Seasonal abundance of major sucking insect pests of okra and their natural enemies in relation to abiotic factors

Sharwan Lal Jat and Swaroop Singh

Abstract
To study the abundance of sucking pests of okra during summer season under semi-arid ecosystem of Rajasthan. The experiment was conducted at the Horticulture farm, S. K. N. College of Agriculture, Jobner (Rajasthan) during summer, 2017 and 2018. The incidence of leafhopper, Amrasca biguttula biguttula (Ishida) and whitefly, Bemisia tabaci (Genn.) were observed on okra crop during two consecutive seasons. The infestation of leafhopper commenced in the third week and second week of March (12th SMW and 11th SMW) and reached to its peak in the first week of May and third week of April, 2017 and 2018, respectively. The leaf hopper population had positive significant correlation with maximum and minimum temperature (r= 0.74, r=0.66, and r= 0.57, r=0.56 respectively) in 2017 and 2018. Whitefly infestation in the fourth week of March (13th SMW) and reached its peak in the 18th SMW during both the years. The whitefly population exhibited positive significant correlation with (r= 0.65), (r=0.55) maximum, (r=0.60) minimum temperature during 2017 and 2018 and while whitefly populations had negative significant correlation (r= -0.55, r= -0.53) with rainfall during both the year.

Keywords: Summer, leafhopper, whitefly, abundance and natural enemies

Introduction
Okra, Abelmoschus esculentus (L.) Moench commonly known as bhindi or lady’s finger belongs to the family Malvaceae is a popular fruit vegetable crop and said to be originated from Africa. It is an important summer and rainy season vegetable crop grown throughout the world. Okra is cultivated throughout India with major share in the states of Andhra Pradesh, West Bengal, Bihar, Gujarat, Odisha, Jharkhand, Maharashtra, Madhya Pradesh, Chhattisgarh, Assam, Uttar Pradesh and Haryana occupying an area of 528 thousand hectares with annual production of 6146 thousand metric tonnes and productivity 11.60 tonnes/ha (Anonymous, 2017-18) [1]. In Rajasthan, the major okra growing districts are Alwar, Bundi, Kota, Chittorgarh, Jaipur, Sriganganagar and Dausa. It is grown in an area of 41.53 thousand hectares with an annual production 21.39 thousand metric tonnes and productivity of 51.51 q/ha (Anonymous, 2017-18) [1]. It is one of the important cash crops paying high returns to the growers. The crop is attacked near about 72 species of insect pests right from germination to harvest (Rao and Rajendran, 2003) [22]. The major insect pests are shoot and fruit borer, Earias insulana (Boisd.), Earias vitella (Fab.), leafflower, Amrasca biguttula biguttula (Ishida), leaf roller, Sylepta derogata (Fab.), whitefly, Bemisia tabaci (Genn.); aphid, Aphis gossypii (Glover) and mite, Tetanychus cinnabarinus (Boisd.) (Meena and Kanwat, 2005, Kumar et al. 2014) [13, 8]. Out of these, leafflower, whitefly, shoot and fruit borer are major insect pests of okra.

The leafflower, A. biguttula biguttula sucks the cell sap from lower surface of the leaves and injects toxic substance in it, resulting in yellowing and curling of leaf margins and stunted plant growth. The severe infestation causes burning of leaves which fall down later and resulted in 40-60 per cent yield loss (Narke and Suryawanshi, 1987) [17]. The whitefly, B. tabaci also sucks the cell sap from the leaves which lower the vitality of plants. The whitefly also transmits viral diseases and acts as vector of ‘yellow vein mosaic’ virus in the plants (Nath et al., 1992) [18]. In order to prevent the infestation of insect pests and to produce a quality crop, it is essential to manage the pest population at appropriate time with suitable control measures. As such the knowledge of insect pest incidence in the changing climatic situations is essential during study, therefore, was undertaken to find out the correlation of

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insect pests, populations and their natural enemies with the weather parameters to know the hospitable conditions for insect development.

Materials and Methods
For studying the effect of abiotic factors on the abundance of major sucking pests of okra, the variety Pusa Sawani was sown on 25th February 2017 and 18th February 2018 in five separate plots of 3.0 x 2.25 m² size keeping row to row and plant to plant distance of 45 cm and 30 cm, respectively. All agronomical practices were followed as per package of practices for rainy the crop.

Method of observation
For recording the observations, five plants were randomly selected and tagged in each plot to record the pest populations. The observations of leafhopper and whitefly were recorded at weekly interval right from germination to harvesting of the crop. The population of sucking insect pests (leafhopper and whitefly) were counted in early morning hours of the day (before 8 AM) when they remained less active by visual count on three leaves, i.e. one each from top, middle and bottom of tagged plants (absolute counting) (Yadav, 2015, Thakkar and Rote, 2001 and Sharma and Sinha, 2009) [34, 31, 27]. All the stages of nymphs and adults of these pests were taken into account while counting. The leafhopper and whitefly on upper surface of leaves were counted first and then on lower surface by gentle turning, taking all possible care not to disturb them. The observations on the population of natural enemies viz., Coccinellids, and Chrysoperla carnea corresponding to the population of insect pests were recorded on the same tagged plants at the same time interval. The observations on natural enemies of pests were recorded soon after their appearance till last picking of the fruits

Interpretation of data
To interpret the results of seasonal abundance of major sucking insect pests of okra and their natural enemies, simple correlation was computed between population of insect pests, predator and abiotic factors (maximum and minimum temperatures, relative humidity and rainfall). The following formula was used for calculating correlation coefficient.

\[ r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{N \sum x^2 - (\sum x)^2} \cdot \sqrt{N \sum y^2 - (\sum y)^2}} \]

Where,
- \( r \) = Simple correlation coefficient
- \( x \) = Independent variables i.e. abiotic components
- \( y \) = Dependent variables i.e. pests
- \( N \) = Number of observations

Results and Discussion
During the field experimentation, sucking pests of okra were recorded quantitatively at different stages of plant growth with a view to provide a sound base for the management of major insect pests of okra in relation to key abiotic factors, viz., maximum and minimum temperature, relative humidity and rainfall under the prevailing agro-climatic conditions. Two major sucking insect pest species, viz., leafhopper, Amrasca biguttula biguttula (Ishida) and whitefly, Bemisia tabaci (Genn.) were noticed to attack the crop. On account of high population, these insect pests were categorized as major pests. The infestation of leafhopper, A. biguttula biguttula commenced in the first week of March (12th and 11th standard meteorological week, SMW) and remained active throughout the crop season fourth and third week of March during 2017 & 2018. Initially, the population of leafhopper was 1.80 and 1.20 per three leaves in 2017 and 2018, respectively. The population leafhopper was gradually increased (13th and 12th SMW) and reached to its peak in the fourth week of March (19.33/three leaves) and third week of March 18.66/per three leaves during 2017 and 2018, respectively. The population of leafhopper was recorded ranged from 1.80 to 19.33 and 1.20 to (18.66/three leaves) during both the years of study period, respectively. After reaching the peak, the population of leafhopper started to decline and reached to low level in third and fourth week of May in both the years, respectively.

The infestation of leafhopper population on okra crop at 34.8 °C maximum, 15.1 °C minimum temperature and 47 per cent mean relative humidity during 2017, in 2018 the maximum temperature was 34.00 °C, minimum temperature at 12.7 °C and per cent relative humidity was 41. Whereas, there was no rainfall was recorded during both the study years. The maximum leafhopper population (19.33/ three leaves) was recorded at 40.1 °C and 22.9 °C maximum and minimum temperature, respectively and 46.00 per cent mean relative humidity in the year, 2017 and at 40.4 °C maximum, 19.9 °C minimum temperature and 29.00 per cent mean relative humidity during 2018. The leafhopper population had positive significant correlation with maximum temperature and minimum temperature, \((r= 0.74, r=0.57\) and \(r=0.66, 0.56\) respectively) during both the years.

The infestation of leafhopper, A. biguttula biguttula commenced in the first week of March (12th and 11th standard meteorological week, SMW) and remained active throughout the crop season, i.e. second and third week of March 2017 and 2018. The present results are in agreement with those of Yadav et al. (2007) [32], Iqbal et al. (2010) [5] and Meena et al. (2010) [14].

Initially, the population of leafhopper was 1.80 and 1.20 per three leaves during 2017 and 2018, respectively. The leafhopper population gradually increased and reached to its peak in the fourth and last week of April (19.33 and 18.66/ three leaves during 2017 and 2018, respectively). The population of leafhopper was ranged from 1.80 to 19.33 and 1.20 to 18.66/ three leaves during 2017 and 2018, respectively. After reaching the peak, the population of leafhopper started declining and reached to low level in the fourth and third week of May and till the crop matured during both the years. The present results corroborate with the observations of Iqbal et al. (2010) [5], Yadav et al. (2007) [32], Kumawat et al. (2000) [11], Potaij et al. (2018) [21] and Meena et al. (2010) [14] who reported the peak population of leafhopper from the last week of August to September on okra crop. Yadav (2015) [34] who reported the infestation of leafhopper commenced in the first week of August and reached its peak in the second and third week of September. Kumari et al. (2012) [19] who reported the jassid was initially observed in the second week of April and its population reached peak in the fourth week of May (mean density of 22.3 per 3 leaves). The results also got support from the findings of Khating et al. (2016) [17], Meena et al. (2010) [14] and Nagar et al. (2017a) [16] who reported that peak leafhopper population on okra in the second and third week of September and then declined gradually. Rehman et al. (2016) [23] observed more population of leafhopper in the first week of July. The slight variation in commencement of incidence and peak period of incidence may probably be due to the difference in agro-
The mean relative humidity showed non significant correlation with whitefly population in present findings. The present findings are in close akin with those of Kumawat et al. (2000) [31], Meena et al. (2010) [34], Nath et al. (2011) [29] who found non-significant correlation between whitefly population and relative humidity. Yadav (2015) [34] reported that incidence of whitefly population exhibited positive significant correlation with minimum temperature and had negative significant correlation with rainfall, mean relative humidity during first year. The same trend has been recorded in second year. Nagar et al. (2017a) [10] who reported that the infestation of whitefly on okra crop showed non-significant correlation with maximum, minimum temperature and rainfall while, positive significant correlation with mean relative humidity. Contrary to this Bhute et al. (2012) [3] who reported a significant negative correlation with relative humidity do not support the present finding. The rainfall showed non significant negative correlation with whitefly population in present findings during both the years. Khati et al. (2016) [7] who reported that the incidence of whitefly had non significant do not show any significant correlation with abiotic maximum temperature. These results are in agreement with those of Yadav et al. (2007) [32] Kumawat et al. (2000) [11] and who found non significant correlation between whitefly population and rainfall. The observation was recorded on population of predatory species, viz., ladybird beetles, Coccinella septempunctata Linn., Menochilus sexmaculatus (Fab.) and green lacewing, Chrysoperla carnea (Stephens) were found preying leafhopper, A. biguttula biguttula and whitefly, B. tabaci on okra crop under field conditions during both the years (Table 1,2). Among them, the C. septempunctata and Chrysoperla carnea (Stephens) were observed dominant.

The correlation matrix indicated whitefly population had positive and significant correlation with maximum temperature (r= 0.57) during 2017. It exhibited whitefly population positive and significant correlation with minimum temperature (r=0.60) during 2018.

The present findings are in partial akin with the observations of Yadav (2015) [32] who reported that incidence of whitefly on okra infestation of whitefly commenced in the first week of August and reached its peak in the second and third week of September. Yadav et al. 2007 [32] reported incidence of whitefly started from the first week of August and persisted till second week of October. Kumawat et al. (2000) [11] who reported the maximum population of whitefly in the fourth week of September. Nath et al. (2011) [19] and Meena et al. (2010) [24] who reported that the Incidence of the population of whitefly on okra was started in the first week of August. Potaij et. al. (2018) [21] and Nagar et al. (2017a) [10] who reported that the incidence of whitefly on okra crop was first commenced in the second week of August, Mohanasundaram and Sharma (2011a) [15] reported that incidence of whitefly in the month of July, and peak in the month of September partially support the present findings. The slight difference in the incidence might be attributed due to the difference in sowing date of the crop and climatic factors of the region.

The leafhopper population had positive and significant correlation (r= 0.74, 0.66, respectively) with maximum, minimum temperature. The present results are in conformity with those of Mohanasundaram and Sharma (2011a) [15], Bhute et al. (2012) [3] and Jaysimha et al. (2012) who found a significant positive and correlation with maximum temperature and leafhopper population. These results are also in conformity with those of Khati et al. (2016) [7]. Yadav (2015) [34] who reported that leafhopper population had positive significant correlation with maximum, minimum temperature in first year while relative humidity had positive significant correlation in second year. Nagar et al. (2017a) [10] who was reported that population of leafhopper showed negative correlation with maximum temperature and positive significant correlation with relative. Similarly, Rehman et al. (2016) [23] who reported that leafhopper population had significant positive correlation with minimum temperature. The leafhopper population had non significant correlation with mean relative humidity and rainfall in the 2017 and 2018 which got support from the findings of Khati et al. (2016) [7], Saroj, et al. (2017) [25] and Singh et al. (2013) [29].

The populations of whitefly, B. tabaci on okra crop were recorded after five weeks of sowing and till maturity of the crop. The whitefly infestation commenced in the fourth week of March (13th SMW) and remained active throughout the crop season, i.e. third week of April during both the years i.e. 2017 and 2018. In the starting the population of whitefly was very low but it increased gradually and reached to its peak in the 18th SMW both the years. The peak population of whitefly 11.34 and 12.02 per three leaves was recorded during, 2017 and 2018, respectively. Population of whitefly ranged from 2.00 to 11.34 and 1.00 to 12.02 during both the years, respectively. The population of whitefly was declined at low level in the first week of June during, 2017, whereas, in 2018 the population was reached very low in the fourth week of May.

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The population of C. septempunctata commenced in the fourth week of March with a population of 1.20 and 180/five, plants in 2017 and in 2018, respectively. The population started to increase in the subsequent observations and reached its maximum in the first week of May with a count of 5.20/five, plants and fourth week of April with a count of 5.60/ five plants in 2017 and 2018, respectively. After reaching the peak, the population declined from the first week of June in 2017 and last week of May, 2018.

The appearance of C. septempunctata on okra crop at 39.9 0C, 32.5 0C maximum temperature and 16.1 0C, 13.5 0C minimum temperature with 37, 41 per cent mean relative humidity during 2017 and 2018. The maximum Coccinella septempunctata population was recorded at 43.4 0C 42.9 0C and 25.1 0C, 25.6 0C maximum and minimum temperature, respectively with 47, 29 per cent mean relative humidity during both the years.

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The population of green lacewing, were recorded during 2018. The coccinellid population had positive significant correlation with mean relative humidity (r = 0.57) during 2018. The coccinellid population had positive significant correlation with maximum, minimum temperature, mean relative humidity and rainfall showed in conformity to Meena (2004) and Yadav (2015) reported that the coccinellid population had positive significant correlation with maximum temperature and rainfall. Similar observations were made by Sanjay et al. (2018) who reported that the population of coccinellids were positively correlated with minimum temperature.

The population of green lacewing, were recorded 1.80, 2.60 / five plant on okra crop started at 38.1 °C, 39.2 °C maximum, 14.9 °C, 18.2 °C minimum temperature, 40.00, 35 per cent mean relative humidity and 2.60, 0.00 mm rainfall during 2017 and 2018, respectively. The population of green lacewing reached its peak in the first and second week of April during both the years, respectively. At the time of peak population of green lacewing (4.20 / five plant) during 2017, maximum and minimum temperature, mean relative humidity and rainfall were 40.1 °C, 22.9 °C, 46 per cent and 0.0 mm, respectively. The population of green lacewing increased gradually during 2018, reached its peak with 4.80 green lacewing /five plants in 18th SMW when 42.9 °C maximum, 25.6 °C minimum temperature and 29 per cent mean relative humidity prevailed (table 1, 2). Above observations are in conformity with findings of Sharma et al. (2004) (0.52-2.0 /five plant), Sanjay et al., 2018 who reported that the green lacewing population ranged from 1.42 to 3.88 and 1.08 to 3.56 adult /five plant. The leafhopper and whitefly had positively significant (r = 0.58, r = 0.76, r = 0.66, r = 0.65, respectively) correlation with maximum temperature, minimum temperature, and rainfall revealed exhibited green lacewing population had non significant correlation with mean relative humidity, in the year of 2017. Leafhopper and whitefly had positively significant (r = 0.69, r = 0.76, r = 0.81, r = 0.87, respectively) correlation with maximum, minimum temperature, and lacewing population had negatively significant (r = -0.58) correlation with mean relative humidity. However, revealed exhibited green lacewing population non significant correlation with rainfall, in the year of 2018. Similarly, Yadav et al. (2009), Sanjay et al., 2018 who reported that the population of C. carnea was positive correlated with maximum, minimum temperature i.e. (0.595, and 0.399).

**Table 1:** Effect of abiotic factors on abundance of leafhopper and whitefly on okra and their natural enemies, 2017

<table>
<thead>
<tr>
<th>Standard Meteorological Week (SMW)</th>
<th>Date of Observation</th>
<th>Temperature (°C)</th>
<th>Mean Relative Humidity (RH.) (%)</th>
<th>Rainfall (mm)</th>
<th>Mean population/ three leaves</th>
<th>Mean population/ five plants of Natural enemies</th>
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**Table 2:** Effect of abiotic factors on abundance of leafhopper and whitefly on okra and their natural enemies, 2018

<table>
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<tr>
<th>Standard Meteorological Week (SMW)</th>
<th>Date of Observation</th>
<th>Temperature (°C)</th>
<th>Mean Relative Humidity (RH.) (%)</th>
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<th>Mean population / three leaves</th>
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Conclusion
The major insect pests of sucking infesting okra during two consecutive summer seasons were observed leafhopper, *Amrasca biguttula biguttula* and whitefly, *B. tabaci*. The infestation of leafhopper commenced in the third week and second week of March (12th SMW and 11th SMW) and reached its peak in the first week of May and third week of April, 2017 and 2018, respectively. The leafhopper population had positive significant correlation with maximum and minimum temperature (*r*= 0.74, *r*=0.66, and *r*= 0.57, *r*=0.56 respectively) during 2017 and 2018. The whitefly *B. tabaci* commenced in the fourth week of March (13th SMW) and reached its peak in the 18th SMW during 2017 and 2018, respectively. The population exhibited had positive significant correlation with (*r*= 0.57), (*r*= 0.55) maximum, (*r*= 0.60) minimum temperature during 2017 and 2018. The *Coccinellids* and green lacewing population had positive and significant correlation with Maximum (*r*=0.72, *r*=0.61 and *r*=0.58, *r*=0.69), minimum temperature (*r*=0.57, *r*=0.63 and *r*= 0.76, *r*=0.77), leafhopper (*r*= 0.68, *r*=0.85 and *r*= 0.66, *r*=0.81) and whitefly (*r*=0.74, *r*=0.88 and *r*=0.65, *r*=0.87). While the predator, negative and significant correlation with mean relative humidity (*r=* -0.57 and *r=* -0.58) during both the years.

Acknowledgement
The authors are thankful to the Dean, SKN College of Agriculture, SKN Agriculture University, Jobner for providing necessary facilities and permission to conduct the study.

References
21. Potaij A, Chandrakar G. Studies on the Seasonal Incidence of major Insect Pests and its natural enemies on

<table>
<thead>
<tr>
<th>Max. temperature(r)</th>
<th>Min. temperature(r)</th>
<th>R.H. (r)</th>
<th>Rainfall(r)</th>
<th>Leaf hopper</th>
<th>Whitefly</th>
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<td>0.57*</td>
<td>0.55*</td>
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<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>0.56*</td>
<td>0.60*</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.85*</td>
</tr>
<tr>
<td>0.61*</td>
<td>0.63*</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.88*</td>
</tr>
<tr>
<td>0.69*</td>
<td>0.77*</td>
<td></td>
<td>-</td>
<td>-</td>
<td>0.87*</td>
</tr>
</tbody>
</table>

*Significant at 5 per cent level, NS: Non significant