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Multiple regression of weather parameters against shoot & fruit-borer on okra

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Abstract
An experiment has been conducted to assess the effect of different weather parameters and their multiple regression in okra against okra fruit and shoot borer. The results revealed that the R2 value indicated that the weather parameters contributed for shoot and fruit borer 79.5 and 92.6 per cent in 2017-18 and 2018-19 in of total variation in *Earias vitella* on okra. The weather parameters indicted that 73.9 and 75.9 per cent for shoot damage and for fruit damage were 88.7 and 99.5 per cent, during 2017-18 and 2018-19 respectively.

Keywords: *Earias vitella*, weather parameters and fruit damage

Introduction
In India, vegetables have occupied the prime position in human diet, as these are the cheaper source of carbohydrate, minerals, vitamins, proteins, dietary fibers besides having medicinal value and provide nutritional security to a predominately vegetarian population. Among different vegetables, okra, *Abelmoschus esculentus* (L.) Moench belonging to the family Malvaceae is an important annual vegetable, grown for its immature green non-fibrous edible fruits in the tropical and sub-tropical regions of the world. It is commonly known as "Gumbo" as well as "Okra" in USA, lady's finger in England and "*Bhindi*" or "*Bhinda*" in India. It is probably originated in Ethiopian region of Africa, but is now widely grown in Sudan and Nigeria regions of the Africa besides being grown in other countries. Because of its high nutritive value and prolonged shelf life as compared to others, okra has captured a prominent position among export-oriented vegetable crops. It has a vast potential as one of the foreign exchange earner crop and accounts for about 60 per cent of the total export of fresh vegetables [1, 2, 3, 4].

Okra has its own importance, taste, flavor and nutritional values as human food. It has good nutritional value particularly high content of calcium and vitamin C [5, 6]. It is grown extensively in the tropical, subtropical and warm temperature regions of the world especially in India, U.S.A., Africa, Asia, Nigeria, Sudan, Iraq, Pakistan, Turkey, Australia, U.K. and other neighboring countries. India ranks first in area and production in the world. It is a major commercial vegetable cultivated all over India particularly in the states of Andhra Pradesh, West Bengal, Jharkhand, Orissa, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat and Maharashtra. India occupies an area of 532.66 thousand hectares with a production of 6346.37 thousand tones and productivity of 11.9 MT/ha [7, 32, 33, 34, 35].

The *Earias vittella* (Lepidoptera: Noctuidae) is a widely distributed insect pest. The attack of shoot and fruit borer (*E. vittella*) on okra starts 4 to 5 weeks after germination both in *Kharif* and summer seasons. The infested top tender shoots dries-up while flower, buds and developing fruits drop down pre-maturely and damaged fruits become unfit for human consumption. It is estimated that about 69 per cent loss in marketable yield due to attack of this insect on okra [8, 29, 30, 31]. In general, the overall damage due to the insect pests attack, results in 48.97 per cent loss in pod yield [9].

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Material and Methods
The experiment was carried out on the seasonal incidence of shoot and fruit borer on okra at the farm of Department of Agril.

Entomology, VNMKV, Parbhani during *Kharif* season of 2017-18 and 2018-19. The okra (Parbhani OK) was sown in a block size of 10 m x 10 m keeping the spacing of 60 X 30 cm. All the recommended agronomic practices *viz.* weeding, harrowing, application of fertilizer doses and irrigation were carried out timely and properly to raise good crop. This area was divided into four quadrates (5 m X 5m). No insecticidal treatments were applied at any stage of the crop growth. The number of larvae per plant was counted and recorded till harvest of crop at weekly intervals on five randomly selected plants. Total number of fruits and damaged fruits were counted till harvest of crop at weekly intervals on five randomly selected plants from each quadrate and per cent fruit damage was worked out. Total number of damaged shoots and healthy shoots were counted from each quadrate and per cent shoot damage was worked out.

Result and Discussion

Regression studies of *Earis vitella*

The multiple regression was worked out between weather parameters and larval population of shoot and fruit borer during 2017-18 and 2018-19 and presented in Table 1 and Table 2, respectively.

Table 1: Multiple regression of weather parameters and larval population of shoot & fruit borer on okra (2017-18)

Weather parameters	Reg. coefficients (b)	SE(b)	T Test	T table (0.05)
Rainfall (mm) (B1)	0.001	0.007	0.093	2.571
Max. Temp. (0C) (B2)	0.021	0.025	0.845	2.571
Min. Temp. (0C) (B3)	0.013	0.038	0.338	2.571
Morning RH (%)(B4)	0.032	0.081	0.392	2.571
Evening RH (%)(B5)	0.052	0.027	1.937	2.571
EVP (mm) (B6)	0.453	0.363	1.249	2.571
BSS (Hrs.) (B7)	0.149	0.169	0.882	2.571
Wind velocity (B8) (Hrs/km)	-0.535	0.218	-2.451	2.571

Intercept (a) = 5.919
Coefficient of determination (R Square) = 0.795

Table 2: Multiple regression of weather parameters and larval population of shoot & fruit borer on okra (2018-19)

Weather parameters	Reg. coefficients (b)	SE(b)	T Test	T table (0.05)
Rainfall (mm) (B1)	-0.003	0.003	-1.030	2.571
Max. Temp. (0C) (B2)	-0.207	0.056	-3.676	2.571
Min. Temp. (0C) (B3)	0.108	0.093	1.160	2.571
Morning RH (%)(B4)	0.114	0.048	2.382	2.571
Evening RH (%)(B5)	-0.013	0.021	-0.612	2.571
EVP (mm) (B6)	0.125	0.179	0.698	2.571
BSS (Hrs.) (B7)	-0.094	0.061	-1.540	2.571
Wind velocity (B8) (Hrs/km)	0.091	0.126	0.724	2.571

Intercept (a) = 1.548
Coefficient of determination (R Square) = 0.926

The regression equation worked out during 2017-18 is as follow.

Y = 5.919+ (0.001) B1 + (0.021) B2 + (0.013) B3 + (0.032) B4 + (0.052) B5 +(0.453) B6+(0.149) B7 + (-0.535) B8 +0.443

The regression equation worked out during 2018-19 is as follow.

Y = 1.548+ (-0.003) B1 +(-0.207) B2 + (0.108) B3 + (0.114) B4 + (-0.013) B5 +(0.125) B6 +(-0.094) B7 + (0.091) B8 +0.248. The weather parameters contributed for 79.5 per cent during 2017-18 and 92.6 per cent during 2018-19 of total variation in the population of shoot and fruit borer on okra. The coefficient of determination was very high during 2018-19 indicating that the prediction of shoot and fruit borer population by using weather parameters was more reliable [10, 11, 12, 13, 14].

Regression studies of shoot damage

The multiple regression was worked out between weather parameters and per cent shoot damage by shoot and fruit borer during 2017-18 and 2018-19 and presented in Table 3 and Table 4, respectively.

Table 3: Multiple regression of weather parameters with per cent shoot damage by shoot & fruit borer on okra (2017-18)

Weather parameters	Reg. coefficients (b)	SE(b)	T Test	T table (0.05)
Rainfall (mm) (B1)	-0.044	0.027	-1.638	2.571
Max. Temp. (0C) (B2)	-0.466	0.447	-1.044	2.571
Min. Temp. (0C) (B3)	-0.318	0.741	-0.429	2.571
Morning RH (%)(B4)	0.483	0.378	1.277	2.571
Evening RH (%)(B5)	0.085	0.170	0.499	2.571
EVP (mm) (B6)	-0.601	1.419	-0.424	2.571
BSS (Hrs.) (B7)	0.372	0.486	0.766	2.571
Wind velocity (B8) (Hrs/km)	-0.498	0.997	-0.499	2.571

Intercept (a) = 10.867 Coefficient of determination (R Square) = 0.759

Table 4: Multiple regression of weather parameters with per cent shoot damage by shoot & fruit borer on okra (2018-19)

Weather parameters	Reg. coefficients (b)	SE(b)	T Test	T table (0.05)
Rainfall (mm) (B1)	-0.004	0.033	-0.115	2.571
Max. Temp. (0C) (B2)	-0.009	0.123	-0.072	2.571
Min. Temp. (0C) (B3)	0.124	0.191	0.651	2.571
Morning RH (%)(B4)	0.288	0.407	0.708	2.571
Evening RH (%)(B5)	0.216	0.134	1.605	2.571
EVP (mm) (B6)	1.112	1.814	0.613	2.571
BSS (Hrs.) (B7)	1.321	0.846	1.562	2.571
Wind velocity (B8) (Hrs/km)	-1.578	1.091	-1.446	2.571

Intercept (a) = 40.692
Coefficient of determination (R Square) = 0.739

Regression equation (2017-18)

The regression equation worked out during 2017-18 is as follow.

Y = 40.692+ (-0.004) B1 + (-0.009) B2 + (0.124) B3 + (0.288) B4 + (0.216) B5 +(1.112) B6+(1.321) B7 + (-1.578) B8 +2.213

Regression equation (2018-19)

The regression equation worked out during 2018-19 is as follow.

Y = 10.867+ (-0.044) B1 + (-0.466) B2 + (-0.318) B3 + (0.483) B4 + (0.085) B5 +(-0.601) B6 +(0.372) B7 + (-0.498) B8 +1.967

The high value of coefficient of determination (R2 = 73.9 and 75.9 per cent during 2017-18 and 2018-19, respectively) showed that these are the critical factors for maintaining per cent shoot damage on okra. [15, 16, 17, 18, 19, 20]

Regression studies fruit damage

The multiple regression was worked out between weather parameters and per cent fruit damage by shoot and fruit borer during 2017-18 and 2018-19 and presented in Table 5 and Table 6. The regression models worked out during 2017-18 and 2018-19 are as follow.

Regression Model (2017-18)

The regression equation worked out during 2017-18 is as follow.

Y = 137.725+ (0.124) B1 + (0.466) B2 + (-0.100) B3 + (0.770) B4 + (0.702) B5 + (9.601) B6 + (5.180) B7 + (-12.324) B8 +6.492 [21, 22, 23, 24, 25, 26, 27, 28].

The regression equation worked out during 2017-18 is as follow. Y = 166.407+ (-0.007) B1 + (-5.451) B2 + (4.084) B3 + (-0.426) B4 + (0.032) B5 + (9.601) B6 + (-2.918) B7 + (1.202) B8 +2.003

Table 5: Multiple regression of weather parameters with per cent fruit damage by shoot & fruit borer on okra (2017-18)

Weather parameters	Reg. coefficients (b)	SE(b)	T Test	T table (0.05)
Rainfall (mm) (B1)	0.124	0.097	1.276	2.571
Max. Temp. (0C) (B2)	0.466	0.362	1.288	2.571
Min. Temp. (0C) (B3)	-0.100	0.560	-0.179	2.571
Morning RH (%)(B4)	0.770	1.194	0.645	2.571
Evening RH (%)(B5)	0.702	0.395	1.778	2.571
EVP (mm) (B6)	9.601	5.322	1.804	2.571
BSS (Hrs.) (B7)	5.180	2.481	2.087	2.571
Wind velocity (B8) (Hrs/km)	-12.324	3.200	-3.851	2.571

Intercept (a) = 137.725

Coefficient of determination (R Square) = 0.887

Table 6: Multiple regression of weather parameters with per cent fruit damage by shoot & fruit borer on okra (2018-19)

Weather parameters	Reg. coefficients (b)	SE(b)	T Test	T table (0.05)
Rainfall (mm) (B1)	-0.007	0.027	-0.241	2.571
Max. Temp. (0C) (B2)	-5.451	0.455	-11.985	2.571
Min. Temp. (0C) (B3)	4.084	0.755	5.413	2.571
Morning RH (%)(B4)	-0.426	0.385	-1.106	2.571
Evening RH (%)(B5)	0.032	0.173	0.187	2.571
EVP (mm) (B6)	-2.918	1.445	-2.020	2.571
BSS (Hrs.) (B7)	1.202	0.495	2.431	2.571
Wind velocity (B8) (Hrs/km)	3.041	1.015	2.995	2.571

Intercept (a) = 166.407

Coefficient of determination (R Square) = 0.995

Conclusion

The study revealed that weather factors like wind velocity, rain fall and others largely imparting resistance in okra plants and showing resistance and susceptibility of different levels. The weather parameters contributed for 88.7 per cent during 2017-18 and 99.5 per cent during 2018-19 of total variation in the per cent fruit damage by shoot and fruit borer on okra. The coefficient of determination was very high during 2018-19 indicating that the prediction of fruit damage by using weather parameters was more reliable.

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