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Studies on influence of weather parameters on population abundance of some major insect pests of okra during rabi season under red and lateritic zone of West Bengal

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Abstract
The present study was carried out during the period of November 2016 to April 2017 at Agriculture farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, at Sriniketan. Influence of weather parameters on the seasonal incidence of insect pests of okra was observed during rabi season. In okra the incidence of *A. gossypii*, was maximum during February (8th MSW) and minimum during March (10th MSW). The incidence of *B. tabaci* was maximum during February (6th MSW) and minimum during March (9th MSW). The incidence of *A. biguttula biguttula*, was maximum during March (12th MSW) and minimum during April (14th MSW). Leafhopper had significant positive correlation with maximum temperature when correlated with Actual week weather data. The incidence of *Tetranychus spp*., was maximum during March (12th MSW) and minimum during April (14th MSW). The incidence of *E. vitella/ insulana* fruit infestation was maximum during March (11th MSW) and minimum during April (14th MSW). The coefficient of determination (R^2) for aphid, whitefly, leafhopper, and mite and fruit infestation was 0.671, 0.576, 0.754, 0.752 and 0.743, respectively. The statistically significant values indicated that occurrence of insect pests population was due to the prevailing ecological conditions.

Keywords: Okra, *A. gossypii, A. biguttula biguttula, E. vitella, Tetranychus spp* seasonal incidence, pest calendar

Introduction
Among the vegetable crops grown in India, okra (*Abelmoschus esculentus* L. Moench), also known as lady's finger or bhendi, belongs to family Malvaceae and is an important crop grown throughout the year. Besides India, it is grown in many tropical and subtropical parts of the world. Tender fruits are used as vegetables or in culinary preparations as sliced and dried pieces. The roots and stems of okra are used for cleaning cane juice [5].

In India, it occupies an area of 498.0 thousand ha with an annual production of 5784.0 thousand tons. Andhra Pradesh is the leading okra producing state which has production of around 1184.2 thousand tons followed by West Bengal 862.1 thousand tons (Indian Horticulture Database – 2011).

Matured fruits and stems containing crude fibre are used in paper industry. It has good nutritional value, particularly the high content of Vitamin C (30 mg/100 g), Calcium (90 mg/100 g), Iron (1.5 mg/100 g) and other minerals like magnesium and potassium, Vitamin A and B, fats and carbohydrates [2].

One of the important limiting factors in the cultivation of okra is insect pests. Many of the pests occurring on cotton are found to ravage okra crop. As high as 72 species of insects have been recorded on okra [15], of which, the sucking pests comprising of Aphids, *Aphis gossypii* (Glover), leafhopper, A*mrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Gennadius) and mite, *Tetranychus cinnabarinus* (Boisduval) causes significant damage to the crop. Krishnaiah (1980) [7] reported about 40 to 56% losses in okra due to leafhopper. Aphids and leafhoppers are important pests in the early stage of the crop which suck the plants, make them weak and reduce the yield. Failure to control them in the initial stages was reported to cause a yield loss to the tune of 54.04% [4]. The spider mite, *T. cinnabarinus* has assumed the status of major pest and caused 17.46% yield loss in okra [13]. Okra crop is susceptible from early stage to maturity. Among the wide array of insect pests infesting okra crop, the sucking pests which are, aphid, *A. gossypii* (Glover), leafhopper (*A. biguttula biguttula* (Ishida), and

whitefly, *B. tabaci (*Gennadius), were reported to be quite serious during all stages of the crop growth [3].

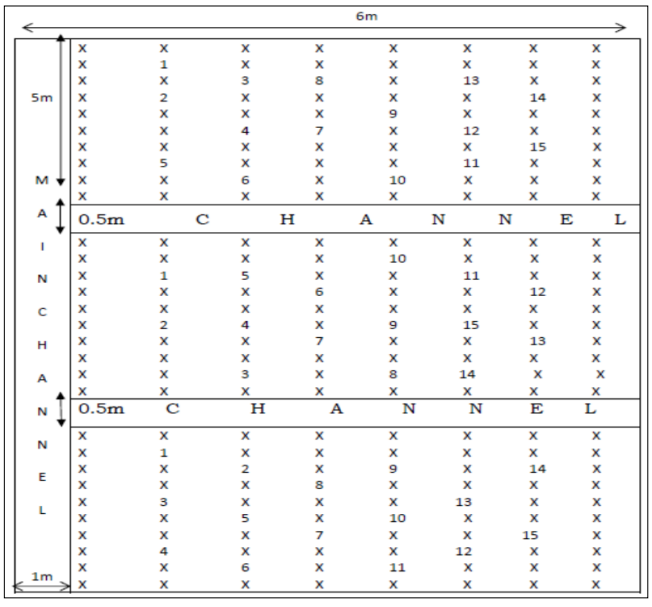
So, before execution of any management strategies to manage these hazardous pests we need to have full knowledge on the population dynamics and seasonal incidence of those target pests. As because, abiotic factors play important roles in population development of the insect species and their subsequent damage on crop plants and hence, correlation of the weather parameters and incidence of the important pests (whitefly, aphid, leaf hopper, mite and fruit borer) were the prime purpose of this study.

Material methods

Experimental details: The field experiment was conducted during *rabi* season of the year 2016-2017 at Agriculture Farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, West Bengal. The field is situated at 24.03^{0}N latitude, 87.05^{0}F longitude and at an average altitude of 58.90 m above mean sea level in western part of South Bengal. The test variety was selected for the study was "*Pankaj*" was sown in experimental site during the r*abi* season of 2016. The crop has been raised following standard agronomic practices without applying any insecticide. The experimental details have been given in the following.

The experimental details have been given in the following.

Subject Particulars	
Crop:	Okra
Botanical Name	*Abelmoschus esculentus*
Variety	Pankaj
Season	*Rabi* (2016)
Date of sowing	1st week of November 2016
Spacing (PP X RR)	0.5m X 0.75m
Total area	15.0 X 6.0 sq. m
Observation	2 leaves stage to harvest
No. of harvesting	Once in a week



X – Indicates that plants in the quadrat.
1-15 - Numbers indicates that tagged plants in the quadrat.

Layout plan of okra experimental trial

Method of observations

Sucking pests: Sampling of insect pests started one week after transplanting and it continued till harvesting of the crop at each meteorological week. The inner rows leaving the border one in plot were considered for sampling the insects. Observations on sucking pests' *viz.*, aphid, leafhopper and whitefly from three leaves (top, middle and bottom) of tagged 15 plants at each quadrate were observed carefully and minutely with the help of magnifying glass (10x) for the presence of insect during early morning hours when the pests were less active. Mean population of the insects was expressed as number of insect/leaf/plant.

Mite: Observations on Mite from three leaves (top, middle and bottom) of tagged 15 plants at each quadrate were carefully examined for the presence of nymph and adults during early morning hours.

Okra shoot and fruit borer: Number of healthy and damaged fruits was recorded from whole experimental plants in plot. The infestation of fruits was observed at every picking with respect to meteorological standard week. Number of healthy and damage fruits were recorded separately at each picking. The data thus obtained were converted to per cent shoot and fruit damage.

The cumulative per cent of fruit damage was worked out using following formulae.

$$\text{Per cent Fruit damage} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \text{X } 100$$

Results and Discussion

Studies on population dynamics of major insect pests of okra

1. Seasonal incidence of insect pests and mites of okra

The population dynamics of important insect pests of okra viz. *A. gossypii*, *B. tabaci*, *A. biguttula biguttula*, *Tetranychus urticae*, shoot and fruit borer *E. vitella/E. insulana* during different periods of the crop growing season was examined critically in relation to some important climatic factors viz. temperature (maximum and minimum), relative humidity, rainfall, sunshine hours during the whole experimental period as they have significant role on the biology of the insect pests of okra plants.

Perusal of Table 1 and Fig.1.showed that population of aphid during field trial initiated on or before 1st week of January (1st SW) at vegetative stage of the crop. Population build up gradually increased and attained at peak (6.9aphid/leaf/plant) on 4th week of February (8th SW) during peak fruiting period of the crop. In this period, population was recorded significantly higher than rest of the period. Thereafter, the population gradually decreased and disappeared after 2nd week of March (10th SW). The results were the findings of Shubham *et al.*, (2016) [14], where peak population of aphid observed on third week (11th SW) of March. The aphid preferred to attack the tender apical plant parts and also under surface of the leaves resulted in crinkled leaves and stunted plant growth.

The incidence of whitefly population initiated on or before 1st week of January (1st SW) at vegetative stage. Population build up gradually increased and attained at peak (2.7whitefly/leaf/plant) on 2nd week of February (6th SW) during fruiting initiation period of the crop. Thereafter, the population gradually decreased and disappeared after 1st week of March (9thMSW) (Table 1 & Fig. 2). Shubham *et al.*, (2016) [14] studied on seasonal incidence of major sucking insect pests of okra and the results revealed that the peak

population of whitefly observed on third week of March (11th SW) with mean population of 18.07 whitefly/plant.

Leafhopper is an important pest of okra and caused havoc damage especially in early growth stage of the crop where a single plant might be served as inoculums for total devastation. In the present investigation of this noxious pests initiated on or before 1st week of January (1st SW) at vegetative stage of the crop. Population builds up gradually increased and attained peak (11.5leafhopper/leaf/plant) on 4th week of March (12th SW) during fruiting and initiation of senescence period of the crop. In this period, population was recorded significantly higher than rest of the period. Thereafter, the population gradually decreased and remained up to 2nd week of April (14th SW) (Table 1 and Fig. 3).The result was an agreement with the findings of Shubham *et al*., (2016) [14].

The population of mite during field trial initiated on or before 2nd week of February (6th SW) at fruiting initiation stage. Population build up gradually increased and attained at peak (31.3mite/leaf/plant) on 4th week of March (12th SW) during fruiting and initiation of senescence period of the crop. Thereafter, the population gradually decreased and remained up to 2nd week of April (14th SW), which is sown in (Table 1 & Fig. 4). Jadhav *et al.,* (2016) [6] reported that the seasonal incidence as influenced by weather parameters on mites' population on summer okra and population reached its peak during last week of April with 8.40 mites in 6.25cm2 leaf area/ 3 leaves.

The data presented in (Table 1 and Fig. 5) revealed that the infestation of shoot and fruit borer on fruits of okra crop, commenced in the 3rdweek of February (1.6%)(7th SW) i.e. three months after sowing which gradually increased and reached its peak (19.1%) in the 4thweek of March(12th SW). Thereafter, the infestation gradually decreased and remained during the 2st week of April (14th SW).On the contrary to the present observation, Madav and Dumbre (1985) [9] reported the incidence of shoot and fruit borer on okra at Dapoli (Maharashtra).During rabi season, the pest activity started in last week of November, increased steadily and reached its peak in last week of December.

2. Pests calendar of okra

Pest calendar of a crop represents the chronological appearance of different insect pests of a particular crop during the total crop growth period. It is a comprehensive chart where comparative abundance is depicted over the backgrounds of the crop phrenology. In practice it clearly indicates the degree of periodic vulnerability towards different groups of insect spp. or intensity of damage actually received during that period. The entire spectra of activity are represented against six month divisions. Major insect pests, the period of activity in a fortnight interval during the crop growing season (1stNovember, 2016 to April, 2017) were considered while preparing the calendar. The details are being illustrated in the Fig.6.

Table 1: Incidence of major insects and non-insect pests of okra at different growth stages of the crop during 2016-2017

Meteorological Standard Week (Month)	Crop Growth stages	Population of Insect-Pests					Meteorological information during crop season				
		Aphids (No./leaf/ plant)	Whitefly (No./leaf/ plant)	Leafhopper (No./leaf/ plant)	Mite (No./leaf/ plant)	Fruit borer (%infestation)	Min. Temperature (ºC)	Max. Temperature (ºC)	Relative Humidity (%)	Rainfall (mm)	Sunshine Hours
45(1st week of November)	---------	0.0	0.0	0.0	0.0	0.0	31.38	17.25	74.00	0	7.6
46(2nd week of November)	---------	0.0	0.0	0.0	0.0	0.0	30.95	14.68	71.28	0	8.6
47(3rd week of November)	2 Leaf	0.0	0.0	0.0	0.0	0.0	29.42	14.26	76.00	0	6.0
48(4th week of November)	2 leaf	0.0	0.0	0.0	0.0	0.0	26.83	12.01	79.86	0	6.67
49(1st week of December)	4 leaf	0.0	0.0	0.0	0.0	0.0	28.72	13.14	82.29	0	7.69
50(2nd week of December)	5-6 leaf	0.0	0.0	0.0	0.0	0.0	26.36	10.07	82.57	0	7.34
51(3rd week of December)	Initiation of Branching	0.0	0.0	0.0	0.0	0.0	26.90	12.11	81.29	0	4.15
52(4th week of December)	Branching	0.0	0.0	0.0	0.0	0.0	26.20	12.86	88.29	0	4.41
1(1st week of January)	Vegetative	0.2	0.1	0.3	0.0	0.0	26.47	12.11	84.85	0	5.66
2(2nd week of January)	Peak vegetative	0.7	0.5	0.8	0.0	0.0	23.77	10.44	77.14	0.3	5.90
3(3rd week of January)	Initiation of Flowering	0.9	1.1	1.2	0.0	0.0	26.74	9.02	70.71	0	8.47
4(4th week of January)	Flowering	1.3	1.7	1.6	0.0	0.0	28.48	12.15	73.57	0	7.65
5(1st week of February)	Peak Flowering	2.7	2.3	2.2	0.0	0.0	26.98	11.41	79.71	0	6.79
6(2nd week of February)	Fruiting Initiation	3.9	2.7	2.6	0.9	0.0	29.84	12.87	66.14	0	8.66
7(3rd week of February)	Fruiting	5.6	1.8	3.0	3.7	1.6	29.63	15.15	68.57	0	4.54
8(4th week of February)	Peak Fruiting	6.9	0.5	3.4	10.1	3.9	32.30	16.62	66.14	0	6.78
9(1st week of March)	Peak Fruiting	1.7	0.2	3.9	13.3	5.2	33.29	15.19	54.29	0	8.84
10(2nd week of	Peak	0.6	0.0	4.0	18.6	6.4	30.40	18.34	68.71	0.57	4.68

March)	Fruiting										
11(3rd week of March)	Fruiting	0.0	0.0	5.3	25.7	9.7	31.99	14.84	55.14	0	8.90
12(4th week of March)	Fruiting + Initiation Senescence	0.0	0.0	11.5	31.3	19.1	34.14	19.12	69.28	0.10	4.50
13(1st week of April)	Fruiting + Senescence	0.0	0.0	5.5	23.2	7.3	37.32	24.97	72.85	0.80	7.42
14(2nd week of April)	Harvesting	0.0	0.0	2.5	11.4	4.4	37.52	25.62	73.57	0	8.65

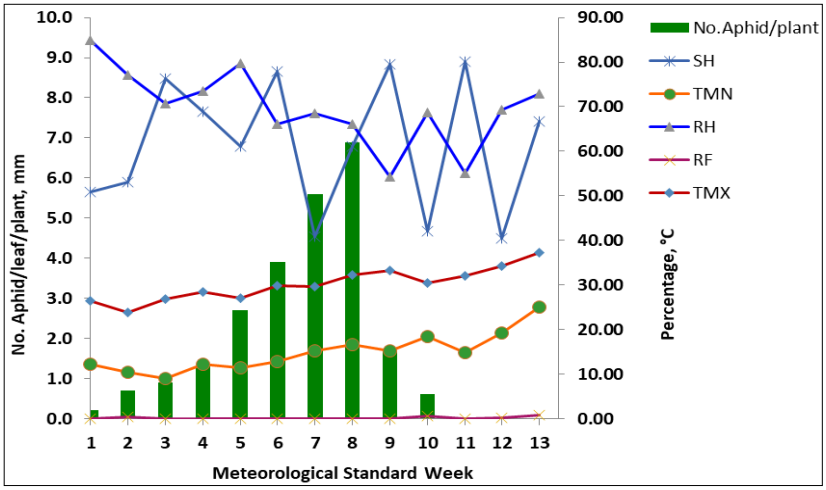


Fig 1: Population fluctuation of aphid on okra at different MSW of 2016-17

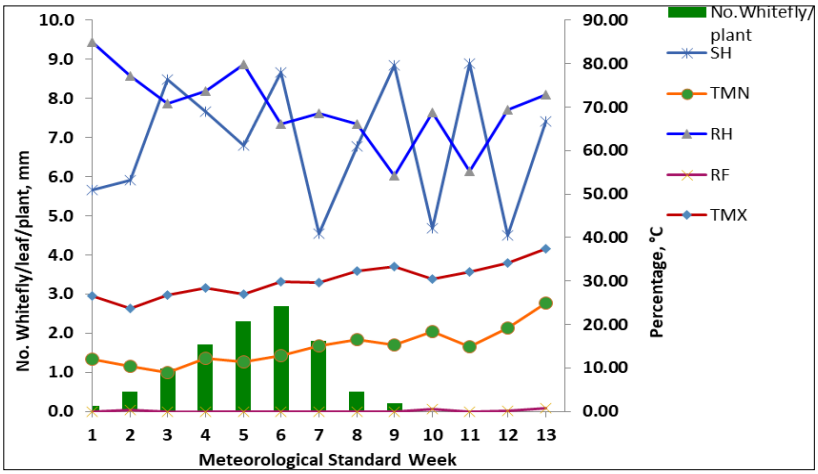


Fig 2: Population fluctuation of whitefly on okra at different MSW of 2016-17

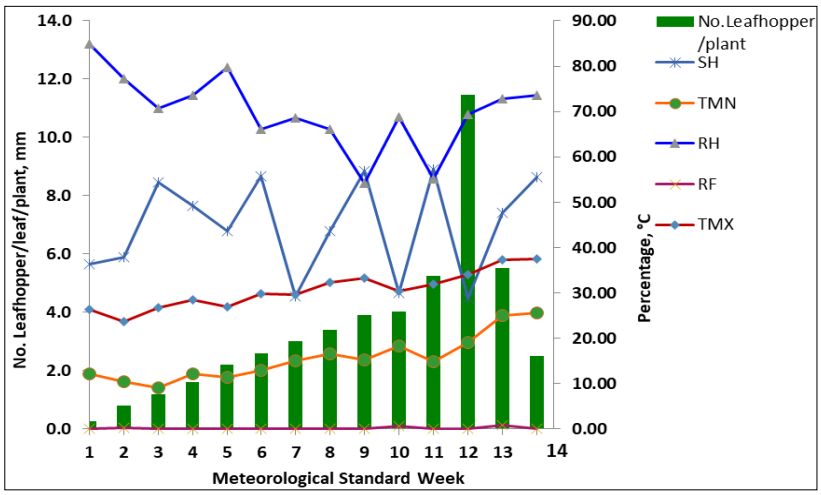


Fig 3: Population fluctuation of leafhopper on okra at different MSW of 2016-17

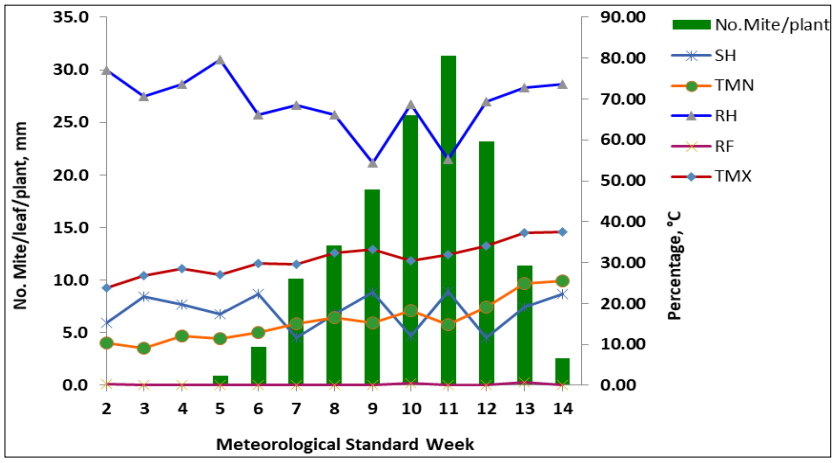


Fig 4: Population fluctuation of mite on okra at different MSW of 2016-17

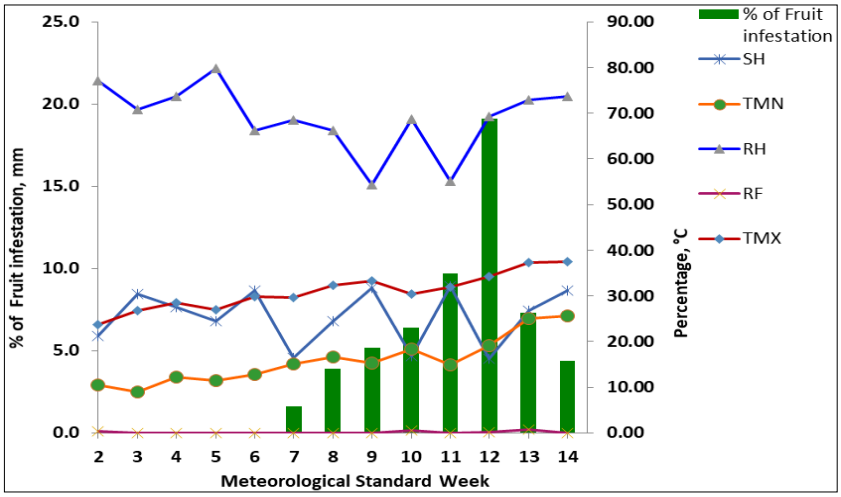


Fig 5: Population fluctuation of shoot and fruit borer (%fruit infestation) on okra at different MSW of 2016-17

Insect pests	November		December		January		February		March		April	
	1st Fortnight	2nd Fortnight	1st Fortnight	2nd Fortnight	1st Fortnight	2nd Fortnight	1st Fortnight	2nd Fortnight	1st Fortnight	2nd Fortnight	1st Fortnight	2nd Fortnight
Aphid *A. gossypii*												
Whitefly *B. tabaci*												
Leafhopper *A. biguttulabiguttula*												
Mite *Tertanychus spp.*												
Shoot& fruit borer *E. vitella/insulana*												

Lighter colour indicates lesser population density and darker colour indicates higher population density of the insects Darkest colour indicates peak population density of insects.

Fig 6: Insects and non-insect pests calendar of okra crop

The role of weather parameters on the population fluctuation of insects and non-insect pests of okra

Table.2. revealed that correlation between aphid population and weather data failed to show any significant relationship. However, minimum temperature (r= -0.404), relative humidity (r= -0.351), rainfall (r= -0.393) and sunshine hours (r= -0.047) showed negative correlations while maximum temperature (r= 0.510) was positively correlated. On the contrary to present results Naziya *et al.* (2016) [12] reported that the aphid population showed highly significant negative association with bright sunshine hours (BSS) (r = -0.720**). The coefficient of determination (R^2=0.671) between aphid population and independent variable indicated that 67.1% variation in aphid population was caused due to abiotic factors.

In case of whitefly, the insect population had a non-significant positive correlations with relative humidity (r= 0.040) and sunshine hours (r=0.133) but non-significant negative correlations with maximum temperature (r=-0.032), minimum temperature (r= -0.139) and rainfall (r= -0.280) (Table.2.). Meena *et al.*, (2010) [11] results revealed that the abiotic stress (maximum and minimum temperature, relative humidity and rainfall) had non-significant correlation coefficient with the population of whitefly. The coefficient of

determination (R^2=0.576) between whitefly population and weather factors indicated that 57.6% variation happened due to the combined effect of abiotic factors.

Leafhopper population had a significant positive correlation with maximum temperature (r= 0.599*) while minimum temperature (r=0.500), rainfall (r=0.219), relative humidity (r= - 0.398) and sunshine hours (r= -0.251 showed no significant association with the population. The findings were similar in line with Kumari *et al*. (2012) [8] who reported that leafhopper population was positively correlated with maximum temperature and minimum temperature but it showed a negative correlation with relative humidity and rainfall. The coefficient of determination (R^2=0.754) between leaf hopper population and independent variable indicated that 75.4% variation in leaf hopper population was caused due to abiotic factors.

Mite population had negative correlation with relative humidity (r= -0.651*), minimum temperature (r= -0.015) and sunshine hours (r= -0.194). Whereas, maximum temperature (r=0.085), rainfall (r= 0.199) had non-significant positive association with mite population for the analyses based on weather data (Table 4). The coefficient of determination (R^2=0.752) between mite population and weather factors indicated that 75.2% variation happened due to the combined effect of abiotic factors.

Fruit borer showed highly significant positive correlation with rainfall (r=0.865**) when the infestation was correlated with two weeks before data. Other parameters had positive and negative effects on the infestation but no significant results recorded (Table.2.). Mandal *et al*. (2006) [10] reported that maximum temperature had negative effect, while minimum temperature, relative humidly (morning and evening) and rainfall had positive effect on larval population and fruit damage. The coefficient of determination (R^2=0.743) between fruit borer infestation and weather factors indicated that 74.3% variation happened due to the combined effect of abiotic factors.

Table 2: Correlation coefficient and regression equation between different weather parameters and mean population of major insect pests of okra during 2016-17

Insect pest	Maximum Temperature	Minimum Temperature	Rainfall	Relative Humidity	Sunshine (h)	Coefficient of determination (R^2)	Regression equation ($Y=A+Bx_1+Cx_2+Dx_3+Ex_4$)
Aphid	0.510	-0.404	-0.351	-0.393	-0.047	0.671	$Y=52.338-2.382X_1+2.457X_2-0.251X_3-19.304X_4+0.800X_5$
Whitefly	-0.032	-0.139	0.040	-0.280	0.133	0.576	$Y=-97.257-4.282X_1+3.225X_2-0.393X_3-34.790X_4+2.048X_5$
Leafhopper	0.599*	0.500	-0.398	0.219	-0.251	0.754	$Y=-20.502+1.549X_1-0.938X_2-0.007X_3+2.578X_4-1.264X_5$
Mite	0.085	-0.015	-0.651*	0.199	-0.194	0.752	$Y=122.891-0.445X_1+0.515X_2-1.281X_3+8.990X_4-2.631X_5$
Fruit borer (Fruit infestation)	0.085	-0.015	-0.651*	0.199	-0.194	0.743	$Y=59.788+1.843X_1+1.674X_2-1.617X_3-5.118X_4-5.538X_5$

Conclusion

Based on the present findings, it can be concluded that correlation of insect pest populations with advanced week's weather data is very much helpful in predicting the pest population in advance. The outcome of the study will be helpful to adopt control measure in time, so that pest population can be managed before it reaches to economic threshold level.

From the overall observations it was concluded that the above mentioned 'Pest Calendar' will provide a distinct picture of key pests of okra and its seasonal incidence in this Lateritic zone of West Bengal. This will be served as a ready recovers for future survey and surveillance and also helps in forecasting and determination of population build-up of insect pests during the crop growing season.

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