



ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 471-474
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www.thepharmajournal.com
Received: 02-04-2022
Accepted: 05-05-2022

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Fall armyworm: Threat to agriculture in India

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Abstract

The global agriculture often faces new threats from invasive alien insect pests, pathogens, weeds etc requiring immediate attention and co-operative action to manage the pest. In this regard, the fall armyworm (FAW), *Spodoptera frugiperda* is a notorious pestiferous insect. The pest has been reported for the first time in India in Karnataka in July 2018 and subsequently in a few other states such as Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Odisha. The caterpillars are voracious feeders and attack all parts of the maize crop (stem, leaves, cobs, tassels,) at all stages of the crop development. Managing this pest is very challenging due to the pest characteristics of high reproduction, long distant flight, diverse pathways of spread coupled with favourable prevailing climatic conditions for its population build up. The pest can persist in an area throughout the year where there is availability of alternative hosts and favourable temperatures. The pest threatens to Food and nutrition security, Feeds industry, Employment and Trade. As the pest *Spodoptera frugiperda* is polyphagous pest as per the available literature, efforts are needed to manage the pest effectively and its further spread. The present paper reviews the current status and management of fall armyworm in India.

Keywords: *Spodoptera frugiperda*, maize, India

Introduction

The fall armyworm, *Spodoptera frugiperda*, is a lepidopteran pest that feeds in large numbers on the leaves, stems and reproductive parts of more than 350 plant species, causing major damage to economically important cultivated grasses such as maize, rice, sorghum, sugarcane and wheat but also other vegetable crop and cotton. Native to the Americas, it has been repeatedly intercepted at quarantine in Europe and was first reported from Africa in 2016 where it caused significant damage to maize crops. In 2018, *S. frugiperda* was first reported from the India. It has since invaded Bangladesh, Thailand, Myanmar, China and Sri Lanka. The ideal climatic conditions for fall armyworm present in many parts of Africa and Asia, and the abundance of suitable host plants suggests the pest can produce several generations in a single season, and is likely to lead to the pest becoming endemic.

Why FAW is a serious pest

- High reproductive rate.
- Feeds on many different crops.
- Strong flyer, disperses long distances.
- Continuous generations throughout the year.
- Natural enemies do not act effectively enough to prevent crop injury.

1. Spread of fall armyworm in India

In 2018, it began to spread widely in India. The Fall Army Worm (FAW), a pest found to attack maize and other crops, had spread to 14 States in the country. (Press Information Bureau Government of India, 2019) ^[5] The pest incidence first reported from Karnataka in 2018. (Chormule *et al.*, 2019) ^[1]

2. Fall Armyworm Identification

Larger caterpillars may contain characteristic marks and spot. Marks that are often used for identification include the upside 'Y' mark on the head region and the four larger spots on the second last segment. Also four smaller dorsal spots in a trapeze arrangement on most other segment. (Venkateswarlu *et al.*, 2018) ^[6]

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3. Life cycle of fall armyworm

The life cycle is completing in about 30 days. 100-200 eggs are generally laid on the underside of the leaves. After hatching the young caterpillars feed superficially, usually on the undersides of leaves. Young caterpillars can spin silken threads which catch the wind and transport the caterpillars to a new plant. The leaf whorl is preferred in young plants. After approximately 14 days the fully grown caterpillar drop to the ground for pupation up to depth 2-8cm. Approximately 8 days after adult moth emerges to restart the cycle. (Deole and Paul, 2018)^[2]

- **Colorations in fall armyworm caterpillars:** Caterpillars show different colorations and hide inside the whorls during day time. Saw dust like appearance of dry excrement often seen on leaves, which protect them from natural enemies. (Extension book Published by The Director, ICAR, 2019)^[3]
- **Cannibalism in Fall Armyworm:** Caterpillars show high degree of cannibalism. Large larva often eats smaller one, differs them from true armyworm. (Extension book Published by The Director, ICAR, 2019)^[3]

4. Nature of damage and symptoms

Larvae cause damage by consuming foliage. Young larvae initially consume leaf tissue from one side, leaving the opposite epidermal layer intact. By the second or third instar, larvae begin to make holes in leaves, and eat from the edge of the leaves inward. Feeding in the whorl of corn often produces a characteristic row of perforations in the leaves. Larval densities are usually reduced to one to two per plant when larvae feed in close proximity to one another, due to cannibalistic behavior. Older larvae cause extensive defoliation often leaving only the ribs and stalks of corn plants or a ragged, torn appearance. (Extension book Published by The Director, ICAR, 2019)^[3] Marenco *et al.* (1992)^[4] studied the effects of fall armyworm injury to early vegetative growth of sweet corn in Florida. They reported that the early whorl stage was least sensitive to injury, the mid whorl stage intermediate, and the late whorl stage was most sensitive to injury.

5. Area affected due to fall armyworm

Details of area affected due to Fall Army Worm during the Last three years in India

Area affected due to fall armyworm

Sl. No.	State	Details of area affected due to Fall Army Worm during Last three years (area in ha.)		
		2017-18	2018-19	2019-20 (up to may, 2019)
1.	Chhattisgarh		1539	1007.74
2.	Himachal Pradesh		-	-
3.	Andhra Pradesh		2538	-
4.	Madhya Pradesh		-	110
5.	Rajasthan		-	-
6.	Gujarat		70	14
7.	Karnataka		211300	-
8.	Uttar Pradesh		-	2
9.	Sikkim		-	376
10.	Mizoram		-	1877.29
11.	Manipur		-	4341.64
12.	Nagaland		-	4553.29
13.	Meghalaya		-	40
14.	Tripura	No incidence of Fall Army Worm was reported in the country during 2016-17 and 2017-18	-	7.08
15.	Assam		-	27.65
16.	Telangana		24288.40	-
17.	West Bengal		-	485
18.	Arunachal Pradesh		-	250
19.	Kerala		-	-
20.	Tamil Nadu		315	-
21.	Odisha		60	-
22.	Uttarakhand		-	-
23.	Punjab		-	-
24.	Bihar		-	-
25.	Jharkhand		-	7.08
26.	Maharashtra		5144	-
27.	Jammu & Kashmir		-	-
28.	Haryana		-	-
29.	Goa		-	-

(Press Information Bureau Government of India Ministry of Agriculture & Farmers Welfare, June-2019)^[5]

5. Management plan suggested by Government of India

1. Monitoring

Monitoring is the deliberate effort of checking for the presence of Fall armyworm on maize growing in your garden. It is important to monitor your maize crop frequently after germination for presence of the pest and or signs/damage symptoms. Early detection of the pest allows quick and timely response which will help minimise damages to your maize crop and reduce harvest losses. The Fall Armyworm

caterpillar attacks all stages of maize growth i.e. seedling, vegetative, tasseling and grain filling stages. The following guidelines are recommended during monitoring;

- Start monitoring your garden two weeks after planting and continuously visit your garden every 3 days.
- Walk through the maize garden in either a X, Zig Zag or any other pattern while avoiding the edges of your garden
- Randomly select 5 spots (per acre) in your garden. The

spots should be spread out through your garden. Carefully examine 10 maize plants at each spot for signs and symptoms paying attention to the newest 2 – 3 leaves, tassels and cobs. It is important to note that FAW caterpillars and moths hide inside the maize funnel during the day so check the funnel.

- Record the number of affected maize plants from each spot.
- Take immediate action if the Fall armyworm is present in your garden. Alert your neighbours and follow appropriate control measures as described in the next section of this document or consult your Agriculture Officer
- Check for presence of FAW on other alternate hosts like sorghum, sugar cane, rice, millet and pasture grasses (rhodes grass and elephant grass).
- Pheromone traps can also be used for monitoring the presence of FAW in the garden. If you notice the presence of the male FAW moth in the trap, take appropriate control measures as described in the next section of this document.

2. Scouting

Start scouting in 'W' manner as soon as maize seedlings emerge

At seedling to early whorl stage (3-4 weeks after emergence).

Action can be taken if 5% plants are damaged.

At Mid whorl to late whorl stage (5-7 weeks after emergence)-

Action can be taken if 10% whorls are freshly damaged in mid whorl stage and 20% whorl damage in late whorl stage.

At tasseling and post tasseling (Silking stage)-

Do not spray insecticides (No insecticide application). But 10% ear damage needs action.

3. Cultural control

- Deep ploughing is recommended before sowing. This will expose FAW pupae to predators.
- Timely sowing is advised. Avoid staggered sowings.
- Intercropping of maize with suitable pulse crops of particular region. (eg. Maize + pigeon pea/black gram /green gram).
- Erection of bird perches @ 10 /acre during early stage of the crop (up to 30 days)
- Sowing of 3-4 rows of trap crops (eg. Napier) around maize field and spray with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop shows symptom of FAW damage.
- Clean cultivation and balanced use of fertilizers.
- Cultivation of maize hybrids with tight husk cover will reduce ear damage by FAW.

4. Mechanical control

- Hand picking and destruction of egg masses and neonate larvae in mass by crushing or immersing in kerosene water.
- Application of dry sand in to the whorl of affected maize plants soon after observation of FAW incidence in the field.
- Soil application inside the whorls
- Mass trapping of male moths using pheromone traps @15/acre.

5. Biological control

- In *situ* protection of natural enemies by habitat

management: Increase the plant diversity by intercropping with pulses and ornamental flowering plants which help in build-up of natural enemies.

- Augmentative release of *Trichogramma pretiosum* Or *Telenomus remus* @ 50,000 per acre at weekly intervals or based on trap catch of 3 moths/trap

Biopesticides

Suitable at 5% damage in seedling to early whorl stage and 10% ear damage with entomopathogenic fungi and bacteria

- *Nomuraea rileyi* rice grain formulation (1x10⁸ cfu/g) @ 3g/litre whorl application at 15-25 days after sowing. Another 1-2 sprays may also be given at an interval of 10 days depending on pest damage
- Application of *Metarhizium anisopliae* talc formulation (1x10⁸ cfu/g) @ 5g/litre whorl application at 15-25 days after sowing. Another 1-2 sprays may also be given at an interval of 10 days depending on pest damage.
- Application of *Bacillus thuringiensis* var *kurstaki* formulations @ 2g/litre (or) 400g/acre

6. Stage wise options including chemical control

Seed treatment

With Cyantraniliprole 19.8% + Thionethoxant 19.8% @ 4 ml per kg seed reported to offer protection up to 2-3 weeks after germination (Note that this ,, formulation is not registered in India and also has not been evaluated in AICRP program. However, based on the Jbedback /iont seed growers this insecticide is giving protection for 2- 3 weeks after germination)

First Window (seedling to early whorl stage):

To control FAW larvae at 5% damage to reduce hatch ability of freshly laid eggs, spray 5% NSE OR Azadirachtin 1500 ppm @ 5ml/ litre of water.

Second window (mid whorl to late whorl stage):

To manage 2nd and 3rd instars larvae at 10-20% damage spray Spinetoram 11.7% SC @ 0.5 ml/litre of water OR Thiamethoxam 12.6% + lambda cyhalothrin 9.5% @ 0.25 ml/l of water OR Chlorantraniliprole 18.5% SC @ 0.4 ml/litre of water.

Poison baiting

Poison baiting is recommended for late instar larvae of second window. Keep the mixture of 10 kg rice bran + 2 kg jaggery with 2-3 litres of water for 24 hours to ferment. Add 100 g Thiodicarb just half an hour before application in the field. The bait should be applied into the whorl of the plants.

Third Window (8 weeks after emergence to tasseling and post tasseling):

Insecticide management is not cost effective at this stage. Hand picking of the larvae is advisable.

Infestation threshold for crop growth stages

Sr. No.	Crop stage	Action threshold
1	Seedling to mid whorl stage (1-4 weeks after emergence)	5-10% infested plants
2	Mid whorl to late whorl stage (4-7 weeks after emergence)	10-20 % infested plants
3	Late whorl stage (7 weeks onwards of emergence)	> 20% infested plants
4	Tasseling stage to harvest	> 10% ear damage

(Indian Institute of Maize Research)

7. The Government has taken following steps to control the spread of Fall Army Worm (FAW):-

- 1) The Indian Council of Agriculture Research has prepared a detailed Package of Practices (POOP) against FAW in Maize crop. The POP, inter-alia, contains mechanical, cultural, biological and chemical measures to control FAW. The POP has been circulated to all the States for its implementation. Timely advisories are being issued regularly to State Departments of Agriculture to adopt preventive measures.
- 2) A High Power Committee (HPC) has been constituted, headed by the Secretary (DAC&FW) and Secretary (DARE) to review the status and to recommend appropriate strategies. Based on the recommendations of the HPC, various Sub-Committees have also been constituted in the State of Karnataka, Maharashtra, Madhya Pradesh, Tamil Nadu, Andhra Pradesh, Telangana, Bihar and Rajasthan States, which are headed by the Director / Commissioner of Agriculture / Principal Secretary of the respective State.
- 3) Regular surveys, surveillance and monitoring were conducted by the Central Integrated Pest Management Centres (CIPMCs) in collaboration with the State Department of Agriculture, SAUs and ICAR etc. Further, awareness programmes for the farmers were organized to advise them to adopt cultural and farm practices.
- 4) Certain Bio-control Agents have found effective against FAW. Mass production of these bio-control agents has been promoted.
(Press Information Bureau Government of India Ministry of Agriculture & Farmers Welfare, June-2019)^[5]

Conclusion

- Based on the present studies, it can be concluded that the fall armyworm has spread all over India and is able to cause potential damage to the maize crop.
- Due to high reproductive rate, ability to feeds on many different crops, strong flyer, disperses long distances, continuous generations throughout the year this is very serious pest.
- India is a tropical country where a wide range of crops are cultivated. In near future, the pest may stretch to other important crops of the region like wheat, sugarcane, sorghum, cotton, pigeon pea and vegetables which are grown all throughout the year at one or the other locations.

Future Thrust

The FAW may have found a new home in India, thus

- Strengthen surveillance and monitoring systems
- Develop sustainable management options based on an integrated pest management approach, and this will require:
 - Investment in coordinated research on the pest
 - Strengthened coordination and information sharing among Member States and other stakeholders
 - Lessons learning and exchange of expertise from other regions (Americas) on FAW management

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