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Mini Review

Fall Armyworm (*Spodoptera Frugiperda*) in Maize: An Emerging Threat in Nepal and its Management

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Abstract

Fall armyworm ((*Spodoptera frugiperda*) commonly known as FAW is polyphagous pest of maize with more than 85 host species. It is native to tropical and subtropical region of America. It has already been detected in India and reports from Nepal also suggests presence of FAW. Due to Open broader between Nepal and India chance of spreading in Nepal is very high. Delay maturing hybrids and late planted maize crops are likely to be affected by this pest. It can cause serious leaf damage along with direct injury to the ear. Major damage is done by younger larvae. Larvae causes damage by consuming foliage. Terai and inner terai region are considered to be affected more as climatic condition of this region highly favors FAW. So, timely preventive and management practices should be done before it leads to havoc condition. Management of the pest can be done through many biological, chemical and cultural means. Quality seed, Avoidance of late planting, Push-pull technology can be adopted for management practices. Different biological agents have been identified for controlling FAW such *as Bacillus thuringenesis* (*Bt*), *Baculovirus* and *Beauveria bassiana* etc. Chemicals like Methomyl, Methyl parathion, chlorpyrifos, malathion, permethrin are used to control the pest. However, use of chemical should be discouraged as it may affect soil fertility and natural enemy of FAW.

Keywords: *Fall Armyworm*; Integrated Pest Management; maize

Introduction

Fall armyworm *(Spodoptera frugiperda*) is the major pest of maize. This pest is native to tropical and sub-tropical part of USA (CABI, 2017a). Though it is major pest of maize but it also attacks more than 80 additional species of crop such as rice, millet, sorghum, cotton (FAO, 2020). It is polyphagous in nature with more than 85 host species. It was first detected in central and western Africa in 2016 (Chhetri & Acharya, 2019). In Nepal it was first detected in Nawalparasi district in maize crop. Recently, Nepal Agriculture Research Council (NARC) has reported the first sighting of FAW which is locally named as phaujikira in Nepal (Pokharel, 2019). This pest has currently become new invasive pest (Goergen *et al*., 2016). Within the short period of time it has spread to more than 100 countries. It has been found that this pest has migratory nature, it can fly about 1600km in 3 hours (Rose *et al*., 1975). Fall armyworm has already attacked different states of India especially tropical region and caused several losses. Due to the open boarder between Nepal and India there is great chance of spreading of this pest in Nepal

(Bhusal & Chapagain, 2020). Since there is no proper management of quarantine, free open border can lead to spread of pest in Nepal. The climate region of Nepal especially terai region is favorable to this pest. Since maize is major cereal crop of Nepal and pest can potentially cause severe loss if proper attention is not given.

Fall armyworm has already been great threat to world, till 2015 the pest was not reported expect America. Since then there has been several reports of incidence of fall armyworm, southern Karnataka state of India (2018), subsequently appearing in Bangladesh (2019), China (2019), Myanmar (2019), Sri Lanka (2019) and Thailand (2018). Food security and livelihood of small scale farmers are in great threat as this invasive is likely to spread further from India as south east Asia and south china at high risk(FAO, 2018). A report published by Indian council of agriculture research (ICAR) confirmed existence of more than 70% fall armyworm in maize field of Chikkaballapur, Karnataka (CGIAR, 2018). This pest has high potential to spread not only in India but throughout the Asia due to favorable climatic condition.

This article can be very useful to gain more information about the fall armyworm along its potential damage to maize plant and some of measures to mitigate the damage caused by fall armyworm. Especially, Farmers can learn different management practices to cope with fall armyworm.

Status of Fall Armyworm in Nepal

The open border between India and Nepal has been considered as the major reason of incidence of fall armyworm in Nepal. Along with this reason other factors such as favorable climatic condition, maize being 2nd most cultivated cereal crop after rice, use of hybrid maize seed from India by Nepali farmers are responsible for the incidence of fall armyworm in Nepal. This pest was first reported in Nepal in Nawalparasi district in May 9,2019 (Rijal, 2019).

Plant quarantine and pest management center along with national plant protection have confirmed the entry of fall armyworm. Different field visits were done for the detection of pest from Jhapa (east) to Dang (west) and suspected samples were collected and sent to National Bureau of Agriculture insect Resources (NBAIR), India for confirmation (NPPO, 2019). Lab report from first two samples suggest no fall worm but report from third sample suggest present of fall armyworm (Guragain, 2019). Reports suggest mid inner terai and mid hills of Nepal are most favorable for the attack of this pest.

Although the entry of fall armyworm has been confirmed in Nepal but its loss assessment has not been done yet as it was recently introduced and has attacked only few regions. Since the climatic condition of Nepal is favorable to fall armyworm so if proper management is not done in time it may result havoc condition. CIMMYT has been working in push-pull method for the elimination of this pest. Mainly two crops has been used: Napier grass (*Pennisetum purpureum*) and silverleaf Desmodium legume (*Desmodium uncinatum*) (Pradhan *et al*., 1983). Technique is intercropping *Desmodium* in rows with maize crop and Napier grass is cropped surrounding the maize. *Desmodium* produces volatile compound that is responsible for repelling the fall armyworm moth and Napier attracts the female moth by producing chemical compound. This method can control the fall armyworm without having adverse effect on environment(Pradhan *et al*., 1983).

Damage Symptoms

Delay maturing hybrids and late planted maize crops are likely to be affected by this pest. Fall armyworm are responsible for serious leaf feeding damage along with direct injury to the ear (Bessin, 2019). Major damage is done by younger larvae. Larvae causes damage by consuming foliage. Mainly young larvae they feed on leaf tissue making hole on them which is typical symptoms of this pest (Sesay *et al*., 2019). Generally feeding on the young plant by fall armyworm through whorl may lead to dead heart. Older larvae can cause greater damage and defoliation leaving only ribs and stalk of corn plant giving torn or ragged appearance (Capinera, 2017). (Marenco *et al*., 1992) reported that early whorl leaf stage was least sensitive to injury, mid-whorl was intermediate and late whorl stage the most sensitive to injury.

Biology of Fall Armyworm

The life cycle of pest is completed in four stages: Egg, Larvae, Pupa and Adult. Life cycle duration varies with the season, during summer it is completed in 30 days and 60days during in autumn and spring. But during winter this duration is prolonged to 60 days (Luginbil, 1928). The different stages of fall armyworm are described briefly below.

Egg

Female lays eggs of white dome shaped in cluster of 50-150 mainly on the underside of leaves near the base junction of stem and leaves (Hardke *et al*., 2015). The eggs measure 0.8mm diameter and 0.3mm height with pale yellow and creamy color which later changes to light brown before hatching. Temperature of 20-30°C is favorable for maturing of eggs within 2-3 days.

Larvae

Fall armyworm goes through six larval instars to complete the larval phase. During first instar larvae are greenish in color which during second instar change to orange color. larvae are about 1mm in first instar and length changes to 45mm in six instar (Prasanna *et al*., 2018). During the fourth and six instar the head is reddish brown mottled with white with lateral lines (Igyuve *et al*., 2018).

Pupae

After 14 days ,the caterpillar falls to ground, pupation occurs at soil depth of 2-8cm (Prasanna *et al*., 2018). Loose oval silk cocoon of 20-30mm length is secreted during pupation (CABI, 2017b). Inside this cocoon reddish brown color pupa of length 14 to 18mm length and 4.5mm width can be found. Duration of pupal stage varies with climatic condition , generally in summer it is completed in 8-9 days in summer and 20-30 days in winter season (CABI, 2019).

Adult

Adult are nocturnal in nature and mostly remain active during humid and warm evening. Generally female moth is bigger as comparison to male moth. Adult moth wingspan is about 32-40mm. Presence of triangular white spots in tip and center of wing along with mottled forewing is the distinctive feature of male moth. Adult phase last for about 7-21 days.

Integrated Pest Management

Integrated pest management (IPM) is the one of most preferred and effective management of fall armyworm(Day *et al*., 2017) . Since the complete elimination of pest is not possible from the field so it is important to develop flexible, coordinated and effective techniques. IPM techniques has been widely used and also has been found to be effective. In long run, this holistic approach has been found to reduce use of pesticides ,has been economical and safe to environment (Ehler, 2006) . The goal of IPM is to suppress the population of pest from reaching economical level using techniques that are cost effective and less harmful to environment and human(Prasanna *et al*., 2018). IPM mainly focus on environment friendly methods with the minimum utilization of chemical fertilizer. IPM techniques includes following practices:

Cultural Method

Cultural methods are widely used and eco-friendly method of management of fall armyworm. One of the techniques is adjustment of planting time. Late planting of maize is more prone to infestation of fall armyworm. Early planting of maize can help to escape the arrival time of pest as result plant can be protected from attack of this pest. Another technique can be the use of the trap crops like legumes which can attract the pest towards them as result plant can be protected. Another method can be deep ploughing field before planting maize. Deep ploughing can expose the pupa and larvae to predictor which can decrease infestation of FAW. Exposing larvae and pupae in winter can also help to control FAW. Push-Pull techniques has been widely used in controlling FAW in which *Desmodium spp* is used as push crop and *Napier grass* are used as pull crop(Hailu *et al*., 2018). Other techniques that come under cultural methods are sanitation, picking of larvae by hand, clean cultivation, weeding etc. Pest monitoring can be another best method for management of FAW. Pheromone trap and light trap are mostly used for fall armyworm monitoring. Pheromone are mostly used for trapping of male fall armyworm.(Batista-Pereira *et al*., 2006).

Biological Method

Table 1 shows Some of parasitic, predicator and pathogenic natural enemies. Biology control refers to the direct or indirect use of living natural enemies to reduce the population of pest below economic damage level (Perera, 1968). This method is widely used as the alternatives to pesticides application. In this method different biological agent such as parasites, predictor, and pathogens are used(Prasanna *et al*., 2018). *Trichogramma* or *Telenomus* wasps are widely used species in to control FAW eggs. *Telenomus remus* can enter into the eff of FAW as they are very small in size and lay eggs there. This eggs on hatching give offspring that can feed the egg of FAW. *Bacillus thuringenesis (Bt), Baculovirus and Beauveria Bassiana* are also used biological control agents against FAW. The braconid wasp *Chelonus insularis* Cresson is one of the key natural biological control agents ,it parasitizes the egg of FAW (Meagher *et al*., 2016). Some of the predators are shown in Table 2.

Botanical Pesticides

Botanical pesticides are those pesticides that are derived from pant or plant extract. Botanical pesticides are environment friendly and no residual effect to natural enemies and human beings. Among various plant Neem (*Azadiracta indicia*) has been found to be effective against FAW. Other plants such as long pepper (*Pepper hispidinervum*), castor (*Ricinus communis*), *Couroupita guianensis etc.* has also been found to be effective.

Table 1: Some of parasitic, predicator and pathogenic natural enemies

S. N	Natural enemy	Life stage	Host
1.	*Archytas incertus*	Larvae	maize
2.	*Archytas marmoratus*	larvae	maize
3.	*Campoletis flavicincta*	larvae	maize
4.	*Chelonus curvimaculatus*	Egg/larvae	maize
5.	*Chelonus insularis*	Egg/larvae	maize/sorghum
6.	*Brachymeria ovata*	Pupae	
7.	*Microchelonus heliopae*	Egg/larvae	maize

Source:(CABI, 2019)

Table 2: Some of the predictors

S. N	Natural enemy	Life stage	host
1.	*Calleida decora*	larvae	Maize
2.	*Calosoma alternans*	larvae	Maize
3.	*Doru luteipes*	larvae	Maize/Sorghum
4.	*Doru taeniatum*	larvae	Maize
5.	*Ectatomma ruidum*	Larvae/Egg	Maize/Sorghum
6.	*Geocoris punctipes*	larvae	Maize

Source:(CABI, 2019)

Chemical Method

Chemical control means use of chemical pesticides to control the pest. chemical pesticides are artificially synthesized in industry in such way that they affect different stages of pest hence reducing their number. Different chemical pesticides are used against FAW. some of the recommended insecticides for *Spodoptera* spp. are esfenvalerate, carbaryl, chlorpyrifos, malathion, permethrin, emamectin benzoate etc. (CABI, 2019). However, use of chemical should be discouraged as it may affect soil fertility and natural enemy of FAW.

Conclusion

Fall armyworm is very dangerous and damaging pest of maize. Although it was only reported in 2016 but within short period of time it has spread in more than 100 countries. Since it has already reported in India in 2018 and reports from Nepal also suggests fall armyworm has already entered in Nepal. In countries like Nepal where most of people are unaware of modern agriculture practices it can cause 100% damage. So, before it's too late time has come, farmers should be made aware about this damaging pest and different management practices such as biological, cultural, chemical. Biological practices, cultural practices and integrated pest management (IPM) should be encouraged. Open boarder of Nepal and India can cause entry of more of this pest so quarantine should be strength in this Places. Import of hybrid seed from India should be banned. Proper monitoring should be done to find out the presence of pest. If pest is detected proper management practices should be adopted.

Authors' Contribution

Santosh Kandel designed the research plan; Rakshya Poudel collected the required data. Both authors were involved in analyzing the data, preparing the manuscript and finalizing the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

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