

FALL ARMY WORM: AN INVASIVE PEST AND ITS MANAGEMENT: A REVIEW

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ABSTRACT

*The fall armyworm (FAW) *Spodoptera frugiperda*, (J. E. Smith) (Lepidoptera: Noctuidae) is new invasive pests observed in maize growing regions of world including India. It is considerably spreading very fast across and among the continent and getting status of globally invasive pest. It is notorious pestiferous insect with high dispersal ability, wide host range and high fecundity. The pest can be effectively managed with Bt technology (PowerCore containing the Bt protein Cry1A105, Cry2Ab2 and Cry1F) shows the maximum resistance, behavioral control (pheromone traps), mechanical control (light trap), biological control (parasitoids like *Trichogramma* sp. & *Telenomus* sp. and the biopesticides like *Beauveria bassiana* and *SfMNPV*) and chemical control (spinosad 45 SC, chlorantraniliprole 18.5 SC, thiodicarb 75 WP and emamectin benzoate 0.5 EC).*

KEY WORDS: Fall armyworm, Maize, Management , *Spodoptera frugiperda*

INTRODUCTION

Maize (*Zea mays* L.) popularly known as corn is one of the most important fodder and cereal crops in India. It is cultivated widely throughout the tropical, subtropical and temperate region of the world. It belongs to family *gramineae* and ranking third among the food crops, next to rice and wheat in the world and ranking fourth after rice, wheat and sorghum in India, in respect of area and production. In different parts of India, maize is known as “Makka, Makai, Chhali, Bhutta, Cholum, Mokochana, and Khaukiri”. There is no any cereal on the earth, which has so immense potentially as to maize and also gives high biological yield as well as grain yield in a short period due to its unique photosynthesis

mechanism owing to C₄ mechanism and hence, occupied a place as “**Queen of Cereals**”. In India, maize is grown more or less in all the states. It is mainly cultivated in Uttar Pradesh, Bihar, Rajasthan, Himachal Pradesh, Madhya Pradesh and Gujarat.

There are many factors responsible for low productivity of maize. Among them, insect pests are a major factor for low productivity of maize and caused appreciable damage which ultimately affects the yield. Maize crop is attacked by nearly 130 species of insect pests in India (Atwal and Dhaliwal, 2002).

The fall armyworm (FAW) *Spodoptera frugiperda*, (J. E. Smith) (Lepidoptera: Noctuidae) is an insect native to tropical and subtropical regions of the

Americas (Cruz and Turpin, 1983). The scientific name is derived from the feeding habits of the larval life stage, *frugiperda* meaning “lost fruit” in Latin, as the pest can cause damage to crops resulting in severe yield loss.

Invasive pest

Invasive pests are non-native or exotic organisms that are outside their native geographical range and may become injurious to plants or animals or human health, economy and natural environments. They are also called introduced or alien species.

Such species may arrive in new areas through natural migration, movement of commodities through global trade which provides the pathways for many insects in to new areas.

The classical example is grape phylloxera, *Daktulosphaira vitifoliae* Fitch, introduced in France from USA in 1859 and became threat to wine industry.

History and distribution

Outside its native areas, the pest has been reported for the first time from Central and Western Africa (Sao Tome, Nigeria, Benin and Togo) in early 2016 and in 2017 from Ghana, Kenya, Niger, South Africa, Zambia, and Zimbabwe and it is expected to move further (Anon., 2017a). It has since spread to neighbouring countries including Ghana, Niger and Cameroon. In mid-December 2016, came the first reports of fall armyworm in Southern Africa, first in Zambia and Zimbabwe, then neighbouring Malawi, Burundi, Botswana, Namibia and South Africa. By early 2017, it had started to spread into East Africa including Tanzania, Kenya, Uganda and Ethiopia (Anon., 2018a). Sharanabasappa *et al.* (2018) first reported the fall armyworm, an alien invasive pest on maize in India. This pest is causing severe damage to maize in southern part of Karnataka during May and June, 2018. The report of this pest was also

reported on bajra and sorghum in Andhra Pradesh by Venkateswarlu *et al.* (2018). In Gujarat, the first report of fall armyworm an alien invasive pest was observed from field of sweet corn at Ankav village, Anand (Gujarat) during September, 2018 (Sisodiya *et al.*, 2018). Fall Armyworm in Gujarat was reported by Dr. P. S. Patel and his co-workers on 26th September, 2018 from sweet corn field in Umiyanagar Kampa of Vadali taluka of Sabarkantha district in North Gujarat.

Host range

FAW feed on the leaves, stems and reproductive parts of more than 100 plant species (Abrahams *et al.*, 2017), causing major damage to economically important crops, such as maize, rice, sorghum, sugarcane, pearl millet and cotton, as well as other vegetable crops like tomato, cabbage, beet, peanut, soybean, alfalfa, onion, potato and pasture grasses. Fall armyworm small caterpillars (high population density) shows an aggregated distribution in the field, whereas the large ones (low population density) could be more dispersed, tending to an at random distribution (Farias *et al.*, 2001). Some sweet corn varieties have developed partial resistance to fall army worms by producing a unique 33-kD proteinase that significantly retards fall army worm growth (Pechan *et al.*, 2000).

Economic impact

The pest can cause damage to crops resulting in severe yield loss. The losses due to this pest was between \$ 2.4 to 6.2 billion for maize, a major staple crop in Africa on which more than 200 million people depend. Overall cost of losses for maize, sorghum, rice and sugarcane in Africa are estimated to be approximately \$ 13,383m (Anon., 2017a).

Marks of identification

Egg is dome shaped (Image A), measures around 0.4 mm in diameter and 0.3 mm in height. Larva passes through six instars. Early instar larvae are pale green in

colour with a dark head where the late instar larva have four tubercles in square manner on the 8th abdominal segment and dark head with a pale inverted Y-shape marking (Image G). Pupa is shiny reddish brown (Image D) and usually found 2 to 8 cm into the soil. It possess a pair of cremasters (Image I). Adult moths are nocturnal having a wing span of 32 to 40 mm. Forewings of male are brown with triangular white spots at the tip of the wing (Image E). Female is slightly bigger than male (Abrahams *et al.*, 2017).

Life history

The life cycle is completed within 30 days during summer and 60 days during the spring and autumn. Eggs are laid on the upper and underside of leaves as ‘egg masses’ in batches of 100–200 and potential fecundity of up to 1,000 eggs per female that hatch in 2 to 4 days in optimum temperature (Image B). Larval duration is 14 to 22 days and the development take place between 11 and 30°C. Larval stage shows the cannibalism (Chapman *et al.*, 2000) (Image H). Pupal stage lasts for 7 to 13 days and survives at the temperature range of 18-24°C in the soil. After a preoviposition period of 3 to 4 days, the female moth normally deposits most of her eggs. Adult life is estimated to about 10 days, with a range of about 7-21 days. Adult moth can migrate with a capacity of 100 km overnight and 300 miles per generation. FAW found throughout the year and had 6 to 11 generations per year (Luginbill, 1928).

Nature of damage

Feeding of young larva creating a characteristic “windowing” effect or a line of identical “shot” holes on leaves and ragged leaf edges are observed. Moist saw dust- like frass near the funnel is observed. Mature caterpillar damage the reproductive parts like tassels, kernels and borrow into cobs in maize. In cotton, first few instars “skeletonize” leaves and older instars

feeding on fruiting structures typically injure bracts, large squares (flower buds) and young and mature bolls in a manner similar to the bollworm. The incidence of FAW on maize crop was ranged between 9.0 and 62.5 per cent (Shylesha *et al.*, 2018).

Management

Cultural control

Deep ploughing, collection and destruction of egg masses, crop rotation, resistant varieties, early planting and neem cake application @ 250 kg/ha to reduce the adult emergence from pupae (Anon., 2018a).

The Bt technology, PowerCore containing the Bt protein Cry1A105, Cry2Ab2 and Cry1F shows maximum resistance against FAW damage (Burtet *et al.*, 2017).

Implementing the push-pull technology

Push-pull is a habitat management strategy which appears to be effective in the management of FAW and other lepidopteran pests (such as stem borers) compared to maize mono cropping systems. Push-pull intercropping system is pesticide free, could reduce FAW occurrence and damage, by reducing oviposition, feeding and increasing populations of natural enemies. The technology entails using a repellent intercrop (Desmodium as a “push”) and an attractive trap plant (Napier grass as a “pull”).as the intercropping (Bermunda grass) and trap cropping (Anon., 2017b).

Use of pheromone trap

Female FAW moths attract males by emitting a pheromone. The sexual pheromone of *S. frugiperda* contains (Z) -9-tetradecenyl acetate. The sex pheromone traps @ 4 to 5/ ha for monitoring can be installed in the field.

Use of light trap

More moths were collected in traps baited with Scenturion lures, the Trece and Scentry 2 lures ranked second in number of moths captured. Traps baited with the

Hercone lure captured the fewest number of moths (Hall *et al.*, 2005).

Use of gamma radiation

Arthur *et al.* (2016) recorded that effect of gamma radiation on pupation. Dose of gamma radiation (Gy) @ 200 was found very effective with very less pupation percentage found and Adult emergence was also very low.

Biological control

Several egg (*Trichogramma* sp. and *Telenomus* sp.), larval (*Chelonous* sp. and *Cotesia* sp.) and pupal parasitoids are effective for FAW management. Maximum number of FAW larvae parasitized by *Chelonousinsularis* under different locations (Cruz *et al.*, 2010). During the survey, FAW larvae were collected from maize fields and brought to the laboratory, Department of Entomology, C. P. College of Agriculture, S. D. Agricultural University and were critically observed daily for any emergence of parasite. Based on observation, approximately 7 per cent larvae were found parasitized and only one parasite was emerged per larva. On emergence, the adult parasites were critically studied on morphological characters and were identified as *Habrobracon hebetor* (Anon., 2018b).

Microbial pesticides

There are number of microbial pesticides available in the market such as *Beauveria bassiana* and *Metarhizium* sp. and the viruses like *SfMNPV* and *Bt* based insecticides for this pest. The mixture of *SfMNPV* (1.2×10^{12} OB/ha) with 3 ppm spinosad resulted in 90 per cent control of *S. frugiperda* (Mendez *et al.*, 2002). NPV infected larvae were found during survey, more number of NPV infected larvae were found and collected at Kanisa village of Anand districts (Raghunandan *et al.*, 2019). A team of Entomologist from Department of Entomology, S. D. Agricultural University, studied eco-friendly management of fall army worm, *S. frugiperda* on maize crop at

farmers field in Sabarkantha District found high larval mortality (up to 50% mortality) in Bhandval village of Vadali taluka.

Botanicals

The hatching percentage of recently laid eggs of FAW reduced up to 11.30 per cent by using 1 per cent piperine extract (Tavares *et al.*, 2011). Hydro alcoholic extract obtained from the bark of *Mulaterio*, *Calycophyllum spruceanum* (Benth.) had the highest ovicidal activity against eggs of FAW among 15 plant species in the Amazon region (Santos *et al.*, 2016). Extracts of many plants like neem (Azadirachtin) and pyrethrum (pyrethrins) shows insecticidal activity against FAW and the most effective product is Azadirachtin 1 EC @ 20 ml / 10 lit (Anonymous, 2018a).

Chemical control

Viana and Costa (1998) observed that chlorpyrifos 20 EC @ 288 g a.i./ha has 93 per cent efficacy against FAW infesting maize. Adamczyk *et al.* (1999) recommended spinosad 45 SC, thiodicarb 3.2 F and chlorfenpyr 3 SC as effective pesticides against FAW larva feeds on cotton leaves, flowers and bolls. Cruz *et al.* (2010) mentioned that the application of spinosad 45 SC @ 50 ml/ha reduced the infestation of FAW up to 1.2 ± 1.2 percentage after 11th day of application followed by methomyl @ 600 ml/ha in maize crop. Hardke *et al.* (2011) evaluated different insecticides and found that chlorantraniliprole 18.5 SC @ 0.10 kg a. i./ha and cyantraniliprole @ 0.09 kg a. i./ha have maximum (100 %) mortality of FAW feed on sorghum grains. Spinetoram @ 12 g a.i. /ha found most effective against FAW in maize crop (Burtet *et al.*, 2017). Nascimento *et al.* (2017) found that FAW fed on Si-treated rice plant through soil application exhibited lower larval weight, male and female longevity and viability of eggs.

CONCLUSION

Fall armyworm is considerably spreading very fast across and among the continent and getting status of globally invasive pest in maize growing regions of world including India. There is a big threat to other crops like cotton, sorghum, rice, sugarcane, pearl millet and vegetables growing areas. The pest can be effectively managed with behavioral control (pheromone traps), mechanical control (light trap), biological control (parasitoids like *Trichogramma* sp. & *Telenomus* sp. and the biopesticides like *Beauveria bassiana* and *SfMNPV*) and chemical insecticides (spinosad 45 SC, chlorantraniliprole 18.5 SC, thiodicarb 75 WP and emamectin benzoate 0.5 EC).

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A. Egg mass



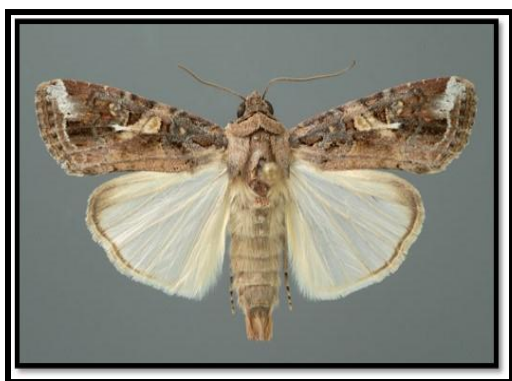
B. Egg hatching



C. Larva



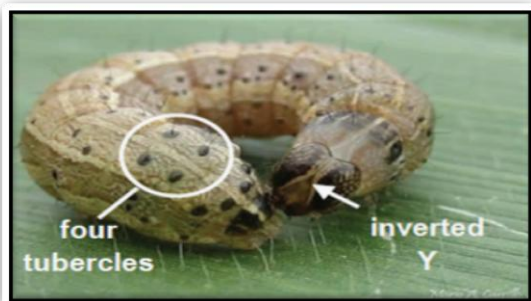
D. Pupa



E. Adult (Male)



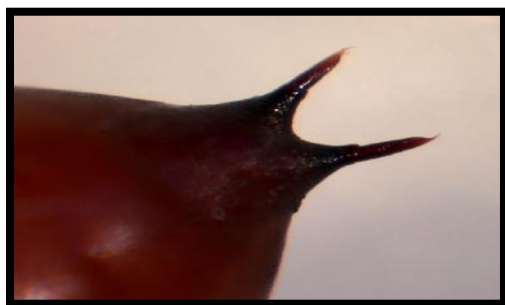
F. Adult (Female)



G. Morphological larval character



H. Cannibalism



I. Cremester



J. Nature of damage caused by fall army worm, S. frugiperda

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