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Purushotam Sharma
Department of Agricultural Entomology, S.K.N. College of Agriculture Jobner, Jaipur, Rajasthan, India

Anita Sharma
Department of Agricultural Entomology, S.K.N. College of Agriculture Jobner, Jaipur, Rajasthan, India

SM Jat
Department of Entomology, Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan, India

Dr. KC Kumawat
Department of Agricultural Entomology, S.K.N. College of Agriculture Jobner, Jaipur, Rajasthan, India

Badriprasad
Department of Agricultural Entomology, S.K.N. College of Agriculture Jobner, Jaipur, Rajasthan, India

Corresponding Author:
Purushotam Sharma
Department of Agricultural Entomology, S.K.N. College of Agriculture Jobner, Jaipur, Rajasthan, India

Seasonal abundance of diamondback moth and natural enemies on cabbage

Purushotam Sharma, Anita Sharma, SM Jat, Dr. KC Kumawat and Badriprasad

Abstract
The cabbage crop was found to be infested by diamondback moth (*Plutella xylostella* L). The infestation of diamondback moth started from the third week of November and reached 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 whereas, non-significant correlation with relative humidity and sunshine hours. The coccinellid beetle was recorded as an important predator of aphid, which was maximum (20.2 /10 plants) in the fourth week of January.

Keywords: Diamondback moth, *Plutella xylostella,* coccinellid, cabbage, seasonal abundance and natural enemies

1. Introduction
Cabbage, *Brassica oleracea* var. *capitata* L. is one of the important cruciferous vegetable crops grown in India. It is grown more or less in all the states. The nutritional value/ 100 g of cabbage consists of carbohydrates 5.8 g, fat 0.1 g, protein 1.28 g, vitamins (thiamine or vitamin B_1 0.061 mg, riboflavin or B_2 0.040 mg, niacin or vitamin B_3 0.234 mg, pantothenic acid or vitamin B_5 0.212 mg, folate or vitamin B_9 43 mg, vitamin C 36.6 mg, and vitamin K 76 mg), minerals (Ca 40 mg, Fe 0.47 mg, Mg 12 mg, Mn 0.16 mg, P 26 mg, K 170 mg, Na 18 mg, Zn 0.18 mg) [1]. The total area under cultivation of cabbage in India is 372 thousand hectares with an annual production to the tune of 8534 thousand tonnes with productivity of 18.3 metric tonnes [2]. The total area under cultivation of cabbage in Rajasthan is 346 hectares with an annual production to the tune of 7588 tonnes [3]. China is major cabbage producing country with 47 per cent of world followed by India with 12 per cent of world production [4]. The yield of cabbage is adversely affected by many bottlenecks including insect pest, diseases, environmental stresses, nutritional imbalance etc. Among them, insect pests, *viz.*, tobacco caterpillar, *Spodoptera litura* (Fab.); diamondback moth, *Plutella xylostella* (L.) cabbage borer, *Hellula undalis* Fab.; cabbage looper, *Tricoplusia ni* Hub and aphid, *Lipaphis erysimi* (Kalt.) [5-9]. Out of these, aphid and diamondback moth are major pests causing significant loss in North India. The diamondback moth, *P. xylostella* was first reported on cruciferous vegetables in 1914 [10]. It is sometimes called cabbage moth. So, to have clear proven idea on the seasonal incidence of diamondback moth and natural enemies in cabbage ecosystem and their relation with abiotic factors like temperature and relative humidity, the present experiment was conducted for further understanding of the role played by the abiotic factors in the incidence of diamondback moth which is harmful to cabbage growers which ultimately will help cabbage growers for better return in terms of yield as well as income generation.

2. Materials and Methods
2.1 site and location of experiments: The present investigations were conducted at Horticulture Farm of S.K.N. College of Agriculture, Jobner, Jaipur during *Rabi,* 2015-16. Geographically, Jobner is located at longitude of 75°28' East, latitude of 26°06' North and at an altitude of 427 metres above mean sea level (MSL) in Jaipur district of Rajasthan.

2.2 Climatic and weather conditions of location: The climate of the region is typically semi arid which is characterized by extremes of the temperature during summer and winter. During summer, temperature may rise as high as 47 ^{0}C and in winter, it may fall as low as 2-3 ^{0}C. The total rainfall is 500 mm which is mostly received from last week of June to September.

This region provides a safe long growing season for most of the crops.

2.3 Layout and design of Experiment: The experiment was laid out in five plots of 2.25 x 2.25 m^2 sizes during *Rabi*, 2015-16. These plots were contiguous to each. Five weeks old seedlings were transplanted at row to row and plant to plant distance of 45 x 45 cm, respectively. The transplanting was done on 20th October during *Rabi*, 2015-16 in the evening hours followed by light irrigation. Other cultural practices as recommended in Packages of Practices were followed during the experimental period.

2.4 Observations: Observations on the abundance of diamondback moth and natural enemies were recorded from very beginning of their appearance on plants till harvesting of the crop.

2.4.1 Diamond back moth: In order to register the larval population of diamondback moth (DBM); direct visual counting method was used [11]. Ten plants were selected randomly from each plot and the total larval population of the pest was recorded at weekly interval.

2.4.2 Natural enemies: Coccinellid predator *C. septempunctata* was appeared as the major natural enemy in cabbage ecosystem; its population was recorded on ten randomly selected plants per plot.

2.4.3 Meteorological data: Weekly data of temperature (maximum and minimum), relative humidity and sunshine hours were collected from Meteorological observatory, Department of Agronomy, S.K.N. college of Agriculture, Jobner, Jaipur, and Rajasthan.

2.5 Statistical analysis: Population data of *Plutella xylostella* and natural enemy (Coccinelids) thus obtained were subjected to statistical analysis to find out the coefficient of correlation with average temperature relative humidity and sunshine hours. A simple correlation was worked out between the population of *P. xylostella* and natural enemy (Coccinelids) with abiotic environmental factor using the following formula.

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

Where,

r_{xy} = Simple correlation coefficient

X = Variable i.e. abiotic component. (Average temperature and relative humidity)

Y = Variable i.e. mean number of insect pests

n = Number of paired observations

$$t = \frac{r}{\sqrt{1 - r^2}} \times \sqrt{n - 2} \sim t_{n-2}\ d.f.$$

Significance of correlation is tested by using following formula.

3. Results and Discussion

During the present study, the crop was found to be abundantly infested with diamondback moth, *P. xylostella*. Among the natural enemies of insect pests of cabbage, coccinellid predator, *Coccinella septempunctata* L. was found major in the cabbage ecosystem which feeds on the aphids. Other natural enemies like *Cotesia plutellae* and Syrphid flies were present in traces only. This insect pest has also been reported as serious insect pest of cabbage crop by some entomologists [6, 12, 13] who also support the present findings

3.1 Seasonal abundance of *P. xylostella*: The data is presented in Table 1 and revealed that the infestation of *P. xylostella* on cabbage was started from second week of November (47th SMW) and reached to maximum (45.2 larvae /10 plants) in the first week of January 1st SMW) during the year, thereafter, population started declining. The infestation starts from third week of November and reached to maximum (45.75 and 42.50 larvae/10 plants) in the first week of January thereafter; population started declined [14]. Peak population of diamond back moth (DBM) was recorded on 1st March and 23rd February with 13.60 and 14.33 larvae/plant during 2011-12 and 2012-13 respectively [15]. The peak population of diamondback moth was found in the first week of February [16]. The infestation of *P. xylostella* started from second week of November and reached to peak in the last week of January to first week of February [17-20]. The larval population of diamondback moth had significantly negative correlation with maximum (r= -0.56) and minimum temperatures (r= -0.59) and non-significant correlation with relative humidity. The studies showed that the incidence of diamondback moth was only affected by temperature, *i.e*, with rise in temperature, the population of pest declined. Population of diamondback moth was negatively correlated with mean temperature and non-significant with relatively humidity [16]. Non-significant positive [13], and significant positive correlation [18], respectively were also recorded between the population of diamondback moth and temperature but these were controversy result. Population of diamondback moth started to build up after the cauliflower crop was transplanted [22].

3.2 Seasonal abundance of natural enemies *Coccinella septempunctata* L: Among the natural enemies *Coccinella septempunctata* L., a preadator of aphid was found in abundance. The data is presented in Table 1 and revealed that the population of *C. septempunctata* was maximum (20.2 /10 plants) in the fourth week of January (4th SMW) and had non-significant correlation with maximum and minimum temperatures, relative humidity and negative sunshine hours. The *C. septempunctata*, population was maximum (35.25 and 40.00/10 plants) in the third and second week of January, 2008-09 and 2009-10 [14], whereas maximum coccinellid was observed on 23rd February of 2011-12 and 2012-13 crop seasons with 11.67 and 9.67 coccinellids/ 5plants, respectively [15]. The population of *C. septempunctata* had non-significant correlation with maximum and minimum temperatures, relative humidity and negative sunshine hours [23, 24]. The results also get evidence from the finding of some entomologists that the parasitization of diamondback moth by *Cotesia plutellae* [25- 27] and *Tetrastichus sokolowskii* [28] were not recorded in cabbage ecosystem.

Table 1: Seasonal abundance of diamondback moth, *Plutella xylostella* (L.) and natural enemies in cabbage crop during *rabi*, 2015-16

S. No.	Date of observation	Standard meteorological week (SMW)	Temperature (^{0}C)		Relative humidity (%)	Sunshine hours/ day	*P. xylostella* Larvae / 10 plants	No. of *C. septempunctata* /10 plants
			Maximum	Minimum				
1	19/11/15	47	29.1	09.0	53	8.5	2.0	0.00
2	26/11/15	48	27.2	09.3	61	8.4	10.0	0.00
3	3/12/15	49	28.4	06.9	60	8.4	21.6	8.6
4	10/12/15	50	23.5	03.2	63	7.6	28.2	10.0
5	17/12/15	51	23.0	02.1	57	6.1	33.6	10.8
6	24/12/15	52	24.7	04.0	57	8.3	40.4	11.8
7	1/1/16	1	27.2	08.1	63	7.6	45.2	14.8
8	8/1/16	2	26.1	05.5	59	7.0	40.2	16.8
9	15/1/16	3	21.7	03.3	67	5.3	37.2	17.2
10	22/1/16	4	24.1	03.5	62	8.1	35.4	20.2
11	29/1/16	5	25.7	07.7	64	8.4	30.4	18.4
12	5/2/16	6	25.2	05.2	51	6.8	27.6	14.8
13	12/2/16	7	25.0	09.3	48	8.2	25.6	9.2
14	19/2/16	8	27.6	09.6	55	8.7	22.4	5.6
Seasonal Mean			25.61	6.19	58.57	7.67	28.56	11.30
Coefficient of correlation (r) for population and Maximum Temperature							-0.56*	-0.48
Coefficient of correlation (r) for population and Minimum Temperature							-0.55*	-0.37
Coefficient of correlation (r) for population and Relative Humidity							0.37	0.30
Coefficient of correlation (r) for population and Sunshine							-0.47	-0.37

* Significant at the 5% level of significance

4. Conclusion

The seasonal abundance of diamondback moth of cabbage was studied that will be helpful in preparing proper schedule for effective management of this pest. During the present study, the crop was found to be abundantly infested with diamondback moth, *P. xylostella* throughout the growing season. Among the natural enemies of insect pests of cabbage, coccinellid predator, *Coccinella septempunctata* L. was appeared as the major natural enemy in cabbage ecosystem. Other natural enemies like *Cotesia* and Syrphid flies were presented in limited numbers. *C. septempunctata* was appeared as the major natural enemy in cabbage ecosystem.

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