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BIOLOGY, ECOLOGY AND IPM OF FALL ARMY WORM *SPODOPTERA FRUGIPERDA* (J E SMITH): A REVIEW

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ABSTRACT

The fall armyworm, *Spodoptera frugiperda* (J E Smith) is an emerging polyphagous pest. Its primary food is the corn cob, which suffers significant damage with its larvae skeletonizing or "windowing" the leaves. Only the larval stage is seriously risky and small and large communities as well as researchers have used a variety of control methods A number of low-cost mitigation strategies are available and these strategies include encouraging smallholder farmers to plant crops directly after major rainstorms, using cultural methods, such as intercropping and crop rotation, and avoiding some of the ineffective insecticides. Understanding the function of natural enemies in agricultural systems requires monitoring them in the field. *Chelonus insularis, Pristomerus spinator, Cotesia marginiventris, Meteorus laphygmae, Chelonus sonorensis, Orius insidiosus, Chelonus texanus, Archytas marmoratus, Elenomus remus*, and *Trichogramma* spp. are parasitoids of *S. frugiperda Metarhizium anisopliae, Erynia radicans, Fusarium solani, Nomuraea rileyi* and *Beauveria bassiana* are the main entomopathogenic fungi. These biocontrol agents should be promoted to manage this pest in a sustainable manner.

Key words: *Spodoptera frugiperda, m*aize, biology, ecology, cultural control, biological control, botanical and chemical, IPM

The fall armyworm (FAW)—*Spodoptera frugiperda* (J E Smith) is a destructive polyphagous pest and its larval stage attack all the growth stages. It is mostly found in maize growing areas of the tropical, subtropical and temperate regions (Prasanna et al., 2021; Montezano et al., 2018; Overton et al., 2021). It is native to Americas but now widely distributed. The control strategies to minimize this are becoming challenging due to various reasons such as high migratory power, morbidity and fecundity (Montezano et al., 2019; Sharanabasappa et al., 2018). This review discusses the biology, ecology, and IPM strategies. This aims to provide an understanding and basic information about the pest.

Distribution

It is native to American continents till 2015 and cause huge damage in many temperate areas (Rwomushana, 2019). This pest was detected in West and Central Africa in 2016 by Goergen et al. (2016). Several management strategies were used against this pest in Africa in 2016, but in few years, it invaded many African areas. In India, it was reported in 2018, while it was reported from maize in Pakistan (Naeem-Ullah et al., 2019), China (He et al., 2021), and Sri Lanka in 2019. Now it has spread to Australia, Turkey and Korea and many other countries. (Lee et al., 2020; Maino et al., 2021) and thus observed in >47 countries of Africa and 18 countries of Asia including Pakistan (Naharki et al., 2020; Rwomushana et al., 2018).

Host Plants

Being a polyphagous pest, *S. frugiperda* invade more than 353 host plants especially Poaceae, Fabaceae, and Asteraceae families. According to the report of Montezano et al. (2018), *S. frugiperda* attack more than 76 crop families.106 and 31 host taxa belonged to Poaceae and Asteraceae and Fabaceae families, respectively. The larvae consumed both vegetative and reproductive parts of the cultivated and wild host plant. Due to vigorous feeding, high migratory potential and fecundity, pest feed on other hosts (Sokame et al., 2020; Prasanna et al., 2021). The major host plants are maize, rice, sorghum, cotton, sunflower, lettuce, aster, safflower, barley, rye, sugarcane, wheat, millet, peanut, chickpea, soybean, alfalfa, sweet clover, garden pea, kidney bean, cowpea, red and white clover etc. (Montezano et al., 2018; Bateman et al., 2018).

Biology Methods

Sharanabasappa et al. (2018) observed its life history in June- July 2018. Eggs are laid in groups and a female can lay 100-200 eggs on the dorsal or ventral side of the leaves (Prasanna et al., 2018; CABI, 2018b). The eggs have a dome like shape, 0.4 and 0.3 mm dia and length respectively (Prasanna et al., 2018), while colour of eggs was creamy white as reported by Bajracharya and Bhat (2019). The 1st-2nd instar larva were green, while dark brown in 3rd to 6th instars (CABI, 2018b). The main difference from other *Spodoptera* spp., is the presence of inverted Y on the front of larval head (Prasanna et al., 2018; Ramzan et al., 2021) with four square shaped dark spots on the 8th abdominal segment. The total developmental period of larvae and pupae 14-19 and 9- 12 days, respectively on maize. The pupal period was 8.54 days as reported by Débora et al. (2017).

The forewings of male are grey and brown with triangular white patch at the apical region. A circular spot is found at the center of the forewings. Females are with greyish brown forewings; hind wings of both sexes have silver-white with a narrow dark border. The preovipositional, ovipositional and post ovipositional period was 3 to 4, 2 to 3 and 4 to 5 days, respectively. It has been reported that females live longer (Sharma et al., 2022; Srikanth et al., 2018; Tendeng et al., 2019).

The IPM strategies used against insect pests include cultural, mechanical, physical biological, botanical, microbial and chemical control. All these strategies have been used against several insect pests.

Globally, there are many cultural and physical recommended, such as timely sowing, intercropping, crop rotation (Assefa, 2018; Kasoma et al., 2020), proper application of nitrogenous fertilizers etc. The pest population can be reduced by planting the early maturing varieties (Chhetri and Acharya, 2019). Rainfall at early stage of crop can reduce the population as reported by Harrison et al. (2019), and 56 and 70% reduction in Ghana and Zambia, respectively had been reported (Rwomushana et al., 2018). Another method is the use of traditional method i.e. crop rotation, but this cannot directly reduce the pest population due to polyphagous nature (Montezano et al., 2018) and high migratory potential (Kansiime et al., 2019) Crop rotation not only controls the pest but also prove good in improving the soil fertility that supports healthy plant growth (Prasanna et al., 2018; Meagher et al., 2016). 018). Many plants used in push-pull technique, may lead to anti-appetizing action towards several pests like FAW (Hruska, 2019). Such types of plants can attract or repel the insect pests which provide protection to plants from pest damage (Khan et al., 2016; Hassanali, 2008). The immature stages such as larvae and egg masses can be hand-picked and this is not only adopted in Africa but as old method tested by several farmers and researchers (Yigezu and Wakgari, 2020). Many non-chemical elements such as salts, oil, urine, soaps and detergents are applied on FAW to kill them. To control the high infestation and to reduce crop losses, farmers used sand with chemicals in the form of granules (FAO, 2017). The light traps can be used to attract adults (Shimoda and Honda, 2013).

Botanicals: The chemicals extracted from plants have some toxic effects on insect pests. These kill the pests, reduce the larval performance and reduces the growth and development. By the application of such chemicals, the fertility and fecundity can be reduced (Rioba and Stevenson, 2020). There are several plant extracts tested against FAW but among them *Azadirachta indica, Phytolacca dodecandra* and *Schinnusmolle* are the most widely (Lin et al., 2020).

Biological control: Predators, parasitoids and pathogens are the main component of biological control (Nafiu et al., 2014). More than 150 parasitoids and nematodes attack the different stages of FAW (Sisay et al., 2018; Tendeng et al., 2019), while several insect and spider predators (Koffi et al., 2020) and pathogenic bacteria, fungi and viruses also invade the pest stages (Shylesha et al., 2018) which causes up to 42% mortality (Day et al., 2017; Caniço et al., 2020; Mohamed et al., 2021). *Cotesia icipe, Apanteles marginiventris, Anatrichus erinaceus, Chelonus insularis, Telenomus remus, Rogus laphygmae, Trichogramma pretiosum, Campoletis grioti, Ephisoma vitticole,* and *Meteorus autographae* are the most important parasitoids as reported by Mohamed et al. (2021); Abbas et al. (2022) and Carneiro et al. (2012). Some predators such as *Pheidole megacephaly, Haematochares obscuripennis* and *Peprius nodulipes* had been reported by Kenis et al. (2019).

More than 750-800 fungal species are found of which *Beauveria bassiana* is the effective one (Khan and Ahmad, 2015). *Nomuraea rileyi* is another fungal species that gives best control (Romero-Arenas et al., 2014). More than 72.5% larval mortality was recorded by the use of such fungi. Another pathogen is gram positive bacteria, *Bacillus thuringensis* which was used widely. The biological and morphological parameters of the pest have been reduced by the application of such pathogens (Farias et al., 2014; Dangal and Huang, 2015). Viruses and nematodes have also been used (Gichuhi et al., 2020; Botha et al., 2019). Entomopathogenic nematodes (EPNs) such as Steinernematidae and Heterorhabditidae are linked with some symbiotic bacteria (Sree and Varma, 2015). These have proved most effective with 100% larval mortality in combination with insecticides (Negrisoli et al., 2013); *H. indica* and *S. carpocapsae* and *S. riobravis* caused 28% and 53% larval mortality, respectively (Negrisoli et al., 2010).

Chemical control: The insecticides are the last option to control *S. frugiperda* as these gives quick response and protect the crop (Togola et al., 2018). Different insecticides are used of which most important are deltamethrin, cypermethrin, lambda-cyhalothrin, chorpyrifos and permethrin. The excessive applications of these has caused environmental pollution and insecticides resistance (Sellami et al., 2015). Azevedo et al. (2004) reported that pest population can be minimized by treating seeds with some chemicals (malathion, lambda-cyhalothrin, chlorpyrifos, permethrin), Thiodicarb and clothianidin tested by Camillo et al. (2005) proved efficient on larvae. Niaz et al. (2018) concluded that indoxacarb, emamectin benzoate, methomyl, llufenuron and fubendiamide caused with maximum larval mortality.

CONCLUSIONS

Recently, FAW has evolved into an invasive species and adapted to the environmental settings of numerous locations. Since its wide area expansion across the world, there is an urgent need to device effective IPM strategies. It is also necessary to raise awareness among farming communities about pest scouting, recognizing when pests attack which stage of the crop, applying treatment at the proper time, and implementing low-cost agronomic measures. Additional research should be done to examine the host plants, life cycle, and effectiveness of various control strategies. The best technique for enhancing natural enemies is to increase the population or diversity of plants. The optimum management choice for FAW may be a push-pull strategy, such as the cultivation of Napier and Desmodium grass with maize crop. The greatest method for eradicating this pest would be area-wise management and the promotion of biological fauna.

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