RESPONDING TO BANANA XANTHOMONAS WILT AMIDST MULTIPLE PATHOGENS AND PESTS

A Crop Crisis Control Project brief

Maina Mwangi.

P.O. Box 7878, Kampala, Uganda.
m.mwangi@iita-uganda.org

Abstract

Xanthomonas wilt (BXW) is the most serious threat to sustainable banana production in East and Central Africa. Before the advent of BXW major biotic constraints were black leaf streak (Sigatoka), Fusarium wilt, bunchy top and streak viruses, weevils and nematodes. The rapid spread of BXW has diverted attention from the other biotic constraints, which, unlike BXW, rarely cause total yield loss. In addition, there are resistant varieties for most biotic constraints of banana, but not for BXW. Although in C3P the focus is on BXW, the pest complexes in the region cannot be overlooked, as they are on the same crop and system. There are interactive effects between pests and pathogens that must be managed for successful rehabilitation of banana production, while extension messages need to be well developed to communicate clearly on numerous biotic constraints. The multiplicity of pests also demands increased investments in technical capacity to improve diagnosis and ensure responses are timely and appropriate. With little extra effort, measures targeting BXW can also contribute to management of other biotic constraints. For example, the provision of clean planting material would in one stroke limit spread of several pathogens and pests that are potentially transmitted through infected suckers. This brief highlights areas of convergence in management BXW and other key biotic constraints facing farmers in East and central Africa.

Introduction

Bananas have sustained livelihoods in the Great Lakes region for well over two centuries. Over that period productivity has faced numerous constraints, the major ones being declining soil fertility, pests and poorly developed seed production and product marketing systems. Bananas are grown in diverse farming systems that face a multitude of pests. There are no single pest/disease situations in sub Saharan Africa banana systems, but a complex of pest/disease systems whose distribution is greatly influenced by the broad range of agroecological and socioeconomic factors (Karamura, 1999)[1]. The most serious threat currently is Banana Xanthomonas wilt (BXW). Previously, the major biotic constraints were black leaf streak (*Mycosphaerella fijiensis)*, Fusarium wilt (*Fusarium oxysporum* f.sp. *cubense*), nematodes (e.g. *Radopholus similis),* weevils *(Cosmopolites sordidus*)[2], and in a few areas, viruses. Most effort is currently focused on managing BXW, but the other pests still need attention as they continue to present serious challenges.

Managing multiple pests and diseases simultaneously has several unique challenges that must be taken into consideration when developing IPM strategies. More resources and technical competence are needed, e.g. diagnostic manuals/guides, equipment and trained personnel for proper diagnosis and responses. Interactive effects between pathogens and pests often exacerbate disease severity and increase proportion of yield lost. For breeders, pest and disease complexes have implications as each new variety needs to be screened for resistance to different pests likely to be encountered. For extension, multiple messages may need to be developed and communicated, which could confuse farmers.

On the other hand disease/pest complexes present unique opportunities for developing, testing and implementing solutions with multiple targets. For example, eradication of mats infected by BXW also knocks off all pests that depended on such mats for survival, while planting healthy seed prevents spread of all pests that are transmitted through suckers. Regional co-ordination efforts targeting one pest, e.g. BXW could also be broadened to include policies for all pests with a

[1] Proceedings of a workshop on banana IPM held in Nelspruit South Africa, 23-28 Nov 1998. E.A. Frison, C.S. Gold, E.B. Karamura, R.A. Sikora (eds). International Plant Genetic Resources Institute, 1999.

[2] T. Ramirez Pedraza, L. González Díaz, J.de la C. Ventura Martín, S. Rodríguez Morales and J.R. Gálvez Guerra. Infomusa 14-1: 11-13.

trans-boundary character. In the Crop Crisis Control Project management strategies for BXW need to be conscious of the other pests and diseases, and where possible, activities to be integrated to holistically address the maximum number of constraints from this single investment. Some of the key diseases and pests in the Great Lakes region are highlighted below.

Fusarium wilt

Fusarium wilt is caused by a soilborne fungus (*Fusarium oxysporum* f.sp *cubense*) and the disease occurs everywhere bananas are grown. In E. Africa[3] Fusarium wilt was first reported in the early 1950s in Kenya, Tanzania and Uganda and is now widely spread in the region. All the affected cultivars were widely planted in the last century, e.g. cv Pisang Awak (*Kayinja* - genome ABB) and Ney Poovan (Sukari ndizi). The East African highland bananas (matooke - genome AAA) are reported to be resistant to Fusarium, but there have been reports of infected mats in Mbarara, in the Kivu region, and recently from a young Mbwazirume sucker infected in Rwanda[4]. Traditionally four races of the pathogen are recognized, but there are reports of new pathogen populations.

Fusarium wilt reduces bunch size but in rare severe cases it can cause 100%[5] yield loss. Recent surveys in western Kenya[6] and Burundi found Fusarium wilt in 71 and 63.6% of the surveyed fields, respectively. The disease spreads mostly through infected suckers and rhizomes, but also in soil, water and on tools. The most effective management method is planting healthy suckers and starting on virgin land. Crop rotation is ineffective since *Fusarium* propagules can survive in soil for 30 years. In commercial plantations soil fumigation has previously been effective but cost, environmental considerations and banning of methyl bromide has eliminated this option.

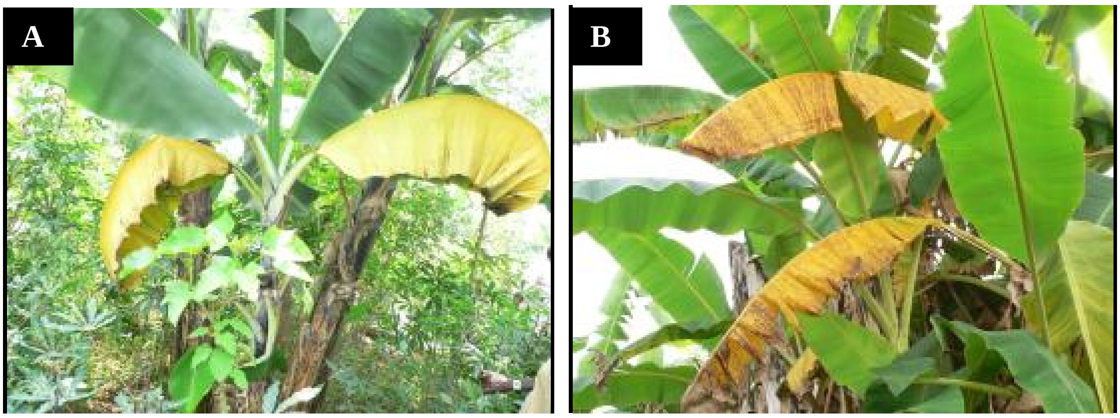

Figure 1: Yellowing symptoms caused by *Xanthomonas* [A] and *Fusarium* [B]. Some of the similarities can complicate visual diagnosis and delay initiation of management measures. There is need to develop robust diagnostic capacity in all countries to ensure immediate and appropriate responses to diseases.

In relation to BXW management, *Fusarium* wilt presents challenges due to some similarities of leaf yellowing symptoms caused by the two diseases (Fig. 1). Where *Fusarium* is confused with BXW

---

[3] Fusarium wilt of banana, R.C. Ploetz (Ed.). APS Press, St. Paul, Minnesota1990. 140 pp.
[4] Samples delivered by Murekezi Charles (ISAR), isolated by Maina Mwangi (IITA). 2007.
[5] W. Tushemereirwe & M. Bagabe, 1999. Review of disease distribution and pest status in Africa. IPM Workshop, IPGRI, Nelspruit, S. Africa. 1999.
[6] Mwangi et al., 2007. Crop Crisis Control Project disease survey reports. IITA, 2007.

farmers have been slow to take appropriate measures to halt disease spread, since traditionally farmers have not been taking measures for *Fusarium* management as it rarely manifests drastic yield reductions. Extension messages on disease recognition and management need to stress on the key differences between BXW and *Fusarium*, and insist on the need to take immediate measures when BXW is diagnosed. Importantly, the efforts being made through C3P to increase availability of clean planting suckers through macropropagation will prevent spread of Fusarium wilt as well.

Black sigatoka leaf spot

The black leaf streak disease (BLSD) is caused by a fungus, *Mycosphaerella fijiensis.* It is the most aggressive form of the *Mycosphaerella* leaf spot disease complex and causes up to 37%[7] yield loss. BSD was first noticed in Fiji in 1963 and was confirmed in all countries in East Africa between 1986 and 1990. Unlike BXW, black sigatoka does not kill plants immediately, but loss increases with time and as plantation ages. The disease destroys leaves, reducing functional leaf area. Infected fruit ripens prematurely and does not fill properly. Plants in the ratoon crop are much weaker and could sustain higher losses of up to 75%. Disease severity and incidence is high where plant density is high, since shading leaves creates favourable microclimates for the pathogen. BLSD is managed by regular removal of leaves (every 7-10 days) to reduce shading and remove leaves with fungal lesions so as to reduce inoculum production.

- Where farmers remove leaves intensely to manage BLSD (e.g. in western Uganda matooke systems), the regular use of tools could greatly increase spread of BXW (Fig. 2). Farmers in such areas must disinfect tools rigorously to avoid BXW spread.
- A careful assessment of BLSD incidence is required before recommendations touching on leaf removal are given. In most *matooke* systems, once BXW presence is noted farmers are advised to immediately stop use of tools, including leaf removal, for up to three months. This allows latently infected mats to express BXW symptoms and be removed, without further disease spread. However, keeping leaves on the plants increases BLSD inoculum which can significantly affect yield.
- BLSD can be effectively managed using resistant hybrids, but *M. fijiensis* has a high level of pathogen variability and could easily break newly introduced resistance. Breeding for resistance to BXW thus needs to consider resistance to BLSD as well.
- In commercial plantations BLSD is managed through fungicides, but this is expensive, requiring up to 36 spay cycles per year, and taking about 27% of total production costs.

Cigar end rot

Cigar end rot (CER) is caused by a fungus, *Verticillium theobromae* or *Trachysphaera fructigena*. Both pathogens exist in central Africa with the latter being more common. In recent surveys CER was common in north western Rwanda, some areas in Burundi and east D.R. Congo. The disease causes a black necrosis spreading from the perinth into the tip of immature fingers, and the pulp undergoes a dry rot. The infected tissues are covered with fungal mycelia that resemble the grayish ash of a cigar end. The rot spreads slowly and rarely affects more than the first 2cm of the finger tip. Incidence is highest during the rainy season. The pathogen colonizes banana leaf trash and flowers, from where spores are disseminated in air currents to other drying flower parts (Fig.

---

[7] W. Tush & M. Bagabe, 1999. Review of disease distribution and pest status in Africa. IPGRI IPM seminar, Nelspruit, 1999.

3). *T. fructigena* causes premature ripening of fruits, and can attack fruits after harvest, invading freshly cut crown surfaces and wounds in the peel caused by improper handling. Disease control is by:

- Early removal of dead leaves and flowers to eliminate inoculum before it reaches developing fruits. Infected fingers should be cut off before harvesting and packaging.
- With improved packaging fruits can be washed in disinfectant to remove pathogen. This should help to kill any Xanthomonas cells that may be smeared on the surface of fruits.
- In Rwanda a common practice for CER control is to put a string on the male buds so that the bracts remain tightly held as the bud emerges and elongates. Bracts held in place could prevent spread of BXW by restricting insect vectors from accessing male cushions.
- Early removal of the male bud (after formation of last fruit cluster) should be promoted as it prevents spread of both BXW and cigar end rot, although through different mechanisms.

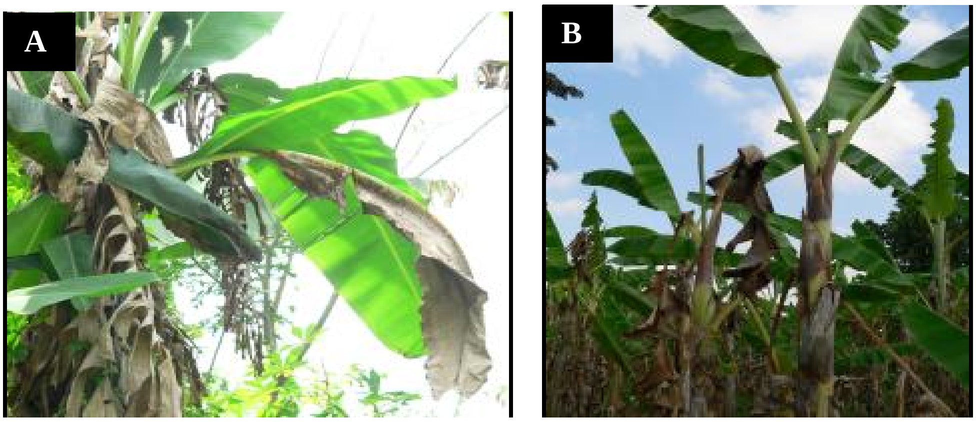

Figure 2: Leaves infected with Black leaf streak (sigatoka) [A] should be removed regularly to reduce inoculum sources and shading which creates suitable microclimates. Precautions should be taken to avoid spreading *Xanthomonas* wilt through tools when removing leaves [B].

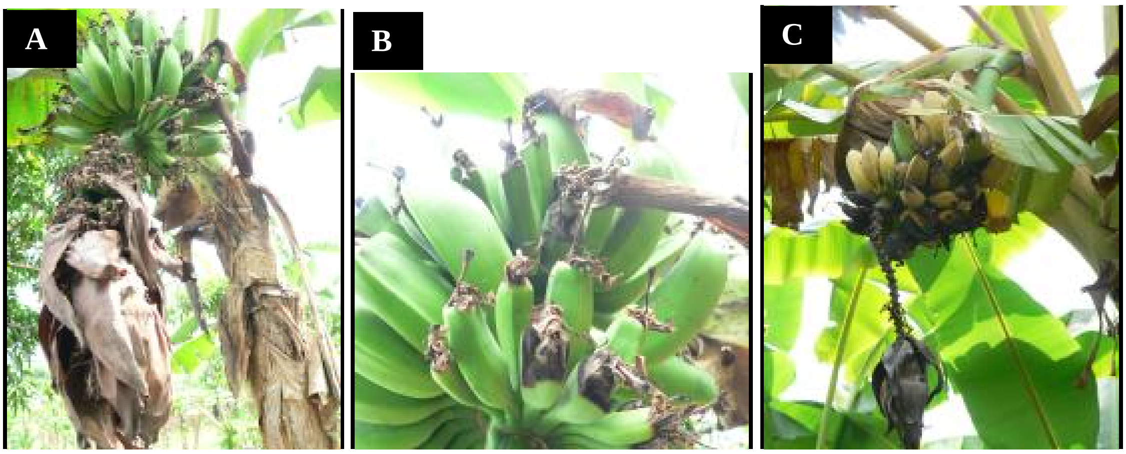

Figure 3: Failure to remove dead flowers and male bud [A] provides incubation sites for pathogen causing cigar end rot [B] and entry sites for Xanthomonas wilt [C]. Early removal of male bud can provide a solution to both BXW and cigar end rot diseases.

Banana streak virus

Banana streak virus (BSV) has been confirmed in Kenya (1993), Rwanda (1988), Tanzania (1988), Uganda (1990) and recently in D.R. Congo[8] near Goma. Where BSV is severe (Fig. 4) mats have to be replaced after every three years due to rapid decline in productivity. Symptom expression is temperature dependent and the effect on yield depends on whether flowering and bunch initiation coincide with temperatures that increase virus replication within plant. If temperatures are unfavourable, bunches would be normal, even though leaves show symptoms. BSV infection can reduce plant stem girth by 6-53% and reduce yield by 6-7%. This virus is globally spread and it is the most commonly detected virus at banana indexing centers, presenting a major hindrance to movement of germplasm around the world. BSV spreads primarily through infected suckers. The virus can be transmitted by mealybugs, e.g. *Planococus citri* and *Pseudococus* sp., but under field conditions this is limited. The disease has not been transmitted mechanically successfully, thus can not be passed on through cutting tools. Disease management is by:

- Using healthy suckers (e.g. through macropropagation targeting for BXW management).
- Destruction of infected plants to reduce sources of inoculum for mealybugs. (There are no methods at present to eliminate BSV from infected material, even through tissue culture, thus all infected material should be destroyed.

.

Banana bunchy top disease

Bunchy top disease is caused by the banana bunchy top virus (BBTV), and is one of the most serious diseases affecting banana[9]. The disease was first reported in Fiji in 1889 and has been confirmed in Burundi and Rwanda (1988) and D.R. Congo (1982). Other reports are in Angola, Central African Republic, Congo, Egypt, Gabon and Malawi[10]. Plants can be infected at any stage of growth. Symptoms include rosetted and small leaves that are more erect than normal, giving the plant a 'bunchy top' (Fig. 4). Infected plants rarely produce a bunch though plants infected late in the season may fruit once, but the stalk and fruit are small and distorted. As with BXW, all suckers on a stool infected with BBTV are eventually infected. The virus is transmitted through infected suckers and can be transmitted by banana aphid *Pentalonia nigronervosa,* but not mechanically. In studies on BBTV outbreaks the average distance of aphid spread was 15-17m, and nearly 2/3 of new infections were within 20m of the nearest source of infection. As with BXW, there are no know resistant cultivars to BBTV.

- Disease management is by using healthy suckers (thus will benefit from ongoing macropropagation efforts and enforcing eradication of infected mats to remove sources of inoculum for aphids.

Banana weevil

The weevil, *Cosmopolites sordidus* is the most important insect pest of banana and plantain. The weevil has a narrow host range and attacks only plants in the genera *Musa* and *Ensete*. Damage is caused by larvae feeding within the corm and pseudostem, causing galleries that weaken the plant and provide entry points for ants and other pests (e.g. BXW) (Fig. 5). Damage eventually leads to plant toppling after snapping at the base. Affected plants suffer retarded and stunted growth, leaf drop and reduced bunch size, and the number and vigor of suckers is reduced. Eggs are laid at the

---

[8] Mwangi, M. IITA. Unpublished observations, 2006.

[9] Dale J.L. 1987. Banana bunchy top: an economically important tropical virus disease. Advances in virus research 33:301-325.

[10] Pillay, M., Blomme, G., Rodriguez, E., L. Ferreira. Infomusa 14-1:44-45.

base of the plant and emerging larvae tunnel into the corm and the pseudostem. The larvae are the only damaging stage of the insect but adults can live for two to four years. Many weevils reside in residues or burrowed in the soil near mats.

Weevils are mostly spread through planting suckers containing eggs, larva, pupae or adults. The adults can also walk over short distances. Weevil attacks are often severe and important in newly planted fields, but become unimportant after crop establishment and thereafter for several crop cycles. Weevil problems build up slowly and are more visible in ratoon crops, generally more during rainy season and greater in mulched fields. Weevil management measures include:

- Using clean planting suckers (thus will benefit from ongoing macropropagation effort).
- Deep planting (60cm) prevents weevils from locating the corm to lay eggs. This practice will benefit BXW management since deep roots can not be injured easily by tools.
- Removal and chopping down of residues, exposing them to dry to reduce weevil breeding sites. This practice benefits BXW management since bacteria in residues would die as residues dry. Removing mats for BXW management will thus reduce weevil populations.
- Crop sanitation and placement of mulches further away from the base of a banana mat is important for management as it reduces suitable habitat from close to the plant.
- Paring and hot water treatment of corms before planting.
    - However paring injuries can increase BXW incidence if corms are planted in soil infested with Xanthomonas. Farmers need to cure pared corms for 2 - 3 days.
    - Weevil management also requires regular weeding and trash removal which could increase BXW spread due to intense use of tools. This increases need for disinfection.

Nematodes

Nematodes parasitize the banana root system and can reduce yield by up to 80%[11], [12]. Root damage is induced directly and indirectly by facilitating the entry of fungi (e.g. Fusarium) and bacteria (e.g. BXW), results in lower nutrient uptake, extends the harvest-to-harvest interval and increases plant toppling (Fig. 5). The major nematodes include *Radopholus similis, Pratylenchus goodeyi*, *Pratylenchus coffeae*, *Helicotylenchus multicinctus* and *Meloidogyne* spp. In Uganda production losses of over 50% have been observed on Nakitemebe and 37% for Mbwazirume. *R. similis* contributes to most plant toppling, but generally production losses are genotype dependent. A strong interaction between nematode and weevil damage has been reported in Kenya. Banana nematodes are generally difficult to manage as they live well protected in the root and rhizomes. Management measures include:

- Planting healthy suckers (Fig. 6). Starting with healthy suckers would lengthen plantation life from two to over five cycles and increase production by 30-50% for each cycle for a period of at least 3 cycles due to reduced nematode effects.
- Using resistant varieties. Most breeding efforts have had considerable success finding resistance; the major challenge is identifying resistance to several species.
- Crop rotation, break cropping and fallowing. This aims to starve the nematode and reduce the population so the next crop starts with a lower population. However, the perennial

[11] Thomas Moens. 2006. Variability in reproductive fitness and pathogenicity of *Radopholus similis* in Musa: effect of biotic and abiotic factors. Infomusa 14-1:39-40.

[12] Carine Dochez. Breeding for resistance to *Radopholus similis* in East African highland bananas (Musa spp.). Infomusa 14-1: 41-43.

nature of banana production does not provide opportunities for crop rotation. Some opportunities are coming up where mats infected by BXW are being removed and six months recommended between crops. Rotation crop should be selected carefully since some nematode species have a wide host range. For example, cassava, sweet potato and pineapple are good rotation crops to suppress *R. similis* and *H. multicinctus*.

- Application of nematicides. In relation to BXW management, nematicides would be more helpful if applied at the time of planting when young suckers are more fragile and vulnerable to attack by pests. Research has shown some pesticides may have adverse effect on Xanthomonas populations in the soil. However, cost, availability and environmental concerns are some factors that do not favor use of nematicides.

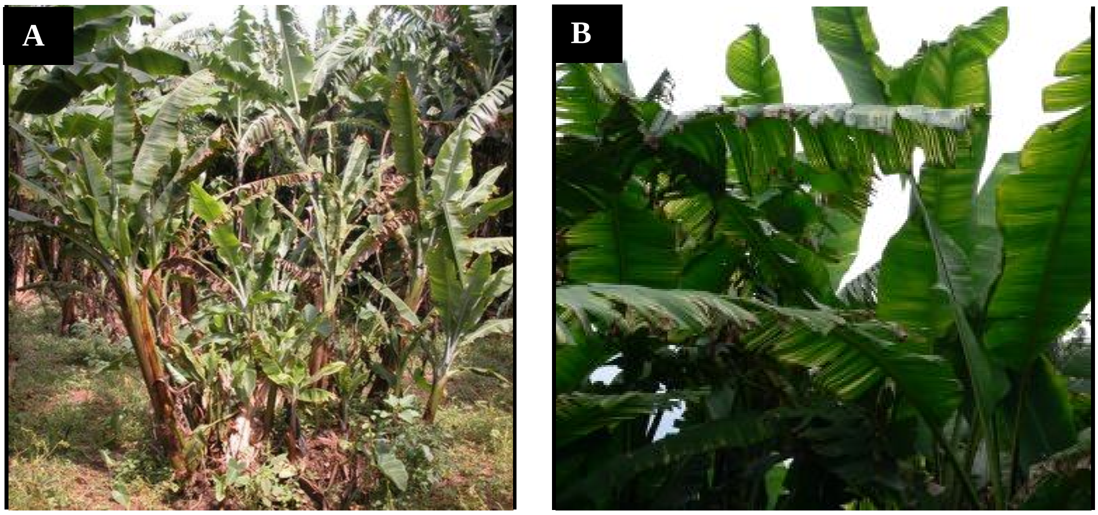

Figure 4: Banana bunchy top [A] and streak virus infection [B]. Both diseases can be effectively contained through use of healthy planting suckers.

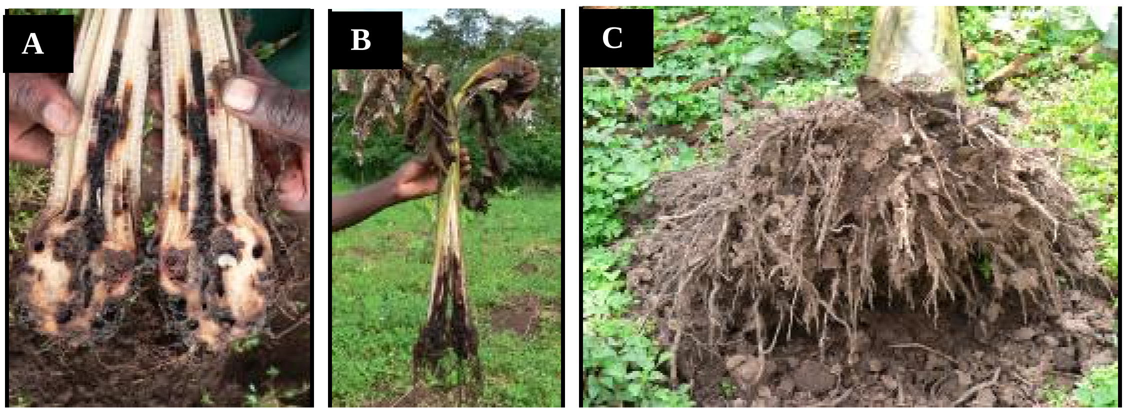

Figure 5: Weevils damage to roots and corm [A] can facilitate spread of *Xanthomonas* wilt [B]. Nematodes damage roots and cause toppling of plants prematurely [C]. Nematodes and weevils are effectively managed by use of healthy planting suckers and crop rotation.

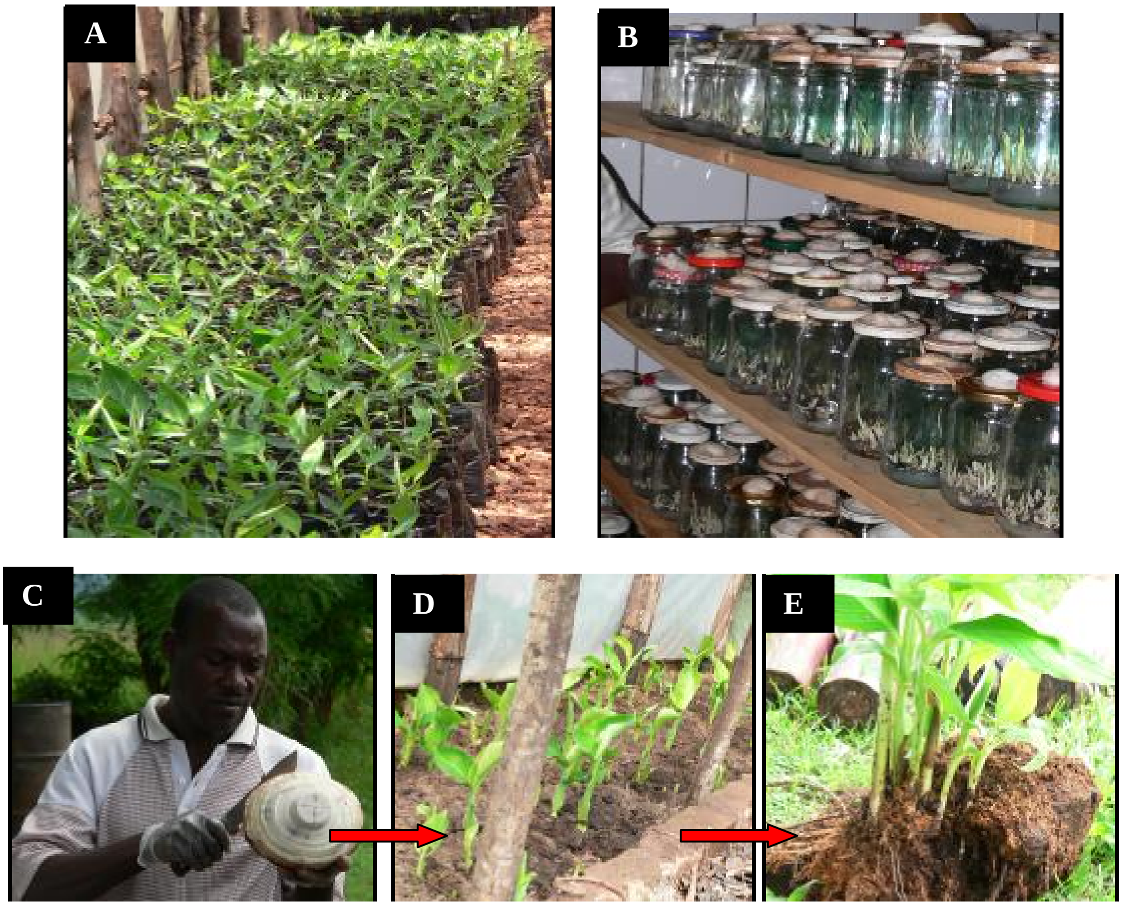

Figure 6: Planting healthy suckers [A] produced by tissue culture [B] or macropropagation [photos C, D & E] is one of the most efficient ways of preventing spread of pests and diseases.

Conclusion

Biotic constraints will continue being major challenges to production of banana and plantains in East and central Africa. While the current focus in C3P is on management of Xanthomonas wilt, with good planning the resources available could also contribute to addressing other pests. As amply demonstrated above, helping farmers to produce and use healthy planting suckers will have far reaching effects beyond management of BXW. Thus, for example, the single investment made to promote macropropagation will have a multiplier effect with regard to management of biotic constraints. It is important to recognise that pests and disease distribution varies with regions and agroecologies, thus extension messages need to be well tailored to fit the specific constraints facing different target audiences. Considering the evolving nature of biotic elements it is important to develop continuous education for extension practitioners so they have updated information on pests and disease threats as they emerge and shift. Governments in the region also need to continuously invest in technology and development of human capacity to ensure rapid and appropriate diagnosis of pests within their territories.