Integrated Management of the Invasive Cocoa Pathogen *Moniliophthora roreri*

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Moniliophthora roreri causes Frosty Pod Rot (FPR) of Cocoa (*Theobroma cacao*)

- **Spanish: moniliasis**
- **Highly invasive pathogen**
- **Losses up to 100%**
- **Crop abandonment**
- **Loss of livelihoods**
- **Change of land use with loss of biodiversity**

Invasive Spread of *M. roreri* throughout Mesoamerica

Source: Phillips *et al.*, 2005

Management Cascade for Invasive Alien Species (IAS)

- **Prevention**
  - Most cost-effective approach
- **Early detection and rapid response**
  - Based on analyses of pathways and risks
- **Impact mitigation**
  - Integrated approach
  - Benefit : cost analyses

Both require:
- ✓ strategic planning
- ✓ public awareness
- ✓ training
- ✓ effective enforcement mechanisms

Prevention

- **Scope:**
  - Insular Caribbean, Eastern Venezuela, Guyanas and Bolivia:
    - Extreme alertness
    - Regional cooperation
  - Africa and Asia:
    - Strategic measures for intercontinental germplasm transfer, transport and trade
- **Public awareness and education**
  - FPR destroys livelihoods
  - Apparently healthy pods may harbour the pathogen
- **More efficient enforcement of existing regulations**
  - Ports of entry by air, sea and land

Early Detection and Rapid Response

- **Train quarantine and survey personnel in early detection**
  - Latent infection last up to two months
  - Least visible on outside of pod

Focus on early stages

Looks like witches' broom

5 diseased pods

5 healthy pods

6-8 week window of opportunity

Diagnostic confirmation

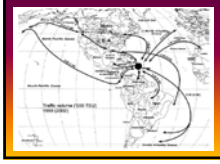
Early Detection and Rapid Response

- **Emergency plan**
  - Develop with anticipation
  - Focus on high risk pathways: the infamous ***"4 Ts"***

Tourism

Travel

Trade



Transport

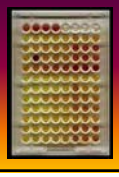
Source: Meissner *et al.*, 2009

snails

Early Detection and Rapid Response

- **Implementation and enforcement mechanisms**
  - Prompt host elimination
  - Farmer compensation scheme
  - Replanting capacity

- **Early detection and rapid response have never been used successfully against FPR!**



Impact Mitigation: Integrated (IPM) Approach

- **Invariably centres around cultural control**
  - Fundamental to IPM approach: no short-cuts
  - Already available (short term)
  - Epidemiology urges weekly phytosanitation,

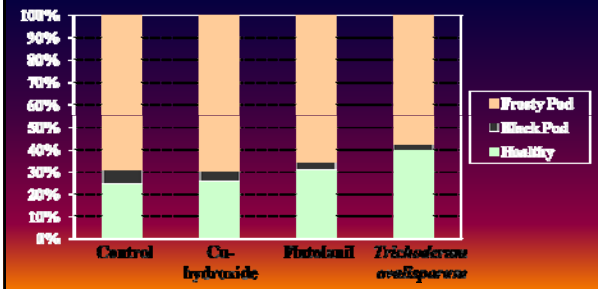
- **Benefit : cost analysis may highlight need to modify**
  - Frequency and combination of interventions
  - Modelling as decision- making tool

- **Complemented by**:
  - Chemical control
  - Biopesticides
  - Disease resilient agroforestry systems
  - Classical biocontrol, e.g. with endophytes
  - Genetic and induced resistance

Impact Mitigation: IPM - Chemical Control

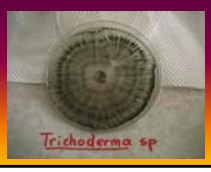
- **Already available (short term)**
- **Copper fungicides consistently most cost-effective**
  - Select low hazard class (Cu hydroxide; NOT Cu sulphate)
  - Cu still permitted in organic cocoa if ≤ 8 kg ha^{-1} yr^{-1}
- **Flutolanil (oxathiin: systemic, specific against basidiomycetes)**
  - Beneficial in early season
  - Best applied with a sticker
  - No measurable residue
- **Targeted application**
  - Determines %age waste and thus cost-effectiveness
  - Requires manageable tree height => CULTURAL MEASURES !

Impact Mitigation: IPM
Biological and chemical control



Impact Mitigation: IPM
Biological control – inundative and classical

- **Short term:**
  - Inundative use of local antagonist mixtures in Peru
- **Medium term:**
  - Classical biocontrol approach in Central America
  - Using coevolved endophytes



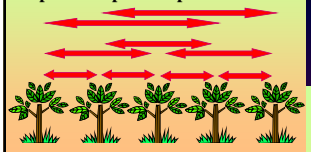
Impact Mitigation: IPM
Resistance – genetic and induced

- Long term perspective
- Horizontal (multi-gene) resistance is less complete but more durable
- ICS-95 showed consistent resistance against seven isolates from four genetic groups of the pathogen
- QTL-assisted breeding under investigation
- Immunization with endophytes building on phosphonate experience?



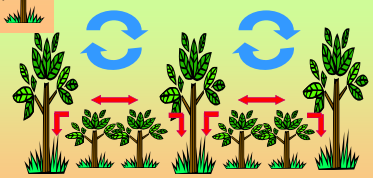
Source: Schnell *et al.*, 2007

Monoculture:
Continuous cross-infection
Splash-dispersal up to 8m



Impact Mitigation: IPM
Disease-resilient agroforestry systems (AFS)

Air circulation in upper canopy



Non-hosts intercept inoculum, but increased humidity

- **AFS design to diversify risks and to regulate**
  - Temperature / Shade
  - Aeration
  - Inoculum interception

Conclusion

- **Prevention is the first choice**
- **Early detection and rapid response have never been used successfully against FPR**
  => Approach needs to be more rigorous
- **Impact mitigation must centre around sound cultural management**
- **Priority action points:**
  => Proactiveness of intervention cascade
  => Training and public awareness
  => Effective enforcement cascade, including funding
  => Regional and international cooperation

Thank you!

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