

A superior technology to control Banana Xanthomonas Wilt (BXW) in Rwanda

In this brief we discuss a new and promising technology to control xanthomonas wilt of banana, commonly referred to as BXW. We describe why this disease is a threat and what has been done to control it in the past. We also present evidence on an alternative technology to control BXW called Single Diseased Stem Removal (SDSR) and explain how we can make this technology accessible to Rwandese banana farmers.

1. What is BXW? How is it a threat and why is it a threat?

Xanthomonas wilt of banana (BXW) is a bacterial disease that seriously affects banana production. Yield losses of up to 100% have been reported in the East African region. The disease was first discovered on Enset (a banana-relative, also called false banana) in Ethiopia in 1967 and first spread to East Africa (Uganda) in 2001. In Rwanda, BXW was officially reported in 2005 for the first time. BXW is reported to have caused reduced availability of banana in households and in markets in Rwanda and, thus, is a large threat to food security and income. There is no cure for BXW but scientists have formulated technical recommendations to reduce the probability of infection and to manage and control existing infections.



BOX 1. Importance of Banana in Rwanda

Banana is a major commodity in Rwanda, used both as a cash and (staple) food crop. Banana covers 23% of Rwanda's land and is grown by 90% of households. Rwanda is one of the largest producers of bananas in the Eastern Africa Region and ranks second in banana consumption in the world with an annual per capita consumption of approximately 144 kg.

In Rwanda, Banana is produced and consumed for cooking, juicing, and dessert, and for each type of consumption, different varieties are used. Some of these banana varieties have been introduced only recently in Rwanda, while others are unique to Rwanda, the result of centuries of farmer selection. BXW infection is fatal to all banana types, however, some varieties are more susceptible to infection than others.

There are many different uses for banana:

- As a staple food crop for Rwandese consumers;
- For making banana juice and banana wine;
- To feed animals; and
- To make handicraft like baskets.

Banana plays an important role in Rwandan cultural life:

- Bunches are often exchanged as gifts during social functions;
- Banana wine is consumed on cultural events;
- Banana plants are used for decoration during weddings and public events; and
- Banana plantations are believed to be a security against risk in times of financial or food security crisis.

Banana is an important landscape element: Compared to other annual food crops, banana offers superior erosion control, water purification, and carbon sequestration.

2. BXW in Rwanda; first occurrence, spread and strategies to control the disease

In Rwanda, BXW was first observed in Gisenyi province in 2002. In October 2005, BXW was found in Rubavu district and quickly the disease spread to other parts of the country. Currently the status of BXW in different areas of Rwanda ranges from 'contained outbreak' to 'endemic'. Contained outbreak means a disease is more common than expected whereas 'endemic' means that the disease exists permanently in a particular region. In some areas, where it was believed BXW had been contained, a resurgence of the disease has occurred.

In 2005, a National Task Force was set up by the Ministry of Agriculture to address BXW. They were following the advice advocated across East and Central Africa during the initial years of the outbreak. Working through Umuganda, a monthly holiday of community service in Rwanda, volunteers uprooted infected banana mats and buried them in the soil. These practices to control BXW are referred to as 'Complete Diseased Mat Uprooting' (CDMU). In addition to applying CDMU, the land was kept free from banana cultivation for several years and various annual crops were planted during this time. After this, re-planting with a selection of high-yielding banana cultivars such as 'FHIA 17' was promoted. Meanwhile, the Rwandan government has made it mandatory for farmers to use CDMU and re-plant the selected banana cultivars although an official policy in which CDMU was proposed as the only correct measure to control BXW was never signed.

However, CDMU has only been partially effective for three reasons:

- 1) To uproot a whole banana mat is laborious and time intensive. For the elderly and some women, this is not a feasible option, and hiring laborers to do this work may not be financially possible for small-scale farmers.
- 2) Farmers are reluctant to uproot whole banana mats because they do not want to relinquish their entire banana garden, holding on to hope that some plants may be salvaged. In this way, banana plants and gardens not only represent economic value but also emotional and social value. Many of the banana plantations have been passed on from one generation to the next and they provide the owners with status and security.
- 3) Re-infections from other farms and regions, including neighboring countries without similarly rigorous control measures, often occur on newly established fields, thus discouraging farmers from undertaking CDMU in the first place.

By 2010-2011 BXW had spread to most of the highland banana producing areas in the eastern African region and a similar reluctance to embrace CDMU was also apparent in other countries than Rwanda. Scientists noticed that some farmers would cut only the diseased stems of a BXW-infected banana mat instead of uprooting the entire mat (as was advised) and numerous edible bunches would still be produced in these fields. Systemicity, or bacterial movement, studies carried out in Uganda also revealed that BXW does not invade all physically-attached shoots, and latent infections often occur. Subsequently, the Single Diseased Stem Removal (SDSR) technology was developed and fine-tuned, and since 2013, scaled in Uganda, eastern DR Congo, Western-Kenya and Burundi.

BOX 2. What are the symptoms of BXW?

- The banana leaves gradually turn pale yellow and start looking lifeless, as if they have been hanging above a fire. Eventually they turn brown and die.
- In flowering plants, the first symptoms of insect transmission of BXW are a drying rot and blackening of the male bud that starts with the outer bracts and eventually extends to the rachis.
- The banana fruits ripen unevenly and prematurely, turning from green to yellow and black rapidly. The pulp of the affected rotting fruits shows rusty brown stains.
- Internal symptoms revealed by cutting an infected banana pseudo-stem is the presence of a yellow bacterial ooze, which can also be seen in any other infected part of the plant.

3. Single-diseased stem removal (SDSR) for efficient control of BXW

SDSR is a disease management practice to control BXW and recover banana production rapidly. Instead of uprooting the whole sick banana mat, only the stem of a plant that is showing symptoms of BXW is cut at soil level. By continuously cutting only the diseased stem(s) of sick plants in a banana garden, the disease incidence within the garden drops rapidly. Other stems and suckers on the banana mats, which supported the diseased stems, will often not get sick and will still be able to produce edible bunches.

We recommend to support SDSR by sterilizing garden tools used for cutting diseased stems, either by holding the tool in fire for a minute or by cleaning it with soap and water or chlorine. Ideally this work is combined with the removal of the male floral bud after formation of the last cluster on the bunch, using a forked stick. This is a preventive practice that reduces likelihood of infection in the first place. Compared to CDMU in combination with banana free fallows for several years, SDSR has several advantages for banana farmers in Rwanda:

- 1) SDSR can be easily applied, without too much physical effort, and in less time than CDMU;
- 2) Through continuous and correct application of SDSR, banana production can be recovered rapidly, limiting yield loss to BXW and saving banana gardens;
- 3) The application of SDSR also reduces and/or prevents the need for new planting materials and will enable banana production with fewer interruptions.

4. Evidence for SDSR over CDMU

In order to showcase the potential of SDSR for banana farmers in Rwanda, scientists from the Rwanda Agricultural Board (RAB), the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) and the International Institute for Tropical Agriculture (IITA), collaborated to design and implement a trial and study in four sites with two main objectives:

1. To assess the potential of both CDMU and SDSR for controlling BXW under Rwandan agro-ecological conditions; and
2. To conduct a cost-benefit analysis for both technologies measuring time needed and labor costs to apply the technology and their effects on banana bunch yields.

The study was conducted in four Rwandan districts: Kayonza, Gisagara, Rubavu and Rulindo. In relation to objective 1, results show that in all four sites both SDSR and CDMU were highly effective in halting the disease: disease incidence dropped below 1% by the end of the first month. In subsequent months, during which the banana plants were regularly monitored for symptoms of BXW, incidence remained below 2% when either SDSR or CDMU was applied on sick plants. This was a marked difference from the plots with BXW where no techniques were applied to control the disease. In these plots, incidence rapidly increased in the first month at all four sites with an average of 7.5% (Figure 1).

BOX 3. Trial methodology

Four treatments were established in each of the four sites located in the districts of Kayonza, Gisagara, Rubavu and Rulindo:

- 1) Complete Diseased Mat Uprooting (CDMU)
- 2) Single Diseased Stem Removal (SDSR)
- 3) Control treatment in infested fields – No intervention control.
- 4) Control treatment in healthy (BXW-free) fields – Healthy control

Each site hosted 4 demonstration treatments with each treatment sub-divided into four repetitions (plots) (thus 16 plots per site and 64 in total). Each plot comprised of 50 banana mats of a mixture of cultivars and a mixture of young and mature mats and the initial plant disease incidence (i.e., number of symptomatic plants over total number of plants) levels of the plots used for the CDMU, SDSR and No intervention experiments varied between 3.5 and 9.4%. In each site, treatment plots for SDSR and CDMU were adjacent to each other. The “No intervention control” plots on diseased fields were established at a site, which was at a distance between 100-500 meters from the treatment plots. Plots were established on 5-7 farms per site and a total of 24 farmers for all sites were involved in management.

The trials ran for a period of 13 months and started in January 2019. Data were collected at weekly intervals during the whole trial period by village-based field assistants. During data collection time, the field assistants cut diseased stems or uprooted mats in SDSR and CDMU plots, respectively. Time needed to apply SDSR and CDMU was recorded, also time needed to remove the plant debris onto compost heaps, and for CDMU time needed to replant and possible planting material cost were recorded. Also, the number of bunches harvested and bunch weight were recorded.

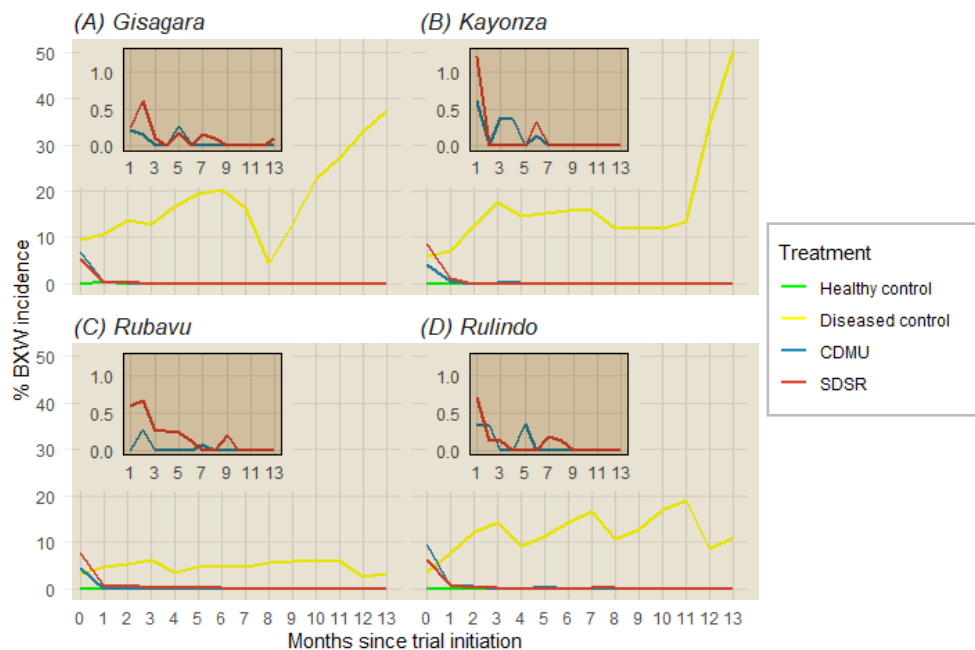


Figure 1. Plant level *Xanthomonas* wilt disease incidences for plots subjected to different *Xanthomonas* wilt management options: complete diseased mat uprooting (CDMU), single diseased stem removal (SDSR), and no intervention over a 12 months period (NI). Healthy banana plots served as controls (H).

Although disease incidence declines were similar for both BXW control technologies, it is important to remember that in the CDMU plots, all plants in a sick banana mat were uprooted whereas in the SDSR plots all healthy looking plants were left in place, leading to continued bunch production. For banana farmers this makes an enormous difference.

We see the difference of impact more clearly in the cost-benefit analysis. For this measure, we noted 1) how much time it takes to apply CDMU and SDSR correctly per sick banana mat/plant and the magnitude of labor costs associated with the two practices; and 2) the banana yields in bunches per plot for the different treatments at all 4 sites.

The results show that SDSR takes much less time than CDMU. The total time (cutting/uprooting, processing plant debris and even replanting in the case of CDMU) needed for SDSR is 88% lower compared with CDMU, averaging 4.3 ± 0.3 minutes treatment time for removing one affected plant, compared to 36.5 ± 4.5 minutes for uprooting one affected whole mat (Figure 2). It logically follows that the labor costs associated with CDMU are much higher (Figure 3).

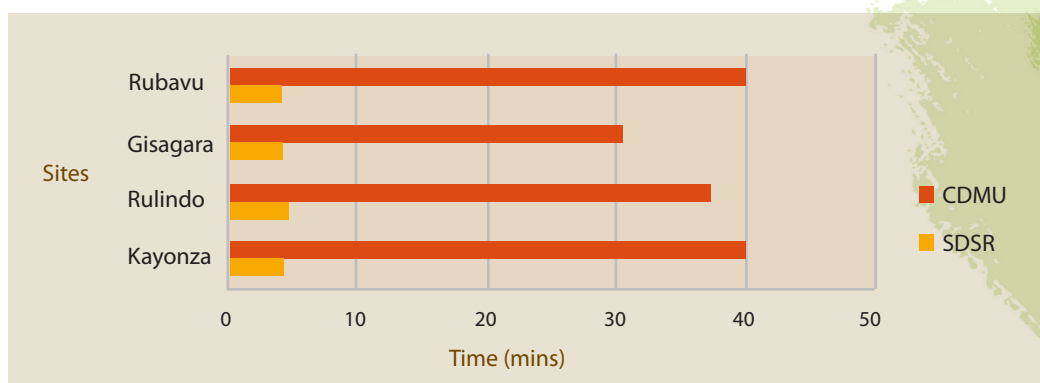


Figure 2: Time needed in minutes to apply SDR and CDMU per one diseased plant or mat at all four sites.

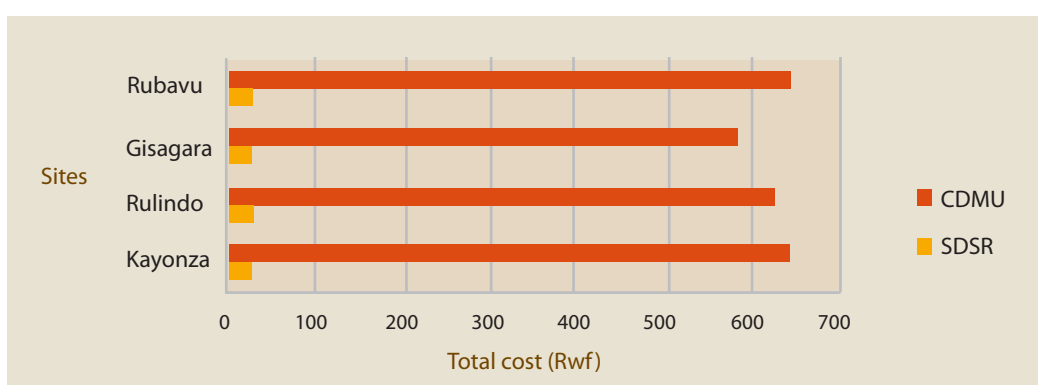


Figure 3: Total costs by control technique – CDMU and SDR – for one diseased plant or mat at all four sites.

Experiences with SDR in neighbouring countries

In addition to this new evidence from Rwanda, studies in neighbouring countries show similar positive results for SDR. In Uganda, adopting BXW control measures has been reported to reduce incidence while increasing yields, sales and income. Full adoption of SDR (see box 4) was more profitable and increased the value of production by USD 187 per acre per year. A lower benefit (USD 139) was realized when only two control tasks/options (cutting of single diseased plants with either tool sterilization or male bud removal) within the SDR package were adopted (see Box 4). In Burundi, SDR has been successfully scaled up in Muyinga province. All extension officers and farmer promoters in the province received training on SDR and delivered these techniques to 86,500 farmers. Currently in Muyinga province, one hardly sees any male-buds on developed bunches and farmers are investing again in banana production in places where banana cultivation had been abandoned/neglected due to BXW.

5. How to teach Banana farmers in Rwanda to apply SDR?

SDR is easy to apply but farmers require more information and training to identify BXW and apply the technique correctly. Once a banana plant is infected with BXW it shows certain distinctive symptoms (Box 2). Farmers need to monitor their banana plants, regularly and bi-weekly, for these symptoms. Once they identify a sick plant, they need to take action as soon as possible (Box 4).

Box 4. SDR consists of three separate tasks:

- 1) Cut the stem which shows symptoms of BXW at soil level;
- 2) Disinfect the cutting tool (once, after all sick stems have been cut at soil level); and
- 3) Remove male-buds after last hand formation with a forked stick.

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