

What is fall armyworm?

Fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is a destructive pest native to Americas, recently invaded India and presently causing economic damage in maize. The incidence of this pest was first observed in Shivamogga, Karnataka on 18th May 2018. FAW was later reported in Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Madhya Pradesh, Odisha, West Bengal, Gujarat, Chhattisgarh, Kerala, Rajasthan, Jharkhand, Mizoram, Manipur, Nagaland, Tripura, Meghalaya, Arunachal Pradesh and Sikkim at mild to alarming levels in farmer's fields.

Which crops are in danger?

Maize! It is primarily a pest of maize. If maize is not available it will look for sorghum! If both are not available it will attack other crops belong to poaceae, the family of grasses, such as sugarcane, rice, wheat, ragi, fodder grasses etc. It may attack cotton and vegetables as well, which is not reported yet.

How to recognize FAW has arrived in your field?

Adult moth is a strong flier, can fly over 100 Km in search of host plants. Pheromone traps specific to FAW will attract male moths. Male moth has two characteristic markings, viz., a fawn coloured spot towards the centre and a white patch at the apical margin of forewing (Figure 1A). Forewing of female is dull with faint markings (Figure 1B).

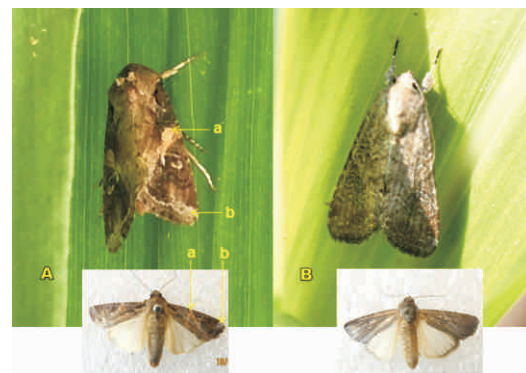


Fig. 1 A Male moth has fawn coloured spot (a) and white a patch (b) in forewing. B Female moth's forewing is dull with faint markings.

What the moths will do after reaching its favourite crops?

A female moth lays over 1000 eggs in single or multiple clusters, covered with hairs (Figure 2A a). Incubation period varies from 4.30 ± 0.57 to 5.67 ± 0.58 days. New born larvae in groups disperse from the hatching site and reach to feed on epidermal layers of lower surface of young leaves. Larvae undergo 6 stages called instars (Figure 2 B 1st to 6th) in its growth of 14.33 ± 0.58 to 17.60 ± 0.57 days and then undergo pupation. Pupa is reddish brown in colour (Figure 2A c) and takes 7.33 ± 0.58 to 8.30 ± 2.30 days to emerge into adult moth (Figure 2A d). Adult moth can survive 3.67 ± 0.58 to 6.30 ± 1.52 days. The

total life-cycle takes 30.67 ± 1.15 to 34.60 ± 2.88 days (Figure 2A) as observed from August to January under natural rearing conditions in ICAR-IIMR Winter Nursery Centre, Hyderabad. Only the larval stage of FAW damages maize.

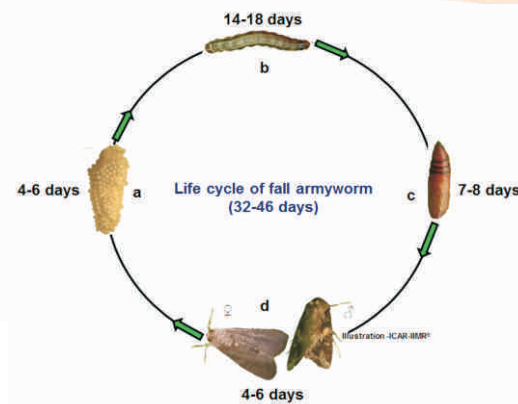


Fig. 2 A Life-cycle of fall armyworm a. Egg mass; b. Larva; c. Pupa; d. Adult female (♀) and male (♂) moths.

Which stage of FAW cause crop damage?

Larval stage of FAW damages maize. FAW larvae are smooth-skinned and vary in colour from light green or tan to grey as they grow (Figure 2B).

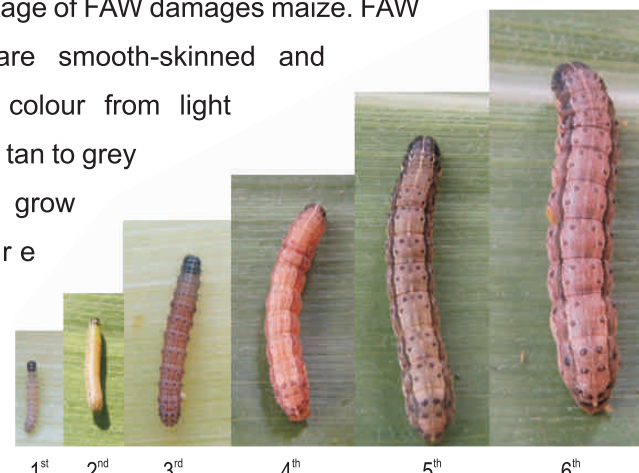


Fig. 2 B First (1st) to sixth (6th) instar larvae of FAW

How to ascertain the larva feeding your crop is FAW?

Larvae of many species of armyworm belong to the genus *Mythimna* and *Spodoptera* look the same for a layman and cause similar symptoms in maize. FAW larvae appear in shades of green, olive, tan and grey with four black spots in each abdominal segment (Figure 2B) and has three creamy yellow lines running down its back (Fig. 3 a, b & c). It is easily identified from any other armyworm species by its tail end, where the black spots are bigger and arranged in square pattern on abdominal segment 8 (Fig. 3 e) and trapezoid on segment 9 (Fig. 3 f). The head has a predominant white, inverted Y-shaped suture between eyes (Fig. 3 d).

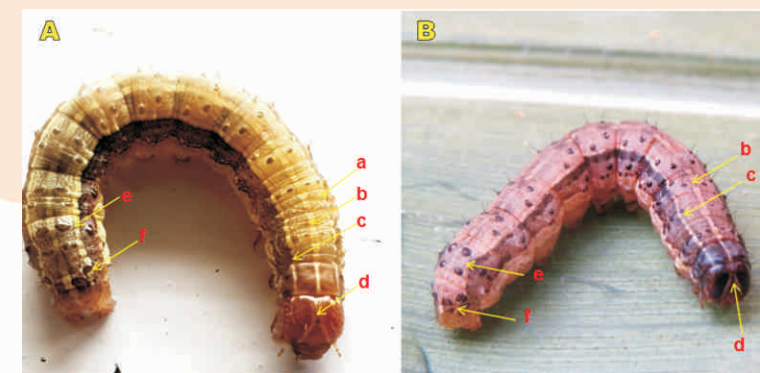


Fig. 3 Olive (A) and tan (B) coloured FAW larvae. Characteristic identification marks are three prominent lines on back (a, b & c); white Y-shaped suture on head (d); and bigger spots arranged in square on abdominal segment 8 (e) and trapezoid on abdominal segment 9 (f).

What are the symptoms of FAW damage in maize and what are the management measures to be taken with progression of symptoms?

Symptom based treatment is very much essential in FAW management because of two reasons, viz., (i) the stage of symptom progression indicate the stage of larval growth and (ii) the stage of larval growth decides the choice of pesticide/control measure.

1) Elongated papery windows: Start observing the maize crop from seedling stage. If elongated papery windows of all sizes are seen spread all over the leaves (Figure 4) in a few adjacent plants the crop might have been infested with FAW. This symptom is caused by 1st and 2nd instar FAW larvae which feed by scrapping on leaf surface. Early identification of this symptom is necessary for effective management of FAW.



Fig. 4 Farmers identifying the initial damage symptom of FAW

What measure to be taken at this stage?

It is easy to manage the larvae at this stage with botanical and microbial pesticides. The choices are

1. 5% Neem Seed Kernel emulsion (NSKE) or azadirachtin 1500ppm @ 5ml/l water.
2. *Bacillus thuringiensis* variety *kurstaki* commercial formulations @ 2g/l water.
3. Entomopathogenic fungi *Metarhizium anisopliae* (1×10^8 cfu/g) @ 5g/l and/or *Nomurea rileyi* rice grain formulation (1×10^8 cfu/g) @ 3 g/l water.

However, when infestation is more than 10% in the field, it is better to resort to chemical pesticides which are recommended for bigger larvae. Apart from pesticide sprays, put some sand/soil alone or mixed with lime/ash (9:1) into the plant whorl when the whorl is well formed to withstand its weight. This will directly harm larvae and increase the effectiveness of pesticides sprayed, especially by soil acting as substrate and reserve for microbial pesticides.

2) ragged-edged holes: Once the larva enter 3rd instar, its feeding cause ragged-edged round to oblong holes on leaves (Figure 5 A). The size of holes increases with growth of larvae (Figure 5 B).



Fig. 5 Damage caused by 3rd (A) and 4th instar (B) FAW larvae

What measure to be taken at this stage?

Damage at this stage needs application of chemical pesticides. The choices are,

1. Spinetoram 11.7 % SC @ 0.5 ml/l
2. Chlorantraniliprole 18.5 SC @ 0.4 ml/l
3. Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC @ 0.25 ml/l

3) Extensive leaf damage: Once the larva enters 5th instar, it feed voraciously, loosing larger areas of leaves (Figure 6 A). Sixth instar larva extensively defoliate the leaves and produce large amount of faecal matter (Figure 6 B).



Fig. 6 Damage caused by 5th (A) and 6th instar (B) FAW larvae

What measure to be taken at this stage?

Pesticides sprays often fail to control 5th and 6th instar larvae. Most effective measure at this stage is poison baiting. Mix 10 kg rice bran and 2 kg jaggery in 2-3 litres of water and keep the mixture for 24 hours to ferment. Add 100g Thiodicarb 75% WP and roll into balls of 0.5-1cm diameter just half an hour before application in the field. Add some sand while rolling if the balls are too sticky. The bait should be applied into the whorl of the plant in the evening. The above mixture is sufficient to cover one acre.

4) Damage to tassel and corn ear: In reproductive stage of the maize crop, tassel and corn ears are the vulnerable parts. Tassel damage is most common (Fig. 7A), which would not lead to economic damage, but boring into corn ears (Fig. 7B) directly affects the yield. Sweet corn ear is more prone to FAW damage, which render the ears unmarketable (Fig. 7C).

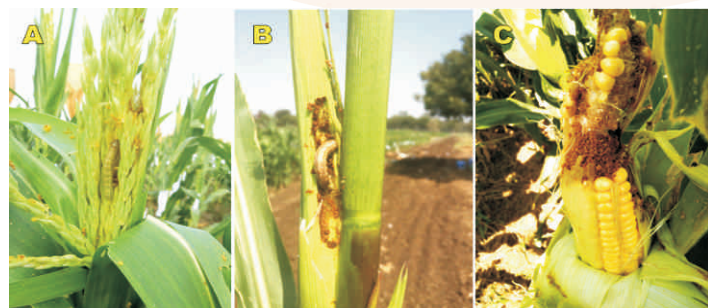


Fig. 7 Damaged Tassel (A) and developing ear (B) and sweet corn (C) by FAW larvae

What measure is to be taken at this stage?

Chemical control measures are not advisable in reproductive stage of maize crop since tassel damage may not cause economical loss and spraying on corn ears are futile as larvae hiding inside the ear would not be exposed to sprays. Moreover spraying chemicals in sweet corn and baby corn is strictly not advisable, since it is often consumed with less processing. Choosing a variety with tight husk and husk covering the tip could offer some protection against FAW.

What is the damage threshold to initiate control?

A few plants showing FAW damage need not warrant pesticide application; it would not be economical. The threshold level of infestation for initiating control measures increase with crop growth (Table 1).

How to determine action threshold?

It is done by a leisure walking in "W" pattern in the field after leaving 4-5 outer rows. Observe 10 plants at each stopping point representing the corners of "W" (Figure 8) and record the number of damaged plants. Derive the percent infested plants at each stopping point. For instance, if 1 out of 10 plants sampled is infested by FAW, the percent infestation is 10%. Derive average percent infestation of all stopping points. It warrants a pesticide spray if the average percent infestation is

Table 1 Infestation threshold for the crop growth stages and spray schedule

S.No.	Crop stage	Action threshold	Spray sequence
1	Seedling to early whorl stage (0-2 weeks after emergence)	First catch of 1 moth/ trap and /or 5% infested plants	1) First spray: 5% Neem Seed Kernel emulsion (NSKE) or azadirachtin 1500ppm @ 5ml/l water 2) Second spray after a week if needed: <i>Bacillus thuringiensis</i> variety <i>kurstaki</i> commercial formulations @ 2g/l water 3) Spray any of the chemical pesticides listed if the infestation crosses 10% at this stage i. Spinetoram 11.7 % SC @ 0.5 ml/l ii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l iii. Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC @ 0.25 ml/l
2	Early whorl to mid-whorl stage (2-4 weeks after emergence)	5-10 % infested plants	1) First spray: <i>Bacillus thuringiensis</i> variety <i>kurstaki</i> commercial formulations @ 2g/l water 2) Spray any of the chemical pesticides listed for the second spray and/ or if the infestation crosses 10% i. Spinetoram 11.7 % SC @ 0.5 ml/l ii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l iii. Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC @ 0.25 ml/l
3	Mid-whorl to late-whorl stage (4-7 weeks after emergence)	10-20 % infested plants	1) First Spray: any of the chemical pesticides listed. Alternate the pesticide for second spray. i. Spinetoram 11.7 % SC @ 0.5 ml/l ii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l iii. Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC @ 0.25 ml/l 2) Apply Thiodicarb 75% WP based poison bait if bigger larvae are found feeding inside the whorl
4	Late-whorl stage (7 weeks onwards of emergence)	≥20% infested plants	1) First Spray: any of the chemical pesticides listed. Alternate the pesticide for second spray. i. Spinetoram 11.7 % SC @ 0.5 ml/l ii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l iii. Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5% ZC @ 0.25 ml/l 2) Apply Thiodicarb 75% WP based poison bait if bigger larvae are found feeding inside the whorl
5	Tasseling stage to harvest	10% ear damage	No insecticide application, but manually pick and destroy the larvae.

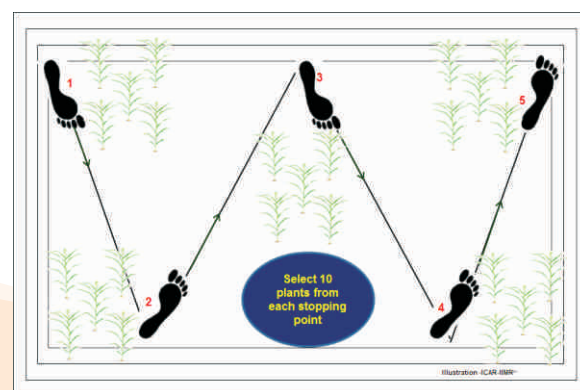


Fig. 8 Sampling technique to estimate FAW damage in maize field

10% at seedling to mid whorl stage, but 20% if the mid-whorl stage is crossed. Scouting should be conducted every week from seedling emergence.

What is the management strategy to be adopted if FAW has

established in an area?

Crop management practices along with systematic plant protection in an area wide manner can manage FAW population below economically damaging levels. An integrated pest management (IPM) approach is to be followed as described below.

- Selection of Single cross maize hybrids. Choose cultivars with tight husk cover, especially for sweet corn.
- Deep ploughing before every crop season to open up the soil to expose FAW pupae to sun light and predators. If zero-tillage is practiced, spread neem cake @ 500kg/ha. Maintain fields weed free and follow balanced fertilizer application.
- Plan for maximizing plant diversity by intercropping of maize with suitable pulse crops of particular region. Eg: Maize + pigeon pea/black gram /green gram. Plant Napier grass in the border rows to act as FAW trap crop.
- Hill planting of maize is to be avoided; one plant should be maintained per hill by thinning.
- Application of nitrogen and irrigation after control measures will boost up the crop growth.
- Plan the sowing time at community level to follow synchronous planting.
- If staggered sowing is unavoidable as in peri-urban baby corn and sweet corn cultivation, spray the crop with 5% NSKE or azadirachtin 1500 ppm @ 5ml/l at weekly interval Or Release *Trichogramma pretiosum* @ 50,000 or *Telenomus remus* @ 10,000 adults per acre at weekly intervals, starting within a week of germination till harvest.
- Install FAW pheromone traps @ 5/acre on or before germination of the crop to monitor pest arrival and population build-up. Use 15 traps/ ac for mass trapping of male moths to keep population build-up under control.
- Erect bird perches @ 10/acre as soon as sowing is completed.
- Follow weekly scouting and adopt symptom based control measures on action thresholds (Table1).
- While scouting, hand pick and destroy egg masses and neonate larvae by crushing or immersing in kerosene water.

Precautions:

- Use gloves and mask while preparing and application of poison bait and pesticide spray.
- All the pesticides spray and poison bait should be applied only to the whorls.
- Enter the field only after a minimum period of 48 hours followed by a pesticide spray.
- Avoid cattle grazing in pesticide sprayed and poison baited fields at least for a month.

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Identification and management of fall armyworm (*Spodoptera frugiperda*)



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