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# Influence of weather parameters on population dynamics of fall armyworm *Spodoptera frugiperda* (J. E. Smith) on maize

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**Abstract**
The field experiments were carried out in the farmer field at Jadamangalam village near Trichy during rabi and kharif 2019-20. The results of experiments revealed that the seasonal incidence by *S. frugiperda* on maize reached a peak on 46th MSW (first fortnight of November) and reduced to the second fortnight of November during rabi season, whereas during kharif, the maximum per cent infestation was noticed on 29th MSW (first fortnight of July) whereas minimum was noticed on second fortnight of October. The seasonal incidence by *S. frugiperda* was exerted significantly positively correlated with maximum (0.232, 0.253 & 0.031) and minimum temperature (0.232, 0.253 & 0.031) exhibited non-significant positive correlation meanwhile rainfall (-0.048, -0.152 & -0.318) and relative humidity (-0.241, -0.049 & -0.130) exhibited non-significant negative association with the FAW incidence in the number of egg masses, population of larvae and percent infestation respectively during rabi season. The kharif season indicated that maximum temperature (0.310, 0.391 & 0.490) exhibited non-significant positive correlation whereas minimum temperature (0.560, 0.421 & 0.723) exhibited significant, non-significant and highly significant positive correlation association, however, rainfall (-0.374, -0,214 & -0.297) and relative humidity (-0.430, -0.223 & -0.347) exhibited non-significant negative association was recorded with the FAW incidence in the number of egg masses, population of larvae and percent infestation respectively.

**Keywords:** maize fall armyworm, seasonal incidence, weather parameter, MSW, per cent infestation

## Introduction
Maize, *Zea mays* Linnaeus, belongs to the family Poaceae and is believed to be originated in Mexico and it is commonly known as “Queen of Cereals” because of its high potential yield and widely grown crop having acceptability under varied agro-climatic conditions and ranks third next to wheat and paddy in production worldwide [9]. It is cultivated to serve various purposes like human consumption, cattle and poultry feed, food processing and the extraction of starch, dextrose, corn syrup, corn oil [5]. It contains approximately 10% protein, 72% starch, and 4% fat, supplying an energy density of 365 Kcal/100 g [12]. At present maize was majorly attacked by a new invasive pest i.e., Fall armyworm *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) which is highly migratory and economically destructive, is native to tropical and subtropical regions of the Americas [3]. The incidence of FAW in India was first observed in Shivamogga district of Karnataka on 18th May 2018 [14]. Then gradually spread to various states and Tamil Nadu, it was first reported at Karur in July 2018 [8]. After this mass spread in 2018, maize production fell down by 3.2% (27.8 MT) in India, so it is expected that the net production will decline further in subsequent years due to the attack of FAW [7]. FAW infects the plants from all phases, from seedling to tasseling and earing, producing defoliation, killing the young plant, grain loss and subsequently reduce quantity and quality of yield [11]. In Tamil Nadu, Maize is cultivated in about 3.5 lakh hectares and around 1.2 lakh hectares have been covered against the menace of FAW, and the worst affected districts are Perambalur, Virudhunagar, Salem, Tirunelveli, Dindigul and Trichy. For that reason, it has become necessary to understand the seasonal occurrence of FAW and its association with weather factors. This study provides an opportunity for the effective monitoring, surveillance and early warning system about the Fall Armyworm on maize.

## Materials and Methods
The field experiments were carried out in farmer field at Jadamangalam village near Trichy during 2019-20. The study was conducted during rabi (Oct-Jan) 2019-20 and kharif (July–Oct) 2020, Fixed plot surveys were conducted to document the occurrences of *S. frugiperda* in the maize field. One acre field with the spacing of 60cm X 20cm were taken for the, seasonal incidence study. Normal agronomic procedures were taken on the entire crop throughout the season without plant protection measures. Scouting is important to determine the action threshold in *S. frugiperda*. For observation, the survey was done in a semi-systematic manner, in which the samples are taken in a zig-zag position, in the form of a “W” pattern to cover the entire field. All the opened leaves and whorls of selected plants were observed thoroughly at weekly intervals in terms of percentage of infestation and mean number of egg masses, number of larvae/plant found were recorded. Weather parameters like temperature, relative humidity, rainfall were recorded and correlated with the incidence of *S. frugiperda.* Correlation analysis was carried out as per Gomez and Gomez [2]. The observation was calculated by using the following formula and worked
Per cent infestation= Number of infested plants/ Total number of plants observed X 100

Number of egg masses/Plant = Total number of egg masses/ Total number of plants observed
Number of larvae / Plant = Total number of larvae/ Total number of plants observed

## Results and Discussion

### Studies on incidence of *S. frugiperda* in maize ecosystem during Rabi and Kharif season 2019-20

In rabi season studies on pest incidence (table 1) revealed that infestation of *S. frugiperda* on maize was noticed from 42nd MSW (Meteorological Standard Week) to 3rd MSW ranging from 20 to 85 per cent. The peak infestation was found during the 46th MSW (85%) which was reduced to 48% in 47th MSW. The highest larval population of (1.42 - 3.21 larvae/ plant/week) was recorded between 44 – 47th MSW. The maximum 0.25 egg mass/ plant/week was recorded in 42nd MSW.

The result in kharif season studies revealed that infestation of *S. frugiperda* on maize was noticed (table1) from 29th MSW to 42nd MSW ranging from 13 to 79 per cent. The peak infestation was found from 29th MSW (79%) which was reduced to 66% in 30th MSW. The maximum larval population was recorded in 29th MSW (2.78 larvae/plant). During 41st and 42nd MSW, has no egg mass was found in the maize field, except the 30th MSW (0.13 egg mass/plant/week), 32nd MSW (0.1 egg mass/plant/week), 33rd MSW (0.14 egg mass /plant/week) all mean standard weeks had shown less than (0.1 egg mass/plant/week).

The present findings are in concordance with Kumar *et al*. (2020) [4], who reported the incidence of *S. frugiperda* was maximum during the second fortnight of July while minimum recorded during the second fortnight of October in kharif season and the incidence of *S. frugiperda*, during the rabi season was maximum in the first fortnight of November and minimum during the second fortnight of November.

Similarly, Reddy *et al*. (2020) [13] observed that the peak infestation was noticed in the third week of August at 45 days old crop during the kharif season.

The survey revealed that the maximum per cent infestation and larval population were found in the vegetative stage during rabi. Meanwhile during kharif thus the maximum infestation was observed at both vegetative and reproductive stages of the crop. It is interpreted that the larvae may feed on both vegetative and reproductive stages as indicated by Capinera (2017) [1].

### Influence of weather parameters on *S. frugiperda* population during Rabi 2019-20 and Kharif 2020

Correlation between weather parameters and seasonal incidence of *S. frugiperda* on maize during rabi 2019 is presented in (table 2). The correlation studies indicated that maximum temperature (r = 0.388, 0.493 & 0.344) and minimum temperature (r = 0.232, 0.253 & 0.031) exhibited non-significant positive correlation with the fall armyworm incidence *i.e.*, egg mass, larval population and per cent infestation respectively. However, rainfall (r = -0.048, -0.152 & -0.318) and R. H (r = -0.241, -0.049 & -0.130) exhibited non-significant negative association with egg mass, larval population and per cent infestation by *S. frugiperda respectively on maize.*

**Table 1:** Studies on incidence of *S. frugiperda* in maize ecosystem during rabi and kharif 2019-20

| Seasonal incidence of *S. frugiperda on maize ecosystem* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Rabi | | | | | Kharif | | | | |
| Month | MSW | *Mean No. of Egg Mass / Plant | *Mean No. of Larvae/ Plant | % infestation | Month | MSW | *Mean No. of Egg Mass / Plant | *Mean No. of Larvae/ Plant | % Infestation |
| Oct | 42 | 0.25 | 0.35 | 20 | July | 29 | 0.09 | 2.78 | 79 |
| | 43 | 0.01 | 0.41 | 38 | | 30 | 0.13 | 1.94 | 66 |
| | 44 | 0.05 | 1.42 | 53 | | 31 | 0.05 | 0.35 | 57 |
| Nov | 45 | 0.13 | 2.63 | 72 | Aug | 32 | 0.10 | 0.41 | 44 |
| | 46 | 0.02 | 3.21 | 85 | | 33 | 0.14 | 1.78 | 74 |
| | 47 | 0.1 | 2.18 | 48 | | 34 | 0.06 | 0.76 | 66 |
| | 48 | 0.05 | 0.28 | 39 | | 35 | 0.03 | 0.33 | 44 |
| Dec | 49 | 0.01 | 0.31 | 31 | Sep | 36 | 0.01 | 0.24 | 36 |
| | 50 | 0.03 | 1.96 | 60 | | 37 | 0.06 | 0.11 | 39 |
| | 51 | 0.07 | 0.83 | 54 | | 38 | 0.02 | 0.42 | 47 |
| | 52 | 0.03 | 0.32 | 36 | | 39 | 0.01 | 0.23 | 56 |
| Jan | 1 | 0.15 | 0.36 | 44 | Oct | 40 | 0.00 | 0.38 | 39 |
| | 2 | 0.32 | 0.26 | 38 | | 41 | 0.00 | 0.32 | 21 |
| | 3 | 0.02 | 0.21 | 32 | | 42 | 0.04 | 1.12 | 13 |

*Mean of 100 plants, Date of sowing: 28. 09. 2019 & 01. 07. 2020, MSW – Meteorological Standard Week

**Table 2:** Correlation coefficients between weather parameters and weekly observed damage of *S. frugiperda* on maize during rabi and kharif season 2019-20

| | Rabi | | | Kharif | | |
|---|---|---|---|---|---|---|
| Weather parameters | Mean No. of Egg Mass / Plant | Mean No. of Larvae/ Plant | % infestation | Mean No. of Egg Mass / Plant | Mean No. of Larvae/ Plant | % infestation |
| Maximum temperature ºC | 0.388 | 0.493 | 0.344 | 0.310 | 0.391 | 0.490 |
| Minimum temperature ºC | 0.232 | 0.253 | 0.031 | 0.560* | 0.421 | 0.723** |
| Rainfall (mm) | -0.048 | -0.152 | -0.318 | -0.374 | -0.214 | -0.297 |
| Relative humidity (%) | -0.241 | -0.049 | -0.130 | -0.430 | -0.223 | -0.347 |

*Significant at 0.05 probability level, ** Significant 0.01 probability level

Multiple regression equations were fitted for regression analysis between the weather parameters (X) and the per cent infestation, mean no. of egg mass and mean no. of larval population on maize by *S. frugiperda* during rabi season 2019-20 (table 3).

**Particular regression equation**

Egg mass Y= - 0.392 + 0.09 $X_1$ + 0.03 $X_2$ -0.02 $X_3$ – 0.06$X_4$

Larvae Y = - 27.96 + 0.49 $X_1$ + 0.21 $X_2$ -0.09 $X_3$ - 0.12 $X_4$

%infestation Y = - 363.3+ 7.95 $X_1$ + 0.65 $X_2$ – 1.65 $X_3$ - 2.15 $X_4$

$X_1$ = Maximum temperature $X_2$ = Minimum temperature

$X_3$ = Rainfall $X_4$ = Relative humidity

The regression equation indicated that a $1^0$ C increase in the maximum temperature would lead to increases (0.17 egg mass/plant/week), (1 larvae/plant/week) and 0.92 per cent of plant infestation. An increase in 1mm rainfall will decrease the (0.32 egg mass/plant/week), (1.27 larvae/plant/week) and 1.25 per cent infestation of plant/week during rabi season. Further, the values of coefficient of determination ($R^2$) 19.3%, 40.4% and 34.4% variation in the mean no. of egg mass, mean no. of larvae and per cent infestation by *S. frugiperda* due to meteorological factors during the rabi 2019-20, respectively.

Correlation between weather parameters and seasonal incidence of *S. frugiperda* on maize during kharif 2020 is presented in (table 2). The correlation studies indicated that maximum temperature (r = 0.310, 0.391 & 0.490) and minimum temperature (r = 0.560, 0.421 & 0.723) exhibited a positive correlation associated with the mean no. of egg mass, mean no. of larva and per cent plant infestation respectively caused by *S. frugiperda* during kharif 2020 (table 2). However, rainfall (r = -0.374, -0,214 & -0.297) and relative humidity (r = -0.430, -0.223 & -0.347) exhibited non-significant negative association with the mean no. of egg mass, mean no. of larva and per cent plant infestation by *S. frugiperda* on maize.

Multiple regression equations were fitted for regression analysis between the weather parameters (X) and the per cent infestation, mean no. of egg mass and mean no. of larval population on maize by *S. frugiperda* during kharif season 2020 table 4.

**Particular regression equation**

Egg mass Y= - 0.590 + 0.03$X_1$ + 0.03 $X_2$ -0.02 $X_3$ – 0.02 $X_4$

Larval Y = - 14.368 + 0.26 $X_1$ + 0.24 $X_2$ -0.06 $X_3$ - 0.02 $X_4$

% infestation Y = - 400.38+ 3.38 $X_1$+ 14.31 $X_2$ – 1.31 $X_3$ – 0.57 $X_4$. The regression equation indicated that an $1^0$ C increase in the maximum temperature would lead to increases (0.02 egg mass/plant/week), (0.81 larvae/plant/week) and 0.65 per cent of plant infestation/plant/week. An increase in 1 mm rainfall will decrease the (0.6egg mass/plant/week), (0.70 larvae/plant/week) and 0.89 per cent of plant infestation/plant/week during kharif season.

Further, the values of coefficient of determination ($R^2$) indicated that there were 51.5%, 28.9% and 66.9%variation in the mean no. of egg mass, mean no. of larvae and per cent infestation by *S. frugiperda* due to meteorological factors during the kharif 2020, respectively. The present findings are in concordance

with Kumar *et al*. (2020) [4] who found that during kharif and rabi, the occurrence of *S. frugiperda* in terms of the larval population showed positive correlation with the maximum temperatures and minimum temperatures and negatively correlated with relative humidity and rainfall. The findings of the present study are in accordance with Pazhanisamy *et al*. (2019) [10] who reported that the incidence of *S. litura* showed negative correlation with rainfall in kharif season. Higher rainfall distribution during rabi has great influence on the *S. frugiperda* population. These results agree with those of Mitchell *et al*. (1991) [6] found that *S. frugiperda* populations in the tropics tend to fluctuate with seasonal changes in rainfall, with the lowest number during the dry season. Similarly, Waddill *et al*. (1981) [15] found that heavy and light rainfall killed a considerable proportion of early instar FAW, reducing the adult population

**Table 3:** Multiple linear regression analysis of mean no. of egg mass, larvae and percent infestation by *S. frugiperda* (Y) and weather parameters (X) in maize during rabi season 2019 (n=14)

| | Variables | Partial regression coefficient | Standard error | 't' value | $r^2$ |
|---|---|---|---|---|---|
| Mean No. of Egg Mass / Plant | X1= Max.Temperature | 0.09 | 0.05 | 0.17 | 0.193 |
| | X2= Min.Temperature | 0.03 | 0.06 | 0.46 | |
| | X3= Rainfall | -0.02 | 0.08 | -0.32 | |
| | X4= Relative Humidity | -0.06 | 0.01 | -0.48 | |
| Mean No. of Larvae/ Plant | X1= Max.Temperature | 0.49 | 0.48 | 1.00 | 0.404 |
| | X2= Min.Temperature | 0.21 | 0.63 | 0.33 | |
| | X3= Rainfall | -0.09 | 0.07 | -1.27 | |
| | X4= Relative Humidity | -0.12 | 0.11 | 1.11 | |
| Percent infestation | X1= Max.Temperature | 7.95 | 8.61 | 0.92 | 0.344 |
| | X2= Min.Temperature | 0.65 | 11.19 | 0.05 | |
| | X3= Rainfall | -1.65 | 1.32 | -1.25 | |
| | X4= Relative Humidity | -2.15 | 2.04 | 1.05 | |

NS= Non-significant, *Significant P= 0.05 CD (P= 0.05): 0.532, **Highly significant P= 0.01 CD (P= 0.01): 0.661

**Table 4:** Multiple linear regression analysis of mean no. of egg mass, larvae and percent infestation by *S. frugiperda* (Y) and weather parameters (X) in maize during kharif season 2020 (n=14)

| | Variables | Partial regression coefficient | Standard error | 't' value | $r^2$ |
|---|---|---|---|---|---|
| Mean No. of Egg Mass / Plant | X1= Max.Temperature | 0.03 | 0.01 | 0.02 | 0.515 |
| | X2= Min.Temperature | 0.03 | 0.01 | 1.95 | |
| | X3= Rainfall | -0.02 | 0.04 | -0.61 | |
| | X4= Relative Humidity | -0.02 | 0.02 | -0.87 | |
| | X1= Max.Temperature | 0.26 | 0.32 | 0.81 | |

| | | | | | |
|---|---|---|---|---|---|
| Mean No. of Larvae/ Plant | X2= Min.Temperature | 0.24 | 0.33 | 0.74 | 0.289 |
| | X3= Rainfall | -0.06 | 0.09 | -0.70 | |
| | X4= Relative Humidity | -0.02 | 0.06 | 0.04 | |
| Per cent infestation | X1= Max.Temperature | 3.38 | 5.16 | 0.65 | 0.669 |
| | X2= Min.Temperature | 14.31 | 5.32 | 2.68 | |
| | X3= Rainfall | -1.31 | 1.47 | -0.89 | |
| | X4= Relative Humidity | -0.57 | 0.98 | -0.58 | |

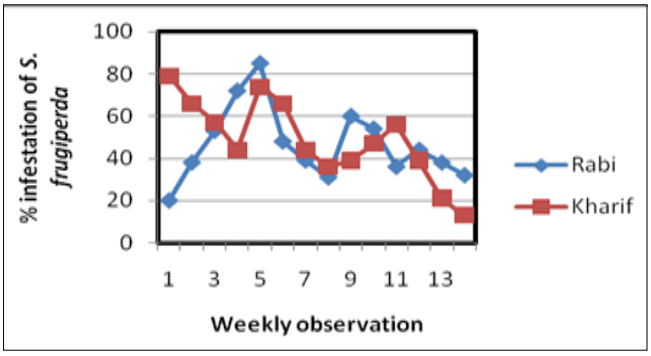


**Fig 1:** Per cent infestation of *S. frugiperda* on maize ecosystem during rabi and kharif season- 2019-20

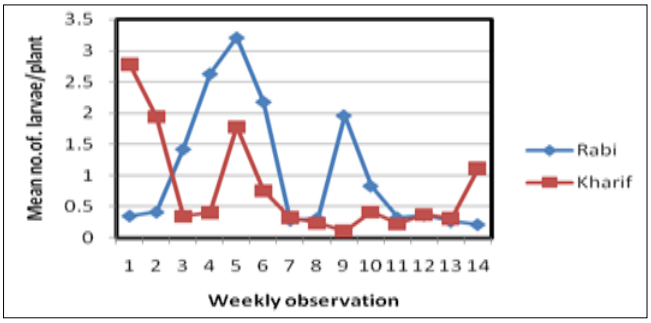


**Fig 2:** No. of. *S. frugiperda* Larvae present in the maize ecosystem during rabi and kharif season 2019-20

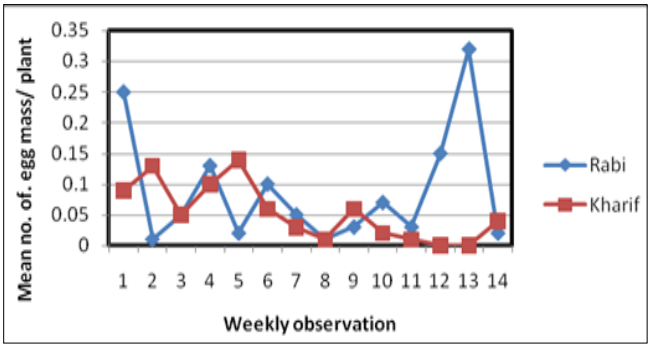


**Fig 3:** No. of. *S. frugiperda* egg mass present in the maize ecosystem during rabi and kharif season 2019-20

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