RESEARCH ARTICLE

INCIDENCE OF SHOOT AND FRUIT BORER, *LEUCINODES ORBONALIS* GUEN. ON BRINJAL IN RELATION TO WEATHER PARAMETERS IN ALLAHABAD REGION

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Abstract: The seasonal incidence of *Leucinodes orbonalis* Guen. (Brinjal Shoot and Fruit Borer) on brinjal was studied at Central Research Farm of the Department of Entomology, Naini Agricultural Institute, SHUATS, Allahabad during 2017. The resultsrevealed thatInitial incidence of the BSFB on shoot was occurred on the 40th standard week (First week of October) and reached the peak in the 43th standard week (Last week of October - 1st week of November); whereas Initial incidence of the BSFB on fruit wasoccurred on the 42nd standard week (Third week of October) and reached the peak in the 45th standard week (2nd week of November). BSFB incidence on shoot showed significant positive correlation with Maximum temperature (r=0.591) and sun shine hours (r=0.657). It was negatively correlated with Evening Relative Humidity (r=-0.610).BSFB incidence on fruit showedsignificant positive correlation with maximum temperature (r = 0.488, on number basis and r = 0.493, on weight basis) and sun shine hours (r = 0.641, on number basis and r = 0.645, on weight basis); whereas it had negative correlation with evening relative humidity (r = -0.650, on number basis and r = 0.655, on weight basis) and evening cloud cover (r = -0.475, on number basis and r = 0.471, on weight basis).The statistically significant values indicated that occurrence of brinjal shoot and fruit borer was influenced by the prevailing ecological conditions specially Temperature, Relative Humidity, wind speed and sun shine hours .Hence the management of brinjal pest during rabisown crop under central plain agro-climatic zone should therefore be promoted and tailored from September onwards using an integrated approach.

Keywords: Brinjal, *Leucinodes orbonalis,* Seasonal incidence, Correlation, Weather parameters, Allahabad

INTRODUCTION

The prospect of climatic changes has simulated considerable research interest across the world and most of the research pursuits are aiming to predict the production of crops. The success of any crop depends on its adoptability to the ambient environment including soil and escape/tolerance to pests that include insects, diseases and weeds (Rao and Bhavani, 2010). The climate change studies in agriculture sector rely on the simulation of crop-growth models that seldom include any crop-pest sub-routine. Often the growth of the crop in the models is considered as function of accumulated thermal time and some pest models also consider thermal time to simulate the crop-pest interactions (Boote *et al.,* 1983; Rabbinge *et al.,* 1989). Most studies on crop-pest interactions quantify the pest population by using empirical approaches or observations (Pinnschmidt *et al.*, 1995).

Vegetable is an utmost important source of nutritional input in human diet throughout the world as its excellent source of vitamins, minerals, and plant.Olericulture is one of the most important and major branches of agriculture, and crucial from the point of view of ability to generate economic revenueVegetables are rapidly becoming an important source of income for the rural population (Singh *et al. (b)*, 2009).

Brinjal (*Solanum melongena* Linnaeus) originated from India and now grown as a vegetable throughout the tropical, sub-tropical and warm temperate areas of the world. Nutritive value per 100 g of raw brinjal indicates that it supplies 25 calories,0.2 gm total fat, 2 mg sodium, 229 mg potassium, 6 gm total carbohydrate, 3 gmdietary fibre, 3.5 gm sugar, 1 gm protein, vitamins (B-6, B-12 and C), iron,magnesium, phosphorus, etc. (USDA, 2013).

In India,brinjal is extensively grown under diverse agro-climaticconditions throughout the year (Nayak *et al.* 2014). It is grown in almost all states, with an area of 679.4 thousand hectares under cultivation and production of 12438.7 thousand metric tons (Anonymous, 2015). The major brinjal growing states in India are Andhra Pradesh, Karnataka, West Bengal, Maharashtra, Orissa, Madhya Pradesh, Bihar, Gujarat and Chhattisgarh. As per FAOSTAT (2016) data, China is the top producer (61% of world output) while India rankssecond (25%) in brinjal production.

Several biotic and abiotic factors contribute in lowering the yield in brinjal. Amongvarious biotic factors, insect pests are important which greatly affect the qualityand productivity of brinjal crop through inflicting a direct damage (Gupta *et al.*, 1987). In the tropics, brinjal production is severely constrained by several insectand mite pests. The major insect pests of brinjal include fruit and shoot borer(BSFR), leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer,blister beetle, red spider mite, etc. (AVRDC, 2009).

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Arthropod biodiversity in the brinjal field showed that the brinjal shoot and fruit borer was the major and serious insect pest of brinjal crop. (Kumar*et al*., 2017).It infests both vegetative as well as reproductive stages of the crop which cause heavy losses in the yield to a tune of 40 to 80% (AVRDC, 2003). Besides brinjal it also attacks potato and other Solanaceous crops.The apparent yield loss due to BFSB varies from 20-90 per cent in various parts of the country (Raju *et al.*, 2007), 85–90 per cent have been reported (Patnaik, 2000; Misra, 2008 and Jagginavar *et al*., 2009).It may cause 100 per cent damage if no control measures are applied (Rahman 2007). It is estimated that the economic injury level equals to 6 per cent infestation of shoot and fruit in India (Alam *et al.*, 2003).

Along with Indian subcontinent it is also distributed in Thailand, Laos, South Africa, Congo, and Malaysia.*L. orbonalis*causes saviour incidence throughout the cropping season by virtue of its reproductive potential, short life period (hence more generations per season) and continuous perpetuation through intensively grown brinjal, potato and other Solanaceous crops, in both irrigated and rainfed condition. The incidence of this insect pest occurs either sporadically or in outbreak every year in the Indian subcontinent (Dhankar, 1988).The variability intheir population and damage can be related to changes in theambient environment. The best way to avoid pest outbreak is possible when the congenital weather condition for the insect infestation is fully known (Dubey and Thorat, 1994). Since theclimate change projections for India indicate a changein temperature and rainfall, an attempt has been made here to studythe impact of weather parameters in relation to seasonal incidence of shoot and fruit borer on brinjal crop under Allahabad Agro climaticconditions.

MATERIALS AND METHODS

The study on seasonal variation in the incidence of brinjal shoot and fruit borer (BSFB) wascarried out at the research farm of the Department of Entomology, Naini Agricultural Institute, SHUATS,Allahabad during kharif season of 2017.

A Variety ofRound Brinjal '*Kanshi Sandesh*' developed by IIVR Varanasi has been chosen for the field experiment. Seeds were sown in nursery of Department of Horticulture in the first week of August and theseedlings were raised on Disposable PVC Cups. Thirty days old seedlings were transplanted during the first week of September and the standard agronomic package ofpractices and irrigation schedule were followed to raise and maintain a healthy crop.

In this experiment, plant spacing of 60 x 50 $cm^2$was kept, on plot size 5x3 m^2area, with 3 replications. No pesticide was used throughout the experiment. Population of BSFB larvae, during the experimental period *i.e*. 31^{st} standard week (First week of August, 2017) to 52^{nd}standard week (Last week of December, 2017) was recorded on these untreated experimental plots. The observations were taken regularly at 7 days interval (every Sunday of each standard week)till the final harvest of the crop.

Installation of sex pheromone trap has been done to record initial incidence. Population of BSFB larvae was first observed on brinjal shoots in the 40^{th}standard week (First week of October, 2017). As fruit bearing initiated, these larvae (BSFB) were observed migrating to developing fruits.

Incidence on *shoots*were recorded as percentage *shoot* infestationby counting infested and healthy shootsfrom a total of 10 randomly selected plants on each replication from the initiation of damage.At each count the affected shoots were removed.

During the fruitbearing stage the fruits were harvested at frequent intervals, as and when they attainedmarketable size.At each count the affected fruits were also removed and harvested. After each harvest, damaged and healthy fruits and their number andweight were recorded. From these results, the percentages of damaged fruits obtained fromthe different harvests were calculated for each week of the year.

To work out percent fruit damage weight of healthy fruits, weight of infested fruits and total weight of fruits were recorded at each harvest. Percent fruit and shoot infestation was calculated using following formula.

Shoot damage on number basis-

$$\textbf{\% Shoot Damage} = \frac{\text{Number of Damaged Shoot}}{\text{Total Number of Shoots (Damage + Healthy)}} \times 100$$

Fruit damage on number/weight basis-

$$\textbf{\% Fruit Damage} = \frac{\text{Weight/number of damaged fruits}}{\text{Total Weight/number of fruits (Damage + Healthy)}} \times 100$$

The data on ecological parameters like Temperature (minimum and maximum), Relative humidity (morning and evening), cloud cover (morning and evening), Rainfall, Sunshine and Wind velocity etc. have been collected from the meteorological observatory, available with Department of Agriculture Meteorology, Naini Institute of Agricultural, SHUATS, Allahabad.Simple correlationcoefficients (r) between themeteorological parameters, multiple linear regression equation and incidence of fruit infestation and shoot borer infestation were calculated with the help of Microsoft Excel software and "ICAR-Web Agri Stat Package (ICAR-WASP)".

RESULTS AND DISCUSSION

Seasonal incidence of brinjal shoot and fruit borer (*Leucinodes orbonalis*)

The data on shoot infestation and fruit infestation of brinjal shoot and fruit borer was recorded from first week of September to last week of December 2017. It is evident from tables-1 that the Shoot infestation of BSFB (Leucinodes orbonalis Guenee) commenced from 40rd standard week (1st week of October) on shoot with an average 3.30% of damaged shoot (Number basis) during commence of experiment. The borer population increased and gradually reached peak level of 46.61% of damaged shoot (Number basis) at 43rd standard week (last week of October - 1st week of November).

Fruit infestation of BSFB (Leucinodes orbonalis Guenee) commenced from 42ndstandard week (3rd week of October) with an average 33.33% of damaged fruit (Number basis) and 30.46% (Weight basis) during the experiment. The borer population increased and gradually reached peak level of 59.09% of damaged fruit (Number basis) and 57.98% of damaged fruit (weight basis) at 45th standard week (2nd week of November).thereafter there was a gradual decrease in per cent shoot infestation till the 48th standard week (5.92%) andgradual decrease in per cent infestation of fruit till 2nd week of December (6.82%, on number basis and 7.04%, on weight basis). Also after the initiation of fruits, infestation on shoots gradually shifted to fruit during 41st standard week to 43rd standard week (2nd week of October to 1nd week of November), thereafter continuously decreasing on shoots and completely eradicated by 48th standard week (3rd week of December), as the onset of winter.

Current study reveals that the shoot infestation of the pest occurred first time in the 40th standard week i.e. 36 days after transplanting. This is in agreement with Tiwari *et al.* (2011) who first seen incidence in 35th day after transplanting. However Kaur *et al.* (2014) reported first appearance in four week (30 DAT); Kumar *et al.(*2014) reported first appearance in 15 DAT and Chetan et al. (2017) reported the incidence on shoot started from one week after transplanting (i.e. during the month of November) in *Rabi* season brinjal.

The findings of current studies are in great accordance with Katiyar and Mukharji (1974) who reported the highest damage of 90 per cent in the month of November; Bharadiya and Patel (2005) who reported that the damage was highest on fruits during third week of November;Also in agreement with Rao and Bhavani (2010), who reported the highest damage of 62.83 per cent in November;Tiwari *et al.* (2012) reported that damage reached at its maximum level of 4.0 larvae/plant in 44thSW in first year 2005-2006And 4.67 larvae/plant in 45th SW during 2006-2007;andYadav*et al*., (2015) whorevealed that the highest percent fruit infestation of shoot and fruit borer was recorded on 43rd and 44th standard week (13.78% and 13.88%), in Varanasi. However Chetan *et al.* (2017) reported peak infestation of BSFB (59.16%) in the month of December in October transplanted crop.

Influence of weather parameters on shoot and fruit borer (*Leucinodes orbonalis*) Incidence on shoot.

Correlation analysis was worked out by correlating 9 weather parameters in consideration and percent fruit infestations with the use of Microsoft excel and ICAR-WASP software (http://www.ccari.res.in/wasp2.0/wasp2.zip) to understand the relationship among them. The correlation coefficients thus obtained and their significance at 0.05 levels (95% confidence level) are presented in Table-2.

It was found that the pest build up on shoot (Damage % number basis) was positively correlated with maximum temperature (r = 0.591) and sun shine hours (r = 0.657). However it was negatively correlated with evening relative humidity (r = -0.610).

Earlier various worker has revealed similar results as positive correlation of percentage infestation with maximum temperature by Shukla and Khatri, 2010 – (r = 0.319); Rao and Bhawani, 2010 – (r = 0.610); Anjali et al., 2012 – (r = 0.035); Sarnabati *et al*., 2014 – (r = 0.129); Kumar and Singh, 2015 – (r = 0.798); Indira Kumar *et al.*, 2016 – (r = 0.035); Kumar *et al*., 2017(a) – (r = 0.422); Ram kinker *et al.*, 2017 – (r = 0.572).

Positive correlation with sunshine hours is in agreement with, Tiwari *et al*. (2012) – (r = 0.476);Sarnabati *et al*., 2014 – (r = 0.350); Ram kinker *et al.* 2017 – (r= 0.860); Kumar *et al*., 2017(a) – (r = 0.381).While negative correlation with evening relative humidity was supported by Anjali et al., 2012 – (r = -0.250); Amit*et al*., (2015) – (r = -0.116); Indira Kumar *et al.*, 2016 – (r = -0.250); Ram kinker *et al.* 2017 – (r = - 0.536); Kumar *et al*., 2017(a) – (r = -0.109).

Table –1		Data of weather parameters obtained from dept. Of agriculture meteorology for the period of experiment									Insect infestation		
Standard week		Temperatures (^{O}C)		Rain fall Mm	Humidity %		Wind speed	Cloud cover (octa)		Sun shine (hours)	%Shoot damage	% fruits damage	
	Dates	T. Max	T. Min	24.h	Morning	Evening	KM/hr	Morning	Evening	24h	No.	No.	Wt.
35	3-09-2017	35.14	29.00	2.43	89.43	49.57	1.95	4.57	4.71	7.11	0	0	0
36	10-09-2017	36.77	30.31	0.00	83.43	45.14	1.64	2.00	3.71	7.21	0	0	0
37	17-09-2017	34.72	30.40	0.00	83.14	44.00	1.37	4.14	3.57	7.51	0	0	0
38	24-09-2017	36.00	28.60	3.31	89.71	56.57	1.22	6.14	5.57	7.89	0	0	0
39	01-10-2017	36.40	29.86	0.14	86.14	48.86	1.23	1.29	4.14	8.21	0	0	0
40	08-10-2017	36.53	30.23	0.00	71.00	49.57	0.96	1.00	2.43	8.63	3.30	0	0
41	15-10-2017	36.64	22.69	0.00	78.00	43.57	0.99	1.00	2.57	8.79	16.13	0	0
42	22-10-2017	37.83	22.77	0.00	80.57	42.29	1.12	0.00	1.71	8.87	26.09	33.33	30.46
43	29-10-2017	39.86	18.86	0.00	81.71	34.57	0.91	0.00	0.71	8.91	46.61	42.86	41.87
44	05-11-2017	39.46	18.83	0.00	84.29	39.14	1.07	0.00	0.43	8.97	30.66	51.85	52.75
45	12-11-2017	39.90	17.83	0.00	86.57	35.57	0.76	0.00	0.00	8.99	20.53	59.09	57.98
46	19-11-2017	32.14	15.97	0.00	90.00	42.29	0.75	0.29	1.00	8.83	15.10	36.47	35.20
47	26-11-2017	31.40	11.71	0.00	92.00	43.00	0.82	0.00	0.00	8.90	9.81	21.43	18.83
48	03-12-2017	28.89	8.89	0.00	92.43	40.14	0.74	0.00	0.71	8.21	5.92	12.24	11.04
49	10-12-2017	27.89	8.97	0.00	92.43	39.43	0.59	0.00	0.00	7.99	0	6.82	7.04
50	17-12-2017	28.71	9.51	0.00	92.14	39.14	0.70	0.43	0.00	7.45	0	0	0
51	24-12-2017	28.29	10.83	0.00	93.00	42.86	0.74	0.29	0.00	7.21	0	0	0
52	31-12-2017	25.77	10.06	0.00	94.71	47.86	0.62	0.00	0.43	5.57	0	0	0

Influence of Weather parameters On incidence of *Leucinodes orbonalis* on shoot and fruits of brinjal

Table - 2	Temperature		Rain Fall	Humidity %		Wind Speed	Cloud Cover		Sun Shine
	(Celsius)		(mm)			(Km/hr)	(Octa)		(hr)
	T. Max	T. Min	24.h	MORNING	EVENING	Wind speed	MORNING	EVENING	24h
Shoot - r	0.591	-0.075	-0.262	-0.362	-0.610	-0.151	-0.419	-0.340	0.657
T value	2.971	0.304	1.083	1.559	3.072	0.616	1.846	1.442	3.476
T tab at5%	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Significance at 5%	S	NS	NS	NS	S	NS	NS	NS	s
Fruit (number) - r	0.488	-0.207	-0.262	-0.095	-0.655	-0.248	-0.459	-0.475	0.641
T value	2.247	0.843	1.086	0.389	3.445	1.038	2.069	2.157	3.416
T tab at5%	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Significance at 5%	S	NS	NS	NS	S	NS	NS	S	s
Fruit (weight) - r	0.493	-0.200	-0.258	-0.098	-0.652	-0.243	-0.452	-0.471	0.645
T value	2.289	0.813	1.065	0.399	3.442	1.016	2.026	2.139	3.333
T tab at5%	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Significance at 5%	S	NS	NS	NS	S	NS	NS	S	S

S **Positive correlation significantly established.**

S **Negative correlation significantly established.**

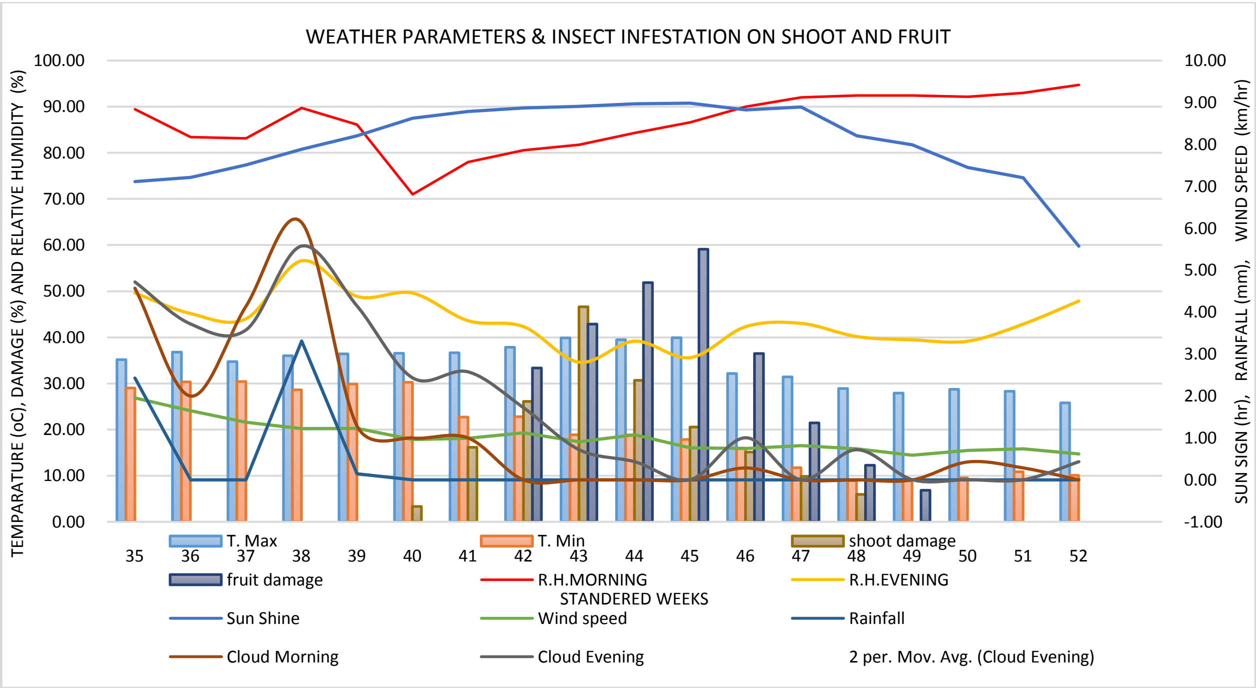

Fig .1 weather parameters and % shoot and % fruit damage in brinjal

Further, the multiple Linear Regression equation derived to predict the population fluctuation of *Leucinodes orbonalis* and extent of % shoot damage they can possibly cause, on brinjal, at Allahabad region, based on weather parameter was:

Shoot % D. = -2.421 + (1.391) x M. Temp+ (2.537) x Sun shine+ (-1.280) x Evn. RH%+8.218

Intercept (a) = -2.421Coefficient of determination (R Square) = 0.703
Multiple Correlation Coefficient (R) =0.834Standard Error = 8.218
Regression coefficients and their significance using t test.

Independent Variables	Average	Regression coefficients (b)	Standard Error(SE(b))	T Test	T table (0.05)	Significance at 5% level
Max. Temp	34.018	1.391	0.561	2.459	2.145	S
Sun Shine	8.064	2.537	3.031	0.832	2.145	NS
Evening R.H.	43.536	-1.280	0.410	-3.116	2.145	S

It was observed that the coefficient of determination for larval incidence was 0.703 which indicated that the climatic factors together were able to explain the variation in the larval incidence to the extent of 70.30 out of 100.

Influence of weather parameters on shoot and fruit borer(*Leucinodes orbonalis*)Incidence on fruit.

It is evident from the analysis that percent fruit infestation had positive correlation with maximum temperature (r = 0.488, on number basis and r = 0.493, on weight basis) and sun shine hours (r = 0.641, on number basis and r = 0.645, on weight basis); whereas it had negative correlation with evening relative humidity (r = -0.650, on number basis and r = 0.655, on weight basis) and evening cloud cover (r = -0.475, on number basis and r = 0.471, on weight basis).

Earlier various worker has revealed similar results as positive correlation of percentage fruit infestation with maximum temperature by Shukla and Khatri, 2010 – (r= 0.319), Rao and Bhawani, 2010 – (r = 0.610), Sarnabati *et al.*, 2014 – (r = 0.962), Amit *et al.*, 2015 – (r = 0.320), Kumar and Singh, 2015 – (r = 0.796, number basis and, r = 0.797, weight basis); Indira Kumar *et al.* (2016), Rattan *et al.*, 2016 – (r= 0.490); Ram kinker *et al.*, 2017 – (r = 0.572).
Positive correlation with sunshine hours is in agreement with, Tiwari *et al.* (2012) – (r = 0.476), Kumar *et al.*, 2017 – (r = 0.521); Ram kinker *et al.* 2017 – (r= 0.860).
While negative correlation with evening relative humidity was supported; Anjali *et al.*, 2012 – (r = -0.204); Amit*et al.*, 2015 – (r = -0.116); Indira Kumar *et al.*, 2016 – (r = -0.204); Kumar *et al.*, 2017 – (r = -0.632); Ram kinker *et al.* 2017 – (r = - 0.536); Sharma and Tayde, 2017 – (r = -0.395).

Further, the multiple Linear Regression equation derived to predict the population fluctuation of Leucinodes orbonalis and extent of % fruit damage they can possibly cause, on brinjal, at Allahabad region, based on weather parameter was:

Number basis:

var5 = -99.064 + (3.268) **x** var1+ (-0.016) **x** var2+ (-8.140) **x** var3+ (2.172) **x** var4+ 11.420

Where,
Var1= Maximum temperature, var2 = Evening Relative humidity,
Var3 = Evening cloud cover, var4 = sun shine
Var5 = % fruit Damage on number basis. Intercept (a) = -99.064
Coefficient of determination (R Square) = 0.767 Standard Error = 11.420
Multiple Correlation Coefficient (R) =0.877
Regression coefficients and their significance using t test.

Independent Variables	Average	Regression coefficients (b)	Standard Error(SE(b))	T Test	t table (0.05)	Significance at 5% level
Max. Temp	34.018	3.268	1.109	2.953	2.160	S
Evening R.H.	43.536	-0.016	1.008	-0.015	2.160	NS
Evening cloud cover	1.765	-8.140	3.380	-2.406	2.160	S
Sun Shine	8.064	2.172	4.441	0.480	2.160	NS

It was observed that the coefficient of determination for fruit damage % was 0.767 which indicated that the climatic factors together were able to explain the variation in the fruit damage % to the extent of 76.70 out of 100.

Weight basis:

var5 = -95.967 + (3.316) **x** var1+ (-0.022) **x** var2+ (-8.071) **x** var3+ (1.560) **x** var4+ 11.163

Where,
Var1= Maximum temperature, var2 = Evening Relative humidity,
Var3 = Evening cloud cover, var4 = sun shine
Var5 = % fruit Damage on weight basis. Intercept (a) = -95.967
Coefficient of determination (R Square) = 0.767 Standard Error = 11.163
Multiple Correlation Coefficient (R) =0.877

Independent Variables	Average	Reg. coefficients (b)	Standard Error(SE(b))	T Test	T table (0.05)	Significance at 5% level
Max. Temp	34.018	3.316	1.079	3.070	2.160	S
Evening R.H	43.536	-0.022	0.989	-0.025	2.160	NS
Evening cloud cover	1.765	-8.071	3.303	-2.447	2.160	S
Sun Shine	8.064	1.560	4.344	0.363	2.160	NS

It was observed that the coefficient of determination for fruit damage % was 0.767 which indicated that the climatic factors together were able to explain the variation in the fruit damage % to the extent of 76.70 out of 100.

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