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Succession and incidence of insect fauna on chilli in Gird region of Madhya Pradesh

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Abstract
Succession and incidence of insect fauna on chilli were studied in Gird region of M.P. during *Rabi* 2018-19 and 2019-20. During investigation two insects were appeared as pests at different stages of the crop *i.e.* 1-2 twigs, vegetative, flowering, fruiting and harvesting. In all, two insect pests namely aphid, *Aphis gossypii* (Glover) and thrips, *Scirtothrips dorsalis* (Hood); and one predator ladybird beetle, *Coccinella septempunctata* (Linnaeus); *Menochilus sexmaculatus* (Fabricius) were observed on different stages of the crop. The activity of aphid was observed from second week of December during 2018 (50th SMW) and first week of December during 2019 (49th SMW), respectively and remained active till harvesting of the crop. The aphid population reached its peak during third week of February during 2018 (7th SMW) and second week of February during 2019 (6th SMW). Thrips population was appeared in second week of December during 2018 (50th SMW) and last week of November during 2019 (48th SMW) and remained active till harvesting of the crop. Thrips population reached its peak in fourth week of February during both years (8th SMW). The ladybird beetle was first appeared in third week of December during 2018 (51th SMW) and second week of December during 2019 (50th SMW) and remained active till harvesting of the crop. The ladybird beetle population reached at its peak in third week of February during both years (7th SMW). The correlation of aphid population with all meteorological parameter showed no significantly relationship. Significant positive correlation was noticed between maximum temperature and thrips population. Significant positive correlation was noticed between minimum temperature and thrips population. Significant negative correlation was noticed between morning relative humidity and thrips population. Significant positive correlation was noticed between maximum temperature and ladybird beetle population. Significant positive correlation was noticed between minimum temperature and ladybird beetle. Significant negative correlation was noticed between evening relative humidity and ladybird beetle. Significant positive correlation was noticed between population of aphid and ladybird beetle.

Keywords: Succession, incidence, insect fauna, aphid, thrips, correlation, chilli

1. Introduction
Chilli (*Capsicum annuum* L.) belongs to the family Solanaceae is an important spice cum vegetable crop commonly used in Indian dietary. It is cash crop so cultivated throughout the year and green and its red ripe dried stage used for their pungency, colour and other various ingredients in all culinary preparations of rich and poor also to give taste, colour and flavour. Nutritionally, it is a rich source of vitamin A, B and C. Pungency in chillies is due to an alkaloid *Capsaicin* has medicinal properties and it dilating the blood vessels so as to prevents heart attack (Gill, 1989) [9]. In India, chilli occupies an area of 6.84 lakh ha with annual production of 19.31 lakh tonnes and productivity of 2490 kg per ha (Anonymous, 2020a) [3]. In Andhra Pradesh, chilli occupies an area of 1.43 lakh ha with annual production of 6.60 lakh tonnes and with highest productivity of 4615 kg per ha whereas, in Madhya Pradesh, chilli occupies an area of 0.88 lakh ha with annual production of 2.18 lakh tonnes and productivity of 2488 kg per ha (Anonymous, 2020b) [4].
Low production and productivity of chilli are due to various factors that include insect pests, diseases, poor quality seeds and adverse climate. Both quality and production of chilli are mainly affects by insects pests have prime importance. This crop was found infested about 51 insects, which belongs to about 27 families of insects (Reddy and Puttaswami, 1988) [20]. Among these mites, *P. latus* Banks, fruit borer, *H. armigera* (Hubner), Jassid, *A. biguttula biguttula* (Ishida), aphid, *A. gossypii* Glover, whitefly, *B. tabaci* Genn. and thrips, *S. dorsalis* Hood are important insect pests causes yield loss in green chilli about 60 to 75 percent (Ahmed *et al*., 1987) [2].

Nature of insect pests is dynamic and insect pests successions occurs with the nature of the agro-ecosystem and on succession of the pests of chilli various reports are available from the different parts of the country. Among insect pests of chilli; of which thrips, *S. dorsalis* Hood is considered as most serious pest and under severe infestation it causing 30 to 50 per cent yield losses (Bhede *et al*., 2008) [7]. For successful insect pests management it is necessary to know seasonal cycle of insect ecosystem. In view of these facts and different scenario of insect pests investigations were planned to study insect pests and their natural enemies associated with chilli ecosystem in Gird region of Madhya Pradesh.

2. Materials and Methods

The investigation was carried out at department of entomology, research farm, RVSKVV, Gwalior (M.P.) during *Rabi* 2018-19 and 2019-20. Seedlings of chilli (Pusa Jwala) were raised in nursery beds and; 48 and 47 days old chilli seedlings were transplanted in the main field on 10th November, 2018 and 25th October, 2019. The experiment was laid out with spacing of 60 x 45 cm and plot size of 9.0 m x 9.0 m respectively. The crop was raised as per the recommended package of practices without imposing of plant protection measures.

Observations on population of different insect pests and their natural enemies were recorded in the morning hour at weekly interval starting immediately after transplanting and continued till last picking of fruits. Data was recorded on ten plants selected randomly from central rows / plot.

The population of aphid was recorded by counting both nymphs and adults. In the initial stage of the crop, counting of aphid was done on whole plant and in later stage on six leaves, two each from *i.e.* top, middle and bottom of each plant. The population of thrips was recorded from 10 cm twig of plants by shaking plant on white paper fixed on cardboard (20 cm x 20 cm). The larvae or adult or both of coccinellid beetle (*Coccinella septempunctata* and *Menochilus sexmaculatus*) were also recorded on the whole 10 plants selected randomly from the appearance of natural enemies till the last picking of fruits.

Weekly meteorological data on different abiotic factors *viz.* temperature (maximum & minimum in °C), relative humidity (morning and evening in %), total rainfall (mm), number of rainy days, etc. during the period of investigation was collected from the meteorological observatory of College of Agriculture, RVSKVV, Gwalior (M.P.). The influence of different meteorological parameters (X) on population of major insect pests (Y) and their natural enemies (Y_1) were studied and correlated.

3. Results and Discussion

During the course of study from December 2018 to March 2019 and November 2019 to March 2020, incidence of different insect pests on chilli were recorded regularly at different stages of the crop *i.e.* 1-2 twigs, vegetative, flowering, fruiting and harvesting. In all, two insect pests namely aphid, *Aphis gossypii* (Glover) and thrips, *Scirtothrips dorsalis* (Hood); and one predator ladybird beetle, *Coccinella septempunctata* (Linnaeus); *Menochilus sexmaculatus* (Fabricius) were recorded on different stages of the crop. Pandey (2015) [16], Chintkuntlawar *et al.* (2015) [8], Band *et al.* (2019) [5], also reported first appearances of aphids and thrips at vegetative stage and remained active upto reproductive stage of the crop. Chintkuntlawar *et al.* (2015) [8] also reported occurrence coccinellid predatory beetles on chilli.

3.1 Insect-pests

3.1.1 Aphid, *Aphis gossypii* Glover

The activity of aphid was noticed from second week of December during 2018 (50th SMW) and first week of December during 2019 (49th SMW), respectively and remained active till harvesting of the crop (13th SMW and 11th SMW, respectively) during both the years. Initially, the aphid population was 0.8 and 0.6 aphids/six leaves during 2018 and 2019, respectively. The aphid population was increased slowly and reached its peak during third week of February during 2018 (7th SMW) with 47.3 aphids/six leaves and second week of February during 2019 (6th SMW) with 41.2 aphids/six leaves. After reaching the peak, the population of aphid started to diminution till the harvesting of the crop (13th SMW and 11th SMW, respectively) in both the years (Table 1.b,c). Bhatt and Karnataka (2020) [6] also observed aphids attained their peak on 6th SMW. Whereas, Mondal *et al.* (2021) [15] observed peak population on 4th week of February (8th MSW) and remained high till 3rd week of March. In contrary to present findings, Hadiya (2015) [11] reported that aphid, *Aphis gossypii* Glover activity was started from first week of November. The variation in peak of pest incidence may be due to weather condition of the place of investigations.

3.1.2 Thrips, *Scirtothrips dorsalis* Hood

The population of thrips was appeared in second week of December during 2018 (50th SMW) and last week of November during 2019 (48th SMW) and remained active till harvesting of the crop (13th SMW and 11th SMW, respectively) in both the years. The thrips population was increased slowly and reached its peak during fourth week of February during both years (8th SMW) with 42.3 and 40.2 thrips/10 cm twig, respectively. After reaching the peak, the population of thrips started to diminution till the harvesting of the crop (13th SMW and 11th SMW, respectively) during both the years (Table 1.b,c). Aarwe *et al.* (2020) [1] also reported first appearance of thrips was observed in 48th SMW. In contrast to present findings, Hadiya (2015) [11] observed the appearance of thrips started from 1st week of October and Reddy *et al.* (2017) [19], Gopal *et al.* (2018) [10] observed peak of thrips population in January 3rd week (3rd std. week) and December last week (52nd std. week). The variation in peak of pest incidence may be due to weather condition of the place of investigations.

3.2 Natural Enemies

3.2.1 Ladybird beetle

The two species of ladybird beetle *Coccinella septempunctata* Linnaeus; *Menochilus sexmaculatus* Fabricius were recorded. The ladybird beetle was first appeared in third week of December during 2018 (51th SMW) and second week of December during 2019 (50th SMW) with the population (larvae and adult) of 0.1 beetle/plant and 0.2 beetle/plant during 2018 and 2019, respectively. The ladybird beetle population was increased slowly and reached at its peak in third week of February during both years (7th SMW) with 2.6 beetles/plant and 2.5 beetles/plant, respectively. After reaching the peak, the population of beetles started to diminution till the harvesting of the crop (13th SMW and 11th SMW, respectively) during both the years (Table 1.b,c). Beetles were observed by feeding on nymph and adult of

aphid. It was observed that peak population synchronizes with the peak of aphid in both the years. In contrary to present findings, Hadiya (2015) [11] reported that the lady bird beetle population noticed from first week of November and recorded the highest peak during fourth week of December and Bhatt and Karnatak (2020) [6] observed maximum ladybird beetle populations in 6th SMW.

3.3 Correlation studies

The correlation of aphid population with all meteorological parameter (maximum and minimum temperature, morning and evening relative humidity, rainfall and number of rainy days) showed no significantly relationship; their value ranged from -0.170 to 0.404 during 2018 whereas, during 2019, -0.086 to 0.304 were observed (Table 1.d). Meena *et al.* (2013) [14], Rajput *et al.* (2017) [18], Havanoor and Rafee (2018) [12], and Mondal *et al.* (2021) [15], also observed the non-significant correlation between above meteorological parameter and aphid population.

Correlation studies revealed that maximum temperature had positive and significant correlation (r= 0.503 during 2018 and 0.595 during 2019) with population of thrips. The regression equation being Y_1 = - 15.68 + 1.474X and Y_1 = - 18.99 + 1.653X during 2018 and 2019, respectively, which indicates that with every 1 °C increase in maximum temperature there will be increase in population of thrips by 1.474 and 1.653 during respective years. Meena *et al.* (2013) [14], Rajput *et al.* (2017) [18], Havanoor and Rafee (2018) [12], Priyadarshini *et al.* (2018) [17] and Kumar *et al.* (2019) [13], also observed significant positive correlation of maximum temperature with thrips population.

Significant positive correlation was noticed between minimum temperature and thrips population (r= 0.760). The regression equation being Y_1= - 0.569 + 2.484X_1, which indicates that with every 1 °C increase in minimum temperature there will be increase in thrips population by 2.484 thrips/10 cm twig during 2018, but not significant during 2019. Priyadarshini *et al.* (2018) [17] also found significant positive correlation of minimum temperature with thrips population.

Significant negative correlation was noticed between morning relative humidity and thrips population (r= -0.510 during 2018 and -0.502 during 2019), the regression equation being Y_1 = 77.59 - 0.650X_2 and Y_1 = 122.8 - 1.129X_2, which indicates that with every one per cent increase in morning relative humidity there will be decrease in thrips population by 0.650 and 1.129 thrips/10 cm twig during 2018 and 2019, respectively. Meena *et al.* (2013) [14], Priyadarshini *et al.* (2018) [17] and Kumar *et al.* (2019) [13], also observed negative and significant correlation of morning relative humidity with thrips population.

Evening relative humidity, rainfall and number of rainy days was found to be no significant correlated in both the years. Havanoor and Rafee (2018) [12] and Priyadarshini *et al.* (2018) [17] also reported non-significant correlation between evening relative humidity, rainfall and thrips population.

Significant positive correlation was noticed between maximum temperature and ladybird beetle population (r= 0.658). The regression equation being Y_2 = - 0.889 + 0.112X. Indicates that with every 1 °C increase in maximum temperature there will be increase in beetle population by 0.112 during 2019, but not significant during 2018. Priyadarshini *et al.* (2018) [17] also observed significant positive correlation between maximum temperature and ladybird beetle population. Whereas, Hadiya (2015) [11] and Sahani *et al.* (2020) [21] observed the non-significant correlation of maximum temperature with ladybird beetle population.

Significant positive correlation was noticed between minimum temperature and ladybird beetle (r= 0.529). The regression equation being Y_2 = 0.491 + 0.116X_1. Indicates that with every 1°C increase in minimum temperature there will be increase in beetle population by 0.116 during 2018, but not significant during 2019. Hadiya (2015) [11], Priyadarshini *et al.* (2018) [17] and Sahani *et al.* (2020) [21] also observed the non-significant correlation of minimum temperature with ladybird beetle population.

Significant negative correlation was noticed between evening relative humidity and ladybird beetle (r= -0.561), the regression equation being Y_2= 3.595 - 0.034X_3, which indicates that with every one per cent increase in evening relative humidity there will be decrease in beetle population by 0.034 during 2019, but not significant during 2018. Priyadarshini *et al.* (2018) [17] and Sahani *et al.* (2020) [21] also observed the non-significant correlation of evening relative humidity with ladybird beetle population.

Significant positive correlation was noticed between population of aphid and ladybird beetle (r= 0.831 during 2018 and 0.761 during 2019). The regression equation being Y_2 = 0.663 + 0.050X_n and Y_2 = 0.854 + 0.049X_n during 2018 and 2019, respectively. Which indicates that with every one increase in aphid there will be increase in beetle population by 0.050 and 0.049 during 2018 and 2019, respectively. The present findings are strongly supported by Hadiya (2015) [11], who reported ladybird beetle, exhibited highly significant positive relationship with aphid.

Morning relative humidity, rainfall and number of rainy days were found to be no significant correlated during both the years. Similarly, Priyadarshini *et al.* (2018) [17] and Sahani *et al.* (2020) [21] also observed the non-significant correlation of morning relative humidity with population of ladybird beetle. In contrast to present findings, Hadiya (2015) [11] reported significant negative correlation between morning relative humidity and ladybird beetle. Similarly, Sahani *et al.* (2020) [21] also observed non-significant correlation between rainfall and ladybird beetle population. In contrast to present investigations, Priyadarshini *et al.* (2018) [17] observed significant negative correlated with rainfall.

Table 1a: Succession of insect fauna at different growing stages on chilli during *Rabi* 2018-19 and 2019-20

Month	SMW	Common name	Crop age (DAT)		Crop stage	
			2018-19	2019-20	2018-19	2019-20
Nov	48	Thrips	-	33	-	1-2 twigs
Dec	49	Thrips, Aphid	-	40	-	2-3 twigs
	50	Thrips, Aphid, Lady bird beetle	31	47	1-2 twigs	>3 twigs
	51		38	54	2-3 twigs	Vegetative
	52		45	61	>3 twigs	Vegetative
Jan	1		52	68	Vegetative	Peak vegetative

	2		59	75	Vegetative	Flower initiation
	3		66	82	Peak vegetative	Flowering
	4		73	89	Flower initiation	Peak flowering
Feb	5		80	96	Flowering	Fruit initiation
	6		87	103	Flowering	Fruiting
	7		94	110	Fruit initiation	Fruiting
	8		101	117	Fruiting	Peak fruiting
Mar	9		108	124	Fruiting	Peak fruiting
	10		115	131	Fruiting	Fruiting
	11		122	138	Fruiting	Harvesting
	12		129	-	Fruiting	-
	13		136	-	Harvesting	-

Table 1b: Seasonal incidence of insect fauna on chilli during *Rabi* 2018-19

Month	SMW	No. of aphid	No. of thrips	No. of ladybird beetle	Temperature (^{O}C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
					Max.	Min.	Morn.	Even.		
Dec	50	0.8	2.4	-	22.4	6.8	90.4	57.7	0	0
	51	2.1	4.2	0.1	23.5	4.5	90.7	38.4	0	0
	52	3.8	6.6	0.2	22.8	3.5	94.5	36.8	0	0
Jan	1	5.9	8.7	0.4	24.0	6.2	94.7	46.7	0	0
	2	7.1	10.8	0.8	21.7	5.5	93.6	41.3	0	0
	3	10.2	14.7	1.2	23.8	4.6	91.7	34.9	0	0
	4	12.6	15.6	1.6	20.6	9.0	92.4	73.9	2.0	0
Feb	5	18.7	21.3	1.9	20.7	5.9	92.9	58.6	0	0
	6	28.9	25.8	2.2	22.8	9.0	85.6	61.3	12.2	1
	7	47.3	33.9	2.6	24.7	10.2	90.0	48.3	0	0
	8	42.5	42.3	2.6	27.0	12.2	84.0	51.4	0	0
Mar	9	33.1	31.2	2.5	23.5	9.1	93.1	50.1	15.7	2
	10	20.4	34.5	2.3	26.8	11.3	80.7	34.0	0	0
	11	9.6	32.7	1.9	29.3	12.5	78.9	34.9	0	0
	12	2.7	30.6	1.5	32.7	14.5	65.6	26.0	0	0
	13	0.2	26.7	1.2	35.8	16.5	63.4	28.6	0	0

SMW = Standard Meteorological Week

Table 1c: Seasonal incidence of insect fauna on chilli during *Rabi* 2019-20

Month	SMW	No. of aphid	No. of thrips	No. of ladybird beetle	Temperature (^{O}C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
					Max.	Min.	Morn.	Even.		
Nov	48	-	2.7	-	27.1	12.4	92.0	52.0	0	0
Dec	49	0.6	6.3	-	24.0	6.7	94.7	43.3	0	0
	50	1.9	8.7	0.2	21.3	9.5	95.9	62.3	2.1	0
	51	2.8	9.3	0.5	19.2	4.9	94.4	54.7	0	0
	52	4.7	10.2	0.9	13.5	2.3	96.6	75.9	0	0
Jan	1	6.9	13.5	1.1	21.7	6.6	96.3	59.0	0	0
	2	11.2	17.4	1.4	20.4	5.6	91.3	72.6	11.2	1
	3	9.4	12.9	1.7	18.3	7.6	96.1	70.7	40.4	2
	4	15.3	15.6	1.9	22.8	5.2	88.4	45.6	0	0
Feb	5	24.6	18.3	2.1	22.2	6.0	94.0	56.9	0	0
	6	41.2	22.5	2.3	22.4	4.9	93.7	44.9	0	0
	7	36.5	29.4	2.5	26.8	6.4	79.7	36.4	0	0
	8	28.6	40.2	2.4	26.5	9.6	93.6	46.9	0.8	0
Mar	9	17.3	38.4	2.5	29.4	13.2	89.1	53.1	2.4	0
	10	10.1	34.8	2.2	26.3	11.1	90.3	53.1	9.2	1
	11	3.3	29.1	1.8	28.9	11.5	80.0	39.4	0	0

SMW = Standard Meteorological Week

Table 1d: Correlation coefficient (r) and regression equation of insect fauna of chilli with the weather parameters during *Rabi* 2018-19 and 2019-20

Weather parameters	Aphid (*Aphis gossypii* Glover)			
	2018-19		2019-20	
	r	Regression equation	r	Regression equation
Max. Temp. (°C)	-0.170	-	0.304	-
Mini. Temp. (°C)	0.182	-	-0.086	-
Morn. R.H. (%)	0.187	-	-0.269	-
Even. R.H. (%)	0.372	-	-0.414	-
Rainfall (mm)	0.404	-	-0.146	-
No. of rainy days	0.397	-	-0.159	-

Weather parameters	Thrips (*Scirtothrips dorsalis* Hood)			
	2018-19		2019-20	
	r	Regression equation	r	Regression equation
Max. Temp. (°C)	0.503*	$y_1 = - 15.68 + 1.474x$	0.595*	$y_1 = - 18.99 + 1.653x$
Mini. Temp. (°C)	0.760*	$y_1 = - 0.569 + 2.484x_1$	0.411	-
Morn. R.H. (%)	-0.510*	$y_1 = 77.59 - 0.650x_2$	-0.502*	$y_1 = 122.8 - 1.129x_2$
Even. R.H. (%)	-0.127	-	-0.384	-
Rainfall (mm)	0.219	-	-0.055	-
No. of rainy days	0.236	-	0.007	-

Weather parameters	Ladybird beetle			
	2018-19		2019-20	
	r	Regression equation	r	Regression equation
Max. Temp. (°C)	0.098	-	0.658*	$y_2 = - 0.889 + 0.112x$
Mini. Temp. (°C)	0.529*	$y_2 = 0.491 + 0.116x_1$	0.335	-
Morn. R.H. (%)	-0.182	-	-0.496	-
Even. R.H. (%)	0.324	-	-0.561*	$y_2 = 3.595 - 0.034x_3$
Rainfall (mm)	0.395	-	0.019	-
No. of rainy days	0.384	-	0.048	-
Aphid	0.831*	$y_2 = 0.663 + 0.050x_n$	0.761*	$y_2 = 0.854 + 0.049x_n$

* = Significant at 5% level of significance;
x = Weather parameters (x = Max. Temp., x_1 = Mini. Temp., x_2 = Morn. R.H., x_3 = Even. R.H., x_4 = Rainfall and x_5 = No. of rainy days);
y = Insect pests population (y or x_n = Aphid, y_1 = Thrips and y_2 = Ladybird beetle

4. Conclusions

Based on the results of findings, it can be concluded that insect fauna (aphid, thrips and ladybird beetle) were appeared from 1-2 twigs stage (1st week of December) and continued till the harvesting of the crop (last week of March). All meteorological parameter showed no significant impact on the population of chilli aphid. Maximum and minimum temperature indicated a positive impact on the chilli thrips population, while morning relative humidity indicated a negative impact. Maximum and minimum temperature indicated a positive impact on ladybird beetle population, while evening relative humidity showed a negative impact.

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