Principles of plant disease control to ensure food security

Fenton Beed

Regional Director, East and Southeast Asia / Oceania

35th IVTC, 22nd September 2016

World Vegetable Center

How to Increase Food Security

- Agricultural intensification through more efficient land use

- Improved management of critical diseases

- Sustainable disease management through understanding dynamic interactions between crops, beneficial and antagonistic organisms

  - Physical environment

  - Human interventions

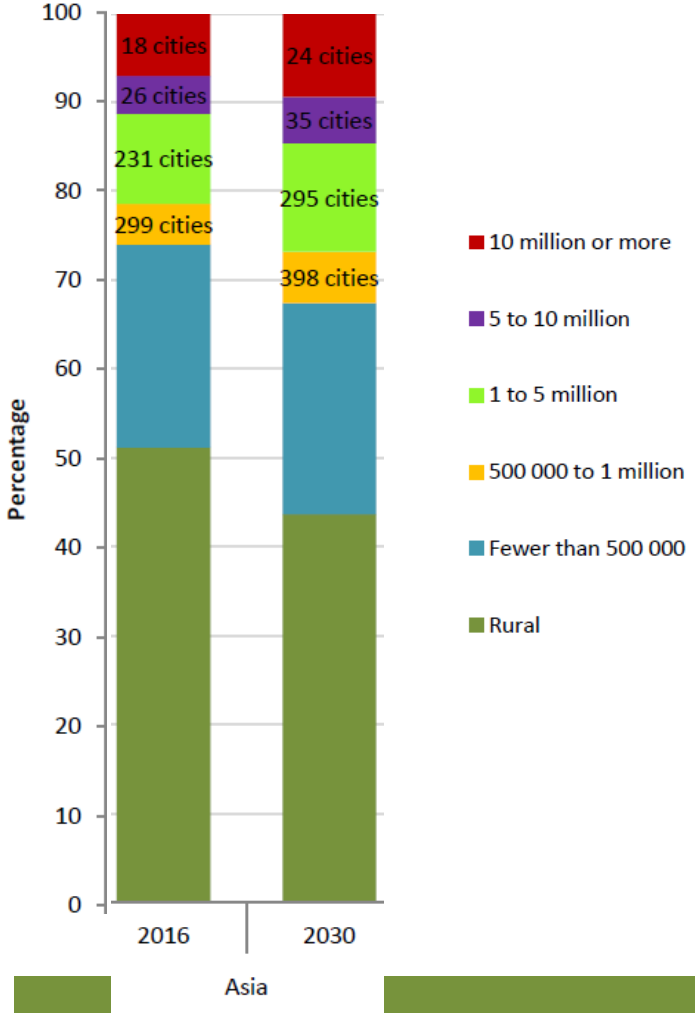
Global growth

- 2015 – 7.3 billion people (60% in Asia)
- 2030 – 8.5 billion people (58% in Asia)
- 2050 – 9.7 billion people (54% in Asia)

United Nations, Department of Economic and Social Affairs, Population Division (2016). *The World's Cities in 2016 – Data Booklet (ST/ESA/ SER.A/392).*
United Nations, Department of Economic and Social Affairs, Population Division (2015). *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.*

Global urbanization

- 2016 - 55 % of world's population in cities
- 2030 - 60 % of world's population in cities
- World's fastest growing cities in Asia and Africa



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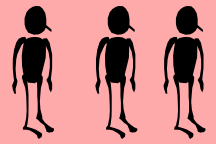
United Nations, Department of Economic and Social Affairs, Population Division (2015). *World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.241.*

Food and nutritional security through vegetables

deficiency in calories and proteins		= HUNGER		800 million underweight
deficiency in vitamins and minerals		= MICRONUTRIENT DEFICIENCY		2 billion malnourished
excess calories		= IMBALANCED CONSUMPTION		2 billion overweight 0.6 billion obese

FAO; IFAD; WFP, 2012; Bereuter and Glickman, 2015: Healthy Food for a Healthy World

Food and nutritional security through vegetables

deficiency in calories and proteins	• Every year > 3M children die due to mal-nutrition • Every day 400 mothers die in childbirth due to iron deficiency
deficiency in vitamins and minerals	• Every day 1400 children go blind due to Vitamin A deficiency • First 1000 days affects physical and mental development
excess calories	• Asia and Africa lose 11% of GNP each year due to poor nutrition • Rates of diabetes increasing fastest in developing countries

FAO; IFAD; WFP, 2012; Bereuter and Glickman, 2015: Healthy Food for a Healthy World

Vegetables WIN (women, income, nutrition)

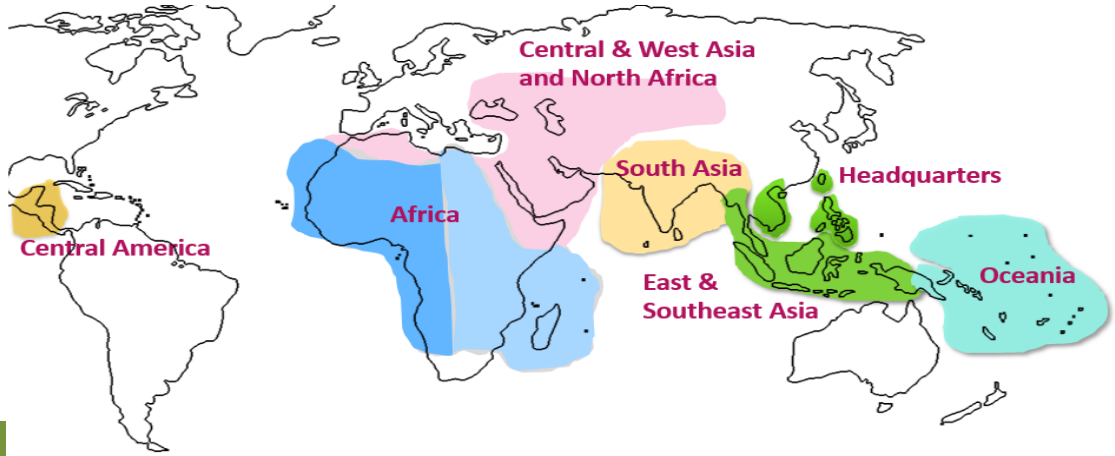
1. empowerment of women to manage small rural and urban plots
2. high value inputs and outputs (fresh and processed)
3. short cultivation cycle and huge diversity
4. increased nutrition provided to family and consumers (micronutrients, vitamins, dietary fiber, phytochemicals and protein)

World Vegetable Center

Vegetables for health and prosperity!

- Founded in 1971 as **AVRDC**
- Research to promote development – **nonprofit**
- Research outputs - **global public goods**
- Profitable value webs – **affordable year round**

Alleviate poverty and malnutrition through increased **production** *and* **consumption** *of health-promoting* **vegetables**



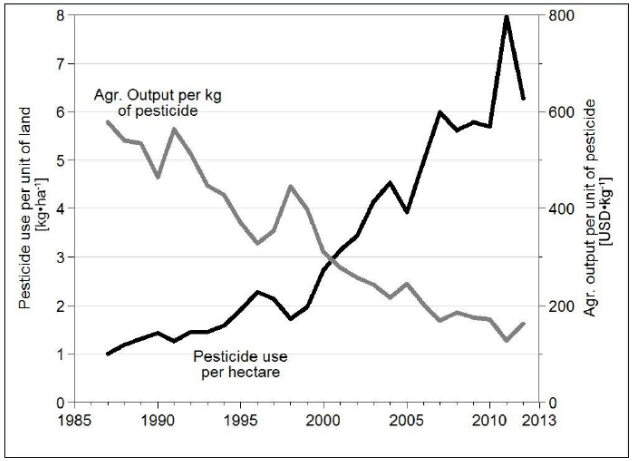
The Association of Southeast Asian Nations

"UNIDO Regional Trade Standards Compliance Report, 2013"

"ASEAN potential to gain from macro trends of increasing population and purchasing powers not met in all countries by increased vegetable production"

- Food safety and quality issues cause import rejections:
  - MRLs exceeded of pesticides (approved and prohibited) and mycotoxins
  - presence of quarantine plant pathogens and pests

Inappropriate pesticide use accepted practice



Loss of producer profit

Loss of trade and value chains

Loss of country and retailer credibility

Loss of biodiversity

Loss of yield

Increased pest resistance

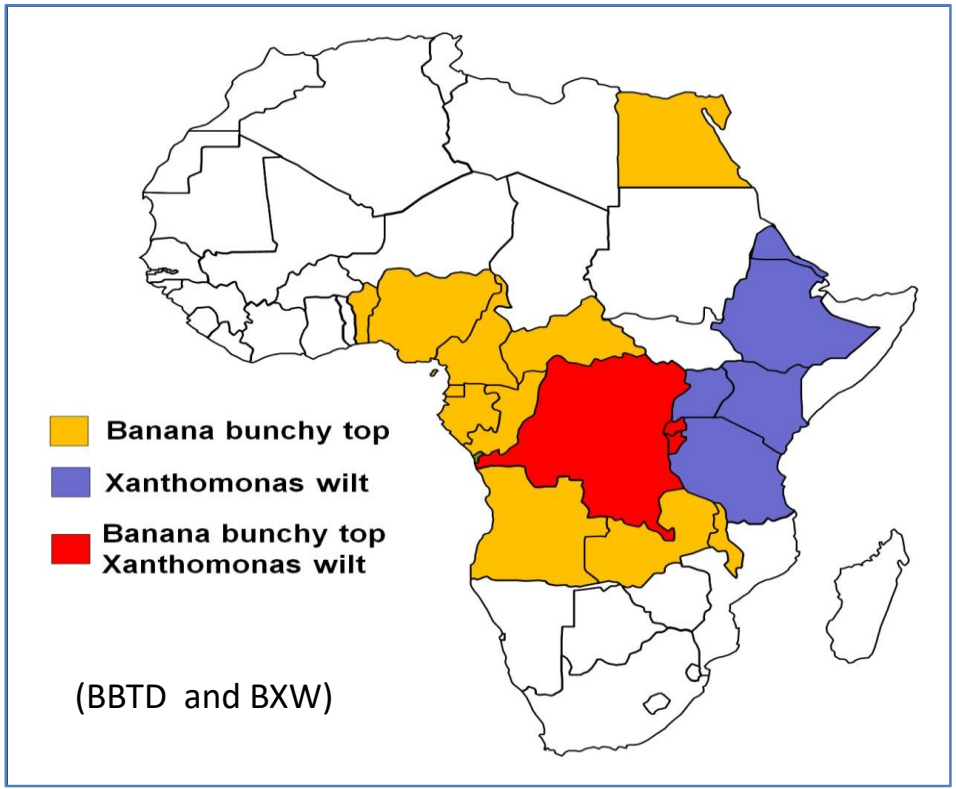
Health hazard to growers

Health hazard to consumers

Solutions to inappropriate pesticide use

- Precise pest and disease diagnostics
- Host resistance
- Agronomic practices
- Judicious pesticide use
- Biological control

Diagnostics - what diseases pose a risk to banana?

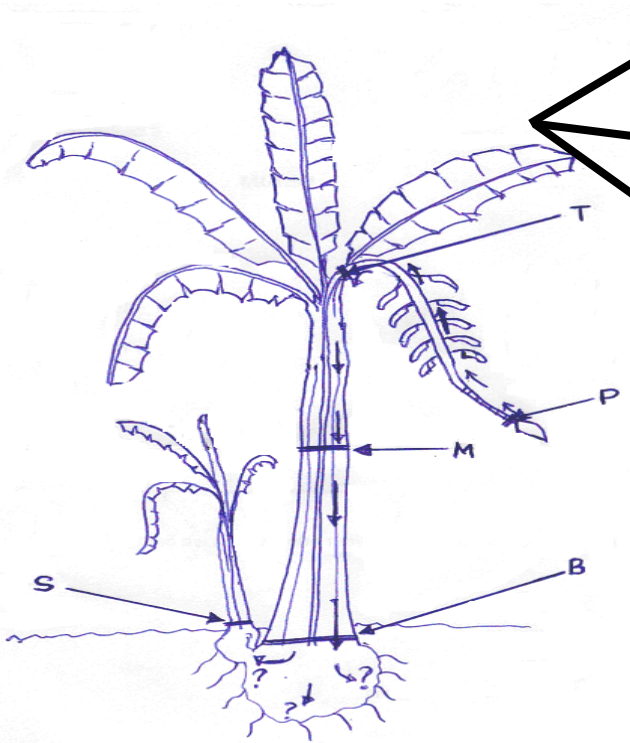


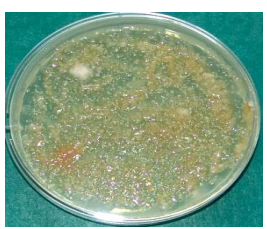
(BBTD and BXW)

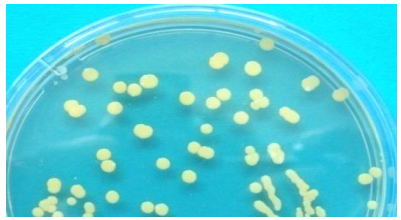
BXW in Uganda

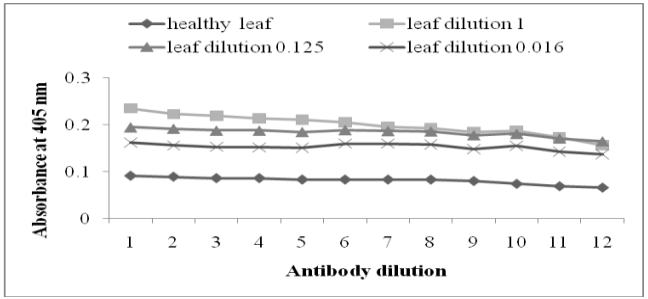
- 56 % production loss last 10 years
- With impact of 7 billion dollars

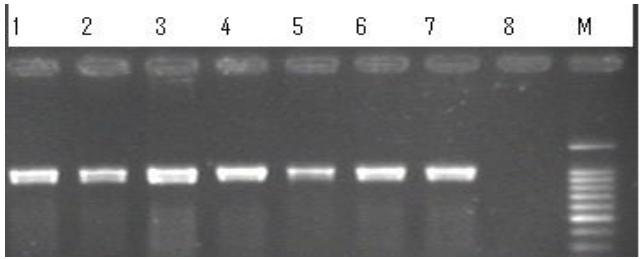
BXW Diagnostics



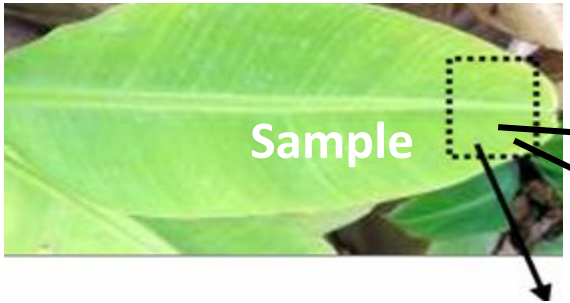




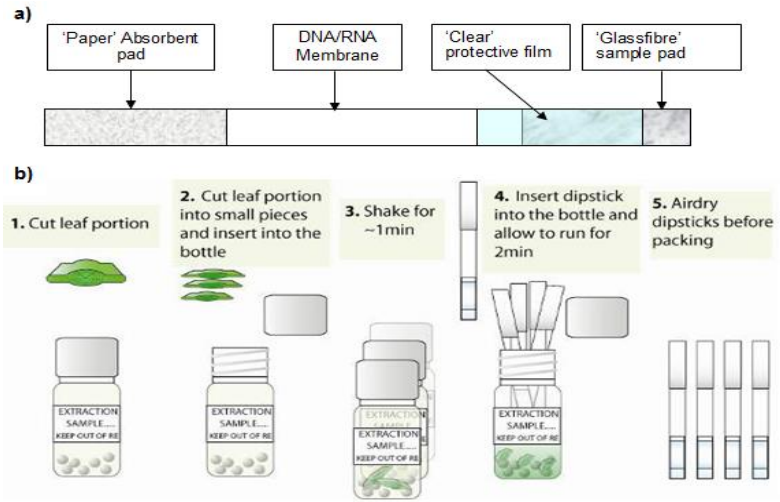




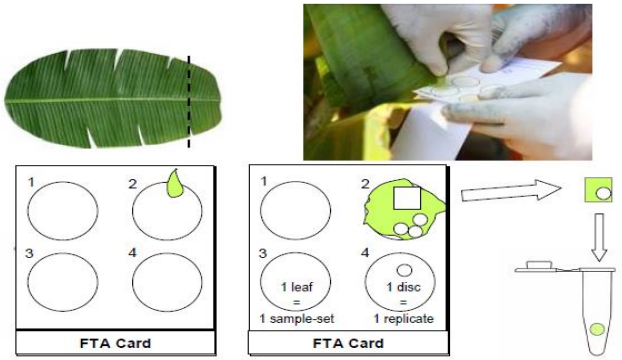
Field to laboratory for confirmatory diagnostics (Xcm and BBTV)



PhytoPASS sticks

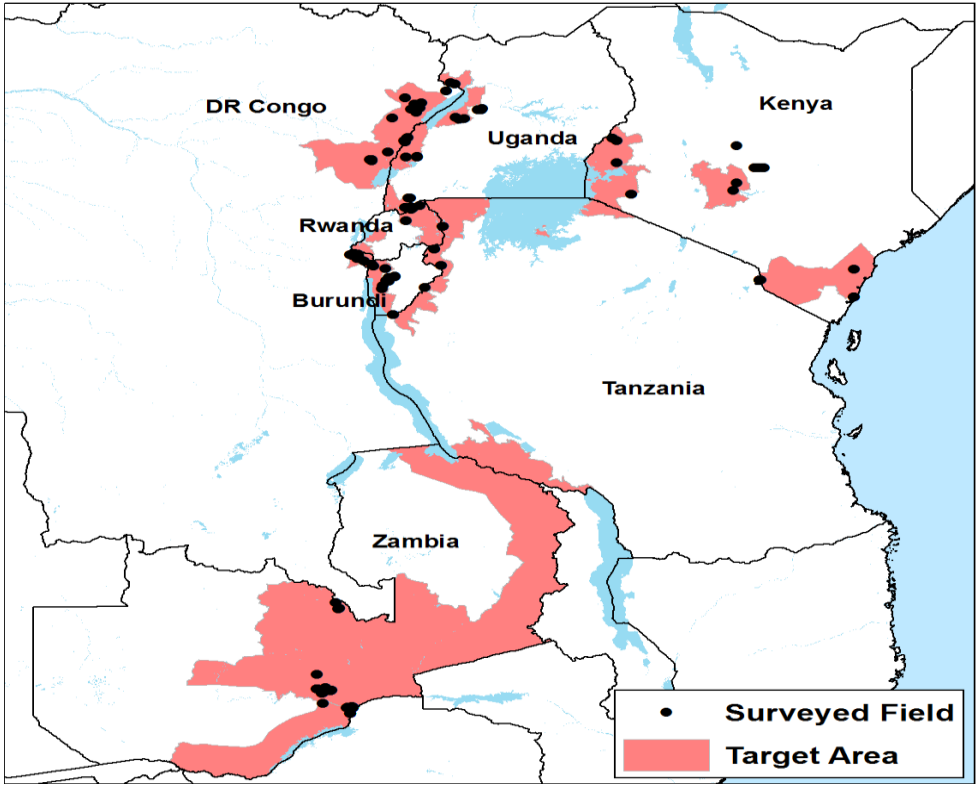


2 min. extraction dipsticks



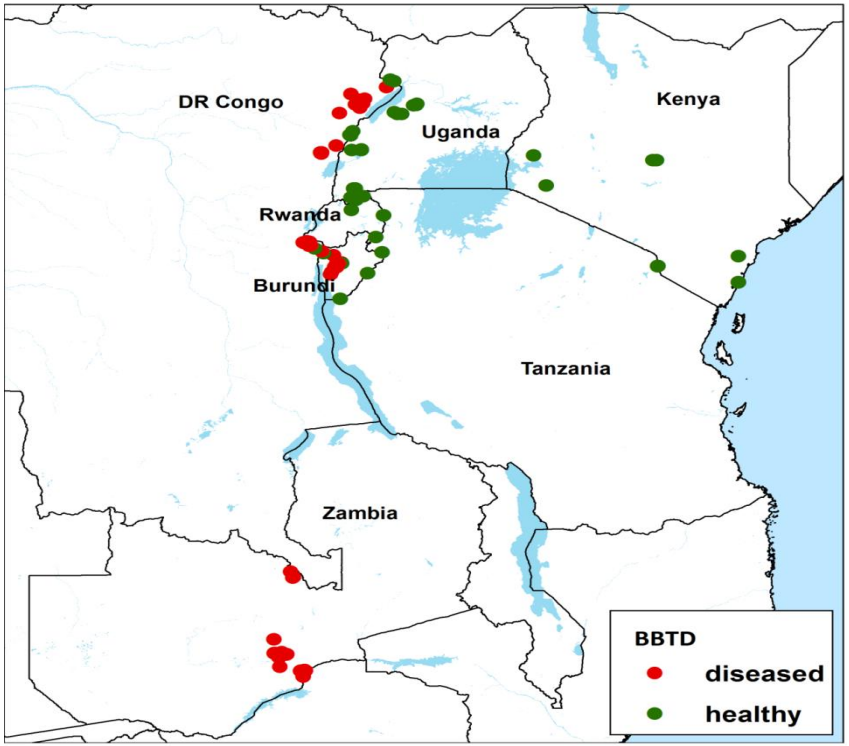
FTA cards

Networking



Research and regulatory staff from 7 countries shared experiences, prioritised where to survey for banana disease and harmonised methods

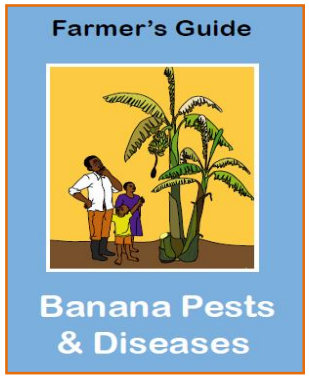
Capacity building, extension and advocacy



Field diagnostics supported by lab (proficiency tests) to provide credible and shared records

BBTD not in Kenya but BXW in Burundi!

Recommend control practices

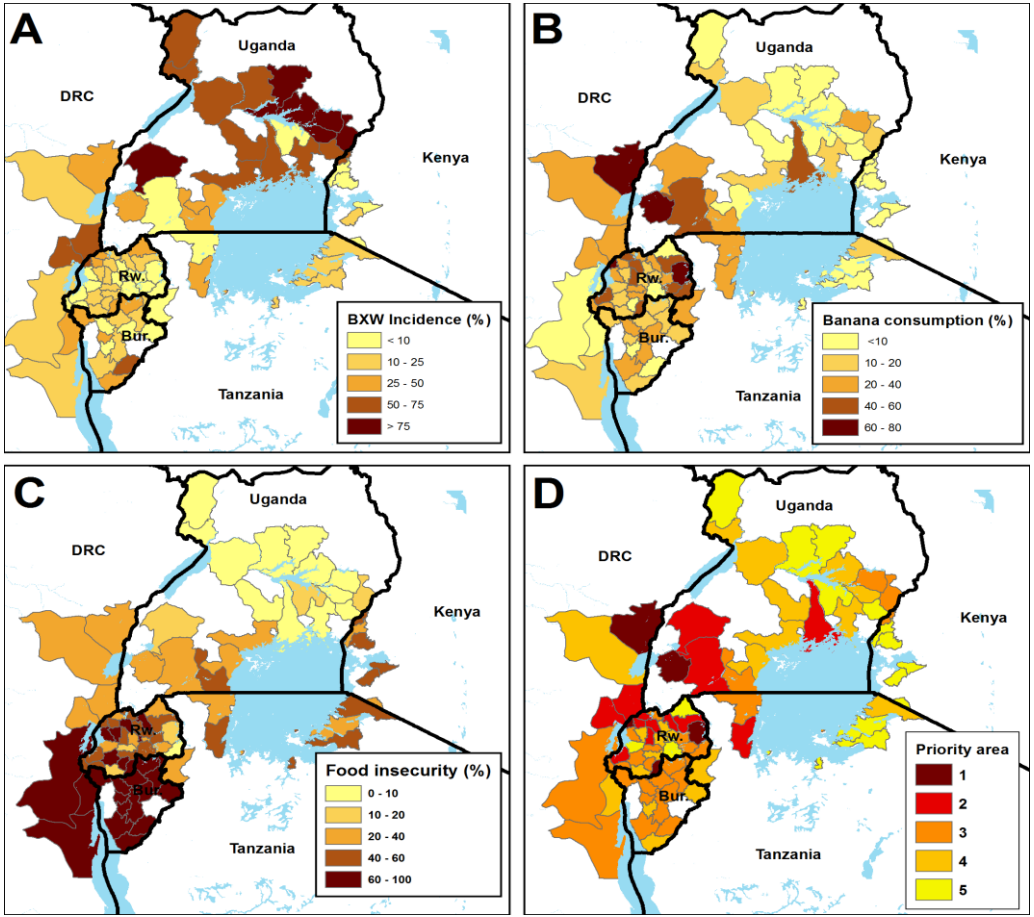


www.cabi.org

Advise policy makers

Monitor, evaluate and refine recommendations

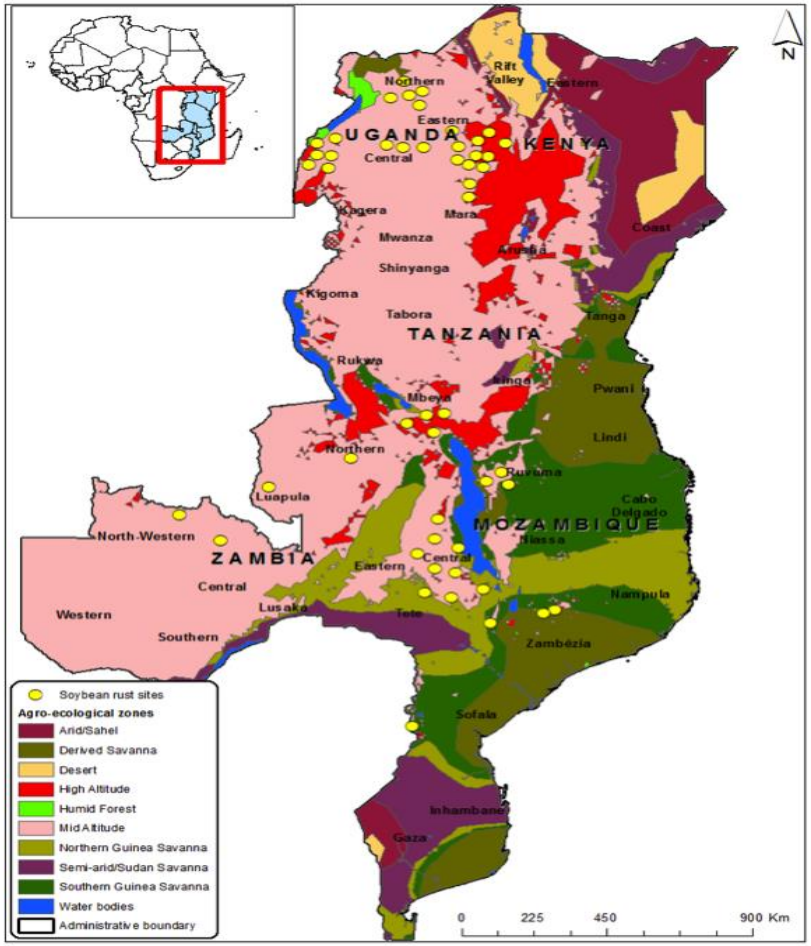
Priority areas for interventions to manage BXW

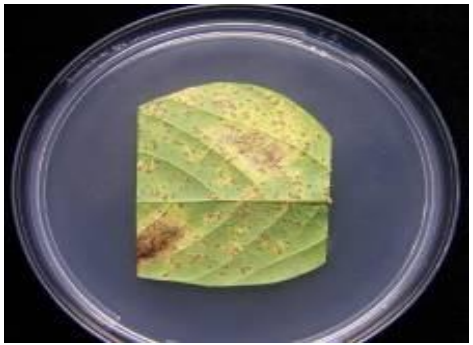


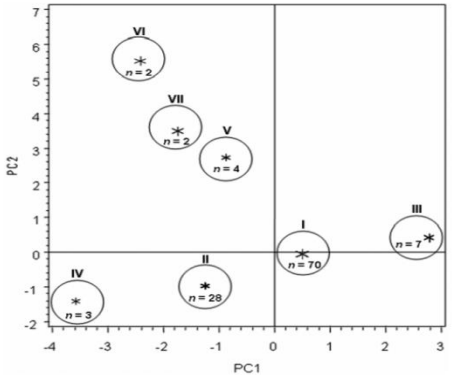
Priority areas based on weighted importance of factors e.g.

1/5*A + 3/5*B + 1/5*C.

Soybean rust mitigation

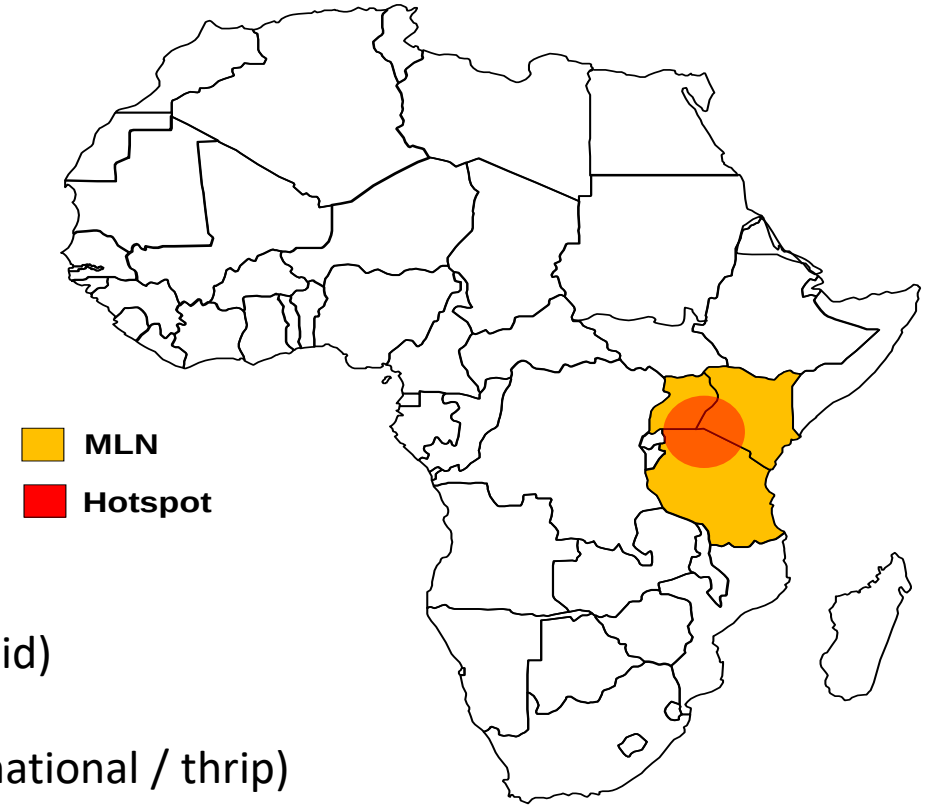






Rapid and precise diagnostics
Map variability of rust populations and risk of spread through prevailing winds
Develop and deploy resistant cultivars, sentinel plots

Maize lethal necrosis



Sugarcane mosaic virus (local / aphid)

+

Maize chlorotic mottle virus (international / thrip)

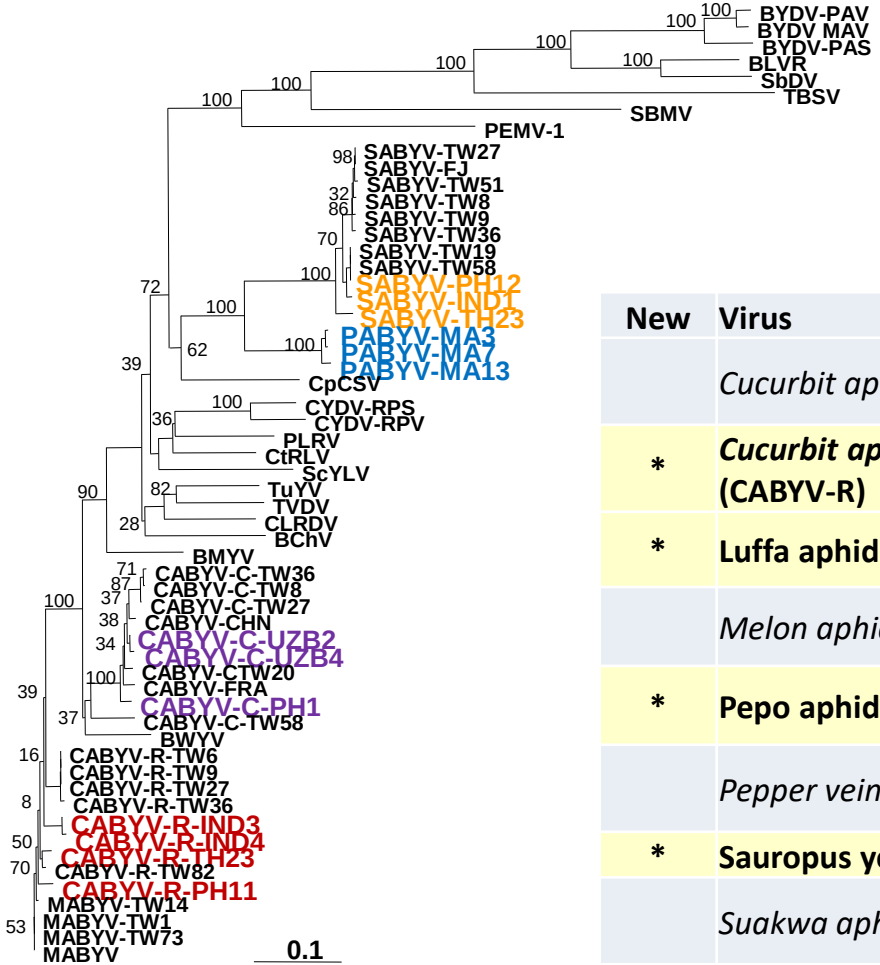
Monitoring known, emerging and new viruses

Crop	Total	BV	CMV	ToMV	CVMV	PMMV	TSWV
Tomato	36	32	1	0	0	0	7
Pepper	38	33	7	7	23	3	0
Eggplant	16	15	0	0	0	0	0

Crop	Total	BV	CMV	ToMV	CVMV	PMMV	TSWV
Tomato	10	9	0	0	0	0	0
Pepper	46	24	7	0	17	0	0
Eggplant	4	1	0	0	0	0	0

Chili infected with PepYLCVs

Aphid-borne Poleroviruses (*Luteoviridae*)



partial RdRp (aa)

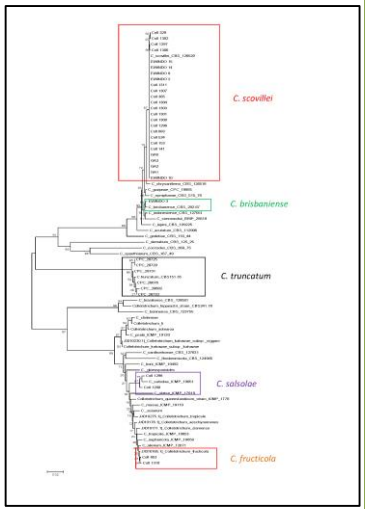
New	Virus	Countries
	Cucurbit aphid-borne yellows virus [Common] (CABYV-C)	PHL, TWN, UZB
*	***Cucurbit aphid-borne yellows virus*** **[Recombinant] (CABYV-R)**	**IND, PHL, THA, TWN**
*	**Luffa aphid-borne yellows virus (LABYV)**	**THA**
	Melon aphid-borne yellows virus (MABYV)	TWN
*	**Pepo aphid-borne yellows virus (PABYV)**	**MLI, CIV**
	Pepper vein yellows virus (PeVYV)	IND, IDN, MLI, PHL, THA, TWN
*	**Sauropus yellowing virus (SaYV)**	**THA**
	Suakwa aphid-borne yellows virus (SABYV)	IND, PHL, THA, TWN

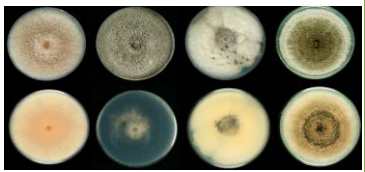
Diagnostics for anthracnose of chili fruit

- Multigene phylogenetics to identify causal spp. of *Colletotrichum* in field (Fiji, Indonesia, Korea, Lao PDR, Solomon Isles, Taiwan and Thailand)
- Validate to pathotype level and map regionally
- Development of qPCR diagnostic tests
- Pathogen taxonomy and population genetics

Benefits to Australia and SE Asia

- Plant biosecurity and protection of country borders (quarantine)
- Adaptation potential of populations to genetic resistance or fungicides
- Artificial inoculation methods
- Improved methods for integrated control including MAS





Host resistance

World Vegetable Center

No. of accessions	62,000
No. of species	442
No. of countries of origin	156
No. of new varieties	520

The world's largest public sector collection of vegetable germplasm

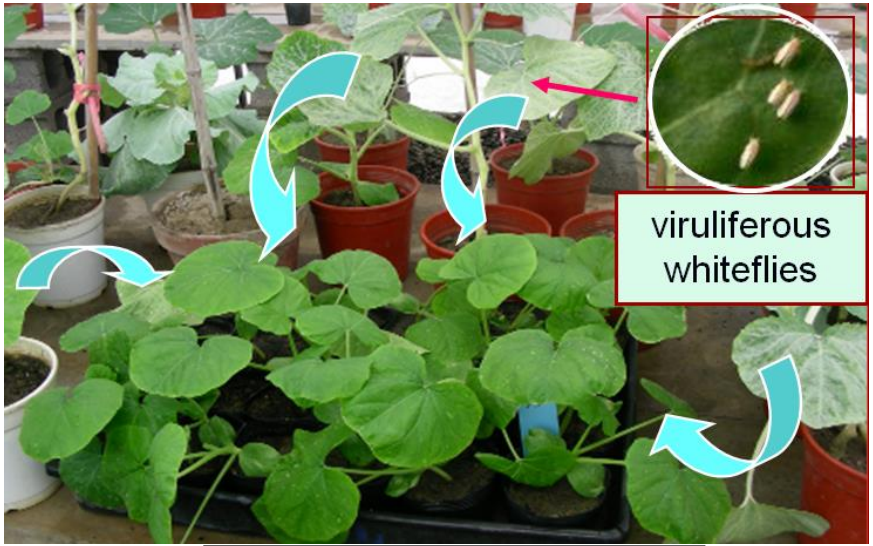
Global vegetables

Traditional vegetables

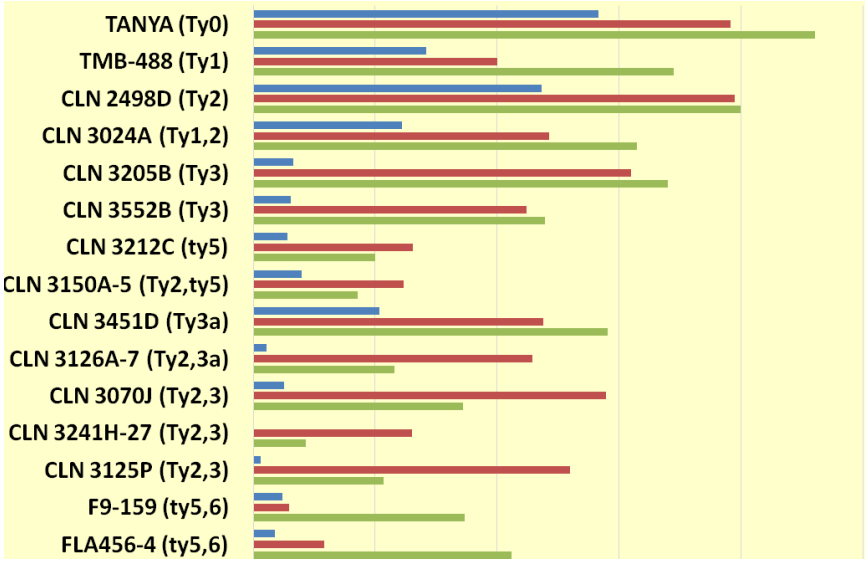
Wild relatives, diverse and unique traits

Hibiscus sabdariffa: Source of vitamin C

Screening for new resistance (Squash leaf curl Philippines virus)



Pyramiding genes (Tomato yellow leaf curl viruses)



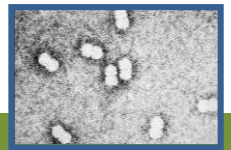
Agronomic practices

Tomato bacterial wilt caused by *Ralstonia solanacearum* (soil-borne, vascular bacterial disease)		
Control principle	Specific measures	Efficacy
Pathogen exclusion	Use a plot without disease history Use clean seedlings No contact with contaminated water	***
Pathogen reduction	Practice rotation Remove diseased plants Apply chemical or organic amendments	**
Host resistance	Use locally effective resistant cultivars	***
Direct protection	Use sterilized pruning tools	*

Agronomic practices

Tomato leaf curl virus caused by begomoviruses (insect-transmitted viral disease)		
Control principle	Specific measures	Efficacy
Pathogen exclusion	Raise healthy seedlings by protection with 60-mesh net	***
Pathogen reduction	Control whitefly, with pesticide, trap crops, pheromone traps Remove and destroy infected plants	*
Host resistance	Use locally effective resistant cultivars	***
Direct protection	Apply summer oil on leaves	*





Agronomic practices

Graft preferred vegetable variety onto rootstock with resistance to prevalent diseases (or flooding)

Grafting

World Vegetable Center

2007:
Lam Dong Province 4000 ha cultivated with grafted seedlings

2012:
Full adoption in Lam Dong and increasing in Red River Delta

Yield increased by 18 t ha^{-1}

Increased profit in Lam Dong of US$ 9million p.a.

Judicious Pesticide Use

Enforce GAP

Increase awareness:

MRLs and health impacts
Appropriate use of approved products at correct dose for specific crops
Appropriate timings of applications (respecting Pre-Harvest Interval)
Use of correct safety and application equipment
Store and dispose responsibly

Grain legume pod borer - *Maruca vitrata*

Apanteles taragamae

Multiple Nucleopolyhedrovirus *Mavi*MNPV

Combining bio-pesticides with chemical pesticides to manage legume pod borer (Maruca vitrata) on yard-long bean in Thailand

S. Yule[a] & R. Srinivasan[b]

[a] AVRDC - The World Vegetable Center, East and Southeast Asia, Research and Training Station, Kasetsart University, Kamphaeng Saen Campus, Kamphaeng Saen, Nakhon Pathom 73140, Thailand

[b] AVRDC - The World Vegetable Center, Shanhua, Tainan 74151, Taiwan

Published online: 25 Apr 2014.

Biological control

Metarhizium anisopliae
var. *acridum*

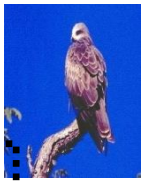
Senegalese grasshopper

(*Oedaleus senegalensis*)

Millet
(*Pennisetum glaucum*)

Green muscle™ Africa
Green guard ™ Australia

Biocontrol – ecological equilibrium



Nosema

Metarhizium

Gold Sparrow

Gr. buzzard

Bombyliidae

Cattle egret

Meloidae

Abdims stork

Scelionidae

Sparrowlark

Acrotylus blondeli

Senegalese Grasshopper

Pyrgomorpha cognata

Sahelian grass

Millet

Sorghum

Biocontrol for *Striga hermonthica*

Degraded soil increases Striga infestation

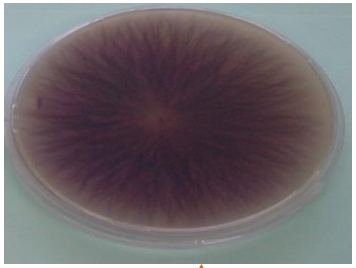
Soil suppression reduces Striga but if soil pasteurised suppression lost, thus **biotic** mechanism

Extensive field surveys across several countries followed by laboratory, pot and field studies identified isolates of ***Fusarium oxysporum* f.sp. *strigae* (Fos)** as most effective

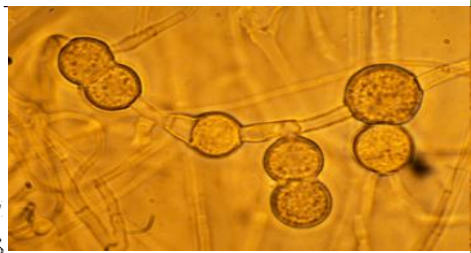
Causes disease during all weed development stages

Host specific to *Striga* and does not produce toxins

Commercialisation underway in Kenya and Nigeria



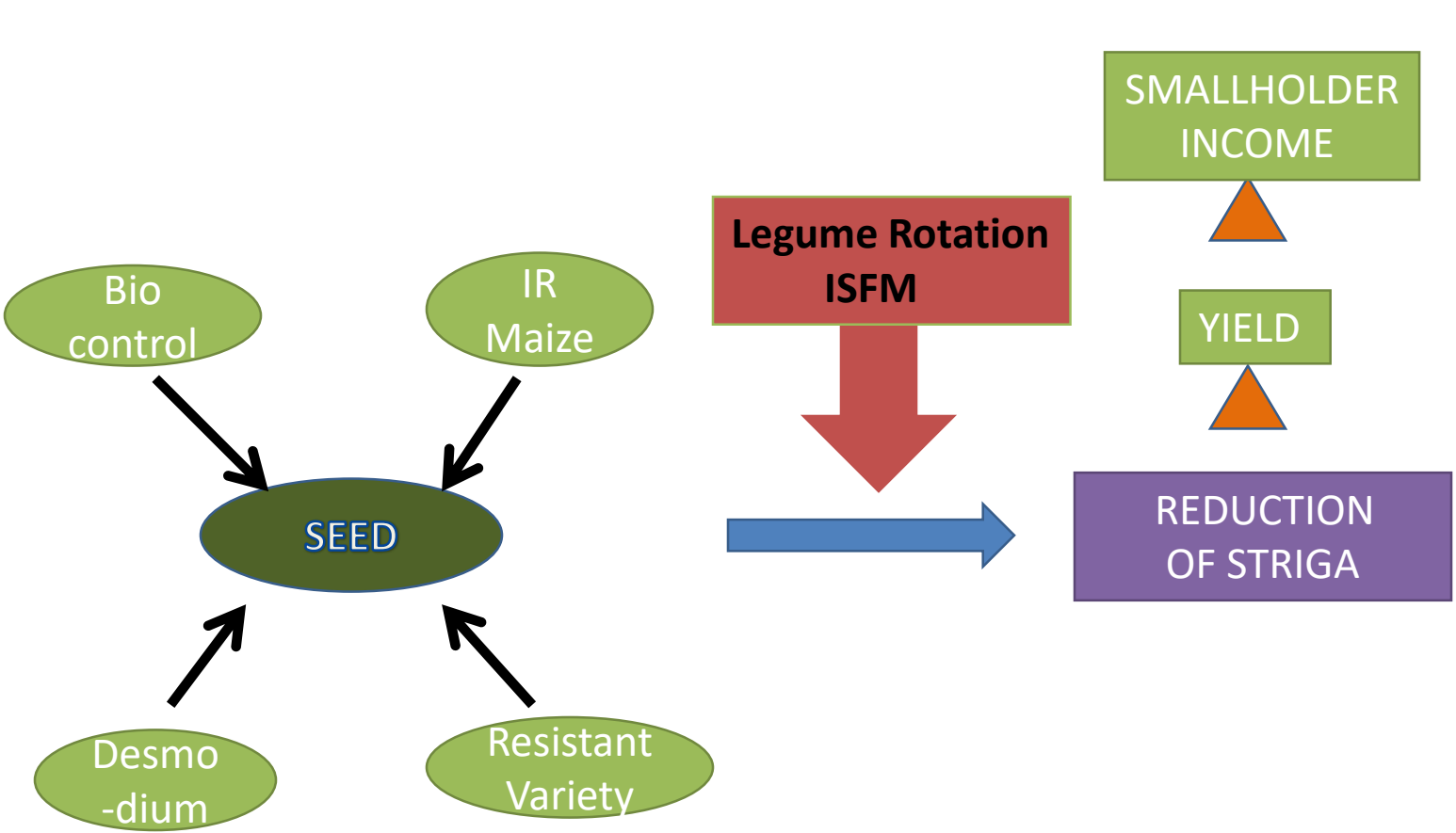
Fos = *Fusarium oxysporum* f.sp. *strigae*



Seed coated with Arabic gum

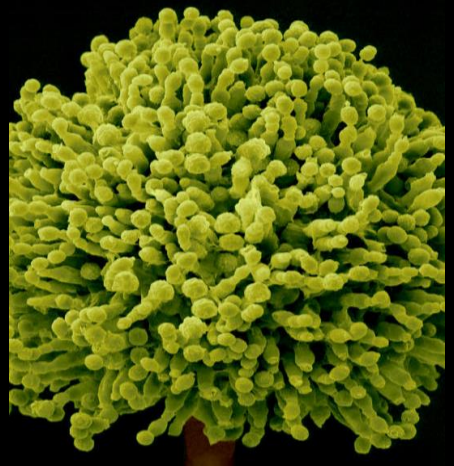
Pesta granules

Integrated management of *Striga hermonthica* in maize



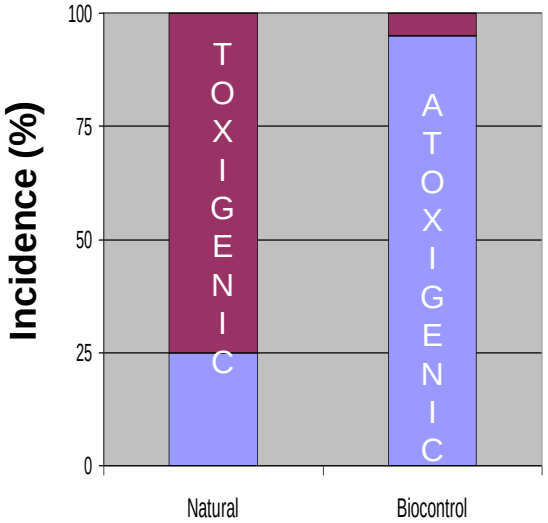
Food quality and safety - Aflatoxin

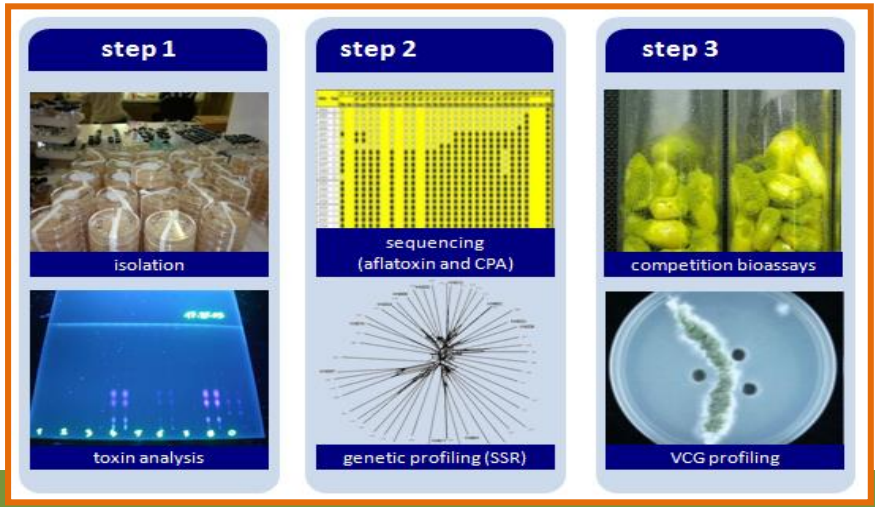
- Highly toxic metabolite produced by ubiquitous *Aspergillus flavus*
- Fungus infects crops and produces toxin in field and store
- Contamination possible without visible signs of the fungus



Biocontrol of aflatoxin - Aflasafe™

- In nature, some strains produce aflatoxin (toxigenic) and others do not (atoxigenic)
- Increase frequency of atoxigenic strains that cannot mate with toxic relatives but that are ecologically competitive against them
- Aflatoxin reduced in field and stores
- Native strains selected and marketed as Aflasafe™





TR4 *Fusarium oxysporum* f.sp. *cubense* Mozambique

SOCIETY FOR GENERAL MICROBIOLOGY

Briefing: Banana Disease

12 DECEMBER 2013 | VOL 504 | NATURE | 195

AGRICULTURE

Fungus threatens top banana

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Contact: William Burns, Society for General Microbiology, Charles Darwin House, 12 Roger Street, London, WC1N 2JU, UK [tel. +44 (0)20 7685 2681; email w.burns@sgm.ac.uk].

Thanks are due to the following individuals for their advice: Fen Beed (International Institute of Tropical Agriculture/ IITA), Sarah Blanford (Sainsbury's), J. S. Heslop-Harrison (University of Leicester), Gert Kema (Wageningen UR), Randy Ploetz (University of Florida), Alistair Smith (Banana Link), John Soluri (Carnegie Mellon University), Rony Swennen (KU Leuven), and the members of the World Banana Forum TR4 Task Force.

SGM remains solely responsible for the content of this briefing.

Issue date: 4 April 2014

Stellenbosch Declaration

Development of a strategy to address the threat of Foc TR4 in Africa

22-24 April, 2014

University of Stellenbosch, South Africa

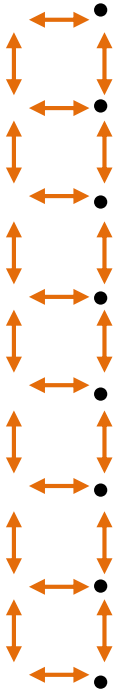
Crop Healthcare System

national responsibility, regional cooperation and global excellence

- risk assessment
- disease surveillance
- disease diagnosis
- control recommendations
- farmer adoption
- impact on value chain
- advocacy
- research interventions

Crop Healthcare System

national responsibility, regional cooperation and global excellence



risk assessment

disease surveillance

disease diagnosis

control recommendations

farmer adoption

impact on value chain

advocacy

research interventions

Active Learning & Capacity Building!

Principles of plant disease control to ensure food security

Questions?

World Vegetable Center

35th IVTC, 22nd September 2016