**A Brief Review on the Invasive Fall Armyworm,** ***Spodoptera frugiperda* J.E. Smith (Lepidoptera: Noctuidae)**

**Abstract**

The fall armyworm (*Spodoptera frugiperda*), a highly destructive and invasive pest species, has rapidly become a major concern for global food production systems. Originally endemic to the Americas, this noctuid moth has aggressively expanded its geographical range causing widespread crop losses and threatening the livelihoods of millions of smallholder farmers. Known for its polyphagous nature , the *S. frugiperda* feeds on over 80 host plant species, with a strong preference for cereal crops such as maize, rice, sorghum, and wheat. Its ability to migrate over long distances, coupled with rapid lifecycle turnover and resistance development to common chemical pesticides, makes *S. frugiperda* a formidable pest in both rainfed and irrigated agro-ecosystems. The species exhibits two genetically distinct strains the rice strain and the corn strain which differ in host preference and geographical behavior, complicating control measures. Moreover, the lack of early warning systems and limited access to effective control technologies in newly invaded regions exacerbates the pest's impact. This review aims to provide a concise overview of the taxonomy, biology, invasion history and all further details about *S. frugiperda*, emphasizing the importance of sustainable and adaptive pest management approaches in the face of ongoing agricultural challenges.

Keywords: ***FAW, Maize, Invasive, Spodoptera frugiperda, Noctuidae, Lepidoptera***

1. **Introduction**

Maize, *Zea mays* considered as Queen of Cereals, is grown for a variety of purposes like human consumption, cattle and poultry feed in India. Industrial processing may also include extraction of starch, corn syrup, dextrose and also corn oil. Being a crucial staple food, it is cultivated in among 160 countries with a diverse soil and climatic conditions [**Mishra et al. 2025**]. *Zea mays* contribute about 36% of global grain production [**Malleta, 2024**]. According to existing reviews it is seen that almost 13% of total production is used for industrial processing, 24% is consumed as human food, 11% as cattle feed and 52% as poultry feed [**Dass 2013**]. Development of Quality Protein Maize using the OPAQUE 2 Gene has overcome the deficiency of essential amino acids [**Maitra et al. 2019**].

Southern states of India such as Karnataka and Madhya Pradesh account a highest percentage of maize plantation. It is prominently seen that during 2020-2021 about 9.86 million ha of maize was grown yielding almost 31.50 mt and 29.5 q/ha productivity in India [**Mishra et al. 2025**]. In 2050, Projected Demand for maize is estimated as 121 mt [**Amarasinghe and Singh, 2008**]. Usually, it is grown as a rainfed crop under residual moisture conditions in India. In Odisha, it is evidently found that southern states are more actively involved in cultivation of maize. Cultivated area is about 2.8 lakh hectare with production of about 7.79 lakh tonne of maize with a productivity of about 2785 kg/ha [**Odisha Agricultural Statistics, 2013-2014**]. Districts like Boudh, Gajapati, Ganjam, Kalahandi, Malkangiri, Koraput, Nabrangpur, Kandhamal, Rayagada and Nuapada is considered to be the production hub of maize in Odisha [**Maitra et al. 2019**].

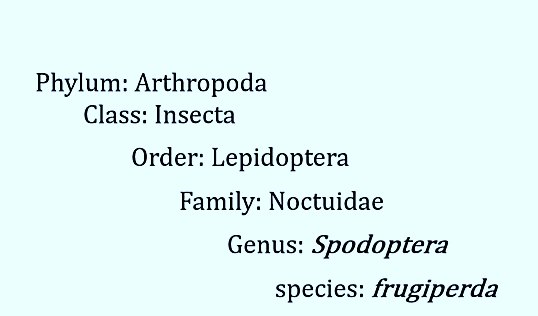
Despite its great contribution to the economy, it is seen that almost 141 insect pests cause a varying degree of damage to the crop from the stage of sowing to harvest **[Reddy and Trivedi, 2008].**  A newly introduced pest, the invasive fall armyworm is considered to be creating havoc in the maize production. *Spodoptera frugiperda* (Noctuidae: Lepidoptera) is a notorious, polyphagous pest feeding voraciously on more than 80 crops and plant species [**Prasanna,2018**]. The name *S.frugiperda* is derived from the feeding habits of the larval lifestage, *frugiperda* in Latin means ‘LOST FRUIT', as the pest can cause severe damage and yield loss. It is also seen that almost 353 plants can be referred as the host of the invasive FAW [**Kansiime et al.2019**] Prominent damage is seen during larval stage feeding in leaves making papery windows subsequently defoliating the plant [**Reddy et al. 2019**]. The insect has army marching behaviour feeding voraciously on the plant preferably during the night and midnight hours. Recent studies on FAW, have revealed that an adult can fly over long distances of about 300 miles.

It is native to Tropical and Subtropical regions of America. In 2016, it was first reported in Africa [**Sisay et al. 2018**]. Currently, the pest has reached to almost 44 countries [**Sisay et al. 2019**]. Through commercial aircrafts and cargo containers, the pest has spread from America to Africa, and later wind acted as the dispersal medium [**Day et al. 2018**]. In Indian continent, the first report of FAW was seen in Karnataka during 2018. Later, it spread to states like Bihar, Odisha, Chhattisgarh, WB [**CABI,2020**]. In India, a sum total of 170,000 ha of maize crops was affected by FAW among 10 different states [**Sangomla and Kukreti, 2019**]

**2. THE INVASIVE FALL ARMYWORM, *Spodoptera frugiperda* J.E. Smith(Lepidoptera: Noctuidae)**

**2.1 Taxonomic Position**

According to **Nagoshi et al. 2007,** two strains of FAW are found such as rice strain and corn Strain. Rice strain feeds on rice and related species, while the corn strain feeds on maize, cotton and sorghum.The systematic taxonomic position is given below:



**Figure 1 : Taxonomic Position of *Spodoptera frugiperda* Smith**

**2.2 Biology of Fall armyworm**

As it is a lepidopteran pest the lifecycle of FAW consists of four stages : egg, larva, pupa and adult [**Panigrahi et al.2023**]. The duration of lifecycle varies with season. In summer season, 30 days, while in autumn and spring the lifecycle is completed in 60 days and when the temperature falls in winter the lifecycle is completed in about 90 days.

**2.2.1 Egg Stage**

The eggs of FAW is generally dome shaped with a flattened base. The eggs are creamy white in colour with reticulate ribs, covered by abdominal hairs which is grey to pink in colour which protects the eggs. These are the anal tuft scales or setae . An adult female lay about 100-200 eggs in a mass. Eggs are mostly laid on the upper and lower sides of the leaf. In some cases, eggs were also found in stalk and funnel of maize plant. [**Prasanna et al. 2018; Bajracharya and Bhat, 2019; CABI,2018b].** In 20-30 degree Celsius, the eggs are matured in 2-3 days.

**2.2.2 Larval Stage**

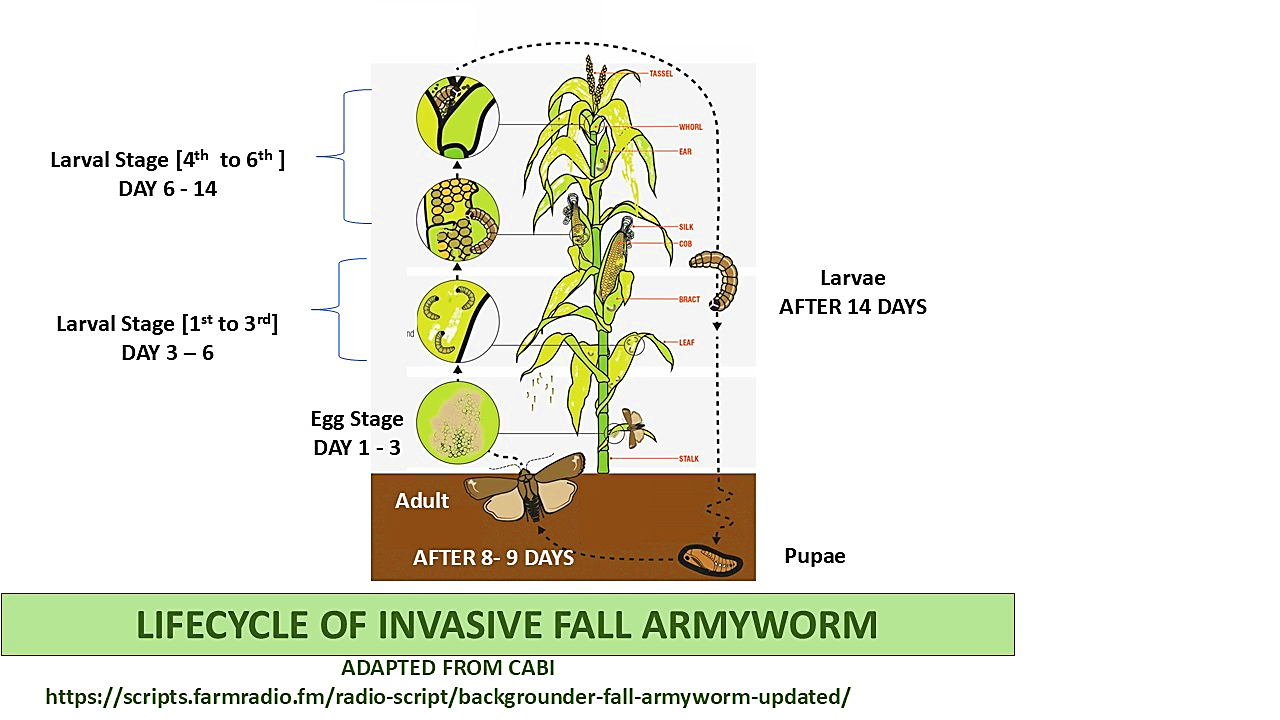
It is considered as the most destructive stage. The newly hatched larvae at first and second instars are green in colour, which gradually turns to blackish brown in colour when it is in third to sixth instars. A prominent inverted Y shaped mark is found on the head. The epidermal pattern is rough and may have granular texture with four dark raised spots in form of square in the front. The four shaped pinacula is found on the eighth segment of the abdomen. The newly hatched larvae is voracious and can be seen with prominent feeding burrowing behaviour [**Prasanna et al. 2018**].

**2.2.3 Pupal Stage**

After 14 days of complete larval cycle it falls to the ground. Pupa is of oval shape generally reddish brown in colour present inside a cocoon located at a depth of 2-10 cm in soil [**Prasanna et al. 2018**]. The cocoon is made by the binding soil particles. In case, if the soil is hard, the leaf debris along with other materials are webbed together on the soil surface,

**2.2.4 Adult Stage**

Emerged adults are nocturnal while the colour may vary. Male adults have shaded grey and brown forewing with prominent white triangular spots at the tip and centre of wing, this feature is restricted to males. The wingspan may be of 40mm. As moths are migratory, having ability to fly long aerial distances [**Prasanna et al. 2018**].



**Figure 2 : Lifecycle of *Spodoptera frugiperda* J.E Smith (Lepidoptera: Noctuidae)**

**2.3 Damage Symptoms and Severity:**

In Maize, the severity starts after the eggs are hatched. The typical symptoms is the formation of papery windows of variable sizes and rugged edges with oval round appearance on the leaves, making them detached from the plant. Eventually, depending on the infestation severe defoliation can be observed with excessive faecal material left out in the plants. Severe defoliation is also the result of voracious feeding by the larval instars. After these symptoms the growth of the crop is eventually stopped leading to malformed development of the cob or tassel [**Reddy,2019**]. Depending on the instars the symptoms of damage may vary, for example translucent patches are seen when it is generally fed by 1st and 2nd Instar larvae, while elongated large hole is seen when it is infested by larvae of 3rd to 6th Instars. The most detrimental and devastating stage of the pest is considered to be the larval stage [**Panigrahi et al.2023**] Depending on growth stage of the plant, the larvae can be seen in different parts of the maize crop including Leaf whorls, young leaves, tassels and cob [**Goergen et al. 2016**]**.** An average of 11.57% of yield reduction is generally seen when the incidence of the pest is in between the range of 27% - 56% [**Buadron et al. 2019**]. **Chimweta et al.2019** revealed that almost 60% of yield reduction is seen, when leaf, silk and tassel damage is in between the range of 25-50%.

**Table 1: Scale for the leaf damage assessment of the crop through fall armyworm (*S. frugiperda*) **

**2.3 Favourable Condition for development of the pest :**

The outbreaks and the intensity of damage by the pest is often governed by climatic factors. Characteristics such as Mortality, Growth, abundance, number of generations and successful survival depends on environmental conditions. [**Ramirez et al, 2017**]. Overwintering mechanism governs the greater invasion of the pest. It can thrive well in wet and cool weather conditions. Outbreak severity is seen after heavy rainfall with humid weather conditions [**Westbrook and Sparks, 1986**]. For the successful reproduction and survival of the pest, a warm and humid growing season with high rainfall are best suited. Generally, when the temperature is less than 10  
 degree Celsius the development is ceased [**Assefa and Ayalew, 2019**]. In tropical areas almost ten generations are found as compared to only two generations in temperate areas which indicates warm temperature conditions favours increasing of the generations [**Assefa and Ayalew, 2019**]. It is also seen that for pupation and adult emergence a threshold temperature of about 10.9 degree Celsius is favourable [**CABI, 2020**]. When the temperature is about 21-26 degree Celsius the egg hatches within two to four days. For larval development a temperature of 28 degree Celsius is preferred while, the threshold temperature of about 14.6 degree Celsius is considered optimum for pupation. Literature studies have also revealed that if the temperature increases to about 30 degree Celsius the wings are deformed [**Assefa and Ayalew, 2019**].

**2.4. Natural Enemies of FAW**

The larvae and eggs of *S.frugiperda* is parasitised by a number of insects. Listed in the Table 2 and 3.

**Table 2 : Indicating FAW list of Parasitoids, Predators and Entomopathogens**

|  |  |  |
| --- | --- | --- |
| **Parasitoids** | | |
| 01 | *Apanteles marginiventris* | **Sisay, 2018; Pokhrel et al. 2022** |
| 02 | *Campoletis grioti* |
| 03 | *Chelonus insularis* |
| 04 | *Meteorus autographae* |
| 05 | *Ophion* spp. |
| 06 | *Eiphosoma vitticolle* |
| 07 | *Cotesia icipie* |
| **Predators** | | |
| 01 | *Calosoma* spp. Ground Beetles | **Sisay, 2018; Pokhrel et al. 2022** |
| 02 | *Labidura riparia* |
| 03 | *Podisus maculiventris* |
| 04 | *Orius insidiosus* |
| **Entomopathogens** | | |
| Fungi | *M.anisopliae* | **Sisay, 2018; Pokhrel et al. 2022** |
| *B. bassiana* |
| Virus | *S. frugiperda* multiple nucleo polyhedrovirus |
| Bacteria | *B. thuringiensis* |

**Table 3 : Indicating FAW list of Natural Enemies and their effective Host stage**

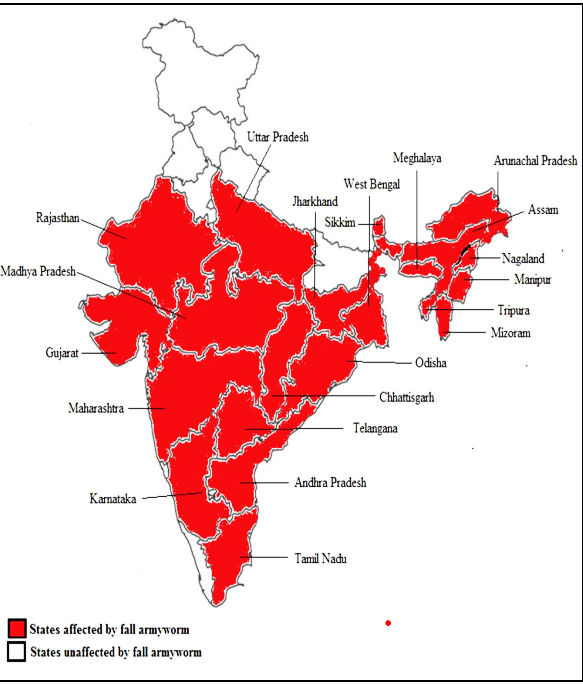
|  |  |  |
| --- | --- | --- |
| **S. No.** | **Scientific name** | **Host stage** |
| 1 | *Telenomus* sp. | Egg parasitoid |
| 2 | *Trichogramma sp* | Egg parasitoid |
| 3 | *Glyptapanteles creatonoti* (Viereck) | Larval parasitoid |
| 4 | *Forficula sp.* | Larval predator |
| 5 | *Coccygidium melleum* (Roman) | Endo larval parasitoid |
| 6 | *Campoletis chlorideae* Uchida | Endo larval parasitoid |
| 7 | *Eriborus* sp | Endo larval parasitoid |
| 8 | *Odontepyris* sp. | Larval parasitoid |
| 9 | *Exorista sorbillans* (Wiedemann) | Endo larval parasitoid |
| 10 | *Forficula* sp. | Predator |
| 11 | *Harmonia octomaculata* (Fabricius) | Predator |
| 12 | *Coccinella transversalis* Fabricius | Predator |
| 13 | *Nomuraea rileyi* (Farlow) Samson | Entomo-pathogen on larva |
| 14 | Nucleopolyhedrovirus (NPV) | Virus on larva |
| Adapted from Repalle et al., 2020 | | |

**2.5 Present Status of FAW in India.**

FAW with its great ability spreads into new territory moving east and north in India. In mid-May of 2017, it was first reported by **Sharanabasappa et al, 2018** in Shivamogga, Karnataka. Now, FAW is reported from Tamil Nadu, Odisha, AP. Maharastra, Telangana, Gujarat.

TABLE 4. **The Table shows the fall armyworm-affected Indian states during the month and year**

|  |  |
| --- | --- |
| **Name of the Indian states** | **Month and Year** |
| Karnataka | May 2018 |
| Chhattisgarh | August 2018 |
| Gujarat | September 2018 |
| Tamil Nadu | November 2018 |
| Maharashtra | September 2018 |
| Odisha and West Bengal | 2018 |
| Andhra Pradesh | March, 2019 |
| Mizoram, Nagaland, Tripura, Manipur and Meghalaya | May 2019 |
| Arunachal Pradesh | June 2019 |
| Telangana | 2019 |
| Madhya Pradesh, Uttar Pradesh, Assam, Sikkim, Rajasthan and Jharkhand | 2019 |
| Adapted from Repalle et al., 2020 | |



**Figure 3. Indicating the states of India affected by FAW**

**2.6. Cause of Dominance**

The dominance of *S frugiperda* (fall armyworm) can be attributed to several key biological and ecological traits. It is highly adaptable to a wide range of temperatures, with cloud cover, moderate rainfall, and low temperatures accelerating population outbreaks. Its short life cycle, multivoltine nature (10–12 generations per year), and absence of diapause allow for continuous reproduction. The larvae exhibit cryptic behavior, feed gregariously, and are capable of cannibalism, which enhances survival. Additionally, the pest has a high reproductive potential and a broad host range, being polyphagous, enabling it to thrive on multiple crops. These features collectively contribute to its rapid spread and dominance in diverse agro-climatic regions

**2.7. Cannibalism in FAW**

Cannibalism in *S.frugiperda* is a distinct intraspecific interaction that becomes progressively evident from the third larval instar. It operates predominantly as a size mediated behavior, wherein larger instars prey upon their smaller conspecifics. This pattern of predation follows a Holling Type II functional response, wherein predation rate initially rises with prey density, and it diminishes as the larvae become fully fed. Cannibalistic interactions are especially common under conditions of high larval density, limited food supply, or cramped rearing environments. These factors not only intensify the frequency of cannibalism but also shape its ecological function as a population regulatory mechanism within confined or resource-limited habitats. Interestingly, the intensity of cannibalism diminishes as larvae progress to the sixth instar. At this stage, the physiological and behavioral drive for predation declines, possibly due to imminent pupation and reduced feeding activity. The reduction in cannibalism is also associated with morphological changes such as shriveling of the body and decreased mobility. While cannibalism may offer short-term survival advantages by reducing competition and supplementing nutrition, it often incurs physiological costs, such as lower pupal weight and reduced adult emergence rates. Cannibalism in *S. frugiperda* is like a survival strategy that helps the insect when conditions are harsh such as unavailability of food and space. By feeding on other larvae, a larvae gets extra nutrition and reduce competition. So in the short term, this behavior can be helpful. However, this same behavior can also cause problems later on. For example, the larvae that practice cannibalism may grow poorly, become weak pupae, or have trouble turning into healthy adult moths. So, while cannibalism helps in the short run during hard times, it might harm the insect’s overall development and chances of surviving or reproducing in the long run.

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**Conclusions**

The global emergence and rapid spread of *S. frugiperda* (fall armyworm) exemplify the intricate and escalating challenges that invasive species present to modern agriculture. Characterized by its remarkable adaptability, high fecundity, and extensive host range spanning over 80 crop species this pest has caused substantial economic damage and ecological imbalance, particularly in regions lacking prior exposure or awareness. Beyond immediate crop losses, *S. frugiperda* infestations have strained pest management resources, disrupted local food security, and necessitated increased reliance on chemical control measures, often leading to pesticide resistance and unintended environmental consequences. Moreover, its ability to migrate over long distances and adapt to diverse agro-climatic conditions complicates control strategies, demanding a more dynamic and informed response. A thorough understanding of the pest’s biology, behavioral ecology, migratory pathways, and genetic strain diversity is essential for developing predictive models and targeted interventions. In this context, early detection, real-time surveillance, and Integrated Pest Management approaches become critical components of a sustainable control framework. Importantly, addressing FAW threat requires not only continued scientific research but also enhanced international cooperation, capacity building among farmers and extension workers, and the development of region-specific management protocols. Strengthening institutional frameworks, investing in biocontrol technologies, and fostering community-level awareness are equally vital to mitigate long-term risks. Ultimately, a proactive, multidisciplinary, and globally coordinated approach is indispensable for building resilient agricultural systems capable of withstanding such invasive biological threats and ensuring sustainable food production for the future.

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**Abbreviation :**  mt – Metric tonne , FAW- Fall armyworm , Ha – Hectare, q- quintal

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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