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Impact of abiotic factors on the population fluctuations of sucking insect pests on okra (*Abelmoschus esculentus* L.)

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Abstract
Impact of abiotic factors on the population fluctuations of sucking insect pests on okra crop were assessed in the present studies conducted at Vegetable Research Farm, BHU, Varanasi during Kharif season 2014-15 and 2015-16. Incidence of jassids was started during 35th SW (15 days after sowing), while initial aphids and whitefly infestation was observed during 36th SW. However, peak population of Jassids had been observed during 40 SW while aphids and whiteflies peak population was observed at 41st SW. In the field sucking insect population persisted up to 46th S.W. (3rd week of November). The aphid population was positively influenced by morning R.H (r = 0.768 and 0.614 during both the years), evening R.H. (r = 0.587 during 2015-16) and average R.H. (r = 0.587 during 2015-16) while negatively (r = -0.720 during 2015-16), influenced by rainfall but not significantly influenced by other weather parameters. The Jassid incidence was also positively influenced by morning R.H. (r = 0.861 during 2014-15) and average R.H. (r = 0.587 during 2015-16), while the whitefly incidence found to have significant positive relationship with morning R.H. (r = 0.782 & 0.608) during both the years and with average R.H. (r = 0.699) during 2015-16.

Keywords: Okra crop, sucking insect population, seasonal incidence and abiotic factors

1. Introduction

Okra or bhindi [*Abelmoschus esculentus* (L.) Moench] also known as ladies finger, is an annual, herbaceous plant belonging to Malvaceae with erect growth habit. It is a bisexual plant with or without branches. Okra is native to Afro-Asian countries but also cultivated widely in India, Nigeria, Pakistan, Ghana, Egypt etc. [1].

In India it was cultivated in an area of 504 '000 ha, out of total vegetable cultivation of 9465 '000 ha with a production of 5794 '000 MT and productivity of 12.0 MT ha^{-1} during 2015-16 [2]. India being second largest vegetable production countries in the world, has produced 168506 '000 MT of vegetables with a productivity of 17.6 MT ha^{-1} during 2015-16 [3].

Okra fruits are cooked as vegetable, matured pods and stem have been used in paper industry where as whole plant is used as clarifier in jaggary production [4]. The ripen seed of 'okra' are, sometimes roasted and ground as a coffee substitute, while the seed-powder has been used as substitute for the aluminum salts for water purification [5]. Moreover, okra mucilage is suitable for medicinal and industrial applications [6].

Okra crop is susceptible to various pest attacks in the field from early stage to maturity. Among the wide array of insect pests infesting okra crop, the sucking pests *viz.,* aphid, *A. gossypii*, leafhopper *A. biguttula biguttula*, and whitefly, *B. tabaci*, were reported to be quite serious during all stages of the crop growth [7].

Jassids (*A. biguttula biguttula*), both nymphs and adults, suck the cell sap usually from the ventral surface of the leaves and while feeding inject toxic saliva into plant tissues, turning affected leaves into yellowish and curl [8]. Whitefly (*B. tabaci*), the milky white minute flies; nymphs and adults suck the cell sap from the leaves. The affected leaves are curled and dried. The affected plants show a stunted growth [4]. Whiteflies are also responsible for transmitting yellow vein mosaic virus. Aphids, (*A. gossypii*) are considered as the major pest of okra. It is a polyphagous pest, attacking a wide range of plant belonging to 46 families. The nymph and adult are found in large numbers and they suck the sap from different parts of the plants [4]. There are many abiotic factors that favour the growth, development and reproduction of various insect pests, thus limit the production of okra.

The present study has been conducted to record the incidence of sucking pests during cropping season in accordance with seasonal fluctuations of various abiotic factors and the results thus obtained may be useful for formulating sustainable management practices of okra crop.

2. Materials and Methods

An area of 50 m^2 was raised with local okra variety "VRO-6" to study the population build up of the sucking pest population during *Kharif* season, 2014-15 and 2015-16 at Vegetable Research Farm, BHU, Varanasi. Okra seeds were sowed at a distance of 60 x 30 cm. The experimental plot was kept unsprayed during the course of investigation and all agronomical practices were adopted to render suitable crop growth. The pest population was recorded in this un-protected plot of okra at 7 days interval from the occurrence or initiation of the pest infestation and was continued up to end of the crop. A total of 25 plants from five locations in the bulk plot @ 5 plants per each sampling area were selected and tagged for recording the observations on sucking pest population. In each plant 3 leaves one each from top, middle and bottom canopy were taken to count the sucking insect population.

Weather data were collected from the metrological observatory available at Agriculture Research Farm, Institute of Agricultural Sciences, BHU, Varanasi and correlated with the occurrence of the sucking insect population. Among weather parameters, relative humidity, temperature, rainfall and sunshine hours were considered for correlating with the occurrence of the insect pests of okra.

2.1 Statistical analysis

To work out the relationship between the occurrence of the insect pests of okra and the weather parameters, simple correlation method was adopted [9].

3. Results and Discussion

3.1 Impact of abiotic factors on the population fluctuations of sucking insect population

The incidence of sucking pest population *viz*., aphids, *A. gossypii*; jassid, *A. biguttula biguttula* and whitefly, *B. tabaci* along and correlation with meterological data were presented in Table 1 and Table 2 while depicted in Fig. 1 and Fig. 2.

3.1.1 Impact of abiotic factors on the population fluctuations of *A. gossypii*

The data recorded on the incidence of *A. gossypii* nymphs and adults during 2014-15 revealed that their population was observed from 36th S.W to 46th S.W. The initial incidence was observed 3 weeks after sowing *i.e.* starting of September month (36th S.W.) with a mean population of 1.14 aphids per 3 leaves. The pest population reached peak during 40th S.W (1st week of October) having mean population of 11.84 per 3 leaves. The very next week of peak infestation, aphid population suddenly decreased (8.12 per 3 leaves) due to rainfall. After 42nd S.W the aphid population declined gradually and reached very low mean population of 1.02 per 3 leaves during 46th S.W. (Mid-week of November). Correlation co-efficient worked out to find out the relationship between aphid population and major weather parameters revealed that the aphid population exhibited positive but non-significant interaction with maximum temperature (r = 0.560), minimum temperature (r = 0.542) and evening R.H. (r = 0.113). Whereas, the relationship between the aphids and the morning R.H. was found positive and significant (r = 0.768) while rainfall showed significant and negative correlation (r= -0.720) with aphid population buildup.

The appearance of aphid population during *Kharif* season 2015-16 was also observed during 36th S.W with a mean population of 2.02 per 3 leaves. Whereas, Peak or highest incidence was observed during 41st S.W (Oct 8th to14th) having 15.14 mean population per 3 leaves. There after aphid population gradually declined and observed very less population at the end of crop period. The close perusal of data of simple correlation between weather parameters and population of aphids during kharif 2015-16 showed that morning R.H. (r = 0.614), evening R.H. (r = 0.587) and average R.H. (r = 0.711) had positive and significant impact on population buildup of aphids while non-significant positive effect with maximum temperature (r = 0.441) and sunshine hours (r = 0.441). Other parameters like minimum temperature and rain fall exhibited non-significantly negative correlation with aphid population.

The results are in agreement with the findings of Singh [4] who reported that, initiation of aphid population occurred 3 to 4 weeks after sowing. It was indicative from the data of present experiments that the aphid population was at its peak during second week of October and these findings in accordance with similar with the findings of Singh [4], Patel and Rote [10]. Singh [4] also reported that after 3rd week of November aphid population disappeared. The slight variation in commencement of incidence and peak period of incidence at present location composed to similar studies at other places of work in India may probably due to the difference in agro-climatic conditions of the locality and age of the crop. The present results were close accordance with the Singh *et al*. [4], Boopathy and Pathak [11], who reported that aphid population was non-significantly positively correlated with maximum temperature. The results were also in close accordance with Chattopadhaya *et al.,* [12] and Shah *et al*. [13] who reported that significant negative and non-significant negative correlation with rainfall, respectively. The present results are in close association with the results of Singh *et al*. [4], Boopathi and pathak [11] who reported minimum temperature had a non-significant negative influence on aphid population.

3.1.2 Impact of abiotic factors on the population fluctuations of *A. bigutula bigutula*

It can be observed from the data presented in the Table 1 and Figure indicated that incidence of jassids on okra crop started during 35th S.W (2 weeks after sowing) and observed up to 46th S.W (3rd week of November). The initial mean population per three leaves recorded as 1.84 and the peek incidence was observed in the first week of October (40th S.W) with a mean population of 13.92 per three leaves. Thereafter, the population gradually decreased. It is evident from the data (Table 1 and Fig. 1) that, jassid population had non-significant, positive correlation with maximum temperature (r = 0.263), minimum temperature (r = 0.255), evening R.H. (r = 0.241), average R.H. (R = 0.372) and sunshine hours (r = 0.384) while rainfall was negatively correlated but found non-significant. Whereas, morning R.H. showed significantly positive correlation (r = 0.861) with jassid incidence during 2014-2015.

During 2015-16 also seasonal incidence of jassids was started during 35th S.W. (2 weeks after sowing) with mean population of 2.16 for three leaves. The maximum temperature, minimum temperature, morning R.H., evening R.H., rainfall and sunshine hours during the initial infestation were 33.40 ^{0}C, 26.70 ^{0}C, 83.00%, 52%, 42.20 mm and 4.50 hours respectively. Highest incidence of jassids was found during starting of October (40th S.W) with a mean population of 14.02 per three leaves and at this time existence of maximum temperature (34.00 ^{0}C), minimum temperature (22.80 ^{0}C), morning R.H. (90.00%), evening R.H. (66.00%), rain fall (0.00 mm) and sunshine (8.80 hours) were found suitable for population buildup. After 40 S.W the jassid population gradually declined and observed very least population in the month of November with a mean number of 1.08 jassids per three leaves, after that the jassid population disappeared. The relation of weather parameters and jassid incidence during *Kharif* season 2015-16 worked out and presented in Table 2 and Fig. 2. The results indicated that non-significant positive correlation observed between jassid population and maximum temperature (r = 0.347), minimum temperature (r = 0.193), morning R.H. (r = 0.482), evening R.H. (r = 0.535) and sunshine hours (r = 0.527) while non-significant negative correlation exhibited with rain fall (r = -0.381). Only average R.H. parameter found significant and positively correlated with jassid incidence.

Earlier singh *et al*. [4] and Yadav *et al.* [14] reported that jassid incidence on okra crop was noticed during 2 weeks after sowing and 3 weeks after sowing, respectively. Kulakarni *et al*. [15], Purohit *et al*. [16] and Kumawat *et al*. [17] reported that peak incidence was noticed during end of September and these results more or less similar with the present findings. Further, Srinivasa [18] and Singh *et al*. [4] also found that the peak occurrence of jassids was observed during October month. The present observations on persistence of residue population till final harvest are in similar with the findings of Mahamood *et al*. [19] who also observed activity of jassids up to end of crop. The present findings are nearly similar with Hegde *et al*. [20], who recorded 16.3 jassids per 3 eaves at the time of peak infestation. Earlier, Prasad and Logiswaran [21], Sharma and Sharma [22] reported a significant positive correlation of jassid population with morning R.H. and average R.H. The present results were in agreement with the findings of Iqbal [23] and Boopathy and Pathak [11] who reported maximum temperature had non-significant positive correlation with jassid population. On the other hand, Sharma and Sharma [24] also obtained a positive correlation with minimum temperature.

3.1.3 Impact of abiotic factors on the population fluctuations of *B. tabaci*

The periodical week wise data on seasonal incidence of whitefly population (Table 1 and Fig. 1) during 2014-15 revealed that the population was recorded in the range of 0.82 to 10.84 whiteflies per three leaves from 36th S.W (September) to 46th S.W (November). It is indicating from the data that the population of whiteflies was high in the month of October, thereafter declined gradually and less whitefly population was observed in the month of November (46th S.W). The relationship between whitefly and weather parameters like maximum temperature (r = 0.092), minimum temperature (r = 0.136), evening R.H. (r = 0.221), average R.H. (r = 0.340) and sunshine hours (r = 0.418) was found positive but non-significant while morning R.H. exhibited significantly positive correlation (r = 0.782). Whereas, rainfall was non-significantly negatively correlated (r = -0.115).

The appearance of whitefly population during 2015-16 was observed from 36th S.W (first week of September) with a mean population of 1.86 per three leaves; thereafter whitefly population gradually increased and attained peak population during 41st S.W with a mean population of 11.78 per three leaves. After this peak, the pest population gradually decreased up to end of the crop period (November). Correlation was worked out to find out the relationship between whitefly population and the major weather parameters. The results mentioned in the Table 2 and Figure 2 revealed existence of positive but non-significant correlation between whitefly population and weather parameters like minimum temperature (r = 0.030), evening R.H. (r = 0.575) and sunshine hours (r = 0.441) while significant and positive association was found with morning R.H. (r = 0.608) and average R.H. (r = 0.699). Whereas rainfall again exhibited non-significant and negative correlation (r = -0.457) with whitefly population.

The present observations are corroborated with the findings of Singh *et al*. [4] and Kulakarni *et al*. [15], who reported as whitefly initiation started 3 weeks after sowing and peak was observed during fortnight of October, respectively. Earlier, Hasan *et al*. [24], reported peak whitefly population when the crop age 60 days old and these results are similar to the present observations. Singh *et al*. [4] also reported that whitefly population gradually declined after peak and least whitefly population observed during 3rd week of November. While comparing the relative incidence, Sharma and Rishi [25] reported a significant positive correlation of whitefly population buildup with relative humidity. The similar results were obtained by Ozur *et al*. [26] and Mohansundaram and Sharma [227], who reported a positive but non-significant correlation of the population with temperature variation. Further a non-significant negative correlation was obtained by Sharma and Rishi (2005) in relation to rainfall and the whitefly population incidence.

Table 1: Impact of abiotic factors on seasonal incidence of sucking insect population on okra during *Kharif* 2014-15

S.W	Month and Date	Temperature (^{0}C)		Relative Humidity (%)			Rainfall (mm)	Sunshine (Hours)	Average* number of sucking pests per 3 leaves		
		Max.	Min.	Morn.	Even.	Avg.			Aphids	Jassids	Whiteflies
35	Aug 27-Sep 02	33.00	27.10	84.00	71.00	77.50	6.50	6.00	0.00	1.84	0.00
36	Sep 03-09	32.70	26.40	85.00	69.00	77.00	34.90	5.30	1.14	2.64	1.96
37	Sep 10-16	31.90	25.80	86.00	80.00	83.00	11.00	4.00	2.62	4.92	3.42
38	Sep 17-23	33.30	26.00	87.00	72.00	79.50	13.70	5.20	5.28	6.85	5.02
39	Sep 24-30	33.40	24.30	90.00	56.00	73.00	2.10	8.40	7.69	9.63	7.38
40	Oct 01-07	32.20	24.20	91.00	64.00	77.50	0.00	6.30	11.84	13.92	10.84
41	Oct 08-14	31.20	24.00	88.00	68.00	78.00	50.70	6.10	8.12	8.49	9.14
42	Oct 15-21	29.80	19.80	88.00	69.00	78.50	0.00	7.20	8.68	7.62	8.00
43	Oct 22-28	29.80	19.20	83.00	58.00	70.50	6.20	6.80	7.02	6.41	6.42
44	Oct 29-Nov 04	30.40	18.00	85.00	41.00	63.00	0.00	6.80	5.26	5.25	4.02
45	Nov 05-11	31.40	16.30	86.00	39.00	62.50	0.00	6.80	3.02	3.38	2.78
46	Nov12-18	27.50	13.60	83.00	37.00	60.00	0.00	5.40	1.02	1.46	0.82
Correlation coefficient (r)							Maximum Temperature (^{0}C)		0.560	0.263	0.092

	Minimum Temperature (^{0}C)	0.542	0.255	0.136
	Morning Relative Humidity (%)	0.768**	0.861**	0.782**
	Evening Relative Humidity (%)	0.113	0.241	0.221
	Average Relative Humidity (%)	0.236	0.372	0.340
	Rainfall (mm)	-0.720*	-0.19	-0.115
	Sunshine (Hours)	0.457	0.384	0.418

Average* of three replications SW= Standard Week *Significant at $p\leq0.05$ **Significant at $p\leq0.01$

Table 2: Impact of abiotic factors on seasonal incidence of sucking insect population on okra during *Kharif* 2015-16

S.W	Month and Date	Temperature (^{0}C)		Relative Humidity (%)			Rainfall (mm)	Sunshine (Hours)	Average* number of sucking pests per 3 leaves		
		Max.	Min.	Morn.	Even.	Avg.			Aphids	Jassids	Whiteflies
35	Aug 27-Sep 02	33.40	26.70	83.00	52.00	67.50	42.20	4.50	0.00	2.16	0.00
36	Sep 03-09	33.50	26.30	79.00	59.00	69.00	0.00	8.80	2.02	3.48	1.86
37	Sep 10-16	24.60	27.50	80.00	64.00	72.00	0.00	8.60	3.85	6.84	3.96
38	Sep 17-23	31.10	26.90	82.00	59.00	70.50	11.90	6.90	5.14	6.28	4.38
39	Sep 24-30	33.30	22.00	89.00	54.00	71.50	0.00	9.00	8.22	9.66	7.25
40	Oct 01-07	34.00	22.80	90.00	66.00	78.00	0.00	8.80	9.62	14.02	9.38
41	Oct 08-14	34.60	23.80	93.00	82.00	87.50	0.00	7.30	15.14	10.14	11.78
42	Oct 15-21	33.00	21.80	88.00	51.00	69.50	0.00	8.00	10.72	8.28	8.65
43	Oct 22-28	32.10	19.00	80.00	56.00	68.00	0.00	8.30	7.55	6.02	5.72
44	Oct 29-Nov 04	30.60	16.60	87.00	74.00	80.50	23.00	5.20	5.42	4.84	3.87
45	Nov 05-11	28.00	18.60	89.00	49.00	69.00	0.00	5.70	2.86	3.02	2.48
46	Nov12-18	30.40	16.60	86.00	40.00	63.00	0.00	7.60	1.18	1.08	0.72
Correlation coefficient (r)							Maximum Temperature (^{0}C)		0.441	0.347	0.416
							Minimum Temperature (^{0}C)		-0.039	0.193	0.030
							Morning Relative Humidity (%)		0.614*	0.482	0.608*
							Evening Relative Humidity (%)		0.587*	0.535	0.575
							Average Relative Humidity (%)		0.711**	0.622*	0.699*
							Rainfall (mm)		-0.457	-0.381	-0.457
							Sunshine (Hours)		0.441	0.527	0.441

Average* of three replications SW= Standard Week *Significant at $p\leq0.05$ **Significant at $p\leq0.01$

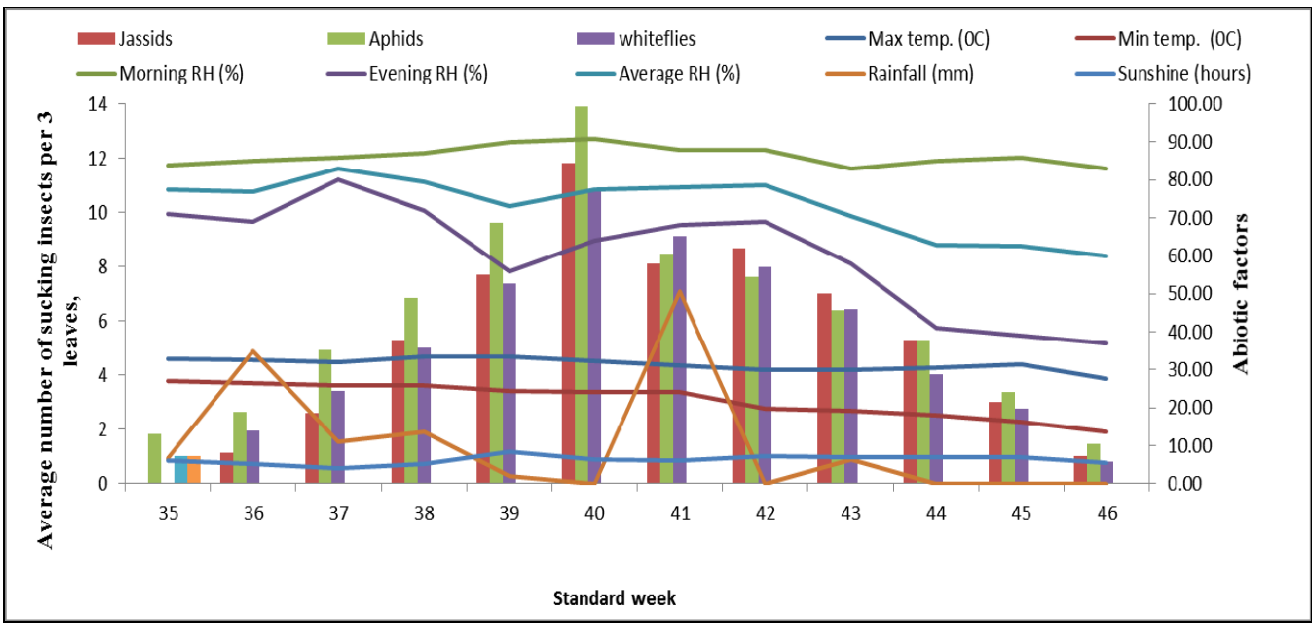

Fig 1: Impact of abiotic factors on seasonal incidence of sucking insects per 3 leaves on okra during 2014-15

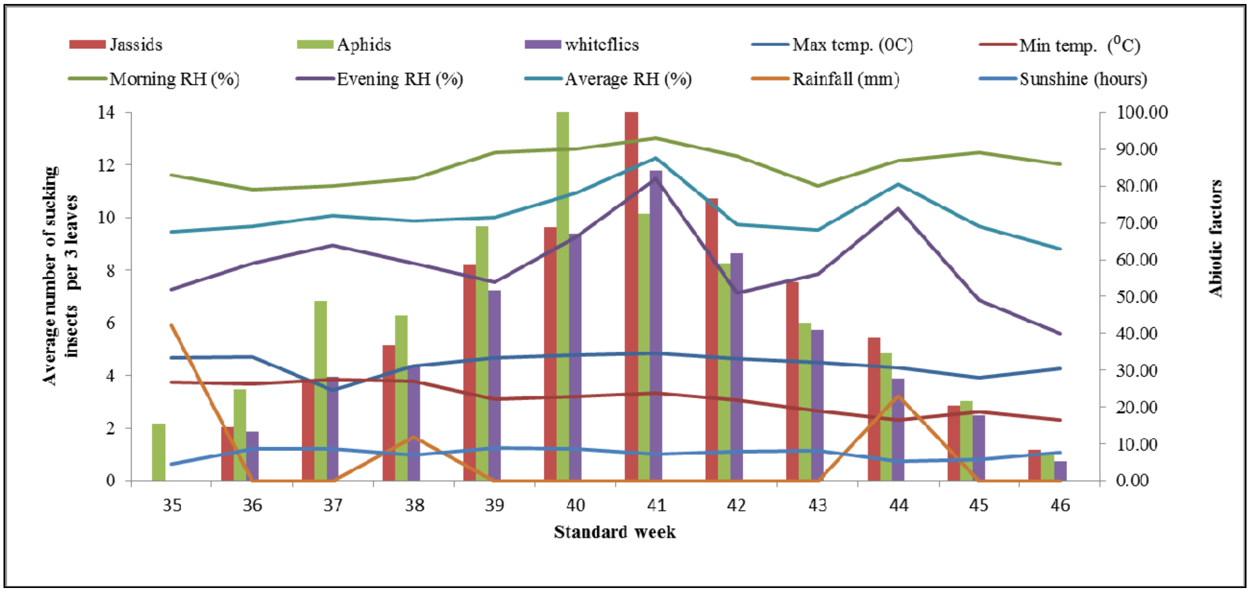

Fig 2: Impact of abiotic factors on seasonal incidence of sucking insects per 3 leaves on okra during 2015-16

4. Conclusion

Incidence of jassids was started during 35th SW (15days after sowing), while initial aphids and whitefly infestation was observed during 36th SW (third week after sowing). During both the years of study a non-significant positive correlation between sucking pests and the abiotic factors like maximum temperature, minimum temperature, average RH and sunshine hours. However, certain parameters like morning and evening RH showed significant positive correlation during second year of experimentation with sucking insect population. On the other hand, rainfall showed significant negative correlation particularly with aphid population.

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