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Ankur
Ph.D., Scholar, Rajasthan College of Agriculture, (RCA), Maharana Pratap University of Agriculture and Technology, University in Udaipur, Rajasthan, India

Ravindra Kumar Patel
Professor, CPCA, Sardarkrushinagar Dantiwada Agricultural University, Gujarat, India

Tanmaya Kumar Bhoi
Scientist-B, ICFRE-Arid Forest Research Institute, Jodhpur, Rajasthan, India

Mohanlal Pensiya
Department of Entomology, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Mohan Lal Tetarwal
Associate Professor, KVK-Jalore-II, Bamanwara, Agriculture University, Jodhpur, Rajasthan, India

Ipsita Samal
Assistant Professor, Sri Sri University, Cuttack, Odisha, India

Prasanta Kumar Majhi
Department of Plant Breeding and Genetics, Regional Research and Technology Transfer Station (RRTTS), Odisha University of Agriculture and Technology (OUAT), Keonjhar, Odisha, India

Corresponding Author:
Ankur
Ph.D., Scholar, Rajasthan College of Agriculture, (RCA), Maharana Pratap University of Agriculture and Technology, University in Udaipur, Rajasthan, India

Impact of weather parameters on okra shoot and fruit borer infestation

Ankur, Ravindra Kumar Patel, Tanmaya Kumar Bhoi, Mohanlal Pensiya, Mohan Lal Tetarwal, Ipsita Samal and Prasanta Kumar Majhi

Abstract
Okra, *Abelmoschus esculentus* (L.) Moench is an important vegetable crop in the tropics and subtropics, grown throughout the year. This crop is severely damaged by more than 30 pests among them shoot and fruit borer (*Earias vittella*) is major one. Climatic factors play vital role in multiplication and distribution of okra fruit and shoot borer (OSFB). Therefore, the experiment was conducted to study the effect of seasonal incidence and weather parameter impact on OSFB infestation. The incidence of shoot damage was observed maximum (23.50%) during the 34th SMW and the infestation of fruits by *E. vittella* observed the peak level (36.80%) at 39th SMW. The correlation analysis revealed that the negative and significant correlation between maximum temperature and shoot damage. Whereas, positive and significant correlation was observed between shoot damage with morning relative humidity and evening relative humidity. Among various weather parameters, minimum temperature and wind velocity shows negative and significant correlation with fruit damage.

Keywords: OSFB, Okra, *Earias vittella,* weather parameters, infestation

Introduction
Okra, *Abelmoschus esculentus* (L.) Moench is an important vegetable crop in the tropics and subtropics, grown throughout the year ((Iqbal *et al*., 2012; Abang *et al*., 2014) [7, 1]. This crop is severely damaged by more than 30 pests at different stages of plant growth (Halder *et al*., 2016) [5]. Among the different insect pests of okra, some of them are key pests and occurring regularly during the crop season. Now a days shoot and fruit borer (*Earias vittella*) is becoming serious and attaining economic importance. Okra shoot and fruit borer (OSFB) infestations typically accounted for a 48.97% loss in the okra pod yield (Hashmi, 1994) [6]. The OSFB larvae cause damage in the vegetative and reproductive phases of the okra. Larvae also bore into the flower buds and fruits in the reproductive stage, and feed on internal tissues. Therefore, the infested flower buds' drop-off and infested fruits become deformed in shape, which lowers their market value (Tariq *et al*., 1991) [17]. OSFB alone causes a damage of between 52.33% and 70.75% (Lateef *et al*., 1991) [8]. Climatic factors like temperature and relative humidity play vital role in multiplication and distribution of insect-pests (Ghongade *et al*., 2021) [4]. Therefore, a good understanding of pest population dynamics is of vital importance for crop protection and proper management of OSFB. Keeping in view the importance of the crop and the damage caused by this pest, the present investigations were initiated to study the population dynamics of *E. vitella* and to deduce relationship with the abiotic factors, which would help in planning strategies for the management of the OSFB under field condition.

Materials and Methods
In order to study the population dynamics of shoot and fruit borer of okra, a field experiment was conducted at Horticultural Instructional Farm, C. P. College of Agriculture, S. D. Agricultural University, Sardarkrushinagar during kharif, 2019-2020in a Randomized Block Design (RBD) with three replications. The okra variety GOA 5 was sown with a plot area of size 3.0 m × 3.6 m, spacing 60 cm X 30 cm. The crop was raised by adopting standard agronomical practices and the whole experimental plot was kept free from application of any insecticides.

Observation
For this purpose, twenty-five plants were selected randomly from the whole experimental plot

and tagged. For the recording of shoot damage, damaged shoots were counted from selected plants and the per cent shoot damage was computed on the basis of number of infested shoots out of total number of shoots from selected plants in each plot. Fruit damage was recorded after each picking. Picking was done at a weekly interval. Infested and healthy fruits were sorted out and weights of infested as well as total harvested fruits were recorded. Per cent fruit damage was worked out on the basis of weight of infested fruits out of total weight of harvested fruits from the selected plants and data was correlated with weather parameters and analysed statistically.

Following formula was used to estimate the damage

$$\text{Per cent shoot damage} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

$$\text{Per cent fruit damage} = \frac{\text{Weight of infested fruits}}{\text{Total weight of harvested fruits}} \times 100$$

Weather parameters
In order to study the influence of weather parameters *viz*., maximum and minimum temperature, morning and evening relative humidity, rainfall, rainy days, wind velocity and sunshine hours on population dynamics of shoot and fruit borer in okra and the simple correlation coefficient was worked out. Weekly meteorological data recorded at the meteorological observatory, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar was used to study the effect of weather parameters on population of okra shoot and fruit borer.

Statistical analysis
The data on weather parameter and percentage of shoot and fruit damage were subjected to analysis of variance (ANOVA) using randomized block design. The significance of differences among treatments will be tested by F-test and the treatment means were compared by least significant differences (LSD) at P = 0.05 using the statistical software SPSS. The correlation between weather parameters and OSFB infestation were analysed using SPSS software.

Results
Percent Shoot damage
The data presented in Table 1 clearly indicated that the per cent shoot infestation by *E. vittella* started from 30th SMW *i.e.*, the 4th week after sowing with 5.00 per cent shoot damage. Shoot damage increased regularly and reached the peak in 34th SMW *i.e.*, the 8th week after sowing with 23.50 per cent shoot damage. Thereafter, the shoot damage declined and reached 3.57 per cent during 37th SMW *i.e.*, 11th week after sowing. The shoot infestation varied from 3.57 to 23.50 per cent. Thus, from the results of seasonal incidence, it can be inferred that the infestation of shoot by *E. vittella* started during July and reached peak level in the month of August.

Percent Fruit damage
The data presented in Table 1 clearly indicated that the per cent fruit infestation by *E. vittella* started from 33rd SMW *i.e.*, the 7th week after sowing with 6.72 per cent fruit damage. Fruit damage increased regularly and reached the peak in 39th SMW *i.e.*, the 13th week after sowing with 36.80 per cent fruit damage. Thereafter, the fruit damage showed declining trend but infestation continued till removal of crop. The fruit infestation varied from 6.72 to 36.80 per cent. Thus, from the results of seasonal incidence, it can be inferred that the infestation of fruits by *E. vittella* started during August and reached peak level in the month of September.

Table 1: Population of *E. vittella* with weather parameters in okra during *kharif* 2019

Observations (Standard Meteorological weeks)	Month and Week	Week After Sowing	Damage (%)		Weather parameters							
			Shoot damage	Fruit damage	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Rainy Days	Wind Velocity (km/hr)	Sunshine (hours/day)
					Maximum	Minimum	Morning	Evening				
27	July I	1	0.00	0.00	36.2	24.5	71.4	60.8	55.0	1	7.7	4.6
28	July II	2	0.00	0.00	36.0	25.8	67.3	63.0	0.0	0	13.6	1.7
29	July III	3	0.00	0.00	38.1	26.1	61.7	56.8	20.0	1	8.6	5.6
30	July IV	4	5.00	0.00	36.5	25.8	72.3	70.1	19.2	2	8.9	5.4
31	August I	5	9.52	0.00	32.2	25.6	81.4	75.7	28.0	2	6.1	0.9
32	August II	6	17.21	0.00	31.2	24.8	84.2	78.1	105.0	4	6.7	0.0
33	August III	7	21.55	6.72	30.2	23.9	81.1	81.6	103.0	4	4.6	1.4
34	August IV	8	23.50	15.80	33.5	25.0	77.3	68.1	24.0	1	2.9	7.8
35	August V	9	13.55	19.21	29.9	24.6	81.7	79.1	150.2	4	4.3	1.6
36	September I	10	7.14	26.87	33.8	25.3	77.6	75.6	34.7	3	3.2	4.4
37	September II	11	3.57	33.55	32.5	25.4	79.7	73.6	29.0	3	3.7	1.3
38	September III	12	0.00	35.14	33.7	24.2	76.5	73.5	25.0	3	3.7	6.2
39	September IV	13	0.00	36.80	30.8	23.8	79.3	77.4	68.8	4	4.4	4.3
40	October I	14	0.00	34.26	33.9	23.1	75.5	60.8	80.0	1	3.5	5.6
41	October II	15	0.00	32.40	35.8	21.1	67.5	52.8	0.0	0	2.0	9.2
Mean			6.74	16.05	33.62	24.6	75.63	69.8	49.46	2.2	5.59	4.00

Correlation of percent shoot damage with weather parameters
The results on influence of weather parameters on shoot damage by *E. vittella* summarized in Table 2 clearly indicated that shoot damage exhibited negative and significant correlation with maximum temperature (r = -0.576*). whereas, it has shown positive and non-significant correlation with minimum temperature, rainfall and rainy days (r = 0.125,

0.456 and 0.411, respectively). Shoot damage exhibited positive and significant correlation with morning relative humidity and evening relative humidity (r = 0.602* and 0.564*, respectively). While it has shown negative and non-significant correlation with wind velocity and sunshine hours (r = -0.235 and -0.306).

Correlation of percent fruit damage with weather parameters

The results on influence of weather parameters on fruit damage by *E. vittella* summarized in Table 2 clearly indicated that fruit damage exhibited negative and non-significant correlation with maximum temperature (r = -0.271). Whereas, fruit damage exhibited a negative and significant correlation with minimum temperature (r = -0.563*) and negative and highly significant with wind velocity (r = -0.743**).There was a positive and non-significant correlation with morning relative humidity, evening relative humidity, rainfall, rainy days and sunshine hours (r = 0.190, 0.033, 0.011, 0.178 and 0.377, respectively).

Table 2: Correlation coefficient of*E. Vittella* with weather parameters

Parameters	Correlation coefficient values (r)							
	Temperature (°C)		R. H. (%)		Rainfall (mm)	Rainy Days	Wind Velocity (km/hr)	Sunshine (hours/ day)
	Maximum	Minimum	Morning	Evening				
Shoot damage	-0.576 *	0.125	0.602 *	0.564 *	0.456	0.411	-0.235	-0.306
Fruit damage	-0.271	-0.563 *	0.190	0.033	0.011	0.178	-0.743**	0.377

*Correlation is significant at the 0.05 level (r = 0.514)

** Correlation is significant at the 0.01 level (r = 0.641)

Discussion

In the present investigation, the shoot damage started from 30th SMW *i.e.*4th week after sowing during *kharif*, 2019-2020. The maximum shoot damage (23.50%) was observed in the 34th SMW *i.e.*8th week after sowing. The shoot infestation varied from 3.57 to 23.50 per cent during the period of study. The infestation of fruits by *E. vittella* started from 33rd SMW *i.e.*7th week after sowing during *kharif*, 2019-2020. It was increased rapidly and reached the peak level (36.80%) during the 13th week after sowing (39th SMW). The fruit infestation varied from 6.72 to 36.80 per cent during the period of study and declining trend continue till removed of crops. Similar pattern of the occurrence and fluctuation of this pest in okra crop also reported by Patel (2004) [12] that the shoot infestation commenced from 31st*i.e*., the first week of August with 6.00 per cent shoot damage and reach peak in 35th SMW *i.e.*, the fourth week of August with 24.00 per cent shoot damage. Meena *et al.* (2010) [10] studied the incidence of shoot and fruit borer (*E. vittella* and *E. insulana*) on okra. They observed that shoot infestation which occurred from the first week of August until the harvesting of the crop, gradually increased from 1.0 and 0.66% during the initial stages to 23.0 and 25.0% on the third week of October in 2002 and 2003, respectively. Minimum temperature and relative humidity had a significant negative correlation with shoot borer infestation. Fruit borer infestation commenced on the first week of September in 2002 and 2003. The level of infestation gradually increased as the crop matured, reaching a peak of 31.6% in terms of number and 29.7% on a weight basis in 2002 (34.0 and 31.0%, respectively, in 2003). The maximum and minimum temperatures were negatively correlated with fruit borer infestation. Sharma *et al.* (2010) [15] conducted a field experiment to study the fluctuation of pest population of *E. vittella* and their relation with prevailing weather conditions. The results revealed that borer incidence commenced in the 29th standard week. The peak infestation of plants (91.6%) was observed in 45th standard week. The maximum numbers of larvae (7.5 larvae/10 plants) were recorded in the 42nd standard week. The maximum quantum of damaged fruits on number basis was 54.3% and on weight basis was 54.7% when the crop was 18 weeks old in 42nd standard week. Furthermore, the correlation analysis revealed that the infestation of *E. vittella* on shoots indicated a positive and significant correlation with morning relative humidity and evening relative humidity. Whereas, the correlation between maximum temperature and shoot damage was negative and significant. The minimum temperature, rainfall and rainy days exerted a positive and non-significant correlation with shoot damage. A negative and non-significant correlation was observed between shoot damage against wind velocity and sunshine hours. Moreover, the infestation of *E. vittella* on fruits was showed negative and significant correlation with minimum temperature and wind velocity. Whereas, the infestation of shoot and fruit borer on fruits was negative and non-significantly correlated with maximum temperature. There was a positive and non-significant correlation between fruit damage and morning relative humidity, evening relative humidity, rainfall, rainy days and sunshine hours. In past, Patel *et al*. (2014) [13] found that the maximum temperature had significant negative influence on shoot damage. Whereas, Singh (2015) [16] found positive and non-significant correlation with minimum temperature. Nath (2011) [11] and Akhila *et al*. (2019) [2] observed that the morning relative humidity and evening relative humidity had a positive and highly significant correlation with shoot damage. Thus, the present finding tally with the earlier works. Patel (2004) [12] studied that the wind velocity showed significantly negative correlation with fruit infestation. Archunan *et al.* (2018) [3] observed that the fruit damage of bhendi was positively non-significant association with relative humidity. Akhila *et al*. (2019) [2] revealed that the rainfall, sunshine hours showed positive and non-significant correlation with fruit damage. Whereas, minimum temperature with fruit damage showed a negative and significant relationship. Rawat *et al*. (2020) [14] observed that the morning relative humidity had a non-significant and positive correlation with fruit damage. Above all the references strongly support the present findings.

Conclusion

It is evident from the study that the incidence of shoot damage was maximum during the 34th SMW (23.50%).The infestation of fruits by *E. vittella* increased rapidly and reached the peak level (36.80%) at 39th SMW. The correlation studies revealed that the positive and significant correlation was observed between shoot damage with morning relative humidity and evening relative humidity. Whereas, negative and significant correlation show between minimum temperature and wind velocity with fruit damage

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Conflict of interest
The authors declare that they have no conflict of interest.

Author Contribution
Ankur has conducted the entire work under the guidance of Ravindra Kumar Patel and Mohan Lal Tetarwal. Tanmaya Kumar Bhoi and Prasnta Kumar Majhi has analysed the data. Ipsita Samal and Mohanlal Pensiy has given constructive suggestions while writing this manuscript.

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