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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 767-771

www.thepharmajournal.com
Received: 10-04-2022
Accepted: 16-06-2022

Lavlesh Kumar
Department of Entomology, CSA University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Dharm Raj Singh
Department of Entomology, CSA University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Ram Singh Umrao
Department of Entomology, CSA University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Corresponding Author:
Lavlesh Kumar
Department of Entomology, CSA University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Population dynamics of diamondback moth, *Plutella xylostella* L. on cabbage (*Brassica oleracea* var. *capitata* L.) in relation to abiotic and biotic factors under field condition

Lavlesh Kumar, Dharm Raj Singh and Ram Singh Umrao

Abstract
Studies on the population dynamics of diamondback moth (*Plutella xylostella* L.) on cabbage were carried out during *rabi* season in 2019-20 and 2020-21 at Student's Instructional Farm (SIF) of the Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur Uttar Pradesh, India on cabbage variety *Savitri.* The *P. xylostella* was active throughout the year with a varying degree of infestation. The initial incidence of the pest was observed (0.92 & 0.52 larvae/ plant) on 3rd and 2nd and reached peak (4.52 & 4.48 larvae/ plant) on 9th SMW during 2019-20 and 2020-21 respectively. The studies indicated positive significant correlation between larval population of *Plutella xylostella* L. and maximum temperature (r = 0.520), minimum temperature (r = 0.513), sunshine hours (r = 0.659) and wind velocity (r = 0.473) but the negative non significant correlation between larval population and relative humidity morning (r = -0.133), relative humidity evening (r = -0.367) and rainfall (r = -0.090) whereas, the correlation between larval population of diamondback moth and adult population of *Coccinella septempunctata* L. was recorded highly positive significant (r = 0.967). The Coccinellid beetles was recorded as an important predator of cabbage ecosystem, which was maximum (4.36 adults/ plant) on 9th SMW during 2019-20 and 2020-21 respectively.

Keywords: Cabbage, *P. xylostella,* population, significant, *C. septempunctata*

Introduction
Cabbage, *Brassica oleracea* var. *capitata* L. is one of the most important cultivated vegetable grown in India, which belongs to the family cruciferae. In India, it is grown extensively in tropical and temperate regions and believed to have originated from Western Europe and Mediterranean region (Khan *et al*., 2017) [7]. India is the second largest producer of cabbage in the world after china, accounting for 16.55 per cent of the world area and 12.79 per cent of the world production. In India, the crop is cultivated in almost all the states occupying an area of about 0.40 million hectares with the total production of about 9.59 million tonnes and average productivity of 22.68 tonnes/hectares. In Uttar Pradesh, the area under cultivation of cabbage is about 9.06 thousand hectares with the production of about 302.97 thousand tonnes and average productivity of 33.44 tonnes/hectares. (Anonymous, 2019-20) [2]. The major constraint in the production of cabbage is pest complex right from germination to harvest. The cabbage crop has a multiple insect pest complex, among them the important insect pest species are diamondback moth (DBM), *Plutella xylostella* Linnaeus; head borer, *Hellula undalis* Fabricius; mustard sawfly, *Athalia lugens proxima* Klug; leaf webber, *Crocidolomia binotalis* Zeller; cabbage aphid, *Brevicoryne brassicae* Linnaeus; cabbage butterfly, *Pieris brassicae* Linnaeus and cabbage semilooper, *Trichoplusia ni* Hubner etc. In India diamondback moth was first recorded in 1914 on crucifer vegetables (Fletcher, 1914) [5] and is now the most devastating pest of cole crops in the states of Punjab, Haryana, Himachal Pradesh, Delhi NCR, Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra and Karnataka. Diamondback moth (DBM), has gained the status of most destructive insect-pest of cruciferous crops throughout the world (Singh *et al*., 2005) [12].

The per cent yield loss in cabbage due to insect pests ranged from 19.24 to 30.30 per cent with an average of 25.80 per cent (Jat *et al*., 2017) [6]. Out of these, diamondback moth, *Plutella xylostella* L. is the most destructive and cosmopolitan pest (Mahla *et al*., 2005) [9]. In India, diamond back moth has national importance on cabbage as it causes 50-80% annual loss in the marketable yield (Devjani and Singh, 1999) [4]. In India, Krishnamoorthy, 2004 [8] also both the

reported 52% yield loss on cabbage due to the attack of diamondback moth. Excessive use of chemicals to control this pest not only causes the economical restrain on farmers but also produces the harmful side effects on the environment as well as human being. The best way to overcome this situation is to destroy the pest at its initial stage of the life cycle. This is possible if timely prediction of the occurrence of the pest can be made. Hence, an investigation on seasonal incidence of the *P. xylostella* on cabbage in relation with different meteorological parameters was carried out.

Materials and Methods

The field experiments were conducted during *rabi* 2019-20 and 2020-21, at Student's Instructional Farm (SIF) of the Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur Uttar Pradesh. The climate of Kanpur city is sub-tropical with hot dry summer and severe cold in winter. Meteorological observations on temperature, relative humidity (RH), rainfall, sunshine hour and wind velocity were recorded at a weekly interval from the meteorological observatory of the C. S. Azad University of Agriculture and Technology, Kanpur Uttar Pradesh. The cabbage variety *Savitri* was planting in five plots with a plot size 4.5 x 2.25 m and spacing 45 x 45 cm during the 25th November 2019 and 23th November 2020 for both the years. For present experiment 30-35 days old seedlings of cabbage were transplanted in the field and all the recommended agronomical practices were followed to raise the crop. Single seedling was transplanted at a single spot and a light irrigation was provided after planting of the seedlings. To estimate the larval population of diamondback moth, *Plutella xylostella* L. and adult population of *Coccinella septempunctata* L. on cabbage by direct visual counting method was used (Meena, *et al.*, 2012) [10]. The observations were recorded at weekly interval throughout the crop growth on five randomly selected plants from each plot. The correlation between larval population of diamondback moth in relation to abiotic and biotic factors *i.e.*, average maximum and minimum temperature (^{0}C), relative humidity (%) rainfall (mm), sunshine (hr/day), wind velocity (km/hr) and the adult population of *Coccinella septempunctata* L. were worked out by using following formula-

$$r_{xy} = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\left[\sum x^2 - \frac{(\sum x)^2}{n}\right]\left[\sum y^2 - \frac{(\sum y)^2}{n}\right]}$$

Where,

r_{xy} = Simple correlation coefficient

x = Variable i.e. abiotic component.

(Average temperature and relative humidity)

y = Variable i.e. mean number of insect-pests

n = Number of observation

Results and Discussion

The data on the population dynamics of diamondback moth (*Plutella xylostella* L.) on cabbage (Table 1) revealed that during 2019-20. The population of *P. xylostella* was first appeared on 3rd SMW (0.92 larvae/ plant), at that particular time the average maximum and minimum temperature prevailed during the initial infestation were 17.30 ºC and 10.90 ºC, respectively, and average morning and evening relative humidity was 96.00 and 81.00 per cent, respectively. The wind speed prevailing during this week was 4.00 km/h. The sun shine was 1.00 hrs/ day during this period. The head infestation reached to peak (4.52 larvae/ plant) on 9th SMW during 2019-20, the average maximum and minimum temperature prevailing during this period were 27.00 ºC and 15.00 ºC, respectively. Morning and evening relative humidity was 87.80 and 53.00, per cent, respectively. The results indicated that (Table 3) the significant positive relationship of larval population of *Plutella xylostella* L. with maximum (r = 0.520) and minimum temperature (r = 0.513). It means maximum and minimum temperature have no any adverse effects on the population of DBM larvae because both temperature increased the population. The negative non significant relationship between relative humidity morning (r = -0.133), relative humidity evening (r = -0.367) and rainfall (r = -0.090) with larval population. The correlation between larval population and wind velocity was recorded significant positive (r = 0.473). The correlation between larval population and sun shine hours was recorded significant positive (r = 0.659) where as the correlation between larval population of diamondback moth and adult population of *Coccinella septempunctata* L. was recorded highly positive significant (r = 0.967). It means when larval population of diamondback moth increases the adult population of ladybird beetle (*Coccinella septempunctata* L.) also increased. The results of present investigation similar to the results of Bhagat *et al.* (2018) [3] who evaluate the seasonal incidence of diamondback moth in cabbage crop and impact of weather parameters on its population dynamics. Infestation of diamondback moth started from the end of December in 2015-2016 (0.075/ 20 plants) and first week of January in 2016-2017 (0.125/ 20 plants) and reached peak in the month of March in both years (6.85/ 20 plants and 5.25/ 20 plants). Correlation study revealed that the maximum temperature had non significant negative correlation (r = -0.005) with larval population but had positive correlation (r = 0.19) in year 2016-17. Minimum temperature had a positive correlation in both years (r = 0.24 and r = 0.21, respectively). Though, the relative humidity had negative and positive relation with the larval population of diamondback moth in both years (r = -0.26 and r = 0.11 respectively). Sunshine hours had negative but non-significant (r = -0.31) effect in 2015-16 while positive relation (r = 0.38) was observed in 2016-2017. However rainfall had positive non significant relation (r = -0.05 and r = -0.08 respectively), in both years. Rajput *et al.* (2021) [11] also found that the cabbage crop was found to be infested by diamondback moth *P. xylostella* first appeared on the crop in the first week of December. Maximum number of larvae was observed during first week of February and thereafter, the population started declining.

More or less similar results on larval population of *Plutella xylostella* were also recorded (Table 2) during 2020-21 as compared to previous year i.e. 2019-20. The initial incidence of the pest was observed in 2nd SMW with a mean head infestation of 0.52 larvae/ plants. The head damage reached to peak by 9th SMW with mean larval population of 4.48 per plant. The average maximum and minimum temperature prevailing during this period were 28.80 ºC and 11.90 ºC, respectively, in the 9th SMW. The average maximum and minimum relative humidity was 80.00 and 34.00, per cent,

respectively. The results indicated that (Table 3) the correlation between larval population and the maximum temperature (r = 0.103), minimum temperature (r = 0.031), rain fall (r = 0.281), sunshine hours (r= 0.367) and rain fall (r = 0.303) was observed positively non significant. The correlation between larval population and the relative humidity morning (r = -0.052) and relative humidity evening (r = -0.063) was recorded negatively non significant. It means when the relative humidity morning and relative humidity evening increases the larval population also decreases and vice versa, whereas the correlation between larval population and adult population of ladybird beetles (*Coccinella septempunctata* L.) was recorded highly positive significant (r= 0.974). The results of present investigation supported by the results of Ahmad *et al.* (2018) [1] also found that the mean maximum and minimum temperature showed non-significant negative and positive association (r = -0.32 and 0.07) with population of *P. xylostella* respectively. Similarly relative humidity (r = 0.89) exhibited positive highly significant whereas rainfall (r = -0.96) showed negative highly significant relationship with *P. xylostella* during the year 2012. Likewise, during the year 2013, mean maximum temperature showed non-significant negative relation (r = -0.21) whereas mean minimum temperature showed positive non-significant association with *P. xylostella* population. Mean relative humidity (RH) also exhibited non-significant positive association (r = 0.06), while the population effectively influenced by total rainfall (r = -0.82) which exhibited highly significant negative association. The results of Venugopal *et al.* (2017) [13] also found that the seasonal incidence of *Plutella xylostella* (L.) infesting cabbage (*Brassica oleracea* var. *capitata* L.) work were carried out at the college of SHIATS, Allahabad during 2015-2016. The diamondback moth, *Plutella xylostella* damage was active throughout the year with a varying degree of infestation. It was recorded from a minimum of 0.32 per cent (second fortnight of Febuary) to maximum of 5.98 per cent (3rd fortnight of March). A study on the correlation studies indicated a significant positive correlation between larval population of diamondback moth and the relative humidity (R.H), total rainfall and sunshine hours (SSH) had negative correlation with the larval population of diamondback moth.

Table 1: Larval intensity of *Plutella xylostella* L. and corresponding periodical meteorological data during 2019-20

S. No.	Date of observation	Standard meteorological week (SMW)	Mean larval population of DBM	Meteorological parameters							
				Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Sun shine hr/day	Wind velocity (km/hr)	Mean adult population of *C. septempunctata*
				Maxi.	Mini.	Morning	Evening				
1.	01/12/19	49th	00	24.30	9.90	92.00	44.00	00	2.7	1.6	00
2.	08/12/19	50th	00	21.30	11.90	95.00	69.00	10.00	0.80	3.50	00
3.	15/12/19	51th	00	16.80	8.80	86.00	66.00	00	2.00	4.20	00
4.	22/12/19	52th	00	13.30	3.90	90.00	72.20	00	0.20	2.60	00
5.	29/12/19	1st	00	20.30	9.50	93.00	62.00	8.00	1.60	3.90	00
6.	05/01/20	2nd	00	18.90	8.10	95.00	67.00	7.60	3.20	4.40	0.56
7.	12/01/20	3rd	0.92	17.30	10.90	96.00	81.00	65.60	1.00	4.00	0.76
8.	19/01/20	4th	2.04	21.20	7.50	89.00	46.00	00	8.00	4.40	1.64
9.	26/01/20	5th	2.60	21.10	8.30	91.00	46.00	00	7.40	5.10	1.72
10.	02/02/20	6th	2.84	21.90	6.70	92.00	46.00	00	7.80	2.40	2.16
11.	09/02/20	7th	3.20	24.70	11.00	77.00	42.00	00	9.60	6.60	2.60
12.	16/02/20	8th	4.00	25.30	13.70	86.00	55.00	1.80	5.40	5.70	3.56
13.	23/02/20	9th	4.52	27.00	15.00	87.80	53.00	2.60	6.00	3.50	4.36
14.	01/03/20	10th	4.44	24.60	13.90	84.00	58.00	24.20	6.00	5.80	3.36
15.	08/03/20	11th	4.04	26.60	14.30	86.00	55.00	3.40	6.0	4.20	2.48
16.	15/03/20	12th	3.20	31.60	16.90	81.00	39.00	00	9.10	3.60	2.08
17.	22/03/20	13th	2.40	31.60	18.00	72.00	38.00	6.00	8.50	6.90	1.60
18.	29/03/20	14th	1.52	35.70	16.90	56.00	17.00	00	10.50	5.00	1.24
Mean			1.98	23.52	11.40	86.04	53.12	7.17	5.32	4.30	1.56

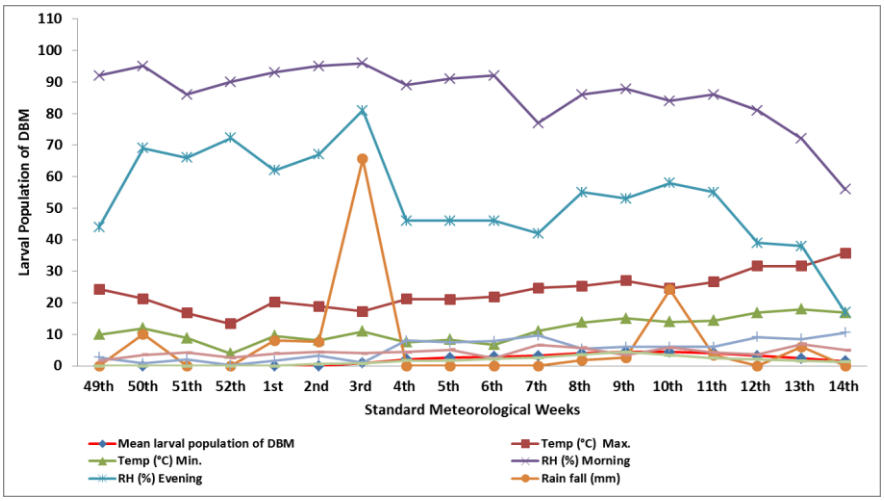

Fig 1: Larval intensity of *Plutella xylostella* L. and corresponding periodical meteorological data during 2019-20

Table 2: Larval intensity of *Plutella xylostella* L. and corresponding periodical meteorological data during 2020-21

S. No.	Date of observation	Standard meteorological week (SMW)	Mean larval population of DBM	Meteorological parameters							
				Temperature (°C)		Relative humidity (%)		Rain fall (mm)	Sun shine hr/day	Wind velocity (km/hr)	Mean adult population of *C. septempunctata*
				Maxi.	Mini.	Morning	Evening				
1.	29/11/20	49th	00	25.60	9.80	85.00	37.00	00	4.30	1.90	00
2.	06/12/20	50th	00	27.50	10.50	93.00	47.00	00	2.30	1.30	00
3.	13/12/20	51th	00	23.80	12.10	92.00	50.00	00	1.60	2.30	00
4.	20/12/20	52th	00	21.40	6.00	83.00	38.00	00	4.30	3.60	00
5.	27/12/20	1st	00	21.30	6.50	89.00	40.00	00	4.20	2.70	0.48
6.	03/01/21	2nd	0.52	13.60	10.60	91.00	51.00	0.30	1.90	2.30	0.72
7.	10/01/21	3rd	1.80	19.90	8.60	94.00	63.00	00	1.50	4.90	1.16
8.	17/01/21	4th	2.32	20.50	7.50	94.00	59.00	00	1.40	3.10	1.60
9.	24/01/21	5th	2.76	17.00	7.90	94.00	68.00	00	1.90	3.80	2.40
10.	31/01/21	6th	3.12	23.80	6.80	87.00	37.00	00	5.40	3.30	2.80
11.	07/02/21	7th	3.60	24.50	10.10	91.00	47.00	4.80	6.40	3.80	3.36
12.	14/02/21	8th	3.72	27.30	10.30	93.00	42.00	00	5.40	1.80	3.40
13.	21/02/21	9th	4.48	28.80	11.90	80.00	34.00	00	6.20	3.10	3.88
14.	28/02/21	10th	3.64	30.50	15.10	67.00	30.00	00	7.10	6.00	2.48
15.	07/03/21	11th	2.52	32.50	16.70	78.00	35.00	00	7.00	4.60	1.60
16.	14/03/21	12th	1.64	32.10	16.80	81.00	40.00	0.60	5.70	4.20	1.08
17.	21/03/21	13th	0.96	34.30	18.50	68.00	27.00	00	5.90	4.40	0.64
18.	28/03/21	14th	0.60	38.40	18.50	41.00	11.00	00	8.10	5.20	0.48
Mean			1.76	25.71	11.34	83.38	42.00	0.31	4.47	3.46	1.44

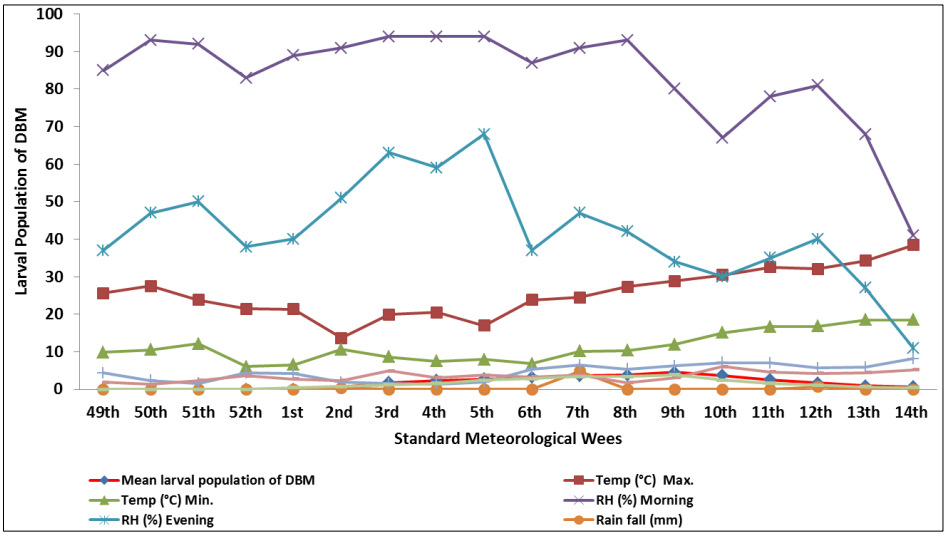

Fig 2: Larval intensity of *Plutella xylostella* L. and corresponding periodical meteorological data during 2020-21

Table 3: Correlation analysis between population of diamondback moth abiotic and biotic factors 2019-20 and 2020-21

Abiotic and biotic factors	Correlation Value 2019-20	Correlation Value 2020-21
Max. temperature (°C)	0.520**	0.103 N.S.
Min. temperature (°C)	0.513**	0.031 N.S.
Humidity morning (%)	-0.133 N.S.	-0.052 N.S.
Humidity evening (%)	-0.367 N.S.	-0.063 N.S.
Rainfall (mm)	-0.090 N.S.	0.281 N.S.
Sun shine (hr/day)	0.659**	0.367 N.S.
Wind speed (km/hr)	0.473**	0.303 N.S.
Coccinella septempunctata L.	0.967***	0.974***

*Correlation is significant at the 0.01 level of significance
**Correlation is significant at the 0.05 level of significance
***Correlation is significant at the 0.001 level of significance.

Conclusion

The cabbage crops was found to be infested by Diamondback moth, *P. xylostella* was observed most serious pest attacking the crop throughout the growth stage. It was first appeared on the crop in the 3rd and 2nd SMW and reached its peak during 9th SMW of February 2019-20 and 2020-21 respectively. The correlation between population of *P. xylostella* and weathers parameters maximum and minimum temperature, sunshine hours, rainfall and relative humidity were found statistically significant and non significant respectively. These findings

can be used by the farmers for developing a sound programme to counter the attack of *P. xylostella* in cabbage crop to minimize losses.

Acknowledgements
The authors are thankful to Professor and Head, Department of Entomology, C. S. Azad University of Agriculture and Technology, Kanpur Uttar Pradesh, for providing necessary facilities and support for carrying out the study successfully.

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