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# Population Dynamics of Fall Armyworm *Spodoptera frugiperda* (J.E. Smith) and its Natural Enemies Maize in India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The studies on seasonal incidence of Fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) on Maize in India was carried out at Maize research centre Rajendranagar, Hyderabad, during Rabi 2022-23. The correlation studies revealed that the percent infestation of FAW was found to be negatively significant with maximum temperatures (-0.491*) and positively significant with morning relative humidity (0.565*). Correlation of natural enemies (coccinellids, spiders, earwigs) with weather parameters (Maximum temperature, Minimum temperature, Relative humidity during

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morning and evening) revealed that coccinellids, spiders and earwigs were found to be positively significant with maximum temperature and spiders found to be negatively significant with evening relative humidity. They were found to be non-significant with remaining parameters.

*Keywords: Cereal crop; Maize; Spodoptera frugiperda; natural enemies.*

## 1. INTRODUCTION

Maize is the most important cereal crop, in India maize is the third most important cereal after rice and wheat, both in terms of area and production. The maize crop suffers from both biotic and abiotic stresses. Insect pests are among the main factors leading to lower maize yield. Over 40 species of insect pest have been identified in maize Fall armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) belonging to lepidoptera is one of the main pests in maize and known to cause reduction of yields. FAW is a polyphagous pest which is native to tropical and subtropical region of America, where it is an important pest of maize but is also known to target over 100 hosts. Moreover, it has been found that it causes significant damage to economically important crops such as rice, sorghum, sugarcane as well as horticultural crops such as cabbage, beetroot, tomato, potato and onion and also to cotton, pasture grasses, peanut, soybean, alfalfa and millets. FAW is the major pest to maize, reducing its yield to 40% in a mono cropped system. FAW had not been recorded outside of America until 2015. However, a serious outbreak of FAW was recorded from the African countries such as Sio Tome, Nigeria, Benin and Togo in 2016 and later in 2017 it was reported in Ghana. In Zambia, FAW infestation was first detected on maize in late 2016 and was reported to affect 22% of the maize grown for the 2017 crop season [1]. In 2018, 98% of farmers reported maize to be affected in Zambia with an average maize loss of 35% [2]. It has now spread to majority of sub-Saharan Africa, as well as to Asia and the Middle East. The introduction of FAW into new areas has caused significant damage to crops such as maize, sorghum, and millet, which are staple foods for millions of people in Africa. The first report of fall armyworm on maize in India is from the Shivamogga district of Karnataka during May-June, 2018 and then it was found to spread in other states like Maharashtra, Gujarat, Chhattisgarh, Andhra Pradesh, Telangana, Tamil Nadu and Odisha. This has led to significant economic losses for farmers and has threatened food security in affected countries.

Insect population fluctuations are closely tied to the biotic and abiotic factors present in their micro and macro climates (Kamata 2000). Insect populations vary throughout the year due to changes in environmental conditions such as temperature, humidity, and rainfall [3]. Studying seasonal population dynamics in relation to these factors offers valuable insights for managing key crops [4]. Research on the effects of temperature on insect pests is essential for comprehending their population dynamics and is instrumental in creating targeted pest control strategies [5]. Another critical abiotic factor affecting insect survival is humidity. Changes in humidity levels can impact the developmental stages of insects. High relative humidity (RH) can benefit the survival and growth of immature stages of some insect species [6]. The present study was conducted to know the influence of various biotic and abiotic factors affecting the population dynamics of Fall armyworm in field conditions.

## 2. MATERIALS AND METHODS

A field study was conducted at Maize Research Centre, Rajendranagar, Hyderabad during *Rabi* 2022-23. Maize crop was sown in 100 $m^2$ plot at spacing of 60 X 20 cm. The cultivar used is DHM 117 and sowing was done on 22/11/2022. The crop was grown following all the recommended package of practices. No plant protection measures were followed for raising the crop. The data was collected on Percent infestation of fall armyworm on plants. The data on percent infestation was collected by selecting randomly 10 plants. The incidence was observed from the 1 week after the germination and continued till harvesting. The incidence was peak during $50^{th}$ SMW. Observations on natural enemies like coccinellids, spiders and earwigs were also collected and correlated with weather parameters like maximum temperature, minimum temperature, morning relative humidity and evening relative humidity. The data on percent infestation of plants and natural enemies were collected in weekly intervals from randomly selected 10 plants. The correlation between weather parameters and natural enemies, Percent infestation was done by using OPSTAT.

Total number of infested plants were calculated by using the following formula.

$$\text{Percent infestation} = \frac{\text{Number of plants infested}}{\text{Total number of plants}} \times 100$$

## 3. RESULTS AND DISCUSSION

### 3.1 Percent Infestation of Plants

The data was collected on the percent infestation of FAW and presented in the Table 1. The observations revealed that the percent infestation of plants was observed from 1 week after emergence and continued till harvest. The highest number of infested plants was observed during 50th SMW (10 dec-16 dec) 43.48%. Weather parameters during this period were Maximum temperature (27.4°C), Minimum temperature (18.6°C), Relative humidity morning (97.1), Relative humidity evening (63.9). Lowest number of infested plants were observed during 12th SMW (1.79). Number of infested plants were in the range of 1.79% to 43.48%. percentage of infested plants were found to be less at the start of the crop but was found to reach peak when the crop is at 50th SMW.

### 3.2 Natural Enemies

The data on number of natural enemies like coccinellids, spiders and earwigs were collected during *Rabi* 2022-23 and presented in the Table 1. The observations revealed that the coccinellids were first observed during 50th SMW mean number of coccinellids per 10 plants were 0.1. Coccinellids were recorded throughout the season from 50th SMW to 12th SMW. Maximum number of coccinellids were observed during 7th SMW. The weather parameters during this period were Maximum temperature (33.2°C), Minimum temperature (11.7°C), Relative humidity morning (74.6 %), Relative humidity evening (17.4 %).

The observations on the mean number of spiders per 10 plants revealed that spiders were recorded throughout the season. The spiders appeared first during 50th SMW. The highest spider population was observed during 9th SMW (3.3) when the maximum temperature (33.8°C), minimum temperature (14.7°C), relative humidity morning (76.3%), relative humidity evening (19.4%). The population of spiders ranged from 0.2 to 3.3 per 10 plants.

The observations on mean number of earwigs per 10 plants revealed that the highest population of earwigs was observed during 7th SMW, where the maximum temperature (33.2°C), minimum temperature (11.7°C), relative humidity morning (74.6%), relative humidity evening (17.4%). The population of earwigs were in the range of 0.4 to 3.12 per 10 plants. The population of earwigs found to appear throughout the season.

### 3.3 Correlation Between Weather Parameters, Natural Enemies and Percent FAW Infestation on Maize

The data collected on natural enemies, Percent FAW infestation were correlated with weather parameters and are analysed statistically and presented in Table 2. Percent FAW infestation found to be negatively significant with maximum temperatures (-0.491*) and positively significant with morning relative humidity (0.565*) whereas negatively non- significant with minimum temperatures and positively non-significant with evening relative humidity.

It is evident from the results that coccinellids were found to be positively significant with maximum temperature (0.638**) and negatively nonsignificant with minimum temperature, morning and evening relative humidity, percent FAW infestation.

Spiders were found to be positively significant with maximum temperature (0.820**) and negatively significant with evening relative humidity (-0.555*) whereas negatively non-significant with minimum temperature, morning relative humidity and percent FAW infestation.

Earwigs were found to be positively significant with maximum temperatures (0.688**) and positively non- significant with % FAW infestation whereas negatively non- significant with minimum temperatures, morning and evening relative humidity.

Sunitha et al. [7] who reported that plant infestation caused by *Spodoptera frugiperda* had shown negative significant correlation with maximum temperature and positive significant correlation with morning relative humidity, the present findings were in accordance with earlier findings. Pradeep *et al*. [8] reported that percentage of plant infestation was positively correlated with relative humidity and negatively correlated with maximum temperature. The present findings were in close conformity with Sunitha *et al* [7] who reported that population of

**Table 1. Seasonal Incidence of Fall armyworm and its natural enemies on Maize during *Rabi* 2022-23**

| Std week | Max temp (°C) | Min temp (°C) | RH Mrng (%) | RH Evng (%) | Mean no.of coccinellids per 10 plants | Mean no. of spiders per 10 plants | Mean no.of earwigs per 10 plants | %infestation |
|---|---|---|---|---|---|---|---|---|
| 47 | 28.50 | 17.50 | 77.86 | 47.43 | 0 | 0 | 0 | 0 |
| 48 | 29.6 | 13.9 | 85.9 | 39.7 | 0 | 0 | 0 | 5.05 |
| 49 | 29.1 | 15.4 | 80.7 | 37.4 | 0 | 0 | 0 | 7.45 |
| 50 | 27.4 | 18.6 | 97.1 | 63.9 | 0.1 | 0.2 | 0.4 | 43.48 |
| 51 | 29.6 | 13.8 | 87.1 | 37.0 | 1.1 | 1.01 | 2.2 | 41.67 |
| 52 | 30.7 | 16.1 | 91.6 | 41.5 | 1.48 | 2.3 | 2.12 | 40.82 |
| 1 | 29.9 | 17.1 | 89.0 | 54.3 | 2.12 | 1.02 | 2.12 | 39.22 |
| 2 | 30.1 | 11.2 | 79.9 | 35.7 | 2.26 | 2.1 | 2.3 | 34.48 |
| 3 | 30.7 | 13.3 | 84.7 | 30.0 | 2.35 | 1.44 | 2.42 | 30.00 |
| 4 | 29.7 | 14.1 | 85.6 | 31.4 | 2.21 | 2.1 | 1.33 | 30.61 |
| 5 | 29.8 | 14.6 | 85.6 | 35.1 | 2.32 | 2.13 | 1.4 | 27.27 |
| 6 | 32.4 | 14.4 | 87.7 | 27.1 | 2.18 | 2.35 | 2.8 | 11.32 |
| 7 | 33.2 | 11.7 | 74.6 | 17.4 | 3.1 | 2.99 | 3.12 | 10.20 |
| 8 | 33.9 | 14.5 | 77.7 | 22.9 | 1.19 | 2.1 | 1.63 | 10.00 |
| 9 | 33.8 | 14.7 | 76.3 | 19.4 | 2.7 | 3.3 | 1.99 | 9.09 |
| 10 | 33.4 | 15.6 | 77.0 | 25.0 | 2.0 | 2.5 | 2.5 | 8.16 |
| 11 | 32.9 | 16.9 | 87.4 | 49.4 | 2.5 | 3.1 | 3.0 | 3.57 |
| 12 | 32.0 | 18.9 | 87.7 | 43.9 | 3.1 | 2.3 | 2.19 | 1.79 |

**Table 2. Correlation of fall armyworm and its natural enemies on maize with weather parameters during *Rabi* 2022-23**

| Natural enemies | Temperatures | | Relative humidity | | % FAW infestation |
|---|---|---|---|---|---|
| | Maximum | Minimum | Morning | Evening | |
| Coccinelids | 0.638** | -0.240 | -0.181 | -0.428 | -0.027 |
| Spiders | 0.820** | -0.250 | -0.281 | -0.555* | -0.144 |
| Earwigs | 0.688** | -0.289 | -0.104 | -0.394 | 0.081 |
| %infestation | -0.491* | -0.113 | 0.565* | 0.323 | - |

spiders showed positive significant correlation with maximum temperatures. Warkad *et al*. [9] reported that earwig's population positive significant correlation with maximum temperature and negative significant correlation with evening relative humidity, the present findings were in accordance with earlier findings [10-12].

## 4. CONCLUSIONS

Percent FAW infestation was correlated negatively significant with maximum temperature and positively significant with morning relative humidity, coccinellids, spiders and earwigs are correlated positively with maximum temperature. The population of spiders are correlated negatively with evening relative humidity.

### DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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