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Impact of Abiotic Factors on the Incidence of Major Insect Pests in Okra, *Abelmoschus esculentus* (L.) Moench

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A B S T R A C T

Leafhopper population showed highly significant positive association with Bright Sunshine Hour (BSS) (r = 0.72**) and maximum temperature (MaxT) (0.70**) during *kharif*, 2014. The highest activity of mite was recorded during 3rd week of October and 2nd week of September during *kharif* 2014 and *kharif* 2015, respectively. Fruit damage caused by *Helicoverpa armigera* (Hubner) Hardwick showed highly significant negative association with WS (r = -0.73**), MinT (-0.78**) and RH_2 (-0.83**) whereas, BSS (0.77**) and MaxT (0.74**) revealed highly significant positive association during *kharif*, 2014. During *kharif*, 2015; MinT (-0.70*) exerted significant negative association. *Earias vittella* (Fabricius) study revealed that BSS (r = 0.88**) and MaxT (0.86**) exhibited highly significant positive impact whereas, WS (-0.75**) and RH_2 (-0.90**) had highly significant negative association during *kharif*, 2014. There was highly significant positive association (0.99**) in simultaneous occurrence between *Scymnus* sp. and mite, whereas it was highly significant between spiders and aphid during *kharif*, 2014. As in case of *kharif*, 2015; coccinellids significant positively associated with aphid (0.88**).

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is the only vegetable crop of significance in the Malvaceae family. As many as 72 insect species have been recorded on okra (Pal *et al.*, 2013). The major insect-pests infesting okra are shoot and fruit borer, *Earias vittella* (Fabricius); leafhopper, *Amrasca biguttula biguttula* Ishida; aphid, *Aphis gossypii* Glover; whitefly, *Bemisia tabaci* Gennadius; fruit borer, *Helicoverpa armigera* (Hubner) Hardwick and red spider mite, *Tetranychus cinnabarinus* Boisduval. Once, the impact of various abiotic factor is established, it can be helpful as tool for decision support system in integrated pest management. When more than one insect pest from the different category occurred, the management strategy become rather difficult.

In addition, there may be some relationship between or among the insect pests in nature. The management strategies for the insect pests can become sound and economically viable when the information on pest succession is integrated in to it. Therefore, present experiment was carried out at Agronomy

Farm, B. A. College of Agriculture, Anand Agricultural University, Anand during *kharif*, 2014 and *kharif*, 2015.

Materials and Methods

The whole experimental plot (15 × 10 m; having okra variety: Gujarat Anand Okra-5) was divided into four equal sectors and ten plants were selected randomly from each sector for recording the observations.

The whole experimental plot was kept free from any insecticides application.

Method of recording major insect pests

Observations on leafhopper, *A. biguttula*; aphid, *A. gossypii*; and whitefly, *B. tabaci* population were counted from three (upper, middle and lower) leaves whereas; mite, *T. cinnabarinus* population was recorded from the same leaves of 4 cm^2 area of the same selected plants in each sector. Shoot and fruit damage due to shoot and fruit borer [*E. vittella*] was also worked out.

Correlation study

In order to study the instantaneous effect of weather parameters on population fluctuation of various pests, the data of physical factors of environment *viz.*, bright sunshine (BSS), rainfall (RF), wind speed (WS), maximum (MaxT) and minimum (MinT) temperature, morning (RH_1) and evening (RH_2) relative humidity were correlated.

In order to determine the succession of insect pests and their natural enemies, the periodic mean incidence of the major insect pests and their natural enemies were worked out. Simple correlation was worked out between various pests and their natural enemies using their weekly mean incidence by adopting a standard statistical procedure (Steel and Torrie, 1980).

Results and Discussion

Occurrence (Leafhopper, *A. biguttula biguttula*)

Kharif, 2014

The data on population of leafhopper presented in Table 1 indicated that the population was commenced from 2nd Week After Germination (WAG) [2nd week of August (32nd SMW (Standard Meteorological Week)] and continued throughout the crop period which ranged from 0.45 to 9.12 leafhoppers per 3 leaves with mean of 3.67. Thus, relatively higher activity (6.62 to 9.12) was observed during 1st week of October to 3rd week of October (40th to 42nd SMW) *i.e.* 10th to 12th WAG in okra crop.

Kharif, 2015

The commencement of leafhopper in okra crop was initiated from 2nd WAG that was 3rd week of July (29th SMW) during *kharif*, 2015 with mean population 3.52 (Table 2). It continues throughout the crop period which ranged from 0.05 to 13.35 per 3 leaves. Later on population of leafhopper showed decreasing trend towards the end of crop season.

Effect of weather parameters

Kharif, 2014

The results of correlation studies (Table 3) between various physical factors during *kharif*, 2014 and the abundance of leafhopper revealed that BSS and MaxT showed highly significant positive association with activity of leafhopper with 'r' value 0.72** and 0.70**, respectively. Abiotic factors *viz.*, RH_2 exhibited highly significant negative association (-0.82**). WS showed highly significant negative association with

leafhopper (-0.76**). MinT indicated negative significant association (-0.68*). Rest of the weather parameters did not show any significant role upon the population fluctuation of leafhopper.

Kharif, 2015

The data presented in Table 4 revealed that there was no significant impact of all the physical factors under study on the incidence of leafhopper population. However, BSS, MaxT and RH_1 showed positive association and rest followed negative association.

Looking to the report of Mohansundaram and Sharma (2011), leafhopper occurred on okra crop during last week of July and reached on peak during last week of August. The findings are in close agreement with the findings emerged out from the present investigation. As per the report of Rehman *et al.,* (2015), higher activity of leafhopper was observed during first week of July with negative associationship with maximum temperature and positive with relative humidity at morning. The results matched with the present findings as in case of relative humidity at morning.

Occurrence (Aphid, *A. gossypii*)

Kharif, 2014

It was evident from the data presented in Table 1 indicated that the occurrence of aphid commenced at 3rd WAG *i.e.* 3rd week of August (33rd SMW, 3rd WAG) and persisted till 2nd week of October (41st SMW, 11th WAG). The higher activity of this pest was observed during 5th week of August

Kharif, 2015

The population data on aphid recorded at weekly interval during *kharif,* 2015 presented in Table 2 clearly indicated that aphid was appeared during 4th week of July (30th SMW, 3rd WAG) and persisted in the range of 0.03 to 4.20 aphids per three leaves. The highest population (4.20) was observed during 1st week of August (31st SMW, 4th WAG).

Effect of weather parameters

Kharif, 2014

Physical factors under investigation (Table 3) showed non-significant association with aphid population. Although, BSS, WS and MaxT showed negative correlation and rest had positive association.

Kharif, 2015

The results (Table 4) revealed that all abiotic factors under study did not show significant impact on the incidence of aphid. However, WS, RH_1 and RH_2 had positive correlation and BSS, RF, MaxT and MinT showed negative association.

While shifting the literature, Pal *et al.,* (2013) experienced with the remarkable lower population of aphid in okra. In present investigations, the activity of this pest was also lower and sporadic. Shukla (2014) reported the peak activity during 14th week after sowing *i.e.* 1st week of July and significant role of temperature and humidity. So far present investigation is concerned, abiotic factors did not show significant role on the pest except BSS.

Occurrence (Whitefly, *B. tabaci*)

Kharif, 2014

The data on population of whitefly presented in Table 1 indicated that population commenced from 3rd week of August (33th SMW, 3rd WAG) during *kharif,* 2014 and

continued throughout crop period which ranged from 0.05 to 0.1 whiteflies per 3 leaves with mean of 0.04. The higher activity of the pest was observed during 2nd and 3rd week of September.

Kharif, 2015

The data presented in Table 2 revealed that whitefly population commenced from 3rd week of July (29th SMW, 2nd WAG) and remained up to 2nd week of September (37th SMW, 10th WAG).

Effect of weather parameters

Kharif, 2014

The data presented in Table 3 revealed that there was no significant impact of all abiotic factors under study on the incidence of whitefly population.

However RF, WS, MaxT and RH_1 showed negative correlation whereas BSS, MinT and RH_2 had positive association with the pest.

Kharif, 2015

Significant association between various abiotic factors and the activity of pest was not observed. However, BSS, WS and MaxT showed negative correlation while RF, MinT, RH_1 and RH_2 showed positive association with abiotic factors (Table 4).

Looking to the past findings; Ahmad *et al.*, (2010), Mohansundaram and Sharma (2011), Nath *et al.*, (2011), Patel *et al.*,(2012), Soomro *et al.*, (2012), Singh *et al.*, (2013) and Pal *et al.*, (2013) reported the activity of whitefly in okra low to high during the crop season.

In fact, the activity of this pest was remained very low during the crop periods in both the seasons in the present investigation. Physical factors prevailing during the crop season did not support to the pest activity as correlation study was found non-significant. Non-significant findings emerged out from the present investigation is matched with the findings of the Nath *et al.*, (2011).

Occurrence (Red spider mite, *T. cinnabarinus*)

Kharif, 2014

The data on population of mite presented in Table 1 indicated that the population was observed during the later part of crop and commenced from 4th week of September (39th SMW, 9th WAG) during *kharif*, 2014 to the tune of 0.03 to 35.46 mites per 3 leaves. The highest density of mite was found during 3rd week of October *i.e.* 35.47 (42nd SMW, 12th WAG).

Kharif, 2015

It is evident from the data presented in Table 2 indicated that occurrence of mite commence from 1st week of September [3.75 mites/3 leaves (36thSMW, 9th WAG)] and persisted till 4th week of September [3.05 (39thSMW, 12thWAG)]. The highest activity of this pest was observed (5.28 /3 leaves) during 2nd week of September (37th SMW, 10th WAG).

Effect of weather parameters

Kharif, 2014

Among the abiotic factors, MinT was highly significant negatively correlated with the activity of mite (r = -0.91**), whereas RH_2 (-0.70*) also exerted significant negative impact on the pest.

So far MaxT (0.63*) and BSS (0.59*) is concerned, they imposed significant positive impact on the activity of mites (Table 3).

Kharif, 2015

The study on the effect of abiotic factors on the mite population (Table 4) revealed that BSS (r = 0.67*) had positive significant and WS (-0.60*) had negative significant association. Higher activity was recorded during *kharif*, 2014 (4.45 ± 3.04 mite/ 3 leaves) than *kharif*, 2015 (1.15 ± 0.54). Mohansundaram and Sharma (2011) also reported the higher incidence of mite during *kharif* season. More or less, it is in conformity with the present findings. The present finding on late occurrence of pest is matched with the finding of Kapoor *et al.*, (2000).

Occurrence (Mealybug, *P. solenopsis*)

Kharif, 2015

The population of mealybug was observed during *kharif*, 2015 season only and the data are presented in Table 2. The population of mealybug appeared during 3rd week of July (29th SMW, 2nd WAG) and remained up to the removal of okra crop *i.e.* 4th week of September (39th SMW, 12th WAG) with mean 0.37 (± 0.10) mealybug per three leaves. The highest population (1.0 /3 leaves) was recorded during 1st week of September (36th SMW, 9th WAG).

Effect of weather parameters

Kharif, 2015

A highly significant positive correlation was established between the incidence of mealybug and BSS (r = 0.77**) whereas, it was significant negative with WS (-0.60*). Rest of the parameters had no any significant role on fluctuation of mealybug population (Table 4). Scantly information is available on this pest. However, Khalid *et al.*, (2015) reported this pest on this different horticulture plants including okra.

Table.1 Population of major insect pests and natural enemies in okra crop during *kharif*, 2014

Month/ Week	SMW	WAG	No. of sucking pests/3 leaves				Damage (%) fruits due to		Larva per plant	Natural enemies/plant		
			Leaf hopper	Aphid	Whitefly	Mite	*H. armigera*	*E. vittella*	Semilooper (*Anomis* sp.)	Coccinellids	*Scymnus* sp.	Spiders
August I	31	1	0	0	0	0	0	0	0	0	0	0
II	32	2	0.45	0	0	0	0	0	0	0	0	0
III	33	3	0.62	0.60	0.05	0	0	0	0	0	0	0
IV	34	4	1.48	1.60	0.05	0	0	0	0	0	0	0
V	35	5	2.18	11.52	0.05	0	0	0	0	0	0	0.10
September – I	36	6	2.90	1.70	0.03	0	3.33	0	0	0.03	0	0.08
II	37	7	4.87	6.62	0.10	0	9.37	0	0.05	0	0	0.10
III	38	8	3.65	7.40	0.10	0	21.42	3.57	0.03	0	0	0.13
IV	39	9	3.97	4.12	0.05	0.03	25.00	6.25	0	0	0	0.10
October – I	40	10	6.62	0.90	0.05	4.50	30.00	10.00	0	0.03	0	0.05
II	41	11	8.22	1.45	0.05	13.40	45.45	9.09	0	0.11	0.11	0.05
III	42	12	9.12	0	0	35.47	87.50	6.25	0	0.31	0.31	0.05
Mean ± SE			**3.67 ± 0.88**	**2.99 ± 1.06**	**0.04 ± 0.01**	**4.45 ± 3.04**	**18.51 ± 7.64**	**2.93 ± 1.14**	-	-	-	**0.05 ± 0.01**

Note: WAG = Week After Germination; SMW = Standard Meteorological Week; No. of observations(n) = 12
Mite recorded from 4 cm^2 area

Table.2 Population of major insect pests and natural enemies in okra crop during *kharif*, 2015

Month/Week	SMW	WAG	No. of sucking pests/3 leaves					Damage (%) fruits due to *H. armigera*	Damage (%) shoot due to *E. vittella*	Damage (%) plants due to *S. exigua*	No. of larvae/ plant (*Anomissp.*)	Natural enemies/plant		
			Leaf hopper	Aphid	Whitefly	Mite	Mealy bug					Coccinellids	*Scymnus* sp.	Spiders
July- II	28	1	0	0	0	0	0	0	0	0	0	0	0	0
III	29	2	0.28	0	0.08	0	0.03	0	0	1.13	0	0	0	0
IV	30	3	0.05	0.18	0.08	0	0.10	0	0	3.33	0	0.05	0	0.03
August – I	31	4	1.30	4.20	0.05	0	0.13	0	0	0	0.10	0.10	0	0.10
II	32	5	0.78	0.20	0.10	0	0.45	0	0	0	0.05	0	0	0.08
III	33	6	1.65	0.00	0.05	0	0.25	0	8.62	0	0	0	0	0.18
IV	34	7	4.08	0.00	0.03	0	0.95	0	6.33	0	0	0	0	0.05
V	35	8	13.35	0.00	0.05	0	0.45	0	1.75	0	0	0	0	0.08
September - I	36	9	5.00	0.08	0.08	3.75	1.00	16.60	0	0	0	0.03	0	0.23
II	37	10	4.50	0.00	0.05	5.28	0.55	17.43	0	0	0	0	0	0.13
III	38	11	7.00	0.03	0	1.68	0.08	36.91	0	0	0.08	0	0.38	0.05
IV	39	12	4.27	0.00	0	3.05	0.45	52.63	0	0	0	0	0.65	0.25
Mean ± SE			**3.52 ± 1.11**	**0.39 ± 0.35**	**0.05 ± 0.01**	**1.15 ± 0.54**	**0.37 ± 0.10**	**10.30 ± 5.10**	**1.39 ± 0.84**	-	-	-	-	**0.10 ± 0.02**

Note: WAG = Week After Germination; SMW = Standard Meteorological Week; No. of observations (n) = 12
Mite recorded from 4 cm^2 area

Table.3 Correlation coefficient (r) between insect pests infesting okra crop and weather parameters during *kharif*, 2014

Weather parameters	Sucking pests				Damage (%) fruits due to		Spiders per plant
	Leafhopper	Aphid	Whitefly	Mite	*H. armigera*	*E. vittella*	
Bright Sunshine, hr/day (BSS)	0.72**	-0.15	0.07	0.59*	0.77**	0.88**	0.17
Rainfall mm (RF)	-0.34	0.02	-0.22	-0.31	-0.41	-0.50	0.11
Wind Speed, km/hr (WS)	-0.76**	-0.12	-0.19	-0.57	-0.73**	-0.75**	-0.29
Maximum Temperature, ^{0}C (MaxT)	0.70**	-0.26	-0.11	0.63*	0.74**	0.86**	-0.04
Minimum Temperature, ^{0}C (MinT)	-0.68*	0.30	0.44	-0.91**	-0.78**	-0.45	0.15
Morning Relative Humidity, % (RH_1)	-0.13	0.21	-0.20	0.23	0.07	-0.51	0.19
Evening Relative Humidity, % (RH_2)	-0.82**	0.19	0.02	-0.70*	-0.83**	-0.90**	-0.09

Note: * Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level
Mite recorded from 4 cm^2 area

Table.4 Correlation coefficient (r) between insect pests infesting okra crop and weather parameters during *kharif*, 2015

Weather parameters	Sucking pests					Damage (%) fruits due to *H. armigera*	Spiders
	Leafhopper	Aphid	Whitefly	Mite	Mealy bug		
Bright Sunshine, hr/day (BSS)	0.48	-0.26	-0.22	0.67*	0.77**	0.48	0.67*
Rainfall mm (RF)	-0.22	-0.04	0.16	-0.18	-0.33	-0.07	-0.31
Wind Speed, km/hr (WS)	-0.42	0.33	-0.09	-0.60*	-0.62*	-0.47	-0.86**
Maximum Temperature, ^{0}C (MaxT)	0.19	-0.30	-0.09	0.39	0.35	-0.03	0.04
Minimum Temperature, ^{0}C (MinT)	-0.34	-0.05	0.17	-0.49	-0.41	-0.70*	-0.70*
Morning Relative Humidity, % (RH_1)	0.28	0.22	0.29	0.08	0.12	0.13	0.28
Evening Relative Humidity, % (RH_2)	-0.12	0.22	0.20	-0.37	-0.49	-0.12	-0.33

Note: * Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level
Mite recorded from 4 cm^2 area

Table.5 Correlation coefficient (r) between major insect pests and natural enemies in okra crop during *kharif*, 2014

Insect pests	No. of sucking pests/ 3 leaves				Damage (%) fruits		No. of larva per plant *Anomis* sp.	Natural enemies/plant		
	Leaf hopper	Aphid	Whitefly	Mite	*H. armigera*	*E. vittella*		Coccinellids	*Scymnus* sp.	Spiders
Leaf hopper	-	-	-	-	-	-	-	-	-	-
Aphid	-0.05	-	-	-	-	-	-	-	-	-
Whitefly	0.13	0.64	-	-	-	-	-	-	-	-
Mite	0.76**	-0.32	-0.37	-	-	-	-	-	-	-
H. armigera	0.89**	-0.23	-0.16	0.93**	-	-	-	-	-	-
E. vittella	0.81**	-0.19	0.06	0.51	0.74**	-	-	-	-	-
Semilooper	0.11	0.46	0.73**	-0.19	-0.09	-0.19	-	-	-	-
Coccinellids	0.17	-0.21	-0.09	-0.10	-0.03	0.25	-0.19	-	-	-
Scymnus sp.	0.71**	-0.29	-0.38	0.99**	0.91**	0.42	-0.17	-0.18	-	-
Spiders	0.38	0.77**	0.63	-0.04	0.18	0.22	0.51	0.08	-0.04	-

Note: * Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level
Mite recorded from 4 cm^2 area

Table.6 Correlation coefficient (r) between major insect pests and natural enemies in okra crop during *kharif*, 2015

Weather parameters	No. of sucking pests/ 3 leaves					Damaged (%) fruits due to *H. armigera*	Damaged (%) shoot due to *E. vittella*	Larvae per plant *Anomis*sp.	Damaged (%) plants due to *S. exigua*	Natural enemies		
	Leaf hopper	Aphid	Whitefly	Mite	Mealy bug					Coccinellids	*Scymnus* sp.	Spiders
Leafhopper	-	-	-	-	-	-	-	-	-	-	-	-
Aphid	-0.20	-	-	-	-	-	-	-	-	-	-	-
Whitefly	-0.22	0.08	-	-	-	-	-	-	-	-	-	-
Mite	0.24	-0.20	-0.12	-	-	-	-	-	-	-	-	-
Mealy bug	0.36	-0.23	0.15	0.44	-	-	-	-	-	-	-	-
H. armigera	0.28	-0.20	-0.55	0.65*	0.11	-	-	-	-	-	-	-
E. vittella	0.04	-0.17	-0.08	-0.32	0.26	-0.30	-	-	-	-	-	-
Semilooper	-0.07	0.73**	-0.02	-0.18	-0.32	0.07	-0.27	-	-	-	-	-
S. exigua	-0.36	-0.09	0.36	-0.25	-0.35	-0.24	-0.20	-0.22	-	-	-	-
Coccinellids	-0.27	0.88**	0.23	-0.17	-0.19	-0.23	-0.24	0.55	0.30	-	-	-
Scymnus sp.	0.20	-0.14	-0.61*	0.34	-0.07	0.93**	-0.21	0.11	-0.17	-0.21	-	-
Spider	0.21	0.01	-0.05	0.61*	0.51	0.56	0.13	-0.13	-0.38	0.00	0.44	-

Note: * Correlation is significant at 0.05 level; ** Correlation is significant at 0.01 level
Mite recorded from 4 cm^2 area

Occurrence [Fruit borer, *H. armigera (Hubner)*]

Kharif, 2014

The data of *kharif*, 2014 are summarized in Table 1. The infestation commenced during 1st week of September (36thSMW, 6th WAG) and gradually increased towards the maturity of okra crop [3rd week of October (42nd SMW, 12th WAG)]. The peak infestation caused by this pest was recorded during 3rd week of October (42nd SMW, 12th WAG) *i.e.* 87.5 percent fruit damage. The per cent fruit damage in okra crop was in the range of 3.33 to 87.5 with the mean of 18.51.

Kharif, 2015

The data on damage due okra fruit borer are presented in Table 2. Fruit damage caused by *H. armigera* was first noticed from 1st week of September (36th SMW, 9th WAG) with 16.6 per cent and recorded till harvest of crop [4th week of September (39th SMW 12th WAG)] with the mean 10.30. The fruit damage periodically increased and reached on peak (52.63%) during 4th week of September (39th SMW, 12th WAG).

Effect of weather parameters

Kharif, 2014

Weather parameter *viz*., WS (r = -0.73**), MinT (-0.78**) and RH_2 (-0.83**) showed highly significant negative association with fruit damage, whereas, BSS (0.77**) and MaxT (0.74**) showed highly significant positive (Table 3).

Kharif, 2015

The data for association between various abiotic factors and damage caused by *H. armigera* are presented in Table 4. MinT (r = -0.70*) revealed significant negative association with the infestation. From the ongoing study, the fruit damage caused by *H. armigera* was higher during *kharif*, 2014

(18.51 ± 7.64 per cent damage fruit) than the *kharif*, 2015 (10.30 ± 5.10). In both the seasons, intensity of fruit damage was periodically increased and reached on the highest level (peak) during 3rd week of October (42nd SMW, 12th WAG) during *kharif*, 2014 (87.5%) and 4th week of September (39th SMW, 12th WAG) during *kharif*, 2015 (52.63%). Nath *et al.*, (2011) also recorded the infestation of *H. armigera* as fruit borer in okra at Meerut during 38th SMW. Present finding are more or less in agreement with the past findings.

Occurrence (Shoot and fruit borer, *E. vittella*)

Kharif, 2014

The periodic data on activity of *E. vittella* are presented in Table 1. Fruit damage due to *E. vittella* commenced from 3rd week of September (38th SMW, 8th WAG) and ranged from 3.57 to 10.00 per cent with mean 2.93 per cent during the crop season. The highest (10.0%) fruit damage was recorded during 1st week of October (40th SMW, 10th WAG).

Kharif, 2015

During *kharif*, 2015; the infestation of *E. vittella* as shoot borer was observed and the data are presented in Table 2. The shoot damage caused by this pest was observed during 3rd to 5th week of August (33rdto 35th SMW, 6th to 8th WAG) with mean 1.39 per cent. The highest shoot damage (8.62%) was observed during 3rd week of August (33rd WAS, 6th WAG).

Effect of weather parameters

Kharif, 2014

The results of *kharif*, 2014 (Table 3) revealed that BSS (0.88**) and MaxT (0.86**) exhibited highly significant positive whereas WS (-0.75**) and RH_2 (-0.90**) had highly significant negative association with the fluctuation of pest. Rest of the parameters under study did not show any significant impact on activity of pest.

In general, the higher activity of *E. vittella* as fruit borer was recorded during *kharif*, 2014 (2.93 ± 1.14), whereas the activity of this pest as shoot borer was observed during *kharif*, 2015 (1.39 ± 0.84). The highest fruit damage was recorded during 3rd week of October (87.50%) during *kharif*, 2014. However, maximum (8.62%) shoot damage was recorded during 3rd week of August in *kharif*, 2015. While shifting the literature, Mohansundaram and Sharma (2011) reported the activity of this pest during middle of August. Further, they also mentioned the association between evening relative humidity and infestation of fruit borer and it was significant negatively correlated. In addition to this report, Pal *et al.*, (2013) stated the activity of this pest and attained maximum level during 16th SMW. Thus, the present findings are in agreement with the earlier reports.

Activity of various natural enemies in okra

The activity of natural enemies *viz*., spiders and coccinellids was also studied during *kharif*, 2014 and *kharif*, 2015. The population fluctuation of spiders in relation to weather parameter was also carried out during *kharif*, 2014 and *kharif*, 2015.

Occurrence

Coccinellids

Kharif, 2014

Mean population of coccinellids recorded at weekly interval presented in Table 1 revealed

that the population of adults appeared during 1st week of September (36th SMW, 6th WAG) and then it was disappeared. Again population appeared during 1st week of October (40th SMW, 10th WAG). Its population ranged from 0.03 to 0.31 coccinellid adults per plant.

Kharif, 2015

Mean population of coccinellids recorded at weekly interval summarised in Table 2. The population of coccinellid adult was recorded on crop during 4th week of July (30th SMW, 3rd WAG), 1st week of August (31st SMW, 4th WAG) and 1st week of September (36th SMW, 9th WAG) in the terms of 0.05, 0.1 and 0.03 coccinellid adults per plant, respectively.

Scymnus sp.

Kharif, 2014

Scymnus sp. as predator of red spider mite reported first time in middle Gujarat (Pathan *et al.*, 2016) in okra ecosystem. The population of *Scymnus* sp. (Table 1) was recorded during the maturity stage of crop *i.e.* 2nd (0.11 adults per plant, 41st SMW, 11th WAG) and 3rd week of October (0.31 adults per plant, 42nd SMW, 12th WAG), just after two week of mite appearance.

Kharif, 2015

During this season, *Scymnus* sp. activity was also recorded at later part of the crop and was observed during 3rd week of September (0.38 adults/plant) and 4th week of September (0.65) (Table 2).

Spiders

Kharif, 2014

The activity of spider presented in Table 1 revealed that the population appeared on the okra crop after 4th week of germination (4th WAG) *i.e.* 5th week of August (35th SMW, 5th WAG) and remained up to harvest of crop with mean population of 0.05 per plant. The highest activity (0.13 spiders/plant) was observed during 3rd week of September (38th SMW, 8th WAG).

Kharif, 2015

Mean population of spiders recorded at weekly interval presented in Table 2 indicated that population noticed on crop after two week of germination *i.e.* on 4th week of July (30th SMW, 3rd WAG). The population ranged from 0.03 to 0.25 per plant. The peak population was recorded during 4th week of September (39th SMW, 12th WAG).

Effect of weather parameter

Kharif, 2014

Correlation study (Table 3) indicated that none of the abiotic factors exerted significant impact on the incidence of spider. However, BSS, RF, MinT and RH_1 showed positive whereas rest had negative correlation.

Kharif, 2015

A correlation study was under taken (Table 4) and the results revealed that WS (r = -0.86**) and MinT (-0.70*) exerted highly significant and significant negative association with the activity of spiders, respectively. A positive significant correlation was established between BSS (0.67*) and spiders population.

Association between/among insect pests in okra (Pest succession)

Kharif, 2014

Based on results of correlation studies between or among the insect pests in okra

ecosystem in *Kharif*, 2014 (Table 5), mite (r = 0.76**), *H. armigera* (0.89**), *E. vittella* (0.81**) and *Scymnus* sp. (0.71**) showed highly significant association with leafhopper. Spiders highly significantly associated with aphid (0.77**).

Whereas, semilooper showed highly significant association with whitefly (r = 0.73**). As in case of *H. armigera* showed highly significant association with *E. vittella* (0.74**), mite (0.93**) and with *Scymnus* sp. (0.91**). Predatory *Scymnus* sp. showed highly significant association with mite (0.99**) activity (Table 6).

Kharif, 2015

There was highly significant positive association between coccinellids and aphid activity (0.88**). The population of whitefly (-0.61*) depicted significant negative association with *Scymnus* sp., while spiders (0.61*) had positive significant correlation with mite. Significant co-existence (0.65*) of mite and *H. armigera* was noted. Similarly, the highly significant co-existence of *Scymnus* sp. (0.93**) was observed during the infestation caused by *H. armigera* in okra fruits. However, Deb (2014) reported positive association among the insect pests of tomato.

During *kharif*, 2014; BSS (r =0.59*) and MaxT (0.63*) exhibited significant positive association while (MinT) (-0.91**) and RH_2 (-0.70*) showed significant negative association with mite. In *kharif*, 2015; BSS (0.67*) showed significant positive whereas, wind speed (WS) (-0.60*) showed significant negative association with mite population. In *kharif*, 2014; WS (r = -0.73**), MinT (-0.78**) and RH_2 (-0.83**) showed highly significant negative association, whereas BSS (0.77**) and MaxT (0.74**) revealed highly significant positive association and during *kharif*, 2015; MinT (-0.70*) exerted significant negative association with *H. armigera* causing fruit damage. During *kharif* (2014), BSS (r = 0.88**) and MaxT (0.86**) exhibited highly significant positive impact whereas, WS (-0.75**) and RH_2 (-0.90**) had highly significant negative association with *E. vittella*.

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