Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(1): 194-198

Received: 11-11-2017
Accepted: 15-12-2017

Dr. Satya Narayan
Department of Agronomy,
Amar Singh P.G. College,
Lakhaoti, Bulandshahr,
Uttar Pradesh, India

Correspondence
Dr. Satya Narayan
Department of Agronomy,
Amar Singh P.G. College,
Lakhaoti, Bulandshahr,
Uttar Pradesh, India

Control of fall armyworm in maize in India

Dr. Satya Narayan

Abstract
Maize is the world's third most widely grown crop, after wheat and rice, and is known as the "Queen of Cereals" due to its great production. In India, farmers are currently dealing with a significant problem with maize crops impacted by the autumn Armyworm bug (*Spodoptera frugiperda*). FAW was first detected in India in May 2018, in Karnataka, and then expanded across the country. The fall army worm cannot be controlled by a single method; instead, it must be controlled by a combination of cultural, mechanical, chemical, and biological methods.

Keywords: armyworm, cultural methods, cereals, FAW

Introduction
Fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) is generally known as a destructive pest belonging to America and it came to India only recently, vastly known for causing damage economically. Later, FAW was detected at mild levels to alarming levels in farmer's fields in Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Madhya Pradesh, Odisha, Bihar, West Bengal, Gujarat, Chhatisgarh, and Kerala.

It is mostly a maize pest. It will look for sorghum if maize is not available. If both are unavailable, it will target other Poaceae (grass) crops such as sugarcane, rice, wheat, ragi, fodder grasses, and so on. It is possible that it will affect cotton and vegetables as well, though no reports have been made yet.

Maize (*Zea mays* L.) is a major cereal crop that originated in Central America and belongs to the grassland family Poaceae. Maize is the world's third most widely grown crop, after wheat and rice, and is known as the "Queen of Cereals" due to its great production. Among cereal crops, India ranked third in terms of area and maize production. It contains a good amount of carbohydrate (72%) as well as quality protein (10%), fibre (8.5%), oil (4.5%), sugar (3%), and ash (1.7 percent). Currently, maize is mostly utilised in India for the production of chicken feed and the extraction of starch, but it also serves as a source of food, animal feed, fodder, and a basic raw material for a variety of industries, including biofuel, food sweeteners, cosmetics, and alcoholic drinks. In India, farmers are currently dealing with a significant problem with maize crops impacted by the autumn Armyworm insect (*Spodoptera frugiperda*). The Fall Armyworm (FAW) is found throughout the Americas' tropical and subtropical climates. More than 80 plant species are suitable for FAW larvae, including maize, rice, sorghum, millet, sugarcane, vegetable crops, and cotton. The moth can have multiple generations per year and can travel up to 100 kilometres per night. In her lifespan, an adult female moth can deposit up to a thousand eggs. From the germination stage to the period of cob production, these insects cause damage to maize. FAW was first detected in India in May 2018, in Karnataka, and then expanded across the country. And, sure enough, the worm moved quickly through India's maize fields as well. Last year, the infestation was recorded in over 14 states across the US in a matter of months, putting the maize harvest in jeopardy. This year, the infestation has spread to 20 states, with the northeastern areas of the country being the hardest hit.

The FAW (*Spodoptera frugiperda*), a moth's caterpillar stage, is a ravenous eater of maize plants and has been labelled an invasive species by biologists. However, it is not a finicky eater. It eats the leaves and stems of around 350 plant species, including rice, sorghum, sugarcane, and wheat, in addition to corn.

In her lifespan, an adult female moth can deposit up to a thousand eggs. They are also excellent flyers, capable of covering up to 100 kilometres in a single night. The adult moth is a powerful flier, capable of flying over 100 kilometres in search of host plants. Male moths will be attracted to FAW-specific pheromone traps.

Fast spread

FAW has expanded very quickly across the Indian subcontinent. Mizoram in the northeast, Uttar Pradesh in the north, Gujarat in the west, Chhattisgarh in central India, and numerous states in the south have all been affected by the bug in 2019. Farmers in the northeastern states have been the most hit so far this year, with a total of 10,772 hectares of corn crop destroyed.

The rapid propagation of FAW does not surprise scientists. "In Africa, we have already seen the infection expand from one country, Nigeria, to over half of the continent in just two years (2016-2018)," said Malvika Chaudhry, regional coordinator, Plantwise Asia, Centre for Agriculture and Bioscience International (CABI).

The northeastern states are ideal for the spread of FAW because of their "high humidity and somewhat high temperatures." In these conditions, its metabolic rate is highly sustained, sometimes even resulting to "intensification of infestation," according to Chaudhry. It means the pest can complete its lifecycle in a shorter amount of time, resulting in more pests in a shorter amount of time.

Farmers and scientists are now battling to keep the infestation under control. After rice and wheat, maize is India's third most important cereal crop. India produced 25.9 million metric tonnes of maize in 2016. The figure increased to 28.7 million tonnes in 2017. Production, on the other hand, declined by 3.2 percent to 27.8 million tonnes in 2018. Due to the pest attack, net production is likely to fall even further in 2019.

Fig 1: Fall armyworm (*Spodoptera frugiperda*) larva on maize cob.

Fig. 2 Fall armyworm larvae feeding on a maize crop

Cascading effect

Despite the fact that maize is not a staple in India, it is a significant source of chicken feed. Since the millennium, the rise of the chicken business has coincided with an increase in the area cultivated under maize. As a result, the reduction in maize production has a knock-on effect on the poultry business.

Poultry farmers in Karnataka and Maharashtra petitioned India's farm minister, Narendra Singh Tomar, to import maize immediately to cover a shortfall earlier this month. As a result of the deficit, maize prices have risen, increasing the cost of producing chicken and eggs. The feed and starch sectors aren't the only ones who are feeling the heat. Maize growers are also experiencing new hurdles as they continue to raise the crop. They've had to deal with crop losses as well as the extra expense of saving their crop from FAW and preventing further infection.

"The expense of raising maize has increased," said Bhagirath Choudhary, founder and director of the South Asia Biotechnology Centre (SABC), a scientific institution based in New Delhi. Farmers must spend money on pheromone traps, safety kits, botanical and biological control measures, and extra insecticides in addition to the typical input costs.

In addition to their exorbitant prices, most of these items are subject to 18 percent taxes. Only botanical and biological controls are subject to a five- to twelve-percentage-point levy. These prices are prohibitive for farmers, particularly smallholders. "The SABC has written to the Union Minister of Finance, Nirmala Sitharaman, requesting that GST (Goods and Services Tax) be totally exempted or reduced to the lowest slab on these items," Choudhary added.

FAW appears to have expanded to crops other than maize, which is concerning. In the fields of an agricultural research station in Ananthapuramu, Andhra Pradesh, scientists discovered FAW infection on sorghum and bajra (millet) in October 2018. The insect was rapidly spreading to other millets farmed in the Ananthapuramu district, according to the researchers.

Stopping FAW's march

When the bug invasion initially began in 2018, most farmers had never heard of FAW. Farmers in 2018 generally asked to identify the pest on Plantix, an AI-based farmer support smartphone application where farmers may ask inquiries, according to Sairekha Kadirimangalam, who works for Plantix in Hyderabad. However, when FAW became more widely known in India, the nature of the questions altered. Farmers are now seeking for ways to prevent the bug from destroying their crops, according to Kadirimangalam.

There is no silver bullet that will bring FAW to a halt. The first steps, according to Chaudhry, are a good monitoring system and farmer awareness of the pest. "When farmers are suddenly confronted with a pest, they often panic and spray their fields with a variety of chemicals," she explained. "Not only is this fear response useless, but it also leads to broad-spectrum pest resistance, which should be avoided."

"The first thing they (farmers) should do is call their local Krishi Vigyan Kendra (agricultural extension centre) or state agriculture officials," said A.N. Shylesha, NBAIR's principal scientist for entomology. ICAR advises a variety of remedies, including mechanical, biological, and chemical approaches, depending on the location and intensity of the infestation. For example, if the infestation is still in its early stages, it can be managed with bio-control agents such as Trichogramma and Telenomus, as well as proper plant nutrition. Only when the infestation is serious is it advisable to use chemicals.

The necessity for appropriate preventive measures will only rise as FAW continues its march across India and other Asian

countries. “Increasing maize monoculture throughout the year and poor pest management practises, such as an overreliance on chemical pesticides, have contributed to FAW becoming a serious pest,” according to G.V. Ramanjaneyulu, executive director of the Centre for Sustainable Agriculture, which works with smallholder farmers. To handle such pest outbreaks, a change toward agro-ecological measures such as non-pesticidal management, organic or natural farming, and various cropping systems is necessary.”

Fall armyworm: Life cycle and damage to Maize

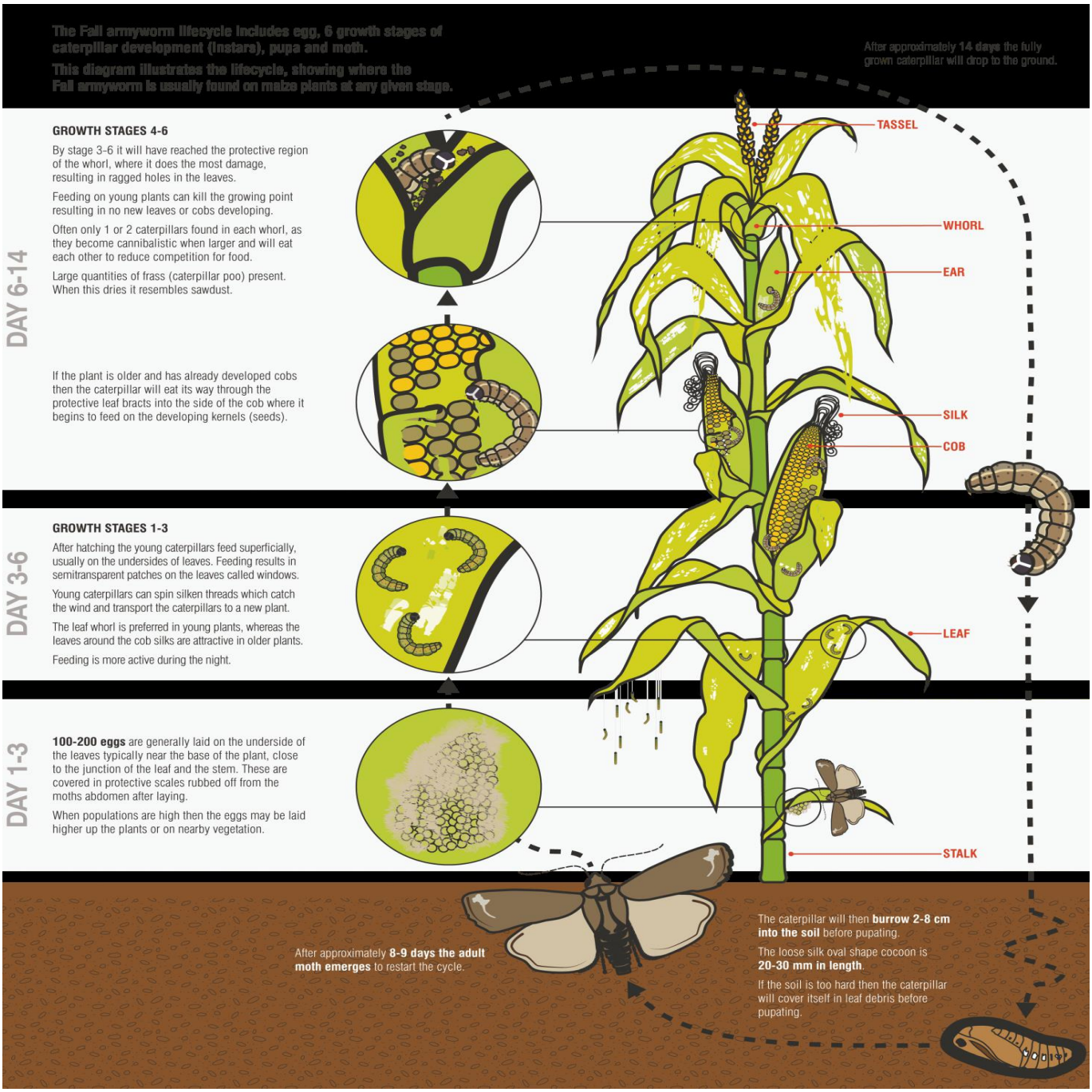

Fig 3: Life Cycle of Fall Armyworm

Nature and symptom of damage

Young larvae devour leaf tissue from one side alone, leaving the epidermal layer on the opposite side untouched. Larvae in the second or third instar begin to eat from the edge of the leaves inward, making holes in the leaves.

Corn that has been fed in the whorl generates a distinctive row of perforations in the leaves (shot holes). Due to cannibalistic behaviour, larval densities are frequently reduced to one to two per plant when larvae eat in close proximity to one another. Older larvae defoliate maize plants extensively, leaving only the ribs and stalks, or a ragged, ripped appearance. Injury sensitivity is lowest in the early whorl stage, intermediate in the mid-whorl stage, and highest in the late whorl stage.

During the late whorl stage, mean densities of 0.2 to 0.8 larvae per plant could diminish yield by 5 to 20%. Larvae will also burrow into the developing point (bud, whorl, etc.) of the plant, reducing its growth potential or cutting the leaves. They sometimes burrow through the ear of maize to munch on kernels. The FAW eats by digging into the husk on the ear's side.

Source: CABI

Source: news.psu.edu

Source: ag.umass.edu

Source: Lyle J. Buss

FAW management

A. Preventive Methods

i. Monitoring

In crop season and off-season, instal pheromone traps at a rate of 5 per acre in the present and potential spread region.

ii. Scouting

- Start scouting as soon as maize seedlings emerge.
- At seedling to early whorl stage (3-4 weeks after emergence)
- Action can be taken if 5% of plants are damaged.
- At mid whorl to late whorl stage (5-7 weeks after emergence)
- Action can be taken if 10% of whorls are freshly damaged in mid whorl stage and 20% whorl damage in late whorl stage (Silking stage)

iii. Cultural control

- Summer digging in deep to expose FAW pupae to predatory birds, heat, and other factors.
- Control is mostly achieved in northern and central India by exposing larvae and pupae within the upper soil surface throughout the winter. Temperatures below freezing result in a high rate of larval death.
- To eliminate the alternate hosts, cultivate in a weed-free environment and utilise fertilisers in a balanced manner.
- To prevent FAW larvae from migrating from one area to another, dig a trench around the field and fill it with water and insecticide.
- Early, synchronised maize sowing to decrease crop availability for FAW population growth and future epidemic. Staggered sowings should be avoided.
- Maize intercropping with appropriate pulse crops for a certain location. (for example, maize plus pigeon peas/black gram/green gram)
- Sowing 3-4 rows of trap crops (such as Napier) around the maize field and spraying with 5% NSKE or azadirachtin 1500 ppm as soon as the trap crop exhibits signs of FAW damage.
- On the whorl of maize, apply charcoal, soil, ash, and local plant extract.

iv. Mechanical control

- Hand picking and destruction of egg masses and neonate larvae in mass by crushing or immersing in kerosine water
- Application of dry sand in to the whorls of afflicted maize plants shortly after detection of FAW incidence in the field
- Application of Sand + lime in 9:1 ration in whorls in first thirty days of sowing
- Mass catching of male moths using FAW specific pheromone traps @ 15/acre

Traps

- Spread blue cloth measuring 2 m in places randomly in an acre area to attract and kill the larvae
- Install FAW pheromone trap @ 5 numbers/ac and light trap @ 1 number/ha at early stage of crop

B. Curative Methods

i. Biological control

- *In situ* natural enemy protection through habitat management: Increase plant diversity by intercropping with pulses, oil seeds, and attractive flowering plants,

which aid in natural enemy build-up.

- 50,000 per acre augmentation release of egg parasitoid Trichogramma pretiosum or Telenomus remus at weekly intervals or based on 3 moths/trap catch
- Augmentative release of egg parasitoid *Trichogramma pretiosum* or *Telenomus remus* @ 50,000 per acre at weekly intervals or based on trap catch of 3 moths/trap
- Bio-pesticides: If infestation level is at 5% damage in seedling to early whorl stage and 10% ear damage, then use following entomopathogenic fungi and bacteria: *Metarhizium anisopliae, Nomuraea rileyi, Beauveria bassiana, Verticilium lecani* (1 × 108cfu/g) @ 5g/litre whorl application. Repeat after 10 days if required
- *Bacillus thuringiensis* var. *kurstaki* formulations @ 2g/l (or) 400g/acre
- Apply Azhadirachtin 1% EC @ 10,000 ppm or neem oil @ 5 mL/lit. as oviposition deterrent on one week after sowing Pheromone trap

ii. Chemical control

- Seed treatment: Cyantraniliprole 19.8% + Thiamethoxam 19.8% FS @ 6 ml/kg of seed will be effective for 15-20 days
- First Window (seedling to early whorl stage): To control FAW larvae at 5% damage to reduce hatchability of freshly laid eggs, spray 5% NSKE /Azadirachtin 1500ppm @ 5ml/l of water.
- Second window (mid whorl to late whorl stage): To manage 2nd and 3rd instars larvae having more than 10% foliar damage the following chemicals may be used upto early tasselling stage: Spinetoram 11.7% SC or Chlorantraniliprole 18.5% SC or Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC
- Poison baiting: Poison baiting is recommended for late instar larvae of second window. Keep the mixture of 10 kg rice bran + 2 kg jaggery with 2-3 litres of water for 24 hours to ferment. Add 100g Thiodicarb just half an hour before application in the field. The bait should be applied into the whorl of the plants
- Third Window (8 weeks after emergence to tasseling and post tasseling): Insecticide management is not cost effective at this stage. Bio-pesticides as recommended above to be applied. Hand picking of the larvae is advisable
- All the sprays should be directed towards whorl and either in the early hours of the day or in the evening time

Conclusion

The fall armyworm was initially discovered on maize in Karnataka in 2018, and it quickly expanded throughout the southern states, with the exception of Telangana. Due to a lack of reference materials or type specimens, identification of the pest appeared to be challenging because it is an invasive pest in India. The pest is quickly spreading in India due to a number of characteristics like as voracity, fast and rapid flight capability, and more than 80 alternate hosts, among others. In India, the development of IPM to manage the pest is still in its infancy due to a lack of basic information about the insect. During the kharif of 2019, FAW infestations were observed in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Rajasthan, and Madhya Pradesh, Uttar Pradesh and Bihar. However, the FAW has been effectively managed in North Eastern states like Mizoram, Manipur, Nagaland, Assam, Arunachal Pradesh, Tripura, Sikkim and Meghalaya due to scouting and monitoring at early stage of the crop Periodic awareness training for maize growers and capacity building for extension agents and input dealers on early scouting, surveillance, and monitoring of FAW incidence are greatly essential to attain such freedom from FAW in other parts of the country.

References

1. Ankush Chormule, Naresh Shejawal, Sharanabasappa, Kalleshwaraswamy CM, Asokan R, Mahadeva Swamy HM. First report of the fall Armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera, Noctuidae) on sugarcane and other crops from Maharashtra, India.
2. Baudron F, Zaman-Allah MA, Chaipa I, Chari N, Chinwada P. Understanding the factors conditioning fall armyworm (*Spodoptera frugiperda* J.E. Smith) infestation in African smallholder maize fields and quantifying its impact on yield: a case study in Eastern Zimbabwe. Crop Protection 2019;120:141-150.
3. CABI. Datasheet. *Spodoptera frugiperda* (fall armyworm). Invasive Species Compendium, 2016. http://www.cabi.org/isc/datasheet/29810 (Date of access: 05/07/2019).
4. Cakir R. Effect of water stress at different development stages on vegetative and reproductive growth of corn. Field Crops Research 2004;89:1-16.
5. Chapman JW, Williams T, Martõ Ânez AM, Cisneros J, Caballero P, Cave RD. Does cannibalism in *Spodoptera frugiperda* (Lepidoptera: Noctuidae) reduce the risk of predation? Behavioral Ecology and Sociobiology 2000;48:321-327. doi: 10.1007/s002650000237.
6. Day R, Abrahams P, Bateman M, Beale T, Clottey V, Cock M *et al*. A. Witt. Fall armyworm: impacts and implications for Africa. Outlooks Pest management 2017;28:196-201.
7. Early R, González-Moreno P, Murphy ST, Day R. Forecasting the global extent of invasion of the cereal pest *Spodoptera frugiperda*, the fall armyworm 2018. NeoBiota.
8. EPPO Reporting Service No. 03 – 2019. Num. article: 2019/053.
9. Ghooshchi F, Seilsepour M, Jafari P. Effects of Water Stress on Yield and Some Agronomic Traits of Maiz [SC 301]. American-Eurasian J Agric. & Environ. Sci 2008;4(3):302-305.
10. Journal of Entomology and Zoology Studies 2019;7(1):114-117.
11. Kumela T, Simiyu J, Sisay B, Likhayo P, Mendesil E, Gohole L *et al.* Farmers' knowledge, perceptions, and management practices of the new invasive pest, fall armyworm (*Spodoptera frugiperda*) in Ethiopia and Kenya. Int. J. Pest Management, 0874 2018, 1-9.
12. Manupriya *et al*. Fall armyworm, destroyer of maize farms, causes concern in India. Mongabay Series: Conserving Agro-biodiversity 2019.
13. Midega CAO, Pittchar J, Pickett JA, Hailu G, Khan ZR., A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (J.E. Smith), in maize in East Africa. Crop Protection 2018;105:10-15.
14. Pogue MA. World revision of the genus *Spodoptera* Guene´e (Lepidoptera: Noctuidae). Memoirs of the American Entomological Society 2002;43:1-202.
15. Prasanna BM, Joseph Huesing E, Regina Eddy, Virginia MP. Fall armyworm in Africa: A Guide for Integrated Pest Management, First Edition. Mexico, 2018.

16. Ramesh Babu S, Kalyan RK, Sonika Joshi, Balai CM, Mahla MK, Rokadia P. Report of an exotic invasive pest the fall armyworm, *Spodoptera frugiperda* (J.E. Smith) on maize in Southern Rajasthan. Journal of Entomology and Zoology Studies 2019;7(3):1296-1300.
17. Sarfaraz Ali, Zakkia Masroor, Mohammad Danish Masroor. First record of the fall armyworm, *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae)
18. Sharanabasappa, Kalleshwaraswamy CM, Asokan R, Mahadeva Swamy HM, Maruthi MS, Pavithra HB *et al*. First report of the fall armyworm, *Spodoptera frugiperda* (J.E.Smith) (Lepidoptera, Noctuidae), an alien invasive pest on maize in India. Pest Management in Horticultural Ecosystems 2018a;24:23-29.
19. Technical Bulletin, ICAR Integrated management of Fall Armyworm in Maize, 2019.