Africa Phytosanitary Programme

(APP) Phase 2 · Train-the-Trainer workshop

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Spodoptera frugiperda (Fall Armyworm)

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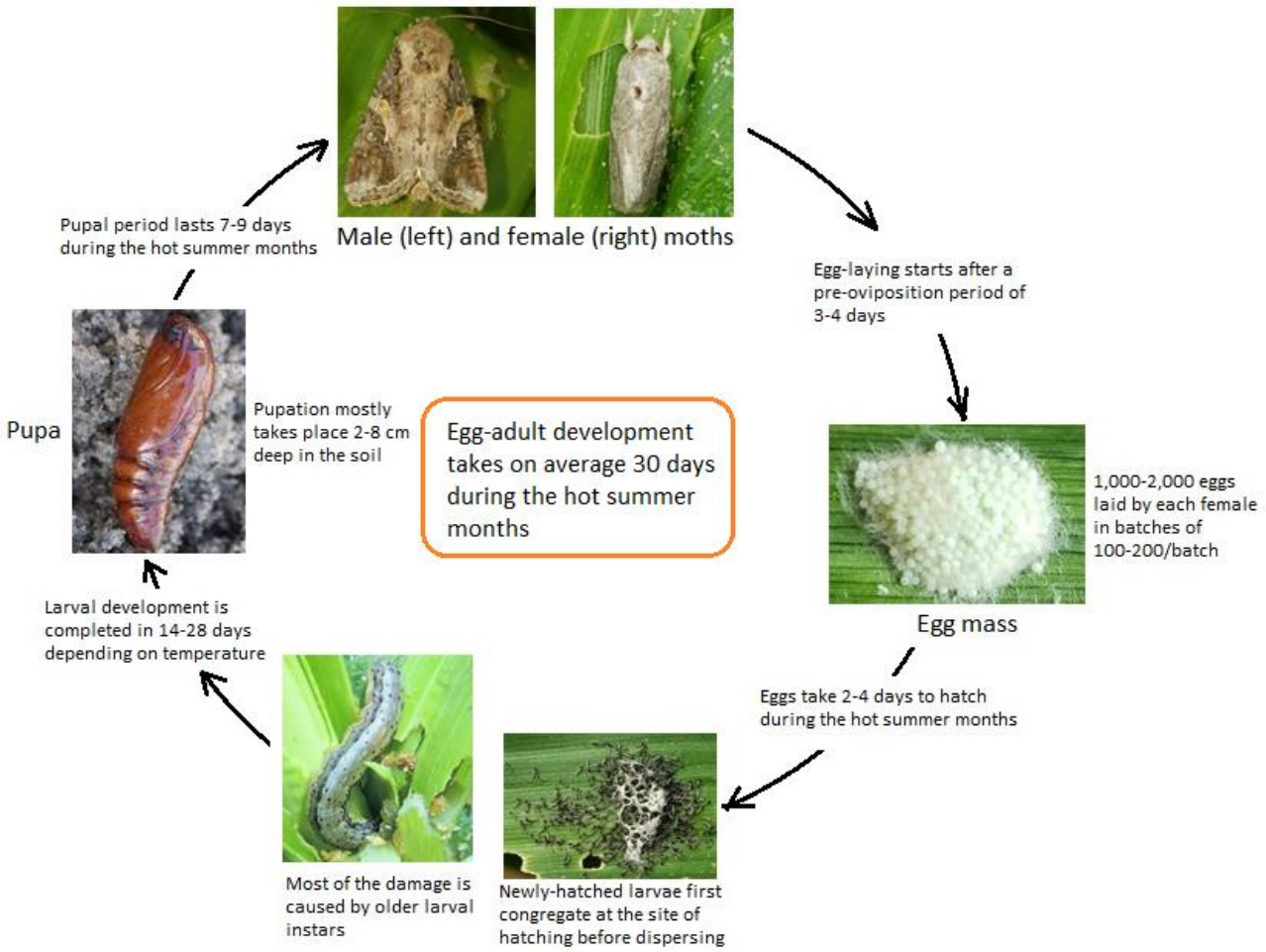
Outline

1. Introduction
2. Biology
3. Identification
4. Survey protocols
5. Samples and screening
6. Conclusion

1. Introduction

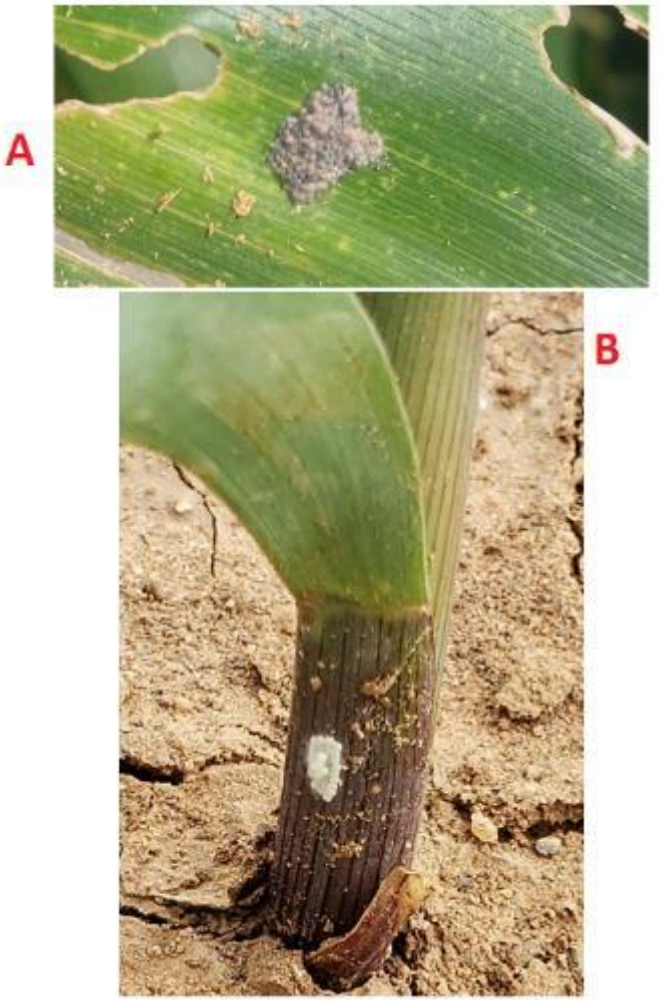
- Fall armyworm (FAW) could arguably top the list of exotic arthropod pests that became highly damaging when introduced into sub-Saharan Africa in the 21st century.
- > 80 host plant species, but preference is for maize.
- For export commodities that are known FAW hosts, the need to comply with stricter quarantine restrictions is an additional production cost.
- 2 genetic strains – **maize** and **rice** strains; differ in host plant preference, distribution and behavioural traits
  - *Maize strain* – commonly associated with maize, sorghum, cotton, sugarcane
  - *Rice strain* – preference is for rice, millet, pasture grasses, *Cynodon dactylon*

2. Biology



Summary of FAW Life Cycle

- Adults (moths) are nocturnal; hide inside maize funnels during the day, but if disturbed they will fly out briefly and land on nearby plants.
- Virgin female moths which are ready to mate emit a sex pheromone which males respond to.
- Females mate multiple times.
- Both sexes migrate hundreds of km during pre-oviposition period (3-4 days) before settling down.
- Eggs are laid in clusters (masses) on the leaf (**more often on the upper surface**) and sometimes on the stem.
- 1,000-2,000 eggs per female, in batches of 100-200 eggs each.



Egg mass on leaf surface (**A**) and on stem (**B**)

- Egg hatches in 2-4 days at 21–27°C.
- Newly emerged larvae first eat the eggshells before starting to feed on the leaves.
- They are initially bunched together but shortly afterwards start to disperse over the leaf.
- Some “balloon” from one leaf/plant to the next via silken threads which they secrete.
- Six larval instars (L1-L6) in the field but may not go beyond L5 under lab conditions.
- Cannibalistic behaviour starts being observed in the L3 and L4 stage.
- A combination of cannibalism-induced dispersal, ballooning and active crawling on the ground leads to rapid dispersal throughout the field.

Newly-hatched larvae “ballooning” on silken threads

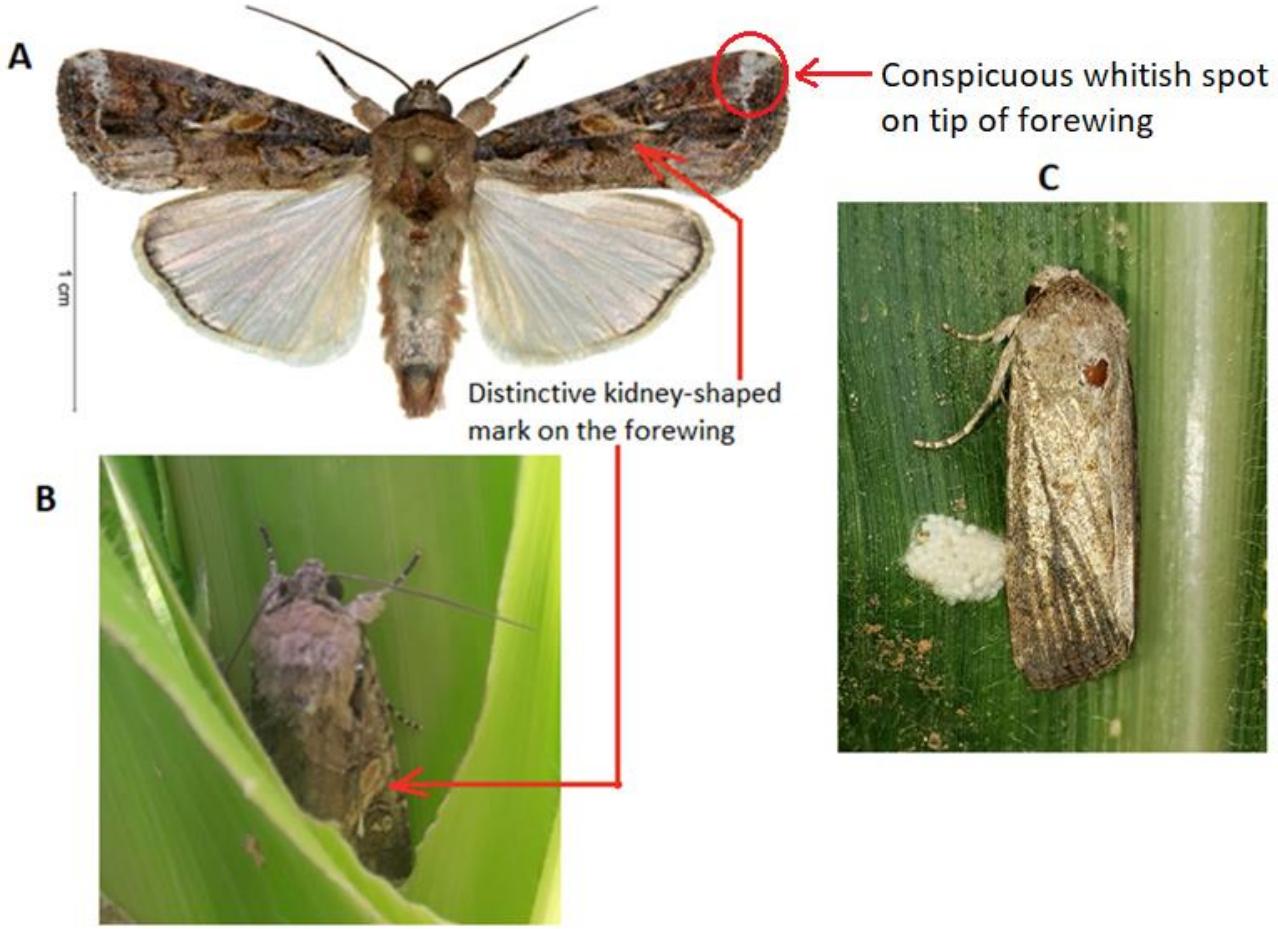
- In fields with close plant spacing (e.g., 25-30 cm for maize), larvae from a single egg mass can potentially disperse to 20-50 or more plants.
  - This high dispersal potential is why **early detection** and **control** are critical in effective FAW management.
- L6 larva eats the most food (77.2%), thus control action needs to be taken when the caterpillars are very young or at the egg stage.
- Larvae complete development in 14-28 days.
- L6 larva drops from the plant and pupates 2-8 cm deep in the soil.
- Moth emerges after about 7-9 days in hot weather but can take > 20 days in cold weather.
- Egg-adult development takes on average 30 days in warm tropical climates.
- Adult life span: 12-14 days.
- FAW does not diapause; survival is therefore guaranteed by closely tracking its main host – maize – in space and time.

Larva crawling from one plant to the next on the ground

3. Identification

3.1 Direct examination of FAW life stages

A. Adults



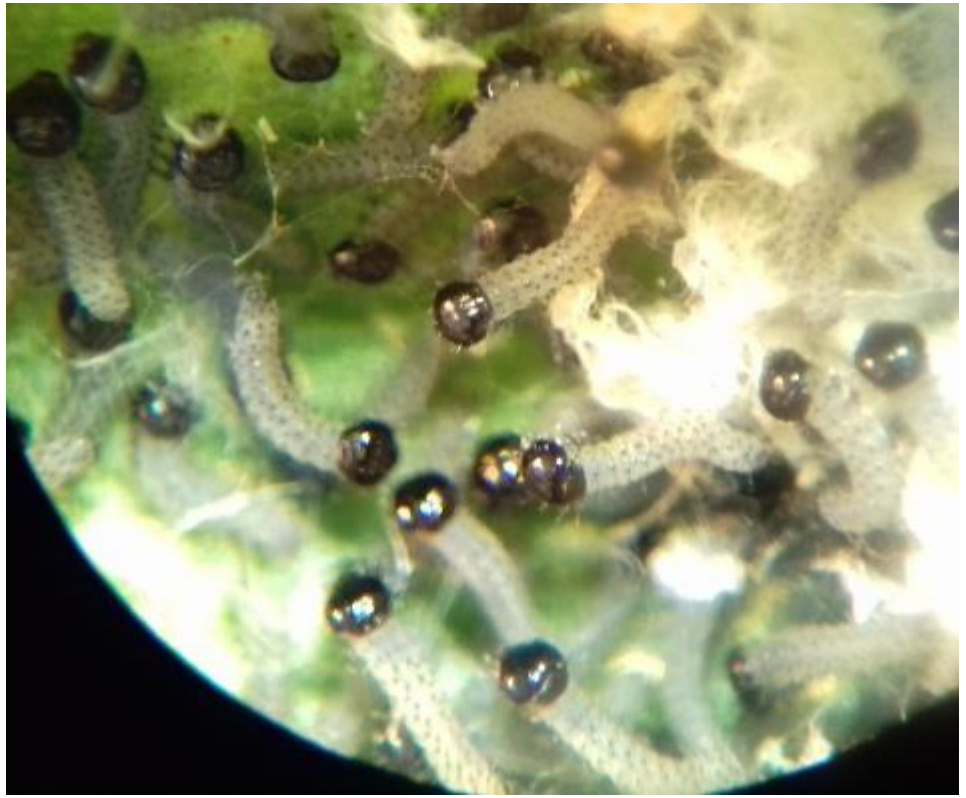
- Male adult (moth) with wings spread out (**A**) [© Georg Goergen]
- Male moth hiding inside maize plant funnel (**B**) [© Peter Chinwada]
- Female moth beside an egg mass (**C**) [© Peter Chinwada]

B. Eggs

- Egg masses covered by a layer of greyish scales and hairs from the female moth(**A**, **B**)
- Outline of egg mass as seen from the opposite side of a maize leaf (**C**)

C. Larvae

Newly hatched larvae at the site of hatching



Newly hatched larvae viewed under a microscope (characterised by a large black head capsules and dark spots along the body)

Inverted 'Y'-shaped whitish suture on the front part of the head

4 tubercles arranged in the form of a trapezium on the other abdominal segments

4 distinct tubercles (raised spots) arranged in a square-like pattern on the last abdominal segment

Larvae are variable in colour - from light green to dark brown

3.2 Indirect Identification Through Characteristic Plant Injury Symptoms

Windowpanes

Irregularly-shaped holes and leaves eaten from the margins inwards

'Shot holes'

'Shaved-off' leaves of the growing point

Extensively damaged growing point

4. Survey Protocols

4.1 General considerations

- FAW survey data need to be collected in a standardized manner using science-based protocols so that inferences can be made on properly analysed data.
- These data serve several crucial purposes, e.g.:

i. Monitoring pest presence and distribution in space and time

ii. Helps to determine the intensity and extent of FAW damage in the field

iii. Supports classification of areas into low, moderate, or high-risk zones

iv. Informs timely and targeted intervention strategies

v. Early warning (EW) – enhances preparedness and rapid response planning

vi. Assesses the performance of control methods

vii. Provides evidence for policy development, resource allocation, and support to farmers

viii. Contributes to national and regional databases for EW, research, modelling, etc.

- Standardized protocols are also necessary for **repeatability** purposes, **comparisons among countries, among regions, and between seasons/years**.
- Protocol to be adopted is dependent on the objectives of the exercise, e.g.:
  a) **Detection survey**, e.g., for detecting presence/absence of the pest
  b) **For delineating pest-free areas**, or **pest-free areas of production**
  c) **For routine monitoring or surveillance**
  d) **For targeted intervention** - e.g., with a synthetic chemical pesticide, biopesticide, mechanical control, etc.
  e) **Assessing effectiveness of a control strategy**
  f) **Collecting data for modelling purposes**
- The survey objective also determines the tools that may be needed.
  - These tools will be essential for direct observation, trapping and sample collection.

4.2 Tools

- **Hand lenses** (10-20x magnification) – e.g., for close examination of egg masses, small larvae, parasitised eggs
- **Sweep nets** – for collecting adult parasitoids (e.g. *Telenomus*, *Cotesia*, *Trichogramma* spp.)
- **Aspirators** – for collecting small insects (e.g. adult parasitoids) from inside a sweep net or directly from the plant

Hand lenses

Aspirator

Sweepnet

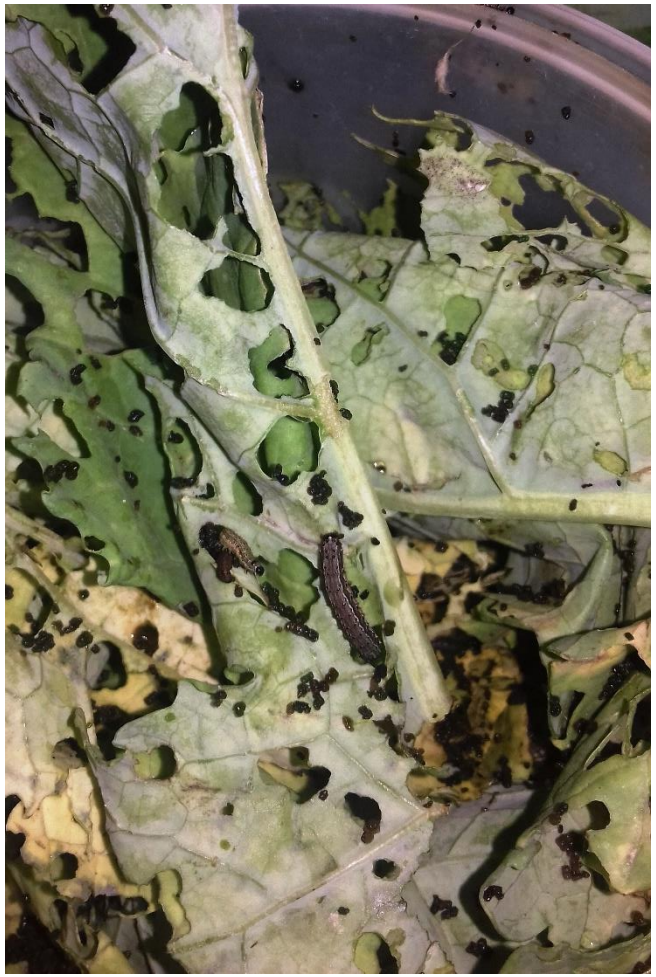
- **Pheromone traps** – for selective trapping of male moths.
  - **Trap should be set at a height of about 30 cm above plants**
  - **However, detection through trap data may not be enough for pest status declaration; evidence that the host plant on which trapping was done is indeed utilized as food may be necessary**.
- **Collection vials/jars** - with or without ethanol
- **'Killing jars'**
- **Forceps** and **brushes** – for picking up larvae
- **Plastic bags** or **envelopes** – for collecting leaf samples showing damage
- **Pocket knives** – to cut open whorls, stems, cobs
- **Identification aids** - Field guides, Reference images or pictures
- **Natural diets** and **customised rearing containers**

Sex pheromone-baited bucket trap

Soaked germinating maize grain for rearing larvae

Individual larvae being reared on pieces of fresh maize leaves inside plastic vials plugged with cotton wool

Potted young maize plants



Fresh brassica leaves are an excellent substitute for maize leaves when collecting live larvae for subsequent rearing or examination in the lab

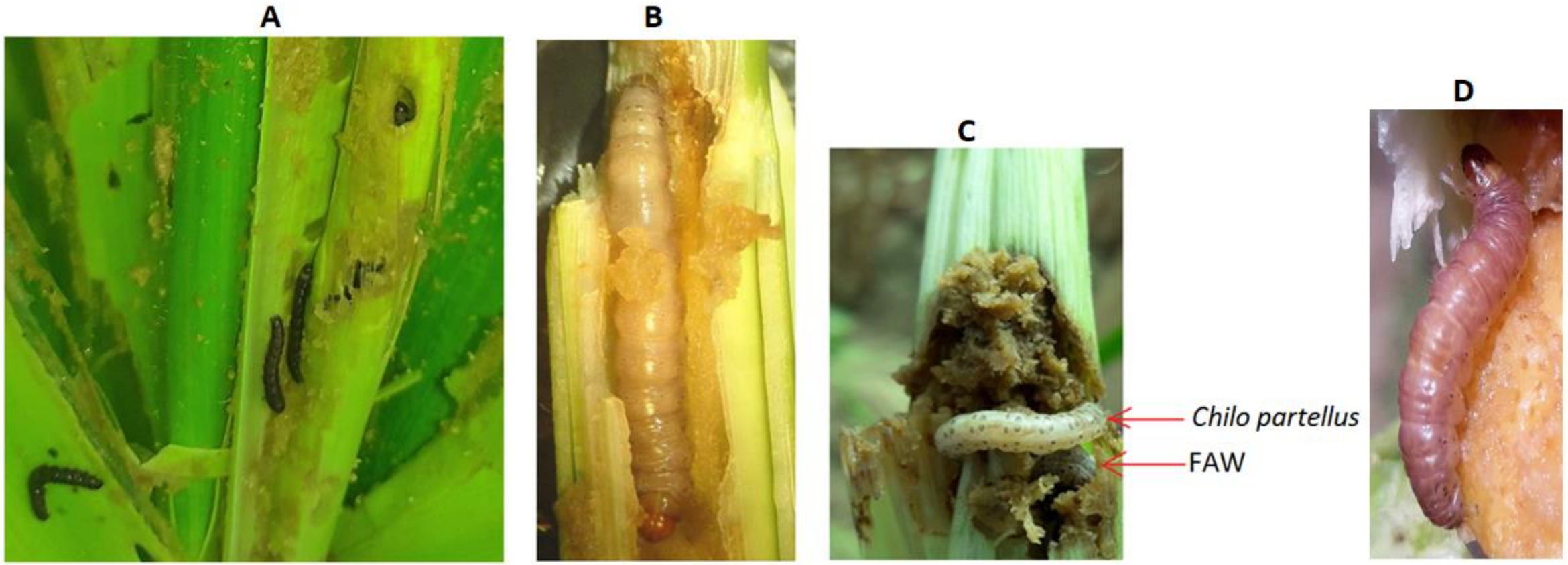
4.3 When to conduct assessments and What to look for

- FAW does not diapause; assessments can therefore be conducted at any time of the year as long as actively growing host plants are available.
  - For maize, assessments should commence **as early as Day 2 after crop emergence**.
- Look for:
  - characteristic plant injury symptoms
  - egg masses
  - larvae*
  - moths hidden in plant whorls - can be easily collected by 'bagging' plants using a transparent plastic bag
  - evidence of parasitism – cocoons, adult parasitoids
  - evidence of entomopathogens – e.g. larvae infected by NPV, entomopathogenic fungi
  - other pest species causing confounding damage* - **confirmation of IDs is necessary**.

* Assessment usually requires destructive sampling

NPV-infected FAW larvae hanging in a characteristic inverted V-position

Maize stem tunnel entrance hole made by a FAW larva (A); FAW larvae inside stems (B & C)



Larvae of the maize stemborer, *Busseola fusca* (A, B); Spotted stemborer, *Chilo partellus* and FAW larvae feeding side by side on a maize cob (C); pink stemborer, Sesamia calamistis (D)

Maize leaf roller (*Cnaphalocrosis trapezalis*) larva and characteristic leaf window-paning and frass droppings

Semilooper and associated windowpanes on a maize leaf

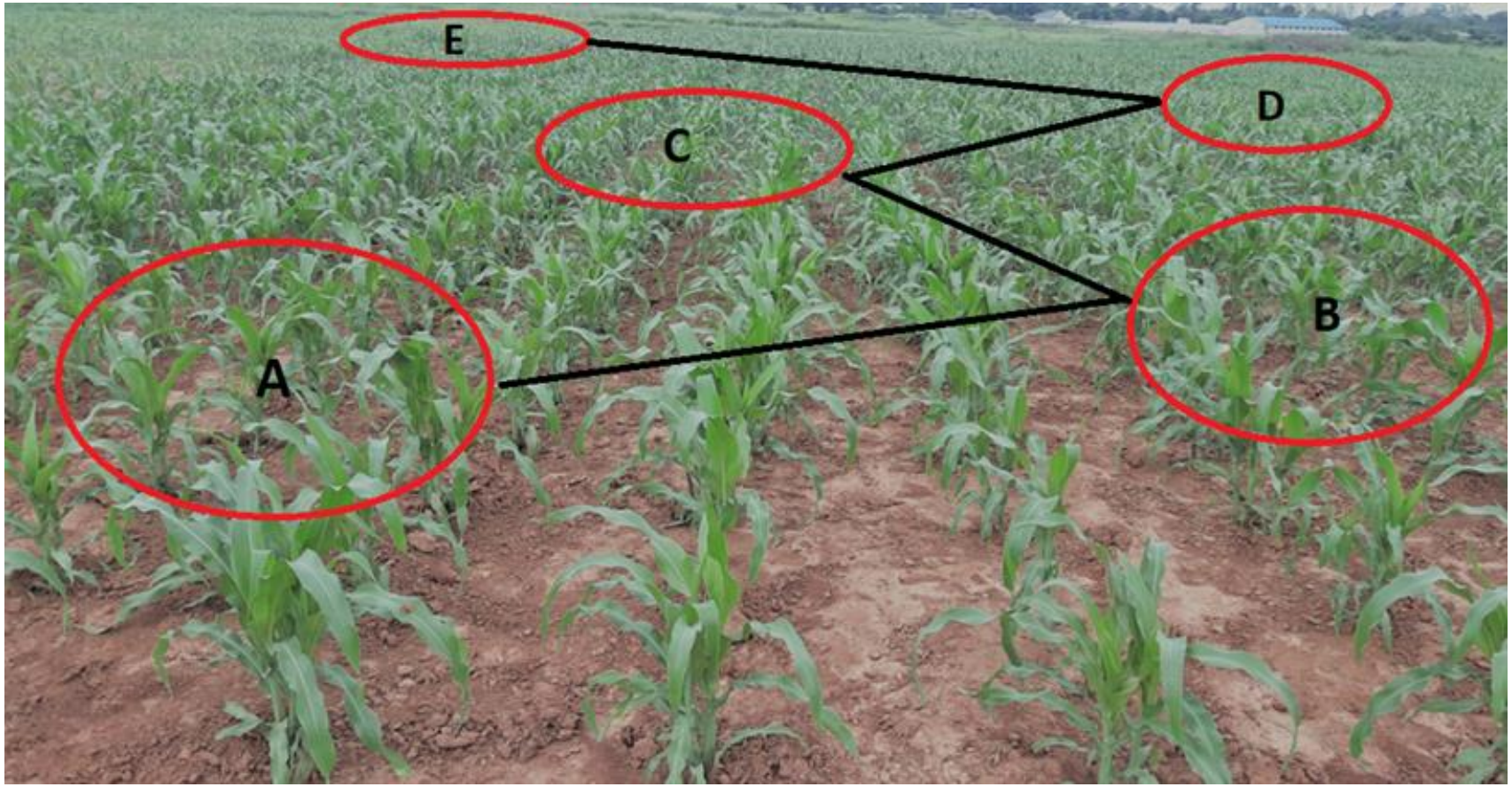
Maize earworm, *Helicoverpa armigera*

4.4 Procedure

- Field sampling patterns may be modified depending on the crop and stage of growth.
- Due to 'ballooning' and cannibalism-induced dispersal, a purely random or uniform distribution is quite rare.
  - Samples should therefore be selected in a semi systematic manner.
- Aim is to make inferences based on a total of 50-100 plants
  - Each plant may be considered as a sampling unit, or the sampling unit may be a plot (10-20 plants in a plot).

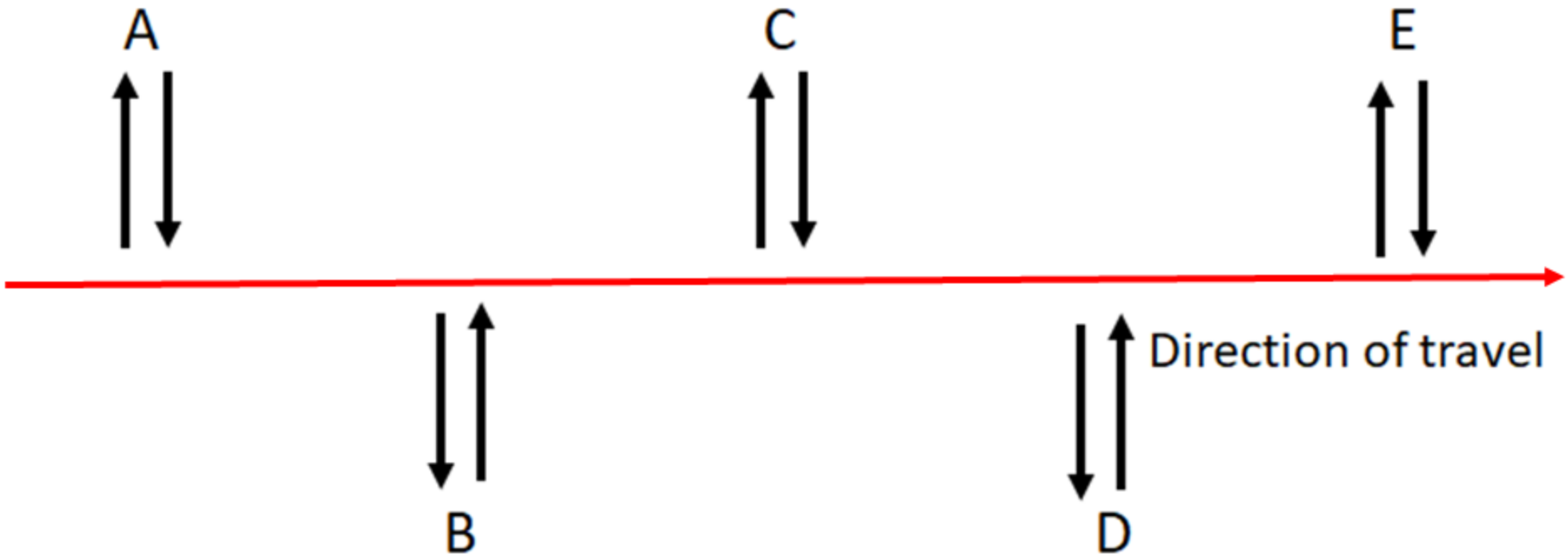
a) ‘W’ sampling pattern

- Select plants at each of five sampling points (10-20 plants /sampling point) which form the letter ‘W’ when joined together by four straight lines.
- Sampling pattern is ideal for young plants.



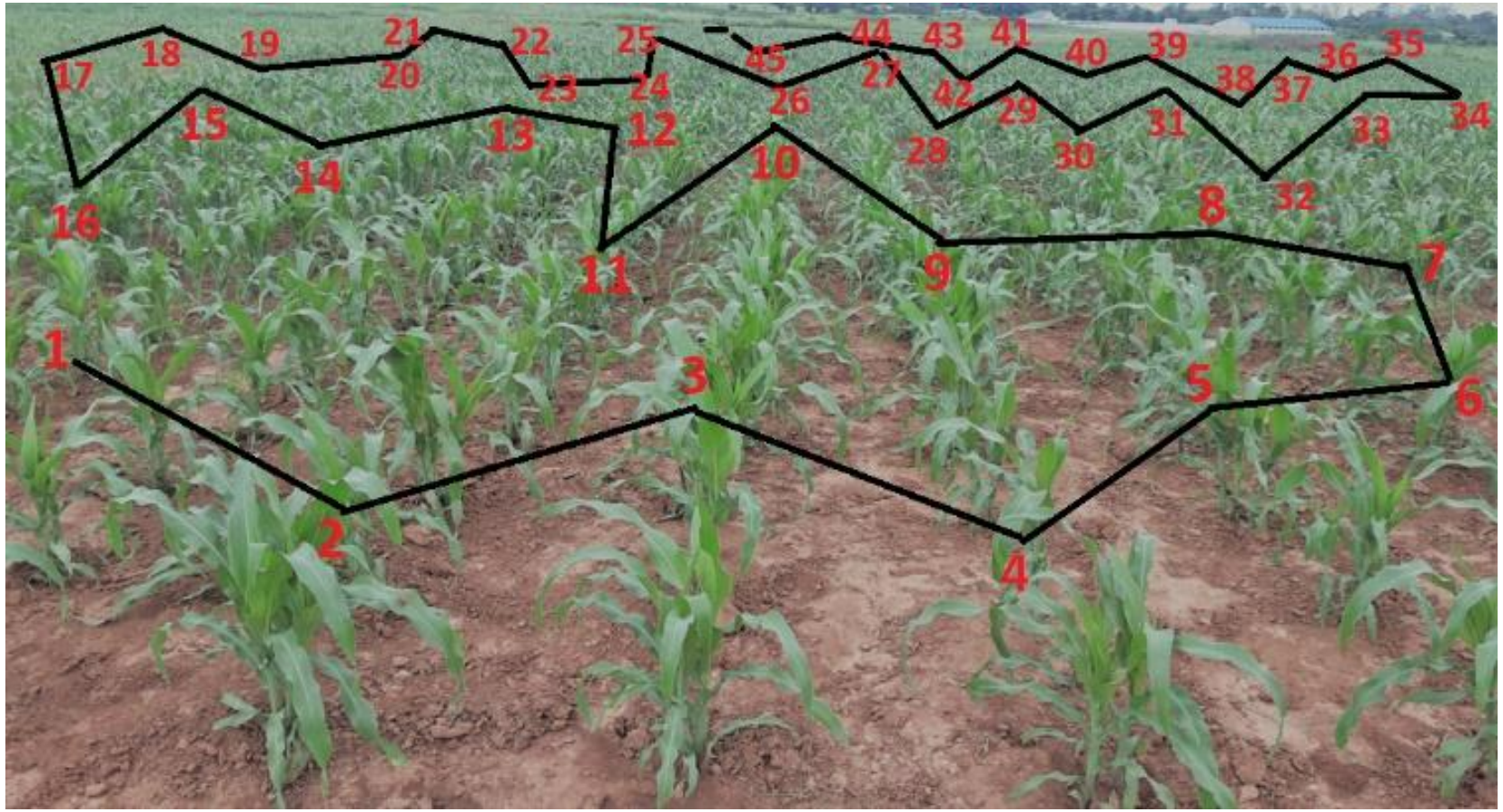
b) ‘Ladder’ sampling pattern

- Select plants at 5 different sampling points (e.g., A-E) along alternating rows which are at right angles to the direction of travel through the field.
- In the case of maize, this pattern is ideal for older crops (VT and R stages) when crossing rows of tall and closely packed plants (which may be shedding pollen) becomes difficult.
- Pattern also well suited to fields which are long and narrow.



c) Zig zag sampling pattern

- Select an individual plant following a zig-zag pattern. The distance between any two sampling points should be chosen in such a way that as much of the field as possible is covered.
- Sampling is ideal when small individual fields are used as replicates.



Parameters

1) **Number of moths per trap/week**
   - However, due to lack of correlation between moth trap catches and field infestation levels, this parameter may only be useful in indicating presence/absence of moths in an area at the beginning of the season and thus prompting intensive field scouting/sampling.
2) **Percentage infestation** – the number of sampled plants showing characteristic fresh injury symptoms and/or with egg masses.
   - However, if a plant is not a known FAW host plant, it cannot be regarded to be infested on the basis of presence of egg masses alone. Ability of larvae to feed and develop on the plant must be confirmed by 'choice' feeding tests.
3) **Plant damage rating** (usually based on the 0-9 Davis visual rating scale)
4) **Number of larvae per plant or plot** – requires destructive sampling

5) Number of egg masses per plant or plot

- However, if the objective of the exercise is to determine the effectiveness of a plant protection product, then this **may not be a useful parameter** as female moths deliberately select plants showing little or no damage (these are usually the most protected plants) for oviposition. One would need to observe the eggs further to see if they hatch, and if they do, to see if the resultant larvae survive.

For egg-laying, female moths will show preference for plants in **A** than in **B**

5. Samples and Screening for FAW

a) **Adults** – Mount properly for examination under a dissecting microscope.

b) **Egg masses**

- Cut out the leaf section containing the egg mass and transfer to a ventilated container lined with a paper towel.
- Incubate at ambient conditions or at 25-27°C.

Male FAW adult [© G. Goergen]

c) Larvae

- Use a brush (for small larvae) or a pair of soft forceps (for medium to large-sized larvae) to pick up larvae from a plant.
- Drop directly into 95-99% alcohol. This method ensures that tissues and DNA remain intact for later analysis or study.
- If needed for rearing, place L3-L6 individually in vials and provide them with food. Plug the mouth with cotton wool. Replenish food as necessary.
- Keep reference specimens preserved in 70% alcohol

❑ **Label each container appropriately – date, location, host plant, plant growth stage, specimen identity (when confirmed), collector's name.**

6. Conclusion

- Due to FAW's damaging potential, polyphagous behaviour, lack of a resting stage and migratory capacity, surveillance is critical for early detection, timely response and effective management.
- The use of standardized protocols and digital tools for pest surveillance improves data collection, enables comparisons between countries and regions, and more importantly, ensures transparency and credibility in pest status declarations.
- In the same way as FAW does not respect political boundaries, training programmes like this one should also be multinational in terms of participation.

- FAW will not be the last exotic and highly damaging pest to be introduced to Africa. Thus, it is our hope that collaboration of IPPC/APP/FAO with, among others, Centres of Excellence (e.g., ARC, Stellenbosch University), the CGIAR (e.g., IITA) and non-profit intergovernmental organizations (e.g., CABI), other NPPO with capacity (e.g., KEPHIS, NPPOZA), and the private sector, on capacity building of NPPOs and scaling of novel technologies, continue to grow from strength to strength.

Some References

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Thank you

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