Fall Armyworm (FAW) Management: A Notorious Devil in Maize (*Zea mays* L.)

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ABSTRACT

The Fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) is a voracious feeder in the maize crop having a typical feeding habit of hiding inside the inner whorl of the maize plant. The final instar larvae are responsible for huge crop loss and yield reduction. That's why, the control of the menace of FAW is now the need of the hour. Although the use of synthetic insecticides gives instant control to the FAW armyworm, the implementation of integrated practices is always advisable because of the insect's hiding behavior. The IPM practices have only the demerit of slow-acting but that is completely eco-friendly, cost-effective, and sustainable.

INTRODUCTION

Introduction and damage: Fall armyworms (FAWs) are highly polyphagous pests that attack over 350 commercial and non-commercial hosts across 76 plant families (*Spodoptera frugiperda* (J. E. Smith) Lepidoptera: Noctuidae), with gramineous plants being their preferred host (Malo and Hore, 2020). Fall armyworms primarily damage the growth points of maize

plants and burrow into the older plants' cobs, reducing the amount, quality, and yield of the plant (FAO, 2018). Larvae feeding on the developing or mature portion might result in direct yield losses (Harrison, 1984), while defoliation can cause indirect yield losses by decreasing the amount of photosynthetic area, which lowers grain production (Capinera, 2008; Vilarinho *et al*., 2011).

In addition to causing quality losses, larval feeding can introduce pathogenic and saprotrophic fungi that can contaminate grain with mycotoxin (Farias *et al*., 2014). According to Sisay *et al*. (2019), first-instar larvae exhibit pin-hole symptoms and scrape leaves. According to Morrill and Greene (1973), later instars often exhibit cryptic feeding behaviors that are found in deep, protected areas of plants like the whorl, leaf base/collar, or fruit. Damage during later vegetative stages results in skeletonized leaves and heavily windowed whorls (Goergen *et al*., 2016).

Management of FAW:

1. Chemical management: Fall armyworm control makes extensive use of insecticides (Gutierrez-Moreno *et al*., 2019; Sisay *et al*., 2019). For fall armyworm treatment, the CIB & RC now advises using Spinetoram 11.7 SC, Thiamethoxam 12.6% + Lambda-cyhalothrin 9.5% ZC, and Chlorantraniliprole 18.5 SC (DPPQS, 2019). Emamectin benzoate is the most dangerous substance for managing FAW, followed by Chlorantraniliprole, Spinetoram, Flubendiamide, and Triflumuron (Deshmukh *et al*., 2020). Chlorantraniliprole was shown to be the most lethal, followed by Flubendamide, Spinosad, Indoxacarb, and Fenvalerate, with a mortality rate of >80%. One efficient emergency-based control strategy for invasive FAW is the application of new synthetic pesticides (Kong *et al*., 2021). The most harmful substance against FAW larvae was found to be spinosad (Daves *et al*., 2008).

2. Cultural and physical management: Because late plantings of maize ears will result in a greater infestation of FAW than early plantings, cultural management entails avoiding late plantings (Bilbo, 2019). Reducing the amount of FAW invasion can also be achieved by intercropping and alternating maize with non-host crops like beans and sunflowers (FAO, 2018). The International Maize and Wheat Improvement Centre (CIMMYT) is investigating the effective use of the Push and Pull cropping system, which is regarded as a significant climate-smart technology, for the control of FAW (Prasanna *et al*., 2019).

Early sowing has the benefit of preventing fall armyworm infestations in early-planted and short-duration genotypes of maize (Kandel and Poudel, 2020; Bhusal and Chapagain, 2020). Fall armyworm monitoring has shown that light traps work well. Pheromones that are frequently utilized include aggregation and sex pheromones (Prasanna *et al*., 2018). Fall armyworm proliferation and development are favored by nitrogen and inhibited by potassium (Kumar *et al*., 2015). planting three to four rows of Napier grass around maize fields to mitigate fall armyworm damage to the trap crop (Guera *et al*., 2020).

4. Mechanical control: Hand-picking the egg masses during routine field observations aids in the pest's small-scale management and has shown some degree of success (Rwomushana *et al*., 2018). 15% of Ethiopian farmers exclusively used handpicking to manage FAW in maize (Kumela *et al*., 2019).

5. Biocontrol: According to Komivi *et al*. (2019), *Metarhizium anisopliae* and *Beauvaria bassiana* are efficient against FAW eggs and second-instar larvae. Among the significant biological controls are the *Spodoptera* *frugiperda* Multiple Nucleo Polyhedro Virus (SfMNPV), the use of parasitoids, or predatory insects, and genetically modified crops containing *Bt* genes, which produce proteins toxic to FAW larvae (Day *et al*., 2017). According to Franz *et al*. (2022), the *Cry1F* protein is believed to be more toxic to FAW than any other Cry protein, even though no commercial *Bt* isolates have been developed to address FAW.

A B C

Fig. 2 Larval infected with entomopathogenic fungal spore of A. Nomuraea rileyi, B. Metarhizium anisopliae, and C. Beauveria bassiana (Source: original research pictures)

According to the FAO (2018), earwigs, ladybird beetles, flower bugs, and ants are significant predatory insects. From FAW larvae, solitary parasitoids belonging to the Hymenoptera genera *Chelonus* and *Campoletis* were found (Tendeng *et al*., 2019), and parasitoids of the *Trichogramma* genus may have great potential as biocontrol agents for the creation of inundative biological control programs (Zhang *et al*., 2021). Among the common insectivorous birds that eat a lot of lepidopteran insects, including FAW, are the black drongo, house sparrows, blue jays, cattle egrets, rosy pastor, and mynah (Jones *et al*., 2005).

6. Botanicals: According to a study, using *Azadirachta indica* seed cake extract caused a significant mortality rate in FAW larvae (Silva *et al*., 2015). Researchers came to the conclusion that the ethanolic extracts from Extracts of neem, *Azadirachta indica* (Family: Meliaceae), and *Argemone ochroleuca* (Papaveraceae) slowed down larval growth and reduced eating, which resulted in FAW larval mortality (Martinez *et al*., 2017). The two most commonly used products are pyrethrin (from pyrethrum) and azadirachtin (from neem). Other products include nicotine, ryanodine, quassia, garlic, and rotenone (Isman, 1997). The highest recorded larval death rate, 66%, was found in *Nicotiana tabacum* (Phambala *et al*., 2020). According to some American smallholder farmers, controlling FAW larvae can be achieved by using whorls of ash, sand, sawdust, or soil (FAO, 2018).

7. Genome editing approach: A study conducted in China revealed that utilizing genetically modified crops was effective in controlling the fall armyworm (Li *et al*., 2021). Because *Bt* crops have a narrow spectrum of activity and can aid with natural pest management by reducing the need for chemical insecticides, growing *Bt* crops has contributed to reducing pollution (Romeis *et al*., 2019). The elimination of the abdominal wall using the CRISPR/Cas9 a homeotic gene in the fall armyworm, suggests that the fall armyworm genome may be edited with great efficiency using CRISPR/Cas9 technology (Wu, 2020). Gene editing methods such as RNA interference (RNAi) have been beneficial in modifying FAW genes associated with pesticide resistance (Ullah *et al*., 2022).

CONCLUSION:

FAW not only feeds on the maize whorl but also causes huge yield loss worldwide in terms of production. The biology and habitat (feeding at the inner whorl of the plant) of the pest make it easier to cope with the chemical insecticide application, without being harmed. So, the integrated management practices including cultural, physical, mechanical, botanical, and biological control methods which are nature's demand in the 21st century, to manage the pest below ETL, to save the maize crop from multibillion-dollar loss and food security.

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