

Introduction to Fall Armyworm: A Training Manual

Version 1



Introduction to Training Manual

This manual is designed to be used as a basic introduction to the fall armyworm, a serious plant pest that is now established in many countries across the Asia Pacific region. It is best used in conjunction with the online training module which can be accessed at the training page at www.aseanfawaction.org

The following people have contributed to this online training resource: Alison Watson, Zتامال (CSIRO/ASEAN FAW Action Plan); Zett Productions; Farmers of Yogyakarta; and Professor Andi Trisyono and his team from University Gadjadara, Indonesia. The use of public online resources developed by other organisations is acknowledged.

Thank you to all those who work to provide education and information to empower farmers to better understand how to monitor and manage fall armyworm and other plant pests and diseases using integrated pest management approaches.

The support for the development of this training manual by the Regional Asia Pacific office of the United Nations Food and Agriculture Organization as well as the Ministry of Agriculture, Forestry and Fisheries, Japan is gratefully acknowledged.

How to use this Training Manual

This training manual is designed to be simple to use. Normally, it is best to start at module 1 and move through the different modules until you finish all 9 modules. However, you can start anywhere according to your level of knowledge and interests. There is no password, and neither are you obliged to register or log in.

This is a live document or training course which means we intend to add to it and change the material over time. If you have videos or resources that you wish to share – please feel free to send them with us and we may add them to the course materials. We are particularly interested in posting interviews or visits to the field – and hearing from farmers from across the Asia Pacific region on how they manage FAW.

The links should all be live and work – but sometimes links change – so please tell us if a link is broken by contacting us.

You can contact us at info@aseanfawaction.org

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Module 1: Identify

Lesson 1 - How can I identify the fall armyworm?



Learning Objective: Participants should be able to identify the fall armyworm.

Introduction

Identifying FAW is important, but it is not always easy!

It is important to look for damage to leaves in the early stage of an infestation as the FAW can be very small in the early stages and when it is bigger, it might be hiding in the whorl of the maize plant.

When the caterpillar is bigger, however, there are some characteristics to look out for, like the **inverted Y pattern on the head** and the **4 dots in a square formation on the second to last segment of the body**.

On other back segments, there are **four dots arranged in a trapezium shape**. Follow the resources below to find out more information on how to spot FAW in maize and then complete the quiz to see how much you can remember.



Watch this [video](#) for simple advice on identifying FAW in the field is excellent. Another good resource to watch is the video, [Identifying the Stages of Fall Armyworm](#) by the [International Centre of Insect Physiology and Ecology \(ICIPE\)](#).



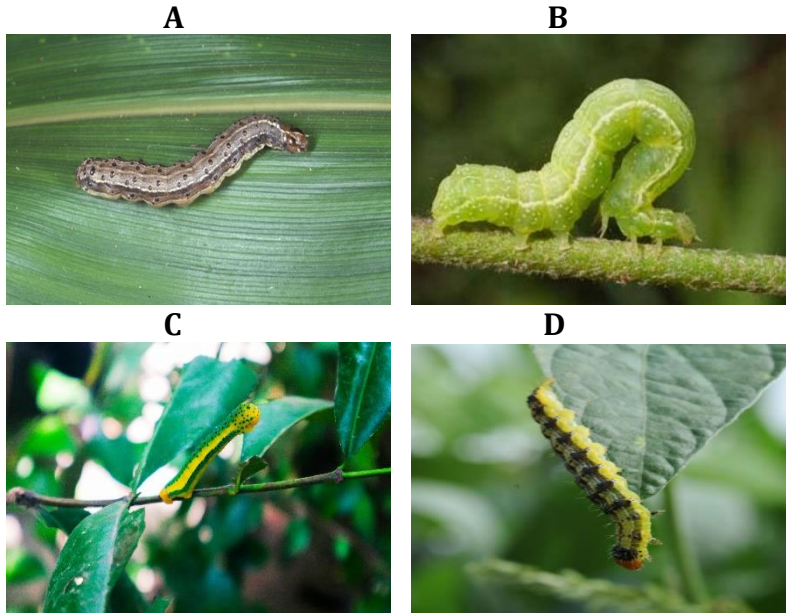
Read this online [resource](#) (Queensland Government of Australia) which provides some handy tips for identifying armyworm larvae. You should also download the [FAO-CABI FAW Field Handbook \(FAO-CABI\)](#). This handbook will be very useful for mastering the basics of FAW identification and management.



Listen to a [farmer](#) talk about FAW and how to identify FAW in the field.

Ready to do the [quiz](#)? You can also go to the online version of this handbook to see the answers.

1. What is the size of a mature Fall armyworm?
 - a. 1 Centimetre
 - b. 1.5 to 2 Centimetres
 - c. 3 to 3.5 Centimetres
 - d. 5 Centimetres
2. Which photo is of the fall armyworm larvae?



3. What familiar mark can be found inverted on the head between the eyes of the fall armyworm?
 - a. Circular mark
 - b. Y mark
 - c. X mark
 - d. Triangular mark
4. How many longitudinal stripes run along the body of a mature fall armyworm?
 - a. 1
 - b. 2
 - c. 3
 - d. 4

5. What kind of damage do fall armyworms mainly cause to crops?
 - a. They eat the leaves and stems of the plant.
 - b. They bore into the fruit of plants.
 - c. They cause discolouration on the leaves of plants.
 - d. They cause the plants to wilt and die.

6. Where does fall armyworm typically lay their eggs?
 - a. On the underside of the leaves of the plants
 - b. On the stem of the plants
 - c. On the ground
 - d. In the soil

7. How many black dots do the adult caterpillars have on the second to last segment of their body and in what shape:
 - a. 3 dots in a triangle shape
 - b. 4 dots in a square shape
 - c. 4 dots in a trapezium shape
 - d. There are normally no dots

Lesson 2 - What other insects and diseases also impact maize?



Tropical armyworm (Source: Stringfixer)

Learning Objective: Participants should be able to identify other common insects and diseases in maize.

Introduction

It is important to know and be able to recognize other insects and diseases that also attack maize. These will change according to the location but might include the: tobacco cutworm, beet armyworm, African armyworm, cotton bollworm, tropical armyworm, Asian corn borer, weevils, blights, and maize rusts. Find out more about these by using the resources below and undertaking the activity.



Write a list of all the diseases and pests that could be found in your maize crop in your region. You may need to ask local experts and farmers as well as search online for local knowledge and resources.



Find out about some other similar caterpillars by visiting this BeatSheet resource by [Queensland Government](#) and [GRDC here](#).



You can also visit the [Pacific Pests, Pathogens & Weeds](#) website and type maize in the search box. This will give you good information about different maize pests as well as photos.



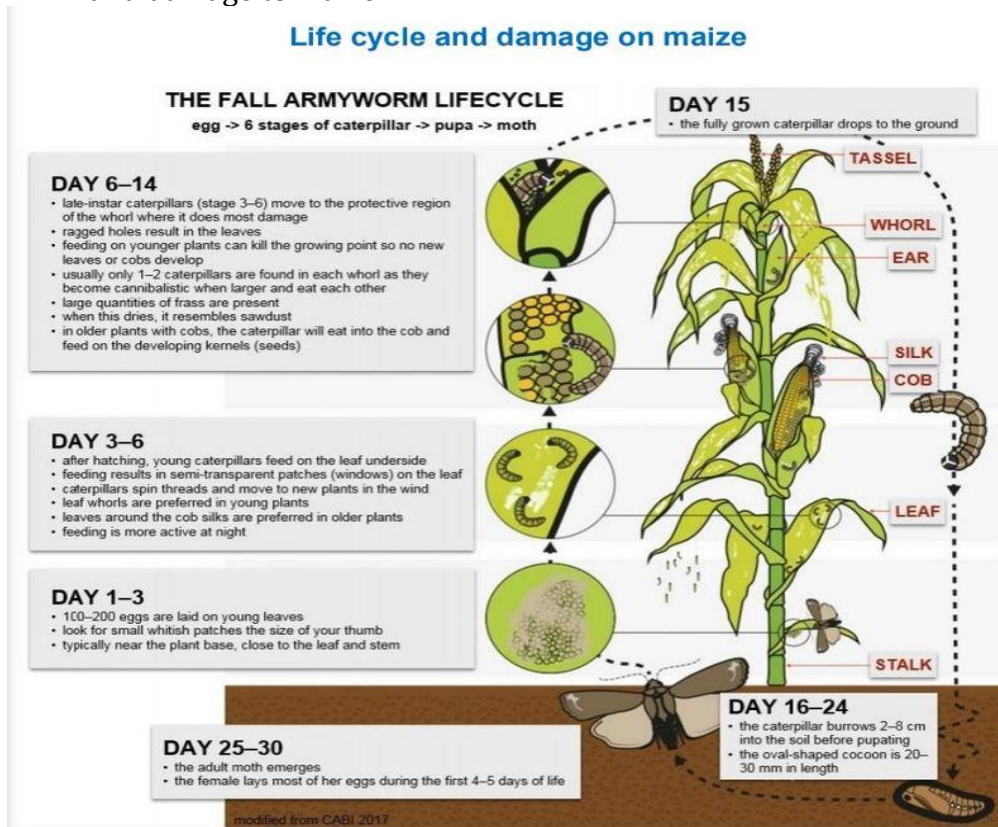
Listen to a [farmer](#) talk about other pests in the field.

Lesson 3 - What is the life cycle of the fall armyworm?

Learning Objective: Participants should be able to identify and explain the life cycle of the fall armyworm.

Introduction

Understanding the different stages of the lifecycle of the fall armyworm is an important part of effective management. This diagram from [CABI](#) in the FAO manual on [Understanding Fall Armyworm \(FAW\) - *Spodoptera frugiperda*](#) shows the different stages of FAW and damage to maize.



Picture modified from CABI 2017 in FAO (2020) *Understanding fall armyworm (FAW) Spodoptera frugiperda*.
At <https://www.fao.org/3/ca9529en/CA9529EN.pdf>.



Make sure you have read the [FAO-CABI FAW Field Handbook](#). It is a handy resource and has all the basic information to get you familiar with FAW.



Watch this [video](#) that shows the different **stages of the FAW lifecycle**.



Download this useful 2-page [FAO-CABI](#) photo identification resource for [Fall Armyworm](#) and become familiar with the different stages of FAW as well as signs of leaf damage.



It can be hard to **see pupae in the soil, but you can find them if you know what to look for**. Watch this [video](#) from [Queensland Government Australia](#) to find out how.



Visit a maize field and use the [FAO-CABI](#) photo identification resource for [Fall Armyworm](#) to see how many different stages of FAW and evidence of infestation you can identify in the field (hopefully there won't be any FAW!).



Ready to do the [quiz](#)? You can also go to the online version of this handbook to see the answers.

1. What is the scientific name for the fall armyworm?
 - a. *Spodoptera frugiperda*
 - b. *Helicoverpa armigera*
 - c. *Mythimna separata*
 - d. *Agrotis ipsilon*
2. What is the preferred food for fall armyworm currently?
 - a. Fruit trees
 - b. Wheat
 - c. Maize
 - d. Citrus
3. How long does it normally take for a fall armyworm to complete its life cycle?
 - a. 1 week
 - b. 2-3 weeks
 - c. 3-5 weeks
 - d. 5 weeks and more

4. What is the primary symptom of fall armyworm infestation in maize crops?
 - a. Yellowing of leaves
 - b. Wilted plants
 - c. Ragged holes and damage to leaves
 - d. Stunted growth

5. At what stage of its life cycle does fall armyworm cause the most damage to crops?
 - a. Larval stage
 - b. Pupal stage
 - c. Adult stage
 - d. Egg stage

6. How many stages are there in the life cycle of the fall armyworm?
 - a. 3
 - b. 6
 - c. 4
 - d. 5

7. How many larval stages (instars) are there before pupating and developing into an adult moth?
 - a. 1
 - b. 3
 - c. 5
 - d. 6

Lesson 4 - Why is it important to manage FAW proactively?

Learning Objective: Participants should be able to understand why the fall armyworm needs to be managed early and proactively to ensure effective control.



Introduction

Like many plant pests and diseases, **early and timely action is critical** before the FAW gets out of control and creates serious damage to the crop. It is especially important with FAW as **it is easier to control FAW when the larvae are small and before the FAW larvae move into the whorl.**

FAW has some characteristics that can make it difficult to manage:

- FAW can multiply fast, with short life cycles in ideal climatic conditions of around 20-30 days and with an adult moth capable of laying 1,000 eggs over her lifetime. There will likely be multiple generations of FAW within a season depending on the conditions.
- FAW has no diapause growth phase.
- Younger larvae are difficult to see, and farmers must instead look for FAW infestation signs and symptoms like small “pin holes” and “windowpanes”. This can be confusing for farmers who may expect to see large caterpillars. Larger larvae and moths are also nocturnal.
- Young larvae tend to migrate to the whorl of maize plants; therefore, older larvae (4th-6th instar) can be more difficult to control because in the whorl they are protected from insecticides or other management approaches.
- The FAW moths can fly very long distances with ease, particularly with ideal wind and climate conditions.
- FAW can evolve resistance to insecticides relatively quickly, and in some areas, this has already occurred. Only use pesticides when necessary and follow good practices such as alternating pesticides with different modes of action. Remember that the presence of FAW in a crop does not necessarily mean that spraying a pesticide is economically justified.

One of the most important actions a farmer can take is to actively scout the maize at regular intervals –**scout at least every 7 days**. Farmers can then decide to take early action, as necessary.

FAW can be managed well through a combination of integrated pest management and plant health practices. **So don't panic about FAW – be smart, use good agricultural practices, and quality seeds, and scout your crop** regularly!



Watch this [CABI video](#) “[Fall Armyworm: What to do](#)” to learn more.



Watch this [video](#) from the Queensland Department of Agriculture to find out how FAW eat holes in leaves without being seen!



This [FAO Global Action Guidance Note](#) on “[How to Manage Fall Armyworm: A Quick Guide for Smallholders to FAW Management](#)” is a useful resource that you should read.



Ready to do the [quiz](#)?

1. How many eggs can an adult FAW moth be capable of laying over its lifetime?
 - a. Less than 50
 - b. Less than 500
 - c. more than 500

2. Larger larvae and moths prefer to come out in the:
 - a. Day (diurnal)
 - b. Night (nocturnal)

3. Younger larvae are easy to see in the crop.
 - a. True
 - b. False

4. It is easy to control the FAW larval when they migrate to the whorl of the maize.
 - a. True
 - b. False

5. When should a farmer scout for FAW?
 - a. When he/she feels like it
 - b. On a regular basis, at least every 7 days
 - c. About a month after planting
 - d. Just before harvest

6. What actions should I take when I see FAW damage in the field? (Choose all that are appropriate)
 - a. Talk to my local agricultural extension worker or trusted expert.
 - b. Panic
 - c. Scout the maize field
 - d. Spray immediately with any available pesticide
 - e. Destroy all the plants to get rid of the FAW
 - f. Crush the larvae and eggs that you find.
 - g. Decide to keep a close watch on the maize and scout more regularly.
 - h. Find out more information on how to manage FAW.
 - i. Take note of what size larvae are present.

Module 2: Monitor and Scout

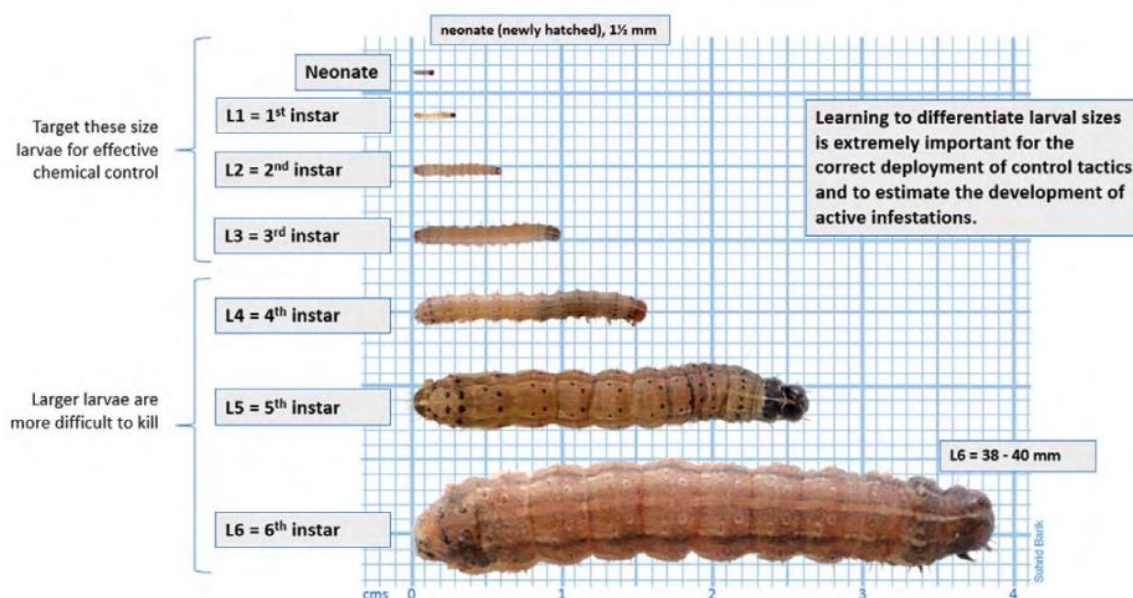
Lesson 1 - How can I monitor and scout for fall armyworms?

Learning Objective: Participants should be able to identify ways to effectively monitor and scout for fall armyworms.

Introduction

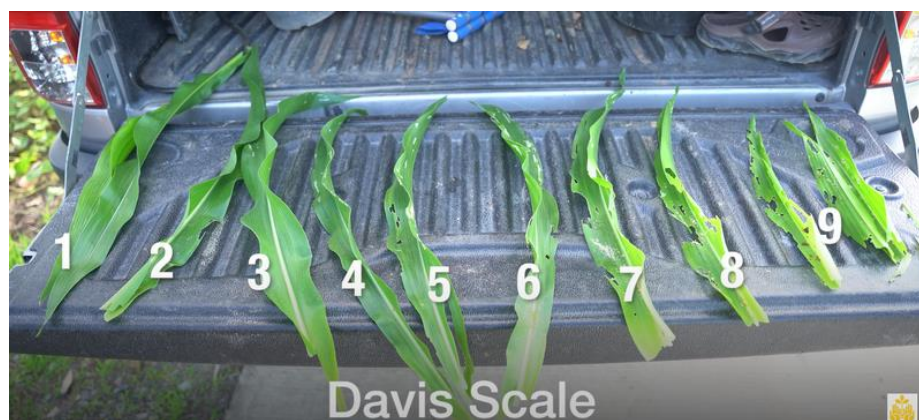
Monitoring FAW is one of the most important activities for successfully managing FAW. Farmers should **monitor the maize crop regularly**, at least every 7 days, and no less than 10 days. Use the following resources to learn how to scout for FAW in the field.

It is also useful to be able to **differentiate between the different larval stages of FAW** because it is easier to control FAW in early larval stages.



Picture from the *Fall Armyworm in Asia: A Guide for Integrated Pest Management* (2021)
(Image credit Suhrid Barik, Corteva)

When scouting for FAW, you may see different levels of leaf damage. The Davis scale has been developed to rate the extent of leaf damage.



Scale	Description
0	No visible leaf damage.
1	Only pinhole damage on leaves.
2	Pinhole and shot hole damage to the leaf.
3	Small, elongated lesions (5–10 mm) on 1–3 leaves.
4	Midsized lesions (10–30 mm) on 4–7 leaves.
5	Large, elongated lesions (>30 mm) or small portions eaten on 3–5 leaves.
6	Elongated lesions (>30 mm) and large portions eaten on 3–5 leaves.
7	Elongated lesions (>30 cm) and 50% of leaf eaten.
8	Most leaves with long lesions and complete defoliation observed.
9	Elongated lesions (30 cm) and large portions eaten on 70% of leaves.

The Davis Scale



Read this [FAO Guidance Note](#) for instructions on how to undertake scouting in the field.

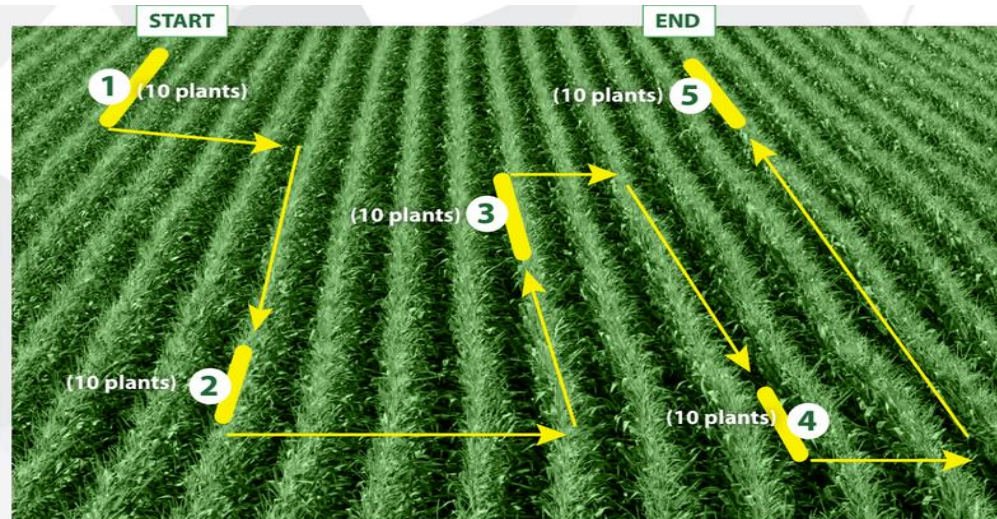


Image from FAO Guidance Note. See <https://www.fao.org/3/i8321en/i8321en.pdf>



Watch this [SAWBO video](#) to see a farmer undertake simplified scouting in the field. You can access this video in different languages.



[Listen](#) to this farmer talk about scouting in his field.



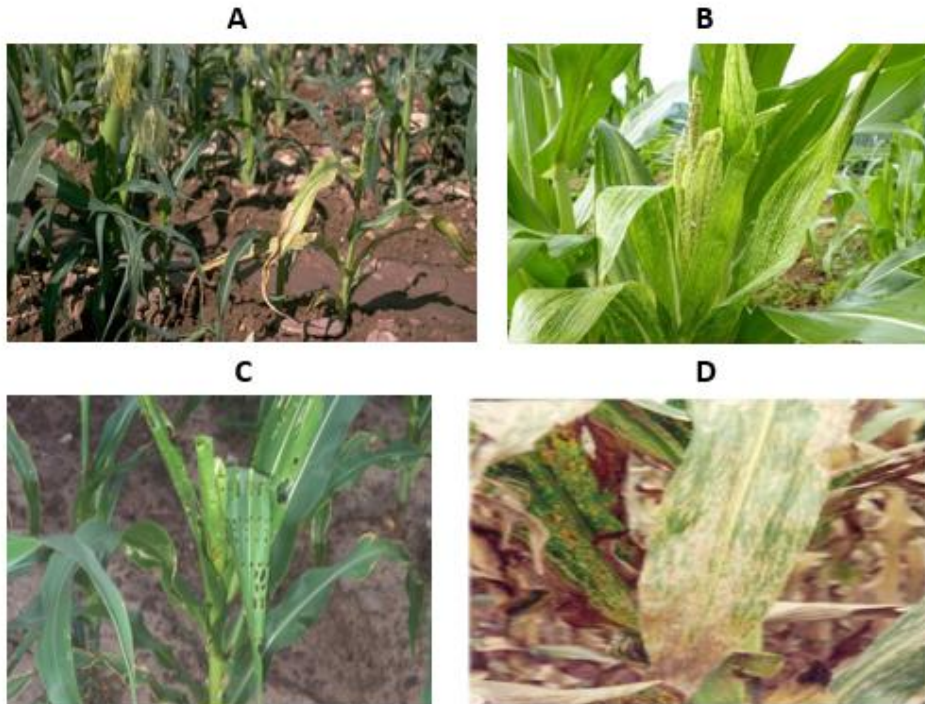
Hear from this [expert](#) on why it is important to monitor your field.



Ready to do the [quiz](#)? You can also go to the online version of this handbook to see the answers.

1. When is the best time to start monitoring fall armyworms in the field?
 - a. During the day
 - b. Early in the morning
 - c. Late in the afternoon
 - d. Options B and C

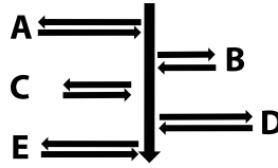
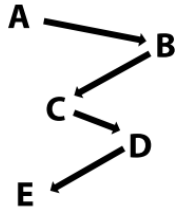
2. In the picture below, which one looks most like the damage caused by the Fall armyworm?



3. What is the recommended frequency for monitoring fall armyworms in the field?
 - a. Every 7 days, and more often if there is FAW observed.
 - b. Once every three weeks
 - c. Once a month

4. During monitoring, what data should be collected by the farmers?
 - a. Location of the infestation
 - b. The size of the larvae
 - c. Levels of damage on the leaf
 - d. All of the above

5. What is the name of these scouting patterns?



- a. W and Ladder pattern
 - b. Ladder and M pattern
 - c. Three and M pattern
 - d. W and M pattern
6. How many spots or areas are recommended to stop and scout for fall armyworms in the field?
- a. 2 areas
 - b. 3 areas
 - c. 5 areas
 - d. 7 areas
7. What is the recommended sample size per area during scouting?
- a. 5-10 plants
 - b. 10 plants
 - c. 20 plants
 - d. 50 plants
8. How should you scout for Fall Armyworm?
- a. Randomly select plants and inspect for damage and larvae presence.
 - b. Only inspect plants that are visibly damaged.
 - c. Inspect every plant in the field.
9. What is the Davis Scale used for?
- a. To measure the amount of rainfall in an area
 - b. To measure the severity of leaf damage in plants caused by the FAW.
 - c. To measure the growth rate of crops
10. How is the W-scouting method performed?
- a. Walking through the field in a zigzag pattern and counting the number of larvae observed on plants in different areas.
 - b. Standing in one spot and counting the number of larvae observed on a single plant.
 - c. Using a drone to fly over the field and take photos of the plants.

Lesson 2: How do I use a pheromone trap?

Learning Objective: Participants should understand how a pheromone trap works and how to use it.



Introduction

A pheromone trap for FAW (Fall Armyworm) is a type of insect trap that uses a synthetic pheromone to attract male Fall Armyworm moths. The pheromone is a chemical that the female moths produce to attract the males for mating. The synthetic version used in the trap mimics this natural pheromone, which attracts male moths and lures them into the trap.

The pheromone trap consists of a container filled with a sticky substance that traps the moths once they enter the trap. The trap is placed in the field or near the crops being monitored. When the moths are trapped in the container, the number of moths caught can be used to estimate the size of the Fall Armyworm population in the area.

The pheromone trap is a valuable tool for monitoring Fall Armyworm populations and assessing the need for control measures. By identifying the presence and severity of the infestation, farmers can take timely action to minimize the damage caused by the pest.



Read this [FAO Guidance Note](#) to find out best practice information on monitoring using pheromone traps.



Watch this video for a masterclass from Dr Rob Meagher on the [Trapping FAW: The Use of Pheromones, Trap Design and Lures for FAW Control](#).



Interested in understanding how a Trap might be used to collect FAW and then how FAW can be identified – watch this [video](#)

Module 3: Decide

Lesson 1: How do I know when a FAW infestation requires immediate action?



Learning objective: Participants should be able to understand the action threshold, when to get further help from an expert and when to consider the use of a biocontrol or chemical pesticide.

Introduction

The action threshold for FAW control varies depending on the crop, stage of growth, and other factors, but it is typically determined based on the number of larvae present per plant. The action threshold is the level at which it is economically justifiable to apply control measures to prevent further damage to the crop.

The recommended action threshold for FAW control is typically between 3 to 5 larvae per plant, although this may vary depending on the crop and the stage of growth. If the number of larvae exceeds the threshold level, it is recommended to implement control measures, such as biopesticides or other methods of pest management, to prevent further damage and minimize crop losses.

It's important to note that the action threshold is just a guideline, and farmers should also consider other factors such as weather conditions, crop health, and economic factors when deciding whether to implement control measures.

Additionally, some crops may be more tolerant to FAW damage than others, so the action threshold may need to be adjusted accordingly.



Read this expert [Guidance](#) from the [USAID CIMMYT Fall Armyworm in Asia: A Guide for Integrated Pest Management](#). This chapter provides you with in-depth information on Scouting and Monitoring and when to take Action.



[Listen](#) to this farmer and expert talk about how they decide when to use a pesticide to control FAW. Can you think of other criteria or points to consider?



Ready to do the [quiz](#)? You can also go to the online version of this handbook to see the answers.

1. What is an action threshold in pest control?
 - a. The level at which a pest becomes a nuisance
 - b. The number of pests that can be tolerated before economic damage occurs
 - c. The minimum amount of pesticide needed to control a pest
2. What factors can influence the action threshold for a specific pest?
 - a. The type of pest and its life cycle
 - b. The crop or area being protected
 - c. The cost and effectiveness of available pest control options
 - d. All of the above
3. How can the action threshold be determined?
 - a. By monitoring pest populations and damage levels
 - b. By following standard industry guidelines
 - c. By using the same threshold for all crops and pests
4. What is one major benefit of using an action threshold in pest control?
 - a. It helps to prevent unnecessary pesticide applications
 - b. It ensures that pests are eliminated as quickly as possible
 - c. It simplifies the decision-making process for pest control
5. What is the recommended course of action when the action threshold is exceeded?
 - a. Do nothing and wait for pest populations to naturally decline
 - b. Apply pesticides immediately to eliminate the pest
 - c. Consider a range of control methods, including biological control or cultural practices and if necessary, a pesticide.
6. What factors are used to determine the economic threshold for a specific pest?
 - a. The cost of control measures
 - b. The value of the crop being protected
 - c. The expected yield of the crop
 - d. All of the above

Module 4: Think Biocontrol



Watch this [CABI video](#) on the [Biological Control of Fall Armyworm in Maize in Bangladesh](#) for a quick introduction to the Biological Control of Fall Armyworm.

Lesson 1 - How to use a Bt Biopesticide

Learning objective: Participants should be able to understand when and how to use a Bt Biopesticide.

Introduction

Bt (*Bacillus thuringiensis*) biopesticides are a type of microbial pesticide that contain living bacterial spores of the Bt bacterium. These spores produce crystal proteins (Cry proteins) that are toxic to specific insect pests, including the fall armyworm. Bt biopesticides are highly specific and only affect target pests, leaving non-target organisms unharmed. They also break down rapidly in the environment, reducing the risk of long-term harm to ecosystems. In addition, Bt biopesticides can be used in integrated pest management programs to minimize the use of chemical pesticides and reduce the risk of developing pesticide resistance.



Using a Bt Biopesticide can be a great choice to help control FAW. Watch this [video](#) to understand how to use and apply a Bt Biopesticide.



A commercial Bt Biopesticide kills FAW through ingestion. Watch this [video](#) to find out how.



Watch this [Masterclass on The Best Timing for Using Bt Biopesticides](#) for FAW Control.

Lesson 2 - How do parasitoids help control FAW?

Learning objective: Participants should be able to explain how parasitoids can be used in the field and what the benefits are.



Introduction

Parasitoids are natural enemies of the Fall Armyworm (FAW) that can be used as a biological control method for managing this pest. Parasitoids are insects that lay their eggs inside or on the larvae or pupae of FAW, and their offspring feed on and ultimately kill the pest. Unlike predators, which kill and consume many prey organisms during their lifetime, parasitoids typically lay their eggs on or in only one host, and their offspring complete their development by feeding on that host.

Using parasitoids for FAW control has several advantages. Unlike chemical insecticides, which can harm non-target organisms and can lead to the development of insecticide resistance, parasitoids only target FAW and do not harm other organisms. Parasitoids can also provide long-term control of FAW populations, as they can reproduce and persist in the environment without the need for ongoing treatment. Additionally, using parasitoids as a biological control method can help reduce reliance on chemical insecticides and promote more sustainable agriculture.



[Watch](#) how this parasitoid, *Chelonus insularis*, parasitizes moth eggs. Thanks to [Jena Johnson](#) for the video!



PlantVillage explains how [How to Use Natural Enemies \(Parasitoids\) to Control Fall Armyworm](#) in the field.

Lesson 3 - What is a Baculovirus?



Learning objective: Participants should be able to explain what a baculovirus is and how it can be used in the field for fall armyworm control.

Introduction

Baculoviruses are a group of insect-specific viruses that can infect and kill FAW. They are typically applied as a spray, and once the FAW ingests the virus, it replicates within the insect's cells, causing the insect to die. The virus then spreads to other FAW individuals, leading to a decrease in the pest population.



Fawligen is a baculovirus that can be used to help control FAW. Learn how to apply in the field by watching this [video](#).

Module 5: Pesticides

Lesson 1 - Do I need to apply pesticides?



Learning objective: Participants should be able to understand why a pesticide is the last resort in the IPM toolbox and why it should only be used as necessary.

Introduction

Pesticides can have negative impacts on the environment, human health, and non-target organisms such as beneficial insects and wildlife. Pesticides can also lead to the development of pesticide-resistant pests, which can reduce the effectiveness of future pest control efforts. Furthermore, pesticides may not always be effective at controlling FAW and other pests, and their use can sometimes lead to unexpected consequences such as outbreaks of secondary pests or the killing of natural predators that help to control pest populations.

Integrated Pest Management prioritizes non-chemical methods of pest control, such as cultural practices, biological control, and mechanical control, before considering the use of pesticides. When using pesticides, it is also important to choose the least toxic option and to apply them in a way that minimizes harm to non-target organisms and the environment.

Overall, pesticides should be viewed as a tool of last resort in the IPM toolbox, to be used only after consideration of the potential risks and benefits and with caution and care.



Read [FAO Guidance Note](#) for more information on pesticides.



FAO recommends the following points to consider when thinking about using pesticides for FAW control:

1. **Optimize the use of non-synthetic pesticide management strategies** before considering pesticide use.
2. **Think carefully about whether a pesticide is needed** and take steps to reduce pesticide reliance. Using IPM principles, routine scouting and economic thresholds should guide the decision, using selective and safe insecticides as a last option.
3. **Use a selective synthetic pesticide** that affects the target pest only and not FAW's natural enemies. Indiscriminate use of synthetic pesticides can disrupt natural enemy-pest populations in FAW habitat, leading to increases in the abundance of FAW.
4. **Select products with the lowest risk to humans, the environment and non-target organisms** from the list of available registered products that are effective against FAW.
5. **Ensure proper use** of the selected products for approved applications and comply with international standards (See [Guidance on Pest and Pesticide Management, FAO/WHO International Code of Conduct on Pesticide Management](#)).
6. **Rotate the active ingredients among the selected synthetic pesticides** to avoid the development of insecticide resistance among FAW populations.



Listen to a [farmer](#) and expert talk about using pesticides in the field.

Lesson 2 - How do I use a pesticide safely and responsibly?



Learning objective: Participants should be able to understand how to safely apply a pesticide in the field.

Introduction

Using pesticides safely and responsibly is essential for protecting human health and the environment, and for promoting sustainable agriculture practices. It requires following recommended guidelines, handling and storage procedures, and disposal methods, as well as understanding the potential risks and benefits associated with pesticide use.



Watch this CABI Video to understand the [safe application of chemical pesticides for managing fall armyworm](#)



[Listen](#) to this discussion on how to safely use a pesticide.



Ready to do the [quiz](#)? You can also go to the online version of this handbook to see the answers.

1. What is the first step in safely using a pesticide?
 - a. Mixing the pesticide with water
 - b. Wearing personal protective equipment (PPE)
 - c. Reading the product label and following directions
2. What should you do if you accidentally spill a pesticide on your skin?
 - a. Wash the affected area with water and soap
 - b. Ignore it and continue working
 - c. Wait until you finish working to wash the affected area

3. What is the proper way to mix a pesticide?
 - a. Add the pesticide to water
 - b. Add water to the pesticide
 - c. Mix the pesticide and water at the same time
4. What are Highly Hazardous Pesticides (HHPs)?
 - a. Pesticides that are only available for use by licensed professionals
 - b. Pesticides that are classified as very toxic to humans and the environment
 - c. Pesticides that are considered to be the most effective against target pests
5. What should you do with leftover pesticide after you are finished applying it?
 - a. Store it for future use
 - b. Dispose of it according to label instructions
 - c. Pour it down the drain
6. How often should you clean your pesticide application equipment?
 - a. Only when switching to a different pesticide
 - b. After each use
 - c. Only at the end of the season

Lesson 3 - Guarding against resistance!

Learning objective: Participants should be able to understand managing resistance is critical and what their role is in supporting best practice

Introduction

Pesticide resistance is a natural evolutionary process in which pests become less susceptible to the effects of pesticides over time. This happens when individuals with genetic traits that allow them to survive exposure to a pesticide reproduce and pass those traits on to their offspring, leading to a build-up of resistant individuals in the population.

Managing pesticide resistance is important for several reasons:

- It helps to preserve the effectiveness of existing pesticides. When resistance develops, the same pesticide may no longer be effective against the target pest, which can result in increased use of pesticides, higher costs for farmers, and negative impacts on the environment and human health.
- It can delay the onset of resistance, allowing for longer-term and more sustainable use of pesticides. This can be achieved through strategies such as rotating the use of different pesticides, using multiple modes of action, and reducing overall pesticide use.
- It can help to prevent the spread of resistance to other regions or countries. When resistant pests are transported from one area to another, they can spread resistance traits to local populations, making control more difficult and costly.
- It can support integrated pest management (IPM) approaches, which rely on a combination of methods, including biological control, cultural practices, and chemical control, to manage pests sustainably.

In summary, managing pesticide resistance is crucial to preserving the effectiveness of pesticides, promoting sustainable agriculture practices, and protecting the environment and human health.



For an introduction on how to manage insecticide resistance management by rotation of different modes of action watch this [video](#) from CropLife International and the Insecticide Resistance Action Committee ([IRAC](#)).



[Watch](#) an Indonesian expert, Prof. Dr Andi Trisyono explain the importance of managing resistance and the role of farmers in supporting best practices.



Ready to do the [quiz](#)? You can also go to the online version of this handbook to see the answers.

1. What is resistance?
 - a. The ability of a plant to withstand insect attacks.
 - b. The ability of an insect to survive exposure to a pesticide that should kill it.
 - c. The ability of a farmer to adapt to changing environmental conditions.
 - d. The ability of a pest to rapidly reproduce and spread to new areas.
2. How can farmers prevent resistance to pesticides in FAW populations?
 - a. Rotate different types of pesticides.
 - b. Use pesticides only when necessary.
 - c. Follow recommended application rates and intervals.
 - d. All of the above
3. What is the most common cause of pesticide resistance?
 - a. Underuse of pesticides
 - b. Overuse of pesticides
 - c. Proper use of pesticides
 - d. Using biocontrol such as *Bacillus thuringiensis*
4. How can farmers help manage or reduce the risk of resistance?
 - a. By rotating pesticides and using multiple modes of action
 - b. By using the same pesticide repeatedly
 - c. By ignoring resistance and continuing to use the same pesticide
 - d. By using high doses of pesticides
5. What best explains what the mode of action means?
 - a. The specific biochemical or physiological process by which a pesticide interacts with the target pest to control it.
 - b. The way in which a pesticide interacts with the environment.
 - c. The way in which a pesticide is absorbed into plants.
 - d. The way or action a pesticide is physically applied to a plant.

6. What is the importance of understanding the mode of action of a pesticide for FAW control?
 - a. It helps farmers select the most effective pesticide for FAW control.
 - b. It helps farmers apply the pesticide correctly for maximum efficacy.
 - c. It helps prevent the development of FAW resistance to pesticides.
 - d. All of the above.

Module 6: Good Preparation



Image from Training Board

How can I help build a resilient maize crop at the start of the season?

Learning objective: Participants should understand and be able to explain the ways they can help prepare for and grow a more resilient maize crop.

Introduction

A healthy maize crop can better withstand diseases and compensate for damage caused by diseases and pests including FAW, so that plant injury does not always lead to yield losses.



A very good [presentation](#) on agroecological approaches to FAW is provided by Dr Timothy Krupnik from [CIMMYT/CGIAR](#).

Grow a Healthy Crop in a Healthy Farming System.



The FAO provides the following [guidance](#):

Maintain healthy soil, including soil organic carbon, soil moisture and structure, and ensure adequate plant nutrition. Research shows that plants grown in healthy soils are less attractive to pests.

Use high-quality seeds and varieties well adapted to the local environment and which are vigorous in the face of pests and diseases.

Planting time can be critical, especially when faced with limited or irregular rainfall. **Avoid late planting and avoid staggered planting.**

Consider using **intercropping, trap crops** and **repellent crops** which can help to reduce FAW infestation.

Optimise fertiliser use: avoid excessive nitrogen use, adding inorganic fertilisers to plants grown in poor soils may increase attack rates, as the high levels of free amino acids in the leaves are attractive to pests.

Don't panic! Maize plants can withstand significant damage by the Fall Armyworm - so become an expert on crop health and FAW to get the best and most sustainable results.



Watch this [video](#) from Indonesia to see some of the actions to build a healthy crop. What more can you think of?

Module 7: Helping Nature



Identifying and supporting natural enemies of fall armyworm

Learning objective: Participants should be able to identify natural enemies of fall armyworm and know how to support and encourage their presence in the field.



Introduction

One way to control fall armyworm populations is by supporting natural enemies. Natural enemies are organisms that naturally prey on or parasitize pests and can help to keep their populations in check. Some examples of natural enemies of fall armyworms include predators such as spiders, ground beetles, and parasitoids such as wasps.

Identifying and supporting natural enemies of fall armyworm is important for several reasons. First, it can reduce the need for synthetic pesticides, which can have negative environmental and health impacts. Second, it can be more cost-effective than using pesticides, especially for smallholder farmers who may not have access to these inputs. Third, natural enemies can provide long-term control of fall armyworm populations, whereas pesticides provide only short-term relief.

In addition, supporting natural enemies can help to preserve biodiversity and ecosystem services, as these organisms often play important roles in the food web. By promoting the natural enemies of fall armyworm, we can help to restore ecological balance and promote sustainable agriculture practices.



Discuss these questions with others and use the internet to **find the answers** to these questions.

- What are beneficial insects?
- Which beneficial insects are known to control fall armyworms?
- What is the role of parasitic wasps and flies in controlling fall armyworms?
- How can you attract and support beneficial insects in your field?
- Why is it important to promote beneficial insects for fall armyworm control?
- How can you reduce the use of chemical insecticides that may harm beneficial insects?
- What are some common plants that you can plant to attract beneficial insects?
- How might you monitor the presence and effectiveness of beneficial insects in controlling fall armyworm?

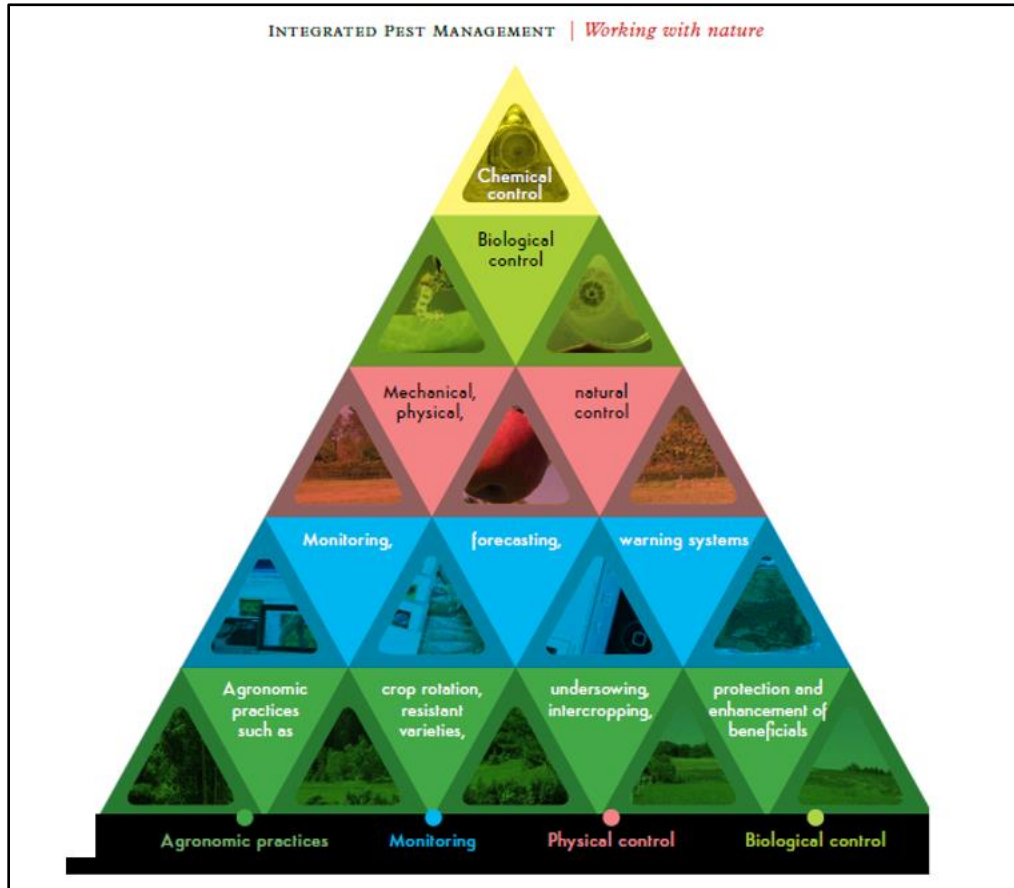


Activity: Be an insect detective! Watch this [explanation](#) of why this farmer uses beneficial insects. Can you identify Earwigs, Ladybirds, Ground beetles, Assassin and flower bugs, Parasitic wasps and flies, Spiders and Ants in your area? Are there any others you notice in or around your maize crops? Make a list of all the insects you can identify in your location.



Activity: An insect hotel provides a habitat for insects to rest and lay eggs and may also help control pest insects by attracting more beneficial insects. Make an insect house to support beneficial insects in your area. You can watch this [video](#) to assist you.

Module 8: IPM and Plant Health



*The Integrated Pest Management Triangle
(version of the International Biocontrol Manufacturers Association)*

Learning objective: Participants should understand and be able to explain to others the principles of IPM and its relationship to a healthy plant and food system.

Introduction

The FAO defines Integrated Pest Management (IPM) as the careful consideration of all available pest control techniques and the subsequent integration of appropriate measures that discourage the development of pest populations. It combines biological, chemical, physical, and crop-specific (cultural) management strategies and practices to grow healthy crops and minimize the use of pesticides, reducing or minimizing risks posed by pesticides to human health and the environment for sustainable pest management. You can find out more by visiting the FAO IPM [homepage](#)



Watch this [introduction to IPM](#) from [GlobalGap](#).



For comprehensive guidance on how to manage FAW using IPM read [the FAO General guidelines for developing and implementing a regional IPM strategy for fall armyworm control in demonstration countries](#).



Activity: Keep a diary of your visits to a maize field. Try to record all your activities and observations in the field. An example of a diary is below.

Name of farm/farmer:			
Date of visit			
Time of visit			
Weather			
Observations (e.g., plant health, pests & diseases present, beneficial insects, soil moisture, weeds)			
Scouting What does my scouting tell me?			
Management Write down any actions you do in the crop e.g. fertilizers, pesticides, weeding, planting, harvesting activities)			
Next steps Are there any actions I need to think about over the next 1-2 weeks to help manage my crop?			
Other notes			

Module 9: Other Resources



Introduction

There are many helpful resources that you can use to learn more about fall armyworm monitoring and management. An extensive list of regional and international resources can be found at the [ASEAN FAW Action Plan website](#).

The United Nations Food and Agricultural Organisation launched the Global Action for FAW Control (GA) as an urgent response to the rapid spread of FAW in December 2019. You can find many valuable resources on their [webpage](#).

We will also be adding further information to this page over time.



Watch this [video](#) to hear how the Philippines implemented a farmer field school programme. Think about what might work in your location and how you might better connect farmers on FAW management.