oicha) in North Kivu, eastern DR Congo within BXW disease hot spots where farms with about 85% BXW disease incidence were selected. The treatments included stem removal by uprooting of BXW disease-infected plants within a mat. Field swere dominated by three banana varieties (Kisubi, Nyaghenge and Nguma). Data collected included the number of infected plants per plot and weight of usable bunches. The data on infected plants was collected at 1st, 3rd and

9th month from the start of the trial. The data was subjected to analysis of variance and mean separation using the least significant difference at 5 %.

Community level trials in Uganda

Severely infected banana fields in villages in disease hotspots were selected (Table 1). The hot spots are villages of at least 200 banana farmers, with 90% of the fields affected by BXW disease in Districts of Kabale, Mbale and Bududa. Four villages were selected in the three districts; two in Kabale District-South western Uganda and one in Mbale and one in Bududa, both in Mt. Elgon region of Eastern Uganda. All the participating farmers were asked to apply practices recommended for controlling BXW disease including single stem removal (carefully cutting of only infected plant from an infected mat at the base) and suspending use of cutting tools. We collected data on the proportion of BXW disease affected fields and number of banana bunches sold over time. The data was collected at 3-month intervals on each of the selected sites and trends of BXW disease reduction and banana sales recovery were subjected to regression analysis.

Table 1 Location of hot spots in Uganda.

Region	District	Hotspot
South western	Kabale	Kaharo
South western	Kabale	Rwamucucu
Mt. Elgon	Mbale	Bungokho
Mt. Elgon	Bududa	Bukigai

Results

Rehabilitation of a field affected by BXW disease in Kenya

Percentage of infected suckers per plot was generally similar between management options at different sampling times, except for the control plots where no management option was applied (Fig. 1). BXW disease incidence in the control gradually reduced probably due to reduction of inoculums load. Incidence of BXW disease was significantly reduced under all the four management option conditions over time,resulted in a corresponding increase in bunch yield (Figs. 1 and 2). Destruction of infected plants using herbicide resulted in a gradual reduction in BXW disease incidence and complete control by the seventh month after implementing the management options. In contrast, other practices drastically reduced BXW disease incidence from over 25% infected plants per plot to less than 3% within three months after implementation of the management options (Fig. 1). Usable banana bunches harvested from the infected fields 6th month after implementation of the management practices. The usable yield increased from about 5 kg per plot to about 70kg in some plots in the 9th and 10th month of application of the control practices (Fig. 2).

Rehabilitation of fields affected by BXW disease in DRCongo

Single stem removal of the BXW disease - infected plants from a mat reduced disease incidence by between 40% and 70% in all the three sites (Fig. 3). This management option reduced BXW disease incidence from 80% to less than 20% within 9 months of application. Among the sites, relatively higher disease incidence was recorded at Oicha compared to Kalunguta and Kirea at the time of establishment of the trials which even out with time as infection reduced. Farmers were able to harvest between 30 and 80 kg of banana per plot (Fig. 4) from formerly severely affected banana fields with BXW disease within nine months from no harvests (data not shown) at the commencement of the trials.

Rehabilitation of fields heavily affected by BXW disease in Uganda

Banana fields that were cleared of BXW disease increased to more than 20% in 6 months in most hotspots (Fig. 5). Such fields further increased to above 60% in 13 months on the three hotspots of Rwamucucu-Kabale, Bukigai-Bududa and Bungokho-Mbale. It is only in Kaharo-Kabale where the proportion of affected fields where BXW disease had been successfully managed increased slowly to only 20% in 15 months.

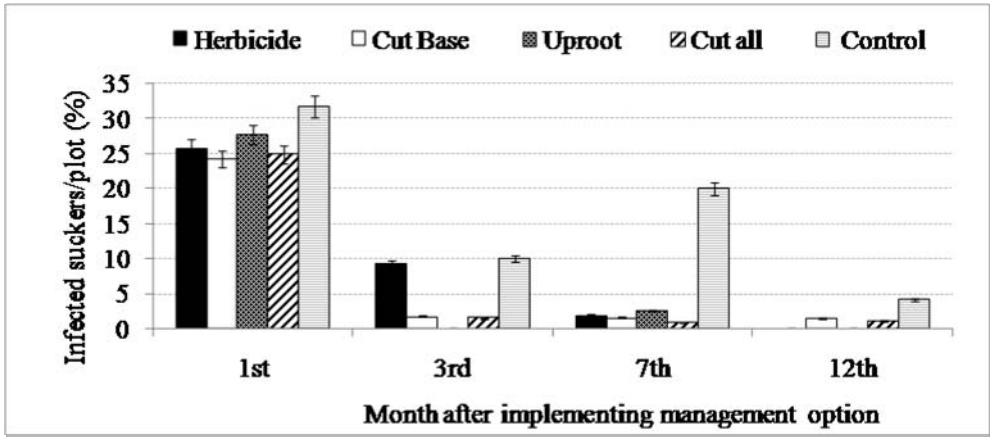

Figure 1 Percentage of BXW disease infected suckers per plot over time after implementation of mat rehabilitation options in Kenya.

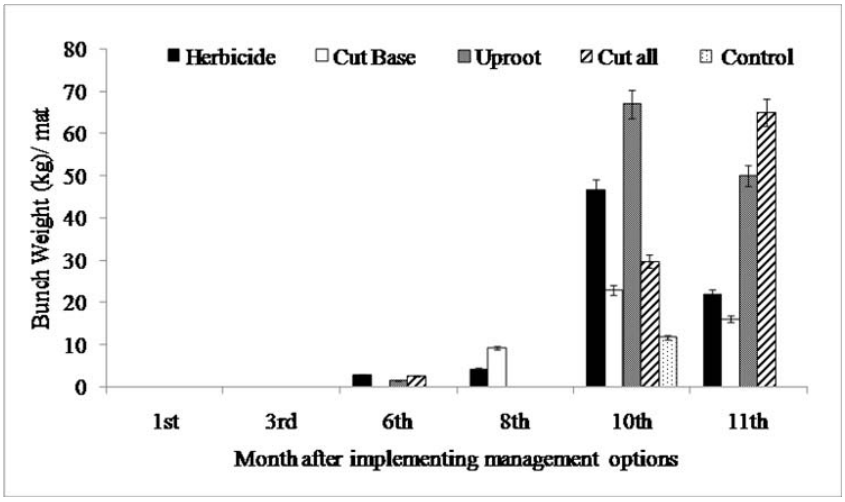

Figure 2 Mean weight of clean banana bunches harvested per plot over time after implementation of BXW disease management strategies in Kenya

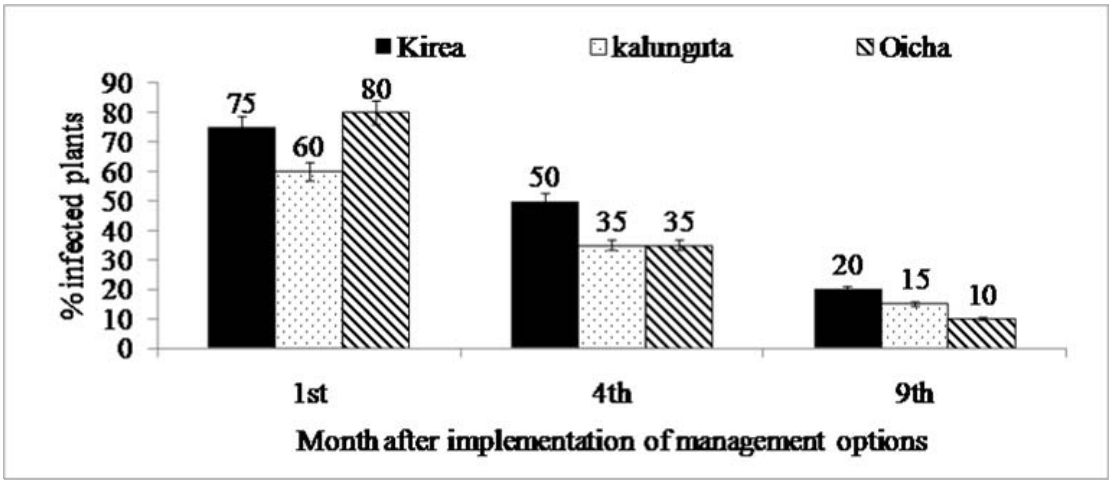

Figure 3 BXW disease incidence over time in field trials where single stems of affected plants were removed in D. R. Congo.

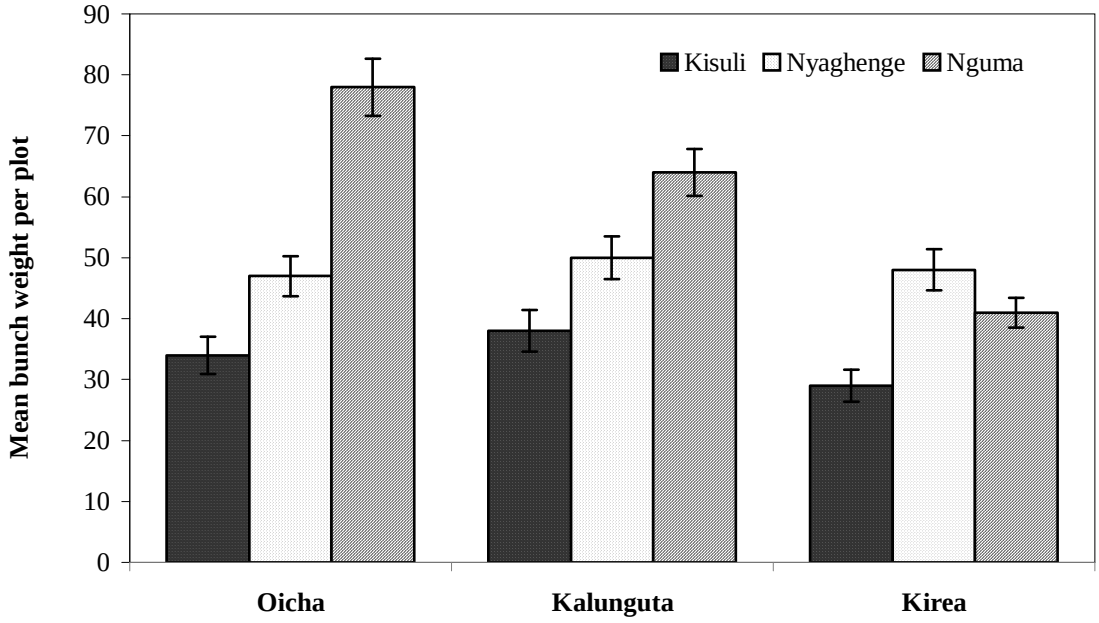

Figure 4 Mean bunch weight per plot in field trials where single stems of affected plants were removed for 9 months in three sites in DRC.

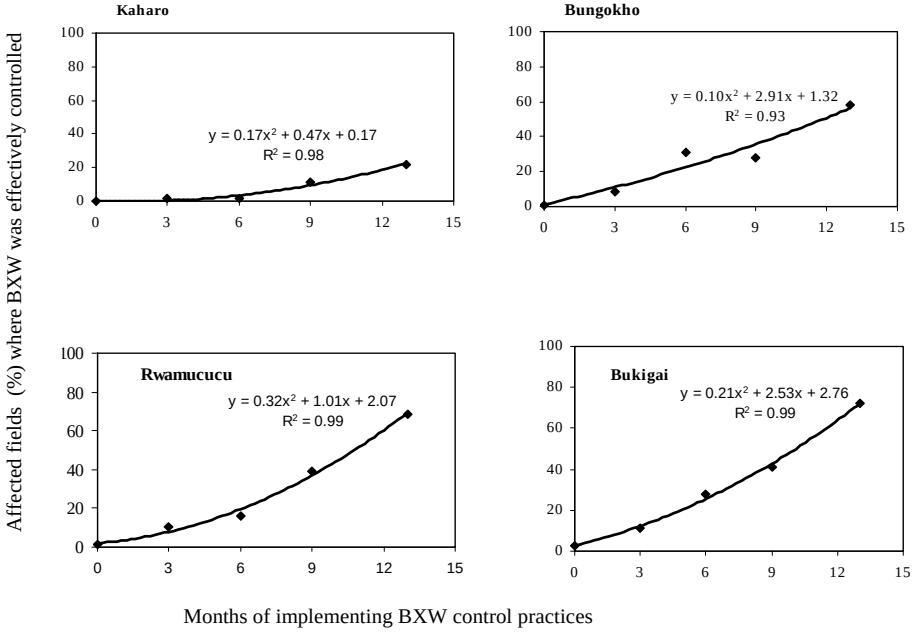

Figure 5 Proportion (%) of farmers that effectively controlled BXW disease on four sites (hotspots) in Uganda.

At the time of the trial establishment, there were no banana sales in any of the four sites in Uganda (Fig. 6), but within three months of application BXW disease management practices, farmers started to sell a few bananas. The sales increased to 30 bunches per month within 12 months. Banana sales between the 4 different sites at 12 months varied. This is probably

because of other factors limiting banana production and sales since the level of BXW disease control in Bukigai and Rwamucucu was comparable and that of Bungokho, which had the highest banana monthly sales was lower.

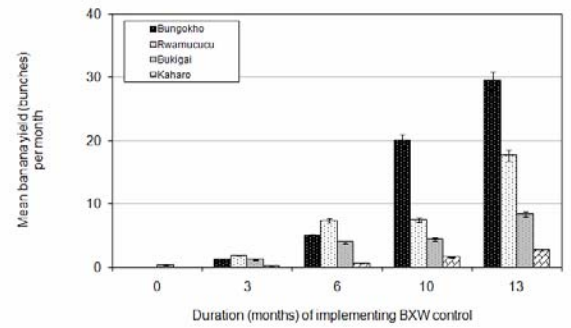

Figure 6 Mean banana yield (bunches) sold per month in the 4 hot spots in Uganda.

Discussion

The management options together significantly reduced BXW disease incidence in Kenya, Uganda and D.R Congo. The control programme hinged on single stem removal, leaving plant debris on the ground and suspending pruning of affected fields for up to three months, in addition to male bud removal with a forked stick and disinfection of tools with fire or JIK. Management of BXW disease is dependent on prompt removal of sources of inoculum and reducing or eliminating opportunities for further spread (Tushemereirwe *et al.,* 2006). The common approach has been to dig up whole mats with infected plants, cutting and burying the infected plants to accelerate decomposition (Tushemereirwe *et al.,* 2004). These practices reduce inoculum from affected field, prevent between plant- and field- BXW disease spread. They, however, expose land on slopes to soil erosion agencies and are labour intensive. Furthermore, it is costly for the farmer to re-establish banana production and the plantations take years to recover previous production levels.

Single stem removal had been recommended in Cv. Pisang awak dominated cropping systems of Central and Western Uganda, but not used in all other banana growing agro-ecologies affected by BXW disease in east and Central Africa. The results of this study showed that it is possible to significantly reduce BXW disease incidence using single stem removal in East African highland banana cropping system in South Western and eastern Uganda, DRCongo and Western Kenya. The epidemiological basis for this recommendation was that most BXW disease infection starts from the upper parts of the banana plant (Ssekiwoko *et al.,* 2006) and the infection then moves slowly down the plants. This gives an opportunity to remove only the infected plant from the mat and leave the other uninfected plants on the same mat. Therefore, early removal of flower-infected pseudostems at the mat base, at the time of first floral symptoms can prevent the disease from moving to rest of the plants on the mat (Blomme *et al*., 2008. The benefits of using this practice are that the farmer does not incur the cost of the uprooting the whole mat and allows the remaining uninfected plants give banana bunches to the farmer within a year without having to replant.

The farm level trials showed that the effectiveness of destroying infected plants by injecting with herbicide was comparable to removal by uprooting or cutting the plants at the base. The results are in agreement with the reports by Blomme *et al.,* (2008) who showed that Roundup and 2-4-D were effective in destroying BXW disease infected banana mats. The use of herbicides in BXW disease management has the advantage of reducing labour costs as compared to manual removal, which is tedious and time consuming. It also minimizes the use of cutting tools, which can easily spread the diseases in areas of high disease incidence (Blomme *et al.,* 2008). However, implementation of the use of herbicides on a large-scale may be limited because of the informal nature of the banana cropping systems and the prohibitive costs (Smith *et al*., 2008). In addition, unlike single stem removal by uprooting or cutting at the base, farmers may not be happy to see infected plants in their plantations for a long time (Bagamba *et al.,* 2006).

Farmers in hotspots in Uganda who had been assigned to bury destroyed plant debris abandoned

the practice within three months after realizing that some of the farmers who left debris on the ground were still able to effectively control the BXW disease. Indeed, banana debris was not buried in all the trials across the three countries as it had been previously recommended in the areas that hosted the trials (Tushemereirwe *et al.,* 2004). This could be due to low survival of *Xanthomonas campestris* pv. *musacearum* (Xcm) in the decomposing refuse. Mwebaze *et al*., (2006) did not isolate Xcm from banana refuse from infected plants after 5 days even when debris from previously infected plants was left on the ground. This study therefore shows that it is possible to effectively manage BXW disease without having to bury infected banana debris. This may offer a more cost effective option of managing banana refuse within the BXW disease affected banana fields in the region.

During the mobilization meetings to establish the farmer managed trials in Uganda, it was recognized that banana plants remained BXW disease-free where farmers did not prune their plantations as opposed to the high infection levels observed on fields where pruning was done. Therefore, suspension of using cutting tools in infected fields was key to management of BXW disease in the trials carried out in Uganda. This could be explained by the fact that the incubation period of BXW disease takes up to three months (Ssekiwoko *et al.,* 2006) and therefore, if pruning is done during this period, the bacteria are spread through the contaminated pruning tools from asymptomatic plants. Suspension of using cutting tools in affected fields allows plants with latent infection to develop full blown show symptoms. They are then clearly identified and carefully removed before spreading to other non-infected plants. It therefore shortens the duration the farmers are involved in BXW disease control.

The results of the study showed that farmers who used a combination of cultural practices were able to significantly reduce BXW disease incidence in their plantations and this eventually led to banana production recovery. The residues resulting from single stem removal do not have to be removed or buried and therefore, implementation of this combination of practices could easily be adopted by the farmers. If the management practices are diligently and consistently applied and the fields are monitored to remove newly infected plants, BXW disease can be effectively controlled within 12 months and banana yield and sales recorded in previously severely infected fields.

In conclusion, it has been demonstrated that it is possible to rehabilitate fields with high BXW disease incidence back to production within a year in the banana growing areas of south-western and eastern Uganda, western Kenya and eastern DRCongo. Single infected stems are removed leaving other uninfected plants on the mat rather than rouging the whole mat. This was complemented by suspending use of cutting tools to effectively manage incubating infection and prevent re-infection through insect mediated BXW disease spread by early removal of male buds. These practices are recommended for implementation as part of the cultural control package for BXW disease management in banana growing areas of east and central Africa perhaps with some modifications to fit the specific ecological and socioeconomic conditions.

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References

Bagamba, F., E. Kikulwe, W. K. Tushemereirwe, D. Ngambeki, J.Muhangi, G. H. Kagezi and S. Green. 2006. Awareness of banana bacterial wilt control in Uganda. Farmers' perspective. African Crop Science Journal, 14 (2): 157-164.

Blomme, G., L. F. Turyagyenda, H. Mukasa and S. Eden-Green. 2008. The effectiveness of different herbicides in the destruction of Banana *xanthomonas* wilt infected plants. African Crop Science Journal 16: 103-110.

Kalyebara, M. R., Ragama, P., Kagezi, G. H., Kubiriba, J., Bagamba, F., Nankinga, C.

And Tushemereirwe, W. K. year Economic importance of the banana Xanthomonaswilt in Uganda. African Crop Science Journal, 14: 93-104.

Karamura E. B., M. Osiru, G. Blomme, C. Lusty and C. Picq (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. International Network for the Improvement of Banana and Plantain, Montpellier, France.

Kubiriba, J., Bagamba, F., Rockfeller, E. and Tushemereirwe, W. K. 2012. The changing spread dynamics of banana Xanthomonas wilt (BX W) in Uganda. Uganda Journal of Agricultural Sciences, 13 (1): 53-60.

Mbaka, J. N., M. Mwangi and M.N. Mwangi. 2008. Banana farming as a business: The role of tissue cultured planting materials in Kenya. Journal of Applied Biosciences, 9 (1): 354-361.

Mgenzi, B. S. S. 2009. Management of banana xanthomonas wilt in Tanzania. In: Karamura E. and Tinzaara, W (Eds.). Management of Banana Xanthomonas Wilt in East and Central Africa. Proceedings of the workshop on review of the strategy for the management of banana xanthomonas wilt, Kigali, Rwanda, 23-27 July 2007; Bioversity International, Uganda, pp. 23-26.

Murekezi, C. 2009. Xanthomonas wilt Management in Rwanda. In: Karamura E. and Tinzaara, W (Eds.). Management of Banana Xanthomonas wilt in East and Central Africa. Proceedings of the workshop on review of the strategy for the management of banana xanthomonas wilt, Hotel la Palisse, Kigali, Rwanda, 23-27 July 2007; Bioversity International, Uganda, pp 18-22.

Mwebaze, J. M., G. Tusiime, W. K. Tushemereirwe and J. Kubiriba. 2006. The survival of *Xanthomonas campestris* pv. *musacearum* in soil and plant debris. African Crop Science Journal. 14: 121-128.

Ndungo, V, S. Eden-Green, G. Blomme, J. and Crozier, J. Smith. 2005. Presence of banana *Xanthomonas* wilt (*Xanthomonas campestris* pv. *musacearum*) in the Democratic Republic of Congo (DRC). Plant Pathology, 55: 294.

Niko, N., Ndayihanzamaso, P., Jogo, W., Karamura, E., Lepoint, P. and Tinzaara, W. 2011. Impacts of banana Xanthomonas wilt disease on banana productivity and livelihoods in Burundi. Abstracts of the conference on challenges and opportunities for agricultural Intensification of the humid highland systems of sub Saharan Africa, 24-27 June 2011, Kigali, Rwanda, pp: 147.

Okurut, W., W. K., Tushemereirwe, V. Aritua and Ragama. 2006. Use of herbicides for control of banana bacterial wilt in Uganda. African Crop Science Journal, 14:143-150.

Smith, J. J., D. R. Jones, E. Karamura, G. Blomme and L. Turyaenda. 2008. An analyisis of risk from *Xanthomonas campestris* pv. *musacearum* to banana cultivation in East, Central and Southern Africa. Bioversity International, Montepellier, France.

Ssekiwoko, F., H. K. Taligoola and W. K. Tushemereirwe. 2006. *Xanthomonas campestris* pv. *musacearum* Host range in Uganda. African Crop Science Journal, 14 (2): 111-120.

Tinzara, W., Gold, C. S., Tushemereirwe, W., Bandyopadhyay, R. and Eden-Green, S. J. 2006. The possible role of insects in the transmission of banana *Xanthomonas* wilt. In: *Proceedings of the 4th International Bacterial Wilt Symposium*, 17th-20th July, 2006. Saddler, G., Elphinstone, J. and Smith, J. (Eds.), pp. 60. The Lakeland Conference Centre, Central Science laboratory, York, UK.

Tushemereirwe, W., A. Kangire, F. Ssekiwoko, L. C. Offord, J. Crozier, M. Ba E. Rutherford, and J. J. Smith. 2004. First report of *Xanthomonas campestris* pv. *musacearum* on banana in Uganda. Plant Pathology, 53: 802.

Tushemereirwe, W. K., O. Okaasai, J. Kubiriba, C. Nankinga, J. Muhangi, N. Odoi and F. Opio. 2006. Status of banana bacterial wilt in Uganda. African Crop Science Journal, 14 (2): 73-82.

راهبردهای احیای باغ‌های موز آلوده به *Xanthomonas campestris* pv. *musacearum*

جروم کوبه‌ریبا[1*]، جیمز موتومی[2]، ویقری ندونگو[3]، جانسون کواچ[4]، راکفلر اریما[1]، ایوان رووموشانا[5]، ویلبرفورس توشه مرئیروه[1] و فینا اُپیو[5]

۱- آزمایشگاه‌های مؤسسه ملی تحقیقات کشاورزی، صندوق پستی: ۷۰۸۴، کامپالا، اوگاندا.
۲- دانشگاه نایروبی، صندوق پستی: ۳۰۱۹۷، نایروبی، کنیا.
۳- دانشگاه کاتولیک گرابن، بنی، بوتمبو، جمهوری دموکراتیک کنگو.
۴- مؤسسه تحقیقات کشاورزی کنیا، صندوق پستی: ۰۰۱۰۰-۵۷۸۱۱، نایروبی، کنیا.
۵- سازمان حمایت از تحقیقات کشاورزی در افریقای شرق مرکزی، صندوق پستی ۷۶۵، انتبه، اوگاندا.
* پست الکترونیکی نویسنده مسئول مکاتبه: jkubiriba@kari.go.ug
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چکیده: سطوح مختلفی از همه‌گیری بیماری پژمردگی موز توسط باکتری *Xanthomons campestries* pv. *musacearum* در آفریقای شرقی و مرکزی رخ می‌دهد. در مناطق اندمیک بیماری آلودگی بسیاری از باغ‌ها بیش از ۸۰ درصد می‌باشد. این پژوهش با هدف احیای باغ‌های موز شدیداً آلوده به بیماری پژمردگی در اوگاندا، کنیا و جمهوری دموکراتیک کنگو انجام شد. در مناطق شدیداً آلوده به بیماری پژمردگی موز واقع در غرب کنیا و جمهوری دموکراتیک کنگو آزمایش‌های مدیریت شده توسط هر باغدار انجام شد. درحالی‌که در اوگاندا آزمایش‌های مشابه در سطح جوامعی از باغداران شامل دست‌کم ۲۰۰ باغ موز شدیداً آلوده انجام شد. گزینه‌های کنترل بیماری که مورد ارزیابی قرار گرفت شامل حذف تک‌ساقه‌ها، تعلیق هرس در باغ‌ها، حذف جوانه‌های نر و ضدعفونی ابزار با شعله یا هیپوکلریت سدیم بود. داده‌ها براساس نسبت باغ‌های آلوده، وقوع بیماری و تعداد خوشه‌های موز فروخته شده طی فواصل زمانی سه ماهه از باغ‌های آلوده به بیماری پژمردگی جمع‌آوری شد. وقوع بیماری در کنیا و جمهوری دموکراتیک کنگو طی مدت ۱۱ ماه بیش از ۸۰ درصد کاهش یافت و در نتیجه ۷۰ درصد محصول در یک‌سال بازیافت شد. در بعضی مناطق شدیداً آلوده اوگاندا تعداد نسبی کشاورزانی که بیماری را به‌طور مؤثری مهار نمودند به میزان ۵ تا ۶۰ درصد در طی یک‌سال افزایش نشان داد. در نتیجه فروش موز تا ۳۰ درصد در بعضی مناطق شدیداً آلوده افزایش داشت. این مطالعه نشان می‌دهد که کنترل مؤثر بیماری در باغ‌های آلوده در مناطق مختلف آفریقای مرکزی و شرقی در طی ۱۲ ماه امکان‌پذیر است.

واژگان کلیدی: وقوع و فراوانی بیماری *BXW*، گزینه‌های کنترل بیماری، احیای محصول و فروش