Self Help Africa

Fall Armyworm Update May 2018

Fall Armyworm, *Spodoptera frugiperda*

Fall Armyworm, *Spodoptera frugiperda*

- Noctuid Moth, native to the Americas.
- Related to African Armyworm but with different behaviour.
- Appeared in Africa in early 2016.
- Probably came to Africa from Brazil via airfreight.
- Two strains: “maize strain” feeds predominantly on maize, cotton, and sorghum. the “rice strain” feeds primarily on rice and pasture grasses
- The two strains are identical but differ in pheromone compositions, mating behaviour, and host range.
- FAW has been confirmed in 28 countries in Africa, with an additional 9 suspected.
- Though the FAW is predominantly found in the maize, it can also attack most cultivated crops (80 listed by CABI) including; sorghum, sugarcane, cotton, Irish potato, tomato, tobacco, spinach, crucifers, chrysanthemum, cucumber, sweet potato, common bean, cowpea, soya bean, groundnut and banana.

Fall Armyworm, *Spodoptera frugiperda*

- Evidence indicates that the FAW has spread to all parts of Africa, except for North Africa.
- female armyworms produces between 50 - 200 eggs per batch) and up to 10 batches within her lifespan.
- Moths are carried by the wind up to 1,000km.
- FAW in Africa aren't being reduced by their natural enemies.
- The FAW population is limited by frosts and predators in its natural habitat (the Americas), the absence of which in most of Africa may have contributed to its rapid spread throughout the continent.
- With predictions of 30% yield losses of maize in the 2017-18 season there is potential for widespread and critical food insecurity.
- The FAW is here to stay so the best we can do is to suppress the population, minimise the damage done to smallholder crops and deal with the consequences.

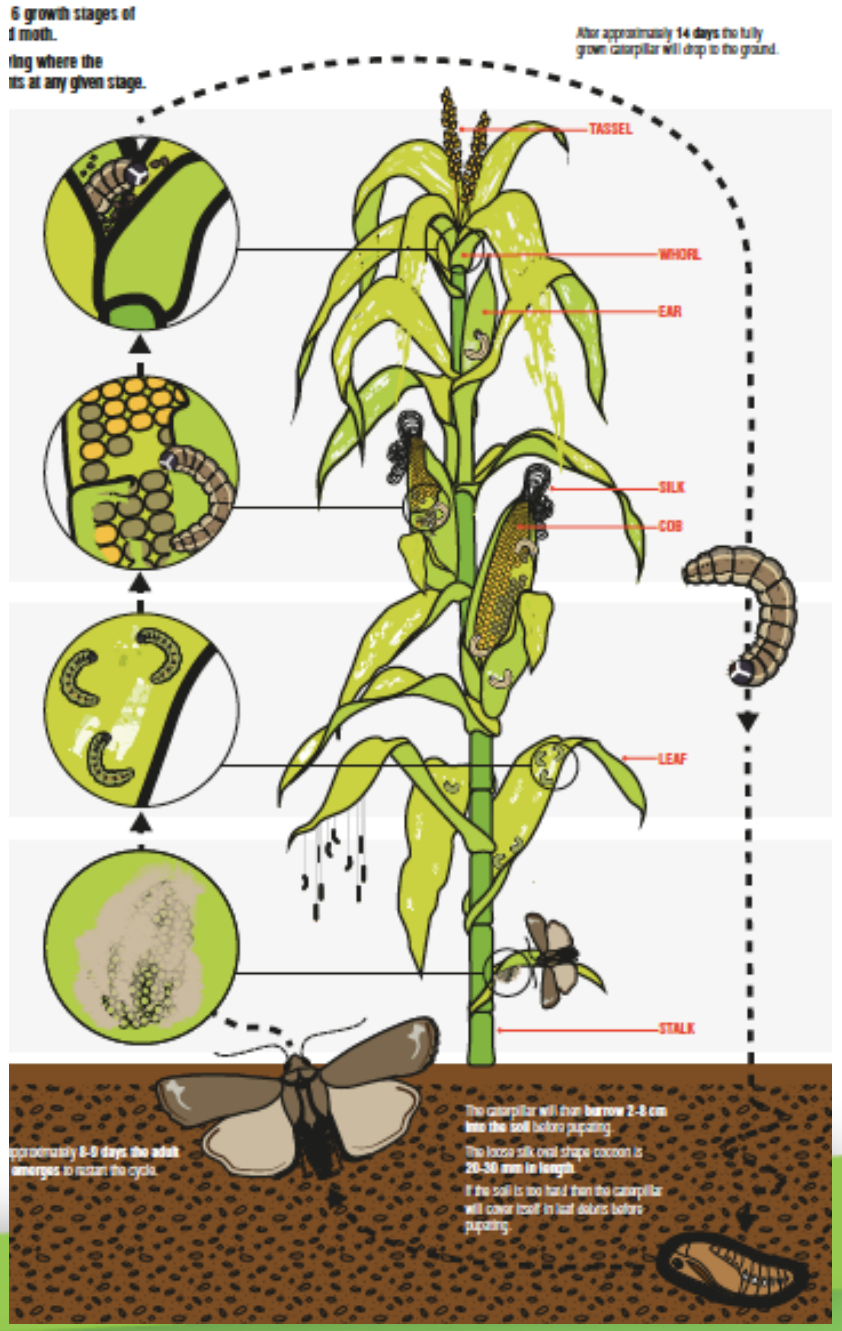
Fall Armyworm lifecycle

100-200 eggs are generally laid on the underside of the leaves typically near the base of the plant,

Growth stages 1-3: After hatching the young caterpillars feed on the undersides of leaves, resulting in windows on the leaves. Young caterpillars can spin silken threads which catch the wind and transport the caterpillars to a new plant. Feeding is more active during the night.

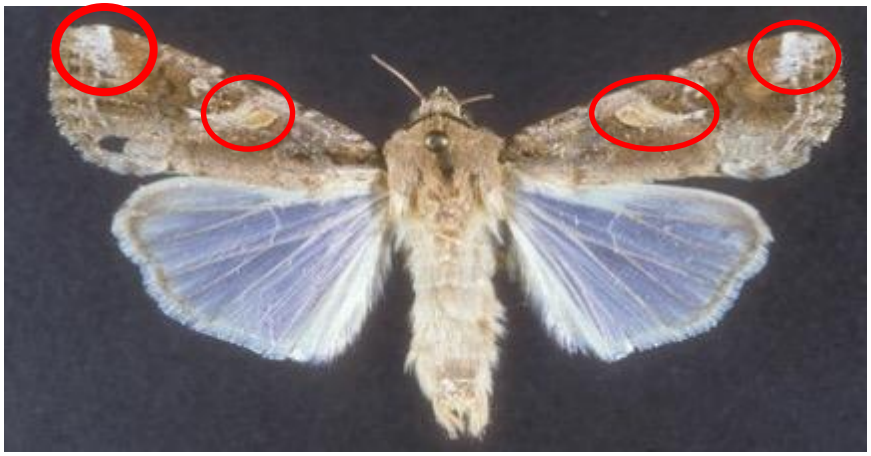
Growth stages 4-6: caterpillars reached the whorl, where it does the most damage, Feeding on young plants can kill the growing point. caterpillars become cannibalistic when larger

After 14 days the fully grown caterpillar will drop to the ground. The caterpillar will then burrow 2-8 cm into the soil before pupating. The loose silk oval shape cocoon is 20-30 mm in length. If the soil is too hard then the caterpillar will cover itself in leaf debris before pupating. After approximately 8-9 days the adult moth emerges to restart the cycle.



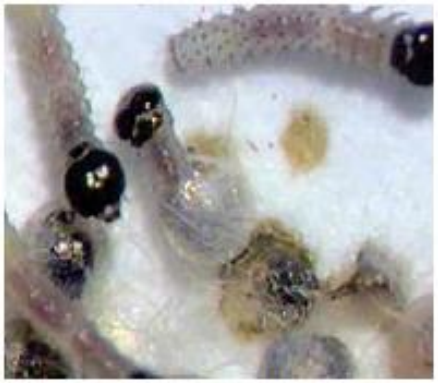
- Eggs: Laid in masses (100-200 per mass) underneath the leaves and are covered with hairs and scales from the female body.
- Hatch after 2-3 days during the summer season.
- Larvae: Usually 6 instars.
- Larval stage is completed in 2 weeks during the warm season but can take about 4 weeks in cooler weather.

Fall Armyworm identification



A. Egg mass placed on stem (left) or leaf (right) at early stage of maize plant

B. Egg mass (left) and larvae hatching three days after oviposition (right)

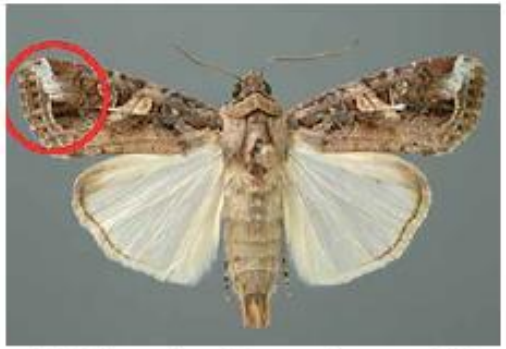


C. Black-headed larvae emerging out of egg mass

D. Larval growth stages (1 mm to 45 mm)

E. Distinguishing marks on medium to large-sized larvae

F. Reddish-brown pupa



G. Male moth with conspicuous white spot on tip of forewing

Smart Phone App

- Fao: FAMEWS. http://bit.ly/2FKraru

Monitoring

- Pheromone trapsuse the smell of a female armyworm to attract a male, can be a very useful surveillance tool. (Russell IPM)
- What happens in the dry/ winter season?
- In theory if enough traps are used mass trapping could be used as a control strategy (an approach used for insect pests in greenhouses). At the moment this approach is not encouraged for FAW until we know more about the biology of FAW in Africa.

Pheromone-Based Monitoring

Pheromone-based monitoring

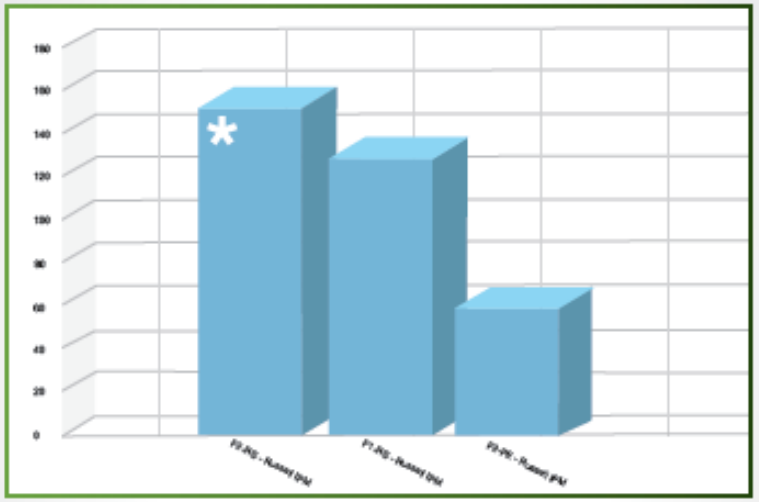
Russell IPM
INTEGRATED PEST MANAGEMENT

Monitoring the pest can help prevent infestations and contain the Fall armyworm population before it grows out of control.

Xlure-FAW, Russell IPM's latest pheromone lure, uses a sex pheromone attractant to trap the FAW moths. This lure should best be applied before the emergence of the first FAW generation and until the end of the season. Provided in a rubber septa, the attractant lasts for 4-6 weeks.

The Mothcatcher is the best trap for dispensing the lure. It is a plastic funnel trap with cage lure holder, which incorporates the septa with the FAW sex pheromone. Use 1-2 traps per ha, attaching the Mothcatcher above crop height with the help of supporting posts.
Raise the traps as the maize plant grows to adjust for its new height.

The Xlure-FAW has been extensively tested in South Africa, where Russell IPM's *F2-RS lure demonstrated the best results compared to the other published pheromone formulations.



Comparison of the trap catch counts of **Russell IPM FAW** pheromone lures trialled in South Africa in February 2017.

While armyworm sex pheromone traps generally only attract males, NRI has developed a general floral attractant which attracts both sexes of Noctuid moths [24] and particularly females.

FAW Field Monitoring

- train extension staff and community extension workers in scouting and identification of the FAW.
- regular sampling of sample plots within fields to count the eggs laid and early instar caterpillars
- identifying infected fields
- identify threshold levels,
- mobile phone based survey tools. The survey data will be GPS-tagged for analysis,

Action Thresholds

Maize Crop Stage	V Stage	Action Threshold for Smallholder Farmer	Action Threshold for Village-Level Progressive Farmer
Early Whorl Stage	VE-V6	20% (10-30%)	20% (10-30%)
Late Whorl Stage	V7-VT	40% (30-50%)	40% (30-50%)
Tassel & Silk Stage	R1-R3	NO SPRAY Unless low-toxicity & supportive of conservation biological control	20% (10-30%)

- threshold based on the percentage of plants damaged
- If pheromone traps are being used, the threshold will be around three moths per trap per hectare (Brazil), but needs testing in Africa.
- Not recommend that smallholder farmers apply insecticide at or post-VT because it is too dangerous for the applicator and for his or her family.

Control Options

- Chemical
- Botanicals
- Physical
- Push-Pull
- Plant resistance
- Biological

Chemical Control

- control using chemicals is difficult as the larva hide within the whorls, away from spray applications.
- Control is best at early maize crop growth stages when the spray can be applied into the whorls.
- The crop should be sprayed during the early development stages of larvae; late-stage larvae may prove to be very difficult to control due to their large size and their habit of feeding on the tassels, ears and cobs.
- Once the plants reach >1m the spray operator is at risk from spray drift.
- Spray in the early morning, evening or night, when caterpillars are actively feeding.

Chemical Control

- Cypermethrin has been used for the 2016-17 growing season in most of Africa. Effective but FAW populations in the Americas show resistance to several synthetic pyrethroids.
- Other synthetic pyrethroids: Lambda cyhalothrin, Deltanex/ Decis forte (Deltamethrin)
  - Belt (phthalic acid diamides)
  - Actellic/ betallic (Pyrimiphos-methyl)
  - Dursban (Chlorpyrophos)
  - Steward (Indoxacarb)
  - Proclaim: Emamectin benzoate/ Abamectin /Emamectin benzoate (anthelminthic / larvicide),
  - dimethoate,
  - Chlorantraniliprole.
- Appearance of secondary pests

Physical control/ Agronomic Practices

- Hand picking eggs. Effective but tedious for large fields – more work for women and children?
- Crop residues: mixed messages. Crop residue mulches are a key part of Conservation Agriculture, however the FAW pupates in the soil or under leaf litter for 8-9 days, so crop mulches could provide pupation sites for FAW. Current opinion is that the pupae are in the soil and not the mulch and benefits of mulch outweigh the risks.
- Early Planting is reported to have reduce FAW damage in the 2016-17 season. Probably due to the growth of the population in newly infested areas. Need to monitor this season to see if early planting has any effect now that FAW is established.

Botanicals

- Natural pest control using botanical pesticides would contribute to the more sustainable management of fall armyworm but there are many challenges of using naturally-extracted compounds.
- the amount of active ingredient extracted is often very low,
- the compounds break down very quickly in sunlight
- often act as repellents and anti-feedants in comparison the fast toxicity of synthetic pesticides

Initial ideas for botanicals include:

- Neem-based formulations (leaves, neem oil, neem oil seed cake). Reported as effective in both Central America and Africa.
- Pyrethrum, *Chrysanthemum leucanthemum*
- *Tephrosia vogelli.* Two chemotypes, only one contains rotenoids.
- Crotalaria (Sunhemp) formulations. allelopathic effects of *Crotalaria juncea* may limit use on crops.
- *Ricinus communis*
- *Jatropha gossypifolia*

Botanicals

- *Neorautanenia mitis* leaves and tuber,
- *Melia azedarach* leaves and seed,
- *Tithonia diversifolia* leaves,
- *Engraulicypris sardella* (Usipa)
- *Senecio salignus,*
- *Salvia microphylla,*
- *Crescentia alata,*
- *Tagetes erecta,*
- Soap
- Tobacco formulations

Other local options:

- Ash, particularly rice husk ash.
- Soil: appears to infect the caterpillar with a bacteria.
- Sawdust
- Lime
- Diatomaceous earths.
- Maltodextrin
- Ethyl palmitate

Push-Pull / Trap Crops Strategies

- Companion planting with plants or the use of chemicals that repel or attract the FAW.
- I met a farmer in Zambia who planted sweet sorghum to protect her seed maize – seems to have worked. FAW ate the sweet sorghum and left her maize alone. 1 small field ≠ a solution but worth further trials.
- While the principle of push-pull using attractive and repellent plants is well established, it does not work in all areas, and farmers cannot always grow the required additional plants.
- maize is inter-cropped with drought-tolerant greenleaf desmodium and planting *Brachiaria* as a border crop. in drier areas of Kenya, Uganda and Tanzania, push-pull showed a reduction of 82.7% in the average number of larvae per plant and 86.7% in plant damage per plot.
- Intercropping maize with legumes can result in up to 40% reduction in armyworm incidence and damage.

Push-Pull / Trap Crops Strategies

- Potential to use repellent chemicals to dissuade pest insects from feeding on crops.
- A system based on portable chemical dispensers releasing attractants and repellents would require less labour costs than traditional push-pull and simpler than multi-plant systems.

Bio-control

- The predators of fall armyworm are generally predators that attack other caterpillars.
- **Insects**: Ground beetles (Coleoptera: Carabidae); striped earwig, *Labidura riparia* (Pallas) (Dermaptera: Labiduridae); spined soldier bug, *Podisus maculiventris* (Say) (Hemiptera: Pentatomidae); insidious flower bug, *Orius insidiosus* (Say) (Hemiptera: Anthocoridae). Lacewings, predatory wasps, ants, parasitic wasps, flies, and spiders.
- *Cotesia icipe* a solitary Parasitic wasp of *Spodoptera littoralis* and *S. exigua* can provide up to 70% control for FAW if released in huge numbers. As they multiply in the fields, they can control the pest as they feed on the pest's larvae.
- Use of sugar, bones, flour to encourage ants.
- Vertebrates: birds, toads, bats, skunks, and rodents consume larvae and pupae.
- egg parasitoid Telenomus remus, Trichograma
- Spodoptera frugiperda nucleopolyhedrovirus (SfMNPV) strain NPV003

Bio-control

- Infect FAW with bacteria/ virus in extracts made from dead FAW.
- The African Armyworm, *Spodoptera exempta*, is vulnerable to a lethal virus *Spodoptera exempta* nucleopolyhedrovirus (SpexNPV), which can be made locally and the Fall armyworm also hosts a specific baculovirus *Spodoptera frugiperda* nucleopolyhedrovirus (SfMNPV). SfMNPV is already registered as a biopesticide in the Americas but it is not yet registered in Africa.
- The fungi *Entomophaga aulicae*, *Nomuraea rileyi*, and *Erynia radicans* used for biological control of FAW in the USA (Capinera, 2014).
- *Beauvaria bassiana* is also an option – used in the horticulture industry.
- fungi *Metarhizium anisopliae*
- entomopathogenic nematodes (EPNs), especially *Heterorhabditis bacteriophora , Heterorhabditis indica* , and *Steinernema carpocapsae.*

Bio-control

- *Bacillus thuringensis* formulations and to fast-track approval in Malawi, which can be sources from Kenya. These include Dipel®, Thuricide®, Xentari® (Biovision Farmer Communication Programme, 2017), Halt 50WP® and Baciguard 16WDG®
- FAW in the Americas show resistance to Bt maize and synthetic pyrethroids but field performance of MON810 single-gene Bt maize further suggests that Bt resistance alleles may not be present in the FAW population currently in Africa. This needs to be confirmed.
- Bt formulations are harmless to non-insects and, as they have to be ingested when an insect eats a leaf sprayed with Bt to have any effect, are harmless to bees and predatory insects and arachnids

Host Plant Resistance: Breeding

- Holy Grail of FAW control.
- there are presently no Africa-adapted maize cultivars with scientifically validated resistance to FAW.
- Water Efficient Maize for Africa. GM Maize. Developed for drought tolerance + stem borer resistance. Shows promising FAW resistance. https://bit.ly/2HThWKS
- GM: Bt. maize in Brazil and USA. Resistance increasing.

Environment

- As FAW is not native to Africa it is not known which African plants can be exploited by adult and juvenile stages.
- Need to identify potential host and non-host plant species for fall armyworm that may supply nectar to adult moths and provide alternative food resources for caterpillars.
- Biodiverse environment: a source of predators but possibly also alternative host plants.

Soil fertility

- A healthy plant should be able to respond to, and recover from, FAW attack.
- FAW moths are known to seek out the healthiest plants to lay their eggs.

Principles of Donor/ NGO support for FAW control

- support the work of the national government to build the capacity of local government and local institutions to suppress the Fall Armyworm, *Spodoptera frugiperda* (FAW)
- ensure that those farmers who have lost food and income from cash crops are protected by Government safety net provisions.
- implement those activities listed in the Government's FAW action plans that are within the technical capacity of NGOs
- complement the research of NAROs, CGIARs and Universities.

Strengthened existing local government structures to manage pest outbreaks

- Training and equipping local government to monitor and manage pest outbreaks.
- Fits within the Resilience agenda (Resilience to insect pest outbreaks).
- District Agriculture Committees, District Executive Committees, District Civil Protection Committees, Village Development Committees, Village Civil Protection Committees. Natural Resource Committees, District Disaster Management Committees

Increased awareness of FAW by farmers and extension staff

- FFS
- Media
- Training materials
- ICT
- Plant Clinics

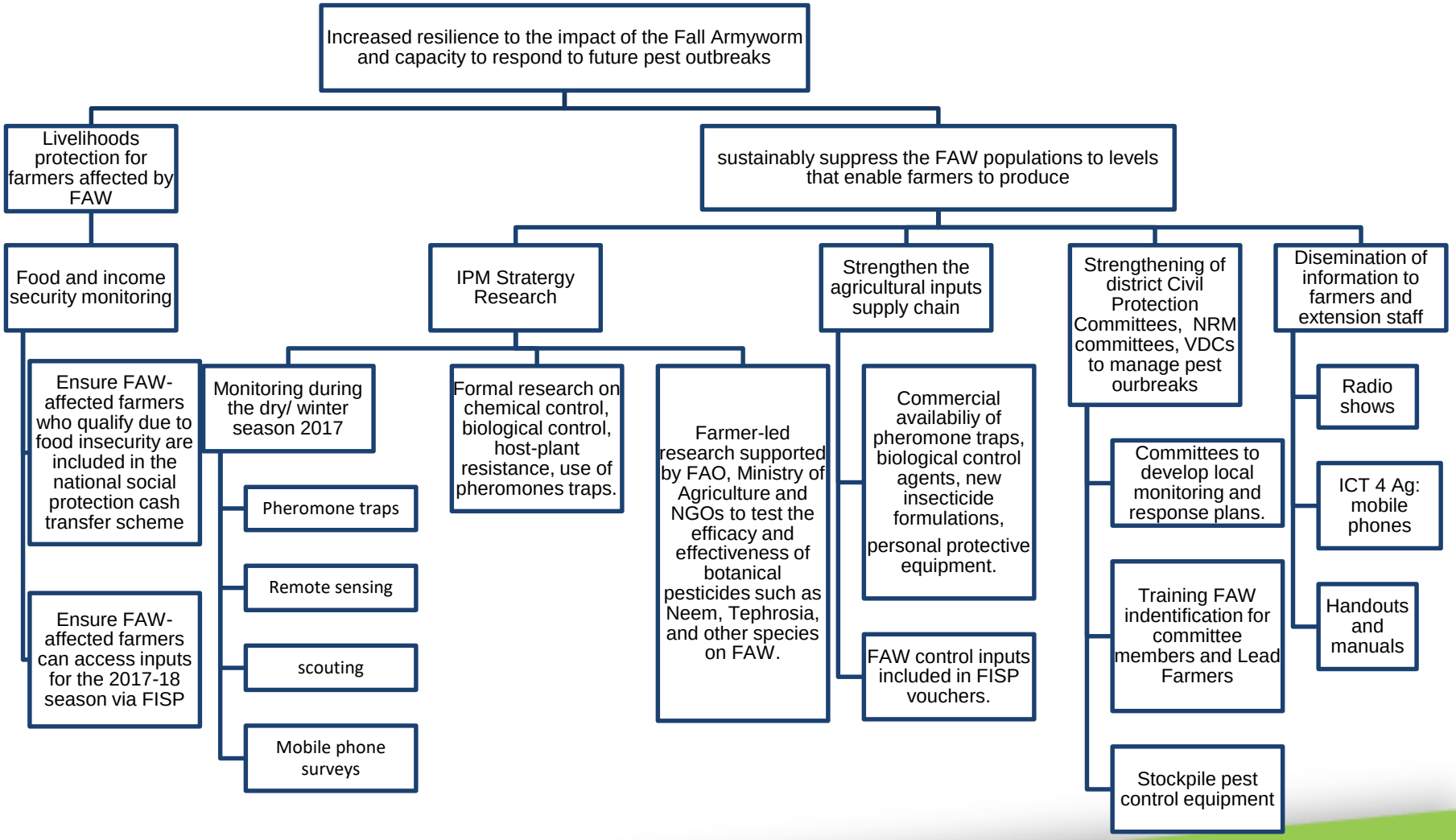
Research to develop an Integrated Pest Management Strategy: Farmer-led Research

- help farmers to set up and monitor simple trials to test these ideas on different crops. The results, while not “academic” will, if properly collected, provide important information on FAW behaviour, the effects of farming practices (CA, intercropping, mulching) and control options.

Strengthening the agricultural inputs supply chain

- review the nationwide availability of the shortlisted insecticides, application and personal protective equipment, and pheromone traps and advocate to policies to improve availability, for example emergency/ fast track approve for control measures already approved in SADC / COMESA countries.
- lobby the government to included insecticides for FAW control to be included in the FISP package, and additional vouchers issued to FAW affected farmers.

Framework for civil society response to the FAW



FAW in SHA countries

- All the countries SHA works in have a FAW problem (with the possible exception of Eritrea).
- We have been supporting CABIs **Plant Clinics** in most of these countries, and these have been our primary focus for FAW control.
- Our focus has been on **Malawi** as the government's capacity to respond is much weaker than the other countries.
- Despite very positive international publicity about the Government of **Zambia's** pro-active response to the FAW, the District Agricultural officers I met in Zambia had little, if any, resources for FAW control.
- In **Uganda** the government is reluctant to let NGOs work on FAW issues.
- In **Kenya** our staff are working flat out on other projects and have not had the time or resources to develop FAW-specific interventions.
- FAW is becoming an issue in our sorghum value chain work in **Burkina Faso**, but the scale of the problem is still unclear – we need to improve insect identification by both our staff and the CABI Plant Clinics.

SHA's response: Ethiopia

- SHA is a member of the Disaster Risk Management Agricultural Task Force (DRM-ATF) and specifically working as a member of the sub-working group-Emergency Seed Working Group under DRM-ATF, where members share information on agriculture related threats and hazards.
- training was given to farmers and some other people in control activities.
  - EE3 project, Discussion on fall army worm identification and control mechanism was included in the seed technology training session. Out of eight project target areas, it is only in one kebele the occurrence of FAW was observed and it was able to control as the farmers took immediate action after the training.
  - EE7 project (22 district development agents were received a Fall army worm introduction and updates to 1398 farmers)
  - EG5 project (104 farmers and 30 DAs were trained about Fall armyworm morphology, biology, lifecycle and identification as part of the training session organized on improving agronomic practices.

SHA's response: Malawi

- SHA formed an NGO FAW consortium: Self Help Africa, Catholic Relief Services, World Vision International, CARE and Christian Aid Save the Children International, Project Concern International, COOPI, Chikwawa CADECOM, Action Against Hunger
- Target districts: Chitipa, Karonga, Balaka, Machinga, Rumphi, Nkhata-Bay, Mzimba, Chikwawa, Zomba, Chiradzulu, Lilongwe, Mchinji, Dedza, Neno, Mwanza, Ntcheu, Nsanje, Mulanje, Thyolo, Phalombe, Blantyre, Kasungu, Dowa, Ntchisi, Salima, Mangochi and Nkhotakota.
- Proposal developed for the Lilongwe offices of Irish Aid, FAO, DFID, USAID, GIZ.

SHA's response: Malawi

Karonga

- 43 percent (9921 hectares) of the land allocated to farming has been attacked by the pest. About 40,459 households have been affected.
- SHA trained extension workers (34), lead farmers (560) and VCPC members (410) on control of FAW, Integrated Pest Management and safe use of pesticides.
- SHA distributed 388 litres of Cypermethrin to Karonga DADO office
- SHA distributed 53 sprayers and sets of protective gear (mask, gloves, googles, overalls, aprons).
- SHA held panel discussions on community radio to sensitize communities about the FAW and supported the district agriculture offices in developing messages on control of FAW which were aired on the radio.

SHA's response: Malawi

Balaka

- about 55 percent (26,025 hectares) of the land allocated to farming has been attacked by the pest and only 42 percent of the infested land has been sprayed. A total of 47,775 farming households have been affected.
- SHA trained project staff and government extension workers in FAW monitoring.
- 100 Lead Farmers have been trained in FAW monitoring through field scouting in addition to control by chemicals and other formulations (Neem and Tephrosia)
- FAW Research: SHA has just started an initiative on FAW monitoring using satellite images and we are working jointly with HQ and University College Dublin (UCD).

Fall Armyworm Remote Sensing Field Survey Protocol V4, 25/01/18

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FAW Survey Methodology

- At each site 15 plants in each quadrat will be inspected for FAW presence in the whorl and damage to the leaves. The plants should be selected in a “x” pattern, walking from corner to corner and inspecting 15 plants.

- Each plant will be assessed on a damage grading scale (0-5):

- 0: No visible damage and no visible presence of either eggs or caterpillars.
- 1: No visible damage, eggs present.
- 2: Shot holes and elongated lesions (>2 cm) on <50% of leaves.
- 3: Elongated lesions on >50% of leaves.
- 4: Elongated lesions or tattering on most leaves (>75%).
- 5: Plant dead, dying (dead heart) or economically worthless (cob damage).

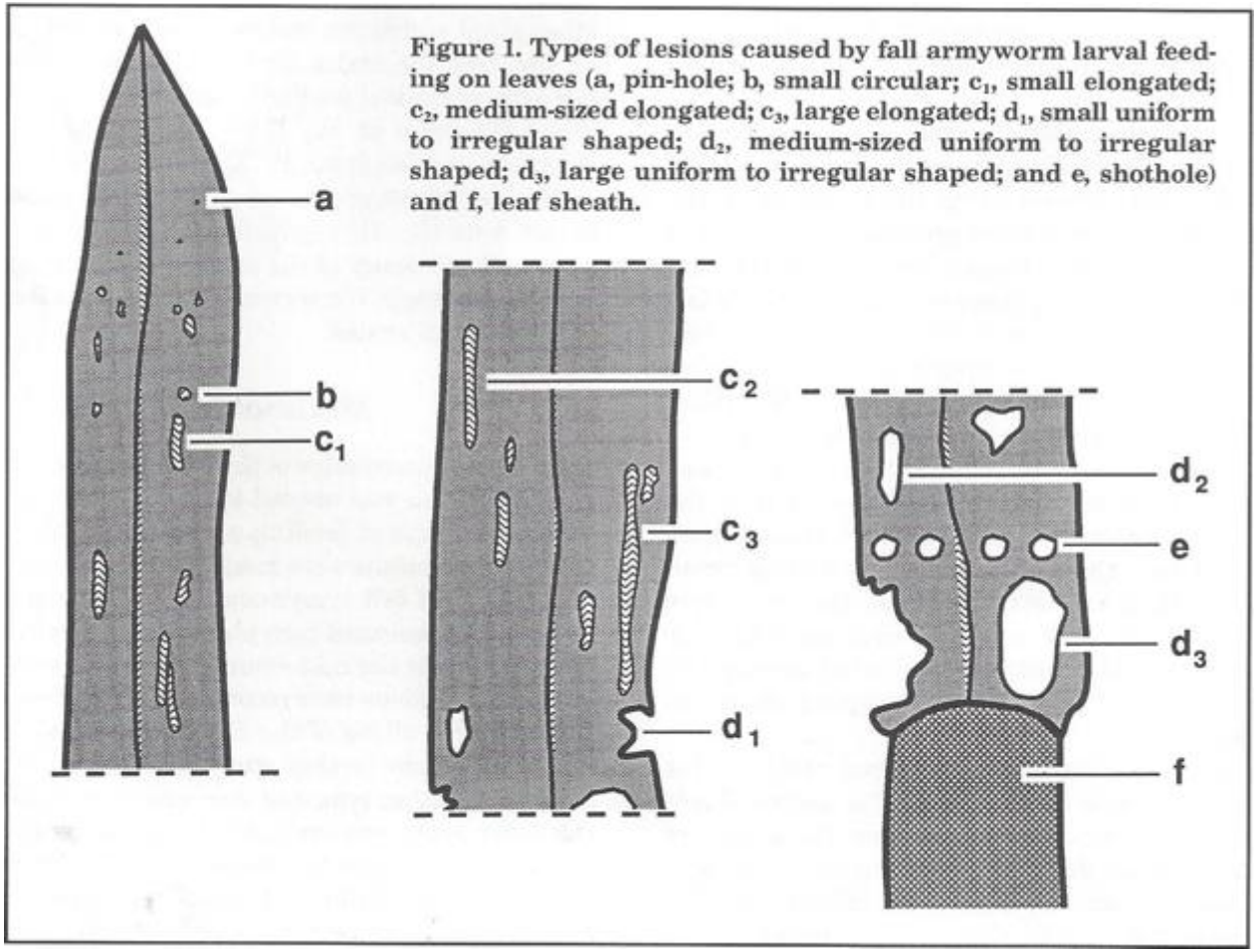
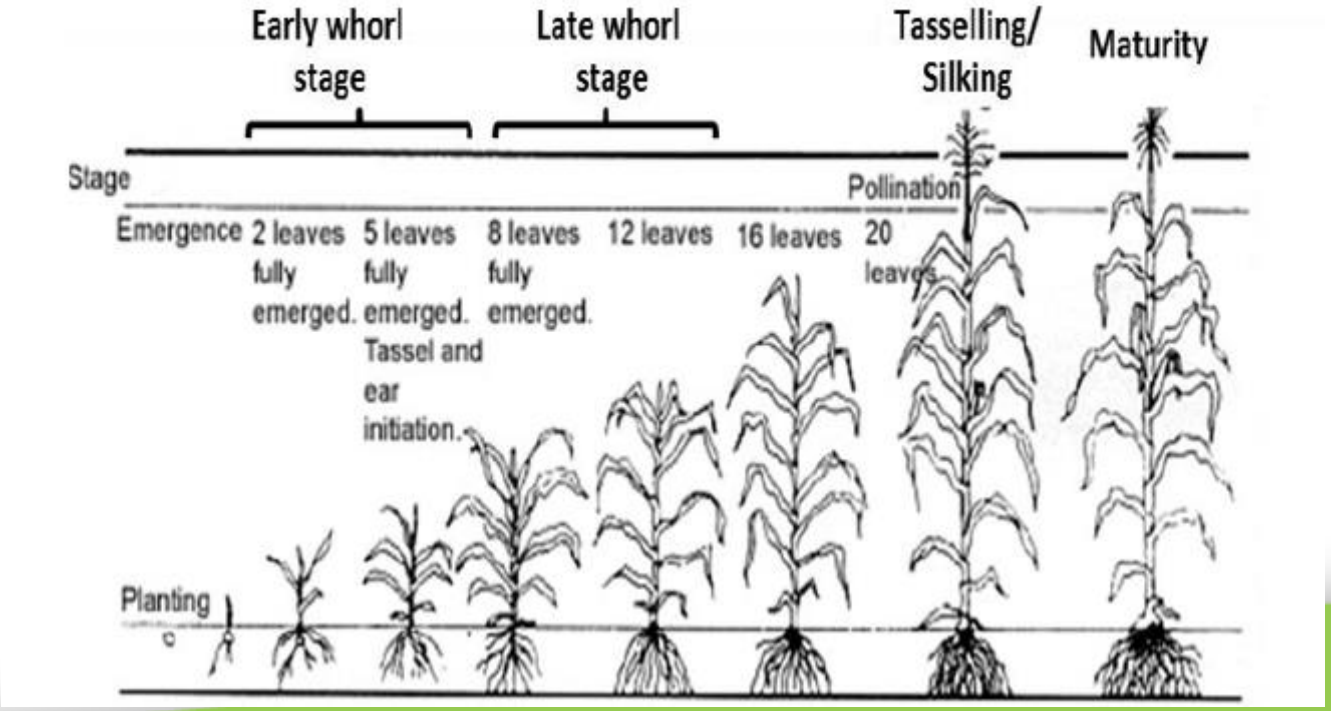


Figure 1. Types of lesions caused by fall armyworm larval feeding on leaves (a, pin-hole; b, small circular; c_1, small elongated; c_2, medium-sized elongated; c_3, large elongated; d_1, small uniform to irregular shaped; d_2, medium-sized uniform to irregular shaped; d_3, large uniform to irregular shaped; and e, shothole) and f, leaf sheath.

FAW Survey Methodology

- Fields sampled four times per season at key stages of crop development: V2, V10, R0, R3; approximately 12, 40, 57 and 80 days after sowing respectively.



USAID/ CIMMYT scoring System

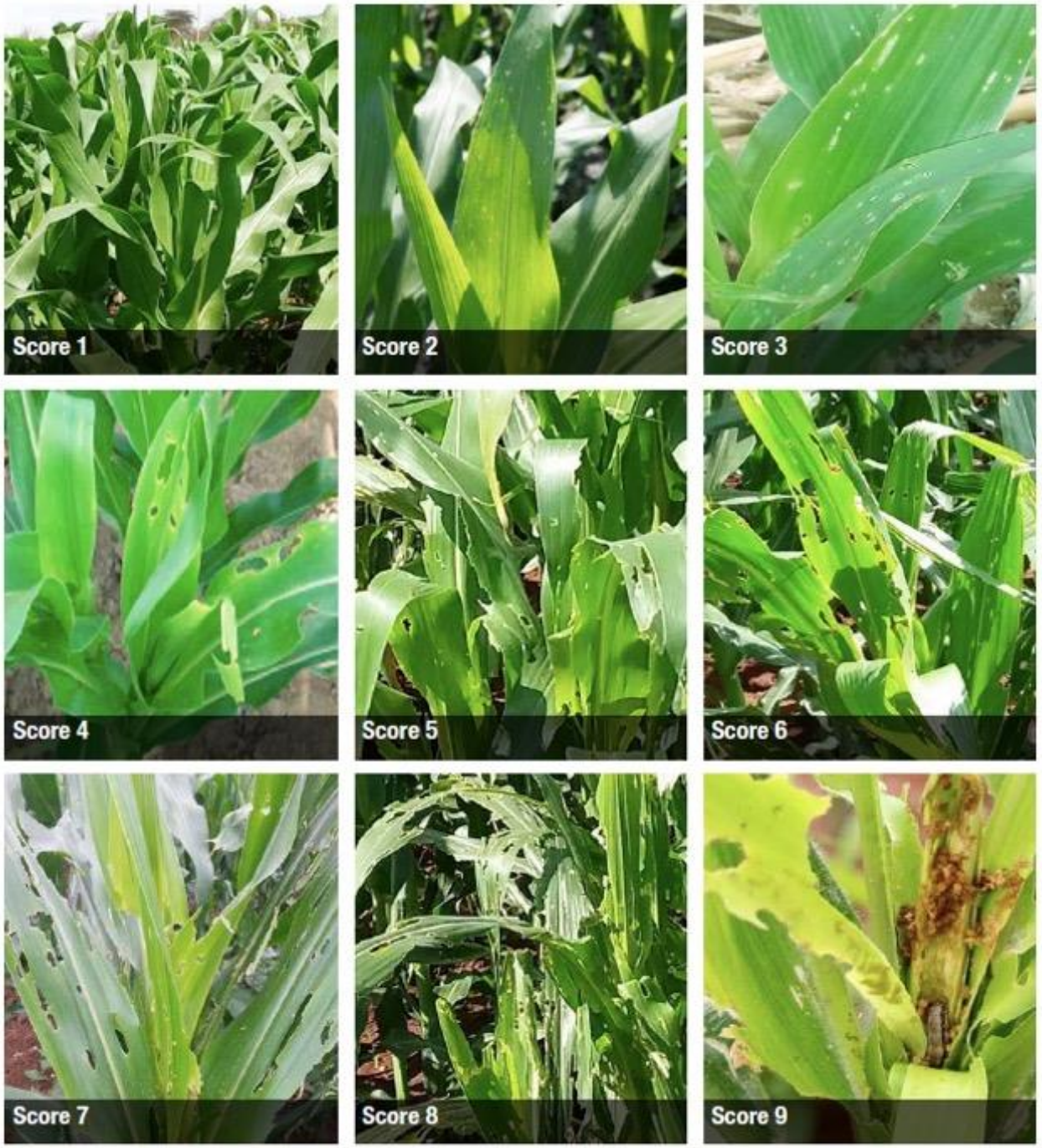


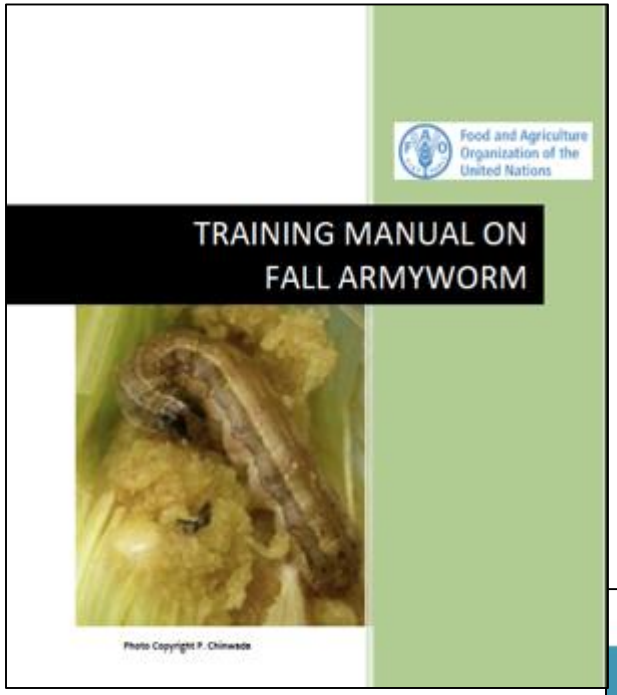
Figure 5. Rating of maize plants based on foliar damage by FAW.

Remote Sensing

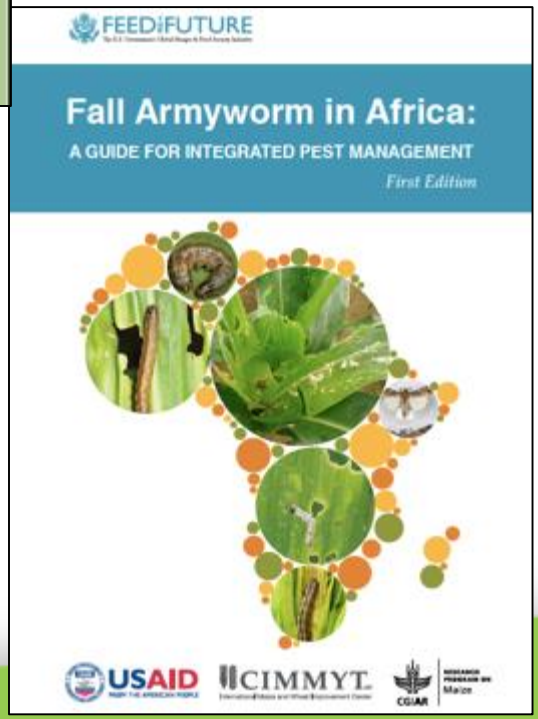
- Detection of FAW hotspots to focus the use of expensive insecticides and understand FAW behaviour, particularly in the dry/ winter season.
- Remote Sensing based on experience with the African Armyworm and Desert Locusts – which show clear, weather related, mass outbreaks.
- FAW shows very different behaviour to African Armyworm. No mass outbreaks in the tropics. In Central America FAW is a constant presence in farmers fields.
- FAW has been detected from satellite imagery with 65-80% accuracy in homogenous, large-scale, maize cropping systems (such as China, USA and Canada). The challenge is to detect FAW in highly heterogeneous environments in Africa.
- Initial work with satellite imagery has been unsuccessful – unable to distinguish between FAW damage and water stress, striga, etc., Better success with drone imagery.
- Requires the use of AI / Machine Learning + lots of ground data.
- SHA has funding from BLF and WB to work with UCD to test Machine Learning algorithms to detect FAW from satellite imagery.

Guides


Self Help Africa
FALL ARMYWORM
Summary of the Fall Armyworm (Spodoptera frugiperda) distribution
IMPACT SURVEY DATA
Balaka and Karonga Districts, Malawi
March 13- 27th 2017


Food and Agriculture Organization of the United Nations
TRAINING MANUAL ON FALL ARMYWORM
Photo Copyright P. Chimwala


UKaid
CABI
Fall Armyworm: Impacts and Implications for Africa
Evidence Note (2), September 2017


FEED the FUTURE
Fall Armyworm in Africa:
A GUIDE FOR INTEGRATED PEST MANAGEMENT
First Edition
USAID
CIMMYT
CGIAR

Useful Contacts

- **FAO's** FAW lead: **Allan Hruska**, Allan.Hruska@fao.org ,. setting up FAW Working Groups.
- **FAO FAW Surveillance** (including remote sensing) working group led by Keith.Crossman@fao.org , head of FAO's desert locust control program.
- **CIMMYT**: **Tom Remington** (retired) tom.remington.2014@gmail.com is assisting **B.M. Prasanna**, (CIMMYT-Kenya) b.m.prasanna@cgiar.org ; **David Hodson**, is CIMMYT's lead on remote sensing) d.hodson@cgiar.org and is on FAO's FAW Surveillance group)
- **David Hughes**, **Penn State Uni**, has successfully identified FAW and quantified damage using drones. David Hughes dph14@psu.edu
- **Shawn C. Kefauver, University of Barcelona**, Faculty of Biology, Plant Physiology: sckefauver@ub.edu - failed to detect FAW from satellite imagery.
- UCD remote sensing: **Jerome O Connell** jerome.oconnell@ucd.ie (Orbas), **Prof. Nicholas Holden** nick.holden@ucd.ie
- **Russell IPM**, **Dr Nayem Hassan**, Hassannayem@russellipm.com, Head, Research and Development, Russell IPM Ltd, 45 First Avenue,, Deeside Industrial park, Deeside Flintshire, CH52NU, UK. **Soliman Masaoudi**, Area Manager, Southern Africa soliman@russellipm.net, http://www.russellipm-agriculture.com/case-studies/fall-armyworm/ http://www.russellipm-agriculture.com/wp-content/uploads/2017/06/FAW-Brochure-UK.pdf
- **CABI: Roger Day r.day@cabi.org** CABI Plantwise websites seem to be down.
- **Lancaster University**: http://www.lancaster.ac.uk/armyworm/

- https://youtu.be/VQxOpixSGmI

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