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CABI



Fall Armyworm Field Handbook

Identification and Management

FAO and CABI (2019) Fall Armyworm Field Handbook: Identification and Management, First Edition.

Cover Photo: Fall armyworm larva ©Georg Goergen, IITA

This field handbook is an adapted version of FAO and CABI (2019) Community-Based Fall Armyworm (*Spodoptera frugiperda*) Monitoring, Early warning and Management, Training of Trainers Manual, First Edition. Licence: CC BY-NC-SA 3.0 IGO. It is intended to help extension workers and farmers in the field to identify fall armyworm and know how to manage it.

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Further information

Fall armyworm portal: www.cabi.org/fallarmyworm

Fall armyworm FAO: www.fao.org/fall-armyworm/en

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How to identify fall armyworm

Fall armyworm larvae (or caterpillars) are similar to caterpillars of other related pests (Figure 1). Look for the following features to determine if the caterpillar you have found in your maize is fall armyworm or belongs to another species.

- A dark head with a pale, upside-down **Y-shaped marking** (Figure 2, black circle).
- **Four raised spots shaped like a trapezium** on each body segment seen from above (Figure 3, orange circle).
- **Four spots** forming a square on the second-to-last body segment (Figure 3, red circle).
- Skin appears smooth to the touch.
- Sawdust-like material called “**frass**” is present in the maize funnel or on the leaves, tassels and cobs. Large clumps are formed during fresh feeding (Figure 4).



1



2

Inverted "Y" © Matt Bertone, NCSU



3

Raised dots on body segments © Russ Ottens, Bugwood.org



4

Clumps of frass formed during (fresh) feeding © CABI

Pests that can be confused with FAW

Cotton bollworm (Figure 5) often shows a similar pattern of dots on its back, but its head is usually paler. Although it can also have an upside-down Y-shaped mark, this is usually a similar colour to the rest of the head. Unlike fall armyworm, these caterpillars feel rough to the touch due to tiny spines. These and other species of caterpillars and borers are illustrated below and should not be mistaken for fall armyworm, although they can also be found on maize.



Cotton bollworm *Helicoverpa armigera*



Fall armyworm and Beet armyworm



Southern armyworm *Spodoptera eridania*



© Rikus Kloppers/PANNAR

African armyworm *Spodoptera exempta*



© Whitney Cranshaw, Bugwood.org

Beet armyworm *Spodoptera exigua*



© David Marquina Reyes, Flickr

African cotton leafworm
Spodoptera littoralis



© NBAIR

Spotted stem borer *Chilo partellus*



© R Reeder, CABI

African maize stalk borer *Busseola fusca*

Life cycle of fall armyworm

Fall armyworm has a four-stage life cycle: eggs, larvae (caterpillars), pupae and adults (moths).

Eggs

Eggs are generally laid on the underside of the leaves. When the population is high, the eggs may also be laid on top of the leaves and the stalk (stem) of young maize seedlings.

- The egg masses are cream, grey or whitish in colour with a hairy covering.
- This mass often contains 100–200 spherical eggs (Figure 6).
- A single female moth produces an average of 1,500 eggs in her lifetime.
- The duration of the egg stage is only 2–3 days during warm conditions.

**6**

Eggs on maize leaf © CABI

Caterpillars

Eggs hatch into small caterpillars within 3–5 days, and move to the funnel. The small caterpillars can also be carried to other plants by wind (Figures 7–8).

Small caterpillars may appear greenish, while bigger caterpillars vary in colour from orange to green and black or brown (Figure 9-10). Caterpillars mature within 14–22 days (2–3 weeks), after which they drop to the ground to pupate. Up to 12 overlapping generations may hatch in a year.



Eggs hatching into caterpillars © CABI



Young caterpillars moving towards the funnel



Green form of FAW caterpillar
© Matt Bertone, NCSU



Brown form of the FAW caterpillar
© Matt Bertone, NCSU

Pupae

The caterpillar develops into a reddish-brown pupa in the soil (Figure 11). This stage is difficult to observe/see.

If the soil is too hard during pupation, the caterpillars may web together leaf debris and other material to form a protective covering called a “cocoon” on the soil surface (Figure 13). Pupae may also be found in the maize cob (Figure 12). The pupal stage lasts for 8-9 days when it is warm but can be as long as 20–30 days in colder areas.

**11**

Pupal stage © Matt Bertone, NCSU

**12**

**Pupa in a maize cob
© Diedrich Visser, ARC**

**13**

**Pupa in soil cocoon
© Diedrich Visser, ARC**

Adults (moths)

Moths are active at night, especially during warm, humid evenings. The dark grey colour of the moths makes them difficult to see, especially when resting near or on the ground, but in some cases when the population is high some may be found resting on the crop in the field.

The male forewing has a conspicuous (visible) white spot. (Figure 15) The duration of adult life is estimated to average 10 days, with a range of 7–21 days.

The female normally lays most of her eggs during the first four to five days of adult life, but some egg laying occurs for up to three weeks.



14

Male moth © Matt Bertone, NCSU



15

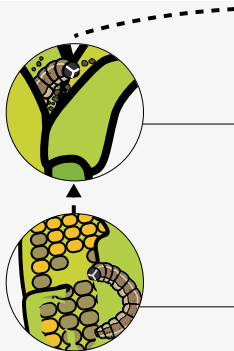
Female moth © Matt Bertone, NCSU

DAY 6–14

LARVAL GROWTH STAGES 4–6

By stage 4, the caterpillar will be bigger and have reached the whorl, where it does the most damage, resulting in ragged holes in the leaves. Feeding on young plants can kill the growing point and as a result no new leaves or cobs will develop.

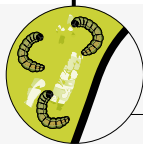
If the plant is older and has already developed cobs, then the caterpillar will eat its way through the protective leaf bracts into the side of the cob, where it begins to feed on the developing kernels (seeds).



DAY 3–6

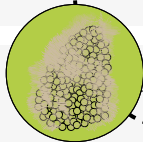
LARVAL GROWTH STAGES 1–3

After hatching, the young caterpillars begin feeding, which creates patches on the leaves called windows. Young caterpillars can spin silken threads that catch the wind and transport the caterpillars to a new plant.

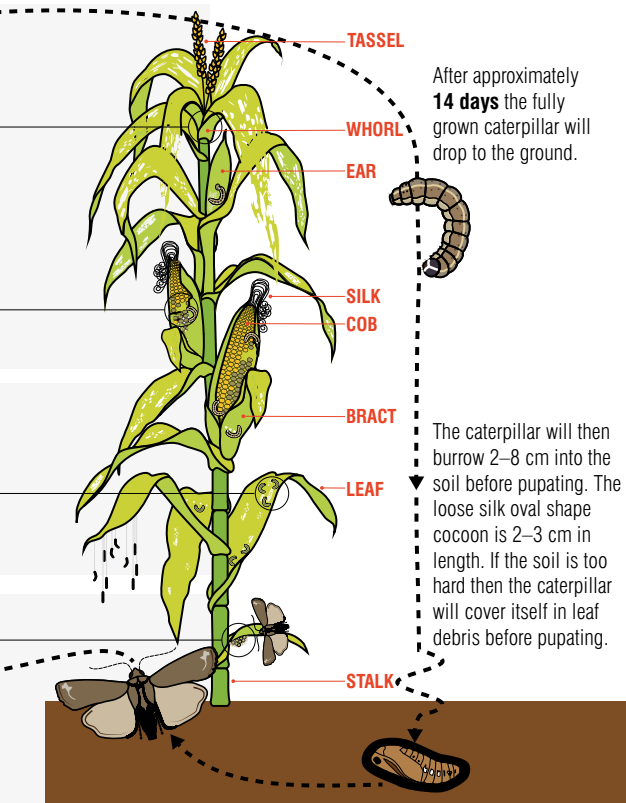


DAY 1–3

Batches of **100–200 eggs** are laid on the lower leaves.



After around **8–9 days** the **adult moth emerges** to restart the cycle.



Suitable conditions and crops for fall armyworm development

Caterpillars will develop in temperatures between 11°C and 30°C, but their optimum temperature is 28°C. In cooler conditions, there may only be one or a few generations per year. Heavy rains may wash off eggs and young caterpillars from the leaf, reducing populations.

Fall armyworm mainly attacks maize. It has also been reported on crops such as rice, sorghum, vegetable and cotton, but to date there has been little damage recorded on these crops.

How to identify fall armyworm damage on maize

Caterpillars feed on maize at nearly all stages of growth from when the plant is young (only three leaves: Figure 16), and also on the cob. Caterpillar damage on the leaves can sometimes be significant and disrupt the plants ability to form good grain and healthy cobs.

**16**



Window panes © Diedrich Visser, ARC

Leaf feeding causes extensive “window pane” damage on maize (Figure 17).

Large irregular and elongated holes on the leaves are caused by the big caterpillars while feeding.

Small caterpillars cause the clear or window-like patches while larger caterpillars cause irregular elongated holes on leaves.

Window panes are the most common damage symptoms at early whorl stage; however, they can be confused with damage caused by other stem borers. Look for the actual larvae that is eating the leaves to confirm if its fall armyworm.

**18**

Migrating caterpillars © Diedrich Visser, ARC

Usually, many small caterpillars will be present on the same plant, but only one or two bigger caterpillars will be found on a single plant. Others will migrate to feed on neighbouring plants (Figure 18).

**19**

Larval droppings © CABI

Bigger caterpillars make larger holes when feeding, causing ragged whorl leaves and producing sawdust-like material called “frass”. Fresh feeding produces big lumps of frass (Figure 19).

**20****Badly infested field © CABI**

Badly infested fields will have damage on the leaves similar to that caused by a hailstorm (Figure 20).

**21****Whorl damage © CABI**

During the day, caterpillars hide deep in the whorls (funnel). They feed inside whorls and can destroy silks and developing tassels on older crops, thereby limiting fertilization of the ear and leading to poor grain development (Figure 21).



Cob damage © CABI

Caterpillars move to the ear zone/funnel and start feeding after tassel emergence. Damage to cobs may lead to fungal infection, aflatoxin contamination and loss of grain quality (Figure 22).



Cobs from infested field © CABI

Cobs that were attacked in the field will have many of the seeds eaten up by the caterpillar (Figure 23).

How to monitor fall armyworm in the field

The aim of monitoring is early detection of the egg batches or small caterpillars, which are easier to control. Monitoring should begin early after the emergence of the crop.

Two methods can be employed for monitoring:

- 1. field scouting**
- 2. pheromone traps**

In both cases, the Fall Armyworm Early Warning System (FAMEWS) should be used. FAMEWS is freely available for any low-cost Android 5.0 or higher smartphone from the Google Play store.

You can download and install the FAMEWS application on your smartphone for regular use in monitoring fall armyworm in your area, and use it obtain data from neighbouring areas if other farmers or extension workers are using it. The App also has an image recognition feature that can help to identify fall armyworm if in doubt

Procedure for scouting for fall armyworm eggs, caterpillars and feeding damage

1. Randomly select five plots, each comprising 10 consecutive plants in a row. Examine each selected plant within the plot.
2. Look for signs of fall armyworm eggs; feeding by small caterpillars, such as pinhole or window pane leaf damage; frass or droppings; ragged and torn leaves; and pupae in the soil. Focus on the newest two or three leaves emerging from the funnel, as this is where caterpillars like to feed and where moths lay eggs. For later maize growth stages, examine the newest three or four leaves emerging from the funnel, plus the emerging tassel.
3. Record the number of plants out of each batch of 10 with fresh window panes or infested funnels in FAMEWS. Use the FAMEWS mobile app to determine percentage of infestation and mean plot infestation. Separately determine the number of egg masses and caterpillars per plant (or plot) and the respective means. Zeros should be recorded for non-infested plants; excluding non-infested plants will overestimate pest densities.
4. Avoid scouting right after spraying pesticides. Re-entry intervals on pesticide labels should be followed in order to avoid exposure during monitoring.



Procedure for using a pheromone trap

A pheromone trap attracts male insects. The Universal Bucket Trap is normally used. The traps and the lure can usually be obtained locally, or from your local extension office.

1. Place the trap on the edge of a maize field or in an open area nearby. Hang the trap on a pole or branch about 1–1.5 m from the ground where it will not be disturbed by animals or children. The trap should be hung straight and level so the lid will keep rain from getting in. Make sure leaves and tassels do not block the entrance to the trap. As the maize grows taller, move the trap higher so that the bottom of the trap is always about 30 cm above the plants.
2. Place the pheromone lure in the compartment in the basket on top of the trap. Unwrap the insecticidal strip (Vaportape) and place it in the trap to kill moths. Do not handle the insecticidal strip with bare hands – it is poisonous. Use gloves or some other tool.
3. Replace the strip every month and the lure every two months. Ten strips and five lures will be required for one trap for a single maize growing season. Do not store extra strips with food; place them in a sealed airtight jar and store in a cool, dark place. Store spare lures in airtight bags or an air-tight bottle and keep in a cool, dry and safe place. Store the lures in a freezer (if available). The Universal Bucket Trap will have instructions to guide installation but when in doubt consult your extension officer.



Strips and lures

Servicing the pheromone trap and collecting data

1. Look inside the trap and count how many moths are there. Record the date and the number of moths using FAMEWS. Throw the moths away. Prepare the trap to be used again.



2. Replace the lure after two months of use, and record that the lure was changed. At the end of the growing season, stop monitoring and store the trap for use next season.

How to manage fall armyworm

Prevent

1. Use high quality certified seed recommended for the area. The seed should germinate well, be disease-free and possess other desirable qualities such as high yields.



2. Improve plant health with appropriate plant spacing, soil management and crop nutrition through the use of organic or inorganic fertilizer, or intercropping with nitrogen-fixing legumes. Practices that boost plant vigour help crops to better withstand pest attacks and escape damage.



3. Avoid late planting or staggered planting in plots of different ages. If your field is one of the few late-planted plots, all the female moths in a region will come to your plot to lay their eggs.



4. Increase plant diversity in your plots. Some plants emit chemicals that attract or repel moths. The “push–pull” technology is one example of this, using one plant species that pushes fall armyworm away from maize and another species that pulls them to where they can be controlled easily. Intercropping maize with non-grass species such as cassava, cowpea, bean or pigeon pea also prevents infestation. Plant diversity can also increase populations of natural enemies, which kill eggs and caterpillars.



4

5. Practise conservation agriculture, combining use of no-tillage, residue retention, rotation and cover crops such as Mucuna and Lablab. This has been found to increase the numbers and diversity of natural enemies (spiders, beetles and ants) and improve soil health.



Monitor

1. Farmers should visit their fields frequently to observe, learn and take action. Beginning one week after planting and at least once a week thereafter, farmers should walk through their fields every 3–4 days. While doing this, they should observe the general health of the plants:
 - do they have a nice dark green colour (indicating good nutrition)?
 - do they appear moisture-stressed?
 - are there signs of damage (from fall armyworm, other insects or diseases)?
 - are there weeds (especially Striga)?
2. check for presence of natural enemies such as ants or wasps, or larvae that appear to have been killed by a pathogen such as a fungus or virus.

Note: sometimes maize plants can compensate for certain levels of leaf damage without losing much yield. Not all fall armyworm damage results in lower yields (Figure 22).





Act

Effective and sustainable fall armyworm management requires action. Some actions prevent fall armyworm from entering the field, while others are required when fall armyworm has already entered and is present in your field.

1. Picking off and crushing fall armyworm eggs and caterpillars is best done as soon as possible, beginning a week after planting. Eggs are laid in a mass which is easily found on maize leaves. Small caterpillars can be picked off the leaves before they penetrate deep into the whorl or funnel.
2. Removing and destroying volunteer plants, weeds and infested crop residues is important, as they provide shelter and food for the pest.
3. “Recycling” of pathogens can be done when dead larvae are found that appear to have been killed by a virus, fungus or bacterium. These can be collected from the field, taken home, ground and mixed with water before sieving. The liquid that is collected after sieving can be diluted and sprayed back onto infested plants. This is a free and effective biopesticide. Many farmers spray only into the whorls or funnels of infested plants so as not to waste the liquid.

1



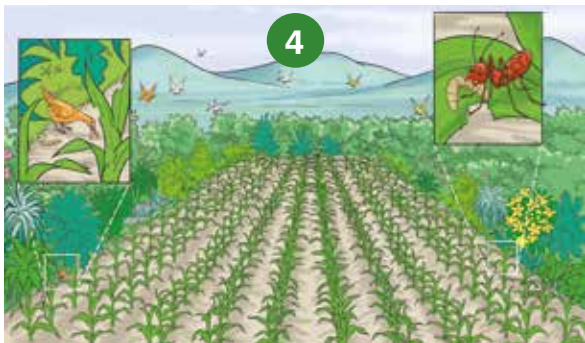
2



3



4. Attracting predators and parasitoids is another natural means of keeping pest populations down. Ants are important natural predators of fall armyworm caterpillars. Farmers are encouraged to maintain good crop diversity to attract these natural enemies, and to reduce or eliminate completely the use of pesticides that kill these “farmer friends”.



5. A number of local substances applied directly to the whorls or funnels of infested plants have been used by farmers with reported success. These include soil, ash, sand, lime, salt, soaps, oils and extracts from local plants such as hot peppers, Tephrosia, marigold flowers and neem. Farmers can try these and other solutions and then compare and share the results to see which work best under their particular conditions. They may find that some of the traditional methods have potential for fall armyworm management.



There are many ways to sustainably manage fall armyworm in Africa. Good management will depend on good knowledge, observations, innovation and action.

Farmers and extensionists are encouraged to learn about fall armyworm biology and ecology, closely observing what happens in their fields, trying some of these practices, developing new ones and sharing their knowledge and experiences!

Chemical control

Although pesticides provide a level of crop protection which cannot be guaranteed by other approaches, they are expensive, may cause health risks to humans and livestock, and may kill natural enemies and other beneficial organisms in the environment. They must be used with extreme caution.

1. Nationally registered, labelled pesticides should be chosen, with a preference for those that are locally available, target specific, rapidly degrading and a low health risk. Fake and banned products must be avoided. To prevent resistance, rotate between pesticide groups with different modes of action. A maximum of 2-3 sprays are recommended per season.



2. Farmers should use proper personal protective equipment and follow the guidance provided on the pesticide label for rates of application, re-entry and preharvest intervals. For pesticides to be effective, spray in the early morning or late afternoon when fall armyworm is more active. Aim the nozzle at the plant whorl to ensure that the target is reached with the maximum spray volume.



Find out more

The best practices for managing and monitoring fall armyworm are different in each country and region.

For more precise recommendations on what might work best in your area, talk to local extension services and experts in your Ministry of Agriculture.

A variety of online resources can be found at CABI's Fall Armyworm Portal: **www.cabi.org/fallarmyworm**

This portal contains a wide range of news, research, practical extension materials, videos and other resources on fall armyworm. Additional resources are available at **www.fao.org/fall-armyworm/en**

The information is contributed by many organizations and sources, and the portal also maintains a list of organizations currently taking action on fall armyworm at **www.cabi.org/isc/fallarmywormaction**



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