QUICK GUIDE - FALL ARMYWORM

Fall armyworm (FAW, *Spodoptera frugiperda*) was first reported in Australia in February 2020 and quickly established across parts of Northern Australia's tropical and sub-tropical regions, including northern Queensland, Northern Territory, and northern parts of Western Australia.

This Quick Guide synthesises essential baseline information on the biology and behaviour of FAW together with symptoms of plant injury and management strategies that will be useful in developing effective local and crop specific management strategies, plans and other requirements to address FAW in Australia.

Key points

- FAW is a highly migratory, invasive pest and as of October 2020 is present in parts of Queensland, the Northern Territory, New South Wales and Western Australia.
- FAW is able to travel long distances into more temperate or arid regions that are unfavourable for permanent populations. Annual population movements of over 2000 km with overnight migration distances of 400 km have been observed.
- FAW completes its lifecycle in around 30 days at optimal temperatures and will be able to complete multiple generations each year in Australia's subtropical and tropical climatic regions.
- Plants within the grass family (Poaceae) including maize, sweetcorn, sorghum and C4 pastures are favoured hosts of FAW.
- While two strains of FAW have been reported internationally, based primarily on their host plant preference, they can mate and form hybrids. In Australia, FAW populations have been detected on several crops including maize/sweet corn, sorghum, chickpea, soybean, melon, green beans and pastures (Rhodes grass).
- The rate of FAW population growth will increase during warmer months and decrease during the colder months.
- Migrations into southern regions are predicted to generally commence from spring with populations subsequently building up into summer.
- Maize, sorghum and other crops can tolerate some level of damage to leaves without yield impacts.
- It is difficult to distinguish the eggs and early instar larvae of FAW from other *Spodoptera* spp. found on grains crops; older larvae have distinct markings that enable them to be more readily identified from other similar pests.
- Monitoring for FAW eggs and larvae should involve visual inspection of the crop or host plant.
- In maize/corn, young leaf tissue is more suitable for larval growth and survival than mature leaves. In mature plants, larvae tend to settle and feed in the ear zone.
- Fortunately, many of the products registered for *Helicoverpa* control will also be effective against FAW, and there will, at certain stages of crop development, be incidental control.
- Getting the crop off to a good start with good agronomy and crop nutrition will ensure plants are more resilient.
- Managing volunteers in fallows and other sources of green bridge will reduce pressure, thereby reducing local populations of FAW.
- Avoiding sequential plantings of preferred crops such as maize and sorghum, will help reduce local populations of FAW.

Assess	Find	Identify	Thresholds	Enact
Assess your inherent FAW regional risk.	Use trigger points to know when to commence active monitoring of crops. Having appropriate traps and lures ready and share trapping results with neighbours.	Accurately identify pests by consulting with your local agronomist or crop protection specialist.	Develop, use and fine tune FAW specific economic thresholds, where available	Make informed selection of appropriate IPM approaches including use of beneficials and the application of good resistance management principles. Do not spray unnecessarily, only spray when economic thresholds are reached.

1. ASSESS

Assessing your regional risk

1. Check the risk zones below to determine whether you are in a zone where there is FAW risk all of the time, most of the time or some of the time. FAW is predicted to be present all year round in zone 1, present in all seasons apart from winter in zone 2 and present in some years from mid spring through summer and into autumn in zone 3 (Figure 1).

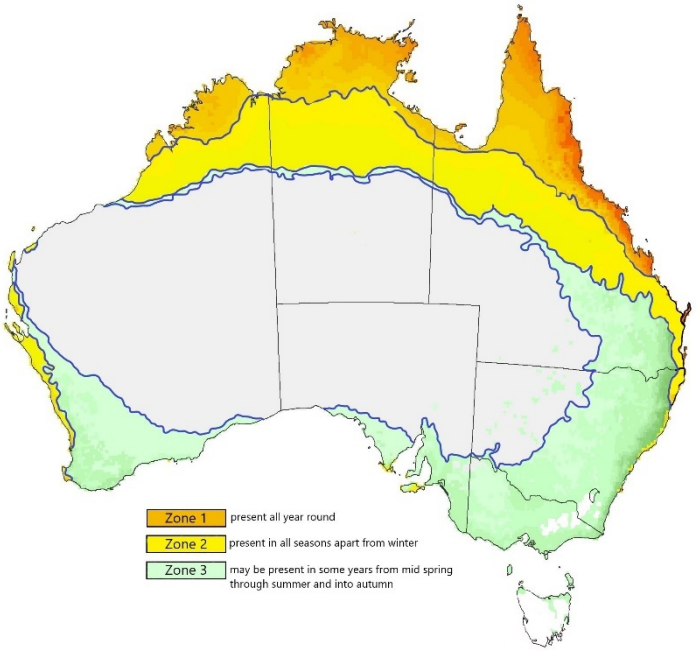

Figure 1. FAW risk prediction map showing zones where there is FAW risk all of the time, most of the time or some of the time

2. Know whether your crops are preferred FAW hosts maize/sweet corn, sorghum, and determine when crops are at risk and their susceptible stages.

3. The host range of FAW includes more than 140 species of reported cultivated and wild plants within the Poaceae (grasses) family and non-grass hosts. While Australian research is ongoing, recent international research indicates that FAW tends to favour summer crops in this general order.

1. Maize
2. Sweet corn
3. Sorghum
4. C4 pasture grasses
5. Sugarcane
6. Rice

More preferred

Less preferred

4. FAW can be particularly difficult to control with chemicals in maize due to the plant's whorl and characteristic ears and protective husks – plant structures that assist the pest's ability to seek shelter and avoid insecticide exposure.
5. When larvae are very numerous**,** they defoliate the preferred plants, acquire an 'army' habit and disperse in large numbers, consuming nearly all vegetation in their path. Many host records reflect such periods of abundance and are not truly indicative of oviposition and feeding behaviour under normal conditions.
6. Actively monitor the presence, population, and movement of FAW in your risk region. Be aware of the population status by checking for local updates and alerts on moth migration provided by relevant networks such as the Beat Sheet trapping network.
7. Share trapping and scouting data with neighbours to ensure high levels of communication and cooperation between growers, consultants, and research/extension personnel in order to better manage pests at a regional level.

2. FIND

Knowing when and how to look for signs of FAW

1. Early detection is critical to ensure effective timing of control measures.
2. The first indicators of FAW arrival in your area is the presence of migrating moths in Zones 2 and 3 and the emergence of adult moths from pupation in Zone 1 and 2.
3. Use pheromone-baited traps, suspended at canopy level, to detect early moth arrival and activity in the region in accordance with APVMA permit requirements.
4. There are a number of commercially available bucket or pheromone traps (Figure 2) that attract male adult FAW. These can be sourced together with lures and insecticide cubes online *via* retailers. Not an exhaustive list, but some examples include Bugs for Bugs, **www.bugsforbugs.com.au/product/bucket-trap** and Grochem Australia, **www.au.grochem.com**
5. Place a dry cellulose sponge in the bottom of the trap to absorb rainwater that may enter the trap, keeping the moths reasonably dry.
6. Consider establishing a trapping and reporting network with neighbours to detect and record the spread of FAW into new regions. Sharing information between growers and agronomists can provide an early-warning of fall armyworm activity and trigger crop monitoring.
7. Traps are best suited to signalling the arrival of significant peaks or influxes in moths over broad areas. They are unreliable indicators of level of egg-laying intensity or infestation of nearby crops. Scouting is required to determine egg-laying intensity (percent infested plants).

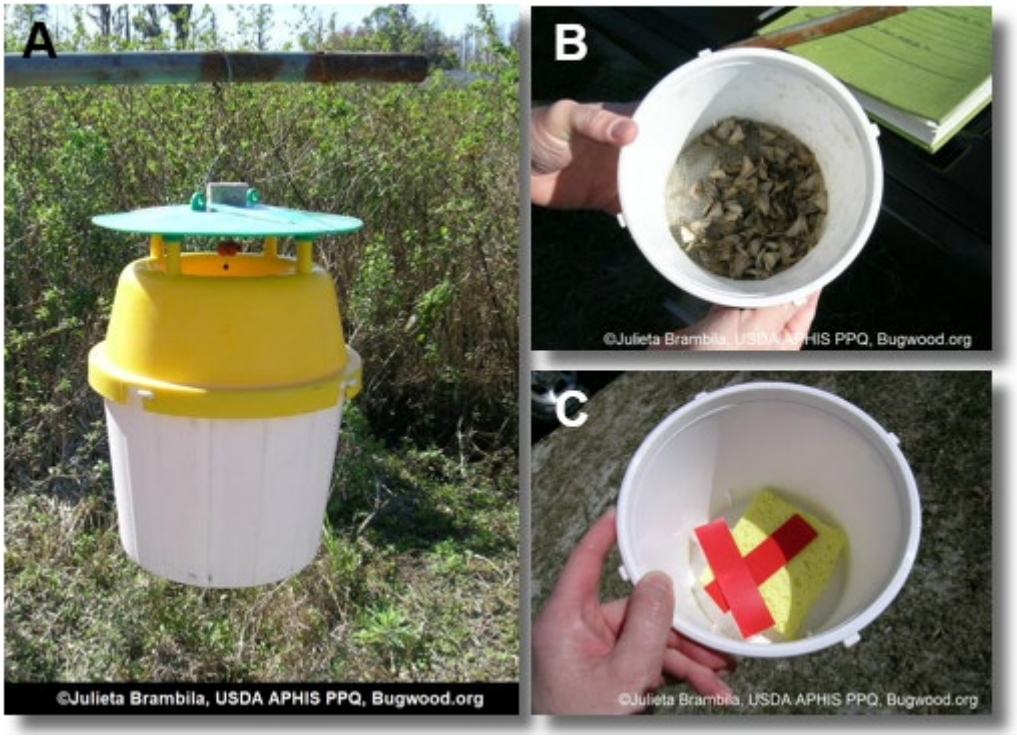

Figure 2. A) Bucket or pheromone trap; B) FAW adult male captures; C) Insecticide strips to kill adult moths

8. Conduct crop scouting regularly when pest migration is imminent. At least fortnightly at vegetative stage and increase to weekly if larvae are detected.
9. Early detection of FAW larvae before they become entrenched in the crop (e.g. whorl of maize, sweet corn or grain sorghum) or before they become later instars is essential for effective management.
10. Using a repeatable pattern, scout entire crops for FAW eggs and larvae as during early infestation (or directly after egg hatch) they are often unevenly distributed and can be confined to small patches within the crop (Figure 3).

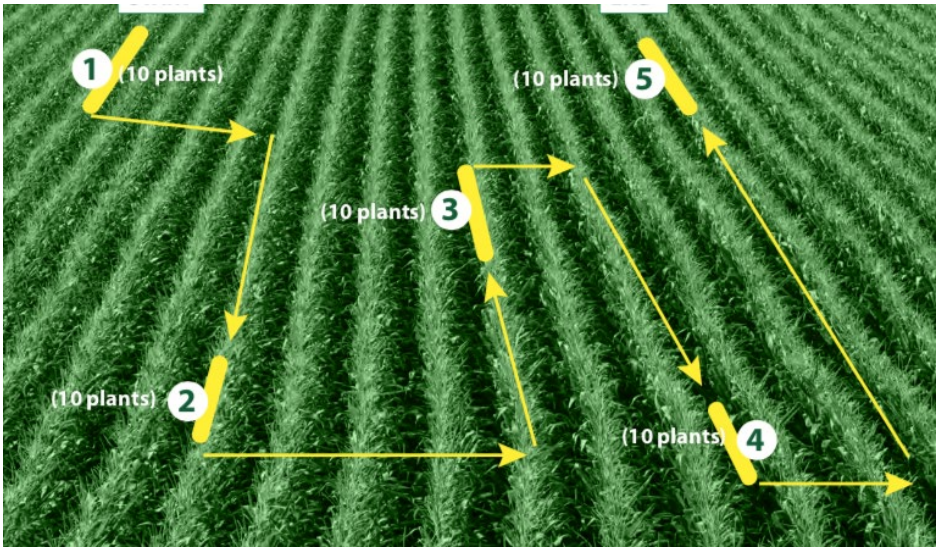

Figure 3 Example 'along the row' scouting pattern may be used for FAW in row crops

11. In row crop situations check 10 consecutive plants in a row (Figure 3) and count the number of larvae per plant. Ensure careful inspection of the plant structure (e.g. open the whorl of maize, sweet corn or grain sorghum). Repeat this at a minimum 5 sites in the crop at 100-200 meters apart to ensure the whole crop is represented. For large fields increase the number of sites from 5 to 10.
12. For solid planted crops use a 'W' shaped search pattern across the crop (Figure 4).

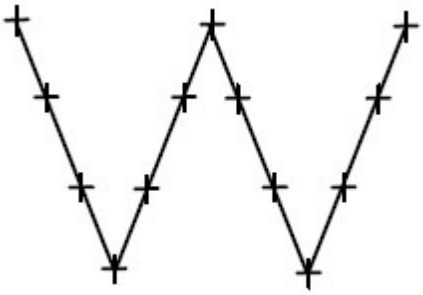

Figure 4 Example 'W' scouting pattern to be used for FAW monitoring in solid planted crops

13. Record the number and size of larvae observed.
14. The first signs of infestation are most often feeding marks by first instars. They typically only feed superficially on one side of the leaf, and create damage that looks like pin holes, shot holes and 'window panes', or windowing (Figure 5a). Young FAW larvae use 'ballooning' (spreading by wind on a thread of silk) to spread to new host plants (Figure 5b). The small airborne larvae have no control on what plants or crops they land on.

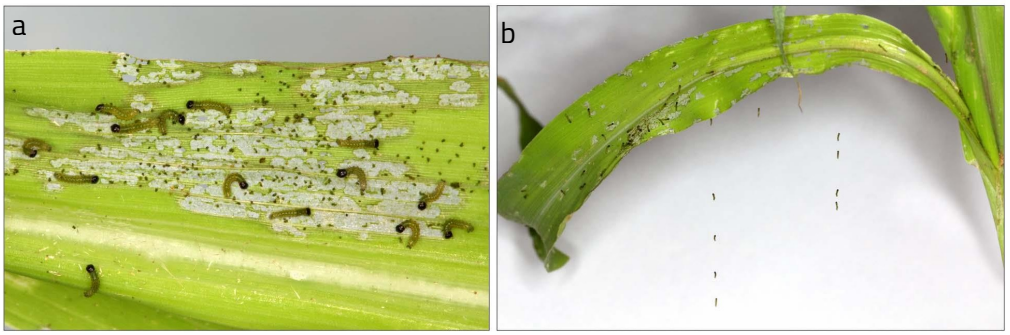

Figure 5. (a) FAW first instar feeding damage (b) 'ballooning' behaviour

3. IDENTIFY

Positively identify FAW by consulting with an industry specialist

1. Familiarise yourself with the key markings and characteristics of FAW through its various growth stages (Figures 6, 7, 8 and 9).

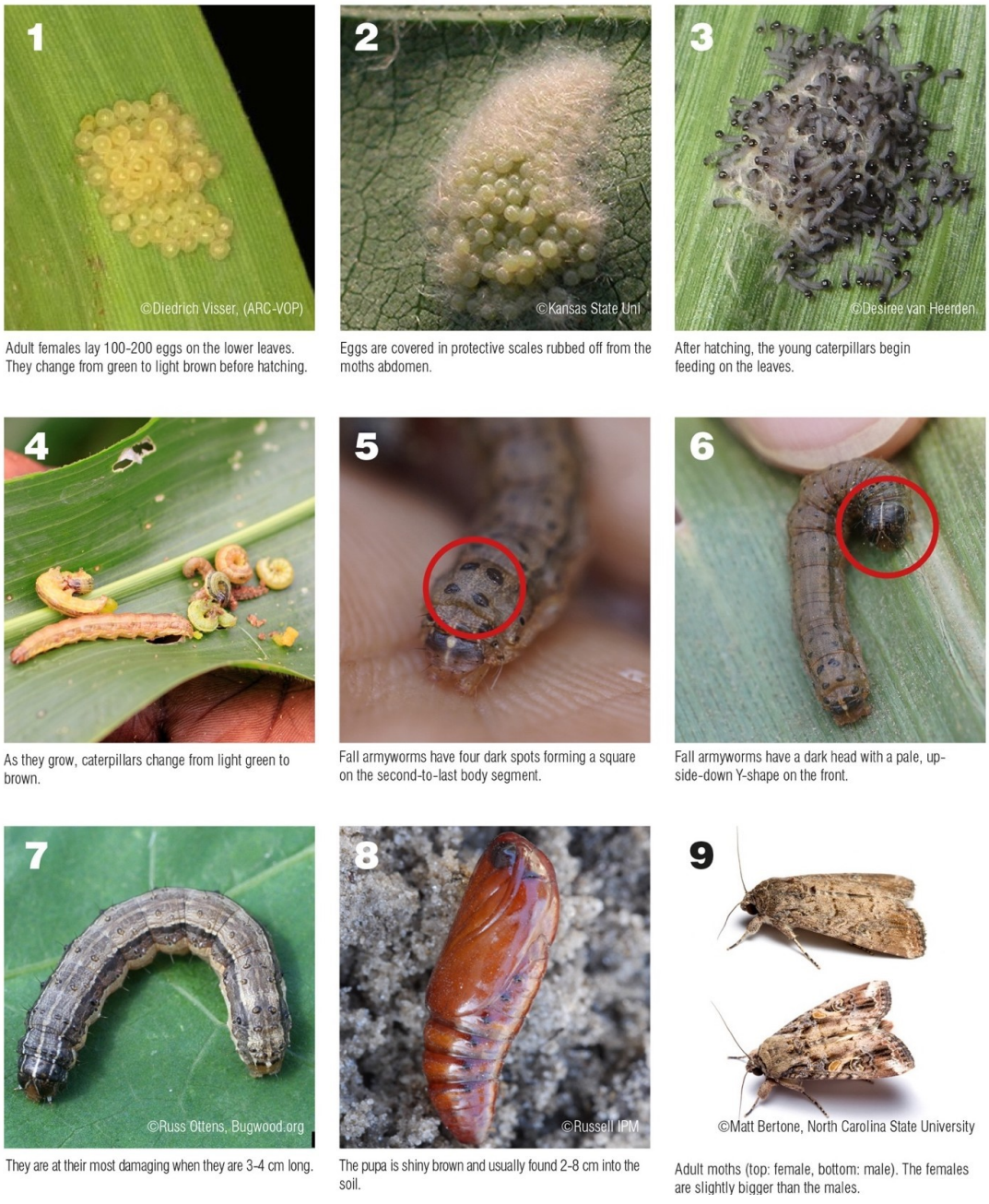

Figure 6. Key identification characteristics of FAW. CABI, 2019

2. Use a hand lens (10x) or hand magnifier to identify key characteristics of captured moth and larval samples.

3. Confirm pest identity by consulting with your local agronomist or crop protection specialist. Diagnostic labs with taxonomic capability, such as your state department of agriculture are also able to provide accurate identification.

Figure 7. FAW armyworm male and female adult moths

4. Fall armyworm moths are nocturnal, i.e. active during the evening and rest during the day. They are sometimes found hiding between maize leaves or in whorls. Male moths find females by following pheromones released by the females. Mating takes place and eggs are laid in masses, two or three days later.

5. Eggs are laid in masses on leaves, mostly on the underside, but also on the upper side and on stems (Figure 8). Females can deposit eggs in more than one layer before they are covered by hairs from the abdomen of the female moth. Egg masses without hair covers may also be encountered. Eggs may be cream-coloured, green or brown, but the whitish colour of the hair covers is easily observed on the green leaves. The presence of egg masses plays an important role in the scouting process.

Figure 8. FAW egg masses

6. Larger caterpillars have characteristic marks and spots (Figure 9). Marks that are often used for identification include the upside Y mark on the head region and the four larger spots on the second last segment. The most common distinguishing characteristics (lines and spots) are indicated below. Note: variations from the illustrations above may be encountered, and other non-related caterpillars may show similar marks and spots, although usually not as vividly as in FAW.

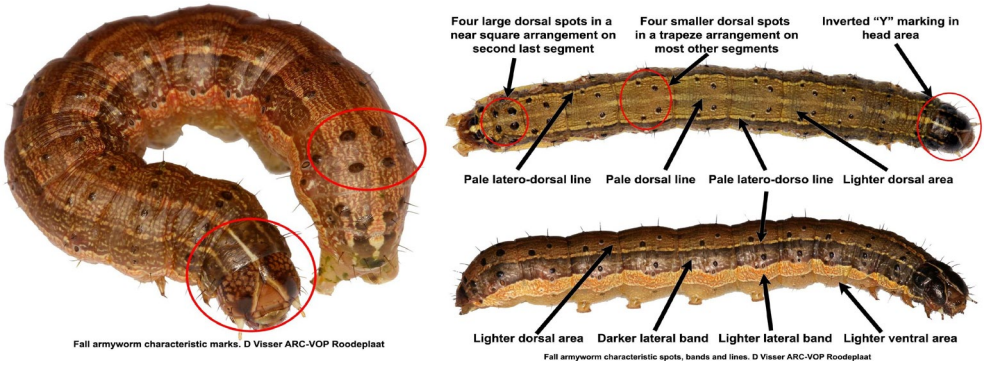

Figure 9. FAW characteristic marks

7. If the crop is not inspected regularly, FAW infestations, may only be noted at later larval stages, when feeding damage is observed. In maize, large holes accompanied by larval droppings (frass), are noticed in the whorls or on surrounding leaves. When dry, the excrement takes on a characteristic appearance of sawdust. Larger larvae usually hide deep in the whorl while the excrement they produce serves as a protective barrier or plug which also helps to camouflage them from predators.

Figure 10. FAW damage to young maize plants

4. THRESHOLDS

Insect pest and damage thresholds

1. Having positively identified FAW, determine your economic threshold in terms of pest pressure and damage threshold. Threshold values from the USA are recommended to guide FAW management decisions in Australia until local thresholds are available (Table 1).
2. Aggressive action to kill FAW larvae should only be taken after numbers reach these thresholds
3. For maize, the threshold for control is reached when 3 or more larvae are found per plant, or 20% of whorl stage plants have 1 or more larvae. When making this assessment, it is essential that a positive identification of FAW larvae is established.
4. For sorghum, control is warranted when damage results in more than 30% defoliation, or there are 1–2 (or more) larvae per whorl. If the infestation occurs during the grain fill stage, use the online *Helicoverpa* economic threshold calculator available at **thebeatsheet.com.au**

Table 1. Best evidence thresholds for a range of crops based on USA data

CROP	THRESHOLD
Maize **vegetative**	>3 larvae per plant and/or 50% of plants show signs of fresh feeding
Maize **whorl stage**	>20% of plants at whorl stage with one or more larvae and/or more than 75% of plants showing signs of feeding damage
Sweet corn **Tassel emergence**	>15% of plants infested at tassel emergence
Sorghum **vegetative**	>30% defoliation, or there are more than 2 larvae per whorl
Sorghum **grain fill**	Economic thresholds (ET) can be calculated using the following formula: ET = (C × R) ÷ (V × N × 2.4), where C is cost of control ($/ha), R is row spacing (cm), V is value of crop ($/t), N is number of heads/m row, 2.4 is damage (g/larva)
Cotton	No established threshold
Soybeans **vegetative**	>33% defoliation
Soybean **budding-podding**	3 larvae /m^2
Pasture **(hay production only)**	18-27 larvae / m^2 There are currently no permits available for FAW control in pastures.

5. When scouting for FAW, examine plants for characteristic leaf damage. The Davis scale has been developed to rate the extent of leaf damage. The rates are from 1 = no foliar damage to 9 = severe foliar damage. Larger larvae consume significantly greater leaf material than younger larvae and are best controlled when young. Plant damage caused by FAW does not necessarily result in yield loss.
6. Visual rating scales for leaf damage assessment.

Scale	Description
0	No visible leaf damage
1	Only pinhole damage on leaves
2	Pinhole and shot hole damage to 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	Elongated lesions (30 cm) and large portions eaten on 70% of leaves
9	Most leaves with long lesions and complete defoliation observed

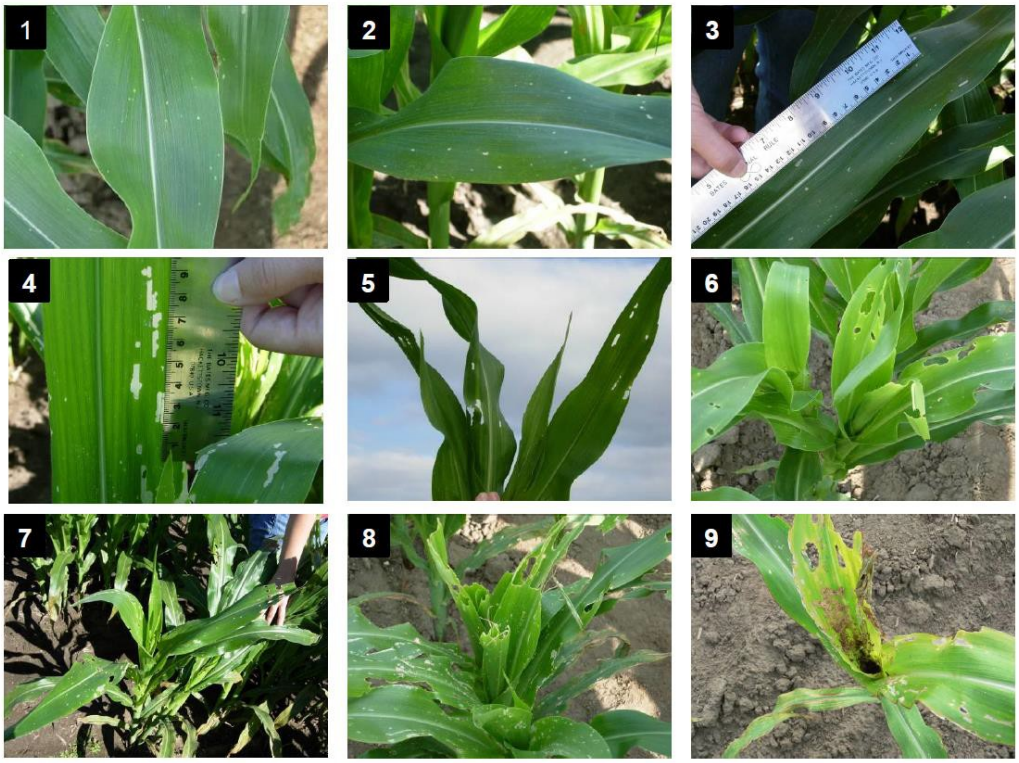

Figure 11. Visual guide of Davis Scale (Source: DuPont Pioneer, Brazil)

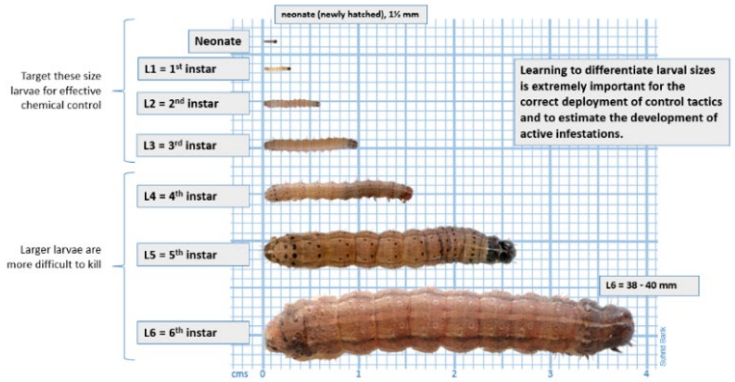

Figure 12. Relative size differences of FAW larval instars and the timing of control tactics

5. ENACT

Make informed decisions and act decisively

1. Do not spray unnecessarily, only spray when economic thresholds are reached.
2. As there may be multiple infestations within a season, multiple treatments may be required.
3. Consider spraying when larvae are actively feeding (e.g. out of the leaf whorls), for instance early morning or at dusk to maximise effectiveness. This is also when honeybees and other pollinators have returned to their hives. During these times be aware of surface temperature inversion conditions as these are unsafe for spraying as the potential for spray drift is high.
4. Select insecticides that have minimal impact on natural FAW enemies, beneficial insects and honeybees.
5. Where possible, avoid the use of broad spectrum foliar applied insecticides in the production system for both larvae and moth control. If broad-spectrum insecticides are to be used, apply at timings when preservation of beneficial species is less likely to be important – i.e. at end of growing season
6. Always follow label and permit directions for individual insecticides.
7. Practice IPM and follow resistance management strategies **croplife.org.au/resources/programs/resistance-management/various-fall-armyworm-spodoptera-frugiperda**
8. Spray smart. Timing and coverage are both critical to achieving good control of FAW. Inappropriate timing risks crop loss and the costs of retreating and increases the likelihood of insecticide resistance.
9. Once thresholds are reached, do not delay; manage the crop early and accurately. Target early instar stages (hatching larvae) of the pest before they become entrenched in the crop (e.g. lower whorl of maize, sweet corn or grain sorghum).
10. When spraying an insecticide: a) use enough water to ensure thorough coverage of the crop; b) use a well calibrated, functioning boom spray with appropriate water rate for the target crop to ensure optimum spray coverage; c) use the full insecticide rates as stipulated on the relevant permit or label; d) use an adjuvant if stipulated on the relevant permit or label.
11. Inspect the performance of application 3 to 4 days after treatment.
12. Always document the effectiveness of each insecticide application and never re-spray a failure with an insecticide with the same Mode of Action (MoA).
13. Do not treat successive generations of FAW with products of the same MoA
14. Rotate insecticides from different MoA groups, especially for crops that currently only have one or two chemicals permitted or registered within a MoA group.
15. Plan future insecticide decisions considering permit and label instructions, such as the maximum number of applications per crop per season, minimum reapplication interval and minimum withholding periods if considering using the crop for feed.
16. Where possible, an Area Wide Management strategy should be adopted where the same MoA insecticides are used by all growers in the same time period.
17. Keep abreast of the evolving FAW status in your area through local newsletters and grower networks.

Reporting

Each jurisdiction has differing reporting requirements for pests of biosecurity concern. For FAW, the reporting requirements within each state or territory are outlined below.

New South Wales

Fall armyworm (*Spodoptera frugiperda*) is a notifiable plant pest in NSW. All notifiable plant pests and diseases must be reported within one working day. You can report notifiable plant pests and diseases by one of the following methods:

Call the Exotic Plant Pest Hotline 1800 084 881.

Email **biosecurity@dpi.nsw.gov.au** with a clear photo and your contact details.

Complete an **online form** at **dpi.nsw.gov.au/biosecurity/report-a-pest-or-disease**

Queensland

Early detection and reporting are key elements in controlling fall armyworm.

If you suspect fall armyworm, report immediately to the Department of Agriculture and Fisheries on 13 25 23.

Victoria

Report any unusual plant pest or disease immediately to the national Exotic Plant Pest Hotline on 1800 084 881.

Early reporting increases the chance of effective control and eradication. Alternatively, you can make a report via our online form via **forms.bio.vic.gov.au/public-reporting** together with a photo (where possible).

South Australia

Report any unusual sightings of caterpillars, reports or identification requests via the **PestFacts Map online report form**.

Insect identification services in South Australia are free to subscribers of PestFacts SA and is open to confirming species identification of caterpillars.

Western Australia

Early detection and reporting of fall armyworm will help protect the State's plant industries and the environment. If you suspect fall armyworm in your crops, home garden or urban area, make a report using:

MyPestGuide™ Reporter (app or **online** tool), or Pest and Disease Information Service (PaDIS) by calling 08 9368 3080 or emailing **padis@dpird.wa.gov.au**

Northern Territory

For more information on control measures contact the Department of Primary Industry and Resources, Entomology unit on 08 8999 2258 or via email **insectinfo@nt.gov.au**

Useful resources

Department of Primary Industries and Regional Development, Western Australia
agric.wa.gov.au/plant-biosecurity/fall-armyworm-western-australia

The Department of Primary Industries and Regions South Australia
pir.sa.gov.au/biosecurity/plant_health/emergency_and_significant_plant_pests/fall

Agriculture Victoria
agriculture.vic.gov.au/biosecurity/pest-insects-and-mites/priority-pest-insects-and-mites/fall-armyworm

New South Wales Department of Primary Industries
dpi.nsw.gov.au/biosecurity/plant/insect-pests-and-plant-diseases/fall-armyworm
lls.nsw.gov.au/news-and-events/news/nc-news/2020/newsletters/winter-2020/fall-armyworm-update

Grains Research and Development Corporation
grdc.com.au/resources-and-publications/resources/fall-armyworm

Department of Agriculture and Fisheries Queensland
business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/priority-pest-disease/fall-armyworm
business.qld.gov.au/industries/farms-fishing-forestry/agriculture/crop-growing/fall-armyworm
publications.qld.gov.au/dataset/queensland-fall-armyworm-resources

Sugar Research
sugarresearch.com.au/pest/fall-armyworm

Northern Territory Government
nt.gov.au/industry/agriculture/food-crops-plants-and-quarantine/fall-armyworm

The Beat Sheet
thebeatsheet.com.au/key-pests/fall-armyworm
thebeatsheet.com.au/fall-armyworm-should-you-be-concerned

CottonInfo
cottoninfo.com.au/publications/insect-id-guide-endemics-exotics

Department of Agriculture Water and the Environment, Australian Government
agriculture.gov.au/pests-diseases-weeds/plant/exotic-armyworm

Fall Armyworm Management – **Quick Guide**

Assess

Assess your inherent regional risk.

Check the risk zones to determine whether you are in a zone where FAW risk is all of the time, most of the time or some of the time.

FAW is predicted to be present all year in Zone 1, present in all seasons apart from winter in Zone 2 and present in summer and autumn in Zone 3 (Figure 1).

Find

Early detection is critical to ensure effective timing of control measures.

The first indicators of FAW arrival in your area is likely to be the presence of migrating moths in Zone 2 and 3 and/or emerging moths from Zone 1 and 2.

Use pheromone-baited traps to detect early moth arrival and activity in the region.

There are a number of commercially available bucket or pheromone traps that attract male adult FAW. These can be sourced online via retailers such as Bugs for Bugs, **bugsforbugs.com.au/product/bucket-trap** and Grochem Australia, **www.au.grochem.com**

Identify

Accurately identify pests by consulting with your local agronomist or crop protection specialist.

Larger caterpillars contain characteristic marks and spots. Marks used for identification include the

1. upside Y mark on the head region,
2. four larger spots on the second last segment and
3. three white stripes on first segment behind the head.

Thresholds

Aggressive action to kill FAW larvae should only be taken after numbers reach economic thresholds.

For maize, a guidance threshold for control is reached when 3 or more larvae are found per plant, or 20% of whorl stage plants have 1 or more larvae. When making this assessment, it is essential that a positive identification of FAW larvae is established.

For sorghum, control is warranted when damage results in more than 30% defoliation, or there are 1–2 (or more) larvae per whorl. If the infestation occurs during the grain fill stage, use the online *Helicoverpa* economic threshold calculator available at **The Beatsheet**.

Enact

Do not spray unnecessarily, only spray when economic thresholds are reached.

Focus spraying when larvae are actively feeding (e.g. in maize, out of the leaf whorls) during early morning or at dusk to maximize effectiveness.

Always follow label or permit directions for individual insecticides.

Spray smart. Timing and coverage are both critical to achieving good control of FAW. Inappropriate timing risks crop loss and the costs of retreating and increases the likelihood of insecticide resistance.