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# Modern approaches for management of fall armyworm (*Spodoptera frugiperda*)

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***Abstract***

The fall armyworm (FAW) is capable of causing a 100% yield loss in maize due to its unforeseen occurrence from the seedling to the cob formation stage. To manage this serious pest, maize growers use a list of practices like physical, cultural, biological, and chemical control methods. Besides these practices, integrated pest management and biotechnological approaches have proven to be excellent in the sustainable management of FAW, with very high scientific relevance.

## Introduction

Fall armyworm (*Spodoptera frugiperda*) is a polyphagous crop pest native to America and later reported in West Africa in 2016. The entry of FAW in India was reported for the first time by Dr. Sharanabasappa and Dr. Kalleshwara Swamy on May 18, 2018 in maize fields at the College of Agriculture, University of Agricultural and Horticultural Sciences (UAHS), Shivamogga, Karnataka. After that, it was reported in Tamil Nadu, Telangana, Andhra Pradesh, Maharashtra, and other Indian states like Bihar, Chhattisgarh, Gujarat, Orissa, and West Bengal on maize crops. Since then, it has been considered the most destructive pest of maize in India. Its rapid spread to more than 90% of maize-growing areas of diverse agro-ecologies in India within a span of 16 months presents a major challenge to smallholder maize farmers, the maize-based industry, as well as food and nutritional security (Kumar et al., 2022). FAW is also reported in other crops, such as sorghum and millets, with a varied proportion of economic damage. Therefore, in this article, we have basically explained the life cycle of FAW and modern approaches to its management.



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**Life cycle of FAW**

The life cycle of FAW is completed in about 30 days during the summer, but 60 days in the spring and autumn, and 80 to 90 days during the winter. It has following stages (Fig. 1).

**Egg**

The egg is dome-shaped. The base is flattened, and the egg curves upward to a broadly rounded point at the apex. The number of eggs per mass varies considerably but is often 100 to 200, and total egg production per female averages about 1500 with a maximum of over 2000. The duration of the egg stage is only two to three days during the summer months.

**Larva**

There are six instars in the fall armyworm. Young larvae are greenish with a black head, the head turning orangish in the second instar. In the third instar, the dorsal surface of the body becomes brownish, and lateral white lines begin to form. In the fourth to sixth instars, the head is reddish brown, mottled with white, and the brownish body bears white sub-dorsal and lateral lines. Elevated spots occur dorsally on the body; they are usually dark in colour and bear spines. The presence of four black spots arranged in a square shape on the dorsal face of the mature larva is also marked by a white inverted Y. The duration of the larval stage tends to be about 14 days during the summer and 30 days during cool weather.

**Pupa**

Pupation normally takes place in the soil, at a depth of 2 to 8 cm. The larva constructs a loose cocoon, oval in shape, by tying together particles of soil with silk. The pupa is reddish brown in color. The duration of the pupal stage is about eight to nine days during the summer, but it reaches 20 to 30 days during the winter.

**Adult**

The duration of adult life is estimated to average about 10 days, with a range of about seven to 21 days.

**Modern approaches for management of fall armyworm (*Spodoptera frugiperda*):**

- ✓ **Physical control**
  - Handpicking egg masses and larvae
  - Deep ploughing to kill pupae in the soil
  - Placing sand or ash in the whorls
- ✓ **Cultural practices**
  - Intercropping with beans has shown to reduce the FAW infestations by 20-30 percent


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**Advantages**

1. It is cost effective method of pest management.
2. This method is safe and do not pose the undesirable residual effects on food, human health and environment.

**Disadvantages**

1. Requires long term planning for greatest effectiveness.
2. The percentage of pest control is lower as compared with other methods of management.

✓ **Biological control**

- Classical: involves introducing natural enemies from a pest's native range into a new area where native natural enemies do not provide control
- Augmentative: involves the massive production and release of natural enemies to control the pest quickly
- Conservation: involves conservation of existing natural enemies in an environment as these natural enemies are already adapted to the habitat and to the target pest, and their conservation can be simple and cost-effective

✓ **Other biological control options**

- Botanicals: Anti-feedant, insecticidal effect

❖ Neem based products: Azadirachtin main component - Align -Azatin -Ecozin -Neemazal -Neememusion -Neemix - Ornazin

❖ Tephrosia

**Advantages**

1. No problem of development of resistance by the pest.
2. It is safe to use and has no adverse effect on human health and environment.
3. It is a very specific strategy; hence possess no danger to non-target pest.
4. It is cost effective method of pest management in a longer run.

**Disadvantages**

1. Initial management cost is high.
2. This management method is a slow process.
3. The pest control percentage with the use of biological control agent is lower as compared to chemical method of pest control.

✓ **Chemical control**

- Insecticides main control option: > 25 % plants damaged



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- Spot treatment for isolated areas effective
- Late afternoon or early morning- best time
- Based on infestation threshold for crop growth stages and spray schedule

| S. No | Crop Stage | Action threshold | Spray schedule |
|---|---|---|---|
| 1 | Seedling to early whorl stage (Two week after emergence) | 5 percent infested plant | Spray any of the chemical pesticides listed if the infestation crosses 10% at this stage<br>i. Emamectin benzoate 5SG @ 0.4 g/l<br>ii. Spinosad 45 SC @ 0.3 ml/l<br>iii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l |
| 2 | Early whorl to mid whorl stage | 5-10 percent infested plant | First Spray: Bt formulation, Dipel @ 2 g/l water<br>Second spray: if the infestation crosses 10% at this stage<br>i. Emamectin benzoate 5SG @ 0.4 g/l<br>ii. Spinosad 45 SC @ 0.3 ml/l<br>iii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l |
| 3 | Mid to late whorl stage | 10-20 percent infested plant | First Spray: any of the chemical pesticide listed. Alternate the pesticide for second spray<br>i. Emamectin benzoate 5SG @ 0.4 g/l<br>ii. Spinosad 45 SC @ 0.3 ml/l<br>iii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l |
| 4 | Late whorl stage | ➢ 20 per cent infested plant | First Spray: any of the chemical pesticide listed. Alternate the pesticide for second spray<br>i. Emamectin benzoate 5SG @ 0.4 g/l<br>ii. Spinosad 45 SC @ 0.3 ml/l<br>iii. Chlorantraniliprole 18.5 SC @ 0.4 ml/l |
| 5 | Teaselling stage to harvest | ➢ 10 per cent infested plant | No insecticide application, but manually pick and destroy the larvae. |

**Advantages**

1. The percentage control through this method is higher than other method of pest control.
2. This method act very fast if selected in proper concentration and proper quantity.

**Disadvantages**

1. This method has detrimental effect on human health and environment.
2. Along with the harmful insects, it also kills the beneficial insects.

✓ **Biotechnological Approach**

- **Host plant resistance**
  - ❖ Transgenic/ BT maize varieties
  - ❖ Several varieties on the market that control FAW and other lepidopteran pests
  - ❖ CIMMYT is addressing this aspect
- **Genetic Engineering**
  - ❖ Utilization of genetically engineered maize that resists fall armyworm is a feasible method of pest management (Li *et al*., 2020). The efficacy of using genetically engineered crops in managing the fall armyworm was reported in China (Kumar *et al*., 2022).
- **Gene Editing Approach (CRISPR-Cas9 System)**
  - ❖ Even though transgenic (Bt) crops have provided significant crop protection benefits, the technology has been plagued by insect resistance, leading to the development of newer biotechnological approaches to insect pest management, such as gene editing (RNA interference (RNAi); gene drives and most recently, the CRISPR-Cas9 system) (Ullah *et al*., 2022)
  - ❖ Wu (2020) revealed CRISPR/Cas9-mediated deletion of the *abdominal-A homeotic gene* in the fall armyworm, implying that the CRISPR/Cas9 technology is highly efficient in editing the fall armyworm genome based on his findings.

**Conclusion**

Modern approaches like IPM and biotechnological approach are proved to be efficient and reliable approaches to control fall armyworm (*Spodoptera frugiperda*).

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