Journal of Applied Biosciences (2008), Vol. 8 (1): 230 – 235.
ISSN 1997 – 5902: www.biosciences.elewa.org

Rehabilitation of banana farms destroyed by Xanthomonas wilt in Uganda

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ABSTRACT

Objective: The measures that have been recommended for banana wilt management in Uganda include de-budding, disinfection of garden tools and destruction of diseased plants. However, the adoption rate for these options has been low and the disease has reached epidemic levels. Destruction and removal of the infected plants followed by a fallow period or planting of a crop that is not a host of *Xcm*, and subsequent replanting with healthy banana suckers could restore banana plantations in areas affected by wilt. This study was carried out to determine the most effective method of destroying infected plants and an appropriate fallow period to ensure replanted suckers are not reinfected.

Methodology and Results: Trials were carried out at three field sites with 68-76% of mats infected at the beginning of the experiment. Treatments evaluated were: (1) killing plants by injecting a herbicide (2,4-D) into the pseudo-stems; (2) plants manually cut down and their rhizomes dug out; (3) plants cut down at ground level and re-sprouting suckers continuously mechanically removed. The banana plant debris was piled on ridges between the plots. Replanting with healthy banana suckers started one month after clearing the diseased plants, using tissue culture plantlets of cultivar Pisang Awak and Mpologoma. A portion of the field was replanted each month up to eight months after the onset of the trials. An economic viability analysis of the different options of destroying infected plants was carried out. Banana suckers planted after a one-month fallow period had a 25% survival rate, while all suckers planted after seven and eight months of fallowing survived. Generally, more dead plants were recorded with cv. Mpologoma than cv. Pisang Awak. Incidence of re-infection was highest in the plots where re-sprouting suckers were being continuously removed and lowest in plots where plants had been completely uprooted.

Conclusion and application of findings: A fallow period of at least six months is required to restore health to farms after infection by Xanthomonas wilt. Complete uprooting of infected plants and removing plant debris onto ridges is the best option for managing Xanthomonas wilt. However, the economic viability analysis indicated that farmers preferred to use herbicide to kill the plants rather than uprooting which is more laborious and expensive. The use of herbicide is hence recommended followed by a 6 month fallow or crop rotation period.

Key words: fallow period, *Musa,* replanting, survival, Xanthomonas wilt

Citation: LF Turyagyenda, G Blomme, F Ssekiwoko, E Karamura, S Mpiira and S Eden-Green, 2008. Rehabilitation of banana farms destroyed by Xanthomonas wilt in Uganda. *Journal of Applied BioSciences* 8 (1): 230 – 235.

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INTRODUCTION

Bananas are one of the world's most important food crops, of which the vast majority are grown and consumed in the tropics and sub-tropics (Tushemereirwe *et al*., 2001). In Uganda, bananas are the most important food crop according to output, acreage, consumption levels and priority ranking by stakeholders (NARO, 2002). Annual banana production is estimated to be over 9.5 million tonnes and an estimated 85% of the production consists of the East African highland bananas (Karamura *et al.,* 1998). Over 7 million people in rural and urban areas of Uganda depend on the crop (Tushemereirwe *et al*., 2001). Most of the bananas produced are consumed or utilized locally with an estimated per capita consumption of over 200kg, the highest rate in the world (Tushemereirwe *et al*., 2002). Nearly 75% of Ugandan farmers grow bananas on 1.5 million hectares, accounting for over 38% of the utilizable arable land in the country (NARO, 2002).

Xanthomonas wilt is a bacterial disease caused by *Xanthomonas campestris* pv *musacearum* (*Xcm*) which has attacked the banana industry severely limiting banana production in Uganda. The disease was initially reported on enset plants in Ethiopia (Yirgou and Bradbury, 1968). The disease was first reported in Kayunga district in 2001 (Tushemereirwe *et al.,* 2004). XW is primarily spread by insects with inoculum transmitted from male buds of diseased plants to those of healthy plants (Tinzaara *et al.,* 2006 and 2007). The disease also spreads on contaminated garden tools (Yirgou & Bradbury, 1974) and infected planting materials.

The disease has spread widely in Uganda causing up to 100% yield loss once established, seriously threatening food and income security of banana farmers (Kagezi *et al*., 2006; Kalyebara *et al*., 2006; Tushemereirwe *et al*., 2006).

The first visible symptom of an inflorescence infection on banana is wilting of male bud bracts, followed by drying of the rachis, then premature fruit ripening and finally bunch rotting, followed by wilting and yellowing of leaves. The disease also affects pre-flowering plants which get infected either from infected mother plants or by contaminated garden tools. These pre-flowering plants develop yellow wilting leaves. Internally, cross-sections of the pseudostems show yellow bacterial ooze, while the cross sections of the banana fingers show rusty brown stains.

There are no known resistant *Musa* spp. cultivars (Ssekiwoko *et al*., 2006(2)). However, some cultivars are able to escape the disease because of their inflorescence morphology (Buddenhagen, 1987). Apart from *Ensete ventricosum* and *Musa* spp. there are currently no known naturally occurring cultivated or wild host plants present in the east and central African region (Ssekiwoko *et al.*, 2006(1)).

When Xanthomonas wilt was initially detected in Uganda several measures were recommended, *e.g.* de-budding with a forked stick, disinfection of garden tools with bleach (NaOCl) or by heating and destruction of diseased plants/mats to eradicate or reduce disease spread. This strategy was based on experience in controlling other banana bacterial wilt diseases with similar epidemiology to XW (Turyagyenda *et al*., 2006). Generally, the adoption rate of these options has been low and the disease has reached epidemic levels, especially in areas where the cultivar Pisang Awak (*Musa* AABB) is dominant. Many farmers with infected banana plantations have lost hope and have abandoned their plantations. One approach to restoring banana productivity would involve the destruction and removal of the infected plants followed by a fallow period or planting of a crop that is not a host of *Xcm*, and subsequent replanting with healthy banana suckers.

However, knowledge on the suitable duration of fallow or crop rotation periods has not been available. Farmers also lack knowledge of the most cost-effective method for destroying and managing infected plants and fields. A study was carried out in Luwero district in central Uganda to determine the most effective method of destroying infected plants and the appropriate fallow period to ensure replanted suckers are not re-infected.

MATERIALS AND METHODS

The study site, Luwero, is located in Central Uganda at 0°39'N; 32°40'E; 1,115 masl with an average daily temperature of 25°C and a maximum temperature of 29°C. The climate is moist, sub-humid, with a mean annual rainfall of 1,100 mm that is bi-modally distributed (March-May and September-November).

Trials were carried out at three sites in fields with 68-76% of mats infected at the beginning of the experiment. Each field was divided into three equal plots measuring 18 m x 22 m. In the first plot plants were killed by injecting a herbicide (2,4-D) into the pseudostems; in the second plot, plants were manually cut down and their rhizomes dug out; while in the third plot, the plants were cut down at ground level and re-sprouting suckers were continuously mechanically removed. The banana plant debris was removed from the plots and piled on ridges in between the plots.

Replanting with healthy planting material started one month after clearing the diseased plants, using tissue culture plantlets of cultivars 'Pisang Awak' (*Musa* AABB group, syn. 'Kayinja') and 'Mpologoma' (AAA, East African Highland subgroup). A portion of the field was replanted each month up to eight months after the onset of the trials. Plant spacing was 2 by 2 meters. Each row consisted of 10 plantlets of each cultivar in a random mix. No fertilization or mulching was done in order to maintain normal farmer field practices and also to avoid mulching with infected plant residues. Farmers were discouraged from pruning leaves and from allowing animals to browse in the trial fields. These measures were necessary to avoid transmission of *Xanthomonas* wilt from infected fields to the trial fields or from one plant to another. During the dry seasons, each plant was watered with 5 liters of water twice a week to avoid drought stress and death.

The plants were observed for Xanthomonas wilt symptoms up to 5 months after the last replanting. An economic viability analysis of the different options of destroying infected plants was carried out. Data on material and labour costs, and farmer's preferences were collected by interviewing farmers using a pre-tested structured questionnaire.

RESULTS AND DISCUSSION

For all treatments the survival of the plantlets increased with an increase in the number of months allowed for the field to fallow. Plantlets planted after a one-month fallow period had a 25% survival rate, while all plantlets planted after seven and eight months of fallowing survived (Figure 1). These observations suggest that a fallow period of at least six months is required to restore health to farms after infection with Xanthomonas wilt. Generally, a higher plant death rate was recorded with cultivar 'Mpologoma' compared to 'Pisang Awak', suggesting that cultivars may respond differently to *Xcm* inoculum in the soil (Figure 1).

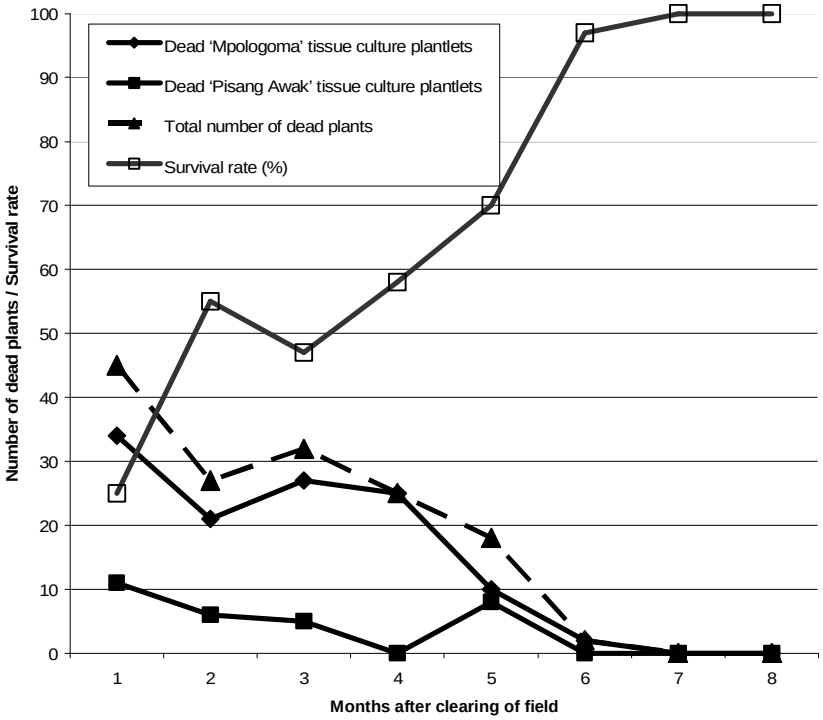

Figure 1: Number of dead tissue culture plantlets and percentage survival rate of different cultivars by month.

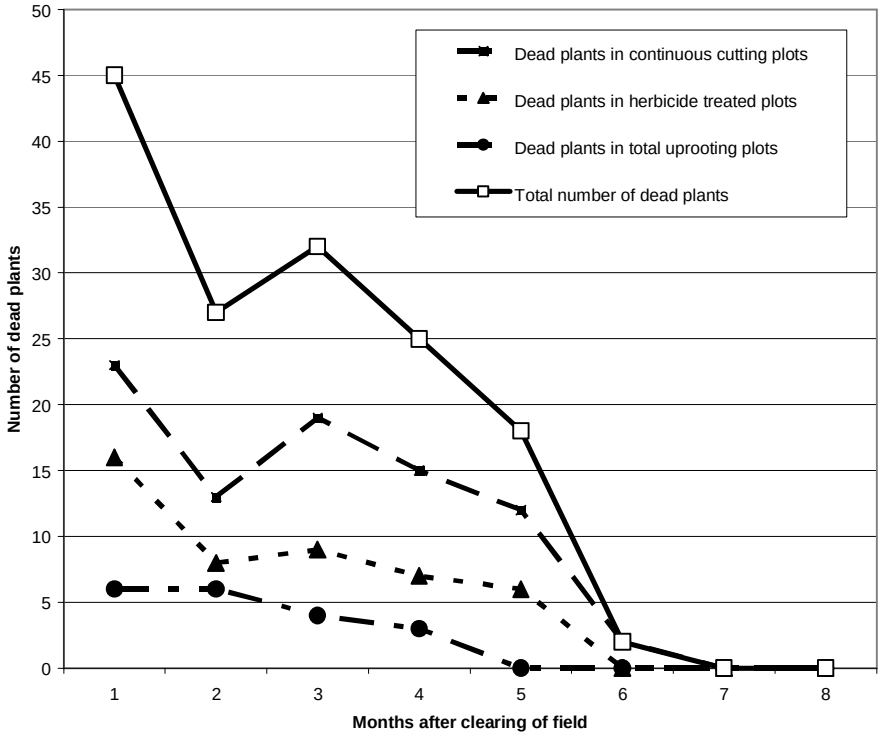

Figure 2: Number of dead plantlets per treatment and per month.

Incidence of re-infection was highest in the plots where re-sprouting suckers were being continuously removed and lowest in plots where infected plants were completely uprooted before fallowing (Figure 2). It seems that the Xanthomonas wilt bacterium does not survive for long in soil in the absence of host tissue. Habte and Alexander (1977) and O'Garo *et al*. (1997) had earlier reported that most bacteria populations decline rapidly after their introduction into the soil due to numerous biological, chemical, and physical factors that affect their survival. Mwebaze *et al.* (2006) has recently reported that *Xanthomonas campestris* pv. *musacearum* survives in the soil for less than three months under laboratory conditions. A study conducted in Ethiopia by Welde-Michael *et al.* (2008) reported that *Xcm* cannot survive in soil in the absence of enset plant material for more than 9 days. In addition, their study revealed that *Xcm* could survive in enset (*Ensete ventricosum*) leaf petioles and leaf sheaths for up to 3 months. It is hence advised that farmers remove infected enset plants from a field and heap/burry and compost them.

In the plots where plants were treated with herbicide, the bacterium probably survived in decaying debris from the rhizomes and roots, thus resulting in the observed intermediate levels of re-infection (Figure 2). The results indicate that complete uprooting of infected plants and removing plant debris onto ridges is an effective measure for managing Xanthomonas wilt. However, the economic viability analysis indicated that farmers preferred to use the herbicide to kill the infected plants rather than uprooting which is more laborious and expensive. The use of herbicide is hence recommended followed by at least 6 months fallow or crop rotation period.

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