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Anjan Kumar Nayak
Department of Agricultural Entomology, BCKV, Nadia, West Bengal, India

Anirban Sarkar
AICRP on Potato, Directorate of Research, BCKV, Nadia, West Bengal, India

Suvash Chandra Bala
AINP on Agril. Acarology, Directorate of Research, BCKV, Kalyani, West Bengal, India

Correspondence
Anirban Sarkar
AICRP on Potato, Directorate of Research, BCKV, Nadia, West Bengal, India

Studies on population fluctuation and effect of biotic and abiotic stresses on the population of *Myzus persicae* (Sulz.) infesting potato in the gangetic basin of West Bengal

Anjan Kumar Nayak, Anirban Sarkar and Suvash Chandra Bala

Abstract
Investigation was conducted at 'C' unit farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal ($22^0$58'52" N; $88^0$26'30" E, 10 m above sea level), India to study the seasonal incidence of aphids and the role of various abiotic and biotic factors influencing their population for consecutive two years during *rabi* season of 2016-17 and 2017-18. The results revealed that aphid first appeared on the crop in the 2nd week of January in during *rabi* 2016-17. Thereafter, the density of aphid increased gradually with a peak in the second week of February and then the population started declining. During *rabi* 2017-18 aphid population first observed on the crop in the last week of December and reached to peak in the third week of February. The aphid species showed a significant positive correlation with maximum temperature and significant negative correlation with the morning, evening and average relative humidity in the first season and in the second season the aphid population were significantly positively correlated with maximum temperature and significantly negatively correlated with morning and evening relative humidity. During both the season the population of coccinellid beetle, staphylinid beetle and spiders was positively correlated with aphid population at 1% and 5% level of significance.

Keywords: Potato, *Myzus persicae* (Sulz.), population dynamics, abiotic factor, biotic factor

1. Introduction
The potato, *Solanum tuberosum* Linn. belongs to the family solanaceae is an important starchy food crop in both sub-tropical and temperate regions. Potato is very widely grown on a world scale and ranks third most important crop after rice and wheat [1]. It is grown in almost all the states in India and under very diverse condition. India is the second largest producer of potato next to China (45.3 million tonnes) in the world with an average yield of 22.8 t/ ha [11]. Nearly 90% of potatoes are grown in the Vast Indo - Gangetic plains of north and eastern India during short winter days from October to March. Among the States Uttar Pradesh, West Bengal and Bihar accounted for nearly 71% area and 76% production of the country [2]. West Bengal ranks second among all potato growing states in India with a production of 12.0 million tonnes from 0.41 million ha, while the productivity was 29.7 t/ ha during 2013-14 [4]. With the developing agriculture and new agronomic and cultural practices the potato cultivation is increasing day by day. The crops are susceptible to various insect pests and non-insect pests *viz.* mites, nematodes etc. Among the important insect pest aphids *Myzus persicae* (Sulz.) and *Aphis gossypii* (Glov.) is an important one [12]; as a pest of potato, aphids can damage the crop directly and cause yield loses and indirectly when they act as vector and spread diseases like Potato virus X and potato virus Y [15]. PVX (Potato virus X) alone can cause 15-52 percent degeneration loss, while PVY (Potato virus Y) can cause 3-11 infection through seed materials [13]. Population fluctuation of *Myzus persicae* by using yellow water traps and its correlation with abiotic factors was studied by [3]. Highest aphid population was obtained at 18-20 ºC. A significant correlation was also obtained between mean temperature and the number of *M. persicae*. The swarming study of aphid was carried out by Kuroli [9] using yellow dish traps. The number of swarming individuals fluctuated from year to year, depending primarily on the rainfall and the temperature conditions.
Keeping in view the importance of the crop and the losses caused by the aphids, this present investigations were initiated to find out the population fluctuation of the aphid species during the crop growth period so that proper management can be applied to avoid crop loss.

2. Materials and methods

Field experiments were carried out at District Seed Farm–C Unit, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India (22_58^0 N latitude, 88_25^0 E longitude, 9 m above mean sea level) in *rabi* season 2016–17 and 2017–18 to study the population dynamics of aphids on potato as well as the effect of different abiotic and biotic stresses on the population buildup of this pest. The seed tubers of variety Kufri Jyoti were planted maintaining 60 cm row to row and 20 cm plant to plant distance on 04.12.2016 and 04.12.1017 during the *rabi* season 2016-17 and 2017-18 respectively. The crop was grown following recommended agronomic practices. Aphid population was recorded on randomly selected 34 plants starting from plant emergence till maturity as per the standard technique prescribed by the Central Potato Research Institute (CPRI), Shimla. The important standard technique followed was visual count per 100 compound leaves. Three fully expanded leaves were examined from each plant - one each from the top, middle and lower parts. The number of aphid counts was taken by moving across the field making 'X' shape movement in the field. For counting the aphid population, the leaf was held at the petiole by thumb and fore finger and turned until the entire underside of leaf was clearly visible. The aphids (both nymph and adult) present on the leaves were counted. The data were taken from 100 compound leaves of these randomly selected plants at an interval of seven days and subsequently demarcated at the plot.

2.1 Statistical Analysis

The influence of different weather parameters like maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, average relative humidity and sunshine hours on population dynamics of aphid had been investigated through correlation studies, calculating respective ― "r" (correlation coefficient) through Pearson's correlation method**.** To observe the effect of predatory population on the activity of the sucking pest like aphid, the population of predators was correlated with the population of the aphid using same statistical method.

3. Results and discussion

3.1 Seasonal incidence pattern of the Aphid (*Myzus persicae* Sulz.) infesting potato along with the different abiotic stresses

Studies on the seasonal incidence of *Myzus persicae* Sulz. infesting potato revealed that the occurrence of the pest was observed from 22-25 days after sowing. Observations were recorded from fourth week of December to first week of March and after that the crop was harvested. Population dynamics of this pest found on potato agro ecosystem during the experimental season *i.e. rabi* 2016-17 and *rabi* 2017-18 have been presented in Table 1 and Table 2. Among the natural enemies five species of lady bird beetles *viz.*, *Menochilus sexmaculata, Coccinella transversalis, Coccinella septumpunctata*, *Micraspis discolor, Propylea dissecta,* two spiders, *Oxyopes* sp. and *Neoscona* sp. and a predatory staphylinid beetle, *Paederous* sp. were found to predate upon this sucking pest, which have been presented in Table 5 and Table 6.

The population of *Myzus persicae* was ranged from 01 to 408 nymphs and adults in season I (2016-17) and 05 to 346 in season II (2017-18) per hundred (100) compound leaves (Table 1 and 2). It was first appeared on the crop during the 2nd week of January in season I when the maximum and minimum temperature, morning and evening relative humidity, rainfall and Sunshine (hr.) were 24.13 °C, 10.50 °C, 91.0%, 46.40%, 0.0 mm and 5.94 hours respectively. Thereafter, the density of aphid increased gradually with a peak of 408 aphids per 100 compound leaves in the second week of February when the maximum and minimum temperature, morning and evening relative humidity, rainfall and Sunshine (hr.) were 29.64 °C, 13.43 °C, 89.6%, 49.4%, 0.00 mm and 8.36 hours respectively and after that the population started declining (Fig. 1). Similarly, in second season aphid was first appeared two weeks earlier i.e during the last week of December when maximum and minimum temperature, morning and evening relative humidity, rainfall and Sunshine (hr.) was 26.04 °C, 11.57 °C, 95.1%, 52.3%, 0.00 mm and 8.04 hours respectively and then their density increased slowly as compared to season I and reached to its peak of 346 aphids per 100 compound leaves in third week of February when the maximum and minimum temperature, morning, evening relative humidity, rainfall and sunshine hour (hr.) was 29.41 °C, 13.96 °C, 88.1%, 43.4%, 0.00 mm and 8.40 hours respectively and after that started declining (Fig. 2).

The present findings are in agreement with those of [5, 6, 8, 19]. They reported that the critical level of wingless from of *Myzus persicae* crossed by the first week of January to the middle of February whereas in case of winged from, it crossed the critical level by first week of January to end of February. [15] reported that aphids were first observed in yellow sticky traps during third week of December and the population of pests gradually increased to reach the peak in second week of February in the first year of study (2006-07) while in second year of study (2007-08) the aphid population appeared in second week of December and attained its peak by the end of February on potato crop in West Bengal.

Table 1: Influence of various abiotic factors on the population dynamics of aphids in the year 2016-17

Standard Met. Week	Temperature (°C)		Relative humidity (%)		Rainfall (Mm)	Sunshine (Hours)	No. of aphids/ 100 compound leaves
	Maximum	Minimum	Morning	Evening			
49-2016	27.80	14.97	93.7	57.0	0	7.67	0
50-2016	25.30	11.80	94.1	54.7	0	7.30	0
51-2016	25.93	12.43	92.0	57.9	0	4.59	0
52-2016	25.93	13.41	95.9	67.0	0	2.89	0
01-2017	25.70	12.41	94.9	57.1	0	5.50	0
02-2017	24.13	10.50	91.0	46.4	0	5.94	1
03-2017	26.29	8.80	91.0	43.3	0	7.67	16
04-2017	27.66	11.31	90.0	50.4	0	6.59	97
05-2017	26.90	11.79	91.7	53.0	0	7.14	244
06-2017	29.64	13.43	89.6	41.4	0	8.36	408
07-2017	30.49	15.74	89.9	44.4	0	4.70	306

08-2017	31.86	18.59	88.6	44.3	0	5.87	184
09-2017	33.27	16.50	91.3	47.0	0	8.80	80

Table 2: Influence of various abiotic factors on the population dynamics of aphids in the year 2017-18

Standard Met. Week	Temperature (°C)		Relative humidity (%)		Rainfall (Mm)	Sunshine (Hours)	No. of aphids/ 100 compound leaves
	Maximum	Minimum	Morning	Evening			
49-2017	25.97	14.86	90.4	62.0	0.37	4.73	0
50-2017	27.62	17.98	96.3	71.8	2.13	5.00	0
51-2017	22.98	13.85	93.7	68.8	0	4.22	0
52-2017	26.04	11.57	95.1	52.3	0	8.04	5
01-2018	23.26	9.34	93.3	51.9	0	6.90	14
02-2018	21.47	7.34	90.6	53.9	0	4.93	16
03-2018	24.97	8.54	91.3	46.4	0	7.09	20
04-2018	26.40	9.76	89.1	42.1	0	7.84	96
05-2018	28.29	11.29	90.7	45.4	0	6.83	185
06-2018	28.85	12.63	89.4	44.4	0	7.62	292
07-2018	29.41	13.96	88.1	43.4	0	8.40	346
08-2018	33.39	17.64	91.3	44.4	0	5.70	208
09-2018	34.77	19.90	91.4	34.6	0	6.31	89

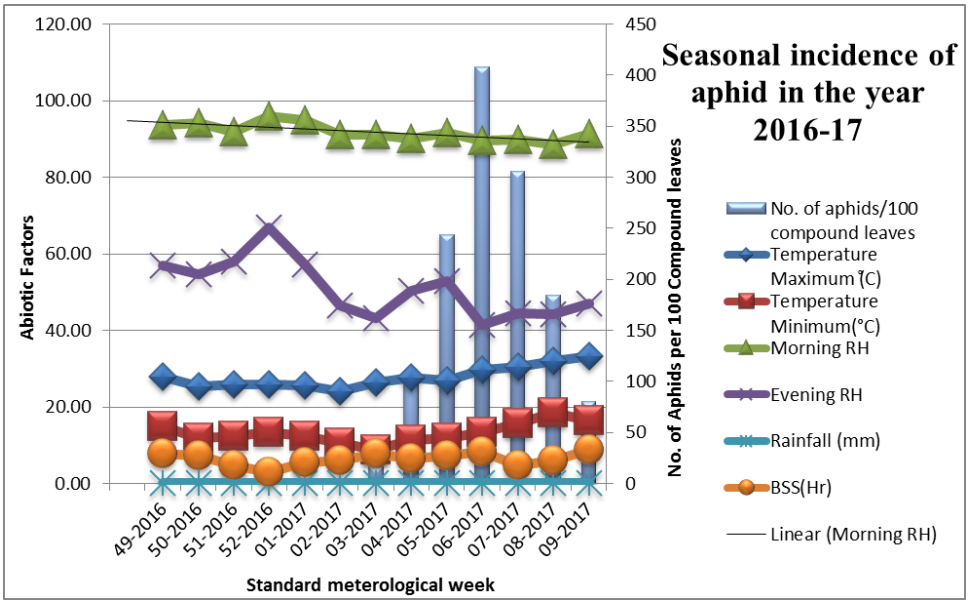

Fig 1: The influence of various abiotic factors on the population dynamics of aphids in the year 2016-17.

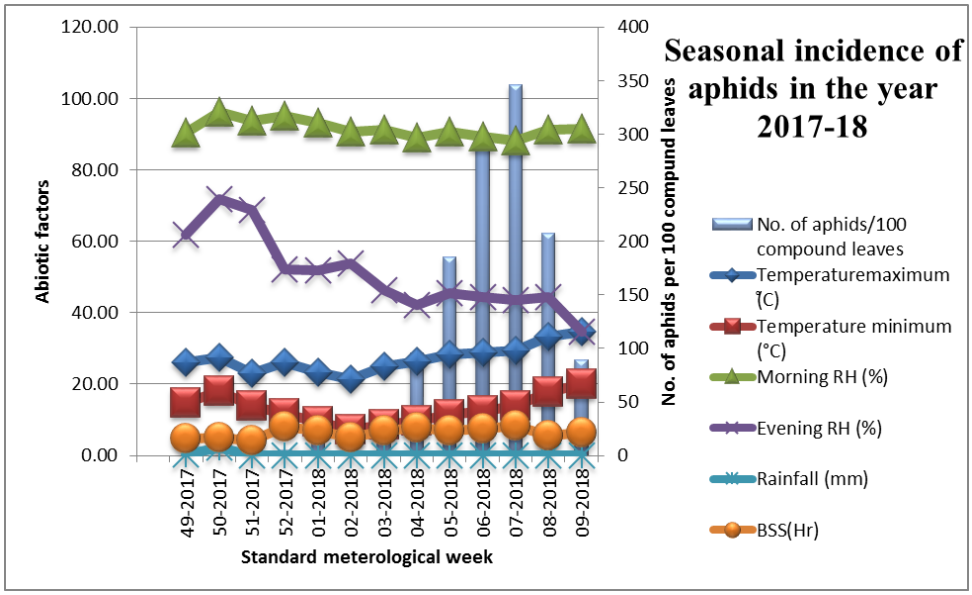

Fig 2: Influence of various abiotic factors on the population dynamics of aphids in the year 2017-18.

3.2 Correlation study of different abiotic factors with aphid population

During the first year (2016-17) data pertaining to the correlation study between number

Table 3: Correlation between aphids and weather parameters in the year 2016-17

Environmental factors		Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Temperature (°C)	Maximum	0.554*	$R^2 = 0.6133$	y = 0.5545x + 23.325
	Minimum	0.342	$R^2 = 0.2027$	y = 0.3077x + 10.745
	Average	0.469	$R^2 = 0.4238$	y = 0.4311x + 17.035
Relative Humidity (%)	Morning	(-)0.636*	$R^2 = 0.5508$	y = -0.4215x + 95.197
	Evening	(-)0.583*	$R^2 = 0.4985$	y = -1.3563x + 61.917
	Average	(-)0.609*	$R^2 = 0.5343$	y = -0.8889x + 78.557
Bright sun shine(hr.)	Duration	0.218	$R^2 = 0.0673$	y = 0.1121x + 5.489

*Significant at 5% level of significance.

of aphid population and different weather factors revealed that there was a significant positive correlation with maximum temperature (r = 0.554, $p \leq 0.05$) and significant negative correlation with the morning (r = -0.636, $p \leq 0.05$), evening (r = -0.583, $p \leq 0.05$) and average (r = -0.609, $p \leq 0.05$) relative humidity (Table 3). Among the different abiotic stresses, it can be said that, maximum temperature was the most influential factor for the fluctuation of the aphid population with a highest value of regression co-efficient ($R^2 = 0.6133$) followed by morning, average and evening relative humidity with a regression coefficient value of 0.5508, 0.5343 and 0.4985 respectively though these three factors were negatively correlated with aphid population which means any changes of these factors inversely affect the aphid population.

Table 4: Correlation between aphids and weather parameters in the year 2017-18

Environmental factors		Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Temperature (°C)	Maximum	0.561*	$R^2 = 0.5244$	y = 0.7186x + 21.437
	Minimum	0.172	$R^2 = 0.0452$	y = 0.2113x + 11.283
	Average	0.390	$R^2 = 0.2479$	y = 0.465x + 16.360
Relative Humidity (%)	Morning	(-) 0.664*	$R^2 = 0.5508$	y = -0.3574x + 94.464
	Evening	(-) 0.625*	$R^2 = 0.7844$	y = -2.4792x + 70.718
	Average	(-) 0.577	$R^2 = 0.7738$	y = -1.4183x + 82.591
Bright sunshine(hr.)	Duration	0.532	$R^2 = 0.2295$	y = 0.1714x + 5.0599

*Significant at 5% level of significance.

During second year (2017-18) significant positive correlation was found between aphid number and maximum temperature (r = 0.561, $p \leq 0.05$) which implies increase in maximum temperature leads to increase in aphid population (Table 4). There was a significant negative correlation between aphid population and morning (r = -0.664, $p \leq 0.05$) and evening (r = -0.625, $p \leq 0.05$) relative humidity which indicates that increase in morning and evening relative humidity leads to decrease in aphid population and vice-versa. Among all the abiotic stresses, which influenced the aphid population, evening relative humidity was the most influential factor for population buildup of this pest with a highest value of coefficient of determination ($R^2 = 0.7844$, $p \leq 0.05$) (Table 4).
These findings are in agreement with [7] who found that the maximum temperature varied between 21.1 °C and 30.3 °C, the minimum temperature ranged from 10.0 °C to 16.6 °C, the maximum relative humidity varied from 73 to 100% and minimum relative humidity ranged from 35 to 56% during the crop growth period. The result of the present study might be well supported by the earlier works done by [14, 18] who found the similar results with aphids on chilly crop in west Bengal.

3.3 Abundance of predatory fauna

3.3.1 Lady bird beetle

The lady bird beetles ranged from 0.40 to 5.60 grubs and adults per square meter with seasonal mean 2.68 per square meter in first year (Table 5) and in the second year population of the beetle varied from 0.40 to 3.80 per square meter with a seasonal mean of 1.68 per square meter (Table 6). Five species of lady bird beetle, *Menochilus. sexmaculata*, *Coccinella transversalis Coccinella septempunctata*, *Micraspis discolor* and *Propylea dissecta* were recorded as the major bio agents of the sucking pests. In both the year, they first appeared on the crop in the 4th week of December with 0.40 grubs and adults per square meter. They were observed feeding on nymphs and adults of aphid. Their activity continued till the last week of February with peak activity in 2nd week of February with 5.60 and 3.80 grubs and adults per square meter respectively.

3.3.2 Staphylinid beetle

From the first year study it was revealed that the staphylinid beetle ranged from 1.20 to 4.00 adults per square meter with seasonal mean 2.03 per square meter (Table 5) and in the second season the population of the beetle ranged from 0.80 to 4.40 per square meter with a seasonal mean of 2.22 (Table 6). In the year 2016-17 they first appeared on the crop in the 4th week of December with 1.20 per square meter and in the year 2017-18 they first appeared on 3rd week of December with 1.00 adults per square meter. They were observed feeding on nymphs and adults of aphid, leaf hopper, thrips and whiteflies. Their activity continued till the last week of February and peak activity was observed in 1st and 2nd week of February with 4.00 and 4.40 adult per square meter in season I and Season II respectively.

3.3.3 Spiders

Besides the lady bird beetle and styphylinid beetle, two predatory spiders, namely, lynx spider and orb weaver spider were found preying upon sucking pests. *Oxyopes* sp. is a hunting spider, whereas, *Neoscona* sp. is a web building spider [10]. The spiders first appeared on the crop in the 4th week of December in season I (2016-17) with mean population of 1.60 spiders per square meter (Table 5) and in season II it was first appeared in the 3rd week of December with a mean of 1.80 spiders per square meter (Table 6). They

were active throughout the growth period of the crop with peak of 3.20 and 3.60 spiders per square meter during 2nd week of February in both the season. In 2016-17 their population ranged from 0.80 to 3.20 per square meter and in 2017-18 it was 0.40 to 3.60 per square meter.

The present findings are in agreement with [16] who reported that the lady bird beetles (Coccinellidae: Coleoptera), green lacewing *Chrysoperla carnea* (Stephens) Neuroptera: Chrysopidae), spider *Tibellus oblongus* (Walckenaer) (Araneae: Philodromidae) and syrphid fly *Syrphus balteaus* De Geer (Diptera: Syrphidae) as predators associated with aphid colonies and the abundance of all these natural enemies was minimum in November and December and maximum during the months of January and February.

Table 5: Seasonal occurrence of aphids and major predatory fauna observed in the potato agro ecosystem during *rabi* 2016-17.

SMW	No. of aphids per 100 compound leaves	Population of predators per square meter		
		Coccinellids	Staphylinid	Spiders
49-2016	0	0.00	0.00	0.0
50-2016	0	0.00	0.00	0.0
51-2016	0	0.00	0.00	0.00
52-2016	0	0.40	1.20	0.80
01-2017	0	0.20	1.60	1.20
02-2017	1	0.40	2.00	1.80
03-2017	16	1.40	3.20	2.20
04-2017	97	3.60	3.60	2.40
05-2017	244	4.80	4.00	2.80
06-2017	408	5.60	3.20	3.20
07-2017	306	5.20	2.80	2.80
08-2017	184	3.60	2.40	2.00
09-2017	80	3.20	2.00	1.60
Seasonal mean	102.76	2.18	2.00	1.6

Table 6: Seasonal occurrence of aphids and major predatory fauna observed in the potato agro ecosystem during *rabi* 2017-18.

SMW	No. of aphids per 100 compound leaves	Population of predators per square meter		
		Coccinellids	Staphylinid	Spiders
49-2017	0	0.00	0.00	0.00
50-2017	0	0.00	0.00	0.00
51-2017	0	0.40	1.00	0.40
52-2017	5	0.60	0.80	0.40
01-2018	14	1.20	1.20	1.00
02-2018	16	0.80	1.60	1.80
03-2018	20	1.80	3.20	2.20
04-2018	96	1.80	3.60	2.60
05-2018	185	2.60	4.00	3.40
06-2018	292	3.80	4.40	3.60
07-2018	346	3.80	4.00	3.20
08-2018	208	2.80	2.80	2.20
09-2018	89	2.20	2.20	2.20
Seasonal mean	97.77	1.68	2.22	1.80

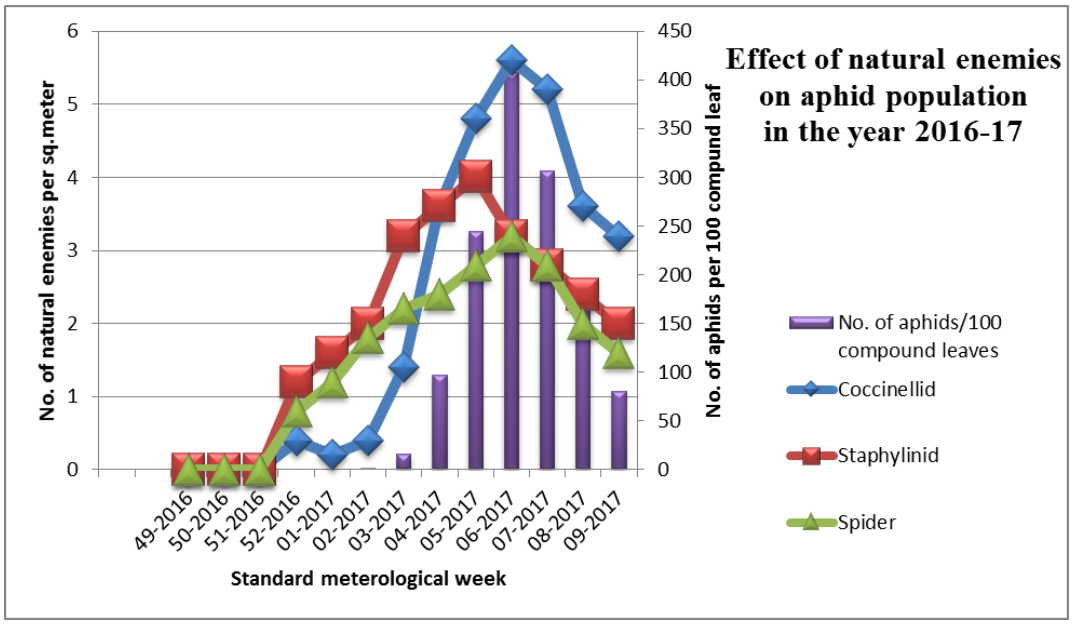

Fig 3: Effect of natural enemy on aphid population 2016-17

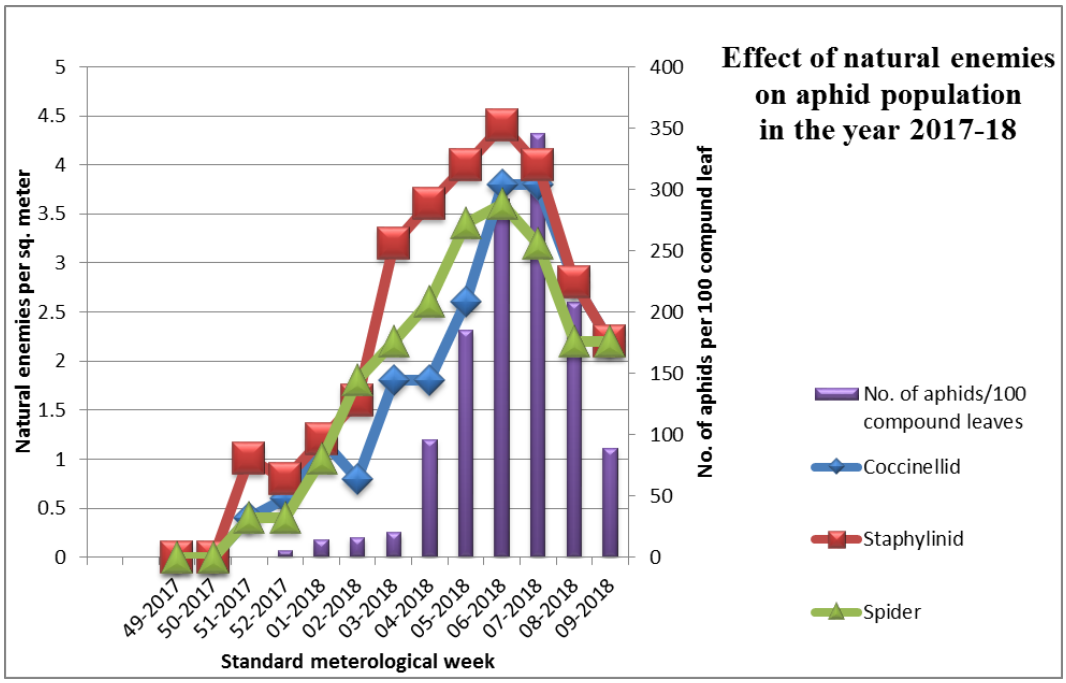

Fig 4: Effect of natural enemy on aphid population 2017-18.

3.4 Correlation study of different abiotic factors with aphid population

Data revealed that there was significant positive correlation between coccinellid beetle, staphylinid beetle and spiders with that of aphid population at 1% and 5% level of significance (Table 7 and 8).

Table 7: Correlation between biotic factors and aphids in the year 2016-17.

Biotic factors	Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Coccinellids	0.936*	$R^2 = 0.7744$	y = 0.2978x - 1.0033
Staphylinid	0.744**	$R^2 = 0.6269$	y = 0.3165x - 0.633
Spiders	0.817**	$R^2 = 0.7067$	y = 0.278x - 0.733

*Significant at 5% level of significance.** Significant at 1% level of significance.

Among the different predators coccinellid beetle was the most influential factor with highest value of coefficient of determination during 2016-17 and 2017-18 (R^2 = 0.7744, $p \leq 0.05$ and R^2 = 0.7021, $p \leq 0.01$ respectively) (Table 7 and 8).

Table 8: Correlation between biotic factors and aphids in the year 2017-18

Biotic factors	Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Coccinellids	0.933**	$R^2 = 0.7021$	y = 0.4725x - 2.0681
Staphylinid	0.636*	$R^2 = 0.5403$	y = 0.2615x - 0.3538
Spiders	0.786**	$R^2 = 0.6349$	y = 0.2297x - 0.467

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

Therefore, the present observation might be corroborated with earlier findings [12] who reported that ladybird beetles are attracted to and feed heavily on aphids (*M. persicae*).

4. Conclusion

From the study it can be concluded that the peak population of aphid was observed in the second and third week of Frebruary during first and second season respectively though the initiation of the population was observed little bit earlier in second season than first season. Among the different weather parameters maximum temperature had a significant positive correlation whereas relative humidity (max., min. and average) had a significant negative correlation with that of aphid population in the first year. Coccinellid predators were highly positively correlated with aphid population in both the year.

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