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Biological Control in Cocoa

Current Status

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International Workshop on the Safe Use of Pesticides in Cocoa and Harmonized Legislation for Food Safety

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Diseases of cocoa

It is estimated that 30-40% of cocoa is lost annually to pests and diseases:

- Witches' broom
- Frosty pod rot
- Black pod
- Vascular-streak dieback
- Cocoa pod borer
- Mirids

Photograph: J Crozier

Methods for disease management

- Pesticides
- Cultural practices
- Resistant/tolerant varieties
- Biological control
- Combinations of the above – integrated pest management (IPM)

Biological control

‘The use of one organism to suppress another’

Types of biological control:

- **Conservation biocontrol** – conservation of natural enemies *in situ*
- **Classical biocontrol** – use of co-evolved natural enemies from the origin of the target pest/pathogen
- **Augmentative biocontrol** – addition of natural enemies where they are absent or in low numbers

Biocontrol agents: predatory insects, spiders, mites, parasitoids, nematodes, fungi or bacteria

Mechanisms for control

- Competition and exclusion
- Production of soluble or volatile metabolites
- Parasitism of the host pathogen
- Induced resistance

So why biological control?

- Growing concern about chemical pesticide toxicity and food safety have led to a call for reduced pesticide use
- The need for alternative control measures has increased interest in the use of biological control agents
- Biological control is deemed to be a more natural or ‘environmentally friendly’ method of disease control
- Biological control can be implemented into IPM strategies and reduce the amount of chemicals applied for disease management

Frosty pod rot (FPR)

Causal agent: *Moniliophthora roreri*
Region: Central and South America

Photographs: K Holmes & J Crozier

Biological control

Costa Rica & Ecuador

- Co-evolved endophytes and mycoparasites from forest host of the frosty pod pathogen were isolated
- Selected on the basis of results from *in vitro* screening: antibiosis, mycoparasitism, colonisation ability
- Small scale field trials to assess ability to colonise cocoa pods
- Large scale field trials to investigate application methods & formulation compared to chemical fungicides
- *T. ovalisporum* applied in oil formulation has increased healthy pods from 10% to 40% performing better than the copper control
- It also reduced the number of sporulating pods

Photographs: J Crozier & K Holmes

Cont...

Peru

- 220 isolates of endophytic *Trichoderma* spp. have been collected from wild cocoa in the Upper Amazon Basin
- Isolate selection is currently underway to assess their antagonistic abilities using *in vitro* screening against *M. roreri* and also *P. palmivora*
- Field trials are planned to assess their ability to reduce incidence of FPR and BP

Future plans

- Investigate other formulation technologies: oils, emulsifiers, nutrient supplements
- Reduced volume application to improve cost efficiency
- Investigate mixtures of *Trichoderma* and *Bacillus* spp.

Witches' broom

Causal agent*: Moniliophthora perniciosa*
Region: South America & Caribbean

Photographs: J Crozier & K Holmes

Biological control

Brazil

- *Trichoderma stromaticum* is a newly discovered mycoparasite of *M. perniciosa* the causal agent of witches' broom
- It has been found in association with diseased brooms and pods
- *T. stromaticum* colonizes the nectrotic tissue of the brooms and suppresses the production of fruiting bodies interupting the disease cycle and lowering the source of inoculum
- This biocontrol agent (BCA) is currently marketed as 'Tricovab' and is available to cocoa farmers in Bahia
- The BCA is applied to pruned brooms which are in contact with the ground and is also tolerant to the copper fungicides traditionally used to manage WB

Photographs: R Bateman & K Holmes

Cont...

Further research

- Further research is currently being conducted to improve production systems, quality of product and delivery methods
- Current studies are underway to identify more locally adapted isolates of *T. stromaticum* which have the ability to colonize brooms in the canopy for effectively. This would eliminate the need to remove brooms from the tree before treatment and reduce costs substantially

Ecuador

- Program to study the effect of *T. stromaticum* on WB
- Endophytic bacteria (Bacillus spp.) have also been shown to reduce incidence of WB throughout the wet season

Black pod (BP)

Causal agent: *Phytophthora megakarya*
Region: Central & West Africa

Photographs: K Holmes & H Evans

Biological control

Cameroon

- Fungal isolates from cocoa, cocoa yam (used for intercropping with cocoa) and soil were screened against *Phytophthora megakarya* using a precolonised plate method and a detached pod assay
- Only four isolates of *T. asperellum* were found to be antagonistic to *P. megakarya* in both assays
- In short term and long term field trials the *T. asperellum* isolates were found to significantly reduce the percentage of diseased pods compared to the untreated controls
- However, they did not perform as well as the chemical treatment traditionally used
- Further field studies using *T. asperellum* (PR11) have shown again that chemical treatments were more successful in controlling black pod, although the use of one isolate followed by application of copper was able to reduce BP by 48%
- Demonstrates the potential for integrated control

Vascular-streak dieback (VSD)

Causal agent: *Oncobasidium theobromae*
Region: South east & South Asia & Melanesia

Photographs: D Guest & M Holderness

Biological control

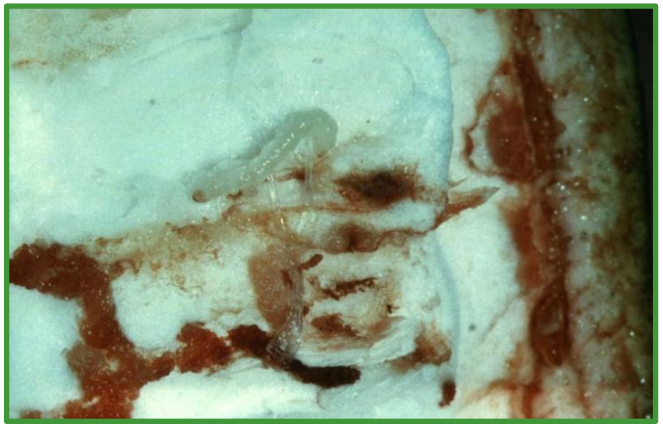
Very little research to date has been published on the biological control of *Oncobasidium theobromae*

However, this fungal pathogen infects young leaves and is associated with the plants vascular system

Great potential exists to explore the use of a mycoparasitic BCA to reduce leaf infection or an endophytic BCA to protect against vascular infection

Cocoa pod borer

Causal agent: *Conopomorpha cramerella*
Region: South east Asia & PNG



Photographs: J Flood, S Lambert & C Prior

Biological control

Black ants & weaver ants
Have been used as natural enemies to reduce CPB incidence in Malaysia and Indonesia where they prey on the larvae

Nematodes
In Indonesia treatment of pods with entomopathogenic nematodes and biodegradable plastic bags significantly reduced CPB

Beauvaria bassiana
Was successful in reducing CPB in Indonesia by infecting the larvae and pupae of the CPB moth

Parasitic wasps have also been found to be successful but not cost effective to produce and release




Mirids/capsids

Causal agent: various sap sucking insects
Region: All cocoa growing regions



Photographs: K Holmes, R Bateman & G Oduor

Biological control

- Mirids are a serious insect pest in areas where cocoa is grown worldwide.
- They are sporadic and difficult to control
- It has been reported in West Africa that mirids can reduce cocoa yields by 30% in 1 year and up to 75% if left for 3 years
- In W Africa weaver ants and in SE Asia black ants and weaver ants have been encouraged as natural enemies of mirids, although weaver ants are reported to be very aggressive
- Their nests can be transferred from plantation to plantation

Summary

Future considerations for BCA

- Mass production costs of BCA are relatively low in comparison to chemical pesticides
- The production processes can be prone to contamination and low quality issues reducing their effectiveness
- Further work needs to be done to improve isolate selection, formulation and delivery systems
- Selection of co-evolved BCA's may have to ability to evolve alongside the pathogen
- Endophytic isolates should be more suited to persist within cocoa tissues prolonging protection
- Potential for use in IPM strategies to reduce the use of chemical pesticides

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