Invasive Nature of Fall Armyworm, Spodoptera frugiperda (J.E Smith) and its Management Strategies

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ABSTRACT

Fall armyworm is one of the key pest infesting major cereal crops across the globe. This notorious alien pest has entered into India during 2018 and created huge damage to the crop within a short span of time. The farmers have opted for numerous pest management options but failed resulting in the high yield losses. The previous reports from the neighboring countries have clearly depicted resistance developed by the pest against major insecticides as well as even transgenic maize also. Hence sole dependency on the pesticides is not a viable option. Integration of several techniques in managing fall armyworm can be a solution to fall armyworm management.

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop serving billions in the world as food, feed and industrial raw material and occupies third position after wheat and rice. Maize is known for its higher genetic yield potential made it to be as "queen of cereals". Fall armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is pest native to America, which was first reported in West Africa during January, 2016 (Goergen *et al.* 2016). In Asian continent, FAW incidence was first reported in the southern state of Karnataka, in May 2018 (Sharanabasappa *et al*. 2018) and subsequently

in all the maize-growing states *viz.*, Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Tamil Nadu, and Telangana in the country (Suby *et al*. 2020). FAW was reported by several countries of Asia *viz.*, Yemen, Bangladesh, Myanmar, China, Sri Lanka, Nepal, the Philippines, Vietnam and Indonesia.

Fall armyworm host crops include, maize, sorghum, rice, other millets etc., It attacks the seedling stage of the crop and cause grain damage of 50.27% in maize, 38.61% in sorghum and 33.19% in millets (Yaméogo *et al*., 2024). Apart from several strategies available for insect pest management, farmers solely depend on chemical control method due to its quick results and ease of application. This even holds good for maize also. Indiscriminate use of chemical pesticides has resulted in resistance development, residue problem and harmful effect on the environment. Since maize is one of the commercial crops grown across the world for food, feed and fodder purpose, yield loss due to fall armyworm is a major concern for farmers to save his or her crop.

Integration of different pest management approaches like cultural control, biological control, genetic control and chemical control will have more advantages over sole use of pesticides. Also, this avoids high plant protection expenses to insect pest management. In this direction, this article focuses on invasive nature of fall armyworm and different strategies available for its management.

Invasive nature of fall armyworm

Fall armyworm is native to the tropical and subtropical Americas and has been considered an occasional pest in the United States since 1797. In 1912, a significant epidemic was documented on corn and millets. In Latin America, the FAW was expected to cause a 73% decrease in maize yield. Apart from America, FAW first invaded Africa, with reports coming from Sao Tome, Nigeria, Benin, and Togo. In India, the FAW was first reported in 2018 by the University of Agricultural and Horticultural Sciences in Shivamogga, Karnataka. Since then, it has spread throughout the country and eastward to India's neighbours, Bangladesh, Myanmar, Sri Lanka, China, and Nepal, as well as Thailand, South Korea, and Japan. The temporal distribution of FAW in India has been documented since first report from Karnataka in May 2018. FAW spread from Peninsular India to the North and North-East in 2018 and early 2019, respectively. As the 2019 monsoon progressed, FAW incidence was also documented in the country's northern and north-east regions (Suby *et al*., 2020).

Host range and economic damage of *S. frugiperda*

S. frugiperda is a polyphagous pest, feeding on 353 plant species from 76 families. However, it primarily eats on grasses, with maize being its preferred food. It also causes economic harm to other cereals (sorghum) and millets (pearl millet, barnyard millet, and finger millet). FAW infestation in maize crops begins with seedling emergence and continues through the cob development stages. The female moth lays over 1000 eggs on foliage, either individually or in groups. Following hatching, the early instars disperse via wind, aided by silken thread secreted. The first and second instar larvae feed on the upper surface of the leaves by scraping the epidermis, resulting in elongated papery windows all over the leaves. Later instar larvae settle on the leaf whorl and inflicts series of feeding holes called as pin holes and the faecal matter in the unopened internodes of early whorl stage of maize and cause plant death. Also, the larvae infest tassel and developing ears (Suby *et al*., 2020).

In FAW, there are two strains viz., corn strain 'C' which feeds mainly on maize, sorghum and cotton, a rice strain 'R' which indicates preference towards rice and turf grass. The molecular studies suggested that the FAW in India belongs to 'R' strain based on the polymorphisms in the *Cytochrome oxidase subunit* 1 gene (*CO1*) (Suby *et al*., 2020). ICAR-NBAIR, Bengaluru reported 9-62% infestation of fall armyworm leading to 34% yield loss in Karnataka.

Strategies to manage *S. frugiperda*

Host plant resistance

Host Plant Resistance is commonly employed to create resistant lines against *S. frugiperda*. FAW resistance is ascribed to morphological traits such as leaf toughness, trichome density, and a thicker cell wall complex of the epidermal layer, which acts as a barrier to insect feeding. Biochemical characteristics, such as higher concentrations of amino acids, including aspartic acid and tyrosine, total nitrogen, leaf cuticular lipids, phenolic chemicals may sin and chlorogenic acid and benzoxazinoids (BXs) play an important role in maize defense against insect herbivores (Suby *et al*., 2020).

Transgenics

The introduction of transgenic maize expressing *Bt* proteins represented a substantial advance in insect pest management. In maize, 179 events have been commercially certified for cultivation with the lepidopteran insect resistance trait in 13 countries. All of these events contain one or more combinations of 13 different cry genes. Seven of the thirteen cry genes have been particularly identified as giving FAW resistance. vip3Aa20, cry1F, cry1Fa2, cry1A.105, cry2Ab2, cry1Ab, and mocry1F. Plant-expressed *Bt* proteins provide resistance to lepidopteran insects by specifically destroying their midgut lining. *Bt* maize, particularly with Cry1F, has been shown to lower the FAW population by more than 50% (Suby *et al*., 2020).

Agro-ecological interventions for management

Agro-ecological treatments are an essential component of IPM, along with insect resistance breeding, biological control and safer pesticides. Cultural methods increase crop health, lower pest populations, and provide shelter and alternate food sources for FAW natural enemies, allowing for natural control. Pest-repelling legumes such as *Desmodium* spp. or *Tephrosia* planted as intercrops 'push' the insect outside crop areas, whereas pest-attractive trap plant species such as napier grass or *Brachiaria* spp. are planted on the border to 'pull' the pest towards them (Suby *et al*., 2020).

Integrated Pest Management Practices for *S. frugiperda*

IPM package for FAW in maize was made by ICAR-IIMR in collaboration with ICAR-NBAIR and communicated to various stakeholders. Ministry of Agriculture and Farmers welfare, Government of India also given management strategies for the S. *frugiperda*.

Monitoring: Installation of pheromone traps at a rate of 5 per acre in the existing and potential spread area during crop and off-season.

Scouting: Begin scouting as soon as maize seedlings sprout.

1. At the seedling to early whorl stage (3-4 weeks following emergence), action can be done if 5% of the plants are injured.

2. At the mid to late whorl stage (5-7 weeks after emergence), action can be taken if 10% of the whorls are newly damaged in the mid whorl stage and 20% in the late whorl stage.

3. Do not spray chemical insecticides during or after tasseling (the silking stage). In the event of ear/cob damage, a suitable biopesticide can be employed.

Cultural Measures

1. Prior to seeding, deep ploughing is recommended. This will expose the FAW pupae to predators.

2. Sowing over a big region should be done in a timely and uniform manner. Avoid staggered seeding.

3. Maize intercropping with region-specific pulse crops. (For example, maize plus pigeon pea, black gram, or green gram).

4. Set up 10 bird perches per acre during the crop's early stages (up to 30 days).

5. Plant 3-4 rows of trap crops (e.g., Napier) surrounding the maize field, then spray with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop shows signs of FAW damage.

6. Clean cultivation and balanced fertilizer application. 7. Growing maize hybrids with a tight husk cover will help to decrease ear damage caused by FAW.

Mechanical control

1. Hand picking and destruction of egg masses and neonate larvae via crushing or immersion in kerosine water.

2. Apply dry sand to the whorls of afflicted maize plants as soon as FAW is observed in the field.

3. Apply sand and lime in whorls in a 9:1 ratio during the first thirty days of sowing.

4. Male moths were mass trapped using FAW-specific pheromone traps at a rate of 15 per acre.

Biological control:

1. In situ protection of natural enemies through habitat management: Increase plant diversity by intercropping with pulses, oil seeds, and decorative flowering plants, which aid in the development of natural enemies.

2. Augmentative release of the egg parasitoid *Trichogramma pretiosum* or *Telenomus remus* at 50,000 per acre at weekly intervals or based on a three-moth trap catch.

3. Bio-pesticides: Use entomopathogenic fungus and bacteria to treat 5% damage in seedling to early whorl stage and 10% damage in ears.

   Metarhizium anisopliae/ *Metarhizium rileyi* (*Nomuraea rileyi*)/ *Beauveria bassiana*/ *Verticilium lecani*: 1×10^8 cfu/g @ 5g/litre whorl application. Repeat after 10 days if required or spraying with *Bacillus thuringiensis* v. *kurstaki* formulations @ 2g/l (or) 400g/acre is also helpful.

4. Application of *Spodoptera frugiperda* NPV and entomopathogenic nematodes is also done.

Chemical Control:

1. **Seed treatment:** Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS at 6 ml/kg of seed will last 15-20 days.

2. **First Window (seedling to early whorl stage):** Spray 5% NSKE / Azadirachtin 1500ppm @ 5ml/l of water to inhibit FAW larvae and diminish the hatchability of newly placed eggs.

3. **Second window (mid whorl to late whorl stage)**: To handle 2nd and 3rd instar larvae with more than 10% foliar damage, the following pesticides can be applied until

the early tasselling stage: Spinetoram 11.7% SC, chlorantraniliprole 18.5% SC, or thiamethoxam 12.6% with lambda cyhalothrin 9.5% ZC.

4. Poison baiting is advised for second window larvae in their late instar stage. Ferment 10 kg rice bran and 2 kg jaggery in 2-3 liters of water for 24 hours. Add 100g Thiodicarb only 30 minutes before applying in the field. The bait should be inserted into the whorl of the plants.

5. **Third window (8 weeks from emergence to tasseling and post-tasseling)**: At this time, insecticide management is not cost-effective. Bio-pesticides, as previously recommended, will be applied. Handpicking the larvae is recommended. All sprays should be directed toward the whorl and applied in the morning or evening.

Capacity building and mass awareness

1. Implementing and enforcing plant protection measures to prevent the pest from spreading from the abandoned crop.

2. Creating awareness among key stakeholders through trainings and group discussions.

3. A community-based and area-wide approach to applying management measures.

CONCLUSION

Fall armyworm is an invasive and alien pest attacking more than 200 host plants and thus causing significant yield loss. A thoughtful pest management plan is a key step to tackle the fall armyworm problem. Scouting and monitoring may provide pest status to decide calendar-based pest management practices. Combined and wise use of different pest management strategies can be a solution for managing pesticide resistant population of fall armyworm.

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