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Fall army worm: An invasive pest in India and its management

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Abstract
Fall army worm is a pest that has recently invaded the Indian sub-continent. Since May 2018, when it had made its first appearance in the country, it has spread very quickly and now is present in all most all parts of the country. In order to control any pest, it is of prime importance that all possible information should be known with respect to that pest, such as its Biology, habitat, Host range, Favorable climatic conditions and most importantly its management. In view of all this, the article presents the right approach towards identification and the management of the pest. It presents a holistic approach, integrating the facts with Practical control measures that can be taken to save the crop and move towards sustainable management.

Keywords: Fall army worm, invasive pest, management

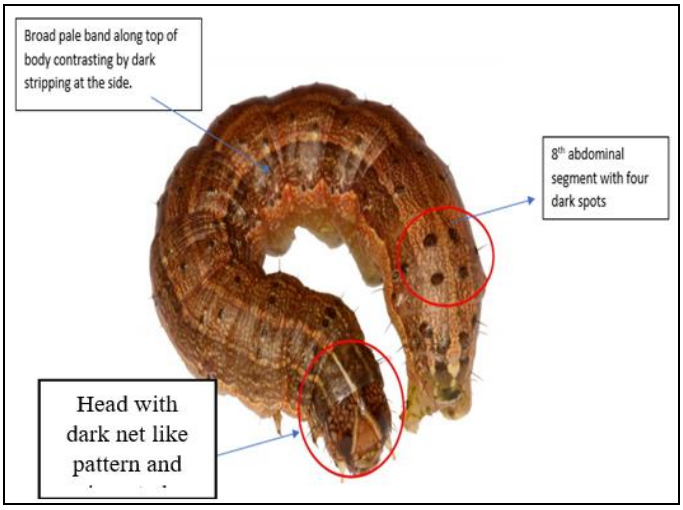
Introduction
Invasive pests are non- endemic or extrinsic entities that occur in locations other than their naturally preferred ones. Such invasions may be a result of the natural evolving process or may also be caused or accelerated due to human interventions. These pests being natural entities possess the mechanisms of establishing themselves in the new environment. And once they establish, they recreate at an overwhelming potential. The population then establishes over a period, identifies its hosts and starts causing economic damage, the degree of which is directly proportional to the number of individuals and their damage potential [1]. Such pests have become a threat to the agricultural biodiversity and are the reasons of huge economic losses. The introduction of such pests has taken place in our country time and again [14].
Incidence of invasive insect pests such as Woolly apple aphid; *Eriosoma lanigerum* (Hausmann), San Jose scale; *Quadraspidiotus perniciosus* (Comstock), Lantana bug; *Orthezia insignis Browne*, Cottony cushion scale; *Icerya purchasi* Maskell, Potato tuber moth; *Phthorimaea operculella* (Zeller), Diamond back moth; *Plutella xylostella* (Linn.) etc. has taken place in our country from time to time [2].
Recently, Fall Armyworm, Spodoptera furgiperda (J.E. Smith) (Lepidoptera: Noctuidae) Spodoptera frugiperda was recorded from many locations in Karnataka on maize crop. The pest had accidently landed in Africa in 2016 from America [7], Since then, it has disseminated to more than quinquagenarian countries in Africa and Asia destroying the crops and causing massive economic losses across, with Maize being the primary host. In 2018 the pest showed its presence in Asia, it is known that this intrusion was brought about through Yemen and the Indian Sub-continent. Presently the pest has spread to the neighboring countries of India viz Bangladesh, Myanmar, Nepal and China.
In India the pest had been detected for the first time in mid-May 2018 in maize fields at College of Agriculture, (UAHS), Shivamogga [9]. There after it made its appearance in Karnataka in August 2018, and was first spotted in Chikkabalapur and adjoining areas, there after by October 2018 it had spread to six other states of the country, including Tamil Nadu, Andhra Pradesh, Odisha, Chhattisgarh and Gujrat. By December 2018, the states of Maharashtra and MP too had spotted the pest in their vicinity. The massive and Vigorous spread was quite alarming and has raised a national concern all over. By September 2019 the pest even showed its presence in the Northern Parts of the country Including, Haryana, Punjab and Uttar Pradesh.

Life cycle and identification
The fall army worm aka FAW life cycle includes, egg, six growth stages of Larval development, Pupa and Moth. The cycle begins when 100- 200 eggs are laid on the underside

of the leaves [11], Typically near the base of the plant. After hatching the young Larvae (Neonates) feed on the leaf, leaving semi transparent patches called as windows. In young Plant the Larvae prefer to eat the leaf whorl, but in older plants they prefer the leaves around the cob silks [12]. Larvae will also eat their way through the protective leaf bracts, into the side of the cobs, where they feed on the developing kernels. By the time the larvae reach the top of the plant, they are bigger and do the most damage, leaving ragged holes in the leaves. On young Plants this can kill the growing points. Stopping new leaves and cobs from developing. After approximately 14 days, fully grown larvae will drop to the ground so that they can pupate. Before pupating, the larvae will burrow 2-8 cm in the soil or cover themselves up in the debris [13]. Around 8-9 days latter adult moths will emerge from the ground and start the life cycle all over again [3].

The Fall Army worm belongs to the Genus Spodoptera. The species furgiperda can be differentiated from the other species based on the following characters.

1. Broad pale band along top of body contrasted by dark stripping at the side.
2. Four dark spots present at the 8th abdominal segment
3. Head with dark net like pattern and inverted, white Y marking



Source: Food and agriculture organization of United Nations

Damage symptoms

The pest feeds on several crops but the most preferred host is Maize. It feeds mostly on all the stages of maize, but prefers the young stages with whorl, it is a voracious feeder and thus consumes a lot of foliage and eats away the young growing tips, thereby leading to crop failure [9]. Young instar eats the leaf tissue and makes thin membranous patches on the leaf, whereas the later instars eat away large holes on the leaves.

The windows and holes cut into the plant are often accompanied by the moist frass and excreta. The larvae often plug in its entry points by the frass and then feeds inside in a protective environment [10]. The pest causes a typical dead heart on the crop thereby causing complete failure of effected plants.

Host crops and ETL of the pest

The Fall army worm is a serious polyphagous pest of voracious nature with a wide host range of approximately more than 100 recorded plant species under 27 families [4]. This pest prefers plants from Gramineae family including many economically important plants such as maize, millet, sorghum, sugarcane, rice, wheat, etc. [14]. There are reports on its infestation on other field crops like cowpea, groundnut, potato, soybean, cotton, etc. The pest has been reported to cause upto 34% damage on Maize [8]

The ETL or economic threshold level of the pest is is the benchmark level, when reached, suggestive of determination of the control measures to be taken in order to prevent an increasing pest population from reaching the economic injury level (EIL) (5) Th ETL levels for Fall army worm are as follows:

A) 1-2 Larvae per whorl
B) 5% Seedling are cut
C) 15% whorl infestation of young plants, during 1st 30 days

Scouting and monitoring

Scouting is usually done to regularly monitor the crop for any kind of infestation of fall armyworm. As it is always easier to control if detected in the early stages. The scouting for the pest may be done by locating five spots on the field, excluding the border areas. The five spots/locations should be

in a zig- zag fashion. 10 plants from each spot/ Location should be closely monitored for the infestation of FAW. If 10 plants out of 50 are infested that means an immediate action is required for Managing FAW, else the complete crop can be lost owing to the FAW infestation [6]. Scouting helps to be better prepared for any kind of pest attack and to be able to save the crop by taking a timely action.

Management of the pest begins with prevention. The pest can be monitored using Pheromone traps @ 5- 10 traps /Ha to trap the Male moths. FAW numbers in the traps are counted, recorded, and used to decide the further action plan for management of insect and judicious use of pesticide.

Integrated pest management

The Problem with the invasive species and why it becomes difficult to control is that they are usually from a different location and invade suddenly. This leaves us with very limited information regarding the pest and its control. The major challenge remains the identification of the pest, as wrong identification can lead to improper practices for controlling the pest. Secondly the pest does not have natural enemies, as present in the native area and it takes time to identify the natural enemies in the changed location. Sometimes the potential natural enemies are restricted only to its native land and do not come along with the invading pest. Such pest are vigorous feeders and proliferators. Once they establish in the new location, [17] it becomes very difficult to control them. The chemicals used may also not be very effective as the pest may be already resistant to many molecules and thus it further takes time to figure out the right option to control them. Thus, considering the above-mentioned factors its always necessary to adopt a holistic and integrated approach for the control of the pest, rather than solely depending on the chemical control. All the below mentioned tools of the IPM should be integrated to combat any invasive pest.

A) Cultural control and Physical: The resistant or resilient varieties should be used so that there is lesser incidence of the pest. A good crop rotation program should be devised so that the Pest does not come across the desired host so that the spread and proliferation by the pest may be combated. Also, late and staggered planting of the crop should be avoided as this can lead to greater pest infestation. The sowing dates play a very important role [16]. As it decides whether the pet will get favorable conditions for development or not. The crop residues should also be well managed in order to break the cycle of FAW, as the crop residue may serve as an inoculum bank and lead to the spread of the pest in the next season as well [17].

B) Biological control: Entomopathogenic fungus such as *Beauveria bassiana*, *Nomuraea rileyi* and *Metarhizium spp* can effectively control the pest not just for the current season, but also provide immunity to the crop for the second season by building up inoculum in the soil. [18] Also, natural enemies like *Telenomous* sp., *Trichogramma* sp. Can help manage the pest

C) Botanical Control: 1- 2 sprays of Azadirachtin at 7 – 10 days interval, alone or in integration with the chemical helps control the pest. [15]

D) Chemical control: A lot of options are available for combating the pest. But care should be taken to choose the right solution.

The chemical control starts from the seed treatment

1. **Seed treatment:** The seeds of corn should be treated with Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS @ 6 ml/kg of seed, this will be effective for 15-20 days.
2. **First window (Seedling to early whorl stage):** To control FAW larvae at 5% damage to reduce hatchability of freshly laid eggs, spray 5% NSKE / Azadirachtin 1500ppm @ 5ml/l of water.
3. **Second window (Mid whorl to late whorl stage):** To manage 2nd and 3rd instars larvae having more than 10% foliar damage the following chemicals may be used upto early tasseling stage: Spinetoram 11.7% SC or Chlorantraniliprole 18.5% SC or Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC.
4. **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 liters 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.
5. **Third window (8 weeks after emergence to tasseling and post tasseling):** Insecticide management is not cost effective at this stage. Bio-pesticides as recommended above to be applied. Hand picking of the larvae is advisable.
6. **Insecticide resistance management**
   Resistance of Insects towards Insecticides is due to evolutionary mechanism and the adaptability of insects to be able to metabolize the chemical and thus reman immune to it. In any population dynamics, some individuals are better adapted, or can easily metabolize certain chemicals, whereas the rest cannot. The individuals that can resist a chemical are resistant. When an insect population is repeatedly exposed to a specific insecticide or a specific class/ group of pesticide, it so happens that the resistant individuals survive, and the susceptible population is killed. Over a period, these resistant individuals survive and reproduce, thereby making most of the population resistant towards the chemical.

Thus, the best way to address this problem is to follow a pesticide rotation programme.

The management of the pest should always be done by following all the tools of Integrated pest management, this also helps in managing the issue of resistance development.

Only the approved and registered insecticide for the pest should be used that too in rotation and at the recommended doses. One should refrain from using the same chemical again and again, even if the control achieved is excellent, as over a period this would lead to resistance development [19].

Conclusion

The issue of FAW, in India has become a matter of National significance owing to the damage potential of the pest. Thus, the Government and Private sector is working in close coordination to combat the pest and protect the crop and the good will of the farmers as well. The above review is thus an effort to better understand the pest, its background, history and invasion rotes. To have a better understanding of the pest biology, along with the identification of the pest, as any kind of control measure can only be initiated once the pest and its

damage potential is known. The improved comprehension of the pest along with the integrated pest control measures enlisted in the above review, not only will help manage the pest, but will also help in Resistance management as well.

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