Cultural practices in relation to integrated pest management in bananas

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Introduction

In the case of commercial banana production, chemical control measures still predominate in the elimination of biotic factors that limit or depress yields. In this group of factors, black Sigatoka, Panama disease, nematodes and the weevil borer are by far the most important. Resistance breeding remains a critically high priority, especially for controlling black Sigatoka and *Fusarium oxysporum* f. sp. *cubense* (race 4), but such resistant material is not yet available for the Cavendish group of cultivars which form the basis of world trade in bananas. For these commercial growers who apply chemicals, cultural practices play only a minor role in the context of integrated pest management (IPM).

In terms of world production, bananas are essentially a smallholder crop in which food security and a localized cash economy are the main considerations. In common with commercial banana production, breeding for resistance to pests and diseases is also critically important for small-scale rural farmers, but is even more so in this sector due to the high cost and inaccessibility of chemicals and the fact that bananas and plantains form the staple food of these people. Therefore, cultural practices are the only measures available to small-scale farmers for the control of pests and diseases. The focus of this paper therefore lies with the latter group of farmers, in relation to cultural practices and IPM.

Smallholder cultivation of *Musa* in sub-Saharan africa

In sub-Saharan Africa (SSA), *Musa* provides more than 25% of the carbohydrate requirements for about 70 million people. Bananas and plantains are an integral component of most farming systems where the emphasis is on food security for the rural

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population. In fact, in Uganda, the per capita consumption of *Musa* is in the excess of 250 kg/year (Karamura 1992).

From 1970 to 1997, cooking banana yields fell from 8 t/ha to 5 t/ha in Uganda and from 11 t/ha to 5 t/ha in Rwanda. Yield decline in new plantations is very rapid and can often be seen within two years, i.e. in the first ratoon cycle. There are many reasons for this yield decline, the most important of which are black Sigatoka, *Fusarium oxysporum* f.sp. *cubense*, weevil borer, nematodes, poor planting material, declining soil fertility and shorter fallow periods. These factors are invariably interrelated in that infected plant material causes more rapid plant decline, which necessitates more frequent replanting, which means shorter fallow periods, which in turn enhances the decline of soil fertility, especially as no inorganic fertilizers are applied. The establishment of "clean" planting material in "clean" soil would reverse this negative spiral. However, because the important role of *Musa* in food security is not fully recognized, research tends to be underfunded and the technology needs of the smallholder are not being addressed. Thus progressive yield decline remains a severe problem.

Cultural practices in relation to IPM in banana

Assuming this paper concentrates on soil pests and diseases, there are four main areas of influence on which to focus:

a. reducing pest numbers in the soil before planting,
b. reducing pest numbers in the planting material before planting,
c. promoting root health and vigour in the plantation to help the plant cope with pest pressure, and
d. reducing the chances of pest entry into the rhizome or roots.

Reducing pest numbers in the soil before planting

Use of clean virgin soil

This is the ideal scenario but such soil is becoming less and less available due to a history of shifting cultivation using infected planting material in new soil. If there is clean virgin soil still available then it is absolutely essential that clean planting material is used to establish a banana plantation.

Fallow and rotation cropping

Since increasing population pressure is reducing the availability of agricultural land, fallow periods are becoming shorter after yield decline has necessitated plantation removal. A two-year fallow is more effective than a one-year fallow, but for however long it is, old rhizomes, suckers and other banana trash must be removed to starve out nematodes. Also, alternative host crops and weeds must be avoided for at least one year. Under bare fallow in Australia, no *R. similis* was recovered from old banana roots after 8 weeks burial, but *R. similis* survived for up to 6 months in old rhizome tissue (Stanton 1998). This emphasizes the need to remove old rhizome tissue when fallowing.

Currently, however, bare fallow is not recommended in Australia due to the risk of soil erosion which would also be a problem in any high rainfall area.

In crop rotation experiments, groundnuts and maize were shown to be hosts for *R. similis*, whereas cassava, potato and cocoyam were not (Price 1994). Banana crop rotations showed that the grasses *Panicum maximum* and *Phaseolus altopurpureus* hosted no *Radopholus similis* or *Meloidogyne javanica* after 32 weeks (Colbran 1964) and sugarcane eliminated *R. similis* after 10 weeks (Loos 1961). In recent work by Stanton (1998), it was determined that sorghum was a strong host for *R. similis* in banana rotation cropping whereas sugarcane and jarra grass were excellent at controlling this nematode. From all this work, it appears that certain crops can be recommended for banana rotations such as sugarcane, various grasses, cassava, potato and cocoyam. On the other hand, groundnuts, maize, and sorghum should be avoided by small-scale banana farmers as rotation crops for bananas.

Environmentally-friendly nematicides

Preplant fumigation with EDB or methylbromide is expensive and very toxic. It is being phased out in commercial plantations and is totally unsuitable for small-scale farmers. Likewise, the use of chemical nematicides in the planting hole is expensive, toxic to humans and damaging to the environment. In addition, they are subject to advanced microbial degradation and resistance buildup of the target organism, which reduce their effectiveness. On the other hand, research being conducted at many institutions is showing that environmentally-friendly products and fungal-based bionematicides can be used to effectively control nematodes. This development fits in better with the IPM concept but currently these products are expensive and not readily available for smallholders to purchase.

Reducing pest numbers in planting material before planting

Tissue culture planting material is totally free from injurious pathogens such as *Fusarium oxysporum*, nematodes and weevil borer. However, it is essential that this material should be used in conjunction with clean soil. If the soil is infected with any of these organisms, then tissue culture material should be avoided because the plants, although very vigorous, have no reserves to withstand severe root damage soon after planting. Suckers can survive better than tissue culture plants under infected soil conditions. However, if the soil is infected with disease, nematodes or weevil borer, higher yields can be expected if suckers are treated. The options for sucker treatment are as follows.

Paring

This involves slicing off the outer layers of the rhizome and inspecting the white tissue for infections or weevil tunnels. All discoloured rhizomes are then discarded and only clean ones are used for planting. The operation is fairly easy and inexpensive although it is not a guarantee that clean looking rhizomes are in fact uninfected.

Solarization

This involves heat treatment by solar radiation. In an experiment by Mbwana and Seshu Reddy (1995), banana suckers were treated in a homemade solarization tank and planted out. After 650 days of growth, roots were inspected and analyzed for numbers of the nematode *Pratylenchus goodeyi*. From unpared suckers there were 29767 *P. goodeyi* per 100 g roots compared with 5027 *P. goodeyi* from pared suckers. With suckers that were both pared and solarized, the count was only 542 *P. goodeyi* per 100 g root. This indicates the beneficial effect of combining two treatments and also shows that paring alone does not remove all nematode infections.

Hot water treatment

This can be used to destroy nematodes and weevil borer in rhizome tissue without damaging the rhizome. In a recent experiment by Hauser (1998) at IITA, plantain suckers were treated with hot water at 52ºC for 20 minutes. Mat survival increased by 11% and plant lodging was reduced from 30% to 10% with this treatment. Yields in the plant crop also showed the interactive benefit of hot water treatment together with fertilizer use. Thus, for control (untreated), hot water-treated suckers, fertilized plots and hot water treatment together with fertilizer, plant crop yields were 10, 13, 15 and 21 t/ha, respectively. In the first ratoon, corresponding yields were 0.17, 3.06, 1.44 and 6.92 t/ha, respectively. The ratoon cycle also shows the interactive benefit of the two treatments but more importantly, it shows that severe yield decline occurred in all treatments by the second cycle, due to the rapid resurgence of pest numbers.

Treatment with neem

As an environmentally-friendly sucker treatment, the use of neem cake (*Azadirachta indica*) at 100 g per sucker at planting, then at 4 and 8 months after planting, reduced *Pratylenchus goodeyi*, *Meloidogyne javanica* and *Cosmopolites sordidus* to the same levels as with the use of Furadan nematicide. The percentage coefficient of infestation with weevils was reduced from 75% down to 5% (Musabyimana 1998).

Promoting root health and vigour in the plantation to counteract pest infestations

Various cultural aspects of *Musa* production can be used to increase root vigour, depth of rooting, survival potential and productivity of banana plants being established in infected soil. For resource-limited, small-scale farmers, some of these measures are possible whereas others are only achieved by costly management inputs.

Soil preparation

It has been widely demonstrated that a soft, easily worked soil, encourages more and longer roots in the root zone than a hard, compact soil. In a survey in Martinique, Delvaux (1995) found that as soil bulk density decreased from 1.2 to 0.6 g/cm^3 so banana root density increased from 1 to 7 roots/dm^2. He also found that certain soil types such as andisols were much less prone to compaction over time than vertisols or ferrisols.

Planting deeply in furrows or basins also encourages a deeper root profile than surface planting. It is logical that a denser and deeper root system would be able to cope better with infections from nematodes than a weak, superficial root system, and in addition, reduce the number of fallen pseudostems.

Inherent vigour of tissue culture planting material

In a comprehensive study by Eckstein and Robinson (1995), tissue culture planting material was compared physiologically with conventional suckers. For 4 months after planting, the tissue culture plants exhibited a higher rate of photosynthesis than sucker leaves. This physiological boost caused total root dry matter of the tissue culture plants to be double that of the sucker root system 4 months after planting and total plant dry matter to be double that of suckers by 5 months after planting. Once again it is emphasized that these differences are only achieved with optimum management and with no biotic constraints whatsoever.

Boosting tissue culture nursery growth with microorganisms

The enhancement of plant and root growth of young tissue culture banana plants was studied by Severn-Ellis (1998) using non-symbiotic bacteria. It was found that plant growth, dry mass and leaf area were significantly improved by a combination of *Bacillus* bacteria and fertilizer. Bacteria alone were less effective than fertilizer alone, but the strong interaction between the two showed that bacteria could play a major role in the presence of plant nutrients, probably by enhancing the availability and uptake of these nutrients. Progress has also been made in the field of using fungal endophytes for the biological control of nematodes. Niere *et al.* (this volume[1]) found that when various fungal isolates were inoculated into 19-week-old tissue culture banana plants, the rate of multiplication of *R. similis* in root segments of these plants was reduced by more than half, compared with non-inoculated plants. Plant height of the inoculated plants was also increased. These techniques may eventually play a role in protecting the root environment in smallholder banana plots.

Supplementary fertilizers

Declining soil fertility is one of the major causes of banana yield decline with smallholders. Many experiments have been conducted to show the beneficial effect of fertilizers on yield. An important finding in all this work is the strong positive interaction of fertilizer use with other inputs like hot water treatments, microorganisms in the tissue culture medium, organic amendments and mulch, on boosting root vigour and yield.

Organic amendments

Manure helps to reduce the level of nematodes in the long term but large amounts are required for direct nematicidal properties. Secondary effects result from increasing root vigour to cope better with nematodes. Chicken litter can also reduce nematode populations. The high nitrogen seems to inhibit nematodes but stimulates microflora which indirectly reduces nematodes.

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Mulching

There are many advantages of mulching in bananas which can all play a role in promoting root health and vigour in the plantation. These are:
a. increasing and replenishing soil organic matter,
b. reducing surface temperature and temperature fluctuations,
c. reducing weed growth,
d. improving soil structure and water infiltration,
e. decreasing soil erosion by wind (less dust),
f. decreasing soil erosion by water (less runoff),
g. reduced soil compaction,
h. decreased water loss via surface evaporation, and
i. roots forage higher and grow more vigorously.

Mulching is essential in dryland banana farming and especially on resource-limited plots. In West Africa, Wilson (1987) found that cumulative plantain yield on mulched plots was fourfold higher than that on clean cultivated plots. In Brazil, Cintra and Borges (1988) found that organic mulch on bananas gave an average yield threefold higher than that on hand weeding or cover crop plots. In West Africa, Swennen (1990) increased plant crop plantain yield from 0.6 to 11.9 to 14.1 and to 18.8 t/ha for control, fertilized, mulched and fertilizer plus mulch plots respectively. Mulch therefore played a more important role than fertilizer but the interaction of mulch with fertilizer was the ideal. In the ratoon crop, yields dropped severely due to pest pressure, but the mulched plots still sustained a yield of 10 t/ha.

Reducing the chance of pathogens entering the rhizome or roots

These techniques mainly relate to plant infestation by the weevil borer, *Cosmopolites sordidus* Germar.

Trapping

Old pseudostems are cut into pieces and placed in the plantation to attract and trap adult weevils which should be regularly collected and destroyed.

Plant residue removal

This involves cutting of old pseudostems low down and chopping into small pieces for faster decomposition.

Sanitation

New suckers should not be left standing on the soil surface overnight before planting the next day.

Although these three practices can help reduce adult weevil populations, they are extremely labour-intensive operations.

Conclusions

- Cultural practices are invariably the only techniques a smallholder can use to control or live with soil pests and diseases in banana/plantain production.
- Much information is already available from experiments on smallholder plots, which relate cultural practices to increases of growth and yield under high pest pressure.
- In much of the experimental work, the inference that increased yields are due to either increased root vigour or lower pest numbers, is often speculative.
- More quantitative studies are required to relate cultural techniques to specific root measurements and/or pest counts. In this way the mode of action of these treatments would be better understood.
- There is a widespread need for better transfer of new technologies to the small-scale farmers via training, demonstration plots and participatory techniques.

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