Options for Controlling Stemborer and Fall Armyworm in Maize

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CIMMYT

Insect pest problem in Agriculture

- Insects are part of agricultural ecosystems
- Affects 46% of global maize growing area
- Insect pests causes 25% world maize loss annually
  - Field pests causes 14.5% world loss annually
  - Storage pests causes 10% world loss annually
- 52 million MT of grains valued at $5.7 billion
- 60% of maize loss is in the tropics
- US$550 M worth of insecticide used annually to control insect pests in crops





Important Insect pests of Maize in SSA

African stemborer | Spotted Stemborer | Fall Armyworm

Busseola fusca | *Chilo partellus* | *Spodoptera frugiperda*

Indigenous | **80 Years** | **2 Years**

Stemborers and FAW damage

Window

Dead heart

Stem tunneling

Stem breakage

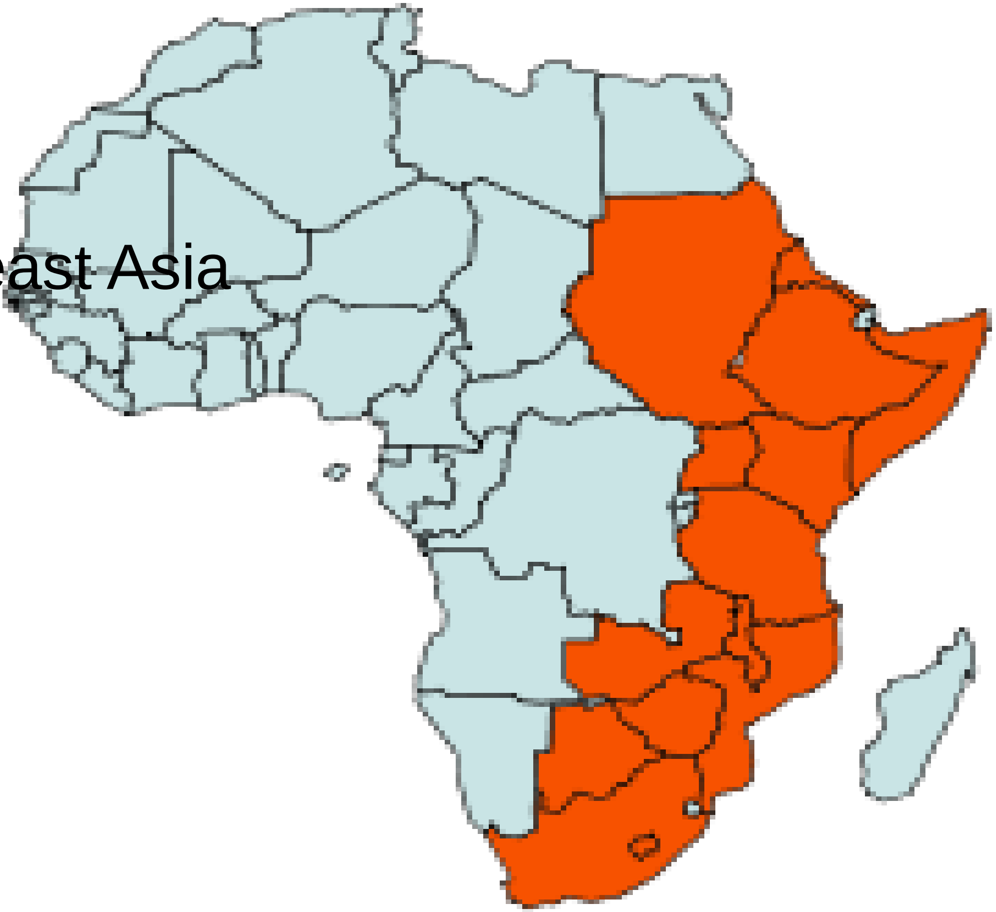
Cob damage

Mycotoxin contamination

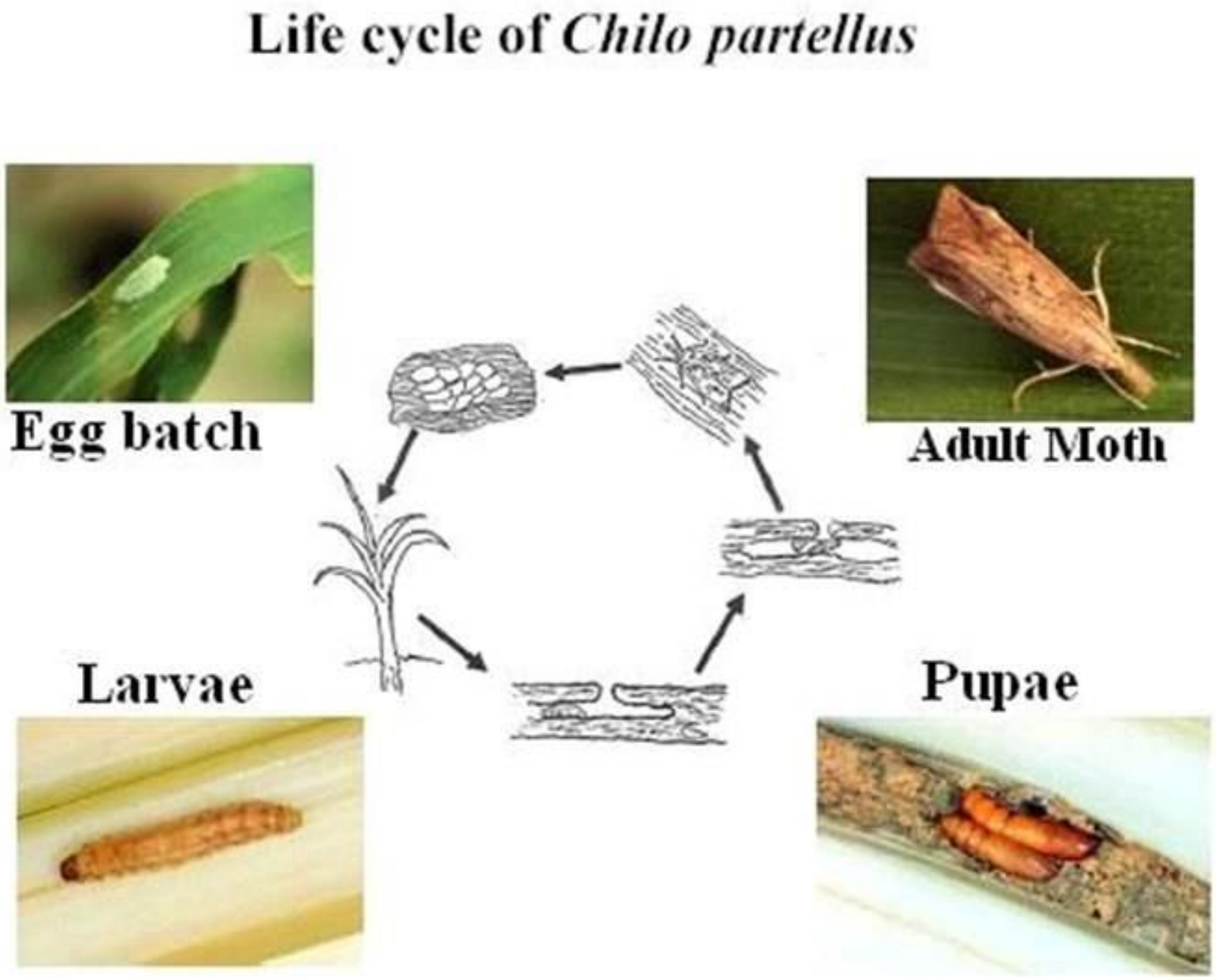
Chilo partellus = the spotted stem borer

- **Nature of damage**
  - Cause rows of oval perforations in leaf whorl
  - Damage the growing point: dead-heart
  - Severe in the lowlands

Geographical distribution
- Introduced to Africa
- Australia, Africa, Southeast Asia



Life cycle of *Chilo partellus*



Busseola fusca = African maize stem borer

Nature of damage

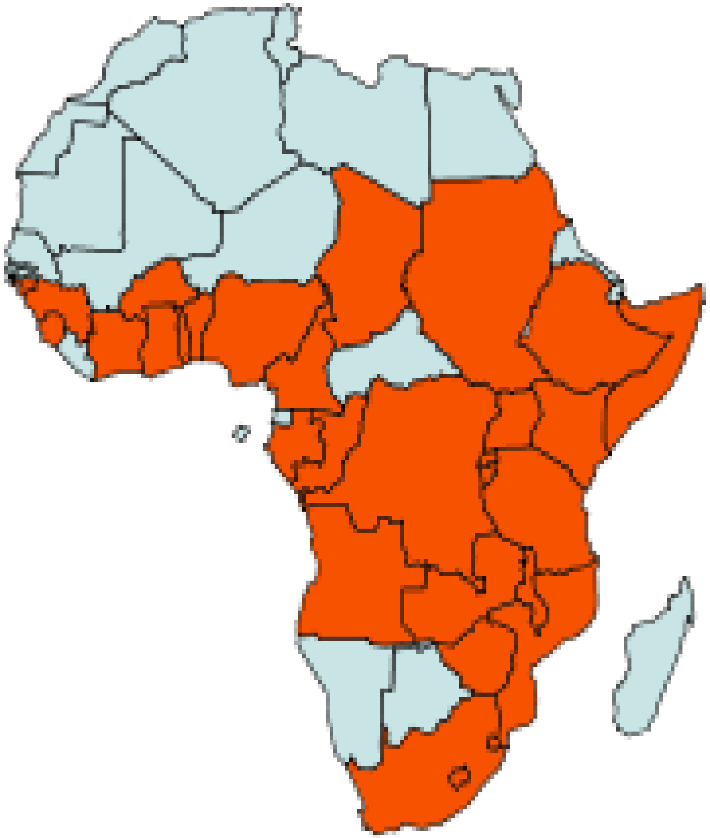
- The larvae migrate to the leaf whorl for feeding
- Causes dead-hearts
- 2nd generation larvae feed on tassels, ears, stems

Description

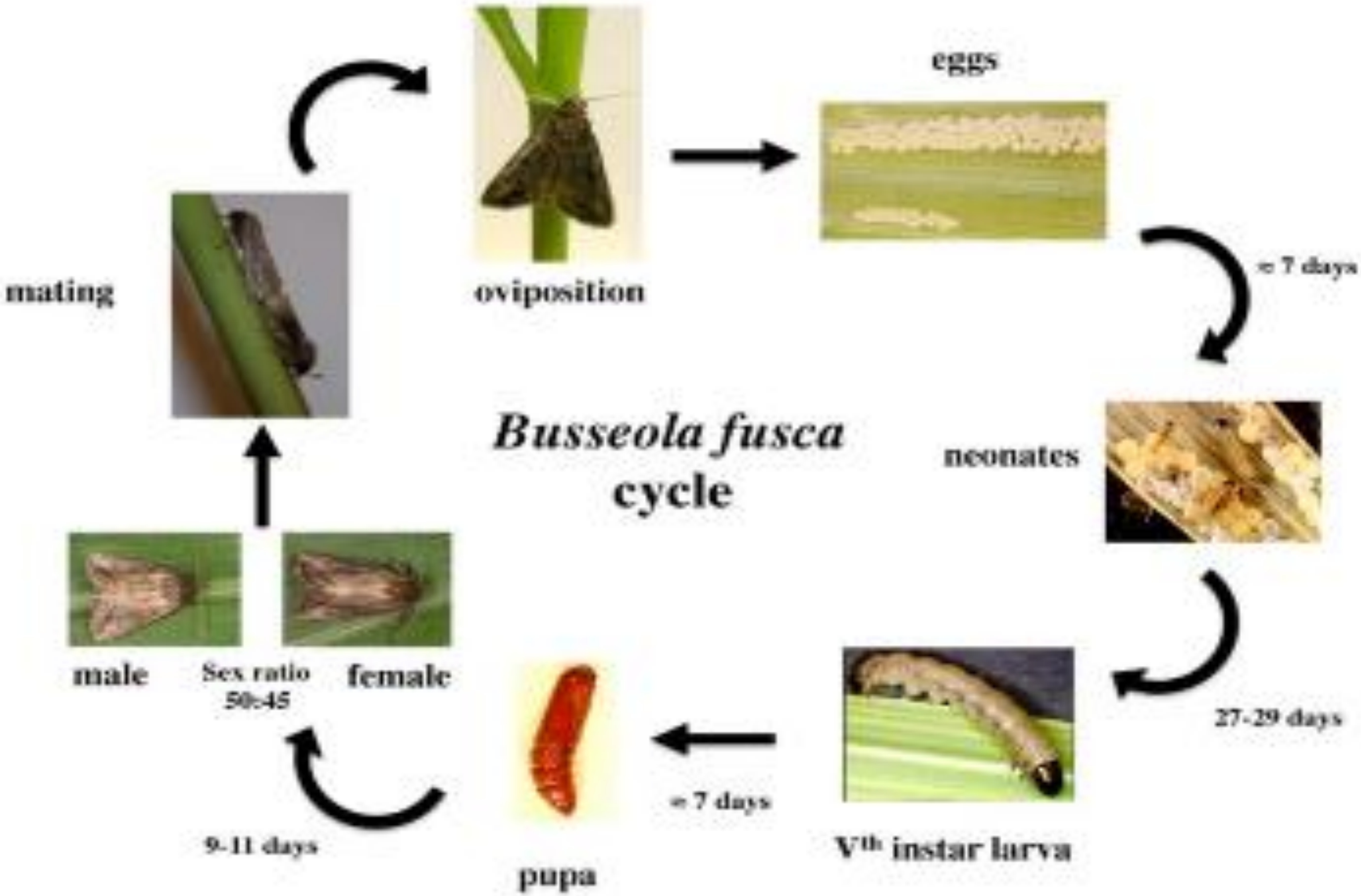
- Larvae grayish body
- Adult is dark brown moth

Geographical distribution

- Sub-Saharan Africa, 500-2500m

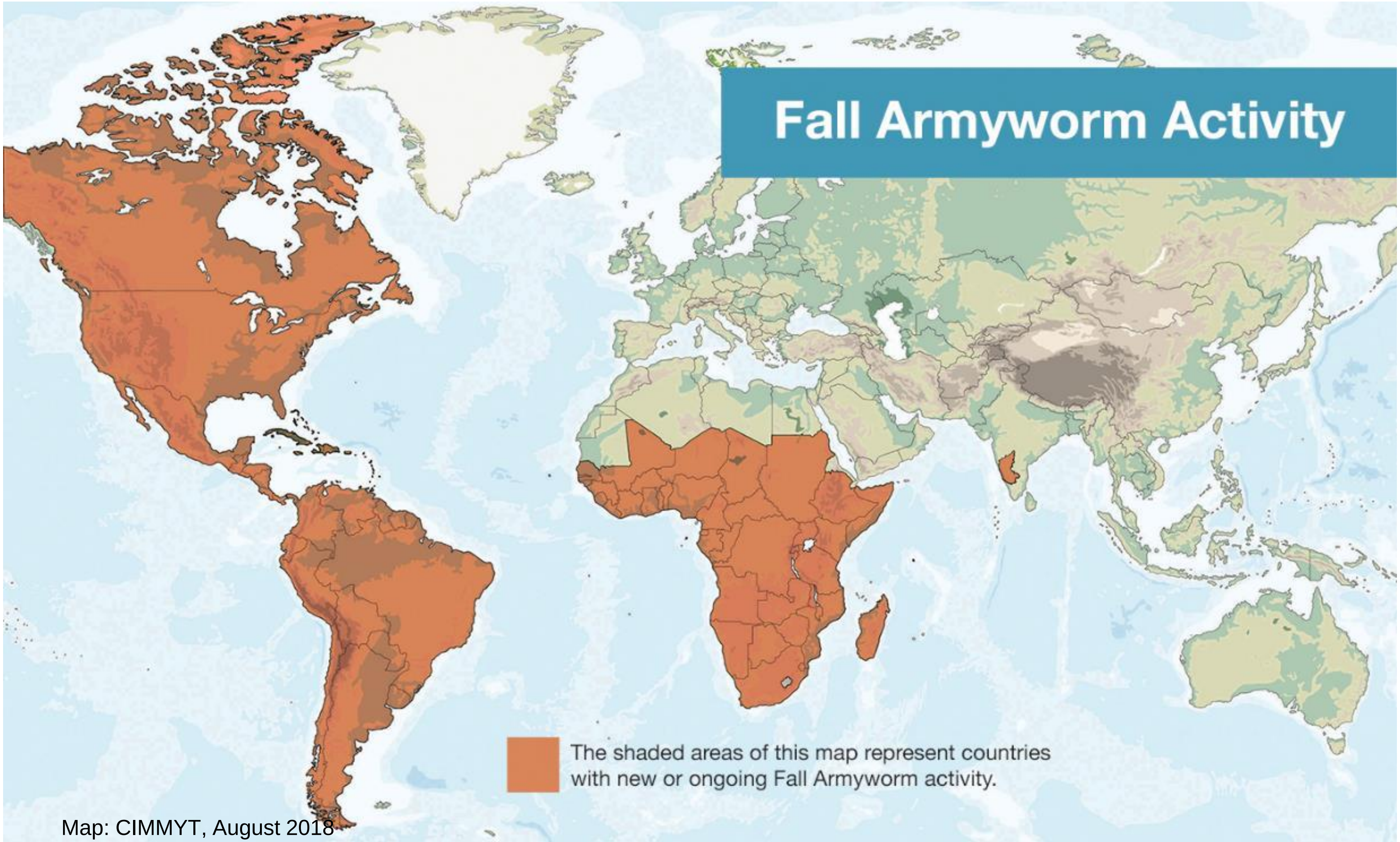


Life cycle of *B. fusca*



turning research into impact

March of the Fall



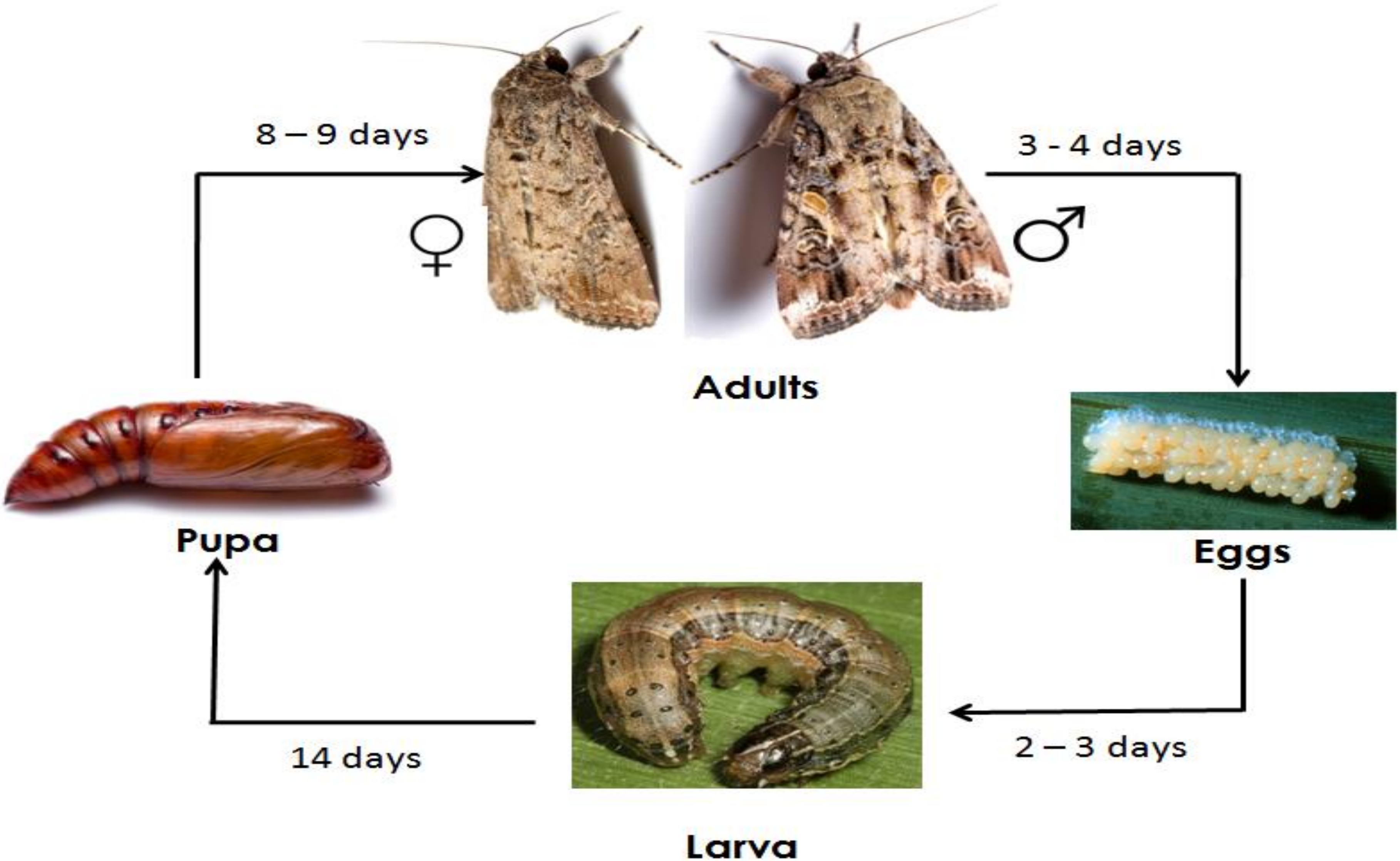
Map: CIMMYT, August 2018

1966 - 2016 CIMMYT
turning research into impact

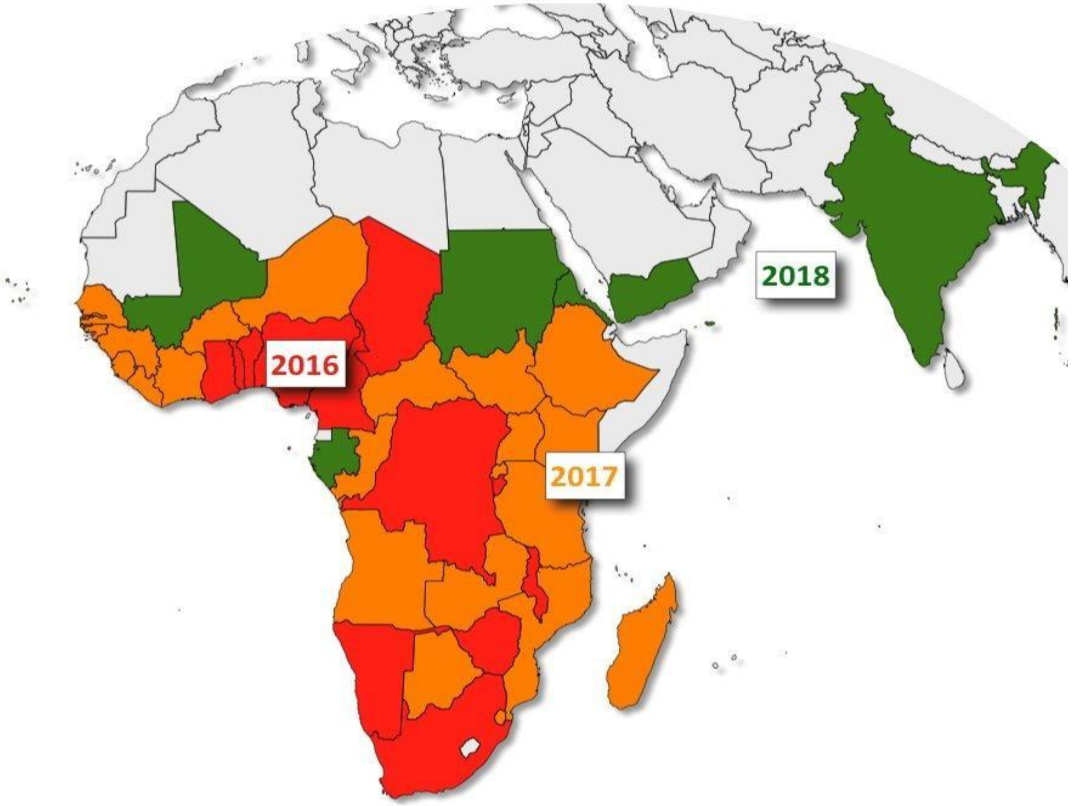
The Pest (*Spodoptera frugiperda*)

- Wide host range (>80 plant species) but with major preference for maize
- Short life cycle: 1-2 months (depending on weather)
- Rapid proliferation (>1000 eggs per female)
- Strong migratory capacity of moths: 500 km before oviposition; with suitable wind >100 km

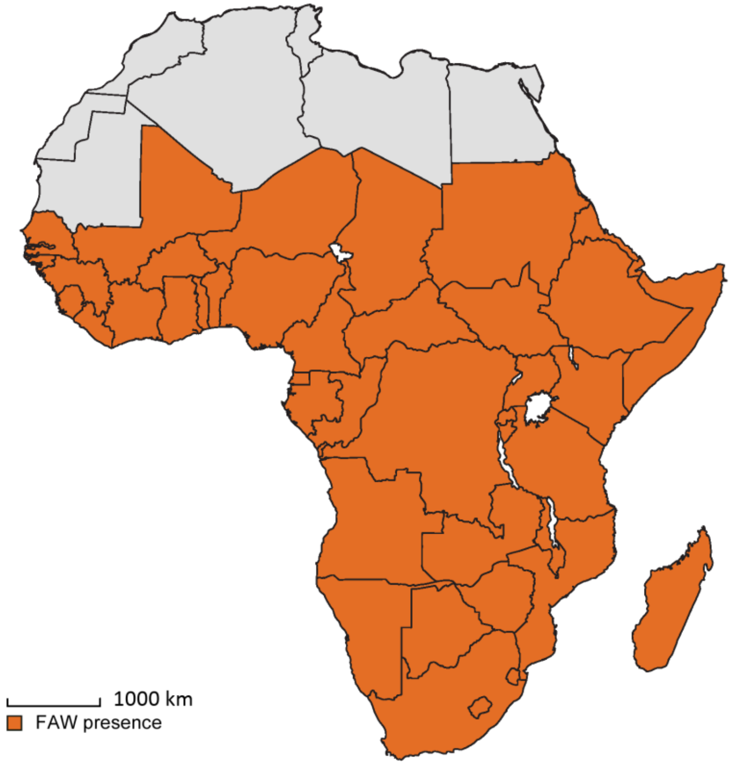
Fall Armyworm (*Spodoptera frugiperda*) life cycle



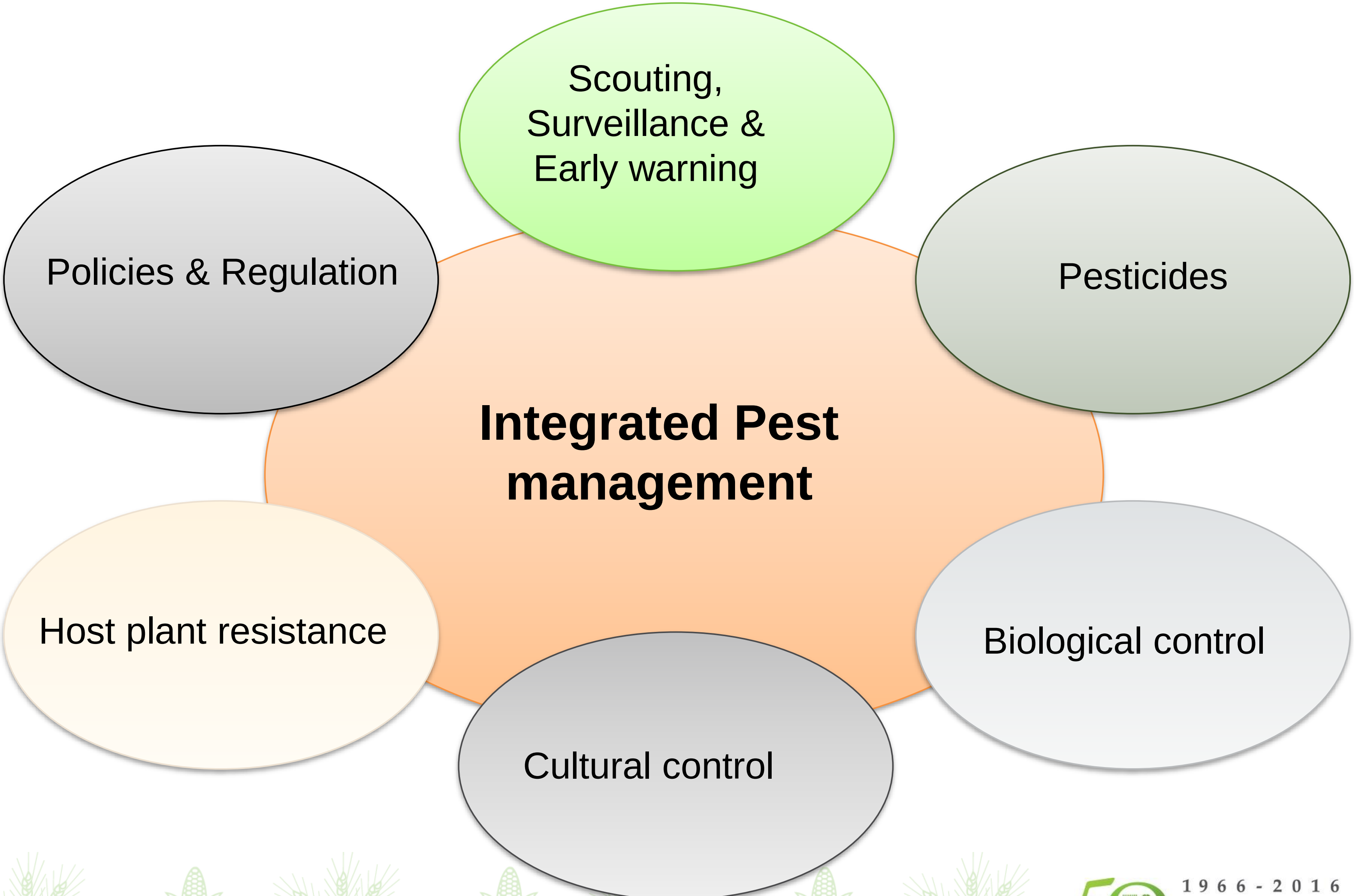
Fall Armyworm Spread in Africa and Asia



Map: FAO, August 2018



Insect Pests management options



Pheromone Traps

Effective **monitoring and scouting** for the pest at both farm and community levels is very important!

Field Scouting

Cultural Control for stemborers and FAW

- Manipulation of the environment in such a way as to render it unfavorable to the pest (the crop and the land)
  - Crop manipulation (intercropping, destruction of residues, planting dates)
  - Land manipulation (crop rotation, tillage)
- Most relevant and feasible pest control for small holder subsistence African farmers

Low-cost Cultural Control and Agro-ecological Management

- Early/timely planting
- Appropriate plant nutrition
- Increased diversification – intercropping with compatible crops (Maize-Cassava; Maize-Gliricidia; Maize-Pigeonpea; Maize-Cowpea, etc.)
- Habitat management
- Companion crop strategy

How to Control Insect Pests

Biological control using

- Parasitoids (**Egg parasites, Larval parasites, and pupal parasites**)
- Predators (**Egg parasites, Larval parasites, and pupal parasites**)
- Pathogens
    - **Fungi, Bacteria, and viruses**

Bio-control for Stemborers

- Classical BC has been attempted against the invasive *Chilo partellus* using the parasitoid *Cotesia flavipes*
- Redistribution of parasitoids – i.e. the geographic expansion of a parasitoid species or population beyond their native range – has been attempted against *B. fusca* introducing Kenyan populations of *C. sesamiae* in western Africa and the West African egg parasitoid *Telenomus isis* into Kenya.
- However, in most cases BC achieves only partial control of the pest and has to be combined with other control techniques.

Some parasitoids of stem borers

Trichogramma bournieri

Telenomus sp.

Pediobus fuvus

Cotesia flavipes

Natural Biological Enemies For FAW

Source: Goerg Goergen (IITA)

Parasitoids:

- *Trichogramma* Spp.
- *Telenomus remus* Nixon (Hym.: Platygastridae)
- *Chelonus insularis* Cresson (Hym.: Braconidae)
- *Cotesia marginiventris* (Cresson) (Hym.: Braconidae)

Biological Control integrated with Host Plant Resistance against FAW in Brazil

***Trichogramma* Egg Parasitoid**

***Bt and Baculovirus-based* biopesticides**

Bio-control: Fungi for stemborers control

- Entomopathogenic fungi produce toxins
- *Metarhizium anisopliae* and *Beauveria bassiana*
- Collection and characterization of isolates

Chemical control for stemborers

- Chemical control using synthetic contact insecticides provides only protection against early attacks but not against borers feeding inside the ear
- It requires pest monitoring and training of farmers but in most countries appropriate training capacities do not exist.
- Inappropriate use of chemicals may affect human health and interfere with natural control by predators and parasitoids leading to outbreaks of secondary pests.
  - Borers are difficult to control with insecticides
  - Stem borers are cryptic feeders-late instars (3rd instars)
  - Early (1st, 2nd) larval instars- leaf whorl feeders

The Response

Source: Ernst Neering

Biopesticides: Use of botanicals against FAW

Home made pesticide instead of commercial product
Low cost production
Easily applicable at smallholder level
Naturally occurring
Smooth degradation, less environmental pollution

Effectiveness:
Short-lived susceptible to UV degradation
Variable action
No residual effect

Constraints:
- Slow effect
- Home production is labour intensive;
- Limitations of the botanical resource;
- Mode of action not always understood
- Concentration levels vary

Source: Georg Goergen (IITA)

Breeding for insect Resistance

1. Has lagged behind disease resistance
2. Requires knowledge on the biology of maize and the pest
3. Dependent upon:
    - The insect pest,
    - Efficient insect rearing technique,
    - Efficient artificial infestation of maize plants,
    - Genetic techniques, and
    - Plant breeding techniques

Host Plant Resistance Breeding

Maize Leaf Damage

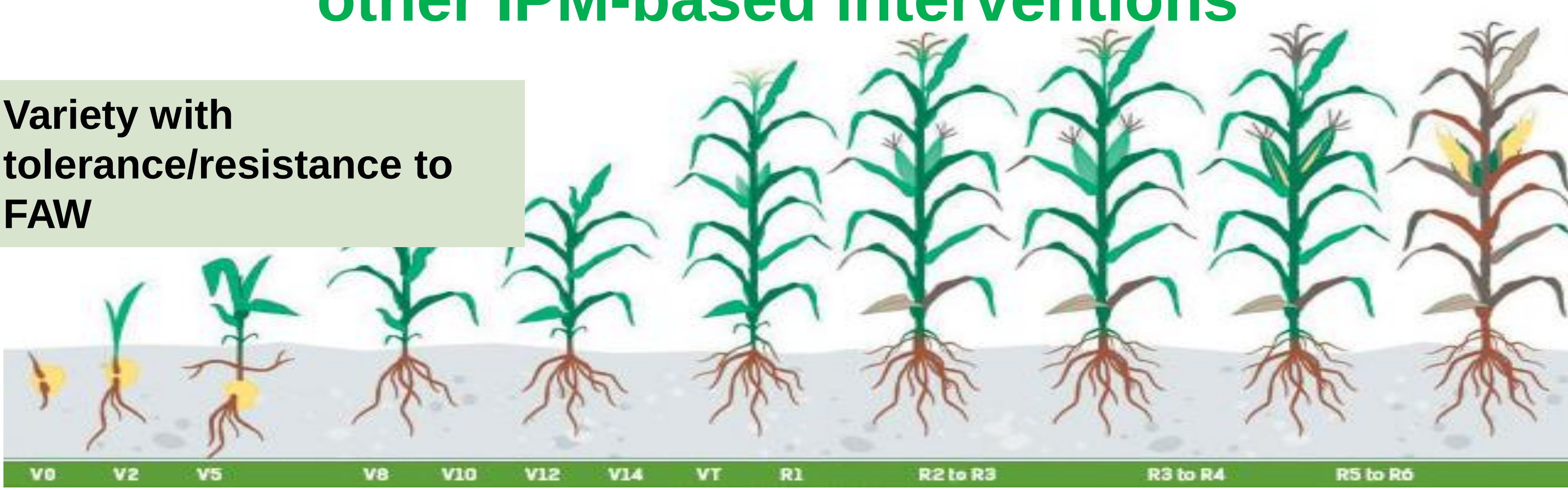
Dead Hearts and Stem Damage

Tunnel Length of Insect Resistant Maize

Stem Borer Resistant and Checks

Host plant resistance is highly compatible with other IPM-based interventions

Variety with tolerance/resistance to FAW



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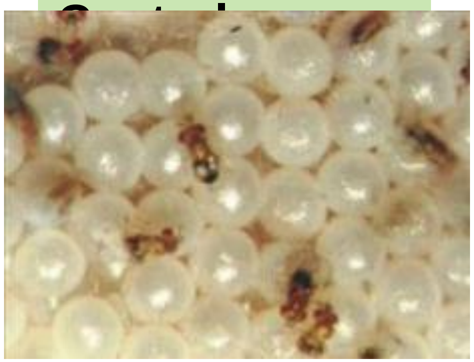
Biological



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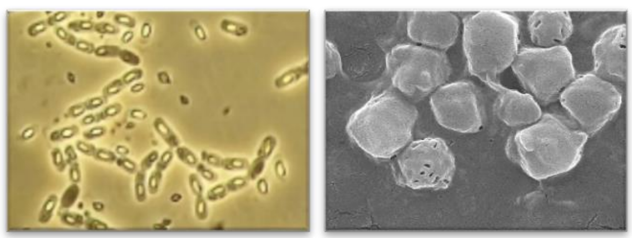
Biopesticides



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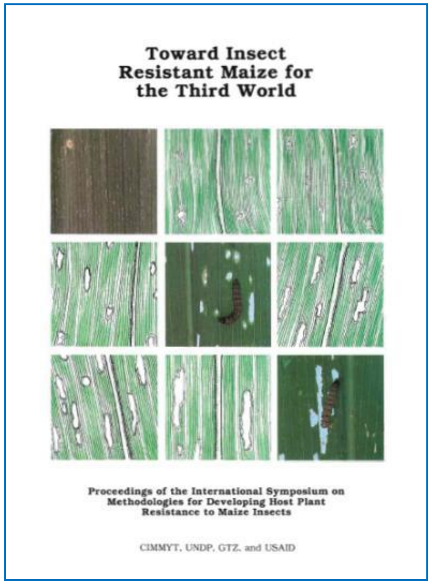
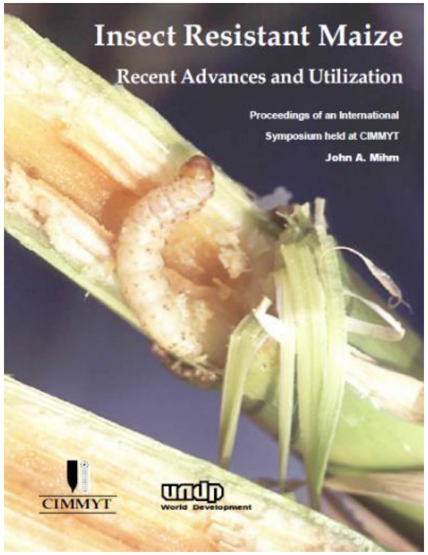
Agro-eco Management

Germplasm Sources

- CIMMYT's breeding efforts against major insect-pests in the tropics, including Fall Armyworm, initiated in the 1970s in Mexico → **MIRT and MBR populations.**
- Polygenic FAW resistance identified in **Caribbean** maize germplasm and **Tuxpeno** germplasm.
- Parallel and significant efforts at **USDA-Mississippi, Univ. of Florida, and Embrapa-Brazil**.

An important germplasm base to identify, validate and deploy native genetic resistance against FAW in Africa

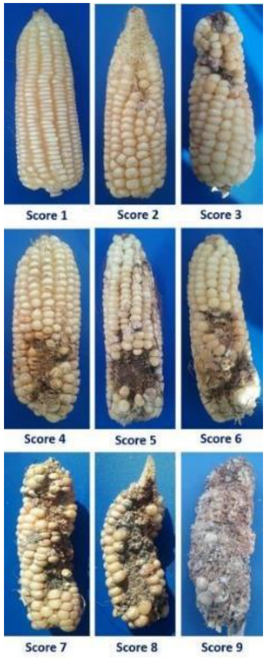




Intensive Germplasm Screening

- Intensive screening of **CIMMYT and IITA maize germplasm in Kenya and Nigeria**, respectively
- FAW-tolerant maize germplasm from **USDA-Mississippi** also screened by CIMMYT in Kenya.

At KALRO-Kiboko Maize Statio



Germplasm Responses

CIMMYT FAW Tolerant hybrids

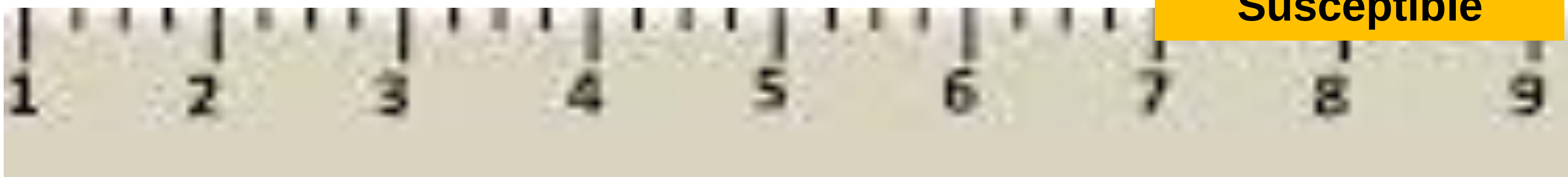
Bt Maize against FAW

- *Cry* genes *cry1A, cry1Ab,* and *cry1F* deployed in commercial *Bt* maize varieties globally for over 20 years.
- In Brazil and North America, where over 80% of the total maize production area is cultivated with *Bt* maize.

Performance of Bt maize under natural stem-borer and natural FAW infestation in Uganda, March 2018

Native genetic resistance and Bt-based transgenic resistance to FAW are complementary...

Resistant | Partially Resistant | Susceptible | Highly Susceptible



Bt **maize** (single gene; high selection pressure on insect)

Conventional / Native genetic resistance (polygenic; low selection pressure on the insect)

Almost all commercial maize varieties in Africa

Conclusions

- Stem borers and FAW are economically the most important insect pest of maize in SSA.
- There are a number of control measures against stem borers and FAW but each comes with its own limitations.
- HPR, the resistance is embedded in the seed, and is, therefore, the easiest control method for subsistence farmers
- Bt Maize offers control stem borers but the right Bt event for FAW control is required.

Thank you for your interest!

1966-2016
CIMMYT