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Population dynamics of fall armyworm, *Spodoptera frugiperda* in maize

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Abstract

The investigation was carried out to know the population dynamics and correlation studies of fall armyworm (FAW), *S. frugiperda* (J. E. Smith) at Junagadh region. The activity of fall armyworm commenced from 31st SMW i.e. first week of August (0.98 larva per plant) which gradually increased and attained peak of 5.74 larva per plant during 38th SMW and reached a minimum during the 46th SMW (0.21 larva per plant). Thereafter, the pest population started declining in the 4th week of September with an average of 4.89 larvae per plant at the 39th SMW. Correlation studies between meteorological parameters and the *S. frugiperda* larval population showed significant positive correlation with mean temperature, positive correlation with maximum temperature, minimum temperature, bright sunshine hours, morning relative humidity and evening relative humidity and evaporation, whereas non-significant negative correlation with wind speed and rainfall.

Keywords: Correlation, meteorological parameters, Standard Meteorological Week, seasonal occurrence, zenith

Introduction

Maize, scientifically known as *Zea mays* subsp. *mays*, traces its roots to Southern Mexico, where indigenous communities first domesticated it around 10,000 years ago. Among cereals, maize stands unparalleled in its vast potential, boasting remarkable biological and grain yield within a short growth cycle. Its distinction as the "Queen of cereals" arises from its extraordinary photosynthesis mechanism, attributed to the C4 mechanism, ensuring a significant place in the realm of agricultural importance. India produced 33.62 million tonnes in an area of 10.04 million hectares in 2021-22, whereas in *Kharif* 2022-23, maize production was 23.10 million tonnes in an area of 9.68 million hectares (Anon., 2022) [5]. In Gujarat, important districts growing maize are Dahod, Panchmahal, Vadodara, Kheda, Banaskatha, Bharuch, Anand and Dang. During 2020-21 in Gujarat, the *kharif* maize area, production and yield are 2867.05 ha., 4360.36 million tonnes, 1520.85 kg/ha yield respectively (Anon., 2020-21) [4]. The maize plant is attacked by 140 species of insect pests causing varying degrees of damage. The fall armyworm is an arthropod invasive pest and larvae are the most damaging stage. Its scientific name is derived from Latin, which is *frugiperda* for last fruit, named because of the ability of species to destroy crops (Anon., 2017a) [3]. The incidence of this pest was also reported on other crops in India viz., pearl millet and sorghum in Andhra Pradesh (Venkateswarlu *et al.*, 2018) [18], sugarcane in Tamil Nadu (Srikanth *et al.*, 2018) [17], paddy in Bihar (Ali *et al.*, 2018) [2], sugarcane and sorghum in Maharashtra (Chormule *et al.*, 2019) [6], sorghum in Karnataka (Sharanabasappa *et al.*, 2019) [16]. Further, it was documented in Chhattisgarh (Deole and Paul., 2018) [8], Telangana (Dayashanakar, 2018) [7], Rajasthan (Ramesh Babu *et al.*, 2019) [14], Odisha (Sahu, 2019) [15], Mizoram (Aizawl, 2019) [11], Manipur (Leivon, 2019) [13] and Assam (Karmakar, 2020) [10].

Materials and Methods

A study on the seasonal occurrence of *S. frugiperda* infestation in maize was conducted at the Instructional farm, Junagadh Agricultural University during the 2022, *Kharif* season. The experimental crop, adhering to recommended agronomical practices, was cultivated in a 20 m x 20 m plot with a spacing of 60 cm x 20 cm between rows and plants, respectively. The plot was subdivided into 1 m x 1 m quadrates.

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Throughout the season, the crop remained untreated with pesticides. Weekly observations on the number of *S. frugiperda* larvae were recorded on five randomly selected plants from each quadrat, starting one week after germination until crop harvest. The mean population of *S. frugiperda* larvae per plant was calculated separately. Additionally, percentages of cob damage and plant damage were determined.

Results and Discussion

Based on larval population

The fall armyworm, *S. frugiperda*, larval activity was observed from the first week of August 31st Standard Meteorological Week (SMW) to the second week of November (46th SMW), with a population range of 0.98 to 5.74 larvae per plant. The data, presented in Table 2 and Fig. 1, clearly showed the initiation of *S. frugiperda* population at the 31st SMW, starting at 0.98 larvae per plant. Throughout the crop period, the larval population exhibited fluctuations. The larval population of fall armyworm consistently increased each week, reaching its peak of 5.74 larvae per plant during the 38th SMW, corresponding to the third week of September. Subsequently, a decline in pest population began in the fourth week of September, with an average of 4.89 larvae per plant at the 39th SMW. This downward trend continued in the following weeks, reaching its minimum of 0.21 larvae per plant during the 46th SMW, aligning with the second week of November. Similar observations recorded by Harsh *et al.* (2020) [9] made similar observations in 2019, noting fluctuations in *S. frugiperda* larval population. In the 37th SMW, a peak of 7.66 larva/10 damaged plants was recorded in the third week of September, followed by a decline to 4.33 larva/10 plants in the 40th SMW (first week of October).

Based on Damaged Plant (%)

From the 1st week of August to the 2nd week of November (31st to 46th SMW), the percentage of plants damaged by fall armyworm varied between 11.33% and 83.33%. The damage coincided with the larval population, reaching its peak of 83.33% during the 33rd week of September 2022 (38th SMW). The fluctuation persisted throughout the crop period. In their 2020 study, Harsh *et al.* examined the percentage of plants damaged by fall armyworm, *S. frugiperda*, coinciding with larval population from the 1st week of August (31st SMW) to the 1st week of October (40th

SMW). The damage ranged from 10% to 81.66%, reaching its peak of 81.66% during the 3rd week of September 2019 (37th SMW). Meanwhile, Kuate *et al.* (2019) [11] found a positive and significant correlation between the incidence of *S. frugiperda* and the severity of damage.

Based on Cob Damage (%)

The data on per cent of cob damage/quadrat are presented in Table 2. The data indicated that the per cent cob damage by fall armyworm commenced from the 2nd week of September, 37th SMW and continued till the 2nd week of November (46th SMW) which ranged from 44.61 to 77.27 per cent. Harsh *et al.* (2020) [9] observed that the per cent cob damage by fall armyworm started from the 4th week of September, 38th SMW and continued till the 1st week of October (40th SMW) which ranged from 46.66 to 60.33 per cent.

Correlation between Weather Parameters and Larval Population of Fall armyworm, *S. frugiperda* infesting maize

The results of the analysis on the correlation between the larval population of fall armyworm and weather parameters (Table 3) revealed that the larval population of fall armyworm had a highly significant positive correlation with mean temperature ($r = 0.635^{**}$) while, it showed a non-significant positive correlation with bright sunshine hours ($r = 0.137$), maximum temperature ($r = 0.025$), minimum temperature ($r = 0.461$), morning relative humidity ($r = 0.220$), evening relative humidity ($r = 0.128$) and evaporation ($r = 0.203$). However, it exhibited a non-significant negative correlation with wind speed ($r = -0.051$) and rainfall ($r = -0.152$).

This indicated that the larval population increased with the increase in the maximum, minimum and mean temperature while decreasing with an increase in rainfall and wind speed.

While shifting the literature, according to Kumar *et al.* (2020) [12] larval population had a significant positive correlation with the maximum temperatures ($r = 0.7205$) and a significant negative correlation with relative humidity ($r = -0.6739$) and rainfall ($r = -0.8293$) during Kharif season which is closely in agreement with the present finding.

Table 1: Weather Parameters and Larval Population of Fall armyworm, *S. frugiperda*

Week after sowing	SMW	Month	No of <i>S. frugiperda</i> / plant	Temperature (°C)			Relative humidity (%)			BSS (hr)	RF (mm)	WS (hr)	Evaporation (mm)
				Max	Min	Mean	Mor. Rh	Eve. Rh	Mean Rh				
4	31	August	0.98	32.4	24.5	28.45	92	74	83	3.4	61.2	6.4	3.9
5	32		1.92	31.6	24.4	28.0	92	83	87.5	1.8	108.6	3.9	1.9
6	33		2.21	29.6	23.6	26.6	94	88	91	0.7	203.9	8.5	1.6
7	34		2.67	30.2	23.8	27.0	90	73	81.5	2.3	3.3	7.8	3.2
8	35		3.91	32.2	23.3	27.75	85	64	74.5	5.1	7.3	3.9	3.4
9	36	September	4.98	33.6	24.4	29.0	86	59	72.5	5.5	14	4.6	3.8
10	37		5.06	32.4	23.5	27.95	91	77	84	3	100.7	3.9	3.1
11	38		5.74	32.4	23.0	27.7	84	57	70.5	9	0	4.6	4.1
12	39		4.89	32.9	22.5	27.7	83	58	70.5	8.2	2.4	4.5	4.6
13	40		4.84	33.8	23.4	28.6	81	49	65	8.3	0	3.9	5.1
14	41	October	4.79	35.0	23.4	29.2	85	47	66	6.9	51.2	2.9	4.2
15	42		3.58	35.9	20.2	28.05	62	25	43.5	10.1	0	2.7	5.1
16	43		3.27	35.6	19.7	27.65	67	27	47	9.5	0	2.6	4.8
17	44		2.34	35.8	17.8	26.8	65	26	45.5	9.3	0	2.2	4.6
18	45		1.24	35.4	18.2	26.8	61	28	44.5	9	0	2.7	4.3
19	46	November	0.21	33.9	16.9	25.4	72	27	49.5	9.1	0	2.4	4.3

SMW: SMW Mor. Rh: Morning Relative Humidity

Eve. Rh: Evening Relative Humidity BSS: Bright Sunshine hours

WS: Wind Speed RF: Rain Fall

No. of observations: 17

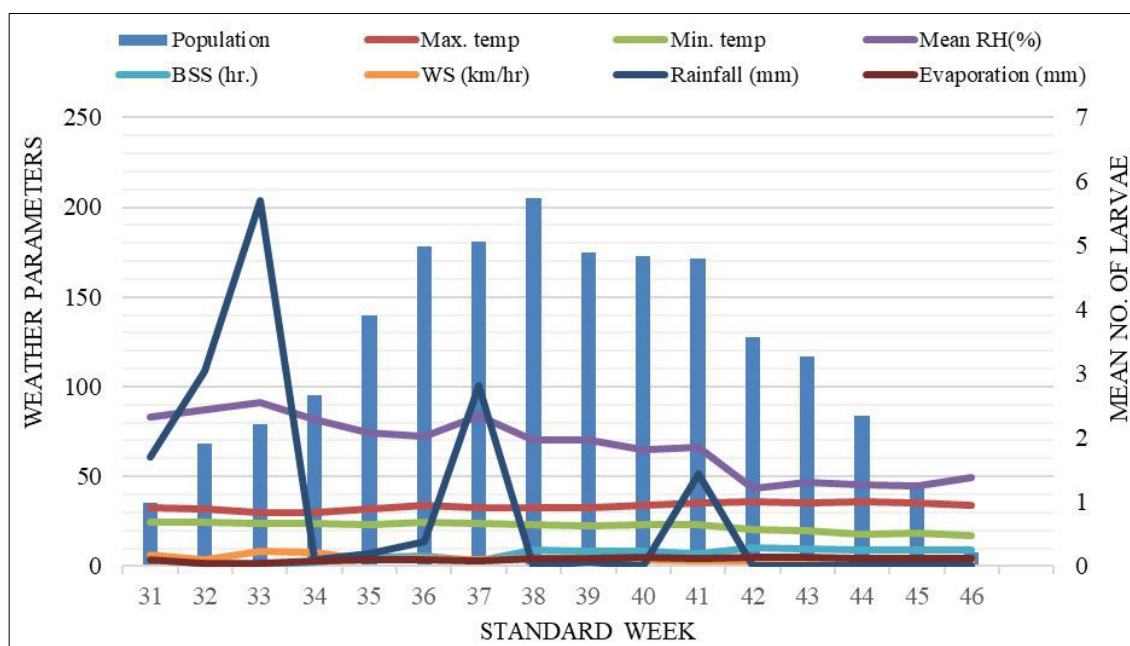
Table 2: Population dynamics of *S. frugiperda* infesting maize

Month	SMW	No of larva per plant	Plant damage (%)	Cob damage (%)
August	31	0.98	11.33	0
	32	1.92	33.66	0
	33	2.21	40.33	0
	34	2.67	46.66	0
	35	3.91	54.33	0
September	36	4.98	62.66	0
	37	5.06	78.66	44.61
	38	5.74	83.66	65.83
	39	4.89	82.33	77.27
October	40	4.84	81.33	76.99
	41	4.79	80.66	75.22
	42	3.58	80.33	74.33
	43	3.27	80.00	73.87
	44	2.34	79.33	73.63
November	45	1.24	78.66	72.72
	46	0.21	78.33	70.17

Table 3: Correlation matrix of weather parameters and *S. frugiperda* population

Weather parameters	Correlation
Maximum Temperature (° C)	0.025
Minimum Temperature (° C)	0.461
Mean Temperature (° C)	0.635**
Morning Relative humidity (%)	0.220
Evening Relative humidity (%)	0.128
Mean Relative humidity (%)	0.161
Bright sunshine (hr.)	0.137
Wind speed (km/hr)	-0.051
Rainfall (mm)	-0.152
Evaporation (mm)	0.203

Note: * Significant at 5% level and ** Highly significant at 5% and 1% level

**Fig 1:** Weather Parameters and Larval Population of Fall armyworm, *S. frugiperda*

Conclusion

The *S. frugiperda* population exhibited a consistent weekly increase, reaching its zenith at 5.74 larvae per plant during the 38th standard meteorological week, aligned with the third week of September. Following this peak, a decline ensued in the fourth week of September, with an average of 4.89 larvae per plant during the 39th standard meteorological week. Examination of weather parameters revealed an inverse relationship between *S. frugiperda* population and

rainfall. The population of *S. frugiperda* increased with the increase in mean temperature. Consequently, both rainfall was determined to be adversely correlated with the incidence of *S. frugiperda* in maize. In contrast, the consideration of temperature as a parameter indicated a positive correlation, signifying that the population of the maize fall armyworm, *S. frugiperda*, increased with rising temperatures.

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