Sustainable agriculture and climate change: threats, challenges and innovation

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Issues and Focus

• Climate change will alter all parameters surrounding sustainable agriculture – for example crop growth, yield, management, disease and pest complexes

• Challenges are in crop management, pest and disease control.

• Focus on tackling food security by reducing losses – this needs innovation in the face of climate change

• Innovations include joined up thinking in IPM (integrated pest management) including the use of biocontrol and biopesticides
Structure

- The threat of climate change impacts
- Crop management - challenges and innovation
- Pests and diseases – challenges and innovation
- Examples: Siam Weed; Banana; Cacao
- Summary
Figure 3.3. Relative changes in precipitation (in percent) for the period 2000-2009, relative to 1980-1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 68% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. (WGI Figure 10.9, SPM)
More extreme weather events

- Increasing destructiveness of tropical cyclones over the past 30 yrs (Emanuel 2005).
- Major impact on crops:
  - 20 March 2006: *Cyclone Larry* (category 5) hit Innisfail, Queensland, devastating 90% of the banana crop
  - 22 August 2007: *Hurricane Dean*, hit Martinique, in the Caribbean, destroying more than 600 million AUD of bananas
Regional impacts of climate change

Africa
By 2020
• up to 250 M people exposed to increased water stress
• yields from rain-fed agriculture reduced by up to 50% in some countries

By 2080
• up to 8% increase of arid and semi-arid land

By 2100
• sea level rise affect coastal areas with large populations – cost of adaptation at least 10% GDP

Asia
By 2050
• freshwater availability in Central, South, East and South-East Asia decreases
• sea level and river flooding will threaten heavily populated megadeltas (South, East and South-East)
• climate change compounds pressures from rapid urbanisation, industrialisation and economic development on natural resources
Projected changes in global agricultural productivity by 2080 due to climate change. Red = a decrease in productivity; Green = an increase in productivity. LDCs/ tropics expected to suffer the most.
Systematic Impacts

Climate change

- rising temperature
- air humidity
- CO₂, N₂O, CH₄
- rainfall
- fire risks

Pest complex

Crop

Weed community

changes in soil water / nutrient dynamics
Effect of higher temperatures on crop yields

-adapted from IPCC (2007) by Norgrove, summarising 69 studies. No adaptation.

< 3 °C increase
higher yields in temperate zones

> 3 °C increase
lower yields in temperate zones

Any increase
lower yields in tropics
Altered distribution of pests

- Changed pest/crop/soil dynamics
- Ranges of some pests may expand to higher altitudes & latitudes
- More extreme climatic disturbances will create opportunities for pest colonisation and establishment
Predicted expansion of Siam weed range

- *Chromolaena odorata* (Siam weed) is a serious weed from S. America, invasive throughout the tropics
- CLIMEX™ (*Sutherst et al 2007*) uses IPCC models plus precipitation, vapour pressure, & temperature data to predict climate change surfaces for global weeds, including Siam weed
- In West Africa, the range of Siam weed is predicted to expand east to Central Africa and beyond (*Kriticos 2007*)
- Biocontrol is contentious as many farmers perceive Siam weed positively as it outcompetes the more difficult-to-manage *Imperata* grass
Pest and Disease Interactions

- Siam weed is an attractant for the African grasshopper *Zonocerus variegatus* (Le Gall 2003)
- Increases in *Zonocerus* populations correlated with and attributed to increasing cover of Siam weed
- *Zonocerus* defoliates banana, cassava and other food crops
- *Zonocerus* can transmit bacterial blight (*Zandianakou-Tachin et al* 2007), a serious disease of cassava, a main staple in the region

*Z. variegatus* on Siam weed credit: Cock

*Z. variegatus* credit: Cock

*Z. variegatus* on cassava (*Manihot esculenta*) credit: Cock
Management options: Green Muscle®

- Green Muscle is an environmentally-friendly mycoinsecticide of *Metarhizium anisopliae* var. *acridum*
- Developed by the collaborative LUBILOSA project comprising CABI, IITA, GTZ & CILSS/AGRHymet
- Can be used to control *Z. variegatus*, *Schistocerca gregaria*, the desert locust and other hoppers
- Commercialised by Biological Control Products SA (Pty) Ltd, South Africa and SenBio, Senegal

Desert locust infected with Green Muscle®
Banana-plantain (Central Africa)

- Most important food cash crop staple
- Cultivated in ‘esep’ long fallow fields intercropped with mélon (*Cucumeropsis mannii*), tannia, macabo; after a fallow >10 y.
- Without fertilizer, pesticides or herbicides
- Weeding twice per year with machete
Pest pressures of banana-plantain

2. Black Sigatoka *Mycosphaerella fijiensis*

3. Weevils. 
*Cosmopolites sordidus*

1. Root nematodes
*Radopholus similis*
*Meloidogyne spp.*
*Pratylenchus goodeyi* (at altitude)
*(Helicotylenchus multicinctus)*
More damage by nematodes at higher temperatures

Temperature effects on *R. similis* populations and root necrosis index.

- Higher temperatures lead to higher reproductive rates, more root necrosis and yield losses
- *R. similis* is absent at the cooler high altitudes & latitudes. But is this changing?
- *R. similis* might replace the less damaging highland species, *Pratylenchus goodeyi* at higher altitude

Data adapted from Fallas & Sarah 1995, Pinochet et al 1995, Norgrove & Hauser unpubl
Promoting better management

**Global Plant Clinic:**
- Establishes rural plant clinics
- Trains local “plant doctors”
- Promotes IPM to farmers

Methods to reduce damage from nematodes:
- Using clean planting material,
- Immersion in hot water to kill nematodes,
- Removal of roots and outer infected tissue from culture plantlets or carefully pared suckers
- Removing all plant parts from old fields, using crop rotation or leaving land fallow for at least 3 years
Smallholder cacao and pest pressure

- Cocoa, of S. American origin, is grown throughout the humid Tropics
- World production ~ 3.5 million tonnes p.a.
- More than 70% of world production is from the coastal zone of West/Central Africa where it is grown by smallholder farmers
- In Africa, blackpod (*Phytophthora palmivora* and *P. megakarya*) are major biotic constraints; similarly frosty pod (*Moniliophthora roreri*) and witches' broom (*Moniliophthora perniciosa*) in Latin America
- Global yield loss to blackpod alone ~ 0.5 million tonnes p.a.
Higher humidity in cacao growing areas?

- Predicted higher temperature, humidity or rainfall in some parts of the humid tropics will exacerbate yield losses to fungal diseases

- Yet, above 26°C, *P. megakarya* growth is sub-optimal (*Brasier & Griffin 1979*) so aggressiveness might reduce as climate change advances

- Farmers use mainly copper-based contact fungicides but this strategy will become less effective if rainfall increases, as the product will be washed off
Novel biocontrol agents in cacao

- Promote more effective control methods to farmers, including rational fungicide use, improved sprayers and spraying techniques (Bateman 2004)

- Novel control methods. *Trichoderma* endophytes are plant symbionts. They can protect their hosts from diseases through various mechanisms: competitive exclusion, antibiosis, induced resistance and mycoparasitism; can be applied as inoculation of seeds (grow with plant)

- *Trichoderma* spp. that exhibit these properties and colonise cocoa tissue are being collected, isolated & screened for potential as biocontrol agents (Holmes et al 2004, Bailey et al 2008)
Summary

- Climate change will reduce crop yields both directly and by new interactions between crops, pests and diseases.
- Developing countries in the tropics are likely to be hit hardest.
- Adaptation strategies are needed:
  - Training and capacity building at local level
  - Community-based early warning and risk management
  - Early control of pest outbreaks
Further work

• Climate change impacts are case-specific. Need to be understood by referring to existing data or conducting new fundamental research

• Need new methods such as biocontrol agents to compensate for reduced efficacy of contact fungicides under greater precipitation (cacao)

• Greater pest problems require more stringent cultural control methods or use of tolerant varieties (bananas)
Thanks

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Thank you for your attention!