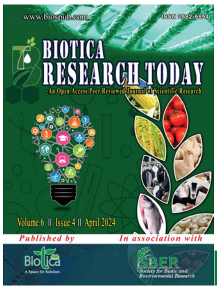

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# Managing Fall Armyworm Infestations: Effective Strategies for Crop Protection

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## Abstract

The fall armyworm (*Spodoptera frugiperda*) is a highly damaging pest that threatens global agriculture. Originating from the Americas, it invaded Sub-Saharan Africa in 2016 and subsequently spread to India and numerous other countries in Africa and Asia. Its life cycle consists of six larval instars over a period of 14 to 18 days, with pupae exhibiting morphological and morphometric differences between sexes. Effective management approaches include monitoring and early detection, cultural practices like crop rotation and mechanical control methods such as handpicking, biological control through natural enemies, host plant resistance and integrated pest management strategies. These measures collectively aim to mitigate the impact of fall armyworm infestations and safeguard agricultural productivity.

**Keywords:** Infestation, Monitoring, Pest management, *Spodoptera frugiperda*

## Introduction

The fall armyworm, scientifically known as *Spodoptera frugiperda* (J.E.Smith) and belonging to the family Noctuidae, is an invasive pest in India with a wide-ranging diet. Originating from the tropical and subtropical regions of the Americas, it caused significant damage in Sub-Saharan Africa in early 2016 before making its way to India in 2018 (Goergen *et al.*, 2016). Within short period of time after its introduction, fall armyworm spread is confirmed over 47 African countries and 19 Asian countries. Fall armyworm infestation was first reported in India on maize in Shivmogga district of Karnataka (Sharanabasappa *et al.*, 2019). Until now, fall armyworm is reported from all over the country except from Jammu and Kashmir and Himachal Pradesh. A recent estimate on fall armyworm in India shows a total of 2.45 lakh hectares area is affected. Highest incidence of fall armyworm was noticed in Karnataka (1.4 lakh ha), followed by Madhya Pradesh (85,000 ha) and Rajasthan (59,000 ha). Globally, fall armyworm is noticed to cause damage to many important cultivated plant species like maize, sorghum, sugarcane, rice, cruciferous crops, cucurbits, cotton, bean, ginger, cowpea and some wild grasses.

## Host and Distribution

Montezano *et al.* (2018) found that fall armyworm larvae exhibited the ability to infest a broad range of host plants, totaling 365 species across 76 plant families. The most prevalent families affected were Poaceae (106), followed by Asteraceae (31) and Fabaceae (31). The fall armyworm poses a threat to sorghum crops at all stages of growth, causing significant damage.

**Damaging Stage**: Larva

## Nature of Damage

In their initial developmental phases, fall armyworm larvae exhibit social behaviour and feed by scraping chlorophyll from one side of leaves, leaving the opposite epidermal

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layer intact, leading to the formation of translucent patches termed "window panes."

Furthermore, they puncture leaves with minute holes and, as they progress across the plant whorl, generate irregular elongated lesions. As they mature, these larvae induce significant defoliation, frequently stripping plants down to their midribs and stalks, accompanied by the production of faecal matter resembling sawdust (Figure 1). During their reproductive phase, they continue feeding on leaves and developing grains in the sorghum panicle, potentially leading to significant crop damage.

Figure 1: Damaging symptoms with faecal materials with early instar larvae of *Spodoptera frugiperda*

## Life Cycles

*Egg*

The freshly laid eggs of the fall armyworm were pale white and displayed a cylindrical or dome-shaped form with a flattened base. These eggs were often grouped together, sometimes in layers and were covered by the dense, greyish-white abdominal hair of the female moth, resulting in a fuzzy appearance to the egg mass [Figure 2(a)].

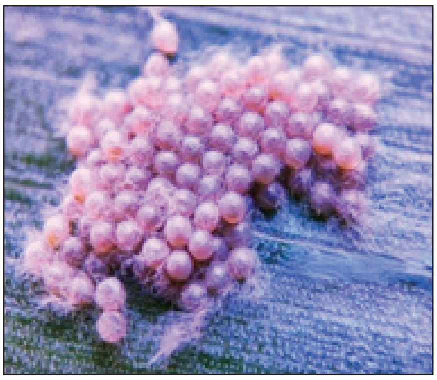
As hatching approached, the egg colour would darken [Figure 2(b)]. A single egg mass typically contained 300-400 eggs and a gravid female would lay approximately 2-4 egg masses.

*Larva*

Fall armyworm, *S. frugiperda*, undergoes six larval instars throughout its life cycle. The larval phase lasted between 14 to 18 days, with an average duration of 16.25 days [Figure 2(c) & 2(d)]. During this period, larvae molted five times.

*Pupa*

The pupae exhibited a reddish-brown coloration [Figure 2(e)] and distinct morphological and morphometric variations were observed between male and female pupae. Sexing of the pupae was achieved by examining the genital opening, with the distance between the genital opening and anal slot serving as a distinguishing factor between males and females. This distance was greater in females compared to males. Additionally, male pupae were found to be slightly larger than female pupae when measured morphometrically.



a) Eggs of S. *frugiperda*

b) Newly hatched larvae 1$^{st}$ instar

c) 2$^{nd}$ instar larvae

d) Late instar larvae (fully matured)

e) Pupae

f) Adult

Figure 2: Different life stages of S. *frugiperda*

*Adult*

Fall armyworm moths were medium-sized and dusky brown in colour. Morphological and morphometric differences distinguished male and female moths. In general, female fall armyworm moths exhibited smaller body length, wingspan and wing length compared to males. Male moths displayed forewings with shades of grey and brown, adorned with triangular white spots at the tip and near the centre. Conversely, females possessed markings that were less pronounced, varying from a uniform greyish-brown to fine mottling of grey and brown [Figure 2(f)]. Both sexes had iridescent silver-white hind wings bordered with dark narrow bands.

## Management

• *Monitoring and Early Detection*: Implement regular scouting and monitoring programs to detect fall armyworm infestations early. Utilize pheromone traps and visual inspections to assess population levels and distribution.

• *Cultural Practices*: Encourage practices such as crop rotation, intercropping and planting early-maturing varieties to disrupt the fall armyworm life cycle and reduce host availability.

• *Mechanical Control*: Employ mechanical methods like handpicking of egg masses and larvae, as well as crushing egg masses to reduce population numbers manually.

• *Biological Control*: Promote habitat management to conserve beneficial insects like parasitoids and predators, crucial for controlling fall armyworm at different life stages. *Telenomus* or *Trichogramma* wasps stand out as top choices for potential biological control programs, particularly for targeting fall armyworm eggs.

• *Chemical Control*: Utilize insecticides judiciously, applying them when population levels exceed economic thresholds or when natural control methods are insufficient. Rotate chemical classes to mitigate resistance development. Korrat *et al.* (2012) established the $LC_{10}$, $LC_{25}$ and $LC_{50}$ values for Emamectin benzoate, Spinosad and Chlorfluazuron against *S. litura*. Analyzing mortality data, they found that after three days post-treatment, Emamectin benzoate demonstrated the highest efficacy, followed by Spinosad and Chlorfluazuron.

• *Host Plant Resistance*: Develop and deploy resistant crop varieties or genetically modified organisms (GMOs) that are less susceptible to fall armyworm damage.

• *Integrated Pest Management (IPM)*: Implement a holistic approach that integrates multiple management strategies, taking into account ecological, economic and social considerations to manage fall armyworm effectively while minimizing environmental impacts and maximizing sustainability.

## Conclusion

In summary, addressing the challenges posed by fall armyworm infestations demands a comprehensive and nuanced strategy that encompasses a variety of approaches. Through diligent monitoring efforts and the early detection of outbreaks, agricultural stakeholders can promptly identify areas of concern and implement timely interventions. Cultural practices such as crop rotation and intercropping offer sustainable means of disrupting the fall armyworm life cycle and reducing its impact on vulnerable crops. Additionally, mechanical control methods, including the manual removal of egg masses and larvae, provide an effective means of population management.

Biological control measures, such as the introduction of natural predators and parasitoids, offer environmentally friendly alternatives to chemical pesticides, contributing to the preservation of ecological balance. Though chemical control remains a viable strategy, its prudent use is essential to minimize harm to non-target organisms and mitigate the emergence of pesticide resistance. Additionally, integrating host plant resistance by developing and deploying resistant crop varieties highlights the significance of genetic innovation in addressing fall armyworm infestations. Ultimately, the adoption of an integrated pest management (IPM) approach, which harmonizes the various control strategies while considering ecological, economic and social factors, represents a holistic and sustainable means of managing fall armyworm populations. By leveraging the synergies between these diverse methods, agricultural communities can enhance resilience against fall armyworm outbreaks and safeguard global food security for generations to come.

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