Manual on

Integrated fall armyworm management
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Preface

In late 2018, the Fall Armyworm (FAW) was detected in Myanmar, and it is clear that adequate measures are needed to manage the pest. Recognizing the need, the Food and Agriculture Organization of the United Nations (FAO), the Plant Protection Division (PPD) the Department of Agriculture at the Ministry of Agriculture, Livestock and Irrigation has prepared this manual on "Integrated Fall Armyworm Management" in Myanmar.

For the FAO, it reflects our commitment to increasing the resilience of agricultural livelihoods at risk of crises. More importantly, it presents a significant step towards providing farmers and frontline community extension service providers with easy-to-use information on how they can manage FAW within their smallholder cropping systems.

The manual consists of six chapters. **Chapter 1** provides a history of FAW infestation and spread to Myanmar and outlines response measures of the PPD, Department of Agriculture (DoA), the General Administration Department, and farmers to manage the spread of FAW. **Chapter 2** examines the FAW identification processes, including signs and symptoms of FAW damage on maize. **Chapter 3** highlights the importance of monitoring, surveillance, and scouting for the successful implementation of an effective Integrated Pest Management (IPM) program. It provides recommendations for monitoring and management processes for farmers. **Chapter 4** explores other methods of using organisms to manage the spread of FAW. **Chapter 5** presents some low-cost cultural practices and landscape management options that can be implemented as part of an effective Integrated Pest Management (IPM) strategy against Fall Armyworm (FAW). Finally, **Chapter 6** outlines the safe handling of pesticides.

The manual is a resource for experts and farmers in agriculture, and it is part of our efforts to reduce the current infestation and spread of FAW in addition to developing sustainable management strategies by strengthening the capacities of relevant stakeholders at all levels.

In conclusion, I wish to acknowledge the efforts and commitment of many individuals, who provided substantive and technical inputs to the various drafts of this manual.

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Chapter 1
Introduction of fall armyworm (FAW)

1.1. History of emerging fall armyworm

Native to the America, the fall armyworm (FAW; *Spodoptera frugiperda* (JE Smith); was first reported to be present in Africa in 2016 (Goergen *et al.*, 2016). Since then, it has become a very destructive invasive pest in sub-Saharan Africa. Its main impact is on maize crops, which it attacks: it affects the crop at different stages of growth, from early vegetative to physiological maturity. Fall Armyworm (FAW) was first detected in India in July 2018 and by January of this year; it had spread to Sri Lanka, Bangladesh, Myanmar, Thailand and China.

Although FAW shows a definite preference for the Poaceae it displays a wide host range attacking over 80 different plant species including major crops such as cotton, groundnuts, sorghum, wheat, potatoes, soybean and sugarcane. A number of fruit trees, ornamental plants and weed species are also hosts to the pest. Its polyphagous nature presents challenges in management due to the presence of numerous alternative hosts outside the production season of main crops.

FAW moths have both a migratory habit and a more localized dispersal habit. In the migratory habit, moths can migrate over 500 km (300 miles) before oviposition. When the wind pattern is right, moths can move much larger distances: for example, a flight of 1 600 km from the southern United States of America to southern Canada in 30 hours has been recorded (Rose *et al.*, 1975).

FAW generations will be continuous throughout the year wherever host plants are available, including off-season and irrigated crops, and climatic conditions are favorable. Based on an evidence note published by the Centre for Agriculture and Bioscience International (CABI) in September 2017, in the absence of proper control methods, FAW has the potential to cause maize yield losses of 8.3 to 20.6 metric tonnes per year. In addition to FAW’s emerging economic and food security impacts, initial responses to the pest highlight the potential for negative human and environmental health impacts. In particular, extensive, indiscriminate, and unguided use of synthetic pesticides is already being reported anecdotally from several countries in SSA for controlling FAW in farmers’ field. Substantial environmental and human health issues are arising from both the initial application of hazardous chemicals and continued exposure to pesticide residues on consumed produce or in the production environment. This can result in several critical problems: damage to populations of natural enemies and predators of FAW and other major pests, further impeding sustainable management of FAW and other pests.
Particularly high risk of pesticide exposure for women and children at the farm level, as women primarily manage agricultural operations.

Plant Protection Division (PPD) issue a warning message to Myanmar farmers that FAW, a new armyworm species with highly destructive and different from the existing one could invade Myanmar soon as it was already present in India according to a report by FAO in August 2018. The PPD staff in different regions and states across the country inspected the fields for the infestation of FAW and its presence was reported from some maize fields of Mandalay region, Shan State (East), Ayeyarwady region and Sagaing region in December 2018. The pest was identified and confirmed as Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) in January 2019.

It is therefore important first to ensure the safe use of such pesticides by farmers, but also, at the same time, to promote and deploy against FAW an integrated pest management (IPM) package made up of proven, sustainable and available technologies. Such a package should include: effective monitoring, scouting and surveillance; timely and need-based application of environmentally safer and low-risk synthetic pesticides and biorationals; conservation of indigenous natural enemies and classical biological control; deployment of cultivars with tolerance or resistance; promotion of low-cost agronomic practices/cultural control; and habitat management strategies, including push-pull technology.

Farmers therefore need the right advice, tools and resources to sustainably manage FAW. This manual presents a significant step towards providing farmers and frontline community extension service providers with easy-to-use information on how they can manage FAW within their smallholder cropping systems. It provides information about modules for training trainers in FAW pest diagnostics, scouting, management and data collection. It sets out the information that those delivering such training need to know. The objective of this training is to provide the trainers, and farmers, with the knowledge and skills that will enable them to: identify FAW, and differentiate it from other similar pests; understand the life cycle of FAW; and know how to monitor and manage the pest.

This manual gives the trained trainers all the information they will need in order to support and sustain an IPM approach for FAW management in their communities, and it provides information that will allow trainers to provide behavioral change communication targeted at farmers.
1.2. Arrival and spread of fall armyworm (FAW)

Since FAO reported that Fall Armyworm (FAW), Spodoptera frugiperda (J.E. Smith) (Lepidoptera: Noctuidae) was already present in the neighbouring countries like India, Sri Lanka and Bangladesh, Myanmar issued warning message to all region and states across the country to get awareness the possible invasion of the new pest not existed before in the country on 17th August 2018.

A workshop entitled “Fall Armyworm (FAW) in Myanmar” was held at PPD Head Office in Yangon jointly organized by the Department of Agriculture, MOALI and Centre for Agricultural and Biosciences International (CABI) on 5th December 2018. In this workshop, the biology and ecology of FAW, the possible invasion to Myanmar, prevention and control measures to be taken in case the pest invades soon were discussed and action plan was developed to be ready for immediate response to the attack of invasive pest.

A team comprising Regional/State and district level staff of DOA and PPD led by the Deputy Director General (Technology) of DOA and Director of PPD inspected the seed-corn fields in Myingyan township, Myingyan district, Mandalay region and Nay Pyi Taw and Tatkon township in Nay Pyi Taw Council Area from 18th to 22nd December 2018.

As it was reported the infestation of FAW in Nyaungdon township, Maubin district, Zalun and Hinthada townships, Hinthada district, a team comprising the staff from the relevant townships and district led by DDG (Technology) and Director of PPD conducted field observation in seed corn plantations in those areas on 4th to 6th December 2018. Pest samples (all stages of FAW) were taken to rear in the laboratory for further identification. Meetings were held to educate farmers to raise awareness of the invading pest as well as to take action at the same time before severe damage was done by the pest.

According to the morphological feature of the pest samples collected from the corn fields, it was identified as *S. frugiperda* which has never been recorded before in Myanmar. It is essential to develop strategic plans to take immediate action as well as long-term plan for the management and to prevent further spread across the country.

The staff from PPD Head Office, Regional/State and district level in cooperation with extension staff from DOA made concerted efforts to inspect the fields for the infestation of FAW. The team also trained maize farmers how to manage the invading pest by in a varieties of control measures including hand picking and destruction of egg masses and larvae, the safe and efficient use of pesticide, encouraging to use biopesticides as much as possible. The team also carried out mass campaigns to raise the awareness of the farmers with FAW by using vinyl, posters, billboard, factsheets, pamphlets and booklets.
The team of DoA also used a lot of media channels including newspaper, journal, TV, radio, etc to raise the awareness of farmers across the country.

As the seed corn growing area in Myanmar was about 2,009,861 ac (1,249,241 acres of seed corn and 760,620 ac of vegetable corn) as of end of December 2018, it is very important to prevent further infestation of FAW and causing severe damage to the crop affecting corn production. The integrated management encompassing the collection and destruction of egg masses, larvae and pupae in the crop and using pesticide as a last resort when all other control measures fail to work. All of these tasks need to be done as a concerted effort of all stakeholders: staff from PPD, DOA, the General Administration Department and farmers as community activities.

**Key messages**

- Fall armyworm invaded Myanmar in December 2018
- PPD issued warning message to the farmers the possible invasion of fall army worm in August 2018
- PPD held a national level workshop on fall armyworm in collaboration with CABI in early December 2018
- PPD and DOA staff inspected the fields and took immediate actions to control the invading pest
- Heavy infestation occurred on winter maize in Ayeyarwady Region in 2019
- Preparation were made to prevent infestation in Shan State where maize was planted on 700,000 acres
Chapter 2
Identification of fall armyworm

2.1. FAW lifecycle

Figure: Eggs are laid in masses on leaves, mostly on underside of leaves but also on upper side and on stems. The female moth cover the eggs by anal hairs.

Figure: Young FAW larvae use ballooning (spreading by wind on a thread of silk) to spread to new host plants. Young larvae are greenish with a black head, the head turning a more orange color. The face of the mature larva may also be marked with a white inverted “Y” and a set of four large spots that form a square on the upper surface of the second last segment of its body.

Figure: Reddish brown pupae and the FAW adult moth (a) male and (b) female.
2.2. Egg

- The egg measures about 0.4 mm in diameter and 0.3 mm in height.
- The number of eggs per mass varies considerably but is often 100 to 200, and total egg production per female averages about 1,500 with a maximum of over 2,000.
- The female also deposits a layer of grayish scales between the eggs and over the egg mass imparting a furry or moldy appearance.
- Duration of the egg stage is only 2 to 3 days during the warm summer months.

2.3. Larval stage

- Larvae generally emerge simultaneously three to five days following oviposition, and migrate to the whorl.
- The mortality rate following emergence may be high in some cases due to climatic factors and attack by predators, parasitoids and pathogens.
- The FAW typically has six larval instars. Young larvae are greenish with a black head, the head turning a more orange color in the second instar.
- Head capsule widths range from about 0.3 mm (instar 1) to 2.6 mm (instar 6), and larvae attain lengths of about 1 mm (instar 1) to 45 mm (instar 6).
- In the second instar, but particularly the third instar, the dorsal surface of the body becomes brownish, and lateral white lines begin to form.
- In the fourth to sixth instars the head is reddish brown, mottled with white, and the brownish body bears white sub-dorsal and lateral lines. Elevated spots occur dorsally on the body; they are usually dark in color and bear spines.
- Duration of the larval stage tends to be about 14 days during the warm summer months and 30 days during cooler weather.

**Distinguish Behavior of Larvae**

- The face of the mature larva may also be marked with a white inverted “Y” and the epidermis of the larva is rough or granular in texture when examined closely.
- The best identifying feature of the FAW is a set of four large spots that form a square on the upper surface of the last segment of its body. Larvae tend to conceal themselves during the brightest time of the day.

2.4. Pupal stage

- Pupae are reddish brown and may be hard to find for a typical farmer.
- Pupation normally takes place in the soil, at a depth of 2 to 8 cm. The larva constructs a loose cocoon, oval in shape and 20 to 30 mm in length. In some instances, the
pupae may also be found in the maize cob. The duration of the pupal stage is about eight to nine days during the summer, but reaches 20 to 30 days during the winter.

- If the soil is too hard, larvae may web together leaf debris and other material to form a cocoon on the soil surface.

2.5. Adult stage

- Adult moths are 20 to 25 mm long, with a wingspan of 30 to 40 mm. The scale and color pattern on the forewings of moth are different between male and female.
- In the male moth, the forewing generally is shaded gray and brown, with triangular white spots at the tip and near the center of the wing. It has the kidney-shape spot with fainted black lining, V-shape marking, an oval shape brown colored spot and a distinct diagonal stripe and a line of black dots at the periphery of the forewing.
- The forewings of female moths are less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown.
- The hind wing is iridescent silver-white with a narrow dark border in both sexes.
- Adults are nocturnal, and are most active during warm, humid evenings.
- The life cycle of female adult is 15-21 days.
- The female moth starts to lay eggs at the age of three - four days and continue until they become 3 weeks old.

The duration of life cycle lasts for about 30 days at 28°C and it may take longer, 60-90 days when the weather is cooler. If conditions are favorable, they feed and breed on the crop year-round.
Description of the FAW lifecycle
2.6. Signs and damage symptoms of FAW

- The pest can affect the crop at different stages of growth, from early vegetative to physiological maturity.
- When the plants are young and the leaf tissues are soft, first-instar FAW larvae produce clusters of pinhole-type damage or small, round “window panes”.
- Later on, as the leaf tissues mature and become more fibrous and tough, window panes may be scattered and elongated rather than clustered. The width of the window panes reflects the width of the larval head capsule.
- Whorl-feeding-damage results from damaged-leaves expanding out of the whorl, producing a horizontal series of holes across a “pinch” in the leaf.
- Later larval instars chew larger holes, causing ragged whorl leaves, and produce sawdust-like larval droppings, while fresh feeding produces big lumps. Damage to cobs may lead to fungal infection and aflatoxins, and loss of grain quality.
- When badly infested fields may look as if they have been hit by a severe hailstorm, they feed inside whorls and can destroy silks and developing tassels, thereby limiting fertilization of the ear.
- Larvae move to the ear zone and start feeding after tassel emergence because they get exposed to natural enemies.
2.7. Host plants of FAW

The FAW has a very wide host range, with over 80 plants recorded. The most frequently consumed plants are field maize and sweet maize, sorghum, Bermuda grass, and grass weeds. Field crops are frequently injured, including alfalfa, barley, Bermuda grass, buckwheat, cotton, clover, maize, oat, millet, peanut, rice, ryegrass, sorghum, sugar beet, Sudan grass, soybean, sugarcane, timothy, tobacco, and wheat.

2.8. FAW strains

FAW consists of two strains adapted to different host plants. One strain (the “maize strain”) feeds predominantly on maize, cotton, and sorghum while the second (the “rice strain”) feeds primarily on rice and pasture grasses (Dumas et al., 2015a). The two strains are morphologically identical but differ in pheromone compositions, mating behavior, and host range.

Conditions that favor survival of FAW

The rate at which FAW larvae develop is affected by diet, temperature and humidity. Rising temperatures increase rates of insect development and the number of pest generations. In cooler climates, development slows down to one or a few generations per year.

The optimum temperature for larval development is 28°C (development can take place within a range of between 11°C and 30°C), although the egg stage and pupal stage require slightly lower temperatures. Frost kills the insect. Rainfall may wash off some of the immature stages of the insect and wind speed may aid the dispersal of moths. Higher CO₂ and O₃ (ozone) concentrations may change natural enemy numbers and behavior that might affect host-finding and predation.

While FAW can damage maize plants in nearly all stages of development, it will concentrate on later plantings that have not yet silked. FAW can only be effectively controlled while the larvae are small (before third instar). Controlling larger larvae (fourth to sixth instars), typically after they are hidden under the frass, is much more difficult and costly.
The maize growth cycle in relation to crop health and FAW

**Fig.** Maize growth stages [VE to V6 (early whorl growth stage), V7 to VT (late whorl stage), R1 to R3 (tasselling and silking)]

2.9. Identifying maize growth stage

Properly identifying the growth stage helps inform the decision as to whether to treat the maize field and, if so, how.

Generally, maize growth stages are divided into Vegetative (V), Tasseling (T), and Reproductive (R). The V stage of the maize is defined as the number of maize leaves displaying a leaf collar and not the total number of leaves on the plant. For example, the maize plant displayed. It is in the V3 stage, not the V5 stage.

A useful simplification is to call the VE to V6 stages “Early Whorl,” the V7 to VT stages “Late Whorl,” and the R1 to R3 stages “Tasseling & Silking.” The latter terms are used in the scouting and Action Threshold recommendations.
The growing point of maize is below ground until the end of the Early Whorl stage (about V6)\(^1\), at which point it can be damaged by FAW causing a condition known as “Dead Heart”.

Application of pesticide, if needed, is also easier to target into the whorl at the earlier V stages and also has the advantage that the treatment can more directly and easily control the early instars (first to third) of the FAW. Finally, pesticide exposure is much lower at these early growth stages because the pesticide applicator is not directing the spray overhead.

As the maize plant matures, i.e. post Late Whorl stage (V7 and beyond), it will be progressively more difficult to get uniform applications of pesticide into the whorl. In addition, later-instar FAW larvae (fourth to sixth instars), if present, may block the whorl with frass (insect excreta), suppressing the ability of the pesticide to effectively reach and affect FAW larvae.

At the VT stage the emerging tassel may push the larger FAW larvae out of the whorl. These larvae then frequently move to the growing ear, and frequently bore into the side of the ear.

The first generation of FAW emerging at the V2 stage could complete development, pupate, emerge, mate, and re-infest the maize crop at the maturity stage during the same planting season. In many instances where FAW is endemic, the maize crop can be often seen with overlapping generations of FAW on the same plant.
Chapter 3
Importance of surveillance, monitoring and scouting

Monitoring, surveillance, and scouting are critical activities necessary for successful implementation of an effective Integrated Pest Management (IPM) program. Certain control measures based on the use of resistant variety, bio-control agents and cultural practice are preferable to use as first line of defense as they have less adverse effects on human-beings, animals and environment. Integrated pest management should be used for the control of FAW based on the local conditions, cropping pattern and the experience of the farmers. Chemical pesticides should be used sensibly when the pest population exceeds the economic threshold level so that to avoid misuse and over-use. Whenever IPM is used, the following points should be clearly understood:

- The life stages of the pest;
- Scouting (both pest and natural enemies);
- The right stage of pest to control; and
- Control measures that cost less.

Monitoring, surveillance and scouting are necessary for the quick detection of the presence of FAW and in order to time interventions to effectively and economically guard against yield loss while preserving needed ecosystem services and minimizing harm to the environment. Surveillance of FAW should be done throughout the year because there are several generations, which attack maize at different stages; they also attack other host plants. During the dry season, irrigated areas become host reservoirs of FAW populations, from which migration occur at the beginning of the rain season. Monitoring and controlling the populations on off-season crops can be critical in reducing infestation on rain-fed crops.

3.1. Scouting

Scouting is the use of science-based protocols by trained individuals (extension staff or farmers) to observe the pest in their fields. Scouting allows the farmer to assess pest pressure (e.g. the intensity of FAW infestation) and crop performance in the field. “Scouting” means rapidly and systematically determining overall crop health and estimating presence of certain organisms causing damage and potentially yield reduction. Scouting is typically performed in order to evaluate both the economic risk of pest infestation and the potential efficacy of pest control interventions. Early detection of FAW infestations requires timely and regular field scouting. Timing may be aided by use of
pheromone traps set up in the farmers’ fields before planting throughout the growing season, to trap male moths; catches are recorded weekly.

3.1.1. How to scout and what to look for when scouting

The aim of scouting is the early detection of the egg batches or young larvae, which are easier to control. Scouting should begin early, at the seedling stage. FAW completes its lifecycle in 30–40 days and the first generation of FAW larvae generally attacks the seedlings, so fields should be rechecked weekly at the seedling and early whorl stages. Farmer scouts should look for signs of FAW egg masses (presence/absence of egg masses even in the absence of damage), egg hatch and feeding by early-instar larvae, such as leaf damage pin holes, “window panes”, frass, ragged and torn leaves, destruction of leaves in funnels, silk, tassel and ear damage, holes in the ear and pupae in the soil.

3.1.2. Scouting technique and protocols

Scouting a maize field involves accurately assessing the level of FAW infestation, usually expressed as a percentage of infested plants. A quick visual assessment in the field can be used to identify “hot spots” of FAW damage while moving through the field. Generally, the field should be scouted at least once a week. A field should be scouted in a semi systematic manner. A commonly used approach is the “W” pattern (Fig. 16). Scouting at the Early Whorl Stage (VE-V6), scouting at the Late Whorl Stage (V7-VT) & scouting at the Tassel & Silk Stage (R1-R3) is must & important to determine threshold level and recommendation.

3.1.3. Field scouting for FAW

Scouting is based on knowledge of the pest and the crop agro-ecosystem, coupled with an understanding of intervention triggers and mitigation tools.

- Searching a maize field looking for FAW is not without cost. For example, to search a maize field of 50,000 plants at a rate of 5 seconds per plant would cost almost 70 hours in labor.
- To effectively and economically scout a maize field, sampling techniques should be employed.

3.1.4. Scouting protocols

Once the growth stage of the maize has been identified, use the appropriate scouting protocol to sample the field to sample the field. The focus of scouting should be on early detection; the smaller the insect, the easier it is to control. Ideally, scouting should begin soon after seedling emergence (VE; Early Whorl). FAW completes its life cycle in 30-40
days and the first generation of FAW larvae generally attacks the seedlings, so fields should be rechecked weekly at the seedling and Early Whorl stages.

In general, scouts should look for signs of FAW egg-hatch and feeding by early-instar larvae, rather than looking for the small FAW larvae themselves. The signs include characteristics such as leaf damage, holes in the ear, and frass. It is a fair representation not only of the relative amount each FAW larva eats throughout its life span, but also of the relative size of the larvae at different instars. Neonate (freshly hatched) and first-instar larvae are quite small – on the order of 1 mm – and can be difficult to find. However, with a little practice, farmers can become quite adept at spotting even the small pinhole signs of FAW feeding. By the time FAW larvae are big enough to identify without a hand lens, they are difficult to control.

For all scouting protocols, two additional considerations should be kept in mind:

- **SAFETY:** ALWAYS first determine whether the field has been treated with insecticide and if so, when and with what active ingredient and rate. Pesticides have labeled re-entry criteria, and it is important that scouts not be exposed to hazardous levels of pesticide by scouting in a field that is not safe for re-entry after a recent pesticide application.

- Scouts should always determine if it has rained, and record any rainfall on the scouting form (Section 5). Heavy rain showers can kill the 1st, 2nd, and 3rd instar larvae and even though damage is present in the field, many larvae may have died.

3.1.5. Scouting pattern

Scouting a maize field involves accurately assessing the level of FAW infestation, usually expressed as a percentage (%) of infested plants. A commonly used approach is the “W” pattern.
The scout walks into the field about 5 meters (avoiding the border rows of the field is important to avoid the edge effects). The scout then zigzags the field, stopping at five different locations. At each of these locations the scout assesses 10-20 plants looking for signs of FAW feeding. The percentage of damaged plants is recorded and the scout moves to the next check point.

There is nothing prescriptive about the “W” scouting pattern. The scouting pattern might need to be improvised based on the maize growth stage or field shape. For example, densely planted maize at the Tassel Stage or beyond may be difficult to traverse using the “W” pattern. An alternative is to use the “Ladder” pattern. In this method, rows A-E are used as alleys to more easily traverse the field in a semi-systematic manner.

**Figure.** Sample scouting pattern for maize field at the early and late whorl stages.

**Figure.** Sample scouting pattern for maize field at the VT and Reproductive stages.

3.1.6. Scouting at the early whorl stage (VE-V6)

- Upon arrival at the field, especially small fields, stop and quickly do a visual assessment. Sometimes spot infestations in a field can be seen at this stage. Likewise, scan for “hot spots” while moving through the field.
- Move through the field quickly. Stop five times. Examine a variety of places in the field (but avoid edge rows).
- At each stop, examine 10-20 plants. Focus on the newest two to three leaves emerging from the whorl as this is where the FAW likes to feed and where FAW moths lay eggs.
- In some cases, FAW larvae cut and tear the seedlings. This damage is very similar to cutworm damage. Generally, the offending insect can be found hiding under dirt or debris near the cut plants. Maize stands damaged in this manner may need to be replanted.

When the plants are young and the leaf tissues are soft, first-instar FAW larvae produce clusters of pinhole-type damage or small, round “window panes”. Record the number of seedlings (out of 20) that have these types of damage.
- Because of the nature of overlapping FAW generations, it may be useful to distinguish between old and fresh damage. For the purposes of scouting, record only fresh damage.
- Signs of infested whorls include fresh window panes (in the whorl), FAW larvae, fresh fecal matter (frass), and fresh whorl-feeding-damage.
- Record the number of seedlings that have infested whorls and calculate the percent (%) infestation for this scouting location.
- Now move to the next spot. Examine 10-20 plants. Record the data. Repeat the process a total of five times.
- After scouting the five locations in the field, calculate the total percent (%) infestation across the field. Therefore, there is to determine if the Action Threshold recommends chemical treatment.
- **Action Threshold: Early Whorl Stage:** If 20 percent (range of 10-30 percent) of the seedlings are infested, an insecticide application is justified.

### 3.1.7. Scouting at the late whorl stage (V7-VT)

- Move through the field quickly. Stop five times. Examine a variety of places in the field (but avoid edge rows).
• At each stop, examine 10-20 plants. Examine the newest three to four leaves emerging from the whorl plus the emerging tassel.
• Signs of infested whorls include fresh window panes (in the whorl), FAW larvae, frass, and fresh whorl-feeding-damage.
• Record the number of plants (out of 20) with fresh window panes or infested whorls

3.1.8. Scouting at the tassel & silk stage (R1-R3)

• Move through the field quickly. Stop 5 times. The “Ladder” scouting pattern may prove helpful at this stage. Examine a variety of places in the field but avoid the edges because of edge effects. At each stop, examine 10-20 plants.
• When the tassel emerges, it pushes the FAW larvae out of the whorl. From this point forward, FAW larvae hide in the leaf axils, at the base of the developing ear/cob, and/or in the tip of the ear. (At this stage, there is no whorl left for the FAW larva to hide in.)
• Examine every ear and the silks. FAW larvae not only eat through the middle of the ear, but also infest the tip. Examine a leaf immediately above and below each ear.
• Record the number of plants with any fresh feeding damage, the number of plants that are infested with FAW larvae, and the number of plants that have damaged cobs/ears.
• Make sure to identify any larvae that are found. The best “field mark” for identifying small FAW is the four-dot square on the eighth abdominal segment.
• **Action Threshold: Tassel & Silk Stage:** If 20 percent (range of 10–30 percent) of the tasseling plants are infested with FAW or have ear/cob damage, an insecticide application may be justified.
3.2. Monitoring for FAW

Regional FAW monitoring is intended to actively track the presence, population, and movement of FAW within a specified geography. This is typically conducted by trained technical personnel at sites throughout a country or region, but can also be conducted at the village and field levels by both smallholder farmers and village-level progressive farmers.

In both cases, monitoring typically relies on pheromone traps erected near fields to trap adult male moths. FAW numbers in the traps are counted, recorded, and used to inform appropriate action (typically reporting the data to appropriate authorities and conducting more intensive, targeted field scouting to inform crop management recommendations and decision making).

3.2.1. Trap selection

A pheromone trap is a type of insect trap that uses pheromones to attract (usually) male insects. A pheromone is a chemical secreted by (usually) a female insect to attract males for mating. Pheromones can travel by air very long distances and hence are very useful for monitoring insect presence. Sex pheromones and aggregation pheromones are the most common types of pheromones in use.

Currently there are several different pheromone lures being assessed as well as a variety of trap types. All of these may work, but some pheromone lures also attract a limited number of non-FAW moths, which may cause some confusion.

3.2.2. Monitoring with pheromone traps

Pheromone traps may be used as an additional tool for insect monitoring. The pheromone attracts (usually) male insects. Because pheromones can travel by air over very long distances, their use is very useful for monitoring FAW presence. However, some pheromone lures also attract a limited number of non-target moths. The universal bucket trap is normally used. Adult moths will be attracted to the pheromone and will get stuck on the sticky pad when they enter the trap. Pheromones should be replaced about every four weeks.

3.2.3. Trap placement and setup

- Establish the pheromone trap one month before planting.
- Place the trap in or next to the maize field so that the scent of the pheromone is carried across the tops of the plants by the wind.
• Hang the trap in a vertical orientation from a long pole (3-4 meters) so that the trap is approximately 1.25 meters off the ground.
• When traps are hanging, they should be oriented in the most vertical, straight up-and-down orientation possible, to prevent water from getting in from the side.

3.2.4. Trap checking

• Check and empty the trap every week. To do so, detach the “moth-trap” from the body of the pheromone trap. Turn the moth-trap upside down. Live FAW moths may crawl up the sides of the trap.
• Pinch the thorax of the moths between your thumb and forefinger to freeze the wing muscles to help identify the FAW moths.
• There may be a number of moths other than the FAW in the trap. Sort out and count the FAW moths (wings with white patch near apex of wing; hind wing veins light-colored) and any African Armyworm (AAW) moths (hind wing veins brown-colored) separately.
• As the maize plants grow taller, move the trap up the pole so that the bottom of the trap is always about 30 cm above the plants.
3.2.5. Data recording

The following data should be recorded on a scouting form:

- Date of present recording
- Maize growth stage
- FAW moth counts
- African Armyworm (AAW) moth counts (if any)

Monitoring means the active tracking of the presence, population and movement of a pest within a specified area or region. Monitoring may take place at various levels (community, district, country or regional), mostly facilitated by governments, through trained technical personnel who systematically gather data to inform policymakers and practitioners about the presence and severity of the pest across a given area.

3.3. Surveillance

Surveillance is the informal, passive detection of pests in an area, mainly carried out at farm level. Farmers in the field are often among the first to identify emerging problems. The collective feedback of thousands of farmers can provide powerful information about the dynamics of pest infestation in an area.

3.4. Action thresholds and recommendations

The following table summarizes the current Action Threshold recommendations.

Table 1. Summary of FAW Action Thresholds. Thresholds are expressed as percentages of plants with typical FAW damage/injury symptoms.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Growth stage</th>
<th>% Action Threshold for small holders</th>
<th>% Action Threshold for Key farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early whorl stage</td>
<td>VE – V6</td>
<td>20 percent (10 -30 percent)</td>
<td>20 percent (10 -30 percent)</td>
</tr>
<tr>
<td>Late whorl stage</td>
<td>V7 - VT</td>
<td>40 percent (30 -50 percent)</td>
<td>40 percent (30 -50 percent)</td>
</tr>
<tr>
<td>Tasseling/Silking</td>
<td>R1 – R3</td>
<td>By not spraying insecticides, poisoning to natural enemies can be reduced and support biological control.</td>
<td>20 percent (10 -30 percent)</td>
</tr>
</tbody>
</table>

* We do not recommend that smallholder farmers apply insecticide at or post-VT because it is too dangerous for the applicator and for his or her family.
### Scouting Form

<table>
<thead>
<tr>
<th>Planting Date:</th>
<th>Distinct</th>
<th>Location:</th>
<th>Your name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sampling Date</th>
<th></th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Maize Grow with Stage: |          |           |           |           |
|                       |          |           |           |           |

| Dates of rainfall/irrigation |          |           |           |           |
|                              |          |           |           |           |

| Insecticides Applied/Rates/Dates: |          |           |           |           |
|                                   |          |           |           |           |

| Pheromone Trap Data |          |           |           |           |
|                     |          |           |           |           |

- Keep the bottom of the trap 30 cm above the plant.

| Number of RAW moths: |          |           |           |           |
|                     |          |           |           |           |

| Number of AAW moths: |          |           |           |           |
|                     |          |           |           |           |

#### Early Whorl Stage (VE-V6)

Examine two to three (2-3) newest leaves emerging from the whorl.

<table>
<thead>
<tr>
<th>Five Steps</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Sum</th>
<th>%</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Sum</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Plants with fresh window panes/Total</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>#Plants with infested whorbs/Total</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

#### Late Whorl Stage (V7-VT)

Examine three to four (3-4) newest leaves emerging from the whorl plus the emerging tassel.

<table>
<thead>
<tr>
<th>Five Steps</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Sum</th>
<th>%</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Sum</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Plants with fresh window panes/Total</td>
<td></td>
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<tr>
<td>#Plants with infested whorbs/Total</td>
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</tbody>
</table>

#### Tassel & Silk Stage (R1-R3)

Examine ears plus leaves and leaf initials above, and below the ears.

<table>
<thead>
<tr>
<th>Five Steps</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Sum</th>
<th>%</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Sum</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Plants with any fresh damage/Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>#Plants with worms/Total</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>#Plants with damaged ears/Total</td>
<td></td>
<td></td>
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<td></td>
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</table>
Chapter 4
Recognizing Indigenous Biological Control to Suppress FAW

Introduction

In nature, the population of any organism is regulated. It is kept fluctuating within an upper and lower threshold, often below economically damaging levels, due to the actions of biotic regulations (availability of food, parasites, predators, and/or pathogens) and/or abiotic factors (climate and soil factors).

Such population regulation is referred to as natural control. However, such natural control when disrupted due to biological, anthropogenic, or climatic factors results in the outbreak of organisms leading to economic damage. Invasiveness of a pest species into new geographies in the absence of biotic regulatory factors often results in the disruption of natural control, leading to devastating outbreaks (e.g. fall armyworm (FAW), Spodoptera frugiperda [J.E. Smith]; tomato leaf miner, Tuta absoluta [Meyrick]).

Anthropogenic changes in crop and pest management practices such as introduction of a susceptible crop/cultivar, monocropping, and irrational use of broad-spectrum pesticides, among others, also often result in disruption of natural control, leading to outbreaks of pest and diseases.

Asynchrony in range expansion of pests and their natural enemies due to climate change could also disrupt the natural control. The best approach to manage such outbreaks is to either revive or establish natural control as much as possible. Biological control primarily focuses on restoring the natural control. Biological control, as defined by Paul DeBach (1964), is the action of living organisms (parasites, predators, or pathogens) introduced by human intervention for regulating the population of another organism at densities less than those that would occur in their absence.

4.1. Biological control-based IPM strategies for FAW

Planting crops that provide shelter, alternative food sources, and conditions for multiplication of beneficial species may be key to regulating the FAW population.

- At the edges of maize cultivation areas, rows of crops such as Mexican sunflower or Crotalaria might be suitable components in landscape management with the goal of increasing the biodiversity of beneficial insects, even those that are not yet associated with FAW.
A “Push-Pull” strategy can also be used, in which pest-repellent plant species are intercropped with the main crop to repel (“push”) pests out of the field, which is also surrounded by a border of a pest-attractive species to “pull” both the pest and beneficial insects into it.

4.2. Advantages of using biological control of FAW

- Biodiversification/ mixed cropping rather than growing maize alone on a huge area of land.
- The use of pesticide on maize is less compared with other countries.
- The natural enemies can be conserved to a large number and establishes in the field in long run.
- Farmers can perform mass production of biocontrol agents in collective manner.

4.3. Exploration, augmentation and conservation of indigenous natural enemies (predators, parasitoids, entomopathogenic fungi/bactria/virus).

- PPD and Extension staff of DOA should be trained to acquire sound knowledge on natural enemies in the field.
- The existing natural enemies should be explored in the crop across the country.
- Make the environment to favour the survival and development of natural enemies.
- The efficiency of the natural enemies for the control of fall armyworm should be tested under the laboratory conditions as well as in the field.
- Rearing and releasing should be done if there is no limitation in the technology and finance.

4.4. Inundative release of biological control agent against FAW

*Trichogramma* or *Telenomus* wasps are the best examples of species used in inundative release to control FAW eggs.

Unlike pesticide treatments, which must cover the entire plant (whorl or maize ear) to reach the target pest, egg parasitoids may be released at some point in the target area. Once released, the wasps, with extreme search capacity, fly to the plants seeking the pest’s eggs. Hence, the releases are made at strategic points ranging from 20 to 40 per hectare (Cruz et al., 2016). Considering the very short (less than three days) longevity of the released female and the fact that a new parasitoid generation occurs 10 days after release, it is necessary to make three releases spaced at three day intervals to provide a continual presence of adults in the area. New releases may be necessary if there is a significant increase in the movement of moths into the production area, as indicated by monitoring traps. The inundative release of *Trichogramma/ Telenomus* wasps in maize fields does not reduce the populations of other beneficial specie.
This parasitoid is larger than that of *Trichogramma* and has a black, shiny body. After the complete development of the immature phase of the parasitoid, the adult perforates a small hole in the FAW egg, through which it emerges. After emergence, the farmer may find the parasitoids roaming around the mass of eggs from which they emerged or they may fly away to seek other parasitized masses.

4.5. Importance of other beneficial insects in the natural control of FAW

Based on how biological control is undertaken, it can be broadly classified as follow:
- Classical (inoculative) biological control
- Augmentation (inundative) biological control
- Conservation biological control

Some insects can be used as biocontrol agents as they are predators and parasitoids. There are some entomopathogenic organisms that can causes diseases to insects. Braconid wasps are larval parasitoid and they are important for the control of FAW as the larval parasitoids. As they are bigger in size so they have more competitive power. As the parasitized larvae feed only 10 percent of a healthy one, these larval parasitoids are more efficient. If FAW eggs escaped the egg parasitoid and hatch as larvae, Braconid wasps can be used to parasite them. It is also necessary to explore the existing natural enemies in the region.
Figure: Larval parasitoid *Campoletis* spp

Eggs and Larval parasitoid *Chelonus* spp. 20 mm long, parasitize egg and larvae. Natural parasitism rate is high - 915 in South Africa and Egypt. The duration of parasitoid larva is about 20 days and the feeding rate of FAW is reduced about 15 times.

Host (FAW) larva is dead and the cuticle of FAW larvae changed into the pupal skin of parasitoid.

Size -15 mm, suitable to parasitize 3rd instar (FAW) larvae. The parasitized larvae are smaller in size than the healthy one and its feeding rate is reduced about 15 times.
Earwig is a predator feeding on eggs and larvae of FAW and an important natural enemy that can suppress the FAW people below economic injury level. For example, a predatory earwig, *Doru luteipes* feeds on eggs and larvae of FAW. In addition, they lay their eggs in the whorl or unfolded leaves of maize plant and their habit is very similar to the nature of FAW. They can be reared easily.
There are about 20 eggs in an egg mass. It takes about 21 days from egg to adult. Both developmental stages, the nymph and adult, are predator. Eggs are milky white to yellow colour and the adults have shiny elytra (hard wings).
4.6. Protocol for monitoring biological control agents of FAW

Among the microbial control agents, virus-based insecticides, which are mostly in the Baculovirus group, have been identified as having the highest potential for development as bioinsecticides due to specificity, high host virulence, and the highest safety to vertebrates. Better efficiency of Baculovirus for the control of FAW is obtained when applied on maize plants at the 6- to 8-leaf stage or 8- to 10-leaf stage with a costal-manual sprayer, using a wettable powder formulation containing the recommended dose of the product seven days after virus application indicated a minimum larval mortality from 79.2 to 97.2 percent. It is more effective against the small larvae (<1.5 cm). When the larvae feed on the fungus, they are infected with fungal disease.

Bacillus thuringiensis is the most commonly used biopesticide. Bt produces crystal proteins and delta endotoxins have the insecticidal action. Although Bt var kurstaki and Bt var aizawai can be used for the control of lepidopteran pest, Bt aizawai is more effective on FAW compared with Bt kurstaki.

Entomopathogenic fungi also reported as important agents for the control of FAW. The fungi can infect the larvae when they have contact with fungi. Metarhizium anispliae, Beauveria bassssiana and Nomuraea are virulent (powerful) fungi against FAW larvae. A number of FAW larvae naturally infected with Nomuraea rileyi are observed in Myanmar.
FAW larvae infected with *Nomuraea rileyi* (Zalun township)

Farmers should look out for dead or infected larvae in their fields to understand the role that pathogens play in FAW control.

4.7. Botanical pesticides

Plant-derived pesticides are commonly referred as botanical pesticides. A large diversity of plants are known to have insecticidal properties and some of them have been used for the management of FAW in America. The botanical pesticides are biodegradable, environmentally safe, less harmful to farmers and consumers, and often safe to natural enemies and hence amenable for use in biocontrol-based IPM strategies. Further, based on the availability of the pesticidal plants in the ecosystem, botanical pesticides could be easily prepared by smallholder farmers.

**Preparation of some botanical pesticides**

Botanical pesticides can constitute a real arsenal in the management of the FAW for African smallholders as part of an IPM approach. Farmers can learn to test local plant that might be effective against the FAW.

**Materials needed:**

Mature fruits or leaves of neem tree, *Azadirachta indica*, mortar and pestle, or small blender/crusher, material to filter, pesticide sprayer, and soap

**Methods/procedures:**

Collect mature fruits of neem (*Azadirachta indica*), remove the flesh and dehusk the seeds OR collect leaves of plant materials (e.g. Neem leaves; Pyrethrum extract)

- grind 500g of neem seed kernel in a mill or pound; or 1kg of plant material
- mix the crushed neem seed with 10 lit of water or more
- allow the extract to stand for at least for 5 hours in a shady area
- filter the mixture to obtain the extract
- add soap or detergent as surfactant/emulsifying agents
- spray the neem extract on maize or other cereal crops.
Indicatively, 6 to 8 Kgs for Neem kernel’s might be required to treat one hectare of maize crop.
Neem extract can be retained for at least 3 to 6 days.

You can also dilute into different simple solutions (75 percent, 50 percent, 25 percent and 0 percent).

4.8. Hand picking and other traditional method for the control of FAW

- Small holder farmers should regularly visit the field to collect and destroy egg masses and FAW larvae. Farmers should visit the field twice a week at the vegetative stage of corn field when the oviposition of FAW is heavy and after that at weekly interval or fortnightly interval.
- Larvae feeding in the whorl can be killed by putting burned rice husk, sand, saw-dust or dust into the whorl. The larvae will die after desiccation. On the other hand, the dust may be contaminated with entomopathogenic nematodes, bacteria or virus that can kill insects.
- Lime, salt, oil and soap solution can be sprayed to kill larvae. Certain botanical pesticides such as neem and chili have repellent action and reduce the pest infestation.
- Dead larvae naturally infected with entomopathogenicmicroorganisms should be collected, crushed and diluted with water to spray infested corn fields.
- By pouring water into the whorl where the larvae are feeding, the larvae will be drowned.
- To attract the natural enemies such as wasps and ants, sugar solution, molasses or some other solution should be sprayed in the field.
Chapter 5
Low-cost agronomic practices and landscape management approaches to control FAW

Introduction

In addition to host plant resistance, biological control, and judicious application of chemical pesticides, a number of low-cost cultural practices and landscape management options can be implemented as part of an effective Integrated Pest Management (IPM) strategy against Fall Armyworm (FAW). Such approaches can be particularly relevant to smallholders who lack financial resources to purchase improved seed, pesticides, or other relatively expensive agricultural inputs.

5.1 Agroecosystem-based IPM approaches

Intercropping, companion cropping and crop rotation with non-grass species, such as cassava and other plants known to repel or confuse female moths from laying their eggs on maize plants can reduce crop damage and provide shelter and alternative food sources for natural enemies and reduce the ability of FAW to move to neighbouring plants. Some common intercrops include maize and legumes, such as beans, cowpeas, pigeon peas and other fodder crops. Conservation agriculture (CA): combined use of no-tillage, residue retention, rotation and use of cover crops (such as mucuna and lablab) has been found to increase the numbers and diversity of natural enemies (spiders, beetles, ants) and to improve soil health.

Habitat management using a push-pull strategy. This involves intercropping maize with a “push” plant, such as Desmodium, that repels FAW from the field, and planting a crop along the field boundary (e.g. Napier grass or Brachiaria spp) that attracts or “pulls” the FAW away from the maize. Reductions of 82.7 percent in the average number of larvae per plant and 86.7 percent in plant damage per plot have been observed in climate-adapted push-pull, compared to maize monocrop plots. Similarly, maize grain yields are reported to be significantly higher, 2.7 times, in climate-adapted push-pull plots (Midega et al., 2018).

Handpicking and destroying egg masses and larvae, or collecting and dropping larvae in hot water. Killing one caterpillar prevents immediate crop damage and the appearance of more than 1,500–2,000 new caterpillars within less than four weeks. Using good quality seeds can increase plant vigour and potentially reduce damage. Eliminating grassy weeds in maize fields and nearby, as they provide shelter and food for the pest.
Agroecological approaches apply knowledge about the complex interactions between organisms and their environment to suggest management options that reduce the frequency and intensity of pest infestation and minimize the damage inflicted by pests on crops. In the context of FAW control in Africa, such approaches typically focus on farmers’ cultural practices or landscape management options that achieve the following:

- **Improve plant health to better withstand pest attack.** Increasing plant health, for example through improved soil management and crop nutrition, can ensure that plants develop well before pest damage significantly affects yield-defining components (*e.g.*, leaf area). Healthy plants can also invest more in defense (Chapin 1991), thereby increasing the likelihood of escaping serious damage.

- **Optimize timing of crop planting and rotations to escape pest pressure.** Manipulating the timing of host plant development relative to pest presence (*e.g.*, early planting, crop rotations). Such approaches work by creating asynchrony between the pest and critical crop growth stages.

- **Create sustainable local ecosystems that are inhospitable to the pest and attractive to its predators and parasitoids.** Intercropping or crop rotations with crops that are not preferred by the pest can help repel FAW. Some intercrops, particularly those producing natural insecticides (*e.g.*, *Tephrosia*) or repugnant semiochemicals (*e.g.*, *Desmodium*), *repel the adult female moths, reducing the number of eggs laid on host plants*. Conversely, creation of sustainable ecosystems (*e.g.*, through surface crop residue retention) that attract and conserve natural enemies of FAW, including generalist predators (*e.g.*, spiders, ants, or birds) and parasitoids, can contribute to enhanced pest predation and parasitism that controls FAW populations.

### 5.2 Cultural and landscape management options recommended practices to control FAW

Based on a review of available evidence, the following low-cost cultural practices and landscape management options are currently recommended for control of FAW.

In the “Push-Pull” companion cropping strategy, farmers protect cereal crops from pest damage by intercropping them with pest-repellent (“push”) plant species (*e.g.*, *Desmodium* spp.), surrounded by a border pest-attractive trap (“pull”) plant species [usually grasses such as napier grass (*Pennisetum purpureum* Schumach.) or *Brachiaria* spp.]. In one recent study conducted across East Africa, farmers who fully implemented the Push-Pull approach reduced FAW infestation and crop damage by up to 86 percent, with a 2.7-fold increase in yield relative to neighboring fields that did not implement the approach (Midega *et al.*, 2018).
5.3 General best practices for cultural control and landscape management

For the management of insect pests, push and pull strategy, by intercropping maize with certain types of crops to attract and repel insects, can be used. Apart from that, landscape management can also be used.

- Grow corn in early monsoon or as soon as the water recedes from submerged areas as FAW infestation can get worse on late sowing crops.
- Apply enough fertilizer to have a healthy crop so that to stand the pest attack.
- Intercrop the main crop, maize, with some other crops, for example, pigeon pea, cassava, sweet potato, sweet pea, beans, pumpkin or green manure crops row by row.
- No tillage, retaining crop residues and crop rotation can encourage the development of beneficial insects (spiders, beetles, ants, beneficial fungi and bacteria) and these biocontrol agents will help control FAW. FAW cannot be controlled by burning crop residues as commonly practiced for the control of other insect pests.
- Grow sunn hemp, lablab bean and some other pulses in free space to get more natural enemies, repelling the pest, less oviposition and less infestation of FAW.

Maize with pigeon pea

Maize with soybean

Maize with Cowpea

Maize with other legumes
• Grow a variety of crops at the boundary/periphery of maize fields for biodiversification. This practice will also enhance the abundance of natural enemies to control FAW.
• Grow large tree like neem or other bushy type at the boundary of main crop, maize. Natural enemies and birds will come and feed on the pest, FAW.
• The effect of intercropping maize with certain legumes (green gram, soybean, cow pea) on the infestation of fall armyworm should be tested.
• Intercropping with pigeon pea and *Gliricidia* should be tested in certain areas.
• The push-pull strategy using *Desmodium* as repellent or pushing the pest away crop and napier grass as a pull crop should be confirmed with field trial before giving recommendations to the maize growers.

5.4 Chemical controls

Always consider an integrated approach with preventive measures together with biological treatments if available. Thresholds for application of control measures may very according to the area but is usually considered when: egg masses are present on 5 percent of the plants or 25 percent of the plant shows damage symptoms and live larvae are still present. Treatments must be applied before larvae burrow deep into the whorl or enters ear of the mature plants.
• The efficacy of chemical insecticides commonly used across the country should be tested in the field in different locations.
• Their impact on non-target organisms (natural enemies and beneficial insects) should be explored at the same time.
• The use of biopesticides and botanical pesticides should be encouraged.
• Training should be given to the farmers for efficient use of chemical pesticides and also to reduce the health hazards of human beings.
• The use of PPE should be encouraged whenever pesticides are applied.
### Table: Recommended pesticides to manage FAW

<table>
<thead>
<tr>
<th>No.</th>
<th>Crop Stage</th>
<th>Action threshold</th>
<th>Spray Sequence</th>
</tr>
</thead>
</table>
| 1   | Seedling to 2 weeks| -first catch 3 moths/trap (5-10 percent) infested plants| (spray soft pesticides listed)  
1. *B.t* (*Bacillus thuringiensis var. izawai*)  
2. *B.t* (*Bacillus thuringiensis var kastaki*)  
3. Neem |
| 2   | 2-4 weeks old      | 10-30 percent infested plants                        | (Spray pesticides listed, not more than two times for same AI.)  
1. Indoxacarb  
2. Emamectin benzoate  
3. Flubendiamide  
4. Chlorantraniliprole  
5. Emamectin benzoate + lambda cyhalothrin |
| 3   | 4-7 weeks old      | 30-50 percent infested plants                        | (Spray pesticides listed, not more than two times for same AI.)  
- Indoxacarb  
- Emamectin benzoate  
- Flubendiamide  
- Chlorantraniliprole  
- Emamectin benzoate + lambda cyhalothrin |
| 4   | 7 weeks to tasseling| more than 20 percent infested plants                 | NO SPRAY  
Unless low-toxicity & supportive of conservation biological control |
| 5   | Tasseling to harvest| 10 percent ear damage                                | No pesticide application, but manually pick and destroy larvae |

**Capacity of Reducing Pesticide Risk**

- The pesticides currently used by the farmers must be already registered in the country.
- The pesticides expired should not be used. The containing with remaining pesticides should not be disposed in the field.
- The children, pregnant women and old people should not enter the filed sprayed with pesticides.
- Someone who sprayed should wear personal protective equipment for the operation and should have a shower and PPE should be washed.
- The pesticides should be applied at the recommended rate.
- The frequency of spray should be as mentioned in the label.
- People should not enter the field immediately after the spray.
- Pesticides should be stored separately, not together with seeds or animal feed.
- It should be checked not to contaminate the water resources.
- Animal should be prevented not to enter the plot where water is present after spraying the crop.
- Mixing pesticides near the water resources should be avoided.
- Dirty water should not be used for irrigation.
5.5 Summary

- FAW is a notorious pest with its internal feeding, very difficult to control.
- The life-cycle of FAW is about 30 days, two - three days in egg stage, 14 days as larval instars and 8-10 days as pupa before emerging as adult. First instar larvae nibble the green tissue of the leaves and window-pane like symptoms appear. The third larval instars enter the whorl and feed inside. The pest is the most destructive before tasseling crop stage. The feeding rate is high at night. Although the growing shoot is attacked, the yield is, sometimes, not affected as the plant can compensate. Pupation normally takes place in the soil. However, they may pupate among the debris when the soil is too hard to enter. Pupa has no habit of hibernation in winter.
- Genetically modified Bt maize is reported be resistant to FAW. Mixed cropping maize with some pulses should be practiced rather than growing maize alone (monocropping). As FAW prefer maize, crop rotation should be done to break the source of infestation. Scouting is necessary at the early stage of maize crop.
- When the infestation is FAW is observed in young crop, soft insecticides such as neem or biopesticide (Bt) should be applied so that not to harm natural enemies.
- Pheromone traps can be used to monitor FAW infestation.
- Egg parasitoids, Trichogramma and Telenomus should be reared and released in the maize fields.
- The use of chemical pesticides as a preventive measure before the infestation of FAW is not recommended.
- Taking action at the early stage of infestation is effective.
- Insecticide spray after the larvae have entered the whorl may not be effective as the frasses are pushed upward and making the chances of having contact with the insecticide and larvae are very small.
- Whenever an insecticide is needed to apply, use registered one, spray at the right time with recommended dosage and appropriate nozzle. Care must be taken not to affect the natural enemies.
- There is no way to eradicate FAW but to reduce or retain the pest population below the economic injury level. The conservation of natural enemies should be done as much as possible for the sustainable management of FAW.
## Chapter 6
### Safe uses of pesticides

6.1 Do’s and Don’ts in safe use of pesticides by the farmers while purchasing and using them

<table>
<thead>
<tr>
<th>Dos</th>
<th>Don’ts</th>
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| **When you purchase the Pesticides,**  
- Read carefully labels on the packages and bottles.  
- Purchase only register products and check the expired date.  
- Purchase only the required amounts.  
- Purchase only the new packages  |  
- Do not purchase the products which is not registered in Myanmar Pesticide Registration Board.  
- Do no purchase extra amounts.  
- Do not purchase and do not use the products without labels.  
- Do not use the expired products.  
- Do not purchase the packages with punctures.  |
| **When you store the Pesticides,**  
- Store the pesticides away from home.  
- Store in original bottles or packages.  
- Store insecticides and herbicides separately.  
- Put the danger signs in the pesticides storage houses.  
- Keep the children away from pesticides storage houses.  |  
- Do not store the pesticides inside the house.  
- Do not split pesticides from original containers to other containers.  
- Do not store the pesticides under direct sunlight and rains.  |
| **When you handle the Pesticides,**  
- Carry pesticides separately from foods and other materials.  
- Handle with mind pesticides by hands.  |  
- Do not carry mixed together with foods.  
- Do not carry pesticides on the shoulders, on the head and on the back.  |
## Dos

**When you prepare spray solutions,**
- Read the labels first before you make spray solution.
- Use clean water to make the spray solution.
- Make the spray volume only for required amount.
- Be careful not to spill outside of sprayers.
- Keep wear the PPE materials all the times when you prepare spray solutions.
- Follow the recommended rates/doses.

**When you spray pesticides,**
- Apply the recommended rates shown in labels.
- Spray the pesticides during the calm weather conditions.
- Use the good spray equipment.
- Use sprayer separately for insecticides and herbicides.

**After you finish spray operations,**
- Puncture and bury the empty pesticides containers away from water resources.
- Wash your clothes separately.
- Shower and wash your face and hands with soap carefully.
- If you have any signs of pesticides risks, go to clinic and bring together the pesticides containers and consult with doctors regularly.

## Don’ts

- Do not use muddy water to make the spray solution.
- Do not make spray solution without reading the labels.
- Do not prepare pesticides without PPEs.
- Do not inhale at the opening of sprayers.
- Do not use over doses.

- Do not eat while you spray the pesticides.
- Do no use leak or damaged spray equipment.
- Do not use the same sprayer both for insecticides and herbicides.
- Do not spray during raining and windy times.
- Do not spray opposite to the winds.
- Do not use insecticide sprayers for herbicides.

- Do not allow (human and animals) to enter the fields after pesticides application.
- Do not reuse the empty pesticides containers.
Chapter 7
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