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Seasonal abundance of fall armyworm, *Spodoptera frugiperda* on maize in relation to abiotic factors

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Abstract
An experiment was conducted to observe the seasonal abundance of *S. frugiperda* were recorded weekly for the both years from July to October (2019-2021) wherein, the data larval population and plant damage were recorded and then subjected to statistical analysis. Seasonal abundance studies revealed that the larval population and plant damage due to *S. frugiperda* was started after 3rd week of sowing. It was increased gradually and reached at its peak in 39th SMW. Thereafter, larval population and plant damage started decline and recorded minimum in 44th SMW. The correlation studies revealed that the damage by *S. frugiperda* on maize showed significant maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, were found positively correlated; remaining three factors *viz*. rainfall and sunshine hour, were found negatively correlated.

Keywords: Seasonal incidence, abiotic factors, fall armyworm

Introduction
Maize, *Zea mays* L. (Poaceae) is one of the most adaptable crop having wider acceptability under varied agro-climatic conditions, in every parts of globe except Antarctica. Universally, maize is known as "Queen of cereals" because of its high genetic yield potential among the cereals and third important cereal crops next to wheat and rice in the world. Seventy countries, including 53 developing countries, plant maize more than 100,000 ha. In India, maize is cultivated to serve various purposes like human consumption, cattle and poultry feed, food processing and in the extraction of starch, dextrose, corn syrup, corn oil. Maize contains approximately 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100 g. The crop is attacked by several pests *viz*., insects, nematodes, mites, birds, rodents. As many as 141 insect pests cause varying degree of damage to maize from the time of sowing till harvest. The Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), an invasive pest which is highly migratory and economically destructive, is native of tropical and subtropical regions of the Americas. Being polyphagous, feeds on maize, rice, sorghum, millet, sugarcane, vegetable crops and cotton but can feed more than 80 additional species of crops. The first infestation of FAW was reported formally in Africa during January 2016 and spread to several parts of African continent. Maize losses have been estimated at 2.5 to 6 million US $ in Africa in 2019. FAW has the potential of causing losses from 8 to 20 million tons of maize every year in the absence of effective control methods in 12 maize producing countries of Africa and has invaded the 44 African nations already. The FAW in the last two years caused damage to more than 1.5 million ha of maize crop in Africa alone affecting the food security and livelihoods of several million small holder farmers. The pest has been reported for the first time in India in Karnataka in July 2018 and subsequently in few other states, such as Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Odisha.

Material and Methods
The studies A field experiment was conducted during *Kharif* 2019 and *Kharif* 2020 at the Research farm of PGI, Department of Agricultural Entomology, MPKV, Rahuri. The plot size was 4x3 m with 45 cm x 15 cm spacing. Number of infested plants per plot was recorded weekly interval. Per cent damage was recorded on five randomly selected plants at an interval of seven days during the crop period. For the ease of analysis and findings, meteorological data will also recorded at weekly interval. The data on infestation of insect pests will be correlated with prevailing temperature, rainfall, relative humidity, sunshine hours and wind velocity. Using standard statistical procedure as suggested Steel and Torrie (1980).

Results and Discussion

Observations on Seasonal abundance (2019-2020)

The data on larval population and plant infestation are tabulated in Table 4.1 and depicted in Fig 4.1 and 4.2, respectively. The data reveals that the maximum larval population (2.6 larvae per plant) along with the highest plant infestation (42.36%) were recorded in the fourth week of September, 2019 (39th SMW). The lowest larval population (0.2 larvae per plant) along with the lowest plant infestation (7.5%) were noticed in the last week of October, 2019 (44th SMW).

The data on per cent plant infestation and larval population were correlated with the abiotic factors are presented in Table 4.3.

The data on plant infestation reveals that the the maximum temperature (r = 0.505), morning relative humidity (r = 0.355), evening relative humidity (r = 0.355), sunshine (r = 0.065) were positively correlated with plant infestation whereas the minimum temperature (r = 0.486) were significantly positively correlated with plant infestation and Rainfall (r = -0.003) were observed to be negative correlation.

The data on larval population reveals that the maximum temperature (r = 0.505) were significant positively correlated with larval population whereas sunshine (r = 0.065) was correlated as highly significantly positive and Rainfall (r = -0.221) were found to be negatively correlated whereas, the minimum temperature (r = 0.389), morning relative humidity (r = 0.355), evening relative humidity (r = 0.355), were observed to be positive correlation with larval population.

Observations on seasonal abundance (2020-2021)

The data on larval population and plant infestation are tabulated in Table 4.2 and depicted in Fig 4.1 and 4.2, respectively. The data reveals that the maximum larval population (2.4 larvae per plant) along with the highest plant infestation (29.33%) was recorded in the fourth week of September, 2020 (39th SMW). The lowest larval populations (0.1 larvae per plants) along with the lowest plant infestation (7.5%) were noticed in the last week of October, 2029 (44th SMW).

The data on per cent plant infestation and larval population were correlated with the abiotic factors are presented in Table 4.4.

The data on plant infestation reveals that maximum temperature (r = 0.563), minimum temperature (r = 0.578), morning relative humidity (r = 0.482), were found to be significant positively correlated with plant infestation whereas, evening relative humidity (r = 0.374) were observed to be positive correlated with plant infestation and rainfall (r = -0.007), Sunshine hr (r = -0.213was correlated as negative.

The data on larval population reveals that maximum temperature (r = 0.567), minimum temperature (r = 0.572), were found to be significant positively correlated whereas the morning relative humidity (r = 0.422), evening relative humidity (r = 0.287) were observed to be positively correlated and rainfall (r = -0.125), Sunshine hr (r = -0.182) was correlated as negative.

Table 1: Seasonal abundance of *S. frugiperda* on maize (2019-2020)

Month	SMW	Average No. of Larvae/ plant *	Plant damage % *	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Sunshine (hr)
				Max	Min	Morning	Evening		
06-12 August	32	0	0	28.0	23.3	80	68	3.6	7.7
13-19 August	33	0	0	31.0	22.5	75	59	1.4	8.3
20-26 August	34	0.8	20.83	32.5	21.3	72	47	84.2	8
27-02 August	35	0.8	18	32.0	23.0	75	56	87.2	9.6
03-09 September	36	1.0	24.16	30.0	23.3	77	71	0.0	9.7
10-16 September	37	1.2	25.83	28.8	22.5	78	68	21.6	9.2
17-23 September	38	1.8	26.66	29.8	21.7	83	71	3.0	8.6
24-30 September	39	2.6	41.66	30.2	21.9	83	67	0.0	8.9
01-07 October	40	2.4	30.33	31.1	21.1	80	59	0.0	8.9
08-14 October	41	1.4	24.8	31.7	21.1	77	50	2.8	9.2
15-21 October	42	1.2	20	31.4	18.6	81	68	4.0	9
22-28 October	43	0.2	14.16	32.1	20.8	87	79	141.8	9.4
29-04 October	44	0.2	7.5	30.4	21.0	84	58	52.8	10.5
05-11 November	45	0	0	31.1	18.4	76	46	2.34	10.3
12-18 November	46	0	0	32.6	16.7	73	48	0.0	10.5
19-25 November	47	0	0	30.8	15.2	74	45	0.0	10.8
26-02 November	48	0	0	30.5	15.9	74	44	0.0	10.9

* Mean of observation from 5 plants

Table 2: Seasonal abundance of *S. frugiperda* on maize (2020-2021)

Month	SMW	Average No. of Larvae/ plant *	Plant damage % *	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	Sunshine (hr)
				Max	Min	Morning	Evening		
06-12 August	32	0	0	30.2	23.8	86	64	016.6	03.4
13-19 August	33	0	0	26.1	23.0	90	69	056.0	0.03
20-26 August	34	0.6	20.83	28.7	23.4	87	64	013.2	04.2
27-02 August	35	0.6	18	29.5	23.1	86	60	002.2	04.3
03-09 September	36	0.8	23.16	32.9	23.7	90	56	024.8	6.7
10-16 September	37	1	24.83	29.7	23.5	92	63	063.4	4.2
17-23 September	38	1.6	25.66	28.4	23.3	93	64	281.8	2.5
24-30 September	39	2.4	29.33	30.3	23.0	90	56	015.8	5.8
01-07 October	40	2.2	23.33	31.7	23.5	85	47	009.4	8.0
08-14 October	41	1.6	23.8	31.4	23.7	89	54	010.6	4.5
15-21 October	42	1.4	19	29.8	23.1	92	63	114.6	4.8

22-28 October	43	0.2	9.5	30.1	21.5	90	55	021.4	6.7
29-04 October	44	0.1	7.5	30.9	18.0	87	37	000.0	8.9
05-11 November	45	0	0	29.1	13.9	84	33	000.0	09.1
12-18 November	46	0	0	29.9	18.4	83	41	000.0	09.2
19-25 November	47	0	0	30.6	19.0	89	44	004.2	07.8
26-02 November	48	0	0	28.2	17.5	82	44	000.0	08.2

*Mean of observation from 5 plants

Table 3: Correlation co-efficient for larval population and plant damage percent of *S. frugiperda* and respective abiotic factors (2019-2020).

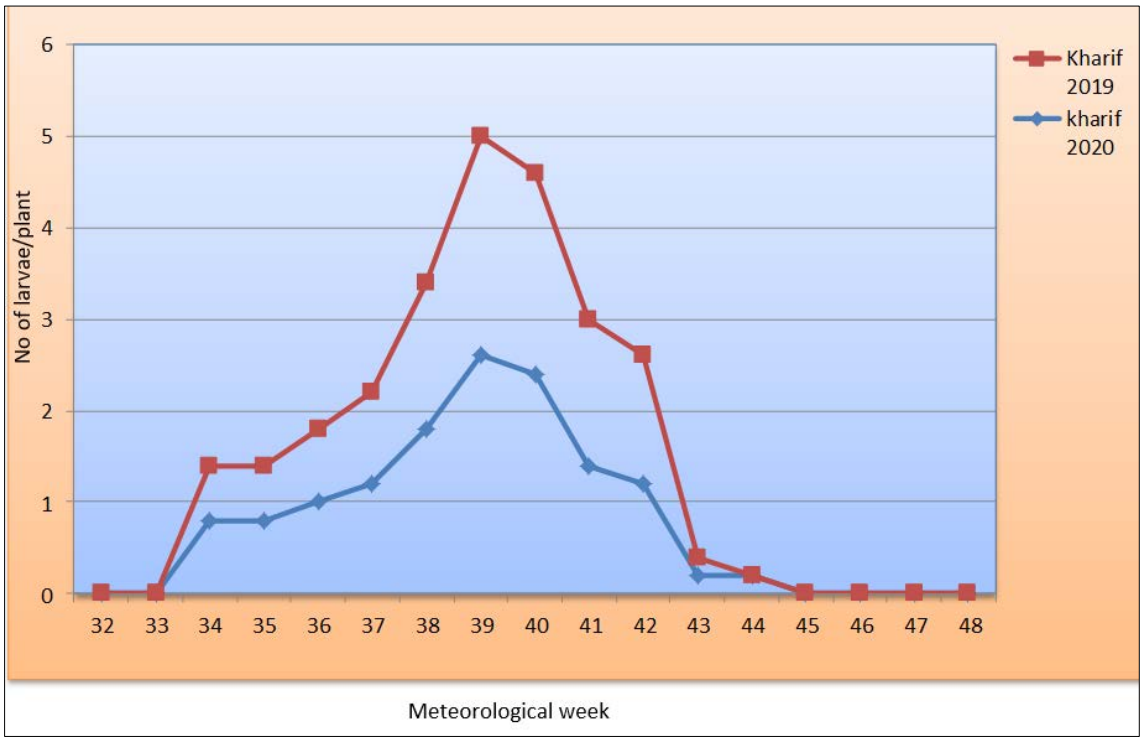
Weather parameters	Correlation coefficient value	
	Average number of Larvae / plant	Plant damage %
Max. Temperature (^{0}C)	0.505*	0.465
Min. Temperature (^{0}C)	0.389	0.486*
Morning RH (%)	0.355	0.354
Evening RH (%)	0.355	0.424
Rainfall (mm)	-0.221	-0.003
Bright Sunshine (hr)	0.065**	0.041

* 5% level of significance df 15=0.482
** 1% level of significance df 15 =0.606

Table 4: Correlation co-efficient for larval population and plant damage percent of *S. frugiperda* and respective abiotic factors (2020-2021)

Weather parameters	Correlation coefficient value	
	Average number of Larvae / plant	Plant damage %
Max. Temperature (^{0}C)	0.567*	0.563*
Min. Temperature (^{0}C)	0.572*	0.578*
Morning RH (%)	0.422	0.482*
Evening RH (%)	0.287	0.374
Rainfall (mm)	-0.125	-0.007
Bright Sunshine (hr)	-0.182	-0.213

* 5% level of significance df 15=0.482
** 1% level of significance df 15 =0.606



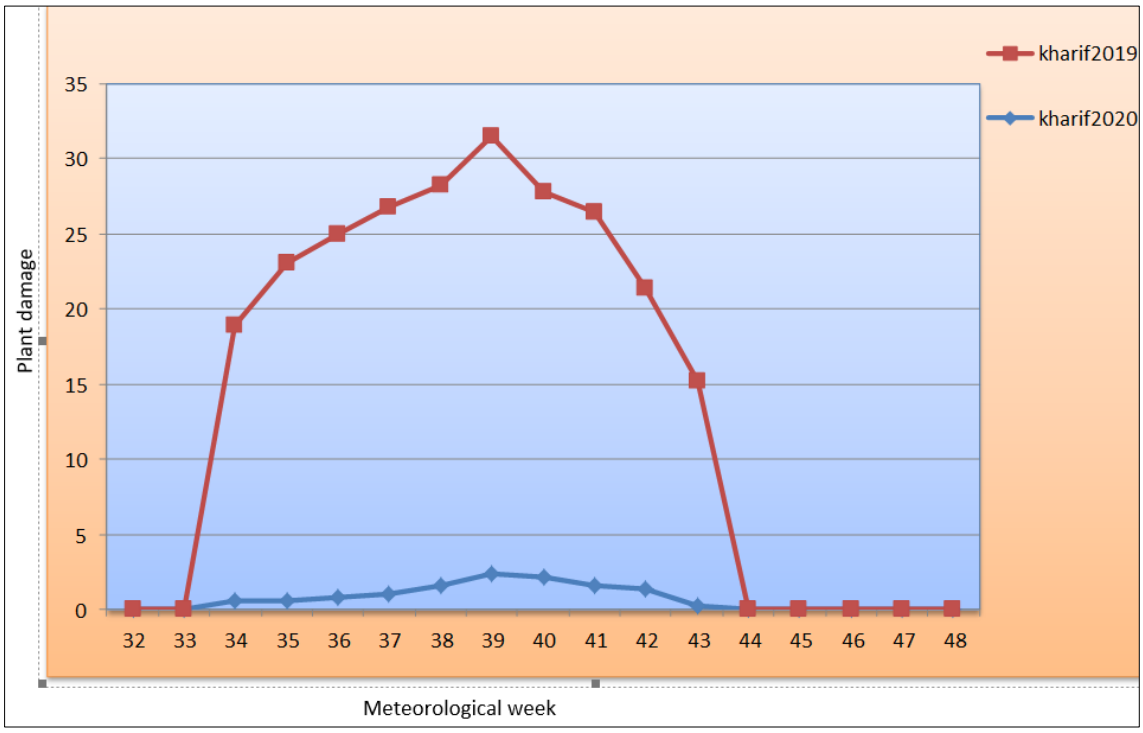


Fig 1: Seasonal abundance of *S. frugiperda* larvae and plant damage on maize during *Kharif*, 2019 and 2020

Conclusion

The pest occurs throughout year. The abiotic factors *viz*. maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, were found positively correlated indicating that the increase in the larval population was synchronized with these factors. The remaining factors *viz*. sunshine (hr), and rainfall were found negatively correlated indicating that the decrease in the larval population was influenced by these factors. There is a close relationship exists between the aforesaid factors and the new flush for the occurrence of the pest which may be useful for developing the prediction model.

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