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SEASONAL INCIDENCE OF SUCKING INSECTS ON CAPSICUM GROWN UNDER PROTECTED CONDITIONS

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Capsicum (*Capsicum annuum* var. *frutescens*) (family-Solanaceae) is nutritious and highly remunerative vegetable crop grown throughout the world in field as well as protected cultivation. It is very rich in vitamins A and C. From every 100 g of edible portion of capsicum 1.3 g of protein, 4.3 g of carbohydrate, 24 k cal of energy and 0.3 g of fat is provided (Sreedhara *et al.,* 2013). During the last decade, its cultivation has greatly increased under protected conditions so as to make it available all around the year. But the production and yield of this crop is often hampered due to attack by sucking pests. In protected cultivation, crops are grown under controlled conditions like water, temperature, fertilizers, humidity, light etc. But the protected environment also provides congenial micro-climate for the multiplication of sucking insects (aphids, jassids, thrips, whiteflies and mealybugs) which cause economic damage to crops. About 35 species of insect and mite pests have been reported to infest capsicum under field conditions which include thrips, aphids, whitefly, fruit borers and mites (Sorensen, 2005). Sucking insects cause direct damage to plant by feeding and indirect damage as vector of viral diseases like leaf curl, mosaic, thus causing significant losses.

Since the degree of incidence of sucking insects changes with season, it is desirable to have thorough understanding of seasonal incidence to devise the pest monitoring system and ecological sound integrated pest management modules. Keeping this in view, the present studies were carried out on seasonal incidence of sucking insects on capsicum under net house conditions.

The seasonal incidence of sucking insects on capsicum was taken at two different locations *viz.* Entomological Research Farm, Department of Entomology, Punjab Agricultural University, Ludhiana (latitude 30° 56' N, longitude 75° 52' E, altitude 247 m). The details of the materials used and methods employed during present investigations are being presented here.

For observing seasonal abundance of insects in capsicum crop under net house cultivation, variety Indra hybrid was raised with plot size of 1m x 5m. For this study, 30 days old seedlings were transplanted on 1st fortnight of November during both the years. The plants were spaced 45 cm apart with row to row spacing of 45 cm and 20 plants were transplanted in each bed. Incidence was recorded for two years at weekly interval from February to June in 2017 and 2018.

For taking observations, population counts of insects per leaf were recorded from three leaves each of top, middle and bottom canopy of randomly selected plants per row. These leaves were collected and kept in separate polythene bags and then brought to laboratory. The number of insects were recorded per leaf under stereo zoom binocular microscope (Carl Zeiss Discovery V 8). Maximum and minimum temperature, relative humidity were also recorded during crop season under net house conditions at Ludhiana (Table 5). Correlation analysis was worked out with the current week insect numbers and mean of previous week weather data.

Simple, multiple correlations and multiple regression equations were worked out between insect population and weather parameters by using the SPSS software. Results were analysed at 1 and 5 per cent levels of significance.

For developing efficient control measures of insect pests on capsicum, seasonal incidence of sucking insects were studied at Ludhiana during both the years. Different insects were recorded from capsicum crop grown under protected conditions along with some natural enemies (Table 1).

Aphid (*Myzus persicae*)

The pooled data of two years showed that the aphid occurred from 3rd week of February (7 SMW) and attained peak population of 8.11 aphids per leaf in 1st week of March. After that population started decreasing gradually and remained less after 1st week of April (Table 2). Similar to our study, Ghose *et al.* (2018) observed that aphid population was high during February to April on tomato, whereas, population was low during May-June.

Aphid population exhibited significant negative correlation with maximum temperature (-0.676), minimum temperature (-0.657) and significant positive correlation with morning RH (0.631) and evening RH (0.578) (Table 3). Roopa and Kumar (2014) found that maximum and minimum temperatures showed negative

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Table 1. Insects recorded from capsicum crop grown under protected conditions

Type of insect	Common Name	Family
Insect-pests		
Aphid	*Myzus persicae* (Sulzer)	Aphididae
Whitefly	*Bemesia tabaci* (Gennadius)	Aleyrodidae
Thrips	*Thrips tabaci* Lindeman	Thripidae
Mealybug	*Phenacoccus solenopsis* Tinsley	Pseudococcidae
Natural enemies		
Parasitoid	*Diaretella rapae* (M'Intosh)	Braconidae
Parasitoid	*Aenasisus arizonensis* (Girault)	Encyrtidae

correlation with aphid population; whereas, positive correlation was exhibited with the morning and evening RH, similar to that observed in our study. Nemade *et al.* (2018) also reported positive correlation of aphid population with morning and evening relative humidity that supports our findings.

The coefficient of multiple correlation between aphid population and independent variables (maximum temperature, minimum temperature, morning RH and evening RH) was found to be 0.700. It suggested that all these weather parameters played a role in the multiplication of aphids (Table 4).

Whitefly (*Bemesia tabaci*)

Incidence of whitefly started from 3rd week of February and reached to peak population (1.9 whitefly/leaf) in 9th SMW. Population was more during February-March and incidence was not observed after the month of April (Table 2). Hadiya (2015) observed similar incidence of whitefly during the month of February in chilli crop.

Significant negative correlation was observed between whitefly poputaion and maximum temperature (-0.458), minimum temperature (-0.446) and significant positive correlation with morning RH (0.437) while

Table 2. Seasonal incidence of sucking insects on net house capsicum at Ludhiana (Mean data of two years, 2017 and 2018)

SMW	Mean Number/leaf			
	Aphid	Whitefly	Thrips	Mealybug
7	3.63	0.25	0.00	0.00
8	6.60	0.63	0.03	0.01
9	8.11	1.91	0.04	0.01
10	4.22	1.22	0.11	0.00
11	1.00	0.41	0.09	0.11
12	0.66	0.19	0.14	0.00
13	0.47	0.33	0.04	0.00
14	0.40	0.00	0.00	0.15
15	1.00	0.00	0.00	0.07
16	0.25	0.00	0.00	0.74
17	0.00	0.00	0.01	0.65
18	0.00	0.00	0.00	1.59
19	0.00	0.00	0.00	2.40
20	0.02	0.00	0.00	3.40
21	0.04	0.00	0.00	3.72
22	0.01	0.00	0.00	4.03
23	0.01	0.00	0.00	7.05
24	0.00	0.00	0.00	8.80
25	0.00	0.00	0.00	7.01

Table 3. Pooled correlation of different insects with weather parameters during 2017 and 2018

Weather parameters	Aphid	Whitefly	Thrips	Mealybug
Max. Temp. (^{0}C)	-0.676**	-0.458**	-0.534**	0.407*
Min. Temp. (^{0}C)	-0.657**	-0.446**	-0.488**	0.482**
Morning RH (%)	0.631**	0.437**	0.458**	-0.375*
Evening RH (%)	0.578**	0.312	0.368*	-0.195

** Significant at 1 per cent level of significance
* Significant at 5 per cent level of significance

correlation was non-significant with evening RH (0.312) as given in Table 3. Our findings gather support from the work of Mathur *et al*. (2012) who reported that whitefly had negative correlation with maximum and minimum temperatures and positive correlation with relative humidity. Jakhar *et al.* (2017) reported that whitefly had significant positive correlation with relative humidity while correlation was non-significant with temperature and rainfall.

The coefficient of multiple correlation between whitefly population and independent variables (maximum temperature, minimum temperature, morning RH and evening RH) was found to be 0.479 (Table 4).

c) Thrips, *Thrips tabaci*: Population of thrips was observed in months of February-March (8-13 SMW), however incidence was less during both the years.

Thrips population exhibited significant negative correlation with maximum temperature (-0.534) and minimum temperature (-0.488) and significant positive correlation with morning RH (0.458) and evening RH (0.368) as given in Table 3. The present findings agree with that of Saini *et al.* (2017) who found that thrips had negative correlation with temperature and positive correlation with relative humidity.

The coefficient of multiple correlation between thrips population and independent variables (maximum temperature, minimum temperature, morning RH and evening RH) was found to be 0.571, which suggested that these weather parameters have some influence on the multiplication of thrips (Table 4).

Mealybug (*Phenacoccus solenopsis)*

Population of mealybugs started appearing from 4th week of February (8 SMW) which then increased gradually and reached to 1.59 mealybug/leaf in 1st week of May (18 SMW). The incidence continued to increase throughout the crop period and attained its peak in 2nd week of June (24 SMW) with 8.80 mealybugs/leaf (Table 2).

Significant positive correlation was observed between mealybug population and maximum temperature (0.407) and minimum temperature (0.482). Significant negative correlation was observed with morning RH (-0.375) while correlation was non-significant with evening RH (-0.195) as depicted in Table 3. Angu *et al.* (2017) found that maximum temperature showed significant positive correlation with mealybug, whereas a negative correlation was established with morning RH and evening RH. Singh and Kumar (2012) also reported that mealybug had positive correlation with temperature and negative correlation with relative humidity which is in support to our findings.

The coefficient of multiple correlation between mealybug population and independent variables (maximum temperature, minimum temperature, morning RH and evening RH) was found to be 0.502, suggesting that these weather parameters had some influence on the multiplication of mealybug (Table 4).

Studies on seasonal incidence of insect pests of capsicum crop provide basic information about seasonal occurrence of insect pest. Statistically significant correlation and regression values indicate

Table 4. Regression equations of insects with weather parameters (2017 and 2018)

Insect	Regression equation	R^2	Multiple correlation
Aphid	Y = 1.478+0.121(Max T)-0.312(Min T)-0.026(MRH)+0.110(ERH)	0.490**	0.700**
Whitefly	Y = 2.480-0.088(Max T) +0.04(Min T)+0.012(MRH)-0.024(ERH)	0.229	0.479
Thrips	Y = 0.439-0.014(Max T)+0.007(Min T)+0.000(MRH)-0.003(ERH)	0.326**	0.571**
Mealybug	Y= -0.381-0.297(Max T)+0.618(Min T)+0.008(MRH)-0.010(ERH)	0.252*	0.502*

** Significant at 1 per cent level of significance
* Significant at 5 per cent level of significance

Table 5. Abiotic parameters during 2017 and 2018 in net house conditions

SMW	Max. Temp.(°C)	Min. Temp.(°C)	M RH(%)	E RH(%)
6	22.90	8.90	92.25	49.45
7	24.70	11.50	90.50	54.00
8	27.15	13.15	90.50	45.50
9	27.65	13.30	91.50	44.50
10	26.05	13.35	89.00	46.00
11	28.55	13.50	88.50	38.00
12	31.80	16.50	87.00	40.50
13	36.00	19.50	81.50	32.00
14	35.85	21.80	69.50	33.00
15	36.95	18.55	66.50	24.50
16	40.55	23.55	56.50	25.50
17	40.25	23.50	51.50	23.00
18	38.75	25.25	53.00	30.50
19	41.64	26.64	53.50	24.00
20	40.80	26.55	52.50	25.50
21	41.55	26.95	48.50	26.10
22	40.95	26.69	53.11	28.33
23	40.81	29.25	63.93	39.43
24	40.16	28.98	59.00	35.50

that population of pests fluctuates with weather parameters. This provides an opportunity for the development of management strategies significant for the control of these pests. These results will support in devising the pest monitoring system and ecological sound integrated pest management modules.

Authors' contribution

Conceptualization research work and designing of experiments (MBB, PK); Execution of experiment and data recording (S); Analysis of data and interpretation (S, MBB); Preparation of manuscript (S, MBB, PK).

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