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RESEARCH ARTICLE

FAW; AN EMERGING THREATS TO AGRICULTURE

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ABSTRACT

The fall armyworm (FAW) *(Spodoptera frugiperda*) is a polyphagous crop pest which has a higher possibility of spreading all over the world, risking the agricultural potential yield by reducing the productivity and production. The rapid breeding ability with a speed migrating tendency along with the voracious feeding nature, has made the monitoring and control of this pest more difficult. With more than 80 host species, the agricultural devastation caused by FAW has been a threat to the agricultural sector. So, an integrated approach of pest management should be in our top priority while dealing with controlling of the pest. Various cultural practices like deep ploughing before the rain onset and intercropping with different leguminous crops has helped to decrease the faw population along with other physical, biological, mechanical and chemical methods. However, chemical methods should be applied below the economic threshold level and only when the pest population is growing in such a rapid form that the other methods has failed to affect the pest population. This review mainly focuses on the Insect distribution, its biology, host preference, field damage along with its management strategies that has been researched by various researchers from different corners of the world.

KEYWORDS

Spodoptera frugiperda, maize, fecundity, egg, larval, pupal periods, total life cycle, larval instars, morphometrics

1. Introduction

Belonging to the family of Noctuidae and order Lepidopetera, The Fall Armyworm (FAW) (*Spodoptera frugiperda)* is one of the most devastating insect pest. (Sagar et al., 2020). FAW is mostly found in western hemisphere (Capinera, 2001; GC et al., 2019) – mainly in tropical and subtropical regions of America (FAO 2017 , CABI 2017). FAW being a noctuid moth pest when it is left to multiply it can destroy a wide range of crop varieties as it is a migratory and polyphagous insect pest (Meagher et al., 2013; Adhikari et al., 2020). The infestation of the Fall Armyworm (FAW) brings a considerable loss in agricultural production and due to lack of awareness of the pest in future its damage ratio increased in geometric ratio (Kushal et al., 2020). After invaded in India on the mid-2018, FAW was reported first time in Nepal on August 2019 (NPPO, 2019). In Nepal, FAW got suitable environmental condition for the growth, establishment and spread.

The most preferred host crop of FAW is Maize which stands second position in terms of production and area in Nepal (MOALD, 2018). FAW feed on both vegetative and reproductive structures which causes significant damage to the crops and their yield (Kushal et al., 2020). When there is lack in proper management of the fall armyworm infestation then it causes a 100 percent loss of maize crops in Nepal (Beshir et al., 2019). FAW is a strong flier, which can fly upto 500km before the oviposition with migratory and the dispersal habit. (Prasanna et al., 2018). With the proper assistance of the wind pattern, FAW is known for travelling a distance of about 1600km from southern US state Mississippi to the southern Canada in 30hrs (Rose et al., 1975). Yield loss in various crops like maize, sorghum, rice and sugarcane by FAW infestation in the African countries was around at 20.15, 7.45, 56.15 and 51.05% bringing about predictable economic loss of around US $ 13,383 million (Abrahams et al., 2017). For the proper management of the FAW, Integrated Pest Management is considered as the best approach (Day et al., 2017).

IPM strategy includes combinations of various control methods available locally with cultural control, biological control and safer use of pesticides to manage the pest. These days, Entomopathogens and biopesticides are also getting popular these days. Various sorts of knowledge, research activities and management activities in invasive pest like fall army worm are very limited and scanty (Sahi, 2016). On the developing countries like Nepal, where Fall Armyworm can cause severe effect as there is lack of awareness, study and research works, expertise, insufficient resource and technical support for their management (Shrestha., 2016). This review has been conducted to understand the invasion of FAW in Nepal. It focuses on the introduction pathway, current status, biology, lifecycle, threat and damage of FAW, control and prevention measures to minimize the loss by FAW with suitable management options have also been identified.

2. Research Methodology

This review completely uses secondary source of information, Pieces of literature were collected from different journals articles, Agriculture institutes, other sources like FAO, CABI, CIMMYT and relevant reports were studied and the major findings were summarized. Also, suggestions from related professor and officers were considered in the paper.

3. Discussion

3.1 Origin and distribution of FAW

Until 2015 AD, the pest was found only in America and in 2016 AD, it was recorded first time in Nigeria (Bista, et al., 2020). Fall Armyworm being a

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threating pest, it is a major concern for the researchers worldwide (Adhikari et al., 2020). The global distribution of Fall Armyworm in different continents is given in Table 1.

Table 1: Global distribution of FAW

Continent	Total Number of countries per continent	No of countries (Incidence of FAW)
Africa	54	47
Asia	48	17
Europe	44	4
North America	23	23
Oceania	14	1
South America	13	13

Source: CABI (2020)

Originated from the tropical regions of the America, In 2016; The FAW is been reported to the Argentina and the Caribbean Region. In 2018 A.D, for the first time in Asia, the Fall army worm was recorded in the Karnataka India. In Nepal, It was recorded in Nawalparasi district in 9th August 2019 (Bista, et al., 2020). Along with Nepal, FAW has invaded 10 countries in the Asia (Poudel, 2020). Till the date, FAW have occurs in the six continents: Asia, Africa, Australia , North and South America. Within a short period of time, the Fall Armyworm had a great potential to cover wider geographical location (Johnson, 1987). The main reason of the rapid spread of Fall Armyworm (FAW) is mainly due to its high reproductive capacity, high migration ability and a wide host range.

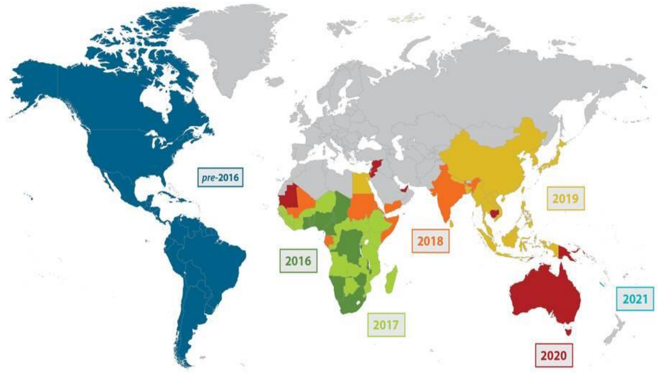

Figure 1: Global Status of FAW

Map of the worldwide spread of fall armyworm since 2016 (as of May 2021). This map was compiled using information from a range of sources, including FAO, International Plant Protection Convention, CABI, the European and Mediterranean Plant Protection Organization, and national governments. Source: (FAO, 2021)

3.2 Classification of Fall Armyworm

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Lepidoptera
Family: Noctuidae
Genus: *Spodoptera*
Species: *Frugiperda*

3.3 Identification of insects

- Eggs: they are recognized on the basis of laying egg ranging from few to hundreds in numbers on the clustered laying nature (Spark, 1979). Eggs of FAW with the anal tuft of hairs or sometimes without hair covers, they are laid on single or multiple layers creamy colored (Firake 2019). Spherical in shape nature, the egg of Fall Armyworm lay beneath the leaves, near the base of the plan, close o the junction of the leaves and stem (CABI 2019).

- Larvae
  - 1st instar: greenish with black head capsule
  - 2nd instar: turned greenish brown as larvae feed upon (Lugin bill; 1969)
  - 3rd instar: brownish in color with three dorsal and lateral white lines.
  - 4th – 6th instar: Brownish black in color with three white dorsal lines and a light lateral lines (Sharanabassappa et al., 2018)
  - Mature larvae's: Having 4 black spots arranged in square at last abdominal segment. It has dark head and upside-down pale Y-shaped marking in head area (CABI, 2017)
- Pupa: A loose cocoon in an earthen cell.
- Moth
  - Male moth: Fore wings with shaded grey and brown, along with the triangular white spot at the tip and center of wings.
  - Female moth: Forewings are less distinctly marked with greyish brown to fine mottling of grey and brown (Prassanna et al., 2019)

3.4 FAW hosts

Spodopeta frugiperda (FAW) threatened a huge number of cultivated plant species (Casmuz et al., 2010). FAW cause severe infestation on its primary host; maize and sorghum and other monoculture crops like soyabean and cottion (Pitre and Hogg 1983, Bueno et al., 2011). On the cereal and forage crops, serious invasion is seen. About 186 plants species from 42 diverse families the Fall Armyworm caterpillar feed on (Casmuz et al., 2010)

Table 2: Common feeding host of Spodoptera frugiperda

Common Name	Scientific Name	Family	References
Peanut	*Arachis hypogea L.*	Fabaceae	Yu, 1982 Sparks, 1979
Bermuda grass	*Cynodon dactylon (L.) Pers.*	Poaceae	Sparks, 1979
Maize	*Zea mays L.*	Poaceae	Paulillo et al., 2000; FAO 2018
Sugarcane	*Saccharaum offcinarum L.*	Poaceae	Chormule et al., 2019
Rice	*Oryza sativa L.*	Poaceae	Stout et al., 2009; Whitford et al., 2015; FAO, 2017; Stout et al., 2009; Whitford et al., 2015; FAO, 2017; Stout et al., 2009; Whitford et al., 2015; FAO, 2017; FAO, 2017
Wheat	*Triticum aestivum L.*	Poaceae	Murúa et al., 2008; Pitre et al., 1983
Tomato	*Solanum lycopersicum (L.) Mill.*	Solanaceae	Rojas et al., 2003
Cabbage	*Brassica oleracea var. capitata L.*	Brassicaceae	Montezano et al., 2018
Barley	*Hordeum vulgare L.*	Poaceae	Alfonso et al., 1997
Rye grass	*Lolium perenne L.*	Poaceae	Pitre and Hogg, 1983
Para grass	*Brachiaria mutica L.*	Poaceae	Ashley et al., 2006; de Sa et al., 2009
Potato	*Solanum tuberosum L.*	Solanaceae	Yu, 1982
Mustard	*Brassica juncea L.*	Brassicaceae	Yu, 1982
Cucumber	*Cucumis sativus L.*	Cucurbitaceae	Yu, 1982; Montezano et al., 2018
Tobacco	*Nicotiana tabacum*	Solanaceae	Leal-Bertioli et al., 2003; Martinelli et al., 2007

4. Biology and Life Cycle of FAW

Depending on weather condition, the pest completes its life cycle in about 30-45 days (Padhee and Prasanna, 2019). The list of plants infected by FAW was rather representative than being inclusive which indicated the FAW infestation on more than 60 species (Luginbill, 1929). When the adult female lays eggs on the upper or underside of leaves, mostly near the base junction of leaf and stem on the underside of leaves, the lifecycle of FAW begins (Jarrod et al., 2015). Though the major preference of FAW is maize, the main staple of SSA, it also affects many other major crops, including sorghum, rice, sugarcane, cabbage, beet, groundnut, soybean, onion, , tomato, potato, pasture grasses, millets, and cotton. (Prasanna et al., 2018).

The adult of FAW was found to be nocturnal i.e., early evening movement of faw around the host plant suitable for feeding, oviposition, and mating was initiated by faw at dusk. Oviposition, when the population density is low, is mainly seen on the lower side of the leaves, and when the density is high, , oviposition is indiscriminate i.e , all over the corn plants (Sparks, 1979). Differentiating the character of FAW within the noctuidae family is that FAW has four dark spots in the 8th abdominal segment and with a white inverted 'Y' on its head (Ashley et al., 1980). Fall armyworm is spreading rapidly in South Asian countries, despite heavy concerns of scientists over this for the last two years (FAO, 2018). FAW completes its life cycle in 3 stages ; Egg, Larval(six instars caterpillar stage) Pupal stage and adult stage.

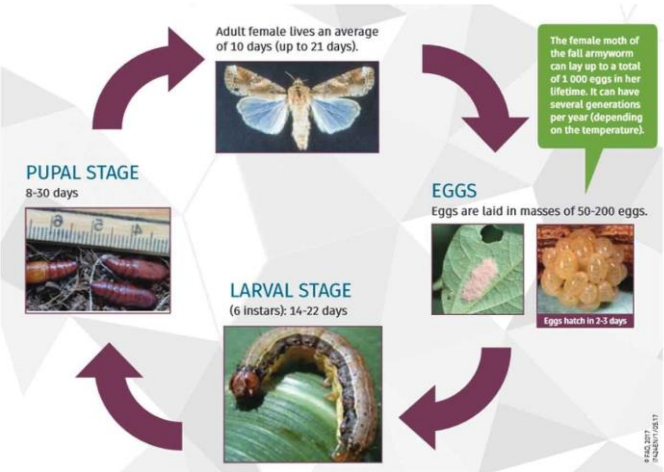

Figure 2: The lifecycle of Fall armyworm, FAO (2017)

Egg Stage: Though 100-200 eggs are the often found number, the number of eggs per mass varies, and total egg production per female averages about 1,500 with a maximum of over 2,000 and the female deposits a layer of grayish scales in between the eggs and over the egg masses. Duration of the egg stage is only 2 to 3 days during the warm summer months. (Prasanna et al., 2018)

Larval stage: According to Sparks larvae eat the shells, after they hatch from the egg and initiate feeding on the host plant which continuously feed on the foliage till the completion of 6 instar and pupation (Sparks, 1979). About after 3-5 days the 2nd -3rd instars young caterpillars with chewing and biting type mouths and eats the leaf whorl and later instars caterpillars eats the cob silk leaving semi-transparent patches i.e., Windows (Luginbill, 1929). The 6th – instar then drops to the ground and pupates in the soil (Hardke et al., 2015).

Pupal stage: The fully-grown larva stops to feed which turns greenish and bright brown when the prepupal period proceeds. Pupae are usually found at the depth of 2-8 cm in soil which are oval in shape, reddish brown in colour and they form a cocoon of 20-30 mm in length (CABI, 2018b; Sharanabasappa, et al., 2018). Pupal period may extend from 7-37 days depending on the soil mean temperature from 59-84 degree (Farenheit Vickery, 1929) .

Adult stage: After the insects come out of the pupal cases, which starts from 2-3 hrs after sunset to midnight, these insects now make their way to the soil and cling to the plant and they inflate their wings and then appear like an adult (Sparks, 1979). Adult females call the male by releasing the pheromones and mating mostly occurs during night. There is a mating order in FAW in which females calles and give 1st priority to virgin males ,2nd to the once mated ones and last to the multiple mated males (Luginbill, 1928).

Table 3: Characteristics of different stages of Fall armyworm

Stages	Shape	Color	Duration (Days)	Suitable Temperature (⁰C)	Special Characteristics
Eggs	Spherical (diameter: 0.75 mm)	Greenish gray in early stage and later turns into brownish black	2-3	20-30	Female covered a layer of scales (downy materials on the egg mass and give moldy appearance.
Larvae	3-4 cm long	greenish to brownish with longitudinal stripes	14-21	26-28	Yellow colored inverted Y-shape structure on the head, black dorsal paniculate with long primary and four black spots arranged in a square on the last abdominal segment.
Pupa	1.3-1.7 cm long	Brownish in the early stage and later turned into back	9-13	13-16	A loose cocoon in an earthen cell
Adult	1.5-1.7 cm long	Dark grey to brown, straw	12-14	below 30	Distinctive white spot near the dorsal tip, or apex, of the wing, Forewing is mottled. Hindwings are straw colored with a dark brown margin

Source: (CABI, 2017)

4.1 Economic importance

The larvae of FAW in an infected plant can be found in different plant parts such as, young leaves, leaf whorls, tassels and cob based on the stage of growth the plant is on (Goergen et al., 2016). Despite the heavy concerns of scientists, fall armyworm is spreading rapidly in South Asian countries since the last two years (FAO, 2018). In Africa this pest had caused millions of dollars of losses. The economic damage produced by different level infestation of Fall armyworm differs on different crops and varies at different stages of development. Seedling plants of soybeans, sorghum, corn, and southern peas which on later stages can tolerate 1 or more of the caterpillars per plant may be economically damaged on their seedling stage by 1 medium to mature larva per root foot (Navas, 1974). According to Mitchell, FAW has challenged the food security of over 300 millions people (Mitchell, 1979). The yield loss of maize production by 45% and about an annual loss of U$D 2400-4800 million by FAW has risked the availability of food (Claire, 2018).

During the general outbreak in the USA that of 1899 and again in 1912, this pest had caused enormous damage throughout the country which was considered a difficulty which caused an aggregated loss of millions of dollars. Major crops that were damaged by FAW in 1912 were corn, alfalfa, millet, sorghum, and other garden crops along with field crops. FAW outbreak resulted in a complete failure of the alfalfa crop for the season. Even the 3-4 times replanted corn plants were infested by FAW. Similarly, the larva of FAW caused a huge injury to the cotton in topping the plants and cutting off squares and branches (Luginbill, 1929). It has been found that the reduction in yield due to FAW infestation was 11.57% when the pest incidence in the maize was 26.4% - 55.9% (Baudron et al., 2019). In India FAW spreaded in 10 states of the country affected a total of 170,000 ha of maize crops as estimated (Sangomla and Kukreti, 2019).

5. Damage of FAW

This pest defoliates every plant as much as they can, when their larval population increases (Bhushal and Chapagain, 2020). The holes present on leaves are the typical damage signs of FAW which is due to the feeding of the epidermal tissues of leaves (Sisay et al., 2019). The voracious feeding of the cob and kernels by the matured larvae of the whorls of older plants was found to be the main reason for yield reduction in maize quality and yield (Capinera, 2017). In Srilanka ,since the infestation, the infestation of FAW which was 20% of 40000 hectare was reported to have caused 1- 3 billion economic loss in Asia and U$D 2400-4000 million loss per year (IPPC, 2018). For the 1st time the population of FAW was reported outside of the Americas, in which FAW was reported in maize of West Africa in early 2016 (Wu et al., 2019). The invasion route to Africa was most likely by air transportation, but colonization of 28 African countries by August 2017 was resulted by subsequent natural migratory flight (Cock et al., 2017). The key source regions of FAW immigrants that threatened the yield of crop in the zones of the tropical and southern subtropical of China was indicated to be Myanmar by a study (Wu et al., 2019). The heavy infestation of FAW has annually caused the loss of about 8.3-20.6 million tons of maize over 12 African countries (Day et al., 2017). In the context of Nepal, a south Asian country, the loss has reached upto 20-30% and 70% with and without control measures respectively (NPPO, 2019).

Table 4: Scale for the leaf damage assessment of the crop through fall armyworm (S. frugiperda)

Scale	Description
0	No visible leaf damage
1	Only pinhole damage on leaves
2	Pinhole and shot hole damage to leaf
3	Small elongated lesions (5-10 mm) on 1-3 leaves
4	Mid-sized lesions (10-30 mm) on 4-7 leaves
5	Large elongated lesions (>30 mm) or small portions eaten on 3-5 leaves
6	Elongated lesions (>30 mm) and large portions eaten on 3-5 leaves
7	Elongated lesions (>30 cm) and 50% of leaf eaten
8	Elongated lesions (30 cm) and large portions eaten on 70 % of leaves
9	Most leaves with long lesions and complete defoliation observed

Source: (Sagar et al., 2020)

Figure 3: Rating of maize plants based on foliar damage by FAW (Source; Prasanna et al., 2018)

5.1 Management of FAW

The management of FAW was also somehow seen elevating by maize-legume intercropping. But, the aim of controlling the FAW infestation was not seen effective on implementing a sole management practices as insecticides application because that application might not be applied at the right stage of the insect's growth or the pest target might be deviated during spray (Baudron et al., 2019; Kassie et al., 2020).

6. Integrated Management of Fall Armyworm

The goal of IPM is to economically suppress pest populations using techniques that minimize harm to the environment, including people. Integrated approach for FAW management keeps the environment disturbance at the lowest level possible while keeping the pest below the economic threshold. This method might integrate more than one method to reduce the FAW population with the minimal(least) possible disturbance to the agroecosystem. It is advisable to consider integrated approach, an integrated FAW management that keeps the pest below economic threshold with least disturbance on the environment. Integrated FAW management might involve integrating two or more than two of the previously described methods that discourage the development of FAW population with the least possible disruption to agroecosystems and encourages natural pest control mechanisms (Gebreziher, 2020). Hruska reported in Africa that for the smallholder farmers of maize, integrated pest management has not been accessible which resulted in the dependence on locally available, low-cost options (Hruska, 2019). A group researchers found Radiant, Ampligo and tracer caused mortality of FAW by 90% after 72 h of application and also stated that the larval mortality was more than 95% after 72 h of application of biopesticides like Azadirachta indica, Schinnus molle, and Phyto laccadodecandra (Sisay et al., 2019). Host- plant resistance, physical, cultural, biological control and environmentally safer synthetic and bio-pesticides that protects the crops from economic injury minimizing the negative impacts on people, animals, and the environment are the aspects included by the effective IPM strategy (Padhee and Prasanna, 2019).

6.1 Physical and Mechanical Method

Research conducted by has shown that though chemical methods help to reduce the FAW population, the combined strategy of chemicals use along with hand picking of insects directly from the crops and ash application was much more effective to reduce the yield loss from FAW (Kassie et al., 2020). Physical method which includes hand picking and inmasss destruction of egg masses, neonate larvae either by crushing or by immersing into kerosene water was also an effective measure to control the risk of FAW infestation which was reported by (Firake, 2019). Use of light traps attracts insects which are very active at nights which helps the farmers to easily kill these adults, hot water treatment is another example of pest management done before sowing the seeds and we can also store the corn in the food grains, or in cold storage or even in a controlled atmosphere all as a physical method that controls the pest population (Badhai et al., 2020).

6.2 Cultural methods

It is one of the best methods for minimizing crop loss by FAW. Cultural methods include the agronomic practices of a farmer to control the pest without any additional expenditure. Practices like deep summer ploughing exposes the pests at the hidden stages or resting stages from the soil like pupae and the egg stages and helps in their destruction before the pest becomes more matured to cause a severe infestation along with this the soil health conditions like good aeration is ensured (Badhai et al., 2020). Intercropping of maize as a main crop with legume crops like pigeon pea and green grams resulted in the control of FAW (Firake, 2019).

6.3 Biocontrol method

This method emphasizes on conservation of both the diversity and density of natural enemies which can be done by providing the conditions conducive of natural control agents near the maize area. We can apply the` Push-Pull' strategy in which with the host plant, pest repellent crops as Mexican sunflower are intercropped and the pest attractive crops are grown as border plants which biologically helps to minimize the pest population Infesting the main crop and maximize the biodiversity (Prasanna et al., 2018). Gebreziher, found reduction in incidence and damage of fall armyworm to be 40% when maize was intercropped with edible legumes (Gebreziher, 2020). The new associations of various species of natural enemies with FAW in Africa across countries and seasons in the current study shows the paramount importance of designing biological controls of FAW both through the conservation of native natural enemies and augmentative release (Prasanna et al., 2018).

6.4 Parasitoids

Similarly, besides using pesticides, which covered the entire plant part, we can use egg parasitoids over the targeted area that reaches the targeted pest such as Trichogramma or Telenomus wasps which are mostly used for FAW control by inundative release. These wasps, in search of pests' eggs , fly to the plants. Though FAW mainly feeds on the leaves, sometimes for a food source,they may use the grain as well. Now when the pest has invaded inside the ear, they become protected in which conventional methods like pesticide use become inefficient. In this condition we can control the pest population by releasing the Trichogramma/Telenomus early in the season (Prasanna et al., 2018). There are other beneficial insects as the braconid wasp *Chelonus insularis* (Meagher et al., 2016). Cresson parasites the egg of FAW and Campoletis *flavicincta* has also been reported to help decrease the pest *(*Matrangolo et al., 2007).

6.5 Predators

Different predators feed FAW based on different stages of their lifecycle as; Ladybird beetle which is phytophagous in nature eats larval and adult stage of FAW, while ant attacked on young and caterpillar stage of FAW, also the Earwig is found to be predating the young caterpillar stage of FAW (Chhetri, 2019). A group researcher also found Calosoma *granulatum* predating on young caterpillars (Prasanna et al., 2018). The major predators helpful for management of FAW are listed below in table.

Table 5: Predators controlling FAW

S.N.	Natural Enemy	Life Stage
1.	Calleida decora	Larva
2.	Calosoma alternans	Larva
3.	Calosoma sayi	Larva
4.	Carabidae	Larva/ Pupa
5.	Doru luteipes	
6.	Doru taeniatum	
7.	Ectatomma ruidum	
8.	Geocoris punctipes	
9.	Steopolybia pallipes	
10.	Podisus maculiventris	

Source: (CABI, 2019)

6.6 Entomopathogen

Though several pathogens like bacteria, fungi, nematodes and viruses affect the crops, some microorganisms are beneficial to the farmers. Nucleo Polyhedral virus (NPV) is a virus affecting insect specially Spodoptera frugiperda, Nucleo polyhydroxy virus where as some of the host specific fungi Beauveria bassiana, Metarhizium anisopliae, Bt bacteria and Protozoa which decreases the population of FAW (Chhetri, 2019). The major entomopathogens helpful for management of FAW are listed below in table.

Table 6: Pathogens controlling FAW

S.N.	Natural Enemy	Life Stage
1.	Bacillus cereus	Larvae
2.	Bacillus thuringiensis	Larvae
3.	Bacillus thuringiensis alesti	Larvae
4.	Bacillus thuringiensis darmstadiensis	Larvae
5.	Bacillus thuringiensis thuringiensis	Larvae
6.	Bacillus thuringiensis kurstaki	Larvae
7.	Beauveria bassiana	Eggs/Larvae
8.	Granulosis virus	Larvae
9.	Metarhizium anisopliae	Eggs/Larvae
10.	Nucleopolyhedrosis virus	Larvae

Source: (CABI, 2019)

6.7 Bio- pesticides

Different Bio-pesticides like Beauveria bassiana strain R444, Bacillus thuringiensis subspecies kurstaki strain SA-11, Spodoptera frugiperda, Baculovirus, Cowurine, SFMNPV- Baculovirus were found to be effective (Prasanna et al., 2018). A research conducted by found that Botanical pesticides like *Azadirachta indica* (NEEM) with 0.25% extract was found larvicidal with upto 80% mortality of FAW larva in the lab (Tavares et al., 2010). In the context where chemical pesticides have the potential dangers, the list of near-term priority activities for the development of lower risk possibilities using biological pesticides for faw is high (Day et al., 2017).

6.7.1 Use of traps with female pheromone as a complementary action with biological control

The traps used in the field of maize production is of double benefits, first it helps to control the faw population by trapping it in any of the stage in which it is prevailing in the field, secondly, the presence of the pest alerts the farmers regarding how much damage the pest can cause and control measures to be adopted. These traps indicate the prevalence of pest, when the pest is trapped in the form of moth, it indicates that the pest has arrived in the farm but no larvaes in the trap means it has not caused any damage yet and soon it`ll start its oviposition. BUt as soon as eggs start being trapped, it is the signal for farmers to use egg parasitoids like *Trichogramma.* Now gradually the farms should be supervised due to risk of larvaes in the field and for the larvas upto 12mm beneficial insects or bio pesticides or even plant extracts will be effective after the local evaluation (Prasanna et al., 2018).

6.8 Chemical Method

Sometimes the chemical methods might not be sufficient to control the pests which might be due to the asynchronization of application of chemicals and the vulnerable stage of the insect's growth, also applied chemicals might be deviated from the targeted pest. Hence, explained that having proper knowledge on the lifecycle of pest is of utmost importance so that the farmers can predict the correct time of chemical application for eg, when the larvae has already entered into the maize whorls and also deeply embedded into the ears of maize , pesticide application is of no effect at day since the pests starts feeding during night, dawn or dusk and comes out during these periods only (Day et al., 2017).

Various carbamate insecticides can be used like Cyfluthrin, Pyrethroid insecticide, Methomyl, common household pesticide, organophosphate insecticide, etc for the control of pests (Tumma and Chandrika, 2018). For the effective chemical control on fall armyworm spraying of certain chemicals as Emamectin benzoate 5% SG @0.5g/liters of water, Chlorpyriphos 50% + Cypermethrin 5% Ec @2ml/liters of water, Azadirachtin @ 2 ml/liter of water , Azadirachtin @ 2 ml/liter of water Chlorantraniliprole @ 0.4ml per liter of water was found effective (Badhai et al., 2020) .However for the smallholder farmers the spray of pesticide after the tassel stage (VT) is recommended to be ceased keeping in mind that in mature crop the exposures to pesticide residues of the farmer and family will be high which envelops the people that enter it being so tall.(Prasanna et al., 2018). And finally, pesticides rather than being used as a prophylactic or preventative measure, should be used based on monitoring and thresholds (Day et al., 2017; Prasanna et al., 2018; Badhai et al., 2020).

7. Conclusion

Since faw is a novel pest which is still establishing, concerned countries must be alert when damages are in the initial phase. To ensure the effective monitoring and scouting methods that have been developed but are yet to be widely distributed, education and support programs should be used as a factor for promoting them. As mentioned above, FAW (Fall Armyworm) control requires an integrated pest management (IPM) approach. However, most of the farmers are not likely to use the IPM approach keeping in mind the devastating loss caused by the pest. But in countries like Nepal, IPM is the best method for the management of pests, where the pest is only in the phase of incidence. For this, the concerned authorities must promote awareness of FAW, its identification, damages, symptoms and control through different approaches like IPM to the farmer level. Agronomic practices with less harm to the environment that maintains the diversity should be implemented.

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