Range Management and Agroforestry 44 (2) : 397-402, 2023
ISSN 0971-2070 (Print); 2249-5231 (Online)
https://doi.org/10.59515/rma.2023.v44.i2.24

Short communication

Seasonal incidence, biology and management of fall army worm (*Spodoptera frugiperda,* J.E. Smith) on fodder maize

N.S. Kulkarni[1*], M.C. Keerthi[2] and B.G. Shivakumar[1]

[1]Southern Regional Research Station, ICAR-IGFRI, Dharwad-580005, India
[2]ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284003, India
*Corresponding author e-mail: narendrask@yahoo.co.in

Received: 12th October, 2022 Accepted: 23rd September, 2023

Abstract

Seasonal incidence of fall army worm in maize at Dharwad indicated its occurrence both in *kharif* and *rabi* seasons. The incidence was more during the *kharif* season. Highest incidence of 50% was noticed during last week of August and second peak incidence of 30% was noticed during last week of December. Correlation between seasonal incidence of fall army worm and weather parameters indicated that there was a significant negative correlation with the rainfall (-0.60**) and morning humidity (-0.50*). Biology of fall army worm indicated that it completed its total life cycle in 31-44 days on maize comprising of six larval instar stages. Among the entomo-pathogens tested against the fall army worm, *Metarhizium (Nomuraea) rileyi* (2 x 10^8cfu/g) was found to be superior and it was at par with neem formulation (azadirachtin 3000 ppm) @ 5ml/l.

Keywords: Entomo-pathogens, Fall army worm, Fodder maize, Seasonal incidence

Maize (*Zea mays* L.) is grown for both grain and fodder purposes (Kumar *et al*., 2018; 2020). Maize is an ideal fodder crop grown throughout the country. It is quick growing, high yielding and supplies nutritious fodder that can be fed at any stage of growth without any risk to animals. It can be fed as green or dry and preserved as excellent silage. Maize green fodder, particularly when it contains the stalk, leaves and ears, is an energy rich feed for ruminant livestock. Maize produces good quality herbaceous fodder with high palatability. Maize is harvested within 3 months for fodder and does not require much labour and high machinery costs. But due to its high biomass and good vegetative growth, it attracts many insect pests which feed on foliage as well as on cobs. Any insect pest which causes huge damage on the foliage needs immediate attention especially in fodder maize. Recently fall army worm (FAW), *Spodoptera frugiperda* (J.E. Smith) entered the country and causing devastating losses by voraciously feeding on the foliage of fodder maize.

The first occurrence of maize army worm, *Spodoptera frugiperda* was reported by Sharanabasappa *et al.* (2018a) on maize at Shimoga in Karnataka. The FAW is a ubiquitous insect pest indigenous to America. It was first reported outside to its natural habitat during 2016 in Africa (Goergen *et al.,* 2016). Recently its infestation has been reported from 16 different countries in Asia including India (Rakshit *et al*., 2019). The FAW is a poly-phagous pest feeding on at least 100 plant species belonging to 27 families (Pogue, 2002). A few sweet corn varieties have partial resistance to army worms. In a survey of 12 maize producing African countries, FAW caused yield losses to the tune of 21-53% in maize, averaged over a three year period in these countries. Even though FAW is reported to feed on more than 350 plant species (Montezano *et al*., 2018), it is known to be a 'pest of cereals' due to its preference for Gramineae family members. Keerthi *et al.* (2021) reported the incidence of this pest on forage sorghum also. The field survey conducted in Northern Karnataka during *kharif* 2018 indicated that entomopathogenic fungus, *Metarhizium* (*Nomuraea*) *rileyi* is naturally occurring on FAW with its infestation ranging from 1.87% in Vijaynagar district to 18.30% in Dharwad district, while the percent damage of FAW on maize ranged between 12.42% in Uttar Kannada and 65.73% in Dharwad district (Mallapur *et al.,* 2018).

© *Range Management Society of India*

There is a need to know its seasonal incidence and biology before initiating its management practices. As fodder maize is grown by usually small farmers on marginal lands, they may not be spending too much money on expensive insecticides which leads to residual toxicity also. Therefore, there was a need to find out alternative and safe methods to manage this FAW without leaving any residual toxicity. Accordingly the available entomopathogens were evaluated for the management of FAW. Indeed, most of the available works on FAW is on grain maize, and meagre information is reported on fodder maize. Hence, field and laboratory experiments were carried out at Research Farm, ICAR-IGFRI, Dharwad to record the seasonal incidence, biology and management of FAW in fodder maize (var. African tall).

Weekly observation on the incidence of fall army worm was taken on randomly selected 20 plants from four different spots in 'Z' fashion round the year in 2021. Weekly observations on weather parameters were collected and correlation studies were made to understand the relationship.

Biology of FAW was studied on fodder maize and first generation larvae were collected from the stock culture and reared using a circular petri dish (Tarsons, 90 mm dia) containing leaves of fodder maize. The petri dishes were kept in BOD incubator with controlled conditions [25 ± 1^{0} C, 70 ± 5% RH and a photoperiod of 16: 8 h (light: dark)]. The adults were released in a plastic container (25 ×15 cm) with paper towel for oviposition. The freshly laid egg masses were collected and kept in petri dishes for incubation under controlled condition. The egg masses were examined at an interval of 6 h for recording incubation period. After hatching, a total of 30 larvae of FAW with similar time of hatching were used for studying biology and an individual larva was reared on fodder maize and leaf bits were changed daily. For longevity and fecundity studies, the adults (10 pairs) of FAW were released in pair in a rearing cage (30×30×45 cm) with 10% honey solution and changed daily. The larvae and adults were observed for recording biological parameters like larval duration during each instar, pupal duration, fecundity, pre-oviposition and oviposition period as well as total life cycle from egg to adult.

All the entomopathogens were procured from the Institute of Organic Farming of UAS, Dharwad and tested along with standard check neem formulation against FAW (Table 1). There were 7 treatments, laid out in randomised block design, replicated thrice in a plot size of 3 m × 4 m, where fodder maize was raised in 45×10 cm spacing. Fodder maize crop was raised as per the recommended package of practices. Number of larvae per plant was recorded on randomly selected 5 plants per plot a day before spraying, 3, 7 and 14 days after spray (DAS). Observations on green fodder yield (GFY) and dry fodder yield (DFY) of fodder maize were also recorded. Data was statistically analysed as per analysis of variance (ANOVA) technique and significant differences between treatments were worked out at 5% probability.

FAW incidence was noticed in both *kharif* and *rabi* seasons, however, the incidence was higher during *kharif* season (Fig 1). The highest incidence of 50% was noticed during last week of August and second peak incidence of 30% was noticed during last week of December. Correlation between seasonal incidence of FAW and weather parameters indicated that there was a significant negative correlation with rainfall (-0.60**) and morning humidity (-0.50*). It might be due to washing away of eggs and larvae by heavy rains. Paul *et al.* (2020) also reported seasonal variation in the incidence of FAW in maize crop. Fall army worm also appeared during second week of September with a mean population of 0.12 larva/

Table 1. Treatment details

Treatment	Dosage
T1: *Lecanicillium (Verticillium) lecanii* 1x10^{8} cfu/ml	2 g/l
T2: *Beauveria bassiana* 1x10^{8} cfu/ml	2 g/l
T3: *Psuedomonas florescens* 1x10^{8} cfu/ml	2 g/l
T4: *Bacillus thruingenesis*	2 gl/l
T5: *Metarhizium (Nomuraea) rileyi* 1x10^{8} cfu/ml	5 ml/l
T6: Neem formulation- azadirachtin 3000 ppm	@ 5ml /l
T7: Untreated control	-

plant. The peak population was observed in fourth week of September with a mean population of 0.56 larva/ plant. Thereafter, the population declined gradually and reached to minimum level of 0.16 larva/ plant during fourth week of October. The correlation between FAW and abiotic parameters indicated that the population had a significant positive correlation with maximum temperature (r=0.586). The larval population was maximum during *kharif* (0.99 to 3.66 larvae per plant) as compared to *rabi* (0.66 to 2.60 larvae per plant) as reported by Anandhi *et al.* (2020). Variations in the results might be due to the prevailing weather conditions in a given locality. However, present findings were in agreement with Kumar *et al.* (2020) who reported higher incidence of FAW in *kharif* and significant negative correlation with the rainfall. The incidence of FAW recorded on fodder maize ranged from 12% to 74%. Damage due to incidence of FAW on fodder maize ranged between 16% and 54% at northern districts of Goa (Maruthadurai and Ramesh, 2020). The incidence of FAW on maize ranged from 6% to 100% in different districts of Karnataka (Mallapur *et al*., 2018; Sharanabasappa *et al.,* 2018a; Shylesha *et al*., 2018).

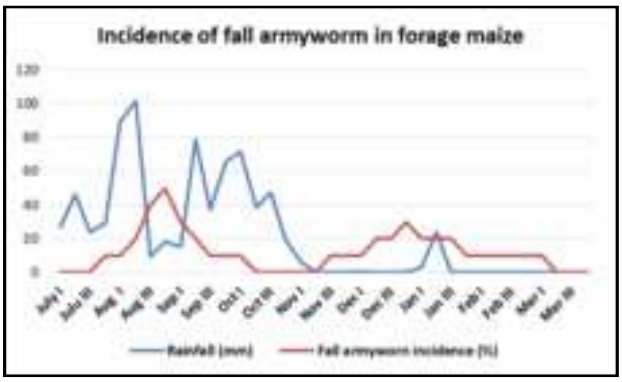

Fig 1. Seasonal incidence of FAW, *Spodoptera frugiperda*

The incubation period ranged between 2.38 ± 0.24 days and larval period and pupal duration were 14.04 ± 0.75 and 8.67 ± 0.50 days, respectively when fed on maize leaves. The adults laid 1083 ± 188.13 eggs and the life cycle was completed in 31-44 days (Table 2). Sharanabasappa *et al.* (2018b) observed that female was laying eggs with the fecundity of 1064 eggs. They reported incubation, total larval and pupal periods of 2-3, 14-19 and 9- 12 days, respectively. The total life cycle of male and female was observed to be 31-42 and 32-44 days, respectively.

There were no significant differences between treatments on incidence before the start of the experiment. However, significant reduction in the incidence was noticed in all the biological control treatments. Among all the entomopathogens tested, *Metarhizium (Nomuraea) rileyi* was found to be more effective during both rounds of spray (Table 3-4) and the incidence was 17.33% as compared to 37.33% in untreated check after 14 days of first rounds of treatment imposition and 6.66% as compared to 15.33% in untreated check after 14 days of second rounds of treatment imposition. Entomopathogen *Metarhizium (Nomuraea) rileyi* was at par with standard check azadirachtin 3000 ppm @ 5ml/l and superior to all other entomopathogens and untreated check. Highest GFY and DMY of 346.0 and 72.5 q/ha were recorded with *Metarhizium (Nomuraea) rileyi* and it was at par with the standard check of azadirachtin 3000 ppm as compared to 250.5 and 56.0 q/ha, respectively in the untreated control (Table 4).

Table 2. Biology of fall army worm on maize

Stages	Days
Incubation period	2.38 ± 0.24
Larval period	14.04 ± 0.75
I Instar	2.40 ± 0.36
II Instar	2.11 ± 0.23
III Instar	2.00 ± 0.05
IV Instar	2.00 ± 0.00
V Instar	2.21 ± 0.29
VI Instar	5.08 ± 0.74
Pupal duration	8.67 ± 0.50
Pre-oviposition period	3.71 ± 0.45
Oviposition period	3.05 ± 0.52
Fecundity/female	1083.6 ± 188.13
Total life cycle- Male	31 - 42
Total life cycle- Female	32 - 44

Yordanys *et al.* (2020) reported that entomopathogens *B. bassiana* and *M. anisopliae* killed 87 and 75% of the fourth larval instars, respectively. The fungus *M. anisopliae* caused the highest sporulation rates during study. These results suggested that the entomopathogenic fungi might have contributed to a sustainable FAW management in maize production in Cuba. Varshne *et al.* (2021) designed a bio-control-based integrated pest management (IPM) strategy and evaluated in farmers field during *rabi* and *kharif* season (2018-2019). IPM strategy comprising of installation of controlled release of FAW pheromone

Table 3. Reduction in maize fall army worm population as influenced by entomopathogens after first spray

Treatments	Dosage	Infestation before spray (%)	3 DAS	7 DAS	15 DAS
T1: *Lecanicillium (Verticillium) lecanii* 1x10^8 cfu/ml	2 g/l	44.33	40.33	30.33	23.66
T2: *Beauveria bassiana* 1x10^8 cfu/ml	2 g/l	43.33	39.33	31.33	24.99
T3: *Psuedomonas florescens* 1x10^8 cfu/ml	2 g/l	44.33	40.66	30.33	23.33
T4: *Bacillus thruingenesis*	2 g/l	46.33	39.33	31.00	24.99
T5: *Metarhizium* (*Nomuraea*) *rileyi* 1x10^8 cfu/ml	2 g/l	43.66	38.66	17.99	17.33
T6: Neem formulation-azadirachtin 3000 ppm	@ 5 ml /l	44.66	29.33	18.66	16.99
T7: Untreated control	-	45.00	46.66	44.66	37.33
SEM		-	3.19	3.76	3.40
CD (P<0.05)/\		NS	4.21	5.00	4.00
CV (%)		-	9.42	10.04	9.42

DAS: Days after spray

Table 4. Reduction in maize FAW population as influenced by entomopathogens after second spray

Treatments	Dosage	3 DAS	7 DAS	15 DAS	GFY (q/ha)	DFY (q/ha)
T1: *Lecanicillium (Verticillium) lecanii* 1x10^8 cfu/ml	2 g/l	20.66	14.33	9.66	305.0	64.50
T2: *Beauveria bassiana* 1x10^8 cfu/ml	2 g/l	19.33	13.33	10.00	302.3	67.5
T3: *Psuedomonas florescens* 1x10^8 cfu/ml	2 g/l	21.66	15.33	10.33	308.5	69.0
T4: *Bacillus thruingenesis*	2 g/l	21.00	14.66	10.00	315.1	66.5
T5: *Metarhizium* (*Nomuraea*) *rileyi* 1x10^8 cfu/ml	2 g/l	21.33	10.33	6.66	346.0	72.5
T6: Neem formulation- azadirachtin 3000 ppm	@ 5 ml /l	15.00	9.00	6.00	347.5	73.5
T7: Untreated control	-	22.66	19.33	15.33	250.5	56.0
SEM		3.11	3.48	2.38	3.08	1.46
CD (P<0.05)		3.00	3.54	3.12	10.32	7.02
CV (%)		9.60	10.08	7.42	9.62	4.58

DAS: Days after spray; GFY: Green fodder yield; DFY: Dry fodder yield; 10 quintals (q) = 1 ton

traps, four releases of *Trichogramma pretiosum Riley*, two sprays of neem oil, one spray each of *Bacillus thuringiensis* (NBAIR-BT25) and *Metarhizium anisopliae* (NBAIR-Ma-35) resulted in 76 and 71.64% egg mass; 80 and 74.44% larval population reduction at 60 days after treatment during *rabi* and *kharif* season, respectively. Similarly Dhobi *et al.* (2020) reported that maize plots treated with *Nomuraea rileyi* 1% WP @ 40 g /10 litre water was at par with *Bacillus thuringiensis* var. *kurstaki* 1%WG @ 20 g/10 litre water, respectively. Of the tested bio-pesticides, the highest grain and fodder yield was recorded from the plot treated with *N. rileyi* 1% WP followed by *B. thuringiensis.*

The findings of this study indicated that FAW incidence occurred in both *kharif* and *rabi* seasons, but the magnitude was higher in *kharif*. The highest incidence of 50% was noticed during last week of August and second peak of incidence of 30% was noticed during last week of December. Correlation between seasonal incidence of FAW and weather parameters indicated that there was a significant negative correlation with the rainfall (-0.60**) and morning humidity (-0.50*). Studies on the biology of FAW suggested that FAW completed its life cycle in 31-44 days with six larval instars. Among the control measures entomopathogen *Metarhizium (Nomuraea) rileyi* (2 x 10^8 cfu/g) was potential biological control agent for FAW.

Acknowledgment

Authors are thankful to the Director ICAR-IGFRI for providing the facilities to carry out this research work.

References

Anandhi, S., V.R. Saminathan, P. Yashotha, P.T. Sharavanan and V. Rajanbabu. 2020. Seasonal dynamics and spatial distribution of fall army worm *Spodoptera frugiperda* (J.E. Smith) on maize (*Zea mays* L.) in Cauvery Delta Zone. *Journal of Pharmacognosy and Phytochemistry* 9: 978-982.

Dhobi, C.B., B. Zala, H.S. Verma, D.B. Sisodiya, R.K. Thumar, M.B. Patel, J.K. Patel and P.K. Borad. 2020. Evaluation of bio-pesticides against fall army worm, *Spodoptera* frugiperda (J.E. Smith) in maize. *International Journal of Current Microbiology and Applied Science* 9: 1150-1160.

Goergen, G., P.L. Kumar, S.B. Sankung, A. Togola and O.M. Tam. 2016. First report of outbreaks of the fall army worm *Spodoptera frugiperda* (J. E. Smith*). Plos One* 11: 165632-165639.

Keerthi, M.C., P.G. Padmaja, H.A. Bhargavi, N. Manjunatha and D. Deb. 2021. Nutritional indices of fall army worm, *Spodoptera frugiperda* (J.E. Smith) on selected sorghum genotypes. *Range Management and Agroforestry* 42: 71-77.

Kumar, P., S. Kumar, M. Choudhary, G. K. Chikappa, B. Kumar, N. K. Singh, and S. K. Sinha. 2020. GGE biplot based stability analysis of experimental hybrids for baby corn purpose and green fodder. *Range Management and Agroforestry* 41: 60-66.

Kumar, R., P. Kumar, Y. Kaur, G.K. Chikkappa, D.P. Chaudhary, M. Goyal, and U.S. Tiwana. 2018. Evaluation of maize hybrids for grain and fodder purpose. *Range Management and Agroforestry* 39: 182-190.

Kumar V., P. Yashodha and C.G.L. Justin. 2020. Seasonal incidence of maize fall army worm *Spodoptera frugiperda* (J.E. Smith) (Noctuidae: Lepidoptera) in Perambalur district of Tamil Nadu, India. *Journal of Entomology and Zoology Studies* 8: 01-04.

Mallapur, C.P., N. Anjan Kumar, H. Sireesh, T. Praveen, R.K. Patil and S. Lingappa 2018. Potentiality of *Nomuraea rileyi* (Farlow) Samson against the fall army worm, *Spodoptera frugiperda* (J.E. Smith) infesting maize. *Journal of Entomology and Zoology Studies* 6:1062-1067.

Maruthadurai, R. and R. Ramesh. 2020. Occurrence, damage pattern and biology of fall army worm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on fodder crops and green amaranth in Goa, India. *Phytoparasitica* 48: 15-23.

Montezano, D.G., A. Specht, D.R. Sosa-Gomez, V.F. Roque-Specht, J.C. Sousa-Silva, S.V. Paula-Moraes, J.A. Peterson and T.E. Hunt. 2018. Host plants of *Spodoptera frugiperda* (Lepidoptera: Noctuidae) in the Americas. *African Entomology* 26: 286-300.

Paul, B.K., J. Koge, B.L. Maass, Notenbaert and M. Peters. 2020. Tropical forage technologies can deliver multiple benefits in sub-Saharan Africa-a meta-analysis. *Agronomy for Sustainable Development* 40: 22.

Pogue, M. A. 2002. World revision of the genus Spodoptera guenée (Lepidoptera: Noctuidae). *Memoirs of the American Entomological Society* 43: 1-202.

Rakshit, S., C.R. Ballal, Y.G. Prasad, J.C. Sekhar and P.S. Lakshmi Soujanya. 2019. Fight against fall army worm *Spodoptera frugiperda* (J. E. Smith). ICAR-Indian Institute of Maize Research, Ludhiana, India. pp. 1-52.

Sharanabasappa, D., C.M. Kalleshwaraswamy, R. Asokan, H.M. Mahadevaswamy, M.S. Maruthi, H.B. Pavithra, K. Hegde, S. Navi, S.T. Prabhu and G. Goergin. 2018a. First report of fall army worm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) an alien invasive pest on maize in India. *Pest Management in Horticultural Ecosystems* 24: 23-29.

Sharanabasappa, D., C.M. Kalleshwaraswamy, M.S. Maruthi and H.B. Pavithra. 2018b. Biology of invasive fall army worm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) on maize. *Indian Journal of Entomology* 80: 540-543.

Shylesha, A.N., S.K. Jalali, A. Gupta, R. Varshney, T. Venkatesan, P. Shetty, R. Ojha, P.C. Ganiger, O. Navik and K.L. Subaharan. 2018. Studies on new invasive pest *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) and its natural enemies. *Journal of Biological Control* 32: 145-151.

Varshney, R., B. Poornesha, A. Raghavendra, Y. Lalitha, V. Apoorva, B. Ramanujam, R. Rangeshwaran, K. Subhaharan, A.N. Shylesha and N. Bahthavatsalam. 2021. Biocontrol-based management of fall army worm, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera : Noctuidae) on Indian maize. *Journal of Plant Diseases and Protection* 128: 87-95.

Yordanys, R., D. Alberto, J. Taibo, J. Ariel and P. Orelvis. 2020. Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in maize plants and its effect against *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) larvae. *Egyptian Journal of Biological Pest Control* 30: 1-6.