Mysore J. Agric. Sci., 56 (2) : 65-75 (2022)

Population Dynamics of Sucking Pests on Okra *Abelmoschus esculentus* (L.) and their Natural Enemies in Relation to Weather Parameters

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ABSTRACT

The experiments were conducted during 2019-20 on okra crop grown at ICAR - NBAIR research farm, Attur, Bengaluru, in three seasons *i.e., rabi* 2019, summer 2020 and *kharif* 2020 to study the population dynamics of sucking pests and their natural enemies in relation to weather parameters. The results revealed that the activity of aphids, leafhoppers, ladybird beetles and spider were more in *kharif* than *rabi* and summer, whereas the activity of whitefly was more in summer. The maximum population of occurrence of pests and natural enemies was seen in between the11th and 14th week crop, after which population reduced drastically. In all three seasons, rainfall recorded significant negative correlation with the population of pests and natural enemies. However, wind speed and maximum temperature significantly impacted on the all population of pests and natural enemies during *rabi* and summer, respectively. The results of the current study help in planning, developing and execution of appropriate strategy for managing the okra pests.

Keywords : Season, Okra, Sucking pests, Natural enemies, Weather parameters

OKRA, *Abelmoschus esculentus* (L.) Moench is the most common vegetable grown and consumed in India. Okra locally known as 'Bhindi' and 'Lady's Finger' is a popular and most common annual vegetable crop in both tropical and subtropical parts of the world (Sree *et al*., 2019). Okra crop is cultivated for its young tender fruits, which are used in preparation of curry and soups. Fruits are also dried or frozen for use during off-season. The root and stem are used for clearing cane juice in preparation of jaggery/gur. Seeds are a source of oil, protein and are also used as a coffee substitute, while ground up okra seeds has been used as a substitute for aluminum salts in water purification. It is highly nutritious, 100 g of edible fruit contains 2 g of protein, 0.19 g fat, 7.45 g carbohydrate, 1.48 g of sugars, 0.7 g, 3.2 g fiber, minerals like K (299 mg), Ca (82 mg), Mg (57 mg), Fe (0.62 mg), Zn (0.58 mg) and Vitamins like A, B1, B2, C, E and K (Patel *et al*., 2018).

Though India is the second largest producer of vegetables after China, ranks first in area (5.19 lakh ha) and production (63.71 lakh MT) of okra. 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 (Anonymous, 2020). However, the growth and quality of crop is affected by incidence of numerous insect pests. More than 72 species of insects have been recorded on this crop, the major pests being shoot and fruit borer, leaf folder and sucking pest complex (Pandey, 2018).

The sucking pests usually attack right from early seedling stage till the harvesting. The important sucking pests are aphid (*Aphis gossypii* Glover), leaf hopper (*Amrasca biguttula biguttula* Ishida) and whitefly (*Bemisia tabaci* Gennadius). Leafhopper attack causes the leaves to curl upward along the tip and margins and develop necrotic areas, which extend over entire surface resulting in hopper burn. Nymphs and adults of aphids and whiteflies suck the cell sap causes reduction in vigor and photosynthesis of plants. Heavy infestation of sucking pests in the early crop stage results in stunted growth and gradual death of the plants.

Seasonal incidence and population dynamics is the study of growth and structure of population together

with the factors that regulate their size and density. The abiotic factors (temperature, rainfall, relative humidity, light period and intensity etc.) are most important environment resistance factors that affects plant pests. Thus, studies on population dynamics give us an idea of the environmental factors that regulate cyclic occurrence of the pest and helps in planning and execution of plant protection measures, as it clearly reveals the peak activity as well as insect free periods during crop growth.

Okra and its pest complex forms 'okra ecosystem' which also includes natural enemies living at the expense of the pests. The predatory insects like lady bird beetle, spider and aphid lion or green lacewing feeds on aphids and others of soft bodied insects, which helps to manage the pests feeding on okra. The current study was carried out to study the incidence of major sucking pests and their predator and effect of abiotic factor on its incidence so as to develop an appropriate management strategy for the pest.

Material and Methods

Experimental Site

The field experiment was conducted at Entomological Research Farm, ICAR - NBAIR, Attur, Bengaluru (Latitude: 13.097221 Longitude:77.568291). Okra variety, Arka Nikita (IIHR) was sown in an area of 20 x 20 m^2 with 45 x 30 cm spacing on 1st October -2019 during *rabi* 2019, 1st January 2020 during summer 2020 and 2nd July during *kharif* 2020. All Agronomical practices were followed to raise the crop except plant protection measures.

Method of Recording Observations

Observations on incidence of sucking pests and natural enemies were recorded at weekly interval from their first appearance till last picking of fruits. The population of sucking insect pests *viz*., aphids, leafhoppers and whitefly were recorded in early morning hours by visually counting on three leaves (top, middle and bottom) in 15 randomly selected plants at weekly interval. For assessing the population density of natural enemies *viz.,* lady bird beetle and spiders, observations were made on per plant basis on 15 randomly selected plants at weekly interval since the emergence of seedlings.

Recording Weather Data

Data on weather factors *viz*., Temperature ^{0}C (maximum and minimum), Relative humidity (%) (Morning and Evening), Rainfall (mm), Wind speed (km/hr.) and Bright sunshine (hrs.) on weekly intervals were collected from meteorological observatory of the faculty UAS, Bangalore (Table 2, 5 and 8). The data obtained was statistically analyzed using R-software. Correlation analysis of weather parameters and weekly incidence of pest and predator was also done.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Seasonal Incidences of Pests and Natural Enemies of Okra

Seasonal incidences of pests, predators and the influence of thermos hygro parameters *viz.,* temperature (maximum and minimum), relative humidity (morning and evening) and rainfall, wind speed and sunshine on population of sucking pests and predators was assessed and presented in three seasons.

Rabi 2019 : Aphids, *Aphis gossypii* (Glover)

The activity of aphids was observed from second week of October till the harvesting of crop. Initially, the population aphid was 7.5 aphids / three leaves / plant. The population of aphid gradually increased and reached its peak population in second week of December (104.8 aphids / three leaves / plant). Thereafter, the aphid population started declining till the maturity of the crop (Table 1 and Fig. 1). The results of the present investigations of the *rabi* season are in close agreement with Deevaraj *et al.* (2020), who reported that there was a gradual increase in aphid population from fourth week of November to first week of January with a maximum population of 28.55 per / top three leaves. However, population gradually decreased from second week of January

TABLE 1

Population dynamics of sucking pests and their natural enemies in okra during *rabi* -2019

Duration	SMW	Pests / 3 Leaf /Plant			NE's number / Plant	
		Aphid	Leafhopper	Whitefly	Ladybird beetle	Spider
01-07 Oct	40	0.0	0.0	0	0	0
08-14 Oct	41	7.50	8.86	3.40	3.26	0.93
15-21 Oct	42	16.23	8.90	3.70	6.56	4.23
22-28 Oct	43	18.50	21.53	7.70	7.00	4.80
29-04 Nov	44	24.73	22.50	7.90	8.00	5.00
05-11 Nov	45	32.53	17.73	8.73	12.00	7.33
12-18 Nov	46	28.06	21.53	8.66	14.93	10.60
19-25 Nov	47	32.63	23.50	6.86	14.50	11.00
26-02 Dec	48	40.40	24.66	7.20	9.93	7.73
03-09 Dec	49	70.50	24.86	9.20	14.46	10.33
10-16 Dec	50	104.8	15.75	8.20	16.20	11.13
17-23 Dec	51	60.50	16.50	6.78	18.50	11.50
24-31 Dec	52	45.20	16.26	6.33	19.33	9.06
01-07 Jan	01	30.33	23.06	12.86	16.33	16.33
08-14 Jan	02	24.60	22.66	7.86	14.80	13.44
15-21 Jan	03	22.50	23.10	5.20	13.46	14.86
22-28 Jan	04	17.50	22.00	8.84	14.80	12.80
29-04 Feb	05	12.50	15.00	6.78	13.50	9.80

(23.40 / top three leaves) and there was no incidence from last week of January onwards. The present findings are also in line with Anitha and Nandihalli (2008) who reported on *rabi* crop, the incidence of aphid started from 49th standard week and reached its peak during first week of January with 24.91 aphids per top three leaves.

Correlation analysis of aphid's populations with weather parameters indicated that there exists a significant positive correlation with evening relative humidity and wind speed, whereas a significant negative correlation was rerecorded with maximum temperature and rainfall. However, other weather parameters showed non-significant correlation with aphid population during the period (Table 3).

Leafhopper, *Amrasca biguttula biguttula* (Ishida)

The leafhopper population infestation commenced in the second week of October. The peak population of leafhoppers was recorded in the first week January (1st SMW) with 23.06 leafhopper / three leaves/plant (Table 1 and Fig. 1).

The current findings are in line with the findings of Anitha and Nandihalli (2008) who reported leafhopper on *rabi* crop during 49th SW and its peak during first week of January. Results are also in line with Deevaraj *et al.* (2020), who reported that the incidence of

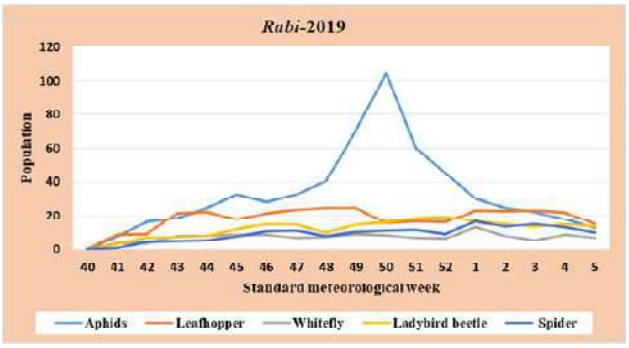

Fig. 1: Population dynamics of Sucking pests and their natural enemies in okra during *rabi* 2019

TABLE 2

Weather data of *rabi* -2019

Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Wind Speed (km/hr)	Sunshine (hrs)
Min	Max	LMT0700*	LMT1400*			
29.20	18.30	92.00	53.00	76.20	3.80	6.00
28.90	18.70	91.00	54.00	71.80	2.80	5.30
27.40	18.60	93.00	62.00	12.00	5.70	5.70
26.30	17.90	93.00	61.00	70.20	5.80	3.40
27.00	18.00	92.00	61.00	70.00	6.10	6.20
29.00	17.00	88.00	54.00	0.40	6.70	8.10
27.10	17.10	91.00	60.00	1.40	5.50	7.10
27.20	17.20	90.00	58.00	8.20	6.68	4.30
26.60	16.50	91.00	61.00	0	8.30	5.36
24.40	16.30	92.80	65.50	0	7.90	3.00
26.40	15.80	89.80	61.70	0	7.10	6.00
26.30	15.90	90.50	59.90	0	7.50	6.00
27.50	17.20	91.40	56.20	0	6.10	6.00
27.50	17.50	89.00	56.00	0	5.40	5.40
28.10	16.30	88.00	52.00	0	6.40	9.10
28.10	15.70	88.00	50.00	0	6.90	9.00
28.50	14.30	88.00	48.00	0	6.70	10.00
29.60	15.00	89.00	48.00	0	6.70	10.00

*LMT: Local Mean Time

leafhopper was started from second week of November (13.43 / top three leaves) and there was a gradual increase from third week of November to last week of December with a maximum population of 15.47 per top three leaves.

Correlation studies of leafhopper population with weather parameter indicated a significant positive correlation with wind speed and a significant negative correlation with maximum temperature. The population showed non-significant correlation with minimum temperature, morning and evening relative humidity, rainfall, wind speed and sunshine (Table 3).

Whitefly, *Bemisia tabaci* (Genn.)

The population of whitefly was appeared in the second week of October. The peak population of the whitefly was observed in the first week January (1st SMW) with 12.86 leafhoppers / three leaves / plant (Table 1 and Fig. 1). The findings of this study are in close agreement with Mani and Singh's observations (2012) who reported peak incidence of whiteflies during first week of January. Deevaraj *et al.* (2020) observed that the incidence of whitefly began in the third week of November and gradually increased from the fourth week of November to the second week of January, with a peak population of 10.90 per top three leaves.

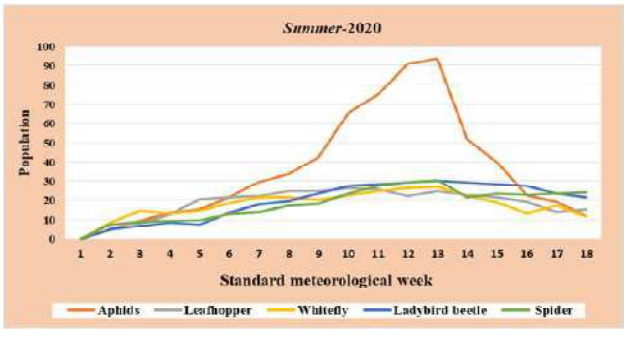

Fig. 2 : Population dynamics of Sucking pests and their natural enemies in okra during summer-2020

TABLE 3

Correlation between population of sucking pests and predator with weather parameters during *rabi* 2019

Weather parameters	Correlation coefficient ('r' value)				
	Aphids	Leafhopper	Whitefly	Lady bird Beetle	Spider
Temp. max (^{0}C)	-0.677 **	-0.489 *	0.385 NS	-0.310 NS	-0.196 NS
Temp. min (^{0}C)	-0.340 NS	-0.428 NS	-0.376 NS	-0.640 **	-0.685 **
Morning RH(%)	0.022 NS	-0.281 NS	-0.334 NS	-0.454 NS	-0.645 **
Evening RH (%)	0.55 *	0.173 NS	0.171 NS	0.002 NS	-0.184 NS
Rainfall (mm)	-0.469 *	-0.462 NS	-0.508 *	-0.827 **	-0.796 **
Wind Speed (km/hr)	0.594 **	0.657 **	0.482 *	0.625 **	0.573 *
Bright Sun shine (hrs)	-0.291 NS	0.000 NS	0.015 NS	0.220 NS	0.348 NS

* Significant at 5.0 %; ** Significant at1.0 %; NS : Non-significant

Correlation studies of whitefly population and weather parameter indicated that a significant positive correlation exist with wind speed and negative significant correlation with rainfall. The maximum and minimum temperature, Morning and evening relative humidity and sunshine showed a non-significant correlation with the whitefly population (Table 3).

Ladybird Beetle

The population of coccinellids (grub and adult) were

TABLE 4

Population dynamics of Sucking pests and their natural enemies in okra during summer 2020

Duration	SMW	Pests 3 Leaf / Plant			NE's number / Plant	
		Aphids	Leafhopper	Whitefly	Ladybird beetle	Spider
1-7 Jan	1	0	0	0	0	0
08-14 Jan	2	4.72	7.72	8.82	5.15	7.61
15-21 Jan	3	9.63	8.16	14.86	6.73	8.91
22-28 Jan	4	13.72	12.73	13.50	8.63	9.73
29-04 Feb	5	15.45	20.63	14.90	7.71	10.10
05-11 Feb	6	21.63	21.50	18.50	13.76	13.12
12-18 Feb	7	29.73	22.30	21.60	17.86	14.26
19-25 Feb	8	33.72	24.68	21.50	19.71	17.38
26-02 Mar	9	42.40	24.72	20.30	23.41	18.41
03-09 Mar	10	65.23	26.32	22.50	27.41	23.41
10-16 Mar	11	75.42	25.78	24.70	28.30	27.49
17-23 Mar	12	90.71	22.30	26.30	29.41	29.41
24-31 Mar	13	93.71	24.70	27.00	30.31	30.41
01-07 Apr	14	52.00	22.80	22.60	29.32	21.41
08-14 Apr	15	40.00	21.63	18.90	28.41	23.48
15-21 Apr	16	22.51	19.23	13.50	27.32	22.92
22-28 Apr	17	19.23	14.11	17.20	23.41	23.41
29-04 Apr	18	12.11	15.48	11.90	21.63	24.21

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TABLE 5

Weather data of summer-2020

Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Wind Speed (Km/hr)	Sunshine (hr)
Max	Min	LMT0700	LMT1400			
27.50	17.50	89.00	56.00	0	5.40	5.40
28.10	16.30	88.00	52.00	0	6.40	9.10
28.50	15.70	88.00	50.00	0	6.90	9.00
29.60	14.30	88.00	48.00	0	6.70	10.00
30.10	14.20	88.00	47.00	0	6.60	10.00
29.40	16.70	90.10	48.00	0	7.10	9.10
30.00	16.20	86.40	47.80	0	7.20	9.90
29.90	16.30	89.20	47.10	0	8.70	8.80
30.10	16.20	90.00	47.20	0	8.50	8.80
31.90	19.90	89.00	40.00	0	5.90	7.80
32.60	19.00	85.00	39.00	0	7.80	9.40
33.10	19.70	87.00	39.00	3.5	5.50	8.00
33.40	18.50	85.00	38.00	0.00	6.50	10.10
33.80	20.30	86.00	37.00	20.80	6.10	8.90
33.00	18.20	87.00	38.00	16.80	5.60	8.70
34.40	20.60	81.00	35.00	0	5.70	10.80
32.50	19.40	83.00	46.00	158	4.10	7.100
32.70	20.90	82.00	31.00	25.80	5.00	8.00

first noticed during the second week of October with gradual increase in succeeding weeks. The peak number (19.33/plant) was noted during 52nd SMW (24-31 December). Only the wind speed showed a significant positive correlation and rainfall showed a significant negative correlation, whereas all other weather parameter shows non-significant correlation with the population of ladybird beetle (Table 3).

Spiders

The population of spider was noticed first in the second week of October (0.93 / plant) and occurred till harvesting of crop (44th SMW). The peak activity (16.33 / plant) was observed during 1st SMW. Spider population showed significant positive correlation with wind speed and showed a significant negative correlation with minimum temperature, morning relative humidity, and rainfall and non-significant correlation with maximum temperature, and sunshine (Table 3).

Summer 2020 : Aphids, *Aphis gossypii* (Glover)

The activity of aphids was observed from the second week of January and till the maturity of crop. Initial infestation of aphid's population was 4.72 aphids / three leaves / plant. The population of aphid was gradually increased and reached its peak population during the fourth week of March (13th SMW) with 93.7 1aphids / three leaves / plant). Thereafter, the

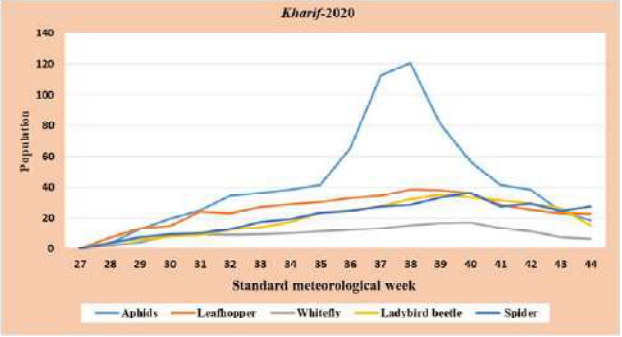

Fig. 3 : Population dynamics of Sucking pests and Their natural enemies in okra during *kharif* 2020

population started declining till the maturity of the crop (Table 4 and Fig. 2). The current findings are consistent with those of Anitha and Nandihalli (2008), who found that peak activity of aphids was observed during three months after sowing crop *i. e*., first week of July 2006 (27.17 aphids per 3 leaves).

Correlation studies of aphid's populations with weather parameters indicated that there exists a significant positive correlation with maximum temperature. The same population showed a significant negative correlation with evening relative humidity, whereas other weather parameters showed a non-significant correlation with aphid population (Table 6).

Leafhopper, *Amrasca biguttula biguttula* (Ishida)

The infestation of leafhoppers commenced in the second week of January and the peak population was recorded in the fourth week March (13th SMW) with 24.07 leafhopper / three leaves / plant (Table 4 and Fig. 2). The current findings are in line with the Anitha and Nandihalli (2008) who reported that peak activity of leafhopper was observed during three months after sowing crop *i.e.,* last week of June 2006 (16.99 leafhoppers per 3 leaves).

Correlation analysis of leafhopper population with weather parameter showed a significant positive correlation with maximum temperature and significant negative correlation with evening relative humidity. population recorded a non-significant correlation with minimum temperature, morning relative humidity, rainfall, wind speed and sunshine (Table 6).

Whitefly, *Bemisia tabaci* (Genn.)

The population of whitefly was appeared in the second week of January. The peak population of the whitefly was observed in the fourth week march (13th SMW) with 27 leafhopper / three leaves / plant. The current findings are in line with the Anitha and Nandihalli (2008) who reported that peak activity whiteflies noticed during last week of April 2006 (14.91 whiteflies per 3 leaves).

Correlation studies of whitefly population and weather parameter indicated that there exists a significant positive correlation with maximum temperature and negative significant correlation with evening relative humidity. The minimum temperature, morning relative humidity, rainfall, wind speed and sunshine shows non-significant correlation with the whitefly population (Table 6).

Ladybird Beetle

The population of coccinellids (grub and adult) were first noticed during the second week of January with gradual increase in the subsequent weeks. The peak number (30.41 / plant) was noted during 13th SMW (24-31 March).

TABLE 6

Correlation between population of sucking pests and predator with weather parameters during *summer*- 2020

Weather parameters	Correlation coefficient ('r' value)				
	Aphids	Leafhopper	Whitefly	Lady bird Beetle	Spider
Temp. max (^{0}C)	0.615 **	0.589 *	0.569 *	0.905 **	0.900 **
Temp. min (^{0}C)	0.421 NS	0.231 NS	0.229 NS	0.707 **	0.701 **
Morning RH(%)	-0.065 NS	-0.028 NS	-0.031 NS	-0.446 NS	-0.528 *
Evening RH (%)	-0.528 *	-0.560 *	-0.483 *	-0.821 **	-0.848 **
Rainfall (mm)	-0.142 NS	-0.137 NS	-0.018 NS	0.174 NS	0.223 NS
Wind Speed (km/hr)	0.131 NS	0.390 NS	0.316 NS	-0.081 NS	-0.153 NS
Bright Sun shine (hrs)	0.143 NS	0.448 NS	0.375 NS	0.190 NS	0.195 NS

*Significant at 5.0 %; ** Significant at 1.0 %; NS: Non significant

Correlation studies of ladybird beetle population with weather parameter indicated a a significant positive and negative correlation with temperature (maximum and minimum) and evening relative humidity, respectively. The other weather parameter showed a non-significant correlation with the population of ladybird beetle (Table 6).

Spiders

The population of spider was first noticed in the second week of January (7.61 / plant) and occurred till harvesting of crop (18th SMW). The peak activity (30.41 / plant) was observed during 13th SMW. Spider population shows very strong positive significant correlation with temperature (maximum and minimum) and shows very strong negative significant correlation with relative humidity (Morning and evening). The same spider population shows non-significant correlation with rainfall, wind and sunshine (Table 6).

***Kharif* 2020 : Aphids, *Aphis gossypii* (Glover)**

The activity of aphid was observed from third week of July 2020 till the crop maturity period, *i.e.,* first week of November 2020. The results are in line with the findings of Raghuwanshi *et al*. (2019), who observed that the population of aphid was notice in the month of August. Initially, the population aphid was 3.24 aphids / three leaves / plant. The population of aphid was gradually increased and reached its peak population during the fourth week of September (120.6 aphids / three leaves / plant). Thereafter, the aphid population started declining till the maturity of the crop (Table 7 and Fig. 3). Balpande and Saxena (2019), Potai and Chandrakar (2018) and Nirmal *et al*. (2018), reported the peak activity of during first week of October (40th SMW).

Correlation studies indicated that there was no significant impact of maximum and minimum

TABLE 7
Population dynamics of sucking pests and their natural enemies in okra during *kharif* -2020

Duration	SMW	Pests 3 Leaf / Plant			NE's number / Plant	
		Aphids	Leafhopper	Whitefly	Ladybird beetle	Spider
02-08 July	27	0	0	0	0	0
09-15 July	28	3.24	6.86	2.20	4.20	3.86
16-22 July	29	12.78	13.12	3.90	5.86	7.27
23-29 July	30	19.76	14.76	8.60	7.93	9.27
20-05 Aug	31	24.75	24.13	9.20	8.92	10.11
06-12 Aug	32	34.51	23.18	8.93	12.11	12.47
13-19 Aug	33	36.41	27.12	9.10	13.78	17.27
20-26 Aug	34	38.43	29.12	10.12	17.47	19.29
27-02 Sept	35	41.47	30.39	11.13	23.41	23.41
03-09 Sept	36	65.43	33.14	12.14	24.76	24.44
10-16 Sept	37	112.4	34.47	13.14	27.52	27.42
17-23 Sept	38	120.6	38.57	15.12	32.41	28.43
24-30 Sept	39	80.48	38.23	16.78	35.41	33.44
01-07 Oct	40	56.42	36.13	17.10	33.42	36.31
08-14 Oct	41	41.73	28.47	13.26	31.44	27.44
15-21 Oct	42	38.43	25.14	11.20	29.42	29.41
22-28 Oct	43	24.17	23.12	7.40	26.41	24.44
29-04 Oct	44	18.73	22.78	6.47	15.14	27.41

TABLE 8
Weather data of *kharif*-2020

Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Wind Speed (km/hr)	Sunshine (hrs)
Min	Max	LMT0700*	LMT1400*			
27.40	18.80	89.00	62.00	16.40	8.50	2.70
28.00	19.20	91.00	59.00	51.00	5.60	4.80
27.50	18.90	92.00	61.00	89.20	5.30	3.90
28.60	18.90	91.00	61.00	74.20	5.00	6.60
28.40	19.00	91.00	43.00	13.20	8.40	4.90
26.60	18.70	94.00	60.00	23.80	9.10	2.20
26.00	18.30	95.00	64.00	14.20	7.80	1.70
27.70	18.90	92.00	57.00	5.20	4.90	2.90
29.70	19.20	92.00	51.00	10.00	4.30	8.50
28.50	19.40	92.00	56.00	149.80	3.70	5.70
26.60	18.20	94.00	62.00	10.20	7.70	1.80
26.80	18.70	93.00	61.00	22.00	8.90	3.00
27.20	18.50	93.00	61.00	47.20	5.60	4.40
27.60	18.20	94.00	57.00	9.00	5.30	5.80
27.70	18.50	89.00	62.00	27.00	6.20	2.90
26.30	18.60	93.00	64.00	67.20	3.20	3.30
26.90	17.70	95.00	62.00	24.40	3.30	4.60
26.80	18.20	95.00	63.00	24.80	3.20	4.60

*LMT: Local Mean Time

temperature, morning and evening relative humidity, wind speed and sunshine on aphid population (Table 9). Similarly, Shanthi *et al.* (2020), Rawat *et al*. (2020) and Khating *et al*. (2016), also reported that the aphid population did not show significant correlation with minimum temperature, morning and evening relative humidity and rainfall (Table 9).

Leafhopper, *Amrasca biguttula biguttula* (Ishida)

The population of Leafhopper infestation commenced in the third week of July. The peak population of leafhopper was recorded from in the fourth week September (38th SMW) with 38.57 leafhopper / three leaves / plant (Table 7 and Fig. 3). These results are agreement with the findings of Rawat *et al*. (2020), Khating *et al*. (2016) and Yadav (2015), who also the peak leafhopper population on okra in the month of September and then declined gradually. Similarly, Balpande and Saxena (2019), Nirmal *et al.* (2018) and Shalini and Mourya (2017) also found that the maximum population of jassids on 40th SMW (1-7 October).

Correlation studies indicates there was no significant impact of maximum and minimum temperature, evening relative humidity, wind speed and sunshine on leafhopper population except morning relative humidity (Table 9).

Whitefly, *Bemisia tabaci* (Genn.)

The population of whitefly appeared in the third week of July and active up to the harvest of the crop. Potai and Chandrakar (2018) and Nagar *et al*. (2017) also reported that the incidence of whitefly on okra crop commenced in the month of August partially, which support to the present findings. The peak population of the pest was observed from in the month of September to October with 17.1 whitefly / three

TABLE 9
Correlation between population of sucking pests and predator with weather parameters during *kharif*- 2020

Weather parameters	Correlation coefficient ('r' value)				
	Aphids	Leafhopper	Whitefly	Lady bird Beetle	Spider
Temp. max (^{0}C)	-0.215 ^{NS}	-0.101 ^{NS}	-0.038 ^{NS}	-0.164 ^{NS}	-0.216 ^{NS}
Temp. min (^{0}C)	-0.166 ^{NS}	-0.238 ^{NS}	-0.211 ^{NS}	-0.393 ^{NS}	- 0.473 *
Morning RH(%)	0.308 ^{NS}	0.457 ^{NS}	0.290 ^{NS}	0.335 ^{NS}	0.491 *
Evening RH (%)	0.068 ^{NS}	-0.124 ^{NS}	-0.096 ^{NS}	0.125 ^{NS}	0.146 ^{NS}
Rainfall (mm)	-0.061 ^{NS}	-0.106 ^{NS}	-0.075 ^{NS}	-0.058 ^{NS}	-0.094 ^{NS}
Wind Speed (km/hr)	0.237 ^{NS}	-0.052 ^{NS}	-0.024 ^{NS}	-0.239 ^{NS}	-0.348 ^{NS}
Bright Sun shine (hrs)	-0.191 ^{NS}	0.026 ^{NS}	0.081 ^{NS}	0.037 ^{NS}	0.72 ^{NS}

*Significant at 5.0 %; * * Significant at 1.0 %; NS: Non significant

leaves / plant (Table 7 and Fig. 3). The present finding is in concordance with the observations of Balpande and Saxena (2019), Nirmala *et al*. (2018), Shalini & Mourya (2017) and Yadav (2015), who reported that incidence of whitefly on okra infestation of whitefly commenced in the first week of August and reached its peak in the month of September.

Correlation studies indicates that there was no significant impact of maximum and minimum temperature, Morning and evening relative humidity, wind speed and sunshine on whitefly population (Table 9).

Ladybird Beetle

The population of coccinellids (grub and adult) were first noticed during the third week of July with gradual increase in following weeks. The peak population (35.41 / plant) was noted during 39th SMW (24-30 September). Only morning relative humidity showed significant positive correlation and minimum temperature showed a significant negative correlation and all other weather parameter showed non-significant correlation (Table 9).

Spiders

The population of spider was noticed first in third week of July (3.86 / plant) and occurred till harvesting of crop. The peak activity (36.31 / plant) was observed during the 40th SMW. Spider population showed a significant positive correlation with morning relative humidity and non-significant negative correlation with all other weather parameters (Table 9).

The current study revealed that the activity of aphids, leafhoppers, ladybird beetles and spider were more in *kharif* than *rabi* and *summer*, Similarly, the activity of whitefly was more in summer. The maximum population of occurrence of pests and natural enemies was observed n between 11th and 14th week old age crop, after which the population of pests and natural enemies reduced drastically due to diminishing their host resources and unavailability of hosts insects, respectively. In all three seasons, rainfall showed a negative correlation with the population of pests and natural enemies, this is mainly because of rainfall may wash away of all sucking pests and natural enemies from host crop. During the *rabi* season, wind speed and in summer season maximum temperature significantly impacted on the all population of pests and natural enemies. The current study is helpful in planning, developing and execution of appropriate strategy for management of okra sucking pests.

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(*Received :* April 2022 *Accepted :* June 2022)