Population dynamics of major sucking insect pests on chilli (*Capsicum annum* L.)

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Population dynamics of major sucking insect pests on chilli (*Capsicum annum* L.)

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Abstract

Studies on population dynamics of major sucking insect pests revealed that the incidence of thrips, *Scirtothrips dorsalis* (Hood), whitefly, *Bemisia tabaci* (Gennadius) and leafhopper, *Amrasca bigutulla bigutulla* (Ishida) along with ladybird beetle, *Coccinella septemtheirpunctata* observed to appear on the chilli crop soon after transplanting. Incidence of thrips commenced in 19th Standard Meteorological Week (SMW) and attained its peak on 25th SMW (18.83 thrips /3 leaves /plant) while an infestation of whitefly was initiated in 20th SMW then it increased gradually and reached its peak on 25th SMW (21.20 whitefly/3 leaves /plant). The peak population of leafhoppers was recorded in 26th SMW (10.4 leafhopper /3 leaves /plant). In case of ladybird beetle, the population ranged from 0.20 to 0.93 per plant and was on the entire crop growth period (18th-37th SMW). Thrips and whitefly exhibited a highly significant positive correlation with maximum temperature, a negative non-significant correlation with evening relative humidity, and a non-significant correlation with wind speed, sunshine hours, and pan evaporation while a negative non-significant correlation with rainfall. Leafhopper population showed highly significant positive correlation with minimum temperature, non-significant negative correlation with maximum temperature, non-significant positive correlation with morning and evening relative humidity, sunshine hours, and rainfall while the negative non-significant correlation with wind speed and pan evaporation. Whereas, the ladybird beetle exhibited a positive non-significant correlation with maximum temperature, wind speed, sunshine hours and a negative non-significant correlation with minimum temperature, morning and evening relative humidity, pan evaporation, and rainfall.

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Introduction

Vegetables constitute an important part of our food, which supply vitamins, carbohydrates and minerals needed for a balanced and healthy diet. Among them, chilli (*Capsicum annuum* var. *annuum* L.) is one of the most economically important and popular vegetable crops grown for its green fruits as vegetable and red fruits as a spice. Originated from Mexico, Southern Peru and Bolivia (Villalon 1981), chilli got introduced into

India for the first time from Brazil by the Portuguese towards the end of fifteenth century. Its cultivation became popular in the seventeenth century and since then, it has gained importance as a marked spice and vegetable crop which became a necessary in many cuisines (Greenleaf 1986). Chillies are part of human diet as spice, condiments and vegetables also rich in vitamins, especially vitamin 'A' and 'C' (MacNeish 1964). On one hand green fruits of chili are used as vegetable while on the other hand, ripe dried fruits as spice because of its pungency and imposing flavours (Hasan et al. 2014; George & Sujatha 2019). Chilli is presently grown extensively throughout the country, both under rainfed and irrigated conditions of India, in almost all the states covering an area of 2.2 thousand hectares with annual production of 4 thousand metric tonnes. Among Indian states, Haryana is the 6th largest chilli producing state with an area of 751.61 thousand hectares, production of 2149.23 thousand tonnes and productivity of 2.86 MT/ha (Anonymous 2017-18).

There are several factors responsible for low yield of chilli, among them insect pests are of prime importance which significantly affect both the quality and quantity of chilli production. The yield losses range between 50 and 90 per cent due to insect pests of chilli (Nelson & Natrajan 1994; Kumar 1995). Aphid, *Aphis gossypii* (Glover), Thrips, *Scirtothrips dorsalis* (Hood), whitefly, *Bemisia tabaci* (Gennadius), leafhopper, *Amrasca bigutulla bigutulla* (Ishida) and yellow mites, *Polyphagotarsonemus latus* (Banks) are the important sucking pests which reduces crop yield (Jadhav et al. 2004). Population dynamics is the aspect of population ecology dealing with factors affecting changes in population densities (Karuppaiah & Sujayanad 2012). Insect pest abundance and population dynamics are affected by abiotic and biotic stresses impacting insect morphology, physiology, and their adaptation to the environment (Karl et al. 2011; Nyamukondiwa et al. 2013; George & Sujatha 2019). Climatic suitability for insect development and its population dynamics directly influences habitat suitability (Danks 1999).

Due to variation in the agro-climatic conditions of different regions insects show varying trends in their incidence, nature and extent of damage to the crop. The incidence and spread of the chilli sucking pests is affected by various abiotic factors *viz.*, temperature, relative humidity, rainfall, *etc*. In recent years increases in pest incidence have been observed in agricultural systems, associated with climate change events, such as prolonged droughts, hurricanes, heavy and out-of-season rains, among others (Valencia et al. 2021). High temperature threshold is the main factor governing insect population dynamics (Regniere et al. 2012). We observe various changes in pest dynamics which often pass unnoticed, overshadowed by human disasters caused by such climatic events and yet, pest outbreaks contribute to incremental losses, forcing the use of pesticides that usually fail to solve the problem (Estay 2009; Vazquez 2011). Pest behaviour and population dynamics in relation to weather parameter is an essential pre-requisite for successful pest management programme. As environmental factors plays an important role in determining the seasonal abundance and damage caused by these insect pests. Therefore, it is important to study the population dynamics of insect pests during the entire crop growing period and creates a basis that could be used by farmers, crop producers, ecologists, agricultural economists, researchers and consultants for systematic and productive pest control. Hence, the study on population dynamics of insect pests on chilli were lacking under Hisar condition of Haryana and was undertaken to create an insight about peak period of their activity and will be helpful in developing sustainable and sound pest management strategies.

Material and Methods

The present study on Population dynamics of major sucking insect pests on chilli (*Capsicum annuum* L.) was conducted at Experimental Area, Department of Entomology, Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Hisar during *Kharif*, 2020. For obtaining good tilth and growth of the crop, summer ploughing was given to the main field with the aim of exposing eggs and another stage of harmful insect pests and under-ground reproductive parts of weeds. Seeds of the test variety, Pusa Kranti were raised in the nursery on the experimental site selected and transplanted on (15th April, 2020: 15th SMW) with three replication. Plot size of 10 x 10 m was maintained in each replication. Row to row and plant to plant spacing were kept at 60 and 45 cm, respectively. All the recommended agronomic package of practices except insecticidal spray were acquired to raise good crop stand.

Major sucking insect pests *viz*., thrips, *Scirtothrips dorsalis* (Hood), whitefly, *Bemisia tabaci* (Gennadius), leafhopper, *Amrasca bigutulla bigutulla* (Ishida) and natural enemies (*Coccinella septempunctata*) were recorded from five randomly tagged plants in each replication till harvesting of the crop (17th september 2020: 38th SMW). Both adults and nymphs of thrips, *Scirtothrips dorsalis* (Hood) were counted from half to fully opened young top three leaves and counted with the help of magnifying lens and later calculated per leaf. Whereas, whitefly and leafhopper were recorded on 3 leaves per plant i.e., top, middle and bottom leaves along with the natural enemies while natural enemies were counted per plant. The population of major sucking insect pests were counted early in the morning before 8 AM when the pests were not much active. The data on weather parameters *viz.*, maximum temperature, minimum temperature, relative humidity (Morning), relative humidity (Evening), average wind speed (AWS), sunshine hours (h) and rainfall (mm) were collected from Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar. Population of major sucking insect-pests (*S. dorsalis*, *B. tabaci*, *A. bigutulla bigutulla*) and natural enemies was correlated with all the above mentioned weather parameters. The computer programme namely OP STAT and Microsoft Excel® were used for statistical analysis of the data.

Results and Discussion

Seasonal incidence of major sucking insect pests on chilli

Chilli thrips, *Scirtothrips dorsalis* (Hood)

The study revealed that there was distinct variance in thrips population as regards to Standard Meteorological Weeks (Table 1, Fig 1 and Plate 1). The mean population of 3.93 thrips per three leaves per plant was first recorded on 19th Standard Meteorological Week (8th-14th May) and ranged from 0.93 to 18.83 per three leaves per plant. The minimum population of 0.93 per three leaves per plant was recorded in 37th SMW (11th-17th September) and maximum population was recorded 18.83 thrips population per three leaves per plant in 25th SMW (19th- 25th June). During this period, maximum and minimum temperature (43.60 and 31.00°C, respectively), morning and evening relative humidity (55 and 28% respectively), wind speed (4.00 Km/h) and bright sunshine hours (8.70 h) prevailed. After 26th SMW the thrips population gradually decreased. The present findings are in conformity with the results of Yadav et al.

(2014) who reported that the population of thrips appeared on the crop in the first week of March and built up in population started from 9th standard week i.e., first week of April and increased up to the third week of May and declined gradually till the crop was matured in September. Saini et al. (2017) also reported initiation of thrips from second week of August and touched the peak during the third week of September (10.2 per three leaves). The results obtained in the present investigation are in close agreement with the result of Rajput et al. (2017) where the incidence of thrips was first noticed during the second week of August (34th SMW) with a mean population of 2.12 thrips per three leaves per plant and its population gradually increased and reached its peak level i.e., 9.5 thrips per three leaves in the third week of September (39th SMW). The thrips population started declining and reached low level (2.20 per three leaves per plant) at the end of crop period.

Table 1. Population dynamics of major sucking insect pests and natural enemies on chilli during *Kharif*, 2020

SMW	Period	Thrips population per 3 leaves	Whitefly population per 3 leaves	Leaf hopper population per 3 leaves	Lady bird beetle population per plant	Temperature (°C)		Relative Humidity (%)	
						Maximum	Minimum	Morning	Evening
18	May 01- 07	0.00	0.00	0.00	0.40	39.30	20.40	67	22
19	May 08-14	3.93	0.00	0.53	0.20	36.80	20.40	65	19
20	May 15- 21	7.86	3.58	2.10	0.33	38.90	20.00	64	28
21	May 22- 28	12.54	6.28	2.20	0.73	42.20	21.10	46	17
22	May 29- 04	15.06	15.99	1.13	0.60	43.60	24.00	66	43
23	Jun 05- 11	14.00	11.95	2.93	0.20	36.90	22.60	71	44
24	Jun 12 -18	16.86	17.56	2.20	0.40	40.00	27.00	67	32
25	Jun 19- 25	18.83	21.20	3.07	0.20	43.60	31.00	55	28
26	Jun 26 - 02	12.26	8.00	10.4	0.40	35.10	26.90	78	80
27	Jul 03 - 09	14.40	12.20	8.23	0.56	41.80	31.30	69	33
28	Jul 10 - 16	10.20	7.38	7.00	0.76	35.90	28.50	87	48
29	Jul 17 - 23	7.23	9.05	6.93	0.40	36.20	28.50	87	71
30	Jul 24 - 30	5.22	7.25	4.26	0.80	34.40	27.10	88	63
31	Jul 31 - 06	3.13	5.32	2.20	0.80	32.60	26.50	88	63
32	Aug07 -13	2.07	6.30	3.46	0.40	36.80	28.00	81	53
33	Aug14-20	1.43	4.25	2.93	0.38	34.60	26.20	91	75
34	Aug21-27	1.20	3.32	2.53	0.67	31.00	25.50	88	80
35	Aug28-03	2.00	3.48	2.80	0.40	35.90	26.00	89	51
36	Sep04- 10	1.53	2.61	1.86	0.93	34.40	25.00	94	66
37	Sep11- 17	0.93	4.35	0.63	0.20	36.20	25.50	82	52

*SMW- Standard Meteorological weeks

A: ***Scirtothrips dorsalis*** **(Hood)**

B: Nymphs of *S. dorsalis*

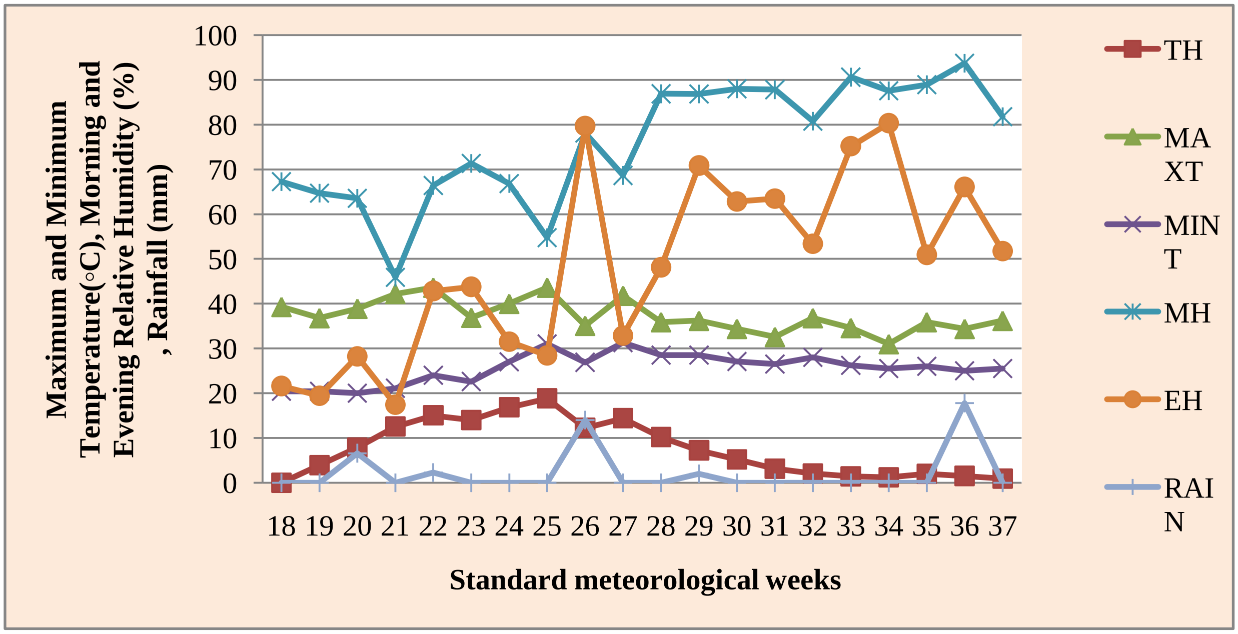
C: Adults of *S. dorsalis*

D: *Bemisia tabaci* (Gennadius)

E: *Amrasca bigutulla bigutulla* (Ishida)

F: *Coccinella septempunctata*

Plate 1. Major sucking insect pests and natural enemy associated with chilli crop

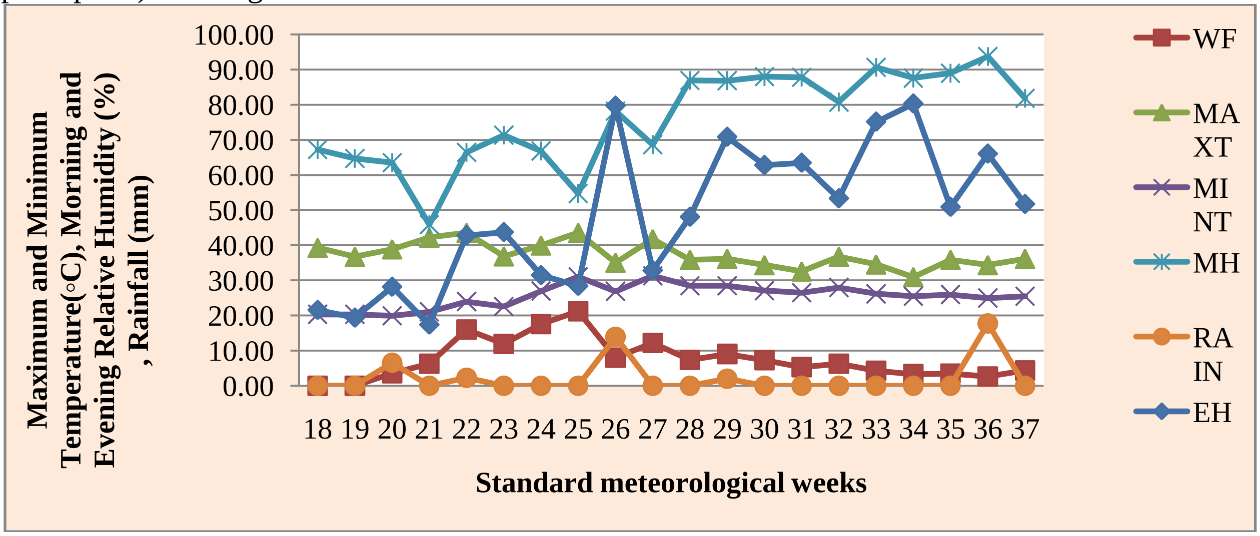


*MAXT and MINT – Maximum and Minimum Temperature, MH and EH- Morning and Evening Relative Humidity, TH- Thrips

Fig 1. Mean population of thrips, *Scirtothrips dorsalis* on chilli crop during *Kharif*, 2020

Whitefly, *Bemisia tabaci* (Gennadius)

Whitefly population showed distinct variance in relation to SMW (Table 1 and Fig 2). The mean population of 3.58 whitefly per three leaves per plant was first recorded in 20th Standard Meteorological Week (15th-21st May). The mean population ranged from 2.61 to 21.20 per three leaves per plant. The minimum population of 2.61 per three leaves per plant was recorded in 36th SMW (4th-10th September) and maximum population 21.20 whitefly population per three leaves per plant was recorded in 25th SMW (19th-25th June). During this period, maximum and minimum temperature (43.60°C and 31.00°C), morning (55%) and evening (28%) relative humidity, wind speed (4.00 Km/h) and bright sunshine hours (8.70 hours) prevailed, respectively. The whitefly population gradually started to decrease from 26th SMW with slight up of population in 27th SMW. The present findings are in accordance with the results of Yadav et al. (2014) who reported initiation of whitefly occurred after two weeks of transplantation and continued till the maturity of the chilli crop, whereas population varied from 1.0 to 23.50 whitefly per three leaves. In the starting the population was very low but it increased gradually and reached to its peak in the 18th SMW and then declined. Similarly, Saini et al. (2017) who concluded that the whitefly initiated from last week of July, (31th SMW) with a mean population of 1.20 per three leaves per plant and maximum population of whitefly (6.8 whitefly per three leaves per plant) was recorded during 37th SMW (second week of September). The results obtained in the present investigation are in close concurrence with the result of Rajput et al. (2017) who showed that the whitefly first appeared in the last week of July (32rd SMW) with 1.38 whitefly per three leaves per plant and population increased gradually and reached the peak (7.12 whitefly per three leaves per plant) in the second week of September (38th SMW). Later on the population decreased gradually and reached at its low level (1.94 whitefly per three leaves per plant) during the fourth week of November.

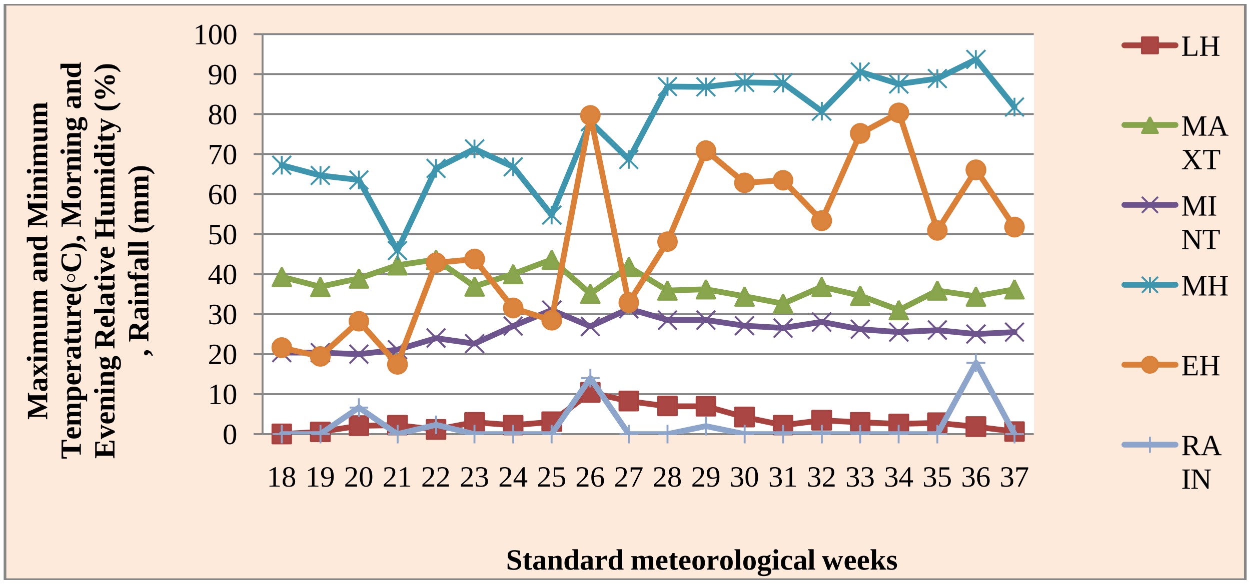


*MAXT and MINT – Maximum and Minimum Temperature, MH and EH- Morning and Evening Relative Humidity, WF- Whitefly

Fig 2. Mean population of whitefly, *Bemisia tabaci* (Gennadius) on chilli crop during *Kharif*, 2020

Leaf hopper, *Amrasca bigutulla bigutulla* (Ishida)

The data presented in (Table 1 and Fig 3) indicated that 0.53 leafhopper per three leaves per plant was first recorded in 19th Standard Meteorological Week (8th-14th May). The mean population ranged from 0.53 to 10.4 per three leaves per plant. The minimum population 0.53 per three leaves per plant was recorded in 19th SMW (8th-14th May) and maximum population 10.4 leafhopper per three leaves per plant was recorded in 26th SMW (26th June-2nd July). During this period, maximum and minimum temperature (35.10˚C and 26.90˚C), morning (78%) and evening (80%) relative humidity, wind speed (5.50 Km/h), bright sunshine hours (6.70 hours) and rainfall (14.00 mm) prevailed. After that leafhopper population started declining gradually from 27th SMW onwards. The current findings are in conformity with the results of Yadav et al. (2014). They reported that the incidence of leafhopper was observed in the first week of May and population increased gradually with slight up and down and reached to its peak (10.42 leafhopper per three leaves per plant) in the last week of July thereafter, it started to decrease gradually. The population of leafhopper on chilli crop ranged from 0.60 to 10.42 leafhopper per three leaves per plant throughout the crop period. Saini et al. (2017) reported that the population of leafhopper appeared on second week of August with a mean population of 1.20 per three leaves per plant and peak population (5.4 leafhopper per three leaves per plant) was observed during 37th SMW. Similarly, the results obtained in the present investigation are in close agreement with the result of Rajput et al. (2017) they reported that the population reached its peak (6.44 leafhopper per three leaves per plant) during the second week of September (38th SMW) while the population decreased gradually and lower number of leafhopper (1.12 leafhopper per three leaves per plant) were observed during the fourth week of November (48th SMW).



*MAXT and MINT – Maximum and Minimum Temperature, MH and EH- Morning and Evening Relative Humidity, LH- Leafhopper

Fig 3. Mean population of leafhopper, *Amrasca bigutulla bigutulla* (Ishida) on chilli crop during *Kharif*, 2020

Lady bird beetle, *Coccinella septempunctata*

The lady bird beetle population appeared from early vegetative stage to entire crop growth period (May to September). The mean population of lady bird beetle 0.40 per plant was first recorded in 18th Standard Meteorological Week (1st-7th May) and ranged from 0.20 to 0.93 per plant (Table 1 and Fig 4). The maximum lady bird beetle population of 0.93 per plant was recorded per plant in 36th SMW (4th-10th September). The current investigation is in close agreement with the result of Samanta et al. (2017) who reported that the mean population of coccinellid predators remain in variable number ranging from 0.25 to 2.05 per plant. The present findings are also in accordance with the results of Bhatt et al. (2020) who reported that the first incidence of coccinellids (0.46 Coccinella per plant) in chilli field was observed on 44th SMW. The predators (coccinellids) population showed a slow increase reaching its maximum (2.72 Coccinella per plant) on 6th SMW. Also, Havanoor et al. (2018) reported that the coccinellids were present throughout the season with varying intensity from 0.12 to 2.02 per plant and reached its peak during fourth week of October (2.02 per plant) and found minimum in last week of July (31st SMW).

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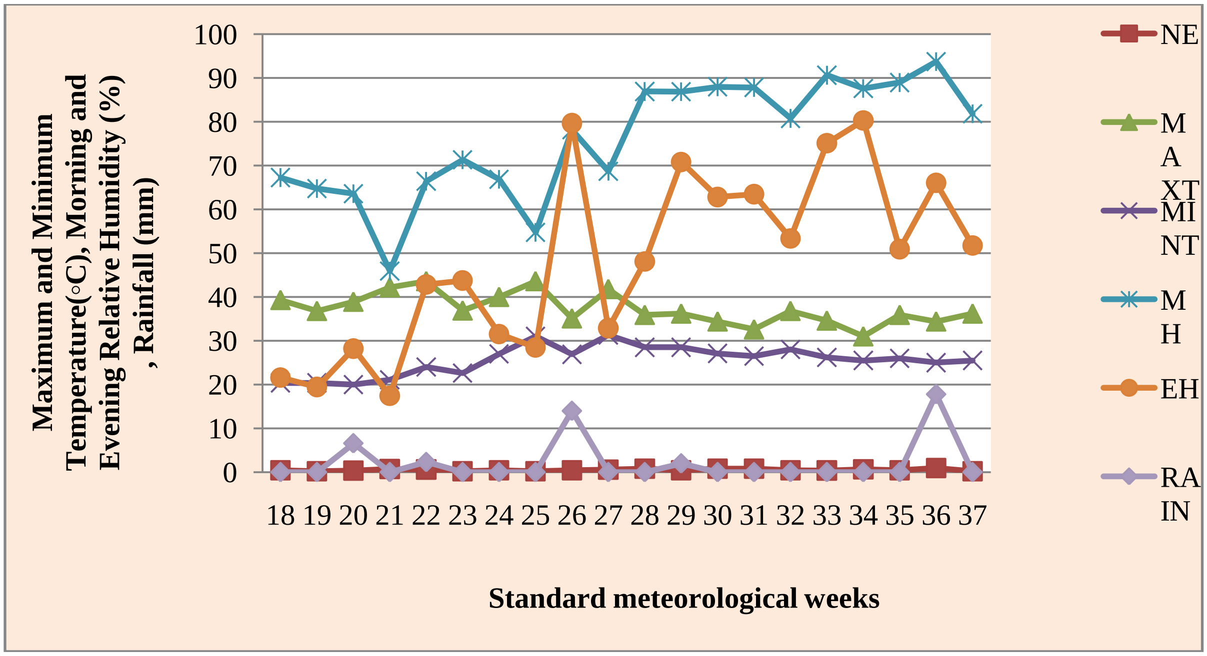

*MAXT and MINT – Maximum and Minimum Temperature, MH and EH- Morning and Evening Relative Humidity, NE- Natural enemy

Fig 4. Mean population of lady bird beetle, *Coccinella septempunctata* on chilli crop during *Kharif,* 2020

Correlation of major sucking insect pests and natural enemies on chilli crop with weather parameters

Chilli thrips, *Scirtothrips dorsalis* (Hood)

The data indicated that the incidence of thrips resulted in highly significant positive correlation (r=0.699**) with maximum temperature, whereas, positive non-significant correlation (r= 0.274^{NS}) with minimum temperature (Table 2). The morning relative humidity recorded highly significant negative correlation (r= -0.626**) and evening relative humidity showed negative non-significant correlation (r= -0.377^{NS}) with the mean population of thrips. Also, rainfall showed negative non-significant correlation (r= -0.037^{NS}) while wind speed, sunshine hours and pan evaporation had non- significant correlation with the mean thrips population. The results of the present findings are in accordance with the results of Yadav et al. (2014) who showed that the incidence of thrips had significant positive correlation (r = 0.56) with maximum temperature, whereas positive non-significant correlation with minimum temperature, mean relative humidity had significant negative correlation (r= - 0.75) and rainfall showed non-significant negative correlation (r= - 0.36). Rajput *et al*. (2017) also noticed that the evening relative humidity (r= - 0.61**) exhibited highly significant negative correlation with thrips population while maximum temperature (r= 0.56*) had significant positive correlation with thrips. Minimum temperature, wind velocity and sunshine hours showed non-significant positive correlation, whereas morning relative humidity and rainfall exhibited negative but non-significant association with the thrips. Also, similar result was reported by Havanoor & Rafee (2018) who concluded that the correlation between the thrips population and weather parameters showed that highly significant positive association with maximum temperature (r = 0.55*) and non-significant negative correlation with minimum temperature (r = -0.40), rainfall (r = -0.34), maximum relative humidity (-0.43) and minimum relative humidity (r = - 0.04).

Table 2. Correlation of weather parameters with major sucking insect pests and natural enemies on chilli during *Kharif*, 2020

Weather parameters	Thrips	Whitefly	Leafhopper	Lady bird beetle
Max Temp (°C)	0.699**	0.603**	-0.094NS	-0.270NS
Min Temp (°C)	0.274NS	0.537*	0.613**	0.123NS
R.H. Morning (%)	-0.626**	-0.387NS	0.205NS	0.342NS
R.H. Evening (%)	-0.377NS	-0.163NS	0.398NS	0.299NS
Wind Speed (Km/h)	0.092NS	0.251NS	-0.036NS	-0.006NS
Sunshine hours (h)	0.275NS	0.136NS	0. 139NS	-0.248NS
PAN Evaporation	0.439NS	0.305NS	-0.060NS	0.036NS
Rainfall (mm)	-0.037NS	-0.154NS	0.252NS	0.262NS

*Significant at 5% level of significance,
**Significance at 1% level of significance

Whitefly, *Bemisia tabaci* (Gennadius)

The maximum temperature reported highly significant positive correlation (r = 0.603**) and significant positive correlation (r = 0.537*) with minimum temperature (Table 2). However, morning and evening relative humidity recorded non-significant negative correlation (r= -0.387NS and r = -0.163NS respectively) with mean population of whitefly. Whereas, rainfall showed non-significant negative correlation (r = -0.154NS). The wind speed, sunshine hours and pan evaporation had positive non-significant correlation. These findings are in assessment with Yadav et al. (2014) who reported that the maximum temperature showed significant positive correlation (r= 0.63) while minimum temperature showed non-significant correlation and average relative humidity showed a significant negative correlation with whitefly (r = -0.34), whereas rainfall exhibited a significant negative correlation with whitefly population. Also, similar result was noticed by Monaro & Choudhary (2018) who showed that temperature and relative humidity showed a positive and a negative correlation with rainfall on whitefly population. Priyadarshini et al. (2018) reported that whitefly population showed significant positive correlation with temperature difference while significant negative correlation with minimum temperature and rainfall.

Leafhopper, *Amrasca bigutulla bigutulla* (Ishida)

A non-significant negative correlation (r = -0.094NS) was observed between leafhopper mean population and maximum temperature while minimum temperature had highly significant positive correlation (r = 0.613**) with mean population of leafhopper (Table 2). The morning and evening relative humidity exhibited non-significant positive correlation (r = 0.205NS and r= 0.398NS) with the mean population of leafhopper, respectively. Rainfall showed positive non-significant correlation (r = 0.252NS) whereas, wind speed and pan evaporation recorded negative non-significant correlation (r = -0.037NS and r = -0.607NS) with the mean population of leafhopper. The sunshine hours recorded non-significant positive correlation (r = 0.139NS). Haldhar et al. (2010) reported that the relationship between butterfly egg, larval population and maximum temperature was (-0.53 & -0.55) negatively correlated whereas the maximum relative humidity was (0.44 & 0.53) positively correlated. Then, the egg and larval population gradually increased and reached to its peak, when the temperature decreased and humidity increased. The rainfall was also negatively correlated (-0.51) with egg population of butterfly. The current findings are in conformity with the findings of Yadav et al. (2014) who showed that the incidence of leafhopper had non-significant negative correlation with maximum temperature and significant positive correlation with minimum temperature, whereas mean relative humidity and rainfall had significant positive correlation with the population of leafhopper. The similar results were reported by Rajput et al. (2017) who outlined that the leafhopper population had positive and significant correlation with minimum temperature (r=0.48*). However, maximum temperature, morning relative humidity, wind velocity and sunshine hours had positive correlation but were non-significant.

Lady bird beetle, *Coccinella septempunctata*

The mean population of lady bird beetle showed non-significant negative correlation with maximum temperature, wind speed and sunshine hours (r = -0.270^{NS}, r = 0.006^{NS} and r = -0.248^{NS} respectively) while minimum temperature, morning and evening relative humidity and pan evaporation recorded non-significant positive correlation (r= 0.123^{NS}, r= 0.342^{NS}, r= 0.299^{NS} and r= 0.036^{NS}) with mean population of lady bird beetle (Table 2). The rainfall showed positive non-significant correlation (r= 0.262^{NS}). The present investigation are in adherence to the results of Bhatt et al. (2020) who reported significant negative influence of maximum temperature (r= -0.663** and r= -0.632**), mean temperature (r= 0.518* and r= -0.515*) and sunshine hours (r= -0.604** and r= -0.570**) on ladybird beetle population while rainfall was positively and significantly correlated (r= 0.553*), whereas wind velocity, morning relative humidity, evening relative humidity and mean relative humidity had positive and non-significant impact on lady bird beetle population. The similar results were reported by Priyadarshani et al. (2018) they outlined that ladybird beetle population had a non-significant positive correlation with temperature difference, minimum temperature, average temperature and maximum relative humidity while non-significant negative correlation with relative humidity. In addition, Sahani et al. (2020) who reported that none of the weather parameters had significant correlation observed similar results.

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