Protocol for Integrated Pest Management of Fall Armyworm (FAW; *Spodoptera frugiperda*) in Nepal

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PQPMC

NARC
Nepal Agriculture Research Council

CIMMYT
International Maize and Wheat Improvement Center

iDE नेपाल Nepal

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Acronyms

@	at the rate of
^0C	Degree Celsius
CABI	Centre for Agriculture and Bioscience International
CIMMYT	International Maize and Wheat Improvement Center
CTWG	Core Technical Working Group
FAO	Food and Agriculture Organization of the United Nations
FAW	Fall Armyworm
FFS	Farmers' Field School
g	gram
iDE	International Development Enterprises
IPM	Integrated Pest Management
ml	milliliter
MoALD	Ministry of Agriculture and Livestock Development
NARC	Nepal Agriculture Research Council
PQPMC	Plant Quarantine and Pesticide Management Center
SC	Suspension Concentrate
SG	Water Soluble Gruanule
TF	Task Force
USAID	United States Agency for International Development
WHO	World Health Organization

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Integrated Pest Management of Fall Armyworm (FAW; *Spodoptera frugiperda)* in Nepal

1 Background

The Fall Armyworm (FAW), *Spodoptera frugiperda* JE Smith (Lepidoptera: Noctuidae), a destructive pest of maize crops is an insect native to Americas and was confined to the Americas till 2015. The pest was formally reported from Africa in 2016, and since then has spread to more than 40 African countries. The pest was reported for the first time in Asia in May 2018 from Shivamogga district in Karnataka, India. This pest has also been recently reported from Sri Lanka, Bangladesh, Myanmar, Thailand, Vietnam, China, Taiwan, Myanmar, S. Korea, Indonesia and Japan. FAWhas recorded for the first time in Nepal from Nawalpur district (N 27°42'16.67", E 084°22'50.61") on 9th May 2019. The invasion of this pest was officially declared on 12th August 2019 by NPPO Nepal. From the time of its introduction in the country, the pest has been reported from different districts, including Chitwan, Sindhupalchowk, Sindhuli, Ramechhap, Udayapur, Khotang, Okhaldhunga, Dolakha, Kavrepalanchowk, Lalitpur, Bhaktapur, Banke, Rolpa, Pyuthan, Salyan, Dailekh etc.

FAW larvae can reportedly feed 353 different plant species (Montezano, 2018), but has a strong preference for maize. In the context of Nepal, FAW has been reported in maize and sorghum field so far. The yield losses from FAW in Africa have been reported ranging from 21 to 53% in maize (Prasanna *et.al*, 2018). Besides the capacity to migrate over long distances during its life span, the fecundity of this pest is high (more than 1000 eggs/moth); thus, there can be multiple pest generations per cropping season or year. Adults typically use their natural pre-oviposition period of 3-4 days to migrate over 500 km before oviposition (CABI, 2019).

2 IPM approaches for FAW in Nepal

Though new agricultural pests are periodically introduced into agricultural environment and pose some degree of risk, a number of characteristic factors make FAW a more devastating pest than many others as it consumes many different crops including maize; spreads quickly across large geographic areas and may persist throughout the year in some warm climate areas.

In addition to emerging economic and food security impacts, responses to the pest are potential for negative health impacts on human animal and environment as a result of extensive, indiscriminate, and unguided use of synthetic pesticides.

Development and implementation of coordinated, evidence-based efforts to manage FAW is an immediate need. As it is a recently introduced pest, scouting by farming communities and effective monitoring mechanism are limited. The lack of surveillance, monitoring, and scouting capacity has delayed efforts to determine the management strategies. With the limited availability of proven approaches to prevent and avoid FAW, efforts to suppress the pest are usually based the application of synthetic pesticides. Education, research, and regulatory processes are yet to be scaled up and effectively coordinated across the country to rapidly disseminate and support emerging best practices for its management as they are identified. Management approach against FAW need to be informed by sound scientific evidence, build on past experience combating FAW in other parts of the world, and be adaptable to low-resource smallholders. An Integrated Pest Management (IPM) approach provides a useful framework to achieve these goals.

The goal of IPM is to manage pest populations using techniques that minimize harm to the environment, including people with affordable costs. Because of its holistic nature and the need to integrate a variety of techniques and disciplines, IPM should not be viewed as an “off-the-shelf” solution. IPM requires that the farmer or agricultural technician possess sound agronomic and pest management knowledge to implement an effective program based on local farming conditions. An effective IPM strategy for control of FAW will employ a variety of management approaches available including host plant resistance (native and/or transgenic), biological control, cultural control, and safer pesticides, to protect the crop from economic injury while minimizing negative impacts on people, animals, and the environment. Owing to the general suppression of the closely related *Spodoptera spp.* in Nepal, the FAW is also likely to be acted upon by the natural enemies locally present. As in all IPM programs, decisions on pesticide use will focus on economically viable interventions that pose the lowest risk to human and environmental health when the basic control options fail to limit the pest damage.

3 FAW Monitoring and scouting

3.1 Monitoring

Monitoring of fall armyworm is the deliberate effort of checking for the presence of a particular pest, in this case FAW in the maize crop fields. It is important to monitor the crop which is especially preferred as a host i.e. the maize crop frequently after germination for presence of the pest and or scout for pest symptoms or damage. Monitoring should also be carried out during the off-season to find out whether the insect shelters in alternate or collateral hosts, and observe the presence of natural enemies of the pest (parasitoids, predators, etc.). Early detection and prediction of FAW and assessing severity of infestation helps in timely and effective management. This also potentially limits the use of the pesticides, while preserving the natural enemies, ecosystem services and minimizing harm to the environment.

Methodology

1. Trap selection: Suitable trap, it could be Funnel trap or Bucket trap
2. Lure selection: Procure FAW specific pheromone lure, and store lures in a Refrigerator (4-5^{0}C); change the lune once every 4-6 weeks
3. Trap placement and setup:
   - Establish the pheromone trap two weeks before planting at a height of approximately 1.25 meters from the ground level.
   - Place the trap in or next to the maize field
   - Install the trap from a long pole in a vertical orientation to prevent water entering into it and adjust the trap height to at least 30 cm above plant height.
4. Install 3 traps per cluster at the distance of at least 50 meters apart.
5. Trap monitoring and recording: Weekly intervals throughout the season
6. Monitoring and crop phenology/stage
7. Area-wide and community-based approaches in terms of pheromone traps could be more effective than at the individual farm level
8. Record the weather record (temperature, humidity, rainfall, etc.), wherever possible.
9. Share and use the FAW monitoring data with extension agents.

3.2 Field scouting

Scouting is the use of science-based protocols by trained individuals (extension staff or farmers) to observe the pest in the field. Scouting involves rapid and systematic determination of overall crop health and estimating presence of FAW and potential yield reduction (Prasanna et al. 2018). Scouting of crop field is necessary for the accurate assessment of the level of infestation of FAW, and is usually expressed as percentage (%) of infested plants. Scouting results are based on proper sampling across the field. The FAW larvae attack all the crop growth stages of maize i.e. seedling, vegetative, tasseling and grain filling. Scouting of the maize field should be started two weeks after planting and be continued in every week. It is important to note that FAW larvae often hide inside the maize whorl during the day time.

3.2.1 Growth stages and action threshold:

Early age of the crop is more susceptible to FAW infestation thus action thresholds at different ages may differ.

Table 3: Plant age-based action threshold

Growth stage of maize	Action threshold	Measures
Vegetative		
Seedling/ early whorl (VE-V6)	Low: 20% (10-30%)	% SFW, % IW
Late whorl/ mature plant (V7-V12)	High: 50% (30-50%)	% SFW, % IW
Reproductive		
Tassel (VT)	Low: 20% (10-30%)	% IP
Cob (R1-R3)	Low: 20% (10-30%)	% IP

Note: V=vegetative, E=emergence, T=tasseling, R=reproductive, SFW=small fresh window, IW=infested window, IP=infested plant.

3.2.2 Scouting pattern:

"W" pattern: to determine the risk of yield depression associated with foliar feeding and density of small and large larvae.

- Scouting in the field is done in a semi systemic manner. It is one of the approaches that follow a "W" pattern to cover the entire field. (As Shown in Figure 1).
- While entering into the field for scouting, at least two outer rows should be left. This is practiced to avoid border effect.
- At every point (as shown in the figure) inspect 10 – 20 plants in a row or around the central plant of the point (in case of scattered planting).
- Observe the signs in upper 3-4 leaves for the damage or fresh frass (excreta) carefully in each plant. Fresh frass indicates the presence of living larvae in the whorl.
- Record the infestation in all the points in observation sheet and calculate the percentage infestation (Annexure 3) and refer to table 1 for guidance to decide if intervention is required.

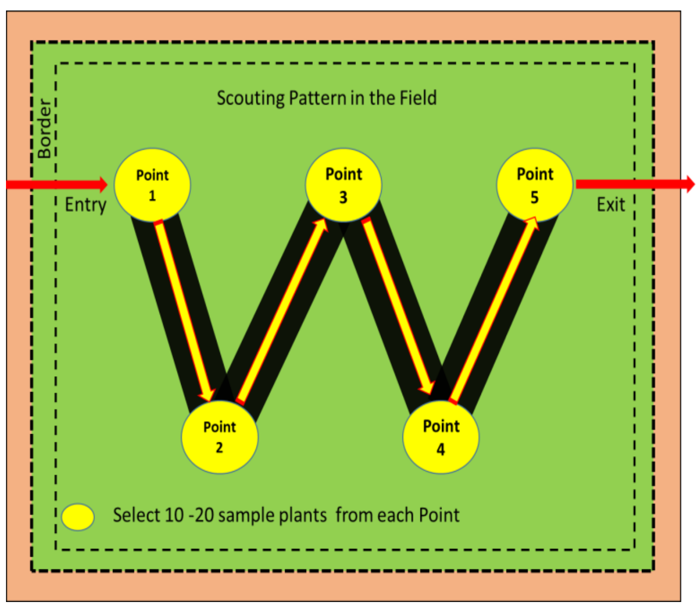

Figure 1: Scouting Pattern in the Field
(Source: Adapted from Shrestha & Joshi, 2019)

“Ladder” Pattern: to determine the risk of yield loss associated with cob damage. Large worms attack the developing cobs.

- Move in a “Ladder” pattern from the first point to the last point, up to 5 points/location in a ha.
- Examine and record damage symptoms by FAW larvae at first tassel stage.
- Examine the base of the ears and the leaf axils immediately above and immediately below the ears.
- Record damaged plants that have worm or any sign of fresh feeding.
- Calculate the % age of IP.

Figure 2. “ladder” patter of maize field monitoring (scouting)

4 Integrated Pest Management Options for FAW

4.1 Seeds and Varieties

- Use quality seed and FAW resistant varieties (if available).
- Seed treatment with Imidachlorpid 48% FS @ 4 ml per kg seed to offer plant protection up to 2-3 weeks after germination.
- It will be useful to select maize varieties with tight husk cover (that is husk that fully covers the ear).

4.2 Cultural Management Practices

- Avoid late and staggered planting. Early planting often helps to escape the peak migration and incidence of FAW adults.
- Use recommended dose of manures and fertilizers.
- Maintain adequate soil moisture for producing vigorous and healthy plants which can withstand pest infestations and damage.
- Ploughing the field to a depth of 10 cm helps to expose FAW pupae to sunshine and natural enemies. Allow 2-3 days after ploughing to get this effect.
- Maintain plant diversity at the field level with a provision of sheltering and pollen resourceful flowering plants around for increasing the presence of natural enemies.
- AdoptPush-Pull technology incorporating Desmodium grass and other legume crops such as pigeon pea, beans, groundnuts as inter-crops for “push”, and border crop of Napier grass for “pull” the FAW.
- Destroy crop residues after harvest for destroying sheltering eggs, larvae and pupae of FAW.
- Practice crop rotation with alternate crops to minimize the attack of FAW.

4.3 Mechanical Control

- Hand picking and crushing of FAW egg masses and young larvae (if found in the field) or immerse them into soap water.

4.4 Biological Control

Natural enemies in field should be conserved with a provision of sheltering and pollen resourceful flowering plants around. Different species of naturally-occurring bio-control agents against FAW have been identified in FAW-endemic countries in Africa and Asia, including Nepal. These can help to suppress FAW (Prasanna et al. 2018). Such biological control agents include:

4.4.1 Predators:

Naturally occurring predators play an important role in the suppression of FAW in the field. Predatory insects and arachnids that can act upon FAW include Earwigs (Dermaptera: Forficulidae, Carcinophoridae), Ladybird beetles (Coleoptera: Coccinellidae), Ground beetles (Coleoptera: Carabidae), Assassin and flower bugs (Hemiptera: Reduviidae, Pentatomidae, Geocoridae, Nabidae, Anthocoridae), Eusocial, solitary and other predatory wasps (Hymenoptera: Vespoidea), Spiders (Arachnida: Araneae), Ants (Hymenoptera: Formicidae) and many birds and bats prey upon FAW.

4.4.2 Parasitoids:

Many species of hymenopteran and dipteran parasitoids attack on the different stages of FAW. These may include *Telenomus remus* Nixon (Hymenoptera: Platygastridae), *Chelonus insularis* Cresson (Hymenoptera: Braconidae), *Cotesia marginiventris* Cresson (Hymenoptera: Braconidae), *Trichogramma* spp. (Hymenoptera: Trichogrammatidae), Fly parasitoids: *Archytas*, *Winthemia* and *Lespesia* (Diptera: Tachinidae).

FAW can also be managed by the release of parasitoids *Trichogramma pretiosum or T. chilonis* @100000/ha., *Telenomus remus* @ 50000/ha and *Bracon hebetor* @ 50,000/ha.

4.4.3 Parasites and microbial pathogens:

Disease causing microorganisms including nematodes, fungi, bacteria, viruses and protozoa, cause lethal infections to FAW. Potential microbial agents against FAW can be NPV, MNPV, BT, *Nomuraea rileyi* and Entomopathogenic Nematodes (*Heterorhabditis, Steinernema*).

Some of the recommended biopesticides are *Bacillus thuringiensis* (2-3 g/liter) and *Metarhizium anisopliae* (2 g/liter)

4.5 Botanicals and Indigenous Management Options

- Use of local botanicals (neem, hot pepper, titepati, Timur and other plant extracts) act as antifeedant and repellant against FAW.
- Sugary sprays, oil, 'fish soup' or other materials can also be used to attract ants and wasps to the maize plants.

4.6 Use of Pesticides

Use of botanical pesticides: Neem based insecticides are effective against the FAW larvae up to the 3rd instar. Use Azadirachtin 1500 ppm @ 5 ml per liter of water at the time of early stage of damages. Quality control of botanical pesticides is important to achieve desired results.

4.7 Use of Synthetic Chemical pesticides

Synthetic pesticides may be needed to control FAW locally. Pesticides so chosen should be environmentally safer, effective, low-risk, economical, accessible and user-friendly. The following points need to be considered:

- Avoid the use of highly hazardous or toxic pesticides although these may be cheaper in the market.
- Do not use pesticide indiscriminately.
- **When to apply pesticides: Use w**hen the pest infestation reaches the action threshold level, there may be a need for pesticide application.
- **Time of pesticide application:** It is effective against FAW, to use pesticides early in the morning from 6:00-10:00am or late afternoon 4:00-7:00pm, if weather conditions are favorable for spraying because FAW actively feeds at night or in early morning. Avoid spraying when it is windy or if rain is imminent.
- **Method of application:** Use appropriate Personal Protective Equipment (full sleeved apron, goggles, gloves, boots and mask) while handling and using pesticides. Follow the instructions given on the product label. Always use a clean pump and clean water for mixing the pesticides. Use an appropriate sprayer/nozzle. Spray the whole plant and target the whorl where the larvae are usually found.
- **The re-**entry interval (REI) (also known as restricted entry interval or re-intry time) is the minimum amount of time that must pass between the time a pesticide was applied to an area or crop and the time that people can go into that area without protective clothing and equipment. The REI, as appropriate for the type of pesticide used and its dosage, must be rigorously followed.
- **Frequency of application of pesticides:** Spray pesticide and check the presence of larvae after 4 days of spraying. Second spray after 2-3 weeks may be necessary if the population is still not suppressed. Use an alternate group of pesticide in the next spray to avoid development of pest resistance.
- **Recommended Pesticides :** Some of the recommended chemical pesticides in Nepal and their doses are as follows:
    - Spinetoram 11.7 SC (Delegate) @ 0.5 ml/liter of water
    - Chlorantraniliprole 18.5% SC @ 0.4 ml/liter of water
    - Spinosad 45%SC @ 0.3 ml/liter of water
    - Emamectin benzoate 5% SG @ 0.4 g/liter of water
      (For further details refer to Annexure 4)

Do's while handling Chemical Pesticides:

- *Consider alternatives before you treat with pesticides*
- *Read the label carefully before you purchase the pesticide*
- *Read the label again before opening the container (each and every time)*
- *Use the proper safety equipment and protective clothing*
- *Apply the correct dosage*
- *Triple rinse all tools and equipment and apply rinse water to target according to label*
- *Properly store in original containers that are tightly closed, labeled and securely stored*
- *Dispose of unused or unwanted pesticides properly*
- *Be safe, responsible and prepared!*

Do not's while handling Chemical Pesticides:

- *Purchase more than you will use in one season*
- *Handle or apply pesticides when you are not feeling well*
- *Smoke or eat while applying pesticides*
- *Mix or apply a pesticide near a water source*
- *Dispose of unused product down the drain, sink or toilet*
- *Reuse empty pesticide containers as they can be as hazardous as a full one*
- *Transfer pesticides to other containers, such as empty milk bottles*
- *Store pesticides with or near food, animal feed or medical supplies*

5 FFS Approach for Farmers' Education on FAW

Farmers Field School (FFS) is a widely used extension approach to educate farmers in agriculture. This approach was initiated in Nepal with the FAO supported TCP project on Community IPM in 1998 for the integrated management of Brown Plant Hopper in rice fields. In addition, FFS curricula have been developed for the integrated pest management in different crops including maize. Different levels of facilitators (Officers, Assistant level staff and farmers) have been developed who can be used to run the FFS for the management of FAW. The FFS curriculum for maize can be revised and updated focusing on the integrated management of FAW. As part of the FAW management strategy to reach rural communities affected by FAW, FFS will be combined with mass information campaigns, rural radio, and participatory videos, community action plans for FAW management and short field courses for farmers and rural advisors based on experiential learning.

Integrated Pest Management (IPM) is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations, and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human and animal health and/or the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms (definition from the International Code of Conduct on Pesticide Management, FAO/WHO, 2014). In order to support this, IPM implementation in Farmer Field Schools is based on four practical principles:

- Grow a healthy crop in a healthy farming system
- Conserve natural enemies
- Observe fields regularly
- Farmers become experts

These principles describe the main actions of IPM implementation through FFS. Specific processes that take into consideration the variation of each field and farm family backup each principle, so that management can be done on a field-by-field, season-by-season basis. IPM is not a "packaged technology", but also a decision-making process that is adopted by farmers and farming community It is gradually improved with greater ecological knowledge and observation skills.

Farmer Field School groups can be a good entry point for farmers to learn about FAW, to test and adapt promising management options and to initiate community action for monitoring and awareness with the larger local population. The actual situation of FAW in the area where an FFS is planned or ongoing will guide the development of a specific curriculum and FFS interventions tailored to the context. If there are no ongoing FFSs or no skilled facilitators in a specific location, then organization of shorter courses which use discovery-learning can be helpful to ensure that farmers have a basic understanding of FAW and options to manage it.

FFS facilitators, already developed, can be mobilized to take a lead to facilitate FAW IPM FFS. FFS facilitators will need additional training on the FAW, since it is a new problem. This kind of refresher courses is necessary not only for the FFS Facilitators but also to the FFS master trainers, who will also need new knowledge and skills on FAW.

Knowledge and skills needed with a focus on IPM for FAW, can be integrated into FFS or used to design short courses in specific circumstances. It does not elaborate at length on the other technical, facilitation and organizational skills which FFS facilitators and master trainers need to implement a quality FFS on maize. It is assumed that they are known, or that this information can be found in other manuals available.

The following knowledge and skills need to be provided on the short course for already trained FFS Facilitators.

- Describe the different crop-development stages
- Know IPM principles and why they are important for good management
- Know how to monitor all elements of the agro-ecosystem, understand relations and interactions between the elements, as a basis for decisions on field management (Agro-Ecosystem Analysis, AESA)
- Describe plant compensation and its importance
- Know ecological function and life cycles of main pests and natural enemies with focus on FAW; be able to recognize and distinguish different pests and natural enemies
- Recognize major diseases, the conditions that favor their development, and possible damage they can cause
- Know the different management options against FAW
- Understand toxicity of different pesticides and how to reduce exposure and use
- Describe effects of pesticides on human health, natural enemies, environment
- Know how to collect information for economic analysis comparing farmers' local practice and IPM practice

6 Acknowledgements

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Annexure 1: Life cycle of Fall Armyworm

The FAW life cycle is completed in 28-48 days depending on temperature and food availability but in laboratory conditions of Nepal (NARC, Khumaltar), it has been observed to complete in 27-32 days at an average daily temperature of 27°C. In the field, it may vary according to climatic conditions. Heavy rainfalls are reported to break the life cycle of FAW. FAW is not reported to have the ability to diapause. In Nepal, considering the low winter temperatures, migratory FAW are supposed to arrive if allowed by environmental conditions are conducive. The pest also may have multiple variable number of generations during the crop season. Reportedly, survival rate are around 10 or lesser percentage in case field temperature is between 4 to 14^{o} C.

1 Eggs

Figure 2: Egg masses of Fall Armyworm (2:A-Egg mass in maize plant in field, 2:B- Enlarged eggs laid in laboratory)

Eggs are creamy white or grey in color covered by light brown wool like material imparting a moldy appearance. The total eggs are dome shaped. 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 normally deposits most of her eggs during the first 4-5 days of life, but some oviposition continues to occur for up to 3 weeks. On average, adults live for 12-14 days. The eggs are sometimes deposited in layers, but most eggs are spread over a single layer attached to foliage (Figure 2 A). Duration of the egg stage is observed to be 2 days during the warm summer months in laboratory conditions.

2 Larvae

The FAW has six larval instars. The first instar larvae are whitish in colors which later change into greenish color with black head. The late larvae measure 30-35 mm long, and their color varies from brown, gray, yellowish, pinkish to greenish with granulated texture all over the body. The total larval period varies from 14 to 15 days in laboratory conditions. Inverted 'Y' shaped whitish marking is present on the head. The best identifying feature of the FAW is a set of four large spots (pinacula)

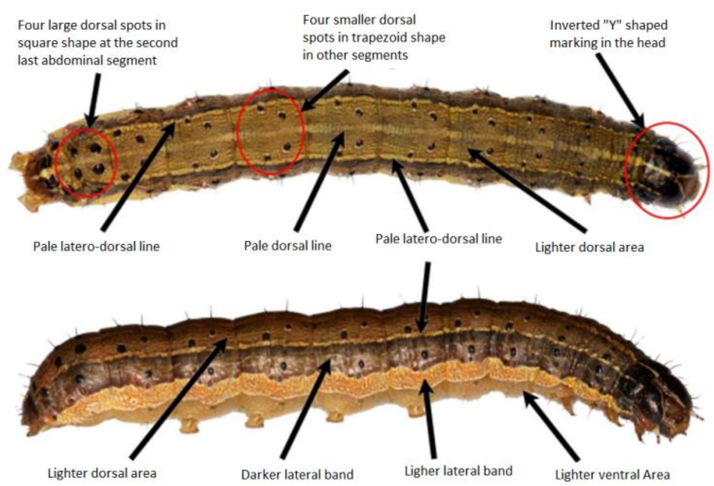

Figure 3: Fall Armyworm characteristic spots, bands and lines
(Adapted from D Visser ARC-VOP Roodeplaat)

that form a square on the upper surface of the 8th segment of its body (Figure3). The late instar larvae also have three creamy yellow stripes on the dorsal surface which run in parallel manner from thorax to last abdominal segment. Larvae tend to hide themselves in the plant whorls during the sunny day.

Figure 1 : Larvae (4:A- First Instar (Magnified), 4:B- Grown up Larva)
(Photo: Ajay, NARC)

3 Pupa

The FAW normally pupates in the soil at a depth of about 2 to 8 cm. The larva constructs a loose cocoon by tying together particles of soil with silk. If the soil is too hard, larvae may web together leaf debris and other material to form a cocoon on the soil surface. The pupa is reddish brown in color (Figure 5), measuring 14 to 18 mm in length and about 4.5 mm in width. Duration of the pupal stage is 6-8 days in laboratory conditions in summer, but may vary according to the climatic conditions.

Figure 5: Pupae (5:A- Laboratory reared, 5:B- Field collected)
(*Photo 5:A- Binu Bhat, Entomology Division, NARC, 5:B- Ram Krishna Subedi, PQPMC****)***

4 Adult

Adult FAW moths have a wingspan of 32 to 40 mm. Hind wings in both male and female are white with black line on inner margins. Adult male moth of the insect has distinct markings on the forewings whereas marking on female forewings are not distinct. In the male moth, the forewing generally is shaded gray and brown, with triangular white spots at the tip. Brown and oval shaped spot is present at the center of forewings (Figures 6 and 7).

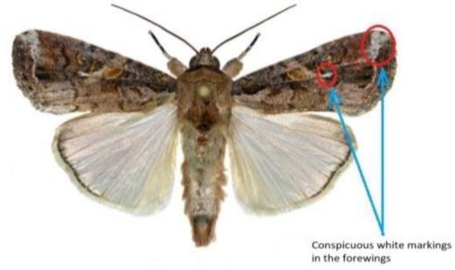

Figure 6: Male fall armyworm moth
(Photo by G. Goergen (IITA))

The forewings of females are less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown. Adults are nocturnal, and are most active during warm, humid evenings. Duration of adult life, as observed in the laboratory condition in Nepal is 5-7 days.

Figure 7 : FAW adult moth 7A - female, 7B- Male
(Photo: Ajay, NARC)

5 Feeding behavior and damage

The FAW larvae can feed and damage the entire plant including leaves, whorls, tassels, silk and ears.

Early (1st-2nd) instars feed by scrapping on the leaf surface leaving the epidermis intact which results in the appearance of elongated papery windows of different size (Figure 8A). They also bore into the whorl resulting into small pin holes in the leaves (Figure 8B).

Figure 2 : Damage Symptoms by early instar larvae- 6A- Papery windows; 6B-Pinholes
(Photo-6A- Mahesh Chandra Acharya, PQPMC; 6B- Lalit Sah, iDE Nepal)

Larvae of 3rd-4th instars voraciously feed on the foliage showing ragged and elongated holes on the plant and the size of the holes increases with the growth of the larvae (Figure 9A).

After the larva enters the 5th instar, it feeds voraciously, loosing large area of leaves. 6th Instar larvae extensively defoliate the leaves. Severe feeding gives the appearance of maize that has been damaged by hail (Figure 9B) After feeding, the larvae leave behind large amounts of moist saw dust like frass near the whorl and upper leaves (Figure 10).

Figure 9 : Foliage damage by grown up larvae- 9A- 3-4th Instar larvae; 9B- Mature larvae (5th -6th Instar)
(Photo-9A- *Madhav Bhatta, MoALD; 9B-Lalit, iDE Nepal)*

Figure 10: Frass excreted by the FAW larvae
(Photo: Hari, CIMMYT)

Figure 113: Damage caused by FAW larvae on the ear
(Photo: S.P Humagain, PQPMC)

In the reproductive stage of maize, tassel and ear are the vulnerable parts. Tassel damage is most common which may not lead to economic damage but the FAW larvae boring into the maize ear and eating the developing kernels can directly affect the yield, besides causing other issues such as mycotoxin contamination, etc. resulting in unmarketable ears/grains (Figure 11).

Annexure 2: Monitoring Data Recording Sheet

Name of the Farmer: Address: Contact No:

Crop/Variety: Location:

Type of Trap Used: Trap Installation date:

Date of Observation	Growth Stage	No. of FAW Moths trapped	No. of Other Moths trapped	Date of Pheromone lure replacement	Weather pattern of the week			Temperature			Name of the Data Recorder	Remarks
					Rainfall	Sunshine	Wind pattern	Max.	Min.	Av.		

Annexure 3: FAW Scouting Observation Sheet

Name of the Farmer: Address: Contact No:

Crop/Variety: Location: No. of Plants observed per Point:

Plant no.	Plant status (√/X)*												
	Point 1	Point 2	Point 3	Point 4	Point 5								
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
…													
…													
20													
Total no. of plant infested													

* √= Infested, X= Not infested

Annexure 4: List of Pesticides that can be potentially used for FAW Management in Nepal

S. No.	Common Name	Registered Trade Names	Remarks
1.	*Azadirachta indica*	MARGO N.F	
2.	Azadirachtin	AGRIGAURD, ASTAN-KILLER- 0.15 EC, ASTHA NEEM SUPER- 1 Cake, AVANA- 0.15 GR, AZADIRECHTIN- 1 EC, BELIEVE- 0.03 EC, BIO - M – POWER- 0.03 WW, BIO DOSE- 0.15 WW, BLACK DOG- 5 EC, MARGOSOM-MULTINEEM- 0.03 EC, MULTINEMOR-0.15 EC, NEEM 1500-0.15 EC, NEEM- F, NEEM GOLD-0.04 GR, NEEM KAVACH-0.15 EC, NEEMATE -10-10 GR, NEEMAZAL-5 EC, NEEMCIDE-0.03 EC, Neemraj- 1%, 5%, 0.03%, 0.15% EC, Neemras 1500 PPM-0.15% EC, Neemtel 1.5 % EC, Neemtel 1- 3% EC, Niconeem- 0.15%, 0.3%, Niconeem 1% EC, Nimazal—TS- 1% EC, Nimbecidine-0.03% EC, Peak Neem 0.03% EC, Refresh 0.03% EC, Signature Gold 1% EC, Superneem+ 0.15% EC, Ultineem 1% EC	
3.	*Bacillus thuringiensis*	CHANDANI - 5 WP, LIPEL, MAHASTRA- 0.5 WP	
4.	Chlorantranilipole 18.5% SC	ALLCORA (18.50 %SC), ALLCORA - G (0.4% GR), COVER LIQ (0.4% GR), NICORA GOLD (18.5% SC), CORAGEN (18.50% SC), FERTERRA (0.4 % GR)	
5.	Emamectin benzoate	ABERKILLER (2% EC), ALLCLAIM (5% SC), AVER KILLER(5% WDG) , AVER KILLER (2% SC), BILLO (1.9% EC), B-KILL (5% WDG) , BOXER (5% SG) , CHEMDOOT (5% SG), COBRA (5% WDG), CROP – STAR (5% WDG), DRAGON (5% SG), ELPIDA (1.9 SG) EM-1 (5% SG), EMA STAR (5 % WDG), EMA STAR (6 % WDG) , EMACTO (5% SG), EMAR (5% EC), EMAR SUPER (5.7 WDG), EMAVAP (2%EC) , EMSTAR – 5 (5% SG), EMVAP (5% SG), FITREST (5 %SG), G - SUPER (5% EC), G - TOP (2% EC), JAPONICA (1.9% EC), JEMSTAR (5.7 % SG), KI - STAR (5% SG), KI - STAR (5.7% WDG), KING STAR (5 SG), KRI - STAR - 5 (5% SG), LARBOTIN (5% SG), MISSILE (5% SC), N-STAR (5% WDG), N-STAR (5.7 % WDG), PROCLAIM (5% SG), RANGE (2.15% EC), REAL STAR (5% SC), REAL STAR - X (5% SG), REALSTAR (5%WDG), RUDRA (5% SG), SAFARI (5% SG), SNAKE VENOM (5% WSG), SUPER STAR(5% SG}, TOP KILLER (5.7% WDG), TRUST (5% SG), YODHA (5% SG)	
6.	*Metarhizium anisopliae*	BIOCIDE MANIC, EMERALD, KALICHAKRA, PACER, PEAK MOTI, RECHARGE, VARUNASTRA	
7.	Spinetoram 11.7 SC	Delegate (11.7 % SC)	Registered in 2019
8.	Spinosad	Tracer (24% EC), Tracer (45% SC),	

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