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ORIGINAL ARTICLE

# Population Dynamics of Fall Armyworm, *Spodopterda frugiperda* and its Natural Enemies in Fodder Maize

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## ABSTRACT

Fall armyworm, *Spodoptera frugiperda* is an invasive alien pest that primarily targets maize crops. The effect of meteorological parameters on the incidence of *S. frugiperda* larva on fodder maize was investigated in the IGFRI, Dharwad, Karnataka, India, during *Kharif,* 2021-2022. Field experiment was conducted to know the pest status in the Dharwad region. The results revealed that the larval counts and % infestation were 0.85 to 2.25 larvae/plant and 10 to 46.05%, respectively. Parasitization by two larval parasitoids viz., *Campoletis chlorideae* (Hymenoptera: Ichneumonidae) and *Exorista xanthaspis* (Diptera: Tachinidae) and predators like *Cheilomenes sexmaculata*, *Harmonia octomaculata, Coccinella transversalis, Illeas cincta,* earwig and spiders were also observed.

**KEY WORDS:** Fall army worm, maize, Population dynamics, *Spodoptera frugiperda*

## INTRODUCTION

Maize (*Zea mays*) is an important cereal as well as fodder crop equally known for its use as food for man and fodder for animals. The yield of fodder is lower in India due to various factors, among which, insect pests are the most important constraint. As many as 141 insect pests cause damage to maize from sowing to harvesting (Reddy & Trivedi, 2008). The fall armyworm, *Spodoptera frugiperda* has been very recently reported on maize from Karnataka as invasive in India (Sharanabasappa *et al*., 2018). There is a chance that this pest may migrate to neighbouring states in India as well as other Asian countries. The main explanation for its rapid spread may be its efficient ability to travel and migrate long distances in short time. The invasion of this pest may contribute to serious losses. The present study evaluates the population dynamics of *S. frugiperda* in fodder maize.

## MATERIALS AND METHODS

The field experiment was conducted during *Kharif,* 2021 fodder maize variety African tall was bulk sown in an area of 200 $m^2$ with a spacing of 30×10 cm between the rows and plants, respectively at IGFRI, SRRS, Dharwad. Weekly observations on the incidence of fall armyworm larvae, leaf damage score, per cent plant infestation and natural enemies were taken starting from 15 days after sowing on randomly selected 20 plants from four different spots in "Z" fashion from the experimental plot at IGFRI, SRRS, Dharwad. Weather data *viz*., temperature (°C), relative humidity (%), and rainfall (mm) were recorded from the meteorological unit of MARS, UAS, Dharwad. The incidence data were subjected to correlation coefficient analysis with weather data. Infected *S. frugiperda* larvae were collected randomly from the experimental field for the observation of larval parasitization after rearing under laboratory conditions. Further, these parasitoids were preserved in 70% ethyl alcohol and were identified. Predators collected from the field were identified at the department level itself.

$$\text{Per cent plant infestation} = \frac{\text{Number of plants infested}}{\text{Total number of plants observed}} \times 100$$

The immature stages of fall armyworm like eggs and different stages of larvae (2nd instar to 6th instars) were weekly collected from the field and reared under laboratory conditions. To check for parasitoid emergence, collected

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egg masses were kept in a glass tube (15 cm L × 2.5 cm dia.) which were plugged with cotton balls to avoid their escapism. The collected larvae were separated instar wise and were reared singly in an insect breeding dish (Himedia, TCP030- 90 x 40 mm dia.) containing the maize leaf bits. Both glass tubes and breeding dishes were kept at 26 ± 2°C, 75 to 80% RH and L12: D12 photoperiod and inspected regularly for the emergence of parasitoids.

Predators were collected from the field on randomly selected 20 plants and they were pinned and stored for identification purposes. However, unidentified predators were collected in the vials and sent to experts for identification. In order to collect predators sweep net and poison bottle were used, wherever it was found necessary. Predators were identified at weekly intervals during peak fall armyworm incidence in the maize cropping period for approximately 3 months. All parasitoids and predators were identified at the department level and unidentified ones were sent to GKVK, Bangalore for identification.

The mean value of fall armyworm and the weather data were correlated for the respective week. For the calculation of correlation coefficient (r), the mean fall armyworm population was considered as a dependent variable (y) and weather parameters as the independent variable (x). The data was subjected to statistical analysis and a correlation coefficient was carried out to determine the type and extent of the relationship.

The data on weather parameters *viz.,* maximum temperature (°C), minimum temperature (°C), rainfall (mm) and relative humidity (%) were collected from the meteorological unit of the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad.

Correlation coefficient (r) between weekly averages of weather parameters and an average number of insects recorded at the weekly interval was worked out by the method of Snedecor & Cochran (1967) to find out the influence of different variables on population dynamics of maize pests and their natural enemies. The mean fall armyworm population was considered as a dependent variable (y) and weather parameters as the independent variable (x). The data was subjected to correlation coefficient analysis to know the type and extent of the relationship.

## RESULTS

The population dynamics of the fall armyworm and its associated natural enemies were recorded at the weekly interval from the last week of July to the second week of October 2021 which are presented in Table 1.

The results revealed that the activity of larvae of fall armyworm commenced from the last week of July, 31st MSW and continued till the second week of October, 41st MSW which ranged from 0.85 to 2.25. Highest mean number of larvae per plant (2.25) was recorded in the third week of August and the least (0.85 larvae/plant) was noticed in the last week of July. During crop season, the larval population of fall armyworm fluctuated. During 3rd week of August 2021 (34th MSW) it showed its peak by recording 2.25 larvae per plant. However, In the subsequent weeks,

Table 1: Population dynamics of fall armyworm, *S. frugiperda* and their natural enemies during *kharif,* 2021 in fodder maize

| Weeks | MSW | Larvae/ plant* | Leaf damage score* | %plant infestation* | Coccinellid/ plant* | *C. chloridae* pupa* (no./plant) | Temperature (°C) | | Relative humidity(%) | | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Max | Min | Morning | Evening | |
| Jul 30-Aug 5 | 31 | 0.85 | 2.65 | 10.00 | 0.00 | 0.00 | 27.0 | 20.7 | 91.7 | 87.1 | 16.4 |
| Aug 6-12 | 32 | 2.05 | 3.15 | 22.50 | 0.25 | 0.00 | 29.2 | 20.8 | 88.6 | 83.0 | 12.3 |
| Aug 13-19 | 33 | 1.80 | 3.95 | 35.00 | 0.20 | 0.05 | 26.8 | 20.1 | 90.4 | 90.3 | 14.0 |
| Aug 20-26 | 34 | 2.25 | 4.55 | 46.05 | 0.35 | 0.25 | 29.0 | 20.2 | 88.7 | 81.3 | 11.0 |
| Aug 27-Sep 2 | 35 | 2.10 | 4.05 | 40.00 | 0.30 | 0.15 | 28.2 | 20.6 | 88.0 | 79.1 | 26.6 |
| Sep 3-9 | 36 | 1.90 | 3.85 | 35.00 | 0.20 | 0.10 | 27.5 | 20.5 | 90.9 | 79.6 | 11.4 |
| Sep 10-16 | 37 | 1.75 | 3.90 | 30.00 | 0.25 | 0.10 | 27.1 | 21.0 | 92.4 | 85.6 | 16.6 |
| Sep 17-23 | 38 | 2.20 | 3.75 | 45.00 | 0.35 | 0.20 | 29.1 | 20.3 | 88.6 | 70.9 | 0.0 |
| Sep 24-30 | 39 | 1.65 | 3.55 | 39.00 | 0.25 | 0.10 | 28.0 | 20.3 | 88.4 | 78.3 | 19.4 |
| Oct 1-7 | 40 | 1.85 | 3.50 | 36.00 | 0.15 | 0.00 | 30.9 | 21.1 | 87.0 | 80.1 | 39.8 |
| Oct 8-14 | 41 | 1.05 | 3.25 | 35.00 | 0.00 | 0.00 | 29.2 | 20.9 | 91.4 | 75.3 | 25.0 |

MSW = Meteorological Standard Weeks, *Mean of 20 plants

the larval population decreased and reached to 1.05 larvae per plant in the 2nd week of October (41st MSW). The larval population decreased slightly from the third week of August to the second week of September and suddenly increased in the third week of September.

The results of the mean leaf damage score are presented in Table 4. The mean leaf damage score ranged from 2.65 to 4.55. The third week of August recorded the highest mean leaf damage score (4.55) and the lowest leaf damage score (2.25) was recorded in the last week of July. However, the leaf damage score increased from the last week of July to the third week of August and then decreased from the second week of September to the second week of October.

The data on per cent plant infestation are presented in Table 4. The data showed that per cent plant infestation by fall armyworm coincided with the larval population and commenced from the last week of July, 31st MSW and continued till the second week of October, 41st MSW which ranged from 10.00 to 46.05 per cent. During 3rd week of August 2021 (34th MSW) it showed its peak by recording 46.05 per cent plant infestation. In the subsequent weeks per cent plant infestation decreased and reached to 30.00 per cent plant in the 2nd week of September and then declined up to 2nd week of October.

The coccinellid population was observed from the last week of July to the second week of October and ranged from 0.00 to 0.35 per plant. They were observed at very low densities during the last stages (0.00 coccinellids/plant in 41st MSW) of the crop. The population trend of coccinellids presented in Table 1 shows that the coccinellids appeared on the maize crop from 32nd MSW with an initial density of 0.25 coccinellids per plant. The abundance of these coccinellids increased with the crop age along with the corresponding increase in the pest population to attain their peak population of 0.35 coccinellids per plant on 34th MSW with a maximum temperature of 29.0°C and minimum temperature of 20.2°C, morning and evening relative humidity of 88.7 and 81.3%, respectively.

The mean number of *Campoletis chlorideae* pupae per plant was 0.05 to 0.25 from the second week of August to the last week of August and 0.10 to 0.20 from the first week of September to the last week of September. Highest mean number of pupae per plant was noticed during the third week of August and it gradually reduced as the crop stage advanced. However, parasitoid pupae were not found in the crop during the vegetative tasseling stage (Table 1).

Correlation studies in case of per cent plant infestation by fall armyworm larvae with weather parameters showed negative correlation with morning relative humidity (r = -0.487), evening relative humidity (r = -0.570) and rainfall (r = -0.070) and positive correlation with maximum temperature (r = 0.347) (Table 2).

Several other predators and parasitoids were identified in the fodder maize ecosystem during *Kharif,* 2021 are presented in Table 3.

## DISCUSSION

Observation was recorded on the population dynamics of fall armyworm and its natural enemies corresponding to each meteorological standard week (MSW). In the present investigation, fodder maize crop was observed for the seasonal incidence of fall armyworms from July 2021 to October 2021. The results obtained during the investigation are discussed here. In the current study, fall armyworm infestation starts soon after crop emergence (15-20 days after sowing). The third week of August recorded the highest number of larvae (2.25 per plant) in *Kharif,* 2021.

The correlation analysis of the larval population with weather parameters revealed a positive correlation with maximum temperature. In contrast, there was a significant negative correlation with relative humidity and a negative correlation with both minimum temperature and rainfall. These results were supported by the findings of Kumar *et al.* (2020) who reported that the larval population showed a significant positive correlation with the maximum temperatures (r = 0.7205) and a negative correlation with rainfall (r = -0.673) and relative humidity (r = -0.829). Similarly, Darshan (2020) reported that the incidence of

Table 2: Correlation between fall armyworm, *S. frugiperda* (J.E. Smith) population with weather parameters during *Kharif,* 2021 in fodder maize

| Parameters | Correlation coefficient | | | | Rainfall |
|---|---|---|---|---|---|
| | Max temp (°C) | Min temp (°C) | Morning RH (%) | Evening RH (%) | (mm) |
| FAW larvae | 0.280 | - 0.351 | - 0.608* | - 0.226 | - 0.277 |
| %plant infestation | 0.347 | - 0.437 | - 0.487 | - 0.570 | - 0.070 |
| Coccinellids | 0.086 | - 0.477 | - 0.503 | -0.229 | - 0.427 |

* Correlation is significant at 5% level

Table 3: List of natural enemies recorded from different stages of *S. frugiperda* in fodder maize

| Natural enemy | Sl.No | Scientific Name | Order: Family | Host stage affected |
|---|---|---|---|---|
| Parasitoids | 1 | *C. chloridae* (Uchida) | Hymenoptera: Ichneumonidae | Larva |
| | 2 | *Brachymeria sp.* | Hymenoptera: Chalcididae | Larva |
| | 3 | *E. xanthaspis* | Diptera: Tachinidae | Larva |
| Predators | 4 | *C. sexmaculata* (Fab.,1781) | Coleoptera: Coccinellidae | Egg and Larva |
| | 5 | *H. octomaculata* (Fab.,1781) | Coleoptera: Coccinellidae | Egg and Larva |
| | 6 | *Coccinella transversalis* (Fab.,1781) | Coleoptera: Coccinellidae | Egg and Larva |
| | 7 | *Illeas cincta* (Fab.,1798) | Coleoptera: Coccinellidae | Egg and Larva |
| | 8 | *Euborellia annulipes* (Lucas, 1837) | Dermaptera: Anisolabididae | Egg and Larva |
| | 9 | *Eucanthecona furcellata* (Wolff) | Hemiptera: Pentatomidae | Larva |
| | 10 | *Ctetus punctiger* | Hemiptera: Coreidae | Larva |
| | 11 | *Oxyopes sp.* | Araneae: Oxyopidae | Larva |

the larval population showed a positive correlation with the maximum and minimum temperature and negatively correlated with relative humidity; whereas the amount of rainfall (r = -0.889) was significantly negatively correlated with the incidence of larval population as heavy rainfall was lethal to the pest because rain drops accumulated in whorls, causing suffocation in larvae.

Nandita *et al.* (2020) reported that fall armyworm appeared during 2nd week of September with 0.12 larvae/ plant and peak population was observed during 4th week of September. The correlation between fall armyworm and abiotic factor during *kharif* showed significant positive correlation with maximum temperature.

The percentage of plant infestation in *Kharif*, in 2021 ranged from 10 to 50 per cent. The vegetative stage of the crop had a higher percentage of plant infestation than the reproductive stage. The correlation analysis of per cent plant infestation with weather parameters showed that there was a positive correlation with maximum temperature and a similar observation was recorded by Jaramillo-Barrios *et al.* (2019). According to Baudron *et al*. (2019), the incidence and severity of crop damage caused by fall armyworm varies with plant age. Similarly, Patel *et al.* (2020) reported that the percentage of plants damaged by the fall armyworm, *S. frugiperda*, had a significant positive correlation with the minimum temperature (r =0.695). While it showed a non-significant positive correlation with the maximum temperature and a significant negative correlation with rainfall.

Coccinellids were one of the natural enemies found in relative abundance during the study period. Coccinellids were recorded at very low density at the last stage of the crop and identified a countable number of predators in the current study like *Cheilomenes sexmaculata, Harmonia octomaculata, Coccinella transversalis, Illeas cincta, Euborellia annulipes, Ctetus punctiger, Eucanthecona furcellata and Oxyopes sp*. During the research, we have seen hemipteran predators like *Eocanthecona furcellata* and spiders like *Oxyopes sp*. feeding on different instars of fall armyworm larvae. However, in earlier studies, *Oxyopes birmanicus* (Firake & Behere, 2020) and *E. furcellata* (Pradeep, 2021) were noted as fall armyworm larval predators. *Brachymeria sp*. reported by Akeme *et al.* (2021).

The correlation analysis of the coccinellid population with weather parameters revealed that there was a positive correlation with maximum temperature however, a negative correlation was obtained with relative humidity, minimum temperature and rainfall. The results were supported by Megha *et al*. (2015) who recorded that population of coccinellids had negative correlation with rainfall (r = -0.324*) and minimum temperature and coccinellids in the maize crop showed a positive correlation with maximum temperature. Similarly, Akshay *et al.* (2020) showed that maximum temperature of spring 2016 had a positive correlation with the coccinellid population among the various weather variables.

In the present study, three larval parasitoids *viz*., *C. chloridae, Brachymeria Sp. and Exorista xanthaspis* were recorded. We frequently come across the *C. chlorideae* pupa in the field among the larval parasitoids from 5 to 14 leaves stage of the crop. The presence of more parasitoid pupa on the maize plants during these growth stages may be due to the availability of early instar larvae. However, the peak per cent parasitization of *C. chloridae* coincides with the peak fall armyworm infestation. This might be a result of the predator-prey dynamics, which increased host density and increased parasitoid parasitism. According to Bajpai *et al.* (2006), *C. chlorideae* primarily attacks the first or second instars of *S. litura.* Sharanabasappa *et al.* (2019) observed 2 to 3 per cent larval parasitism by *C. chlorideae*, while Navik *et al*. (2021) found 1.86-6.63

per cent larval parasitism by *C. chlorideae*. Navik *et al.* (2021) reported *E. xanthaspis* for the first time parasitizing the fall armyworm in India. Sharanabasappa *et al*. (2019) reported predators like *H. octomaculata* and *Coccinella transversalis* and parasitoids like *C. chlorideae* and *E. xanthaspis.*

## CONCLUSION

The studies on population dynamics of fall armyworm and their natural enemies corresponding to each meteorological standard week (MSW) revealed that infestation starts soon after crop emergence (15 to 20 days after sowing) The correlation analysis of larval population with weather parameters showed that there was a positive correlation with maximum temperature. However, a significantly negative correlation with relative humidity and a negative correlation with minimum temperature and rainfall and two predators and coccinellid predators were recorded.

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