The Impact of Pests and Diseases on Crop Production and the Importance of IPM in International Development

Plant Health Management in the Real World – the need for CGIAR systemwide innovation –

R. Sikora, I. Hoeschle-Zeledon, J. Nicol, R. Bandyopadhyay, J. Kroschel, B. James, P. Bramel

Presentation given at World Bank, October 2008
The Real World has Become Unreal

ANAMORPHOSIS OF THE WORLD:
GROSS NATIONAL PRODUCT

for personal use only
Population growth
Food consumption/person, Total consumption (134 countries)

Total food consumption 2003 bis 2050 ca. + 100 % increase

Zeddies, 2008
Wheat yields: 2008 and needed by 2020

UN/FAO production goal for wheat 4 tons/ha by 2020

(Braun, CIMMYT 2007)
Global challenges call for new approaches to crop protection

- Number of food-deficient people increased by at least 75 million over last two years
- Currently >1 billion undernourished people
- Climate variability and change will affect agricultural production positively and negatively
- Climate variability and change will have severe adverse effects on current crop protection strategies

**Challenges:**

Greater importance of pests and diseases in production systems

Need for innovative IPM crop protection approaches

Effective pathways for innovation transfer to the NARs and farmer
Effect of Pests and Crop Protection on Maize Production, 2002-04

Production potential: 940.3 x 10^6 t (= 100%)
Production without control: 296.7 x 10^6 t (= 31.6%)
Loss potential: 68.4%
Production with control: 648.5 x 10^6 t (= 69.0%)
Actual losses: 31.0%

EC Oerke, unpublished
Effect of Pests and Crop Protection on Rice Production, 2002-04

Production potential: 922.7 x 10^6 t (= 100%)
Loss potential: 77.0%
Actual losses: 36.3%

Production without control: 211.9 x 10^6 t (= 23.0%)

Production with control: 588.0 x 10^6 t (= 63.7%)

EC Oerke, unpublished
Climate change impacts

- Increased hunger
- Spread of disease
- Changes in water availability
- Infrastructure damage
- Change in forest cover
- Loss of biodiversity
- Sea level rise
“Hand to mouth reality”

Impacts will not be evenly distributed

Maize yield variability and ENSO activity in Zimbabwe. Source: Cane et al., 1994
Climate variability and change: threats to food production

- increase in population and life cycles of existing pests
- invasion by introduced or migrated alien species of plants or animal pests
- reduction of crops’ tolerance and resistance to pests and diseases
- increase in mycotoxin infestations, incl. appearance of new strains of toxin producing fungi
- loss of CWR for classical and modern crop resistance breeding programs
- decrease in soil fertility, increase in soil erosion reducing the natural capacity of soils to control soil borne pests and diseases
- reduction of beneficial organisms for pest and disease control
- reduction in pesticide effectiveness
Expected Impacts of Climate Change on Pests, Diseases and IPM

- Range expansion
- Higher pest pressure within existing range
- Decreased host tolerance/resistance
- New pest problems
  - secondary pests ⇒ primary pests
  - invasive alien species
- Narrowing of management options
Challenges for pest management

- Deactivation of host resistance
- Diminished genetic diversity for breeding
- Reduced biological control
  - Enemy-herbivore dynamics
  - Effects of soil erosion/loss of SOM on soil born disease control
- Reduced pesticide effectiveness
IPM Research in the CGIAR: Systemwide Program on IPM

• Inter-institutional partnership program

• Established in 1996, response to Agenda 21 action plan formulated by the UN 'Earth Summit' in Rio de Janeiro in 1992 (Agenda 21 identified IPM as a key element in sustainable agricultural development)

• Increased importance due to

  1. the commitments of the international community towards social and economic development in the poorest countries (MDGs, 2000)
  2. the System Priorities for CGIAR Research (2005)
  3. one of the 5 Systemwide Programs assessed by Science Council as critical for development
What SP-IPM does

...develops knowledge and technologies for innovative crop protection to increase and secure production of affordable and safe food in an economically and environmentally sound way.

To better respond to the new global challenges SP-IPM re-oriented its research towards:

- Adaptation of IPM to climate change
- Improving food and feed safety
- Increasing agro-ecosystem resilience
- Capacity building – Innovation pathways
SP-IPM’s answer

• Development of methodologies to identify regions and cropping systems vulnerable to increased pest damage under CC conditions
• Identification of IPM strategies to enhance resilience of vulnerable agro-ecosystems to CC
• Development of strategies for adapting host-plant resistance to pests under different climatic conditions
Climate change: current research
(selected examples)

- Develop and validate temperature-based phenology models for pests and related parasitoids
- Assess potential risks of economically important crops to pests induced by CC

Achievements:

- Phenology model for the potato tuber moth (PTM) (Sporleder et al. 2004, Keller 2003)
- PTM risk assessment worldwide under CC (Sporleder et al. 2007, Sporleder et al. 2008)
Food and feed safety

The situation:

• The right to adequate amounts of food is also the right to healthy food

• Health risks associated with food derive from
  - pesticide residues
  - heavy metals
  - microbialis (E. coli, Clostridium spp., etc)
  - mycotoxins (esp. from Aspergillus, Fusarium, Penicillium spp.)

• Approx. 4.5 billion people in the developing world are exposed daily to mycotoxins, esp. aflatoxins through consumption of staple food

• Contaminants in food limit farmers’ ability to export their crops => farmers and exporting countries are deprived from vital income; export losses in groundnuts >USD 450m/yaer under current EU regulation

• Mycotoxins in feeds represent high risk to growth and development of livestock
Aflatoxin Contamination in W. Africa

- **CODEX standard**: 20 ppb; **EU**: 2 ppb

**Primary products**
- Maize: 4000 – Benin
- Peanut: 216 – Ghana
- Sorghum: 80 – Ghana
- Millet: 200 – Nigeria
- Tiger nuts: 120 – Nigeria

**Food products**
- Peanut paste: 3278 – Ghana
- Peanut sauce: 943 – Ghana
- Lentil sauce: 775 – Gambia
- Maize dough: 313 – Ghana
- Kenkey: 524 – Ghana
- Cashew paste: 366 – Ghana
- Peanut oil: 500 – Nigeria
- Yam flour: 7600 – Nigeria
- Local beer: 135 - Nigeria
Trade losses due to mycotoxins

- Codex Alimentarius: 20 ppb; EU 4 ppb (sum of all aflatoxins in nuts/peanuts for direct human consumption)
- World Bank estimates:
  - US$ 670 millions (2001 study)
  - Tens of millions US$ (2005 study)
- Export losses in groundnuts >USD 450m/year under current EU regulation
- Best quality exported, poorer quality consumed domestically => public health risks
SP-IPM’s answer

• Development of new technologies to identify plant germplasm able to reduce mycotoxin levels (resistance to fungal colonization, reduced toxin production, swifter toxin degradation)

• Development and dissemination of new tools to improve management of contaminants (e.g. biological control of aflatoxin-producing A. flavus)

• Development and promotion of IPM options to reduce inappropriate pesticide application (biocontrol, biopesticides)
SP-IPM achievements in mycotoxin management

• Biological control of mycotoxins:

“Competitive exclusion” of aflatoxin producing strains of *A. flavus* through soil inoculation with atoxigenic strains of *A. flavus*, indigenous to Africa

=> reduction of toxin >90% with single application in lab and field tests;

large-scale testing under way in Nigeria
Planned project

“Management of mycotoxin contamination in staple foods (maize, wheat, groundnuts) in selected countries in Asia, Africa and Latin America”

**Rationale:** mycotoxin contamination remains a problem despite previous achievements due to:
- poor awareness at all levels, hence
- low resource allocation for technology development, dissemination and adoption
- prevailing inappropriate farming practices
- climate change will exacerbate fungal infestations
- fragmented food value chain, lack of incentives for farmers
Agro-ecosystem resilience

The problem:

- Plant health is intimately linked to the health of the agro-ecosystem in which the plant flourishes. Inappropriate agricultural practices disrupt the self-regulatory mechanism between beneficial and detrimental organisms above ground and in the soil leading to higher incidences of pests and diseases.

- Intensification of agricultural production to meet growing food demand may increase application of inappropriate practices.
SP-IPM’s answer

- Improving the understanding of key factors driving trophic interactions in agro-ecosystems, and the role of biodiversity in mitigating instability
- Identifying bio-indicators for assessing how agro-biodiversity responds to intensification of production
- Designing and testing habitat management options for enhancing natural control by beneficial organisms
- Identifying soil management options for improving soil health and enhancing control of soil borne pests and pathogens
- Developing human scientific capacity to work in soil, root and plant health
- Promoting awareness of the role of functional agro-biodiversity at farmers, researchers and policy makers level
Capacity building

SP-IPM has a role in increasing national research and innovation capacities

Rotational Advanced Training and Knowledge-Pathway Program

to expose a large number of NARES and other scientists to effective and new advances in IPM research and modern technologies - upstream

Program will:
- Expose young scientists to innovative IPM systems and tools
- Develop advanced course on new IPM technologies
- Will include scientists and policy makers from the CG Centers, ARIs, industry and extension organizations
Innovative science pathways

- *The New Scientist*, in an article on the current food crisis in its June 14th 2008 issue:

  ‘New Scientist has asked the world’s leading agricultural experts what it would take to boost yields. They were unanimous: we need research and support of farmers so that they can make most of its results…’

  ‘Governments will be able to mitigate the crisis, but only if they invest in the science that can increase yields and in the infrastructure to get the resulting technologies to the farmers who need them’

- New pathways that look at innovation as an emergent property of the interaction among stakeholders (science, networks, coalitions, partnerships, collaboration, linkages, etc.)

N. Röling, Mombasa, Kenya 2008
Take home message

• The solution to future food security problems is not to be found in the funding of narrow research and training programs

• Balanced multi-disciplinary approaches that reflect the pathways to success made in modern agriculture are needed

• Approaches that integrate modern research and advanced training at advanced research centers, universities and at the policy level that will have positive impact at the grower level need support and development

• Adaptable technologies coupled with modern extension methodologies that form effective pathways leading from modern science to stakeholders are required

• Financial support for SP-IPM that is taking advantage of existing expertise across the CGIAR and the international scientific community to develop new innovative IPM techniques and adaptive systems is needed urgently for progress and it is needed now!