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Fall army worm: Current status and management in India

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Abstract
Maize is a traditional crop that is generally cultivated as a source of food, feed and fodder which is cultivated as a single crop during summer season or relayed with millet in the late season. Maize, the queen of cereals was reported to be infested by a range of pests, out of which the fall army worm, *Spodoptera frugiperda* is the recent one reported in India. Due to its migratory behaviour, it is capable of damaging to a serious extent. It causes a damage up to 30 per cent yield reduction in maize crop in 10 states of India. Proper identification of the pest, adoption of IPM practices in a community-based approach is the major component of proper management**.** Integrated pest management practices include monitoring, scouting, cultural, mechanical, physical control and finally curative stage specific chemical control methods. Apart from this, it is important to introduce, validate, and deploy low-cost, environmentally safer and effective technological interventions (like single and pyramided-gene Bt maize) over the short, medium and long-term for sustainable management of FAW.

Keywords: Maize, fall army worm, IPM practices, management

Introduction
Maize is the third most important cereal, also called the "Queen of Cereals" has highest genetic yield potential. Maize is a traditional crop that is generally cultivated as a source of food, feed and fodder which is generally cultivated as a single crop during summer season or relayed with millet in the late season [1]. The total area (9.07 mha), production (23.83 million tonnes), yield (2627 kg/ ha) of maize under Indian condition has been reported to affected by various biotic and abiotic constraints [2]. Demand of maize crop is increasing in higher amount every year due to the higher nutritional benefits. Nutritionally, maize grains have 10% protein, 4% oil, 70% carbohydrate, 2-3% crude fibers, besides having Vitamin A and E, nicotinic acid and riboflavin but its protein Zein is deficient in tryptophan and lysine among essential acids and is deficient in calcium. Like other important Lepidopteran pests, Fall Army Worm (FAW) has infested crops in over 50 countries across two continents in just over two years. Incidence of FAW reported in India during May 2018 and the phylogenetic analysis has revealed that Indian Maize FAW clustered with Florida (rice strain), Ghana, Nigeria, Uganda on maize. It has been noticed that during the first 9 months of infestation in 10 Indian states, FAW caused a serious damage in maize with an extent of 30 per cent yield loss [27].

Significance of the Pest
Being a highly migratory in nature, the pest can cause huge damage to the crop species [3]. FAW has already been the matter of ache to the farmers in India. The pest cannot survive in extreme hot areas and the optimum temperature for the pest spreading is about 28^0C [4]. Similarly, the emergence of pest in such soil increases with increase in temperature i.e. directly proportional to temperature and decreases with increase in relative humidity i.e. inversely proportional to relative humidity [4]. So, in Indian conditions, it is necessary to check the incidence of the FAW.

Identification
Egg: Mass of fall armyworm is difficult to distinguish and are laid in mass inside the whorls or on under surface of leaf or on stem [5]. Eggs may be laid on single or multiple layers. Eggs are creamy coloured either with anal tuft of hairs or sometimes without hair covers. The egg of FAW is dome-shaped with a flattened base that measures about 0.4 mm in diameter and 0.3 mm in height [6].

Larva: There are six instars in fall armyworm. First instar larvae are greenish with a black head, the head turning orangish in the second instar. During the third instar, the dorsal surface of the body becomes brownish, and lateral white lines begin to form. In the fourth to the sixth instars, the head is reddish brown, mottled with white, and the brownish body bears white sub-dorsal and lateral lines. The face of the mature larva is also marked with a white inverted "Y" and the epidermis of the larva is rough or granular in texture when examined closely [6] and the four black dots arranged in a square on the back of the last abdominal segment are also distinctive to FAW larvae [7]. Elevated spots occur dorsally on the body, which is usually dark in colour, and bear spines [4, 7]**.** Newly hatched larvae are burrowing and feed on the leaves of the host plant on which the eggs were deposited, but when they grow larger they will disperse to other plants. The first and second instars feed on one side of the leaf and skeletonize it, but as they grow they feed, making holes on the leaf.

Pupa: Pupation normally takes place in the soil, at a depth 2 to 8 cm. The larva constructs a loose cocoon, oval in shape and 20 to 30 mm in length, by tying together particles of soil with silk. If the soil is too hard, larvae may web together leaf debris and other material to form a cocoon on the soil surface. The pupa is reddish brown in colour, and measures 14 to 18 mm in length and about 4.5 mm in width. Duration of the pupal stage is about eight to nine days during the summer, but reaches 20 to 30 days during the winter.

Adult: Adult moths of FAW are variable in colour and wingspan (32 to 40 mm). Male moths have a shaded grey and brown forewing with triangular white spots at the tip and near the centre of the wing. Forewings of females are less distinctly marked, ranging from a uniform greyish brown to a fine mottling of grey and brown. The hind wing of both sexes is shining silver-white with a narrow dark border [6].

Host Range

This species seemingly displays a very wide host range, with over 80 plants recorded, but clearly prefers grasses which promote its migration success and offseason survival. The most frequently consumed plants are field corn and sweet corn, sorghum, Bermuda grass, and grass weeds such as crabgrass, *Digitaria* spp. When the larvae are very numerous they defoliate the preferred plants, acquire an "armyworm" habit and disperse in large numbers, consuming nearly all vegetation in their path. Many host records reflect such periods of abundance and are not truly indicative of oviposition and feeding behaviour under normal conditions. Field crops are frequently injured, including; alfalfa, barley, bermudagrass, buckwheat, cotton [8], clover, corn, oat, millet, peanut, rice, ryegrass, sorghum, sugar beet, sudan-grass, soybean, sugarcane, timothy, tobacco, and wheat. Among vegetable crops, only sweet corn is regularly damaged, but others are attacked occasionally [9]. Other crops sometimes injured are apple, grape, orange, papaya, peach, strawberry and a number of flowers. Weeds known to serve as hosts include bentgrass, *Agrostis sp*.; crabgrass, *Digitaria* spp.; Johnson grass, *Sorghum halepense*; morning glory, *Ipomoea spp*.; nutsedge, *Cyperus* spp.; pigweed, *Amaranthus* spp.; and sandspur, *Cenchrus tribuloides*. There is some evidence that fall armyworm strains exist, based primarily on their host plant preference. One strain feeds principally on corn, but also on sorghum, cotton and a few other hosts if they are found growing near the primary hosts. The other strain feeds principally on rice, bermudagrass and Johnson grass [10].

Symptoms of Damage

Gregarious larvae feed superficially on one side of leaf (or inside whorls) and spread to new host plant through ballooning mechanism [11]. Initial sign of infestation is papery windows on leaf & defoliation [12]. Second instar caterpillars of FAW feed gregariously in initial phase and make small leaf holes/papery windows. Third, fourth and fifth instar caterpillars of FAW often feed solitarily inside the whorls and cause large holes accompanied by larval droppings (excreta). The older larvae of FAW exhibit a cannibalistic behaviour on other smaller larvae, when they co-occur. Cannibalism was found to account for approximately 40% mortality when maize plants were infested with two or four fourth-instar larvae over a three-day period [13]. This behaviour, which is different from that of African armyworm (*Spodoptera exempta*) is accentuated when food is limited and larvae are crowded [13]. The role of this density-dependent mortality in the overall population dynamics is unclear [14] but could be an important factor that may reduce the intensity of some outbreaks.

Integrated Pest Management Strategies

1. Scouting
2. Monitoring
3. Cultural control
4. Mechanical control
5. Biological control
6. Stage wise options including chemical control

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 damaged. But at mid whorl to late whorl stage (5-7 weeks after emergence) control measures can be initiated 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) spraying of insecticides are not suggested. But if 10% ear damage was observed, then it needs immediate action.

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

Cultural Measures

Deep ploughing before sowing will expose FAW pupae to predators which can reduce FAW population. Timely sowing and avoiding staggered sowings will interrupt the continuous availability of host plants [15]. Intercropping of maize with suitable pulse crops (e.g. Maize + pigeon pea/black gram /green gram) can be effective by diverting the pest from the main crop [16]. Erection of bird perches @ 10 /acre during early stage of the crop (up to 30 days) can be effective in maintaining the FAW population below Economic Threshold Level. Sanitation of the field, clean cultivation and proper weeding are the other major cultural practices to keep the pest population in check. Similarly, plantation of scented and flowering plants like coriander, fennel, rose, marigold etc. can attract natural enemy of FAW and hence reduce the pest population. Push-pull strategy is also one of the strategies of cultural management of the pest in which maize is

intercropped with pest-repellent "push crop" (*Desmodium spp*), surrounded by pest-attractive "pull crop" (Napier Grass, *Pennisetum purpureum* or *Brachiaria* spp) [17]. Sowing of 3-4 rows of trap crops (e.g. Napier) around maize field and spray with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop shows symptom of FAW damage Clean cultivation and balanced use of fertilizers. Cultivation of maize hybrids with tight husk cover will reduce ear damage by FAW. The cultural control includes avoiding late planting since the maize ears would be heavily attacked by a higher FAW infestation than those of the early plantings. Also, intercropping and rotating maize with non-host crops like sunflower and bean may be useful to minimize the invasion of FAW [18]. Plantation of beans at the edges of maize field 10 days prior to the plantation of maize will attract the FAW towards the bean and hence maize can be protected. Another major cultural practice can be planting early or with the other farmers that have field near to own field. This will cause the equal distribution of FAW in all fields.

Mechanical control: Hand picking and destruction of egg masses and neonate larvae in mass by crushing or immersing in kerosene water. Application of dry sand in to the whorl of affected maize plants soon after observation of FAW incidence in the field. Soil application inside the whorls. Mass trapping of male moths using pheromone traps @15/acre. For the successful implementation of an Integrated Pest Management program, effective monitoring through pheromones and Light traps are required (Klun *et al.,* 1996). The sex pheromone for *S. frugiperda* contains (Z)-9-Tetradecenyl acetate (Z-9-14: OAca) which is common to *Trichoplusia ni, Spodoptera exigua* and *Agrotis ipsilon.*. In tomato, lucerne and cotton fields, mating disruption for *S. exigua* was possible by the release of (9Z, 12E)-9, 12-tetradecadienyl acetate at high concentration. Thus, [19] mating disruption may be possible leading to prevent the multiplication of the pest. Universal bucket type pheromones are used in which sex pheromones or chemicals produced by females to attract males are kept which can travel a very long distance through air and make the monitoring easy whereas most commonly used pheromones are sex pheromones and aggregation pheromones [6]. The nocturnal behaviour of the moth makes it monitorable through black light traps.

Bio-control strategies: In *situ* protection of natural enemies by habitat management: Increase the plant diversity by intercropping with pulses and ornamental flowering plants which help in build-up of natural enemies [20]. Augmentative release of *Trichogramma pretiosum* or *Telenomus remus* @ 50,000 per acre at weekly intervals or based on trap catch of 3 moths/trap. The migratory behaviour of the FAW makes the natural enemies less efficient. Various insects have been reported parasitizing FAW larvae and eggs [21]. The predators of FAW are generalists that attack larvae of other lepidopterans. In the Americas, the most important predators of FAW that have been reported include various ground beetles (Coleoptera: Carabidae); the striped earwig, *Labidura riparia* (Pallas) (Dermaptera: Forficulidae, Labiduridae), *Doru luteips*, *D. lineare*, and other earwigs [22][23][24]; the spined soldier bug, *Podisus maculiventris* (Hemiptera: Pentatomidae); and the insidious flower bug, *Orius insidiosus* (Hemiptera: Anthocoridae) [25]. Among the vertebrate predators, birds, skunks and rodents also feed on larvae and pupae of FAW [26].

Table 1: Biocontrol agents of fall army worm along with their targeted stage

Biocontrol agent	Targeted stage
Archytas incertus	Larva
Archytas marmoratus	Larva and pupae
Campoletis flavicincta	Larva
Chelonus curvimaculatus	Eggs/Larva
Chelonus insularis	Eggs/Larva
Cotesia marginiventris	Larva
Cotesia ruficrus	Larva
Euplectrus platyhypenae	Larva
Glyptapanteles creatonoti	Larva
Lespesia archippivora	Larva
Microchelonus heliopae	Eggs/Larva
Brachymeria ovata	Pupa
Telenomus remus	Eggs
Trichogramma achaeae	Eggs
Trichogramma chilotraeae	Eggs
Trichogramma pretiosum	Eggs
Trichogramma rojasi	Eggs

Bio-control strategies

Biopesticides

Suitable at 5% damage in seedling to early whorl stage and 10% ear damage with entomo-pathogenic fungi and bacteria.

Entomopathogenic fungal formulations

Application of *Metarhizium anisopliae* talc formulation ($1x10^8$ cfu/g) @ 5g/litre whorl application at 15-25 days after sowing. Another 1-2 sprays may also be given at an interval of 10 days depending on pest damage. *Nomuraea rileyi* rice grain formulation ($1x10^8$ cfu/g) @ 3g/litre whorl application at 15-25 days after sowing. Another 1-2 sprays may also be given at an interval of 10 days depending on pest damage. Application of *Bacillus thuringiensis* var *kurstaki* formulations @ 2g/litre (or) 400g/acre.

Stage wise options including chemical control

1. **First Window (seedling to early whorl stage):** To control FAW larvae at 5% damage to reduce hatchability of freshly laid eggs, spray 5% NSKE or Azadirachtin 1500 ppm @ 5ml/ litre of water.
2. **Second window (mid whorl to late whorl stage):** To manage 2nd and 3rd instars larvae at 10-20% damage spray Spinetoram 11.7% SC @ 0.5 ml/litre of water or

Thiamethoxam 12.6% + lambda cyhalothrin 9.5% @ 0.25 ml/l of water or Chlorantraniliprole18.5% SC @ 0.4 ml/litre of water.

3. **Poison baiting:** Poison baiting is recommended for late instar larvae of second window. Keep the mixture of 10 kg rice bran + 2 kg jaggery with 2-3 litres of water for 24 hours to ferment. Add 100g thiodicarb just half an hour before application in the field. The bait should be applied into the whorl of the plants.
4. **Third Window (8 weeks after emergence to tasselling and post tasselling):** Insecticide management is not cost effective at this stage. Hand picking of the larvae is advisable. All the sprays should be directed towards whorl and either in the early hours of the day or in the evening time.

Apart from these, capacity building and mass awareness is also necessary for promoting IPM strategies. Furthermore, application and timely plant protection measures to avoid spread of the insect from the abandoned crop and creation of awareness among important stake holders through trainings /group discussions. Moreover, community based and area-wide approach should be followed for implementing management strategies.

Conclusion

Therefore, effective control should focus since it is impossible to avoid this pest unless developing sustainable management. Furthermore, there is an urgent need to increase awareness among the farming communities about the life stages of the pest, scouting for the pest (as well as its natural enemies), understanding the right stages of the crop on which high economical damage may occur by FAW, and the time for management application and implementing low-cost agronomic practices and other landscape management practices for sustainable management of the pest. At the same time, it is important to introduce, validate, and deploy low-cost, environmentally safer, and effective technological interventions (like single and pyramided-gene Bt maize) over the short, medium and long-term for sustainable management of FAW in Ethiopia, especially keeping in view that a huge majority of Ethiopian farmers are low-resource smallholders.

References

1. Paudyal KR, Poudel SK. Impact of public and private sector maize research in Nepal. Impact of Public and Private Sector Maize Breeding research in Asia (1966–1999). CIMMYT, Mexico, DF. 2001, 66-80.
2. Agricultural Statistics at a Glance (ASAG), Ministry of Agriculture and Farmers Welfare. Government of India, 2018. http://agricoop.gov.in/sites/default/files/agristatglance2018.pdf. 20 April, 2020.
3. Luginbill P. The Fall Armyworm. USDA Technical Bulletin. 1928; 34:91.
4. CABI. *Spodoptera frugiperda* (fall armyworm). 2019. https://www.cabi.org/isc/datasheet/29810. 20 April, 2020.
5. Sparks AN. A review of the biology of the fall armyworm. Florida Entomologist 1979; 62:82-87.
6. Prasanna B, Huesing J, Eddy R, Virginia R. Fall Armyworm in Africa: A guide for Integrated Pest Management. Mexico: USAID and CIMMYT, 2018.
7. CABI. Fall Armyworm: Impacts and Implications for Africa. 2017. https://www.invasive-species.org/wp-content/uploads/sites/2/2019/03/Fall-Armyworm-Evidence-Note-September-2017.pdf. 21 April, 2020.
8. Pitre HN, Hogg DB. Development of the fall armyworm on cotton, soybean and corn. Journal of the Georgia Entomological Society. 1983; 18:187-194.
9. All JN. Fall armyworm (Lepidoptera: Noctuidae) infestations in no-tillage cropping systems. Florida Entomologist. 1988; 71:268-272.
10. Foster RE. Strategies for protecting sweet corn ears from damage by fall armyworms (Lepidoptera: Noctuidae) in southern Florida. Florida Entomologist. 1989; 72:146-151.
11. Pannuti LER, Baldin ELL, Hunt TE, Paula-Moraes SV. On-plant larval movement and feeding behavior of fall armyworm (Lepidoptera: Noctuidae) on reproductive corn stages. Environmental Entomology. 2015; 45:192-200.
12. Marenco RJ, Foster RE, Sanchez CA. Sweet corn response to fall armyworm (Lepidoptera: Noctuidae) damage during vegetative growth. Journal of Economic Entomology. 1992; 85:1285-1292.
13. Chapman JW, Williams T, Martínez AM, Cisneros J, Caballero P, Cave RD *et al*. Does cannibalism in *Spodoptera frugiperda* (Lepidoptera: Noctuidae) reduce the risk of predation? Behavioral Ecology and Sociobiology. 2000; 48(4):321-327. doi:10.1007/s002650000237.
14. Chapman JW, Williams T, Escribano A, Caballero P, Cave RD, Goulson D. Age-related cannibalism and horizontal transmission of a nuclear polyhedrosis virus in larval *Spodoptera frugiperda.* Ecological Entomology. 1999; 24(3):268-275. doi:10.1046/ j.1365-2311.1999.00224.x.
15. Mitchell ER. Relationship of planting date to damage by earworms in commercial sweet corn in north central Florida. Florida Entomologist. 1978; 61:251-255.
16. Roberts PM, All JN. Hazard for fall armyworm (Lepidoptera: Noctuidae) infestation of maize in double-cropping systems using sustainable agricultural practices. Florida Entomologist. 1993; 76:276-283.
17. Dively G. Management of Fall armyworm (*Spodoptera frugiperda*) with emphasis on Bt Transgenic Technology. 2018. https://usunrome.usmission.gov/wp-content/uploads/sites/54/2018-Africa-FAW-Talk_Rome-pdf.pdf. 20 April, 2020.
18. FAO. Integrated management of the Fall Armyworm on maize. 2018. http://www.fao.org/3/i8665en/i8665en.pdf. 20 April, 2020.
19. Shorey H, Summers C, Sisk C, Gerber R. Disruption of pheromone communication in *Spodoptera exigua* (Lepidoptera: Noctuidae) in tomatoes, alfalfa, and cotton. Environmental Entomology. 1994, 1529-1533.
20. Pair SD, Gross Jr HR. Field mortality of pupae of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith), by predators and a newly discovered parasitoid, *Diapetimorpha introita*. Journal of the Georgia Entomological Society. 1984; 19:22-26.
21. Ashley TR. Classification and distribution of fall armyworm parasites. The Florida Entomologist. 1979; 62:114-123. doi:10.2307/3494087
22. Jones R, Gilstrap F, Andrews K. Biology and life tables for the predaceous earwig, *Doru taeniatum* [Derm.: Forficulidae]. Entomophaga. 1988; 33(1):43-54.

doi:10.1007/BF02372312
23. Romero Sueldo GM, Dode M, Virla EG. Depredación de Doru luteipes y D. lineare (Dermaptera: Forficulidae) sobre *Rhopalosiphum maidis* (Hemiptera: Aphididae) en condiciones de laboratorio. 2014. https://ri.conicet.gov.ar/handle/11336/17140. 20 April, 2020.
24. Silva GA, Picanço MC, Ferreira LR, Ferreira DO, Farias ES, Souza TC *et al*. Yield losses in transgenic Cry1Ab and non-Bt corn as assessed using a crop-life-table approach. Journal of Economic Entomology. 2018; 111(1):218-226. doi:10.1093/ jee/tox346
25. Capinera J. Handbook of vegetable pests (4th ed.). University of Florida, 2001. http://creatures.ifas.ufl.edu 20 April, 2020.
26. Capinera JL. Fall armyworm, *Spodoptera frugiperda* (JE Smith) (Insecta: Lepidoptera: Noctuidae). University of Florida IFAS Extension, 2000.
27. Fall Armyworm Attack. https://www.downtoearth.org.in/coverage/agriculture/fall-armyworm-attack-the-damage-done-63445. 5 May, 2020.