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Management of Fall Armyworm *Spodoptera frugiperda* (J.E. Smith)

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Introduction

Fall armyworm (*Spodoptera frugiperda* J. E. Smith; FAW) is native to tropical and subtropical Americas and it'sbeen a sporadic pest in the United States since 1797. In India, the report of the invasive pest FAW was first confirmed in maize (May 2018) by the University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka. Since then, it has spread to many states of India causing havoc to maize production. During 2018 and early 2019, FAW extended from peninsular India to the North and North-East respectively. It has been reported in Bihar, Chattisgarh, Gujarat, Maharashtra, Odisha, Tamil Nadu, Telangana, and West Bengal.

FAW is a polyphagous pest that has been found to attack 353 species of plants from 76 different families, including maize, sorghum, millet, sugarcane, and vegetable crops. However, it is a key pest infesting maize, causing a reduction in maize production from 28.7 million tons to 27.8 million tons (3.2%), while the loss can be 21–53% loss in annual maize production in the absence of control measures. Young larvae mainly feed on epidermal leaf tissue and also make holes in leaves, which is the typical damage symptom of FAW. Feeding young plants through the whorl causes a dead heart. In older plants, the later stage larvae in the whorls can feed on maize cob or kernels, reducing yield and quality.FAW is a tropical species adapted to warmer climates with average temperatures between 10.9–30°C. Some of the strategies to combat this invasive pest are mentioned below.

Economic threshold

On maize crops, if 5% of seedlings are damaged or 20% of whorls of small plants(during the first 30 days) are infested, it is recommended that an insecticide be applied.

Management measures according to symptom progression and larval stage

Elongated papery windows (1st and 2ndinstar FAW larvae)

- Chemical sprays are to be avoided.

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- 5% Neem Seed Kernel emulsion (NSKE) or azadirachtin 1500ppm @ 5ml/L of water.
- *Bacillus thuringiensis*variety kurstaki formulations (Dipel 8 l @ 2ml/L of water or Delfin 5WG @ 2g /l water).
- Entomopathogenic fungi *Metarhizium anisopliae* (1 x 10 cfu/g) @ 5g/l and /or *Nomuraearileyi*rice grain formulation (1 x 10 cfu/g) @ 3 g/l water.

Ragged-edged round to oblong holes (3rd and 4th instar FAW larvae)

- Damage at this stage needs application of chemical pesticides.
- Spraying ofEmamectin benzoate 5 SG @ 0.4 g/l; Spinosad 45 SC @ 0.3 ml/L; Chlorantraniliprole 18.5 SC @ 0.4 ml/L; Thiamethaoxam 12.6% + lambdacyhalothrin 9.5% @ 0.25 ml/L are suggested

Extensive leaf damage (5th and 6th in star FAW larvae)

- If pesticides cannot able to control these large larvae then poison baiting will be effective.
- Poison bait-A mixture of 10 kg rice bran + 2kg jiggery with 2-3 litres of water for 24 hours will be kept to ferment. Then add 100g Thiodicarb75% WP and roll into balls, just half an hour before application in the field. Apply the bait into the whorl of the plants. The bait should be applied into the whorl of the plant in the evening.

Damage to tassel and corn ear

- Sweet corn ear is more prone to FAW damage, which render the ears unmarketable.
- Chemical control measures are not advisable in reproductive stage of maize crop, moreover in sweet corn and baby corn it is

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strictly not advisable, as it is often consumed raw.

- Botanicals or bio-pesticides can be applied.
- Usually handpicking of the larvae is advisable.

Integrated management options are very important for effective pest control, also taking into consideration the FAW larval stages cycle and the time of day for application.

Integrated Management strategies

Fall armyworm

1. **Monitoring**
   - Installation of pheromone traps @ 5/acre in the current and potential area of spread in crop season and off-season.
2. **Cultural methods**
   - Deep summer ploughing before every crop season so that the the soil will open up and expose FAW pupae to sunlight and predators. If zero-tillage is practiced, the spreading of neem cake @ 500kg/ha will be effective.
   - Inter cropping of maize with suitable pulse crops of particular region. Eg: Maize + pigeon pea/black gram /green gram.
   - Napier grass in the border rows can act as FAW trap crop, and spray with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop shows symptom of FAW damage.
   - Application of Sand + lime in 9:1 ration in whorls in first thirty days of sowing can be a good practice to control FAW.
3. **Mechanical traps**
   - Blue cloth (2 sq. m) can be spread randomly in an acre area to attract and kill the FAW larvae.
   - Install FAW pheromone trap @ 5 numbers/acre and light trap @ 1/ha at early stage of crop.
   - While scouting, hand pick and destroy egg masses and neonate larvae by crushing or immersing in kerosene water.
4. **Biological control**

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- Augmentative release of egg parasitoid *Trichogramma pretiosum* or *Telenomusremus* @ 50,000 per acre at weekly intervals or iftrap catch of 3 moths/trap.
- Some other associated natural enemies- *Oriusinsidiosus*, *Podissus sp*., Assasin bug, earwigs, *Exorista* sp., *Glyptapantelescreatonoti*(larval parasitoid), *Campolestis chloridae*(larval parasitoid) etc.

5. Botanicals and Biopesticides

- Apply Azhadirachtin 1% EC @ 10,000 ppm or neem oil @ 5 mL/lit. One week after sowing, this acts as ovipositor deterrent.
- Use of *Nicotiana tabacum*and *Lippiajavanica*can cause up to 66% larvalmortality in maize.
- Marigold leaf extract, moringa oil, clove oil (1%), onion-garlic extract, *Jatropha gossypifolia* (leaf extract), castor (seeds extract) can be effective against FAW.
- If infestation level is at 5% damage in seedling toearly whorl stage and 10% ear damage, then use entomopathogens: *Metarhizium anisopliae*,*Nomuraearileyi*, *Beauveria bassiana*, *Verticiliumlecani* (1 × 108cfu/g)@ 5g/litre whorl application. Repeat it after 10 days if required.
- Apply *Bacillus thuringiensis* var. kurstaki formulations @ 2g/l (or)400g/acre.

6. Chemical control

- Seed treatment with mixture ofCyantraniliprole 19.8% + Thiamethoxam 19.8% FS@ 6 ml/kg of seed will be effective for 15-20 days.
- Spray of spinosad 45 SC @ 0.3 ml/L; Chlorantraniliprole 18.5 SC @ 0.4 ml/L is effective.
- Poison baiting is recommended for late instar larvae.
- Avoid organophosphates and carbamate group of insecticides, FAW has shown resistance to them.

Conclusion

Fall armyworm is a widely spreading invasive pest that causes greater economic loss in agriculture. Depending solely on chemical insecticides can develop resistance in FAW, soa need-based application of insecticides is necessary for the sustainable management. It is a current necessity to identify potential native natural enemies of FAW and discover pragmatic

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integrated strategies, which are effective and compatible with agronomic practicesand also suitable to the socio-economic status of farmers. It would be beneficial to create awareness among important stakeholders and farmers through trainings /group discussions, community-based and area-wide approach for management strategies.

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