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Seasonal incidence of major insect pests of cabbage, *Brassica oleracea* var. *capitata* L

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Abstract
The cabbage crop was abundantly infested by major insect pests that were aphids, painted bug, flea beetle and diamond back moth during both years; whereas, tobacco caterpillar recorded as pests during the crop season in 2016-17. Infestation by aphids and DBM (*rabi*, 2016-17) initiated in December and that of painted bug, flea beetles and tobacco caterpillar initiated in the month of January. The major insect pests reached their peak mean populations during February to March. During *rabi*, 2015-16, the mean atmospheric temperature had a significant positive correlation (r = 0.63, 0.63, 0.85) with painted bug, flea beetle and diamond back moth, respectively. The sunshine hours had a significant positive correlation (r = 0.62, 0.78) with painted bug during 2015-16 and 2016-17, respectively. Whereas, relative humidity had a significant negative correlation (r = -0.62) with flea beetle during 2015-16.

Keywords: Cabbage, seasonal incidence, insect pests, correlation

1. Introduction
Cruciferous vegetables have an important place among *rabi* crops grown in India. Cabbage [*Brassica oleracea* var. *capitata* (Linn.): Cruciferae] is one among the abundantly consumed vegetables all over the world. It is cultivated extensively in the tropical and temperate regions of the world including India and has appreciable nutritional and economic value. Cabbage is used as boiled vegetable, in salad, curries and pickles. The total area under cabbage cultivation in India was 399 thousand hectares with an annual production of 9049 thousand tonnes [1]. Insect pests are a serious menace in the profitable cultivation of cabbage; the more important being: tobacco caterpillar, *Spodoptera litura* (Fab.); diamond back moth, *Plutella xylostella* L.; cabbage semilooper, *Trichoplusia ni* (Hubner); painted bug, *Bagrada hilaris* (Burmeister); cabbage butterfly, *Pieris brassicae* L.; flea beetles, *Phyllotreta cruciferae* Goeze; aphids, *Lipaphis erysimi* (Kalt.); and the mustard saw fly, *Athalia lugens proxima* (Klug.) [2, 3]. These pests can cause damage to an extent of 80-100 per cent in the nurseries under favourable conditions [4] and 10-25 per cent to the field crop [5]. The seasonal incidence of any insect pest varies from region to region due to variation in cropping season and climatic conditions. Hence, it was considered imperative to find out the impact of environmental factors on incidence of these important insect pests of cabbage, in order to find out the seasonal pattern of their incidence for a better monitoring and management of these pests.

2. Materials and Methods
The field experiment on "Seasonal incidence of major insect pests of cabbage, *Brassica oleracea* var. *capitata* L." was conducted at the Instructional Farm, Department of Entomology, Rajasthan College of Agriculture, (MPUAT), Udaipur, Rajasthan, during *rabi*, 2015-16 and 2016-17. The details of materials used and methodology adopted during the course of investigation for conducting the experiments are discussed here.

2.1 Site and location of the experiments: The investigations were carried out at the Instructional Farm of Rajasthan College of Agriculture, MPUAT, Udaipur for two successive crop seasons, *rabi* 2015-16 and 2016-17. Geographically, Udaipur is located at 23.4°N Longitude and 75°E Latitude at an elevation of 579.5 MSL in the state of Rajasthan.

2.2 Layout of Experiment: The experiment was laid out in four plots of 4.5 x 4.5 m^2 sizes during *Rabi*, 2015-16 & 2016-17. These plots were contiguous to each. Five weeks old seedlings of cabbage variety golden acre were transplanted at row to row and plant to plant

distance of 45 x 45 cm, respectively. The transplanting was done in the evening hours followed by light irrigation. Other all horticultural operations were followed during the experimental period.

2.3 Observations: Observations on the abundance of major insect pests of cabbage were observed from very beginning of their appearance on plants till harvesting of the crop.

2.3.1 Major insect pests: Populations of the major insect pests were recorded at weekly intervals during morning hours, from five randomly selected and tagged plants in each plot.The population of aphids (both nymphs as well as adults; alate and apterous) was recorded by visual counting method using a magnifying lens on each leaves of each tagged plant; the population of diamondback moth (DBM), flea beetles and painted bugs were recorded by visually counting the number of larvae and adults on the whole tagged plants, respectively [6] on each tagged plant.

2.3.2 Meteorological data: Weekly meteorological data on temperature (^{O}C), relative humidity (%) and sunshine (hrs/day) were obtained from the meteorological unit of the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan.

2.4 Statistical analysis

Population data of major insect pests of cabbage thus obtained were subjected to statistical analysis to find out the coefficient of correlation with mean temperature, relative humidity and sunshine hours. A simple correlation was worked out between the populations of major insect pests (aphids, painted bugs, flea beetles diamond back moth & tobacco caterpillar) with abiotic evironmental factor using the following formula [7].

$$r_{xy} = \frac{\sum XY - \frac{\sum X \sum Y}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n}\right]}}$$

Where,

r_{xy} = Simple correlation coefficient.

x = Independent variable (the key abiotic factors)

y = Dependent variable (the pest population)

N = Number of observations recorded

The correlation coefficient (r) values were subjected to the test of significance (t-test) and the calculated t-values obtained were compared with t- table value at 5% level of significance.

$$t = \frac{r}{\sqrt{1 - r^2}} \times \sqrt{n - 2}$$

3. Results and Discussions

During the present study, the crop was found to be abundantly infested withthe major insect pests infesting cabbage comprised aphids, painted bugs, flea beetles and diamond back moth during both years; whereas, tobacco caterpillar was recorded as a pest during the crop season in 2016-17. This insect pest has also been reported as serious insect pest of cabbage crop by some entomologists [11, 15, 16, 26] who also support the present findings.

3.1 Aphids: The seasonal incidence of the aphids infesting cabbage has been presented in Table (1). During the crop season (Rabi 2015-16), The infestation of aphids initiated in the last week of December 2015 and then gradually increased, reaching a peak mean population of 169.55 aphids/plant during the early in the second week of February, 2016 during which the mean temperature, mean relative humidity and sunshine were 21.21 ^{o}C, 42.65 per cent and 7.59 hrs respectively. Similarly, during the second season of the experiment, rabi 2016-17 (Table-2), the incidence of aphids began from the second week of December, reaching its peak population of 352.05 aphids/ plant in the late first week of February 2017. At the time of peak incidence of the pest, the mean temperature, mean relative humidity and sunshine were 17.77 ^{o}C, 67.64 per cent and 7.43 hrs respectively. Quite similarly from the year 2000 onwards, reported that the correlation between aphid population and maximum and minimum temperatures were negative, but with morning relative humidity it was positive [8]. The incidence of three species of aphids in the cauliflower fields starting from the second week of November [9]. Aphid commenced its activity from mid-December and lingered on the crop till harvest during March end, similar to the present findings [10]. The maximum and minimum temperatures showed significant negative correlation with aphid population [11]. Similarly data on cauliflower and cabbage in different locations, recorded the peak population of aphids in the month of March [12]. With regards to weather parameters [13] and negative correlation with relative humidity [12].

3.2 Painted bug: The data on the incidence of painted bug population are depicted in Table (1) indicating that the population started from the first week of January, 2016 that gradually increased and touched to its peak (2.20/plant) in the last week of February, 2016 during which the mean temperature, mean relative humidity and sunshine were 22.89 ^{o}C, 48.14 per cent and 8.51 hrs respectively. The painted bug painted bug population showed significant positive correlation (r = 0.63) with mean atmospheric temperature. Similarly, during the second season of the experiment, rabi 2016-17. The data depicted in Table (2), which reveal that the population started from the fourth week of January, 2017 touched to its peak (12.35/ plant) in the second week of February, 2017 during which the mean temperature, mean relative humidity and sunshine were 18.31 ^{o}C, 61.64 per cent and 8.11 hrs respectively. The painted bug painted bug population showed non significant positive correlation (r = 0.76) with mean atmospheric temperature. The peak infestation of painted bugs from the last week of February to mid March, [14] similar to our findings. Similarly, observed the peak activity of this pest in 1 week of March [15]. Similar to the present findings, reported a significant positive correlation between the incidence of painted bug and atmospheric temperature and negative correlation between the incidence of painted bug and relative humidity [15, 16].

3.3 Flea beetle: During the *rabi* 2015-16 flea beetle infestation began on first week of January with significant numbers that are presented in Table (1) that gradually increased and reached to its peaked (28.65/plant) in the third week of February, 2016 during which the mean temperature,

mean relative humidity and sunshine were 21.58 ºC, 42.65 per cent and 7.59 hrs respectively. Flea beetle population had significant positive correlation with mean atmospheric temperature (r=0.63) and sunshine (r=0.62); while, mean relative humidity showed significant negative correlation (r= -0.62). During second season *rabi* 2016-17 data are presented in Table (2), flea beetle infestation started early in the third week of January, 2017 that gradually increased and reached a peak 22.15 in the late last week of February 2017 during which the mean temperature, mean relative humidity and sunshine were 21.22 ºC, 57.93 per cent and 8.03 hrs respectively. The flea beetle population showed significant positive correlation with sunshine (r = 0.78). Our observations on flea beetle indicate a little delayed incidence on cabbage as compared to some of the earlier reports, while other reports are similar to our findings. The incidence of insect pests on cauliflower cultivars in *Terai* regions; maximum population of flea beetles, *Phyllotreta cruciferae* (0.78 beetles/ plant) were found during the last week and 3rd week of December [17]. The beetle population showed a close positive correlation with mean day temperature [18]. Population of flea beetle reached its maximum during last week of March in cabbage crop, similar to our observations [19]. Flea beetle appeared in mid-September and reached its peak in first and second week of October [20].

3.4 Diamond back moth (DBM): During the crop season 2015-16, the DBM population appeared in different numbers as depicted in Table (1). The population started from the third week of January, 2016 that gradually increased and reaching the peak (9.30/ plant) in third week of March, 2016 during which the mean temperature, mean relative humidity and sunshine were 24.89 ºC, 34.79 per cent and 8.37 hrs respectively. The mean atmospheric temperature had a significant positive correlation (r= 0.85) with insect population. During the second crop season 2016-17, the diamond back moth infestation was noted and are depicted in Table (2). The diamond back moth infestation appeared late in third week of December, 2016. The population gradually increased and touched to the peak in the second week of February, 2017 with a mean of 10.55 diamond back moth larvae per plant during which the mean temperature, mean relative humidity and sunshine were 18.31 ºC, 61.64 per cent and 8.11 hrs respectively. The mean atmospheric temperature had a positive correlation with diamond back moth larvae population. Similarly, reported that *P. xylostella* began infesting cabbage initially in the last week of November (1.00 larva/plant) and attained its peak (8.06 larvae/plant) in the fourth week of January [21]. Diamond back moth appeared on cabbage in mid-September and peaked in the third and fourth weeks of October and its population was positively correlated with temperature as well as rainfall and negatively with relative humidity [20]. The population of *P. xylostella* abruptly increased from February and peaked in April; Further, they reported that temperature was the key abiotic factor regulating the field population of *P. xylostella*; warm conditions favoured its multiplication, while cold conditions during November-February limited it [22]. The population of diamond back moth started from third week of November and reached peak in first week of January [11]. Diamond back moth first appeared at the end of January, increased gradually and reached to its peak by the end of March [23]. Cabbage to be infested by diamond back moth (*P. xylostella* L) from the third week of November that reached a peak (45.2 larvae /10 plants) in the first week of January; the maximum and minimum temperature showed significant negative correlation with larval population of diamondback moth [24].

3.5 Tobacco caterpillar: tobacco caterpillar recorded as a pest only during the crop season in 2016-17. The tobacco caterpillar population incidence has been presented in Table (2). During the crop season, tobacco caterpillar infestation began from the first week of January, 2017. The population gradually increased and reached to a peak (4.25 caterpillar/ five plants) population was observed in the last week of February, 2017 during which the mean temperature, mean relative humidity and sunshine were 24.89 ºC, 34.79 per cent and 8.37 hrs respectively. Similarly, the first appearance of *S. litura* on cabbage in 6th meteorological week that peaked in 11th (94 larvae / meter-row) and 13th (75 larvae / meter-row) meteorological weeks during 2002 and 2003, respectively [25]. Infestation of *S. litura* during the last week of January in late season cabbage crop; thereafter, it gradually reached to its maximum level (4.20 larvae per plant). *S. litura* population was positively correlated with relative humidity [26].

Table 1: Seasonal incidence of major insect pests of cabbage during *rabi*, 2015-16

Dates of observation	Mean Atm. Temp. (^{0}C)	Mean Relative Humidity (%)	Sunshine (Hrs/Day)	Mean of no. of insects per plant			
				Aphids	Painted bugs	Flea beetles	Diamond back moth
24/12/2015	19.21	54.79	7.17	12.25	0.00	0.00	0.00
01/01/2016	17.77	54.15	7.49	14.30	0.25	1.00	0.00
08/01/2016	15.87	59.07	4.86	54.15	0.30	0.30	0.00
15/01/2016	15.95	51.14	8.91	105.45	0.95	8.80	1.30
22/01/2016	18.83	49.86	8.24	85.25	1.35	11.45	2.00
29/01/2016	16.95	48.79	9.07	68.95	1.00	16.90	2.65
05/02/2016	19.08	47.72	8.19	88.70	1.10	16.35	3.45
12/02/2016	21.21	42.65	7.59	169.55	1.05	12.55	2.15
19/02/2016	21.58	44.25	8.93	164.25	1.25	28.65	6.45
26/02/2016	22.89	48.14	8.51	66.10	2.20	20.60	6.05
04/03/2016	23.02	51.07	6.71	31.55	1.65	16.40	5.00
11/03/2016	24.89	34.79	8.37	12.80	1.05	16.65	9.30
Seasonal Mean				72.78	1.01	12.47	4.26
Coefficient of correlation (r) for population and mean temp.				-0.04	0.63*	0.63*	0.85*
Coefficient of correlation (r) for population and mean RH				-0.28	-0.35	-0.62*	-0.68
Coefficient of correlation (r) for population and Sunshine				0.34	0.41	0.62*	-0.02

* Significant at 0.05% level of significance

Table 2: Seasonal incidence of major insect pests of cabbage during *rabi*, 2016-17

Dates of observation	Mean Atm. Temp. (^{0}C)	Mean Relative Humidity (%)	Sunshine (Hrs/Day)	Mean of number of insects per plant				
				Aphids	Painted bugs	Flea beetles	Diamond back moth	Tobacco caterpillar
13/12/2016	19.28	56.64	8.59	24.35	0.00	0.00	0.00	0.00
20/12/2016	19.37	58.43	8.90	8.30	0.00	0.00	1.00	0.00
27/12/2016	18.37	61.43	8.61	16.65	0.00	0.00	2.55	0.00
03/01/2017	18.64	55.50	8.79	30.40	0.00	0.00	5.05	0.75
10/01/2017	18.64	57.43	8.36	69.05	0.00	0.00	2.80	1.25
17/01/2017	16.88	69.07	6.31	41.75	0.00	1.00	3.80	2.50
24/01/2017	12.55	60.14	6.87	74.85	1.35	1.80	9.45	3.75
31/01/2017	15.58	64.43	4.89	133.85	5.85	3.65	6.80	4.00
07/02/2017	17.77	67.64	7.43	352.05	6.30	8.00	10.35	3.25
14/02/2017	18.31	61.64	8.11	331.40	12.35	14.35	10.55	2.75
21/02/2017	15.73	57.71	9.07	204.80	10.90	18.30	9.75	3.00
28/02/2017	21.22	57.93	8.03	129.15	11.40	22.15	10.15	4.25
Seasonal Mean				118.05	8.03	9.89	6.02	2.83
Coefficient of correlation (r) for population and mean temp.				-0.09	0.76	0.67	-0.25	-0.24
Coefficient of correlation (r) for population and mean RH				0.37	-0.37	-0.70	0.10	0.34
Coefficient of correlation (r) for population and Sunshine				-0.12	0.62	0.78*	-0.16	-0.50

* Significant at 0.05% level of significance

4. Conclusion

Seasonal incidence of major insect pests of cabbage was studied that will be helpful in preparing proper schedule for effective management of major insect pests of this crop. During the present study, the crop was found to be abundantly infested with aphids, painted bugs, flea beetles and diamond back moth throughout the growing season of both years; Whereas, tobacco caterpillar was recorded as a pest during the crop season in 2016-17. Infestation by aphids and DBM (*rabi*, 2016-17) initiated in December and that of painted bug, flea beetles and tobacco caterpillar initiated in the month of January. The major insect pests reached their peak mean populations during February to March.

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