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Fall Armyworm: Threat to Maize Production in India

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Abstract:

Maize has the highest genetic yield potential among all the cereals because of which it is also called as queen of cereals. Maize is regarded as third most important cereals crops of India after wheat and rice. Its productivity is quite greater than any other crops but still less than the world average tons per hectare. The reason of its less productivity is due to some abiotic stresses, diseases and due to some major destructive pest. Among all, fall army worm is one of the major reasons that results in less productivity. It is a polyphagous insect pest native to tropical and subtropical region of America that has entered India in May 2018 and distributed all over in a rapid way due to which the productivity of is decreased. For tropical environment especially FAW is major problem for crop production due to its ability of rapid breeding, migration, and feeding habit on a wide variety of hosts. This pest is a great threat to maize farmers and maize based industries, foods and nutritional securities. The identification of FAW, classification, biology and life cycle, have been reviewed in detail in the present manuscript.

Keywords: fall armyworm, maize, strategies, threat, control

Introduction

MAIZE (*Zea mays* L.) is the most important cereal crop being cultivated in an area of 180.63 m ha in 165 countries across the world with a production of 1134 million tones growing at an average annual rate of 3.46% (APEDA, 2018-19).India stands in fourth position in maize production with 22.57 million tonnes production in the world with a productivity of 2.56 tonnes per hectare (Annual report, IIMR, 2016). Maize is a staple food in many parts of the world. Maize is important to human beings as a staple food and a quality

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feed for animals. Further, Maize serves as a significant raw material to the industry for the production of starch, oil, protein, alcoholic beverages, food sweeteners and more recently bio-fuel (Ethanol).

Besides its significance, its productions in India is much lower than the world average (5.62) tons per hectare due to different abiotic stresses, few important diseases like Turcicum and Maydis Leaf Blights, Downy mildew, charcoal rot and infestation of major insects like stem borer, armyworm, and earworms. Before the report of the destructive pest FAW (*Spodoptera frugiperda*) in maize in May 2018 there was only 3 major pests in maize crop (stem borer, pink stem borer, and shoot fly). Now this FAW has spread rapidly to all maize growing ecologies of India, except Himachal Pradesh and Jammu Kashmir.

FAW is most common in the tropical and subtropical Americas and is known as a sporadic pest in the United States since 1797.A severe outbreak of FAW on corn and millet are documented in 1912. In India, the presence of FAW was confirmed for the first time by the University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka in the year 2018. In India, FAW already affected crops in Karnataka, Andra Pradesh, Telangana, Tamilnadu, Punjab, Maharashtra, Gujrat, Rajasthan, and many other places. This pest is easily identifiable because of its unique inverted "Y" shape mark on its head and four dark spots form a square on the second-to-last body segment. Fall armyworm consists of 2 strains i.e, corn strain "C" and rice strain "R". Corn strain feeds predominantly on maize, sorghum, and cotton and R strain prefers rice and turfgrass. (Nagoshi, R.N, and Meagher,,R.L;2016). As per the molecular genetic diversity studies the fall armyworm population in India belongs to the "R" strain based on polymorphism in the cytochrome oxidase subunit I gene (COI) (Swamy H.M.M *et al*;2018).

But later using other markers the Indian fall armyworm population was found to be predominantly 'C' type by TPI and 'R' type by COI, which indicates inter-strain hybrids of FAW in Africa and India, arising from a common small founder population (Nagoshi, R. N., Dhanani, I., Asokan, R., Mahadevaswamy, H. M., Kalleshwaraswamy, C. M., Sharanabasappa and Meagher, R. L;2019). The FAW genome is sequenced from the Sf21 cell line, is 358 Mb in size with 11,595 genes. The genome of both Rand C strains as sequenced

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are 371 and 438 Mb respectively. The R strain predicated to have 21,329genes whereas the C strains contain 21,700 protein- coding genes.

Classification of Fall Armyworm

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

Biology of pest

Fall armyworm is regarded as invasive pest with a voracious appetite. It is a lepidopteran pest that feeds on leaves and stems of more than 80plant species of cultivated crops like maize, sorghum, sugarcane, cotton, and also some vegetable crops (CABI 2020). The life cycle of this pest is about 30 days during the summer season, 60 days during autumn and spring season, and about 80 to 90 days in the winter season (Capinera, July 1999).

The life cycle of FAW consists of 4stage they are; egg, larva, pupa, and adult.

EGG

Eggs are spherical shape with a diameter of about 0.44mm and a height of about 0.3mm. At the time of oviposition, the color of an egg is pale yellow or creamish and became light brown before eclosion. The egg mass is covered with a protective, felt-like a layer of grey-pink scales from the female abdomen. About 100 to 220 eggs are laid on the underside of the leaves typically near the base and stem but in a young plant, the eggs are lay on the stem. A single female adult can lay about 1000eggs. The Incubation period ranged from 2-

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3days with a mean of 2.50days with favorable temperature of 20-30℃ (Sharanabasappa et.al;2018)

Larva

There are six larval instars of fall armyworm. During these instars larva gains a length of about 1.7,3.5,6.4,10.0,17.2 and 34.2mm respectively. The young larva is green in colour with a blackhead, the head color turns orangish in the second instar. In the third instar, the dorsal surface of the body turns into brownish and lateral white lines begin to form. Similarly in the fourth and sixth instar the head of a larva is reddish-brown, mottled with white, and brownish body bears white sub-dorsal and lateral lines. When larva was reared at 25 ℃, mean development time was determined to be 3.3, 1.7, 2.0, and 3.7 days for instar 1 to 6 respectively (Pitre and Hogg;1983).

Pupa

Pupa of fall armyworm is shorter than the mature larva. Pupation generally takes place inside the soil. The larva builds a loose cocoon by tying the soil particle with silk. The cocoon is oval shape measuring 20 to 30mm in length inside which a reddish-brown pupa about 14 to 18mm in length and 4.5mm in width resides. The time period of the pupal stage is nearly 8to 9 days during summer and 20 to 30 days during winter. (Cabi,2019).

Adult

According to (cabi 2019), the adult of fall armyworm is nocturnal and are more active during the warm and humid evening. An adult male is smaller than an adult female. The body length of an adult males is 1.6cm and the wingspan is 3.7cm whereas the body length of a female adult is 1.7cm and the wingspan is 3.8cm. The Male adult is easily identifiable since its forewing is mottled and contains a discal cell having straw color on 3quarters and dark brown on 1 quarter of the area with triangular white spots at the tip and near the center of a wing (cabi 2019). But the female is quite difficult to distinguish with their forewings because the forewings of females are less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown. The hindwing of both males and females is iridescent silver-white with a narrow dark border (Igyuve et al .2018).

After a pre-oviposition period of 3 to 4 days, the female normally deposits most of the egg during the first 4 or 5 days of life, but some oviposition occurs for up to 3 weeks. Adult

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fall armyworm can live up to an average of about 7-21 days. According to (cabi 2017), the favorable temperature for adult is less than 30℃

Table 1: Characteristics of a different stage of fall armyworm

Stage	Color	Shape	Suitable temperature. (^{0}C)	Duration days	Special characteristics
egg	In the early-stage greenish- grey later turns into brownish black	Spherical diameter 0.75mm	20-30	2-3	Female covered a layer of scales (downy materials on the egg mass and give a moldy appearance.
Larvae	greenish to brownish with longitudinal stripes	3-4cm long	26-28	14-21	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	Brownish in the early stage and later turned into back	1.3-1.7 cm long	13-16	9-13	A loose cocoon in an earthen cell

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Adult	Dark grey to brown	1.5-1.7cm long	Below 30	12-14	A 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,2019)

Incidence of fall armyworm in a different state of India

In India, fall armyworm was first reported in early May-June 2018 in a maize field at the college ofAgriculture, Shivamogga, Karnataka. In Gujrat, fall armyworm incidence was noticed in a sweet corn field located in Ankalv village, Ananda district on 20th September. Similarly, in November 2018 fall armyworm was found in West Bengal in maize field of Malda district in both rabi and summer crops. According to the report published in the Journal of Entomology and Zoology studies in 2019, FAW incidence was detected and reported in September 22, 2018, on sugarcane crops in Gurgaon village, Palus Tehsil, Sangli. In August 2019 and by the end of September it was noticed in the farmer's field in Punjab and later on infestation has been reported in Jalandhar, Hoshiarpur, Ropar, Pathankot, Patiala, and Fatehgarh Sahib district. It was also reported in the Ajmer district of Rajasthan.

Nature of damage

Fall armyworm is a polyphagous pest that attacked 353 plant species belonging to 76plant families (Montezano, D.G.et al,2018). This pest also attacks the grasses and causes economic damage to other cereal and millet crop but most of the damage is done to maize. FAW damage maize crop at various stages of development. It attacks from seedling emergence to the ear development stage. The larva of this pest is responsible to the severe damage of the crop. The 1st and 2nd instar of larva feed the leaves by scrapping the chlorophyll resulting in elongated papery windows all over the leaves. The larva can be found on the whorl, feeding on young leaves at 13 days (Harrison,1986),14 to 21 days after sowing (Melo and Silva). FAW infestation at 8th days after germination was noticed in the

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experiment plots at Main Agricultural Research Station, Dharwad. The 3rd instar larva settles in the whorl of the maize plant and start feeding on leaves leaving a series of holes and fecal matter in the unfurling leaves. Matured larva mostly feed in the whorl of a young plant and cause huge damage during the vegetative stage. It creates a window pane on the leaves of maize. As they grew up their feeding rate also increases so the size of the hole and the amount of fecal matter also increase. Sometimes matured larva bore the developing internodes of early whorl stage of maize which results in the death of the host plant. The Larva of FAW attack the tassel and developing ears as well.1st to 3rd instar larva eat 2% of the total foliage consumed in their life cycle and the 4th, 5th, and 6th instar eat 4.7%, 16.3%, and 77.2% respectively which heavily defoliate the crop. This pest cannot survive in extremely hot temperatures. The optimum temperature for the spreading is about 28°C. This pest can survive in sandy clay soil which is favored for pupation and adult emergence (Cabi 2019).

Fall armyworm; Farmer's Nightmare

Invasive pest fall armyworm having destructive tendencies was recorded in India from the maize field in Karnataka. As the world is facing various barriers in agriculture, the claustrophobic outbreak of this destructive pest had added the challenges in the farming sector. It has become a great nightmare particularly for those farmers who fully rely on farming for their livelihood. Attack of the FAW on maize was reported for the first time in 2016 in Africa (Goergen, et. al.2016, CIPV 2016) and caused huge damage in maize then its presence was confirmed in Ghana, Zimbabwe, Malawi, South Africa, Mozambique, and other various countries as well. Tanzania, Uganda, and Ethiopia of East Africa are expected to be the most affected countries by this pest with an estimated yield loss of up to 3,238,980metric tonnes,1,391,109tonnes and 3,054,727tonnes respectively. This pest has destroyed thousands of hectares of maize fields from different states across the country India. About 45% of the maize harvest losses occurred due to the FAW attack in 2018 in the Democratic Republic Congo that results in a loss of about 0.899millions tons of maize (FAO,2018). Similar cases were recorded in Nicaragua, America, Argentina and the yield loss was about 70%(Hruska and Gould,1977), 39%, and 72% respectively (Ivan et al 2012) (Chamberlin et al 2006) 25.9 metric tons of maize were produced in India in 2016.IN 2017 that number rose to 28.7million tons and in 2018 the production fell by 3.2% to 27.8million tons.

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This pest damages the maize crop by feeding on leaf, whorls, ears, and tassel. The larva consumes almost all the foliage of the crop. In the beginning, the young larva feeds on leaf tissue and the 2nd and 3rd instar larva makes series of holes in the leaves and starts to feeds on the edge of the leaves inward. The adult larva makes huge damage. It burrows the growing parts such as buds, whorl, etc and hindered the growth of maize. It infests ears as well.

Conclusion

Fall armyworm is a menace to maize farmers. It has the ability of rapid breeding, migration, and feeding habit on a wide variety of hosts so it poses a major threat to maize smallholder, maize farmers, maize- based industry, and food and nutrition security. Although the exact loss assessment of the pest in India is not calculated yet, it is expected that the production will decrease as this pest has reached almost all the states of the country. Hence, the ecologically sustainable, economically profitable, and socially acceptable integrated pest management strategies should be developed urgently to mitigate the impact of the fall armyworm in India.