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## ECO FRIENDLY MANAGEMENT TOOLS FOR AN INVASIVE PEST SPECIES MAIZE FALL ARMYWORM (FAW) *Spodoptera frugiperda* (J. E. SMITH) (LEPIDOPTERA: NOCTUIDAE)

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The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), is a polyphagous pest native to North America that was first discovered in West Africa in 2016. (Harrison, et al., 2019). For the first incidence in India, it was reported in 2018. (Sharanabasappa and Kalleshwaraswamy *et al.*, 2018). It was initially seen feeding on maize fields at Sabour in the Bhagalpur district of Bihar in August of this year. (2020, Reddy *et al.*) The fall armyworm is a well-known pest with a broad host range (over 80 plant species) and great fertility, making it one of the most economically damaging pests. The larval stage is the most destructive in nature, affecting crop production by 70 percent in the entire economy. Maize, sorghum, various millets, rice, sugarcane, as well as other vegetable crops and cotton, are all affected from it. The cultural method is the most effective, accounting for 56 percent of pest control, whereas the push and pull method controls 82.2 percent of larvae per plant. Azadirachta indica seed powder was shown to prevent 70% larval mortality in the lab, whereas *Nicotiana tabacum* and *Lippia javanica* seed powder controlled the larvae by 66% in contact toxicity. *Metarhizium anisopliae*, a bio-control agent, kills 87 percent of eggs and 96.5 percent of newly hatched larvae. Small-holder farmers can use chlorpyrifos combined saw dust to control 20% of pests and spinosad to control 90% of larval population, allowing them to take precautions on time and avoid crop loss. Integrated pest management strategy is best for the management of the fall armyworm.

It is an invasive and noxious pest of maize, which is native to tropical and sub-tropical regions of America. The pest invaded to West and Central Africa in 2016 and the spread to all the countries of sub-Saharan Africa. In India incidence of FAW first reported from

Karnataka on maize crop in 2018. Later its presence was confirmed in Maharashtra, Andhra Pradesh, Gujarat, Tamil Nadu and Telangana States. In Bihar FAW is now reported from Sabour in Bhagalpur district in 2019. It is polyphagous pest which can feed on about 186 different plant species including crops such as maize, paddy, sorghum, cotton, sugarcane etc. It cause huge yield loss in maize up to 57% to 58% (Dhar *et al.*, 2019). Damage done in India on maize crop during July-December. As a result, crop mismanagement and crop pests have a significant impact on crop output and profitability, and there is a clear need to manage crops from FAW properly and efficiently to ensure the long-term viability of any agriculture-based business. Farmers utilise a variety of management strategies in different countries, regions, and locations, all of which have no harmful impact on the environment or human health.

### **Eggs Stage**

Female moths lay their eggs on the underside of the leaves towards the plant's base, near the junction of the leaf and the stem. White, pinkish, or light-green eggs have a spherical shape and are white, pinkish, or light-green in colour. The number of eggs in each mass ranges from 100 to 200. After emergence, each female lays 1500 to 2000 eggs over a period of days. The eggs are dome-shaped and range in size from 0.3 to 0.4 mm in diameter. A layer of scales is also laid down by the female between the eggs and over the egg masses. During warm weather, the egg stage lasts only two to three days.

### **Larvae Stage**

Larvae emerge three to five days after oviposition and move to the whorl. There are six phases of larval development. Larvae in the second and third instar stages are commonly cannibalistic, resulting in a whorl with only one larva. The first instar larvae are greenish with a black head, which changes to an orange colour in the second instar. The mature larvae are 30 to 40 mm long and come in a variety of colours. A white inverted "Y" shaped suture can be seen on the face of an adult larva. During the summer, the larval phase is 14 days and in the winter, it is 30 days.

### **Pupa Stage**

Pupation takes occurs in the earth, at a depth of 2 to 8 cm, and the pupae are reddish brown and may be hard. The larva spins a loose cocoon that is 20 to 30 mm in length and is oval in shape. If the soil is too hard, the larvae may weave leaf litter and other materials

together to form a cocoon on the surface. The pupal stage lasts about 8 to 9 days in the summer and 20 to 30 days in the winter.

### Adult Stage

Adult moths are 20 to 25 mm long with a 30 to 40 mm wing span. Adults are nocturnal and most active in the evenings when it is warm and humid. The male moth's forewing is dark grey, whereas the female's is light brown. Silvery white hind wings with a small dark marking on the margins. Adult life is expected to last about 10 days on average, with a range of 7 to 21 days. In 35-60 days, the entire life cycle is accomplished. Each season, 6-12 generations are found.

### Damaging Symptoms

- **Elongated papery windows:** Elongated papery windows of all size are seen spread all over the leaves in a few adjacent plants the crop might have been infested with FAW. This symptom is caused by 1<sup>st</sup> and 2<sup>nd</sup> instar Fall Armyworm larvae which feed by scraping on leaf surface.
- **Ragged-edged holes:** Once the larvae enter 3<sup>rd</sup> instar, its feeding caused ragged-edged round to oblong holes on leaves. The size of holes increases with growth of larvae.
- **Extensive leaf damage:** Once the larvae enter 5<sup>th</sup> instar, it feed faster and damage large area of leaves. Sixth instar larvae extensively defoliate the leaves and produce large amount of faecal matter.

### Integrated Management

#### 1. Monitoring

Pheromone is mostly used in monitoring of FAW because pheromones can travel by air over very long distance. Installation of pheromone trap @ 5/acre in current and potential area of spread in crop season and off-season.

#### 2. Scouting

Start scouting in 'W' MANNER as soon as maize seedlings emerge. At Seedling to early whorl stage (3-4 Weeks after emergence)- Action can be taken if 5% plants are damage. At the mid whorl to late whorl stage (5-7 weeks after emergence) – Action can be taken if

10% whorls are freshly damaged in mid whorl stage and 20% whorl damage in late whorl stage. At tasselling and post tasselling (Silking stage)- Do not spray insecticides. But 10% ear damage needs action.

### 3. Cultural control

- Before sowing, deep ploughing is recommended. This will make FAW pupae vulnerable to predators. Sowing at the right time is recommended. Staggered sowings should be avoided. Maize intercropping with regionally appropriate pulse crops. 3-4 rows of trap crop (e.g. Napier) are sown around the maize field.
- Clean cultivation and balanced use of fertilizers. Cultivation of maize hybrids with tight husk cover will reduce ear damage by FAW.

### 4. Mechanical control

Hand-picking and mass killing of egg masses and neonate larvae using kerosine water or smashing. Bird perches were erected at a rate of 10 per acre throughout the early stages of the crop. Dry sand was applied to the whorls of afflicted maize plants shortly after FAW was discovered in the field. Male moths are mass trapped using pheromone traps at a rate of 15 per acre.

### 5. Bio-control strategies

Release of egg parasitoid *Trichogramma pretiosum*, *Telenomus remus*, *Chelonus insularis* and larval parasitoids *Cotesia margiventris* @ 50,000 per acre at weekly intervals. Application of biopesticide such as *Metarhizium anisopliae* @ 5g/litre or *Nomuraea rileyi* @ 3g/litre whorl application at 15-25 days after sowing. Another 1-2 spray may also be given at an interval of 10 days. Application of *Bacillus thuringiensis* var *kurstaki* formulation @ 2g/litre or NSKE (Neem formulation 1500 ppm) @ 5 ml/lit. of water for control of early instars. If infestation is more than 10%, whorl application of *Bt* var. *kurstaki* formulation (400g/acre) @ 2g/lit. or *Metarhizium anisopliae* or *Beauveria bassiana* with spore count of 1 x10<sup>8</sup>cfu/g (1kg/acre) @ 5g/lit. or entomopathogenic nematode (EPN) (4kg/acre) @ 10g/lit. of water is recommended

### Natural Enemies of Fall Army Worm

- **Predators** – ground beetles, carabid beetles, ladybird beetles, tiger beetles, soldier bugs, ear wigs, birds, bats, spiders, ants and rodents, 60 to 90 % Of pupae are predated by birds, bats, and rodents.
- **Parasitoids**- The important parasitoids are wasps and flies among them *Cotesia marginiventris* , *Chelonus texanus* and *Archytas marmorantus* (Diptera) are potential parasitoids.

### 6. Chemical control

- Seed treatment with Cyantraniliprole 19.8%+ Thiamethoxam 19.8% FS @ 6ml/kg of seed will be effective for 15-20 days.
- **First Window (seedling to early whorl stage):** Spray 5% NSKE / Azadirachtin 1500ppm @ 5ml/l of water.
- **Second Window (mid whorl to late whorl stage):** To manage 2<sup>nd</sup> and 3<sup>rd</sup> instar larvae having more than 10% foliar damage use of Spinetoram 11.7% SC @ 0.5ml/litre of water or Chlorantraniliprole 18.5% SC @ 0.4 ml/litre of water or Thiomethoxame 12.6% + Lambda cyhalothrin 9.5% ZC @ 0.25ml/litre of water.
- For late instar larvae, poison baiting is suggested. Ferment the 10kg rice bran + jaggery mixture with 2-3 litres of water for 24 hours. Just half an hour before field application, add 100g Thiodicarb. The bait should be injected into the plant's inflorescence.
- **Third window (8 week after emergence to tasselling and post tasselling):** Insecticide management is not cost effective at this stage. Bio-pesticide as recommended above to be applied. Hand picking of the larvae is advisable.

### Conclusion

Fall armyworm is one of the most destructive pests on the planet. This insect has a greater chance of spreading over the world, resulting in a major drop in agricultural production and productivity. Fall armyworm control necessitates an integrated management strategy, with early field inspection and identification of the regulating mechanism being critical. A pest awareness campaign involving advisory services on pest identification, damage signs, and control procedures with suitable measures will help to minimise the pest's incidence. Small holder farmers around the world might benefit greatly from locally accessible resources and

approaches, hence there is a pressing need to educate them about fall armyworm control measures. The approaches can help to reduce the number of pest invasions and losses, as well as contribute to world stability. It may be suggested that a communal activity be recommended to help manage the armyworm.

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