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Original Research Article

Surveillance of Fall Armyworm, *Spodoptera frugiperda* (J. E. Smith) Infesting Maize

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A B S T R A C T

Keywords

Fall armyworm, Maize, Rainfall, Wind speed and minimum temperature

The larval population of *S. frugiperda* fluctuated during crop period. During the 3rd week of September, 2019 (37th SMW), it showed its peak by recording 7.66 larvae/ 10 damaged plants. In subsequent week the population declined and become 4.33 larvae/ 10 plants during 1st week of October (40th SMW). The weather parameters *viz.*, rainfall, wind speed and minimum temperature had contributed 49 %, 60 % and 70 % in fluctuation of *S. frugiperda* larval population, respectively.

Introduction

Maize (*Zea mays* L.) popularly known as corn is one of the most important fodder and cereal crop grown in India. It is cultivated widely throughout the tropical, subtropical and temperate region of the world. It belongs to family Gramineae (Poaceae). In different parts of India, maize is known as *Makka, Makai, Chhali, Bhutta, Cholum, Mokochana, and Khaukiri* (Rathore, 2002). Maize is a storehouse of various nutrients such as carbohydrates, proteins, minerals, vitamins, iron *etc* and particularly supplying a high energy of 365 C/100g (Emily and Sherry, 2010). Maize is attacked by nearly 130 species of insect pests in India (Atwal and Dhaliwal, 2002). Now adding new alien invasive pest, fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) is a major crop pest in its native America (Sah *et al*., 2019). The fall armyworm, *S. frugiperda* is a cosmopolitan pest of the maize crop (Wiseman *et al.*, 1966). The cost for controlling the fall armyworm on corn is more than 600 million dollars annually in Brazil. According to the UK Aid and CABI, FAW could potentially cause corn yield losses in a range from 8.3 million to 20.6 million tonnes in 12 African countries per annum (if no control methods are adopted). The value of crop loss is estimated at between US$2,481 million and US$6,187 million (Shylesha *et al*., 2018). In 2018, this notorious, pestiferous and havoc able pest has entered India. In India, 33-36% yield losses have been attributed to this pest as per the preliminary reports (Jagdish *et al.*, 2019; Aruna *et al*., 2019). This pest become havoc in various states of India. Fall armyworm was reported in 1.4 lakh ha in Karnataka, 85,000 ha in Madhya Pradesh, 59,000 ha in Rajasthan, 2000 ha in Maharashtra, 1,747.9 hectares in Mizoram, 200 ha in Tamil Nadu, 137 ha in Andra Pradesh (Anonymous, 2019c; Aizawl, 2019).

In Gujarat, the first report of fall armyworm an alien invasive pest was observed from field of sweet corn at Anklav village, Anand (Gujarat) during September, 2018 (Sisodiya *et al*., 2018). Looking to the ability of the pest to cause economic damage to maize, it is important to undertake study on population dynamics aspects regarding fall armyworm.

Materials and Methods

Details of experiment

Location	:	Entomology farm, BACA, AAU, Anand
Crop and Variety	:	Maize, GM-6
Plot size	:	15 x 10 m
Spacing	:	60 x 20 cm
Season and Year	:	*Kharif*, 2019
Fertilizer dose	:	60-40-00 (N: P: K) kg/ ha
Date of sowing	:	17/7/2019

To study the population dynamics of fall armyworm, the maize variety GM-6 was grown in the plot of 15 × 10 m. The crop was sown during *kharif*, 2019. All standard agronomical practice were followed to grow the crop except application of insecticide. The plot was divided into 6 equal quadrates each of 3 x 5 m size. From each quadrate 10 plants were randomly selected for recording the various observations. The number of larva(e) as well as damaged and healthy plants per 10 plants were counted at weekly interval. At harvest time, cob damage was also recorded. The observations were recorded at weekly interval starting from 15 days of sowing till harvest of the crop. The data were correlated with weather parameter to work out the correlation between pest activity and various weather parameters (abiotic factors) to see the influence of abiotic factors (Steel and Torrie, 1980).

Formula: $$r = \frac{\sum xy}{\sqrt{\sum x^2 . \sum y^2}}$$

Observations recorded

Number of larva(e)/ 10 plants
Number of healthy and damaged plant(s)/ 10 plants
Number of healthy and damaged cob(s)/ 10 plants

Results and Discussions

A study was carried out to know the population dynamics of fall armyworm, *S. frugiperda* infesting maize at entomology field, B. A. College of Agriculture, Anand Agricultural University, Anand during in *kharif* season July, 2019 to October, 2019. The population dynamics of the pest was studied based on no. of larva(e), per cent damaged plant and per cent cob damage at weekly interval during crop period on maize variety GM-6 (Plate XIV).

Based on larval population

The data on number of larva(e)/ 10 plants are presented in Table 1 and depicted in Figure 1. The data indicated that the activity of larva(e) of fall armyworm, *S. frugiperda* commenced from 1st week of August, 31st Standard Meteorological Week (SMW) and continued till 1st week of October (40th SMW) which ranged from 0.83 to 7.66 larva(e)/ 10 plants. The larval population of *S. frugiperda* fluctuated during crop period. During the 3rd week of September, 2019 (37th SMW), it showed its peak by recording 7.66 larvae/ 10 plants. In subsequent week the population decreased and reached to 4.33 larvae/ 10 plants during 1st week of October (40th SMW). The larval population increased continuously from 1st week of August (31st SMW) to 3rd week of September (37 SMW)

and then declined up to 1st week of October (40th SMW).

Based on Damaged Plant (%)

The data on per cent of damaged plant(s)/ 10 plants are presented in Table 1 and depicted in Figure 1. The data indicated that the per cent damaged plants by fall armyworm, *S. frugiperda* were coincide with the larval population and was commenced from 1st week of August, 31st Standard Meteorological Week (SMW) and continued till 1st week of October (40th SMW) which ranged from 10 to 81.66 per cent. The per cent of damage plants by fall armyworm, *S. frugiperda* fluctuated during crop period. During the 3rd week of September, 2019 (37th SMW), it showed its peak by recording 81.66 per cent damaged plants. In subsequent week the per cent damaged plants decreased and reached to 61.66 per cent at end of crop period during 1st week of October (40th SMW). The per cent damaged plant was continuously increase from 1st week of August (31st SMW) to 3rd week of September (37 SMW) and then declined up to 1st week of October (40th SMW).

Based on Cob Damage (%)

The data on per cent of cob damage/ 10 plants are presented in Table 1. The data indicated that the per cent cob damage by fall armyworm, *S. frugiperda* was commenced from 4th week of September, 38th Standard Meteorological Week (SMW) and continued till 1st week of October (40th SMW) which ranged from 46.66 to 60.33 per cent.

In past, Vickery (1929) reported fall armyworm population decrease in September, October and November. In present study, the larval population was decreased when crop reached maturity at 1st week of October (40th SMW). Murua *et al.* (2006) recorded fall armyworm attacked cornfields when plants achieved one or two ligulate leaves and larval populations were consistent throughout the vegetative plant phase and larval densities diminished with age of the corn field. Wyckhuys *et al.* (2006) recorded that the fall armyworm infestation was lowest during early whorl and post whorl stage with peak infestation during whorl stage. In present study also larval population was lower in early and post whorl stage than whorl stage.

Kuate *et al.* (2019) revealed positive and significant correlation between *S. frugiperda* incidence and damage severity. In present study also same results were observed during activity of fall armyworm and changing of per cent damaged plants/ 10 plants. In present study, larval population remained consistent throughout vegetative phase and decline at beginning of reproductive stage. Thus, the above reports are more or less in accordance with present finding.

According to Islam *et al.* (2019), fall armyworm larvae damaged 30-40 per cent plant in vegetative stage of maize which was lower per cent damaged plant as compared to present investigation. It may be due to change in environmental conditions, soil types, variety and location of study.

Correlation of between weather parameters and larval population and damaged plant (%) of fall armyworm, *S. frugiperda*

In nature, the population of insect pests is never truly stable. The rise and fall of population density of any organism depends on many abiotic factors like bright sunshine hours, maximum temperature, minimum temperature, mean temperature, rainfall, morning relative humidity, evening relative humidity, morning vapour vapour, evening vapour pressure and wind speed. To know the effect of various weather parameters on the population fluctuation of fall armyworm

infesting maize, simple correlation was worked out between weekly mean larval population of fall armyworm and weekly mean value of different weather parameters. The correlation are presented in Table 2 and discussed here under.

The results of the analysis on correlation between larval population of fall armyworm and weather parameters revealed that, the larval population of fall armyworm had highly significant positive correlation with minimum temperature (r=0.838). While, it showed non-significant positive correlation with bright sunshine hours (r=0.186), maximum temperature (r=0.505), morning relative humidity (r=0.049) and evening vapour pressure (r=0.049). However, it exhibited highly significantly negative correlation with wind speed (r=-0.776) and significant negative correlation with rainfall (r=-0.705), and non-significant negative correlation with evening relative humidity (r=-0.229).

The results of the analysis on correlation between damaged plant per cent of fall armyworm and weather parameters revealed that, per cent damage plants by fall armyworm, *S. frugiperda* had significant positive correlation with minimum temperature (r=0.695). While, it showed non-significant positive correlation with bright sunshine hours (r=0.323), maximum temperature (r=0.531), morning relative humidity (r=0.014) and evening vapour pressure (r=0.195). However, it exhibited highly significantly negative correlation with wind speed (r=-0.890) and significant negative correlation with rainfall (r=-0.680), and non-significant negative correlation with evening relative humidity (r=-0.295).

This clearly indicated that the larval population of *S. frugiperda* increase as increase in the maximum and mean temperature, while decrease in increase in rainfall and wind speed and same trend observed in per cent damage plant with same weather parameters.

While shifting the literature, According to Kumar *et al.* (2020) larval population had significant positive correlation with the maximum temperatures (r=0.7205) and significant negative correlation with relative humidity (r=-0.6739) and rainfall (r=-0.8293) during *Kharif* and Rabi season. While, it is closely in agreement with the present finding.

Fitting of regression model for no. of larvae and weather parameter

The weather parameters *viz.*, rainfall, wind speed and minimum temperature which are significantly or highly significantly with *S. frugiperda* larvae population.

It is evident from Figure 2A that, the larval population was up to 6.061 larvae which was not affected by rainfall. While, 1 mm increase in rainfall decreased the population by 0.014 larvae during same period. It is evident from the R^2 (0.49), rainfall effect on larval population is 49 per cent.

It is evident from Figure 2B that, the larval population was up to 9.869 larvae which was not affected by wind speed. While, 1 km/hr increase in wind speed decreased the population by 1.078 larvae during same period. It is evident from the R^2 (0.60), wind speed effect on larval population is 60 per cent.

It is evident from Figure 2C that, the larval population was up to -80.36 larvae which was not affected by minimum temperature. While, 1 ^{0}C increase in minimum temperature increased the population by 3.38 larvae during same period. It is evident from the R^2 (0.70), rainfall effect on larval population is 77 per cent.

Table.1 Population dynamics of S. frugiperda infesting maize

Months and Weeks		SMW	WAS	No. of Larva(e)/ 10 plants	Damaged plant (%)	Cob damage at harvest
August, 2019	I	31	3	0.83	10.00	-
	II	32	4	2.16	13.33	-
	III	33	5	3.83	36.66	-
	IV	34	6	4.66	50.00	-
September, 2019	I	35	7	5.33	63.33	-
	II	36	8	6.66	71.33	-
	III	37	9	7.66	81.66	-
	IV	38	10	6.16	70.00	46.66
	V	39	11	4.66	66.66	51.33
October, 2019	I	40	12	4.33	61.66	60.33

Note: SMW = Standard Meteorological Week
WAS = Week After Sowing

Table.2 Correlation coefficient (r) with weather parameters and larval population and damaged plant (%) of S. frugiperda in maize

Weather Parameters	Correlation co-efficient (r)	
	Larvae	Damaged plant (%)
Bright Sunshine Hours (BSS), hr day^{-1}	0.186	0.323
Maximum Temperature (MaxT), ^0C	0.505	0.531
Minimum Temperature (MinT), ^0C	0.838**	0.695*
Rainfall (RF), mm	-0.705*	-0.680*
Morning Relative Humidity (MoRH), %	0.049	0.014
Evening Relative Humidity (EvRH), %	-0.229	-0.295
Morning Vapour Pressure (MoVP), mm of Hg	-0.372	-0.438
Evening Vapour Pressure (EvVP), mm of Hg	0.292	0.195
Wind Speed (WS), $kmhr^{-1}$	-0.776**	-0.890**

* Significant at 5 % level
**Highly significant at 1 % level

Plate I: Nature of damage of fall armyworm, *S. frugiperda* infesting maize

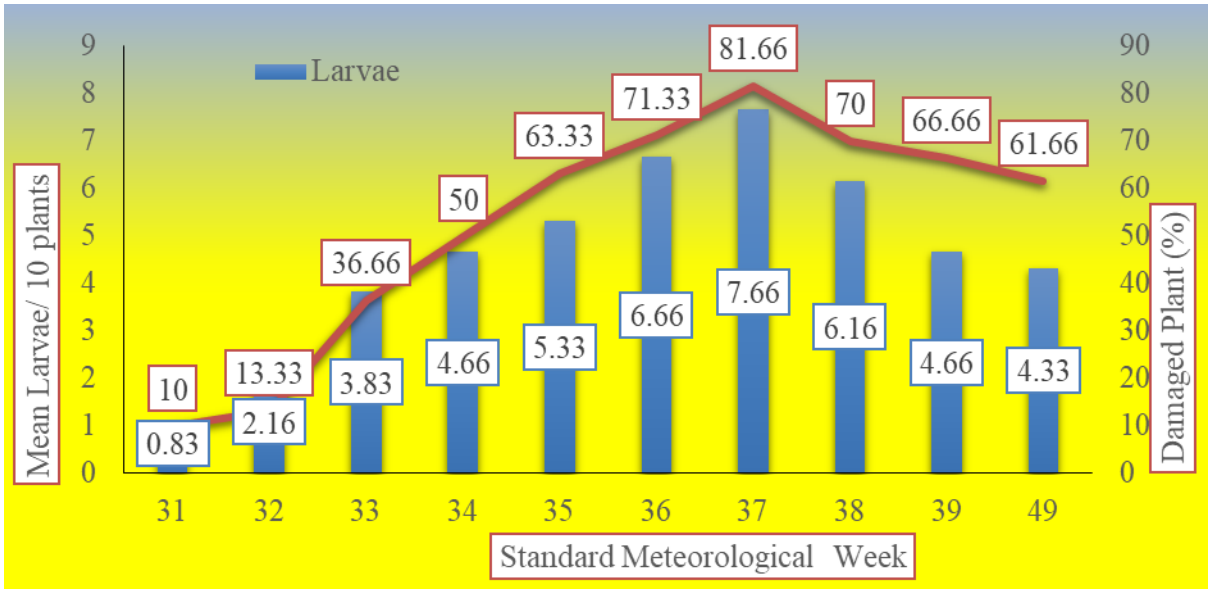
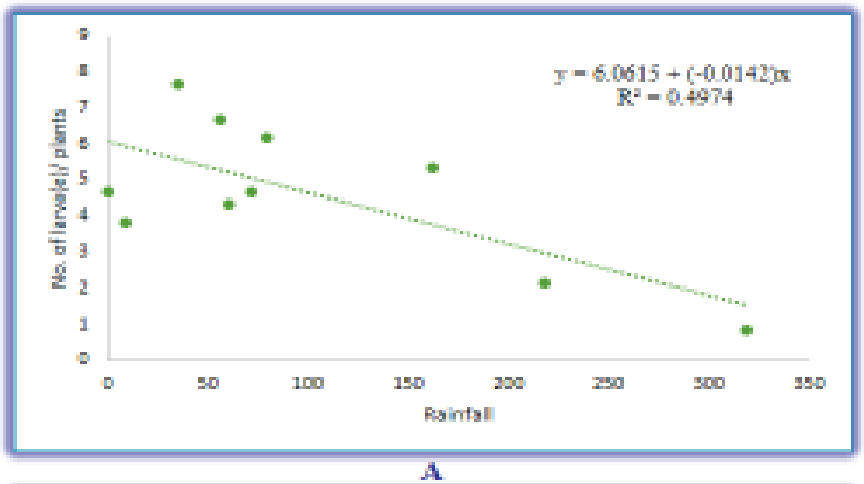
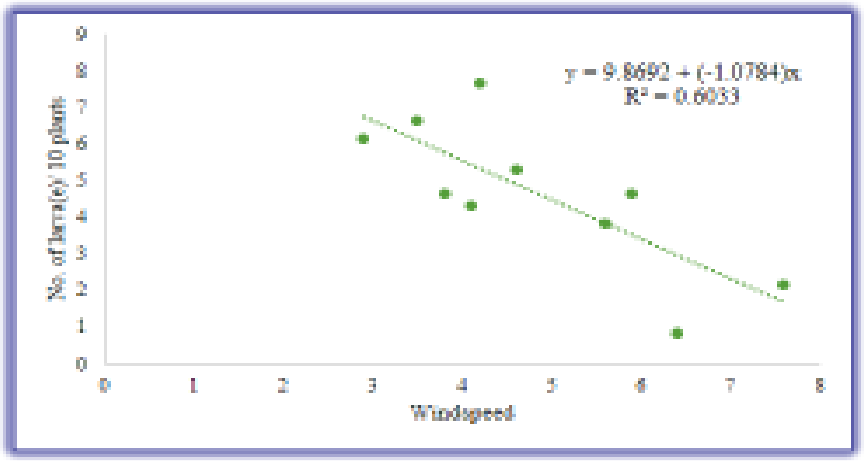


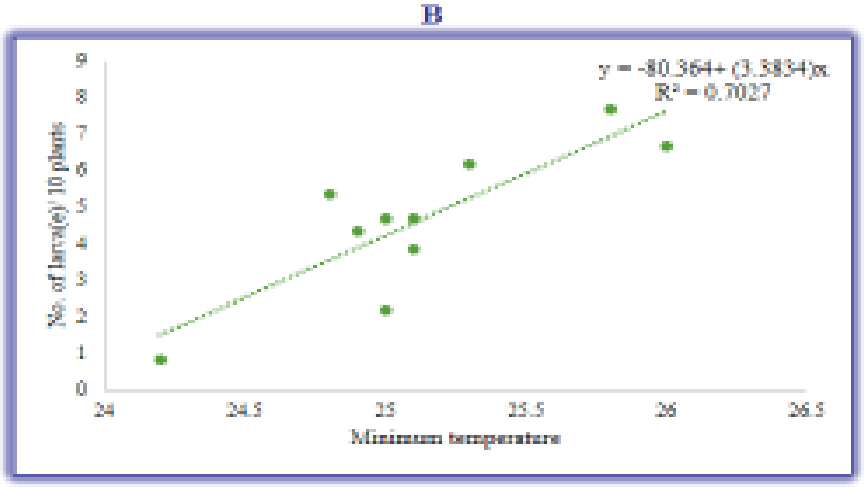
Fig.1 Population dynamics of fall armyworm, *S. frugiperda*



A



B



C

Fig 2: Fitting of regression model for no. of larvae and weather parameter

The weather parameters *viz.*, rainfall, wind speed and minimum temperature had contributed 49 %, 60 % and 70 % in fluctuation of *S. frugiperda* larval population, respectively.

Summary and conclusion are as follows:

The activity of fall armyworm was commenced from 1st week of August *i.e.*, 31st (SMW) and continued till 1st week of October (40th SMW) which was ranged from 0.83 to 7.66 larva(e)/ 10 plants. The larval population of *S. frugiperda* fluctuated during crop period. During the 3rd week of September, 2019 (37th SMW), it showed its peak by recording 7.66 larvae/ 10 damaged plants. In subsequent week the population declined and become 4.33 larvae/ 10 plants during 1st week of October (40th SMW).

The per cent damaged plant due to fall armyworm in maize was also commenced from 1st week of August (31st SMW) and continued till 1st week of October (40th SMW) which was ranged from 10 to 81.66 per cent. The per cent damaged plants caused by fall armyworm, *S. frugiperda* fluctuated during crop period. During the 3rd week of September, 2019 (37th SMW), it showed its peak by recording 81.66 per cent damaged plants. In subsequent week, the per cent damaged plants were decreased and reached to 61.66 per cent at end of crop during 1st week of October (40th SMW). The per cent damage plant was continuously increase from 1st week of August, 31st SMW to 3rd week of September (37 SMW) and then declined up to 1st week of October (40th SMW). The per cent cob damage by fall armyworm, *S. frugiperda* was commenced from 4th week of September (38th SMW) and continued till 1st week of October (40th SMW) which was ranged from 46.66 to 60.33 per cent.

The fluctuation of population density of any organism during crop season depends on many abiotic factors. The larval population of fall armyworm had highly significant positive correlation with minimum temperature (r=0.838). While, it showed non-significant positive correlation with bright sunshine hours (r=0.186), maximum temperature (r=0.505), morning relative humidity (r=0.049) and evening vapour pressure (r=0.049). However, it exhibited highly significantly negative correlation with wind speed (r=-0.776) and significant negative correlation with rainfall (r=-0.705), and non-significant negative correlation with evening relative humidity (r= -0.229). The per cent damaged plants by fall armyworm, *S. frugiperda* had significant positive correlation with minimum temperature (r=0.695). While, it showed non-significant positive correlation with bright sunshine hours (r=0.323), maximum temperature (r=0.531), morning relative humidity (r=0.014) and evening vapour pressure (r=0.195). However, it exhibited highly significantly negative correlation with wind speed (r=-0.890) and significant negative correlation with rainfall (r=-0.680), and non-significant negative correlation with evening relative humidity (r= -0.295).

The weather parameters *viz.*, rainfall, wind speed and minimum temperature which were significantly or highly significantly correlated with larval population and per cent damaged plant due *S. frugiperda*. The weather parameters *viz.*, rainfall, wind speed and minimum temperature had 49 %, 60 % and 70 % contributed in the fluctuation of *S. frugiperda* larval population, respectively.

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