

From the Americas to Asia: The Global Spread of Fall Armyworm and its Impact on Agriculture

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Abstract

The fall armyworm, a major pest of maize, has the potential to cause 100% yield loss, spanning from the early growth stages to cob formation. Its insatiable appetite and broad host range have sparked fears regarding food security. The spread of the fall armyworm beyond its native range has become a global challenge, with the pest successfully invading various African countries, as well as countries in Asia, including India. This article elucidates the biology, distribution, and recommended management strategies for combating this formidable pest.

Introduction

The fall armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), poses a significant threat to agricultural productivity due to its broad host range, rapid spread, and prolific reproduction (Todd *et al.*, 1980). Originally native to tropical and subtropical regions of the Americas, it earned its moniker "fall armyworm" for its tendency to become a late-season pest in the United States (Prasanna *et al.*, 2018). In 2018, FAW was first reported in India, particularly infesting maize fields in Karnataka (Sharanabasappa *et al.*, 2018). FAW is known to infest 353 plant species belonging to 76 plant families. It primarily infests grasses and it has a strong preference for maize. The global crop losses caused by FAW in maize range from 22% to 67% in different regions (De Groote *et al.*, 2020).

Distribution

FAW has been documented as a maize pest in pre-Columbian texts in Mesoamerica (Bricker and Milbrath, 2011). FAW's native distribution spans from Argentina to the southern US, thriving in tropical and subtropical. Despite its intolerance to low temperatures, FAW can migrate long distances, leading to severe infestations observed in the mid-southern US states in 2021 (Stewart, 2021). The

invasion of FAW outside its native range commenced in 2016 in West Africa and subsequently spread globally, including sub-Saharan Africa, the Middle East, Asia, Oceania, and Europe, with genetic analysis tracing West African populations back to Florida and the Antilles (Nagoshi *et al.*, 2018). Intercepted shipments indicate its presence in various countries before official detection. Since its confirmation in India in May 2018, FAW has expanded its geographical range to neighbouring countries, including Bangladesh, Myanmar, Sri Lanka, China, Nepal, Thailand, South Korea, and Japan (Sharanabasappa *et al.*, 2018).

Host range of FAW

FAW is an invasive polyphagous pest that feeds on crops like maize, sorghum, wheat, sugarcane, rice, cotton, soybean, tomato, and banana. This wide host range enables mass oviposition and intraspecific competition, leading to cannibalism in later stages. FAW comprises two strains: C strain, favoring maize, sorghum, and cotton, and R strain, showing a preference for rice and turf grasses. Although morphologically similar, they differ in pheromone components, genetics, mating behavior, and host preference. Initial belief in India's FAW population being the R strain shifted upon molecular studies revealing inter-strain hybrids (Nagoshi *et al.*, 2019).

Nature of damage

Fall Armyworm (FAW) feeding on maize crops starts at the seedling stage and continues through the reproductive stage. Neonate larvae emerge and consume both upper and lower leaf surfaces, leading to characteristic window-paning symptoms (www.cabi.org). Cannibalism among larvae prompts migration, leaving one or two larvae per plant by the second or third instar (Chapman *et al.*, 2000). In the third instar, larvae move to feed within the whorls, filling them with excreta, and later bore into internodes, ultimately causing plant death. FAW

primarily feeds during the daytime, especially in the afternoon, with severe infestations damaging both cob and tassel. Yield losses occur due to foliage consumption, reduced photosynthetic activity, and grain quality deterioration from fungal infections facilitated by larval feeding. Damage extends to other crops, causing 60.1% in sorghum, 41% in pearl millet, 22.9% in barnyard millet, and 10.2% in finger millet (Suby *et al.*, 2020). Damage severity is influenced by factors such as planting time, geographic area, variety,



and cultural practices.

Figure 1: Damage caused by Fall armyworm in maize

Reproductive behaviour

The mating behaviour of Fall Armyworm (FAW) involves female moths emitting sex-specific pheromones to attract males, with mating primarily occurring between 2200 and 0300 hours. Mating frequency peaks at temperatures of 25 and 30°C, with males mating an average of 6.7 times and females 3.7 times during their lifespans (Simmons *et al.*, 1992). Insects reared on a meridic diet exhibit successful mating with a frequency of 1.7, accompanied by a mean fecundity of 1796 eggs and a net reproductive rate of 945.26 (Sagar *et al.*, 2022).

Life history

Eggs: FAW exhibits high reproductive capacity, with females laying 100-300 eggs primarily on the undersides of leaves, occasionally on the upper surface (www.cabidigitallibrary.org). Eggs are typically laid in batches, often in stacked layers, and mature females can lay up to 1796 eggs (Sagar *et al.*, 2022). The incubation period ranges from 2 to 10 days depending on climatic conditions.

Larva: The larval phase of FAW comprises six instars, lasting approximately 14-21 days (Sagar *et al.*, 2022). Larvae exhibit selective feeding behaviour in early stages, transitioning to gregarious feeding, causing substantial leaf damage (Helen *et al.*, 2021).

1. **1st Instar Larva:** Lasting 2.5-3 days, larvae are whitish with a large black head capsule, exhibiting ballooning behavior for dispersal.
2. **2nd Instar Larva:** Pale yellowish-green, lasting 2.5-3 days.
3. **3rd Instar Larva:** Greenish-brown with a white lateral line, lasting 2-2.5 days, marked by cannibalistic behavior.
4. **4th Instar Larva:** Dark brown with square-shaped spots on the eighth abdominal segment, lasting 2-2.5 days.
5. **5th Instar Larva:** Similar to the fourth instar but larger, lasting 2.5-3 days.
6. **6th Instar Larva:** Dull greyish-brown, stout with visible segmentation, reaching up to 4.5 cm, lasting 4.5-5 days.

Pupa: Pupation occurs in soil at depths of 2-8 cm, with pupal duration ranging from 7-9 days in summer to 20-30 days in winter.

Adult: Adult moths are nocturnal, with males displaying distinct wing patterns and smaller body sizes (www.cabi.org). Females have less distinct markings and slightly larger bodies, with lifespans averaging 11.5-13 days.

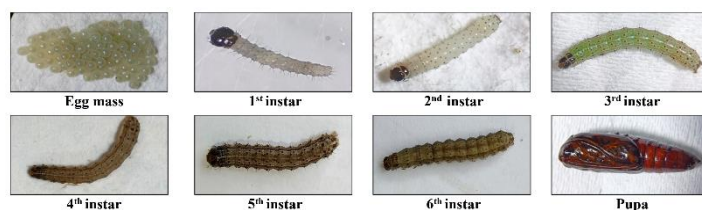


Figure 2: Lifestages of fall armyworm



Management of FAW in maize

The management strategies suggested by DPPQS are as follows-

Monitoring: Installation of pheromone traps @ 5/acre in both crop season and off-season areas of current and potential spread.

Scouting

1. Early Stage (Seedling to Early Whorl): Initiate scouting when maize seedlings emerge. Action threshold: 5% plant damage.
2. Mid to Late Whorl Stage: Scout 5-7 weeks post-emergence. Action thresholds: 10% freshly damaged whorls in mid-stage, 20% in late-stage.
3. Tasseling and Post-Tasseling: Avoid chemical insecticides. Use bio-pesticides if ear/cob damage occurs.

Cultural Measures

1. Deep Ploughing: Expose FAW pupae to predators before sowing.
2. Timely and Uniform Sowing: Avoid staggered sowings.
3. Intercropping: Maize with pulses like pigeon pea or green gram.
4. Bird Perches: Erect @ 10/acre during early crop stage.
5. Trap Crops: Plant 3-4 rows of Napier grass around maize fields. Treat with 5% NSKE or azadirachtin 1500 ppm when damaged.
6. Clean Cultivation: Use balanced fertilizers.
7. Hybrid Selection: Choose maize hybrids with tight husk cover to reduce ear damage.

Mechanical Control

1. Hand Picking: Remove egg masses and neonate larvae manually.
2. Dry Sand Application: Apply sand into affected maize whorls.
3. Sand + Lime Mixture: Apply in whorls within the first 30 days of sowing.
4. Mass Trapping: Use FAW-specific pheromone traps @ 15/acre.

Bio Control

1. Habitat Management: Increase plant diversity for natural enemy protection.
2. Augmentative Release: Release egg parasitoids *Trichogramma pretiosum* or *Telenomus remus* @ 50,000 per acre at weekly intervals.

3. Bio-Pesticides: Apply entomopathogenic fungi such as *Metarhizium anisopliae*, *Metarhizium rileyi* (*Nomuraea rileyi*) - 1×10^8 cfu/g @ 5g/litre whorl application, entomopathogenic bacteria such as *Beauveria bassiana*, *Verticillium lecani*.

Chemical Control

1. Seed Treatment: Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS @ 6 ml/kg of seed.
2. Early-Stage Sprays: Use 5% NSKE or Azadirachtin 1500ppm @ 5ml/l at 5% plant damage.
3. Mid to Late-Stage Sprays: Apply Spinetoram 11.7% SC, Chlorantraniliprole 18.5% SC, or Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC.
4. Poison Baiting: Apply fermented mixture of rice bran, jaggery, and insecticide to late instar larvae.
5. Late-Stage Management: Use bio-pesticides or hand-pick larvae. All sprays should target whorls and be applied early morning or evening.

Conclusion

The fall armyworm (FAW) poses a great threat to global agriculture, inflicting substantial economic losses and endangering food security. Its wide host range, rapid spread, and destructive feeding habits necessitate integrated pest management strategies, including monitoring, cultural practices, mechanical and biological controls, along with judicious use of chemical pesticides. Collaboration among researchers, policymakers, and farmers is imperative to develop and implement sustainable solutions to mitigate FAW's impact on global agriculture.

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