



Influence of Abiotic Factors on Population Dynamics of Sucking Insect Pests and their Natural Enemies in Brinjal

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Abstract: The study investigated the population dynamics of whitefly, leaf hopper, lady bird beetle and spider in kharif, 2022 and 2023, revealing distinct patterns and correlations with weather parameters. Whitefly infestations started in last week of August with initial populations of 6.6 and 7.84 per 3 leaves, peaked at 31.08 and 34.76 per 3 leaves in early October. Leaf hopper populations started in last week of August with 5.24 and 5.96 per 3 leaves, peaked at 25.48 and 28.12 per 3 leaves in last week of September and early October. Lady bird beetles appeared in early September with initial populations of 0.88 and 1.20 per 5 plant, peaked at 3.96 and 4.24 per 5 plant in mid-October. Spider populations started in early September with 1.12 and 0.96 per 5 plant, peaked at 3.04 and 3.44 per 5 plant in second fortnight of October. Correlation analysis showed significant positive correlations between whitefly and maximum temperature ($r = 0.66$ and 0.61), with significant negative correlations with morning relative humidity in 2022 ($r = -0.52$). Leaf hopper populations had significant positive correlations with maximum temperature ($r = 0.69$ and 0.68) and minimum temperature in 2022 ($r = 0.64$). Lady bird beetles had significant positive correlations with maximum temperature ($r = 0.50$ and 0.52), while spiders also showed significant positive correlations with maximum temperature ($r = 0.50$ and 0.50). Multiple linear regression analysis explained a significant portion of population variation due to abiotic factors: 65% and 74% for whiteflies; 61% and 70% for leaf hoppers; 77% and 71% for lady bird beetles and 75% and 72% for spiders in kharif, 2022 and 2023, respectively.

Key words: Population dynamics, insect pest, brinjal, correlation, regression, abiotic factors.

Brinjal (*Solanum melongena* Linn.) is a tropical, herbaceous perennial plant belonging to the family Solanaceae, which is widely cultivated and harvested for its edible fruit throughout the year. It is also referred to as guinea squash or King of vegetables and India and Indochina are considered the centers of origin (Vavilov, 1951). The major brinjal growing states in India are Andhra Pradesh, Chhattisgarh, Jharkhand, Gujarat, Karnataka, West Bengal, Tamil Nadu, Maharashtra, Orissa, Madhya Pradesh, Bihar and Rajasthan. It is cultivated in approximate 0.75 mha area with the annual production

of 12.87 mt with productivity of 17.18 tha^{-1} in India (Anonymous, 2021). In Rajasthan, brinjal is grown in 3.44 thousand hectares area with an annual production of 15.36 thousand metric tonnes with productivity of 4.46 tha^{-1} (Anonymous, 2022-23). Both the biotic and abiotic factors are responsible for poor yield of brinjal but insect pests are major constraint causing huge economic loss. The loss caused by brinjal pests vary from season to season depending upon environmental factors (Gangwar and Sachan, 1981). About 53 species of insect pests attack on brinjal crop worldwide out of which, 20 (19 insects and 1 mite) were reported to cause serious damage. The important insect pests of brinjal are shoot and fruit borer, leafhopper, whitefly, aphids, and spider mites affecting the yield (Kumar *et al.*, 2019). Among them, the sucking insect pests *i.e.* aphid, leaf hopper and whitefly occur on the crop throughout the year. Nymphs and adults suck cell sap which reduces the vigour and vitality of the plants. Due to aphid infestation the plants turn yellow get deformed and dry away. The nymphs and adults of jassid inject toxic saliva while feeding, as a result, the plant become stunted, the leaves crinkle, turn yellowish and become cup shaped. Brownish or reddish colour may develop along the edges of the leaves. Whitefly infestations can result in brinjal leaves wrinkling, curling downward, and ultimately shedding due to severe damage. Populations of these insects are often seen on tender parts of the plant, particularly on leaves. Sucking pests also act as a vector of different diseases on brinjal such as little leaf by leaf hoppers and shooty mould by aphids and whiteflies (Sarkar and Kulshreshtha, 1978). The yield losses in brinjal due to infestation of whitefly, leaf hopper and shoot and fruit borer could be as high as 70-92% in India (Rosaiah, 2001).

The population of insect pests are adversely influenced by abiotic factors in different agro-climatic region. The temperature, rainfall, relative humidity and wind speed are the chief weather parameters that influence pest population. The interaction between pest activity, biotic and abiotic factors help in deriving predictive models that aids in forecasting of pest incidence. Therefore, sufficient knowledge about the seasonal activity of these pests is necessary to manage them with appropriate time period.

Materials and Methods

Experimental details: To study the population dynamics of sucking insect pests and their natural enemies of brinjal, the field experiment was carried out at Horticulture Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) in kharif, 2022 and 2023. A Variety of Round Brinjal "Pusa Vaibhav" developed by IARI, New Delhi was chosen for the field experiment. Seeds were sown in the nursery in two consecutive years: June 22, 2022 and June 25, 2023. The brinjal seedlings were transplanted on August 2, 2022 and August 4, 2023, when they reached a height of approximately 12-15 cm. During the growing period, a standard agronomic package of practices and irrigation schedule was followed to ensure the establishment and maintenance of a healthy crop. In this experiment, plant spacing of $60 \times 50 \text{ cm}^2$ was kept, on plot size $3 \times 2 \text{ m}^2$ area, with five separate plots. No pesticide was used throughout the experiment.

Observations recorded: The observations for population of sucking insect pests *viz.*, whitefly and leaf hopper were counted early in the morning both nymphs and adults from five randomly selected tagged plants from three leaves (upper, middle and lower) in each plot visually or by using magnifying lens from their appearance to last picking of fruits at weekly intervals in early morning. In case of natural enemies *viz.*, lady bird beetles and spiders observation were recorded from five randomly selected tagged plants in each plot from their appearance to till last picking of fruits.

Interpretation of data: To interpret the results of population dynamics of sucking insect pests and their natural enemies, the simple correlation was computed between population of sucking insect pests, natural enemies and weather parameters, *viz.*; maximum and minimum temperatures, morning relative humidity, evening relative humidity and rainfall. The following formula was used for calculating correlation coefficient (Gupta, 1996).

$$r_{xy} = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{N \sum X^2 - (\sum X)^2 \cdot N \sum Y^2 - (\sum Y)^2}}$$

where, r_{xy} = Simple correlation coefficient; X = Independent variables *i.e.* abiotic components; Y = Dependent variables *i.e.* pests; N = Number of observations.

The multiple linear regression was calculated to know the combined effect of abiotic factors, while step wise linear regression explained the individual effect of abiotic factors on the population of whitefly, leaf hopper, lady bird beetles and spiders.

Results and Discussion

In the present study, population of various sucking insect pests (whitefly and leaf hopper) and natural enemies (lady bird beetles and spiders) were observed (Figure 1 and 2).

Population dynamics of whitefly: correlation and regression analysis with weather parameters

The infestation of whitefly commenced from fourth week of August i.e. 34th standard meteorological week (SMW) with a population of 6.6 whitefly/3 leaves and 7.84 whitefly/3 leaves and reached at the peak level of 31.08 whitefly/3 leaves and 34.76 whitefly/3 leaves in first week of October (40th SMW) and second week of October (41th SMW) in kharif, 2022

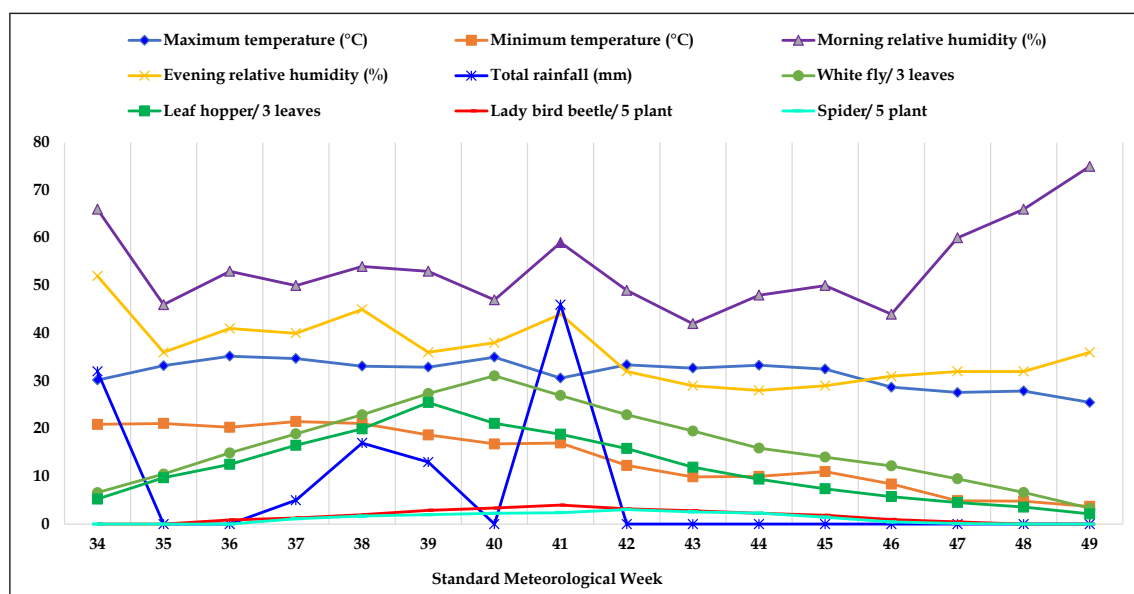


Fig. 1. Influence of abiotic factors on population dynamics of sucking insect pests and their natural enemies on brinjal in kharif, 2022

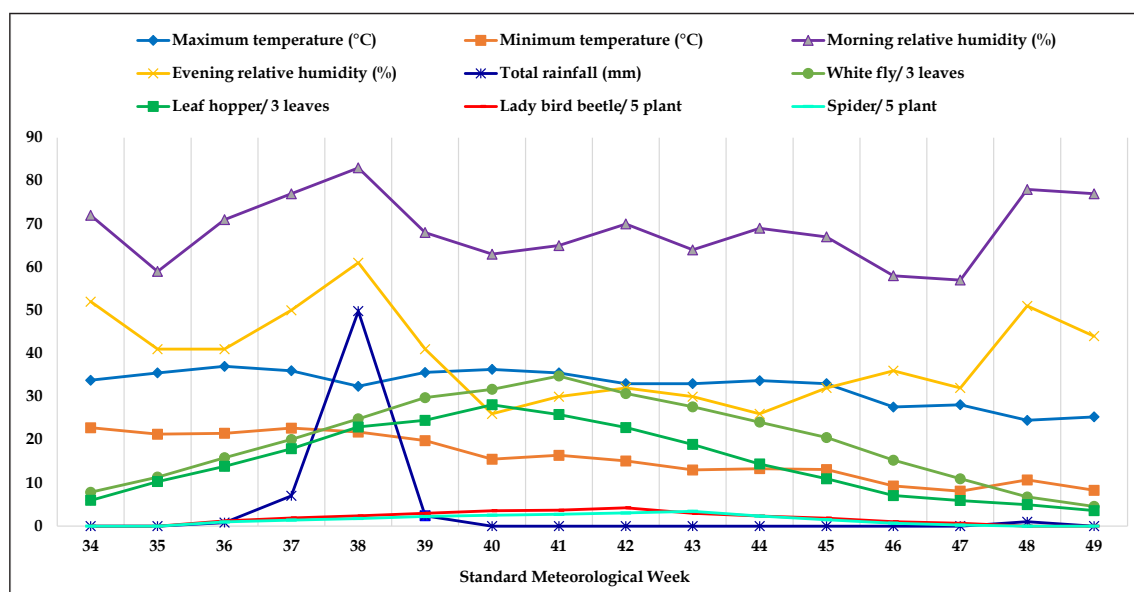


Fig. 2. Influence of abiotic factors on population dynamics of sucking insect pests and their natural enemies on brinjal in kharif, 2023

and 2023, respectively. The present results are in agreement with those of Kumar *et al.* (2023) who reported that the infestation of whitefly on brinjal started from 34th SMW and peak population was observed on 41th SMW. Similarly, Verma *et al.* (2020) recorded that the incidence of whitefly started from 36th SMW and maximum population was observed in 42th SMW. Likewise, Abhirami *et al.* (2021) reported that the initiation of whitefly started from last week of September (39th SMW) and reached to peak in second week of October (41th SMW). The present findings also get support from the observations of Bajpai *et al.* (2021) and Humane *et al.* (2021). The slight variation in commencement of incidence and peak period of incidence may probably be due to the early transplanting of the crop and the difference in agro-climatic conditions of the locality.

The correlation studied revealed (Table 1) that the whitefly population had a significant positive correlation with maximum temperature ($r = 0.66$ and 0.61), while minimum temperature and total rainfall had non-significant positive correlation ($r = 0.46$, 0.20 and $r = 0.25$, 0.14) in kharif, 2022 and 2023, respectively. The whitefly population showed significant negative correlation ($r = -0.52$) with morning relative humidity in kharif, 2022, whereas in kharif, 2023, it had non-significant negative correlation ($r = -0.12$). Additionally, the whitefly exhibited non-significant positive correlation ($r = 0.09$) with evening relative humidity in kharif, 2022, whereas in kharif, 2023, it had non-significant negative correlation

($r = -0.46$). This study is supported by the findings of Kumar *et al.* (2023) reported that the whitefly population had significantly positive correlation with maximum temperature and negative significant correlation with relative humidity (morning and evening) and rainfall. The present finding are in conformity with those of Patel *et al.* (2015) reported that the maximum temperature had positive significant correlation with the population of whitefly and minimum temperature showed positive non-significant, while relative humidity (morning and evening) and rainfall showed negative correlation. The results also corroborate with that of Singh *et al.* (2023) who observed the population of whitefly had significant negative correlation with morning, evening and mean relative humidity. Likewise, Omprakash *et al.* (2013) recorded that the population of whitefly showed positive non-significant correlation with temperature (maximum and minimum) and rainfall. The present findings also get support from the findings of Verma *et al.* (2020), Abhirami *et al.* (2021), Humane *et al.* (2021) and Patel *et al.* (2023). The positive correlation between the temperature and whitefly population can be attributed to the enhanced rate of development and reproduction, shorter life cycle of whitefly and it had been found that the oviposition activity of whitefly was maximum between 33 to 37°C. The negative association between the whitefly population and relative humidity was due to cooler weather and high relative humidity are detrimental to whitefly population and

Table 1. Correlation coefficient between environmental factors and infestation of major insect pests, their natural enemies on brinjal crop in kharif, 2022 and 2023

S. No.	Particulars	Whitefly		Leaf hopper		Lady bird beetles		Spiders	
		2022	2023	2022	2023	2022	2023	2022	2023
A.	Environmental factors								
1.	Temperature (°C)								
	Maximum Temperature	0.66*	0.61**	0.69*	0.68**	0.50*	0.52 *	0.50*	0.50*
	Minimum Temperature	0.46	0.20	0.64*	0.40	0.19	0.12	0.11	0.08
2.	Relative humidity (%)								
	Morning R. H.	-0.52*	-0.12	-0.41	0.03	-0.46	-0.06	-0.50*	-0.06
	Evening R. H.	0.09	-0.46	0.26	-0.24	-0.09	-0.47	-0.21	-0.50*
3.	Total rainfall (mm)	0.25	0.14	0.30	0.28	0.28	0.11	0.14	0.07
B.	Natural enemies								
	Lady bird beetles	0.91**	0.97**	0.76**	0.91**	-	-	-	-
	Spiders	0.81**	0.94**	0.66*	0.85**	-	-	-	-

** Significant at 1% level, * Significant at 5% level.

Table 2. Multiple regression models developed for sucking insect pests and natural enemies on brinjal crop in kharif, 2022 and 2023

	Multiple linear regression equation ($Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$)		R ² Value	
	2022	2023	2022	2023
White fly	$Y = -57.14^a + (2.86) T_{\max} + (-0.86) T_{\min} + (-0.22) RH_{\text{mor}} + (-0.11) RH_{\text{evn}} + (0.38) Rf$	$Y = -0.38^a + (0.79) T_{\max} + (0.27) T_{\min} + (0.38) RH_{\text{mor}} + (-0.96) RH_{\text{evn}} + (0.43) Rf$	0.65	0.74
Leaf hopper	$Y = -37.99^a + (1.69) T_{\max} + (0.18) T_{\min} + (0.07) RH_{\text{mor}} + (-0.32) RH_{\text{evn}} + (0.24) Rf$	$Y = -28.50^a + (1.26) T_{\max} + (-0.06) T_{\min} + (0.32) RH_{\text{mor}} + (-0.51) RH_{\text{evn}} + (0.34) Rf$	0.61	0.70
Lady bird beetles	$Y = -12.32^a + (0.59) T_{\max} + (-0.24) T_{\min} + (-0.03) RH_{\text{mor}} + (-0.01) RH_{\text{evn}} + (0.10) Rf$	$Y = 0.80^a + (0.00) T_{\max} + (0.11) T_{\min} + (0.09) RH_{\text{mor}} + (-0.18) RH_{\text{evn}} + (0.06) Rf$	0.77	0.71
Spiders	$Y = -10.55^a + (0.50) T_{\max} + (-0.20) T_{\min} + (-0.02) RH_{\text{mor}} + (-0.02) RH_{\text{evn}} + (0.07) Rf$	$Y = -0.33^a + (0.02) T_{\max} + (0.07) T_{\min} + (0.08) RH_{\text{mor}} + (-0.15) RH_{\text{evn}} + (0.05) Rf$	0.75	0.72

spread. Hence, a strategy should be planned to minimize the pest and disease attack either by manipulation in agronomic practices or chemical control.

The multiple linear regression analysis (Table 2) explained 65 and 74% variation in whitefly population due to combined contribution of abiotic factors in kharif, 2022 and 2023, respectively. The step wise regression analysis explained 44 and 37% significant variation in whitefly population due to maximum temperature in kharif, 2022 and 2023, respectively (Table 3). The results also corroborate with that of Singh *et al.* (2023) who reported the all six weather parameters were responsible for 79.30% variation in abundance of whitefly in brinjal ecosystem.

Population dynamics of leaf hopper: correlation and regression analysis with weather parameters

The population of leaf hopper was first recorded from fourth week of August (34th SMW) with a population of 5.24 leaf hopper/3 leaves and 5.96 leaf hopper/3 leaves and reached at the peak level of 25.48 leaf hopper/3 leaves and 28.12 leaf hopper/3 leaves in fourth week of September (39th SMW) and first week of October (40th SMW), respectively during both years. The present results are in agreement with those of Javed *et al.* (2017) who reported

that the infestation of leaf hopper on brinjal started from 34th SMW and peak population was observed on 40th SMW. The present finding are in conformity with those of Kumar *et al.* (2023) who reported that the incidence of leaf hopper on brinjal started from 35th SMW and peak population was observed on 42th SMW. Similarly, Verma *et al.* (2020) recorded that the incidence of leaf hopper started from 36th SMW and maximum population was observed in 42th SMW. The present findings also get support from the findings of Abhirami *et al.* (2021), Bajpai *et al.* (2021) and Humane *et al.* (2021). The slight variation in commencement of incidence and peak period of incidence may probably be due to the early date of transplanting of the crop and the difference in agro-climatic conditions of the locality.

The correlation analysis of leaf hopper population (Table 1) revealed a significant positive correlation with maximum temperature ($r = 0.69$ and 0.68) and a non-significant positive correlation with total rainfall ($r = 0.30$ and 0.28) respectively, in both years. The leaf hopper showed significant positive correlation with minimum temperature ($r = 0.64$) in kharif, 2022, whereas in kharif, 2023, it had non-significant positive correlation ($r = 0.40$). The leaf hopper showed non-significant negative correlation with morning relative humidity ($r = -0.41$) in kharif, 2022, whereas in kharif, 2023

Table 3. Step wise regression models developed for sucking insect pests and natural enemies on brinjal crop in kharif, 2022 and 2023

	Regression equation ($Y = a + bX$)		R ² Value	
	2022	2023	2022	2023
White fly	$Y = -42.88^a + (1.87) T_{\max}$	$Y = -28.46^a + (1.48) T_{\max}$	0.44	0.37
Leaf hopper	$Y = -41.28^a + (1.68) T_{\max}$	$Y = -30.91^a + (1.41) T_{\max}$	0.48	0.46
Lady bird beetles	$Y = -5.76^a + (0.23) T_{\max}$	$Y = -4.28^a + (0.19) T_{\max}$	0.25	0.27
Spiders	$Y = 4.53^a + (-0.06) RH_{\text{mor}}$	$Y = 5.22^a + (-0.10) RH_{\text{evn}} + (-0.10) Rf$	0.25	0.50

it had non-significant positive correlation ($r = 0.03$). Additionally, the leaf hopper exhibited non-significant positive correlation ($r = 0.26$) with evening relative humidity in kharif, 2022, whereas in kharif, 2023, it had non-significant negative correlation ($r = -0.24$). This study is supported by the findings of Kumar *et al.* (2023) reported that the leaf hopper population had significantly positive correlation with maximum temperature and negative significant correlation with relative humidity (morning and evening) and rainfall. The present findings are conformity with those of Patel *et al.* (2015) reported that the maximum temperature had positive significant correlation with the population of leaf hopper and minimum temperature showed positive non-significant while, morning relative humidity, evening relative humidity and rainfall showed negative correlation. The results also corroborate with that of Javed *et al.* (2017) who observed the maximum temperature showed significant positive correlation and minimum temperature showed non-significant positive correlation with the population of leaf hopper. Likewise, Omprakash *et al.* (2013) recorded that the population of leaf hopper showed positive non-significant correlation with maximum temperature, minimum temperature and rainfall. The present findings also get support from the findings of Verma *et al.* (2020), Abhirami *et al.* (2021), Humane *et al.* (2021), Patel *et al.* (2023) and Singh *et al.* (2023).

The multiple linear regression analysis (Table 2) explained 61 and 70% variation in leaf hopper population due to combined contribution of abiotic factors, in kharif, 2022 and 2023, respectively. The step wise regression analysis explained 48 and 46% significant variation in leaf hopper population due to maximum temperature in kharif, 2022 and 2023, respectively (Table 3). The results also corroborate with that of Singh *et al.* (2023) who reported the all six weather parameters were responsible for 60% variation in abundance of leaf hopper in brinjal ecosystem.

Population dynamics of lady bird beetles: correlation and regression analysis with weather parameters

The population of lady bird beetles was started from first week of September *i.e.* 36th SMW with a population of 0.88 beetles/5 plant and 1.20 beetles/5 plant and reached at the

peak level of 3.96 beetles/5 plant and 4.24 beetles/5 plant in second week of October (41th SMW) and third week of October (42th SMW) in kharif, 2022 and 2023, respectively. The present investigation are also similar with Meena *et al.* (2017) who had also reported that *C. septempunctata* initiated in the 34th standard meteorological week and reached its peak in 41th SMW. Edpuganti and Kattula (2018) reported that, coccinellids were observed during 31st SW *i.e.*, 0.5 number per plant and reached peak as 0.6 number per plant in following week and persisted up to 9 weeks after transplanting (36th S.W). Sreedhar *et al.* (2020) also reported occurrence of lady bird beetles was seen from starting August to last October.

The correlation of lady bird beetles population (Table 1) indicated a significant positive correlation with maximum temperature ($r = 0.50$ and $r = 0.52$), while minimum temperature and total rainfall had non-significant positive correlation ($r = 0.19, 0.11$ and $r = 0.28, 0.11$) and non-significant negative correlation with morning ($r = -0.46$ and $r = -0.06$) and evening ($r = -0.09$ and $r = -0.47$) relative humidity in kharif, 2022 and 2023, respectively. The present findings are conformity with those of Singh *et al.* (2023) who reported that the population of lady bird beetles showed negative correlation with morning and evening relative humidity and non-significant positive correlation with rainfall. The present results are in agreement with those of Meena *et al.* (2017) who reported that a significant positive correlation of *C. septempunctata* with maximum temperature ($r = 0.79$) and non-significant correlation with minimum temperature and non-significant negative correlation with relative humidity. These findings are also in partial agreement with Borah and Saikia (2017) who reported that coccinellids showed a significant positive correlation with maximum temperature and relative humidity showed negative correlation. Likewise, Kumar *et al.* (2014) reported that, the *C. septempunctata* showed the significant positive correlation with the maximum and minimum temperature, relative humidity, rainfall and evaporation.

The multiple linear regression analysis (Table 2) explained 77 and 71% variation in lady bird beetles population due to combined contribution of abiotic factors in kharif, 2022 and 2023, respectively. The step wise

regression analysis (Table 3) explained 25 and 27% significant variation in lady bird beetles population due to maximum temperatures in kharif, 2022 and 2023, respectively. The present finding are conformity with those of Singh *et al.* (2023) who reported that the weather parameters were responsible for 61.90% variation in abundance of coccinellids in brinjal ecosystem.

Population dynamics of spiders: correlation and regression analysis with weather parameters

The population of spiders was started from second week of September (37th SMW) and first week of September (36th SMW) with a population of 1.12 spiders/ 5 plant and 0.96 spiders/ 5 plant and reached at the peak level of 3.04 spiders/ 5 plant and 3.44 spiders/ 5 plant in third week of October (42th SMW) and fourth week of October (43rd SMW) in kharif, 2022 and 2023, respectively. The present investigation are also similar with Edpuganti and Kattula (2018) who reported that, spiders incidence started from 34th SMW and peaked in 40th SMW. Sreedhar *et al.* (2020) also reported occurrence of spiders was seen from starting mid-August to last November. The present studies are also accordance with the finding of Borkakati *et al.* (2019) who had reported that, predators' viz., spider (*Oxyopes* sp.) was recorded as natural enemies on insect pests of brinjal.

The correlation of spiders population (Table 1) indicated a significant positive correlation with maximum temperature ($r = 0.50$ and $r = 0.50$), while minimum temperature and total rainfall had non-significant positive correlation ($r = 0.11, 0.08$ and $r = 0.14, 0.07$) in kharif, 2022 and 2023, respectively and significant negative correlation with morning relative humidity ($r = -0.50$) in 2022, while a non-significant negative correlation ($r = -0.06$) in 2023. Additionally, the spiders exhibited non-significant negative correlation with evening relative humidity ($r = -0.21$) in 2022, whereas, significant negative correlation ($r = -0.50$) in 2023. The present finding are conformity with those of Singh *et al.* (2023) who reported that the population of spiders showed negative correlation with morning and evening relative humidity and positive correlation with maximum temperature.

The multiple linear regression analysis (Table 2) explained 75 and 72% variation in spiders population due to the combined contribution of abiotic factors in kharif, 2022 and 2023, respectively. The step wise regression analysis (Table 3) explained 25% significant variation in spiders population due to morning relative humidity in 2022 and in 2023 explained 50% significant variation in spiders population due to evening relative humidity and rainfall. The present finding are conformity with those of Singh *et al.* (2023) who reported that the weather parameters were responsible for 61.70% variation in abundance of spiders in brinjal ecosystem.

Impact of natural enemies on population of sucking insect pests

The correlation studies revealed (Table 1) that the population of lady bird beetles and spiders had highly significant positive correlation with population of whitefly ($r = 0.91, 0.81$ and $r = 0.97, 0.91$) and leaf hopper ($r = 0.81, 0.66$ and $r = 0.94, 0.85$) on brinjal in kharif, 2022 and 2023, respectively. The present results are in agreement with those of Meena *et al.* (2017) who reported that a significant positive correlation of *C. septempunctata* with population of whitefly and jassid. Naik *et al.* (2009) reported that, the whitefly population showed non-significant relationship with abiotic factors but significant relationship with abundance of *C. septempunctata* predatory beetles and spiders. These findings are also in partial agreement with Omprakash *et al.* (2013) who reported that, the incidence of sucking pests showed a positive and significant correlation with biotic factors like *C. septempunctata* beetles as well as spiders. These results are also in conformity with the findings of Muthukumar and Kalyanasundaram (2003).

In our experiment the prey population was always higher than that of predators as in most ecosystems due to several factors. Predators generally have a longer life cycle compared to prey, which limits their population growth (Begon *et al.*, 2006). Additionally, predators often exhibit cannibalism and experience high mortality rates, further reducing their numbers (Polis, 1981). In contrast, preys species have a high multiplication rate and greater dispersal capabilities, allowing them to increase their population rapidly (Price, 1997; Hanski, 1999).

Furthermore, prey species have access to a more abundant and diverse range of food sources compared to predators, which supports their population growth (Hairston *et al.*, 1960). These factors collectively contribute to the consistently higher prey population in ecosystems.

Conclusion

The infestation of whitefly and leaf hopper on brinjal crop commenced in the fourth week of August which reached to peak in month of October. The incidence of natural enemy started in month of September and reached to the maximum in month of October. Conclusively, the results of present investigation suggested that sucking insect pests population significantly increased with maximum temperature. Likewise, natural enemies population build up with increased maximum temperature, while it reduced with increased relative humidity. All abiotic factors were responsible for variation in abundance of sucking insect pest and natural enemies in brinjal ecosystem.

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