

Fall armyworm management in maize

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Fall Armyworm (Spodoptera frugiperda) poses a serious threat to global agriculture and causes reduced production and productivity. It is a notorious pestiferous insect with high dispersal ability, wide host range and high fecundity that makes it one of the most severe economic pests. In January 2019, the new invasive agriculture pest infestation of fall armyworm first time appeared in maize cultivars 502 and 9081 at farmers field in Raigarh district of Chhattisgarh. Identification of fall armyworm has been carried out using nature of damage indicating that there was moist sawdust-like frass near the funnel and upper leaves and morphological character based on the maize crop. It is classified as an A1 quarantine pest on the list of the European and Mediterranean Plant Protection Organisation (EPPO), and is a quarantine pest in South Africa. Its high pestiferous nature poses a formidable challenge to Indian agriculture warranting immediate action before it assumes a serious proportion.

Key words: Fall Armyworm, Maize, *Spodoptera frugiperda*

FALL Armyworm (FAW), originally from the tropical regions of the United States, Argentina, Brazil and the Caribbean region, is a serious pest of maize. The fall armyworm is a polyphagous pest that feeds on at least 100 plant species belonging to 27 families. Fall Armyworm has been confirmed in over 43 African countries. It is reported to cause a 34% reduction in grain yield and annual loss up to 400 million US\$ in Brazil. In addition, it is reported to cause major damage to economically important cultivated grasses such as rice, sorghum, and sugarcane as well as 23 horticultural crops like cabbage, beet, tomato, potato and onion besides cotton, pasture grasses, peanut, soybean, alfalfa, millets and others. This pest was detected for the first time on the Indian subcontinent in mid-May, 2018 in maize fields at the College of Agriculture (UAHS), Shivamogga, Karnataka. Similar information has also just been released based on independent investigations by the

National Bureau of Agriculturally Important Micro-organisms (NBAIR) under the Indian Council of Agricultural Research. Fall Armyworm has spread quickly due to its short reproductive cycle and ability to travel long distances quickly in the adult (moth) stage. Therefore, urgent attention and preparedness on the threat of fall armyworm is crucial. Climate change might also be playing a role in the increased risk from fall armyworm. Under the global warming scenario in India the fall armyworm is going to feed more. This will lead to more generations of the insect and early completion of its lifecycle. The pertinent question is, if this notorious pest can be brought under control? Experts feel that this can be done through early detection and subsequent pest management. The fall armyworm flies on prevailing winds, has a short life-cycle, and attacks a wide range of crops, rendering it a serious economic risk to our farmers. The study was conducted under field surveillance

programme by Scientists of Krishi Vigyan Kendra, Raigarh (Chhattisgarh) and maize growers to assess the incidence and confirm its appearance in entire the district and observations were recorded different crop stages of maize (Fig. 1).

Surveillance and monitoring

The study was conducted under field surveillance programme for the appearance and occurrence of fall armyworm (FAW) in different maize growing areas of Raigarh district and larvae were collected from the damaged plant. Young larvae are difficult to identify morphologically as the early instars resemble those of several other noctuids. The mature larvae were recorded 3.1-3.5 cm long and marked with whitish-yellow inverted 'Y' on the head with distinct black spots (pinacula) on the body. The four black spots on the 8th abdominal segment were arranged in a square and on the 1 to 7th and 9th segment arranged in a trapezoidal pattern (Fig. 2). Grown up larvae



Fig. 1. Damage symptoms of fall armyworm (*Spodoptera frugiperda*) in maize field: Larva feeding inside the whorl with fecal matter and shot hole symptoms on the outer leaves

were dark brown with granular texture all over the body. All the larval characters noticed were resembled those of fall armyworm. Fall armyworm late in star showing inverted “Y” on head capsule and four black dots in a square pattern on eighth abdominal segment. All developmental stages of maize plant are attacked, but severe damages occurred on young plants. The crop stand was 15 days, 30-35 days, 40-45 days and 55-60 days old in different localities surveyed. During survey 15 days old maize crop on an average 5 plant damaged out of 10 plants and 2 full grown larvae/ two-three instar larvae were collected in every plants and 30-35 days old crop their 3 to 4 plant damaged out of 10 plants with 1-2 full grown larvae/ two-three instar larvae were collected but in other one location 30-35 days old crop on average 80-90% infestation was noticed in one acre area. In 40-45 days and 55-60 days old maize crop on an average 1-2 plant damaged out of 10 plants and 1 full grown larvae/ three-fourth instar larvae were collected in infested plants by *Spodoptera frugiperda*. Cannibalistic behaviour was also seen when 15 larvae were kept in one plastic box. Larvae were collected from the different villages of Dharamjaigarh block of the district. The observation was recorded 10 randomly selected plants in one square meter area at different crop stages.

Nature of damage of fall armyworm

Fall armyworm incidence was noticed in maize field locations in

Dharamjaigarh block, Raigarh district. Maize plants damaged by the larvae showed characteristic shot holes on the leaves. Neonate's larvae feeding on leaf gregariously and leaf becomes dry, then larvae were moved to other leaf for feeding. Grown up larvae were found confined to whorls and feeding between the leaves showing distinctive symptom of ragged appearance. A mass of faecal matter accumulated within the whorl. Larvae feeding on developing cob as well as silk were also noticed. Very early symptoms of fall armyworm resemble other stem borer's damage like small holes and “window pane” feeding on the leaves emerging from the whorl is common. Therefore, it is important to find the live larvae and determine which insect is causing the damage. Fall armyworm larvae consume large amounts of leaf tissue resulting in a ragged appearance to the leaves similar to grasshopper damage. Larger larvae are usually found deep in the whorl often below a “plug” of yellowish brown frass. Larvae will also move to the ear as plants begin to tassel and young ears become available. Fall armyworm feeds during the day and night, but are usually most active in the morning or late afternoon, the damage was more serious at early growth stages of the plants (vegetative stage). It is also found that, fall armyworm late-instar larvae damage the growing points of the plants causing defoliation and dead hearts (death of the growing tip). Furthermore, older larvae burrow into maize tassels and ears, causing extensive damage.

Management strategies of fall armyworm

Application of an insecticide is usually not economical for control of the fall armyworm. However, it may be necessary if the infestation is extremely severe and/or the plants are under stress. In such cases, if 75% of the plants exhibit whorl feeding damage and larvae are less than 1-1/4 inches (31 mm) long, and the plants are under stress, treatment may be advisable. If high levels of damage are noted in isolated areas of a field, spot treatments may be warranted. Consider when applying controls that fall armyworm frass (excrement) becomes so heavy that it can create a “plug” which prevents penetration of the insecticide into the whorl where the larvae may be feeding. Monitoring of crop season and installation of pheromone traps @ 5/ acre in the current and potential area of spread in crop season and off-season. Scouting as maize seedling emerge: (1) At seedling to early whorl stage (3-4 weeks after emergence)- Action can be taken if 5% plant are damaged. (2) 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 damaged in late whorl stage. (3) At tasseling and post tasseling (silking stage)- Do not spray insecticides (No insecticide application). But 10% ear damage need action. Integrated management strategy for insect/ pest control which aims at prevention of pests and its damage through a combination of techniques such as chemical,



Fig. 2. Different larval instars of *Spodoptera frugiperda*: Raised four black spots on 8th abdominal segment and inverted 'Y' on head of fully grown larva

biological, new cropping system, modification of cultural practices, use of resistant varieties and through mechanical methods. Integrated pest management (IPM) emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

Seed treatment and use of resistant varieties: Treating the seeds with recommended pesticides especially biopesticides will help in reducing the early damage of the seedlings and laying of egg masses. Seed treatment with cyantraniliprole 19.8% + Thiomethoxam 19.8% @ 4 ml per kg seed reported to offer protection up to 2-3 weeks after germination. Cultivation of resistant varieties is also an effective management technique.

Crop management: Timely crop management practice is one of the best method with zero input cost. Deep ploughing is recommended before sowing. This will expose fall armyworm pupae to predators. Timely sowing is advised and avoid staggered sowing and planting will reduce pest incidence. Intercropping of maize with suitable pulse crops for 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 around maize field and spray with 5% NSKE and azadirachtin 1500 ppm as soon as the trap crop shows symptom of fall armyworm damage. Good soil health and adequate moisture help to raise a healthy crop which can withstand infestation. Unbalanced fertilizer

application, especially high nitrogen application will increase the oviposition of the insect. Hybrid maize cultivation with tight husk cover will reduce ear damage.

Cropping system: It is observed that the infestation is more in monocropping of maize. Growing inter crops like legumes will reduce infestation. Certain flowering plants like Coriander, Marigold, Fennel, etc., attract beneficial insects which are natural enemies. Trees also play a major role as they harbor birds which are natural enemies. The "PUSH-PULL" strategy is a habitat management in which a repellent crop or attractive trap crop is grown to repel pests and attract natural enemies.

Mechanical control: Hand picking and destruction of egg masses and neonate larvae in mass by crushing or immersing in kerosene water. Application of sawdust or dry sand into the whorls of affected maize plants soon after observation of fall armyworm incidence in the field. Mass trapping of male moths using pheromone traps @ 15/ acre. Use of traps, bird perches can also be taken up.

Biological control: Naturally existing enemies *in situ* protection by bio-habitat 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 reneus* @ 50,000/ acre at weekly intervals or based on trap catch of 3 moths/ trap. Parasitoids come under this category. These parasitoids lay eggs on egg masses, larvae or adult of

FAW, which destroy the host by growing on them.

Parasitoid	Nature
<i>Telenomus remus</i> Nixon	Females are egg parasitoids
<i>Chelonus insularis</i> Cresson	Females are ovo-larval parasitoid
<i>Cotesia marginiventris</i> Cresson	Females are solitary larval parasitoid
<i>Trichogramma</i> spp.	Females are egg parasitoids
Archytas, Winthemia and Lespesia	Females lay eggs on adult
Ladybird beetles	Phytophagous in nature
<i>Calosoma granulatum</i>	Feeds on young caterpillar

Entomopathogens: Generally pathogens like bacteria, fungi and virus affect the yield of the crop. But some microorganisms are beneficial to farmers. In this NPV's come first especially *Spodoptera frugiperda* Multicapsid Nucleopolyhedrovirus (SfMNPV). Some fungi include *Metarhizium anisopliae*, *Metarhizium rileyi*, *Beauveria bassiana*, bacteria such as *Bacillus thuringiensis* (Bt). Entomopathogenic fungal formulations: Application of *Metarhizium anisopliae* talc formulation (1 × 10⁸ cfu/g) @ 5 g/ litre whorl application at 15-25 days after sowing. Another 1-2 spray may also be given at an interval of 10 days depending on pest damage or *Nomuraea rileyi* rice grain formulation (1 × 10⁸ cfu/g) @ 3 g/ litre whorl application at 15-25 days after sowing. Another 1-2 spray may also be given at an interval of 10 days depending on pest damage. *Bacillus thuringiensis* v. *kurstaki* formulations @ 2 g/ litre or 400 g/acre.

Biopesticides: Bio pesticides are the pesticides that are biological in origin. Generally the formulations are derived from specific strains of bacteria, fungi or virus. For FAW *Beauveria bassiana* strain R444, *Bacillus thuringiensis subspecies kurstaki* strain SA-11, *Baculovirus*, SFMNPV - *Baculovirus Spodoptera frugiperda* are found effective. Biopesticides are suitable at 5% damage in seedling to early whorl stage and 10% ear damage with entomopathogenic fungi and bacteria.

Botanicals: Botanicals are the natural chemicals which are of plant origin. Botanicals are generally with broad spectrum activity with no or minimum effect on mammals. They act as repelling agents, larvicidal or antifeedants. Extracts from neem seed or leaves, Pyrethrin from *Chrysanthemum cinerariifolium* and rotenoids from *Tephrosia vogelii* are found effective against fall armyworm.

Chemical pesticide: Chemical pesticides are artificially manufactured compounds which have mammalian toxicity and harmful to beneficial organisms. They have residual effect and adversely affected to ecosystem. Generally, the

chemicals like Methomyl, Cyfluthrin, Methyl parathion, are sprayed against fall armyworm. Treating the seeds with recommended pesticides especially biopesticides will help in reducing the early damage of the seedlings and laying of egg masses. Seed treatment with cyantraniliprole 19.8% + Thiomethoxam 19.8% @ 4 ml per kg seed reported to officer protection up to 2-3 weeks after germination. However, based on the growers feedback this insecticide is giving protection for 2-3 weeks after germination. In seedling to early whorl stage fall armyworm larvae at 5% damage to reduce hatchability of freshly laid eggs, spray 5% NSKE/ Azadirachtin 1500 ppm @ 5 ml/ litre of water. In mid whorl to late whorl stage 2nd and 3rd instars larvae 10-20% damage, spray of Emamectin Benzoate @ 0.4 g/ litre of water or spinosad @0.3 ml/ litre of water or Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% @ 0.5 ml/ litre of water or Chlorantraniliprole 18.5 SC @ 0.3 ml/litre of water. Wherever fall armyworm infestation is very severe, application of Emamectin Benzoate @ 0.4 g/ litre of water is the most effective insecticide. Keep the mixture of 10

kg rice bran + 2 kg jaggery with 2-3 litre of waters for 24 hours ferment. Add 100 g Thiodicarb just half an hour before application in the field. The bait should be applied into the whorl stage instars larvae of the plants. Insecticide management is not cost effective at 8 weeks after emergence to tasseling and post tasseling.

CONCLUSION

The appearance of new invasive agriculture pest of fall armyworm in Chhattisgarh has made it clear that the pest will cause destruction globally. At this point, the port of entry of the fall armyworm into the State is not yet determined. As this pest is reported to have remarkable dispersal capacity, high reproductive capacity, absence of diapause and wide host range, it is likely to spread to the entire State. Hence, there is urgency for nationwide co-ordinated efforts to contain the pest. The present study may help the growers to through a light on the above said issues.

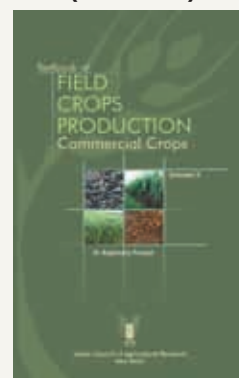
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