Ecologically sustainable technologies for the management of the highland banana pests in East and Central Africa

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Banana: Importance

- Component of food security
- Important cash and food crop
- Accelerated yield declines

Brewing Bananas
Kayinja, Kisubi (ABB, AB)

Dessert Bananas
Gros Michel (AAA)
Sukali Ndizi (AAB)

Cooking Bananas
Highland Bananas (AAA-EA)
Plantains (AAB)
Current challenges

- Pests (weevils and nematodes), diseases and declining soil fertility
- Decline in diversity and productivity
- Lack of markets for matooke (= green cooking AAA endemic cultivars)
- High costs of production in the central region
- Apparent lack of supportive policies
- Export potential not fully exploited
Banana pests: banana weevil

Corm damage

Pseudostem damage

Snapping & toppling
Banana pests: Parasitic Nematodes

- Root necrosis
- Root galling
- Toppling
- Plantation longevity
Control Options Available

♦ **Chemical control** *(environment unfriendly; high costs; effect on non-targets)*

♦ **Biological control** *(no effective agent)*

♦ **Cultural control** *(clean planting material; Trapping and sanitation; Crop mixtures- systems intensification—labour intensive)*

♦ **Enhanced trapping with infochemicals/pheromones integrated with biological control**

♦ **Host plant resistance** *(genetic engineering and conventional breeding: limited availability)*:
Cultural control

Clean planting material for weevil control

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% larvae reduction vs control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pared + cold water</td>
<td>37</td>
</tr>
<tr>
<td>Pared + Hot water</td>
<td>68</td>
</tr>
<tr>
<td>Pared + Dursban</td>
<td>96</td>
</tr>
</tbody>
</table>

♦ Paring alone removes up to 95% of **eggs** from banana corms
### Clean planting material: effect of paring on nematodes in banana suckers

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. nematodes/100g roots</th>
<th>Rodophilus similis</th>
<th>Helicotylenchus spp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unpared suckers</td>
<td>56</td>
<td>1220</td>
<td></td>
</tr>
<tr>
<td>Pared suckers</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Cultural control

On-farm trial in Masaka: effect of sanitation on weevils

Tinzaara et al., 2006:
## Cultural controls

### Use of botanicals: effect of neem on nematodes

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of nematodes per 100g roots</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pg</td>
</tr>
<tr>
<td>Control</td>
<td>257</td>
</tr>
<tr>
<td>Neem</td>
<td>593</td>
</tr>
</tbody>
</table>

Pest suppression is a perennial challenge to farmers, and it is a very important ecosystem service.

Pg = *Plantylenchus goodeyii*

Hm = *Helicotylenchus melictincus*
Cultural control: systems intensification

- Pest control is a perennial challenge to farmers, and it is a very important ecosystem service.
- Greater functional capacity of diverse agro-ecosystems has been found to protect crop productivity against biotic and abiotic stresses change.
- Increasing farm-wide diversification with silviculture, agroforestry, and livestock provides a variety of other functions to the system some of which impacts the pest population significantly.
- Limited research available within the banana cropping systems
Pheromones for weevil control

- Synergistic or additive effects (Tinzaara et al., 2002)
- Pheromone trap efficacy (Tinzaara et al., 2005)
  - Attraction range
  - Weevil density
  - Trap location
  - Mulch effects
- Links with biological control
  - Predators (Tinzaara et al., 2005)
  - Entomopathogenic fungi (Tinzaara et al., 2004)
- Impact on weevil population & damage (Tinzaara et al., 2005)
Maize formulated fungal pathogen, *Beauveria bassiana* applied around banana mat and in a gallon trap baited with the aggregation pheromone (a). White mycelium growing out of dead weevils found at the base of the banana plant in the leaf sheath (b).
Host resistance: conventional breeding

- Advocated for as the **most effective, economic and environmental friendly** option for the resource constrained farmers for banana weevil and nematode control on small scale farms
- Limited success has been achieved towards breeding for resistance towards the banana weevil and nematodes through conventional approaches
- Total or partial resistance has only been reported in clones with the **BB genome**
- Resistant clones from the BB genome may not satisfy consumer tastes if used as parents
Host resistance: Conventional breeding

- Breeding efforts by the national programme with partners (IITA and Bioversity) has resulted in cultivars such as M9 which are tolerant to weevils and nematodes.
- Several matooke hybrids (e.g. M25, M26, M27, M28, and M29) developed and evaluated with farmers and are ready for release.
Host plant resistance: genetic engineering

Against *Cosmopolites sordidus*

- Preliminary *in vitro* bioassays with Cry6A and papaya Cystatin (CpCyst) proteins confirmed delayed weevil development
- The two transgenes were then transformed into banana with the aim of evaluating the genes for their efficacy to control banana weevils
- The transcends are currently under confined field trial evaluation
Host resistance: Genetic engineering

Against nematodes

• Repellent papaya cystatin gene introduced into banana plants sukali ndizi gave over 90% protection against *Rodopholus similis*

• Experiments are in progress to look at the stability of the genes
Host resistance: The RNAi technology

- RNAi has been demonstrated to suppress genes in banana weevil through in vitro studies
- Banana weevil larva growth was significantly retarded and up to 100% mortality at 21 days observed.
- Growth inhibition and mortality increased with dsRNA concentration
- Transgenic banana plants expressing siRNA or hairpin RNA could thus potentially be used for controlling the weevil.
- The nematodes *R. similis* is also susceptible

<table>
<thead>
<tr>
<th>Gene ID</th>
<th>Banana weevil larva growth rate (x10^4 g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 ng/µl</td>
</tr>
<tr>
<td>Water control</td>
<td>17.86 a,x</td>
</tr>
<tr>
<td>CsRIB</td>
<td>20.28 a,x</td>
</tr>
<tr>
<td>CsUBE</td>
<td>07.7 b,x</td>
</tr>
</tbody>
</table>

Means in the same column with the similar letters (a-c) and similar letters (x-y) in the rows are not significantly different at 5% Least Significant Difference.
Conclusions

- **Chemical methods** though fast and effective are not affordable by resource poor farmers and are ecologically unsustainable
- **Cultural practices** ecologically friendly but cumbersome: Trade-offs between the above practices needed
- **Host plant resistance** through conventional breeding and genetic engineering: are eco-friendly and potential approaches for nematode and weevil control
- **Promotion of systems intensification**: Recent studies show that a diverse crop system is beneficial for the farmer because it allows a more stable management of pest and disease pressure than a monoculture allows: future research
  - No single method can provide control of the banana weevil and nematodes: **IPM**- an ecosystem approach
Acknowledgement

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Thank you

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