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Seasonal incidence of Diamondback moth *Plutella xylostella* (Lepidoptera: Yponomeutidae) on cabbage

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Abstract
Field experiments were conducted during Kharif seasons of year 2020 and 2021 to evaluate the seasonal incidence of Diamondback moth on cabbage and influence of weather parameters on its population. Infestation of diamondback moth appeared first in the month of April and reached peak (7.20 larvae/ plant and 6.53 larvae/ plant) in June during both the years. Correlation studies revealed that the maximum temperature had a significant positive correlation (r= 0.5823 and r= 0.7173) with the larval population. Minimum temperature showed non- significant (r= 0.4956) and significant (r = 0.7931) positive correlation in the respective years. Though, the relative humidity morning (r= -0.738 and r= -0.339) and evening (r= -0.57 and r=-0.288) were negatively correlated. However rainfall had negative but significant and non- significant relation (r= 0.5001 and r=-0.259) with the larval population during 2020 and 2021, respectively.

Keywords: Diamondback moth, cabbage, seasonal incidence, correlation, weather parameters

Introduction
Cabbage, *Brassica oleracea* var. *capitata* is a widely grown vegetable throughout the world as it has numerous health benefits. In India, cabbage is cultivated over an area of 3088 hectares with an annual production of 8.75 million tonnes. The limiting factor for optimum cabbage production is the attack of insect pests, the most important of which is Diamond back moth (DBM), *Plutella xylostella* as it hampers the successful production of quality heads [6]. In India, it causes 50-80% annual loss in the marketable yield and has a national importance on cabbage [2]. For the management of this pest large quantities of synthetic pesticides are applied all over the world. Due to the calendar based application of insecticides, Diamondback moth has become one of most difficult pests in the world to control, primarily because of resistance development and the absence of potent natural enemies [10, 17]. Synchronization between the insecticide application and the infestation of diamondback moth is an important tool for its management and is a way forward for amending the available management options for this pest and also reducing the resistance development against the broad spectrum of insecticides. Abiotic factors influence the developmental period of diamondback moth as the rate of development is slow in colder areas and fast in warmer areas [19]. The high temperature causes rapid development of DBM and many generations per year, increasing the rate of resistance development [4]. In view of the detrimental effect of diamondback moth on crop yield economics and its developmental variation in different environmental conditions, present study was undertaken to study the population dynamics of Diamondback moth in temperate conditions which is a prerequisite for devising an effective management strategy against this pest.

Material and Methods
Layout and design
In order to study the population dynamics of Diamondback moth on cabbage, two year field experiments were conducted at research farm of Faculty of Agriculture, SKUAST-Kashmir during *Kharif* 2020 and 2021. Twenty to twenty five days old seedlings of cabbage were transplanted in the month of March with plot size of 4×3m^2 and spacing of 45 x 30 cm^2 replicated thrice during both the years. While raising the crop required irrigation and fertilizers were provided to the crop except pest control measures.

Observations

Direct visual counting method was used to estimate the larval population of DBM [9]. The diamond back moth population was assessed on the basis of number of larvae present on ten randomly selected plants from each replication at weekly intervals. The observations on larval count were recorded from the very time of pest appearance on plants till harvesting of the crop during both the years.

Effect of weather parameters

The observations taken on population dynamics were correlated with key abiotic factors (prevailing weather parameters), *viz.* minimum, maximum temperature; morning as well as evening relative humidity and total rainfall. On the basis of weekly mean meteorological observations and population of Diamondback moth calculations were made. Correlation coefficient (r) was worked out with a view to study the impact of different abiotic factors on the pest population during both the years. Data on weather parameters were obtained from the Division of Agronomy, SKUAST-Kashmir, Shalimar.

Statistical Analysis

The data was analyzed statistically by the application of OPSTAT software for correlation analysis

Results and Discussion

The data on seasonal abundance of diamondback moth recorded on cabbage (Table 1) during 2020, revealed that the infestation of diamondback moth (larva) appeared first in the third week of April (17th SMW) and reached peak (7.20 larvae/ plant) on 3rd week of June (26th SMW) thereafter, the population dwindled to 1.23 larvae/plant on 4th week of July (31^{ist} SMW). The population fluctuation trend was more or less similar during 2021 (Table 2) as the pest population was first observed in 4th week of April (16th SMW) and gradually reached to peak (6.53 larvae/plant) on 4th week of June (26th SMW) thereafter, declined to 2.73 larvae/ plant on 4th week of July (30th SMW). Correlation coefficient was worked out between the number of larvae and the weather parameters *viz*., temperature (max. and min.), relative humidity (morning and evening) and rainfall during both the years. During year, 2020 the maximum (r=0.5823) and minimum (r=0.4956) temperature showed significant and non-significant positive correlation with the larval population, respectively as shown in Table 3. Whereas, the relative humidity morning (r= -0.738) and evening (r= -0.57) and rainfall (r= -0.5001) had negative but significant relationship with the larval population. Similarly, during year 2021, the correlation studies revealed (Table3) that the maximum (r= 0.7173) and minimum (r= 0.7931) temperature had significant and positive relationship with larval population. However, relative humidity morning (r=-0.339) and evening (r=-0.288) and rainfall (r=-0.259) showed negative but non-significant relationship with diamondback moth population. The present investigations are more or less in conformity with the findings of [15] who reported the maximum and minimum temperature had significant positive correlation with larval population of diamondback moth whereas, non-significant correlation with relative humidity and rainfall. Similarly, [13] recorded positive correlation between temperature (maximum and minimum) and larval population while as, rainfall was negatively correlated. Among different abiotic factors, maximum and minimum temperature had significant positive correlation whereas morning and evening relative humidity showed significant negative correlation with diamond back moth population [18] reported higher temperature, lower relative humidity and lower rainfall favour the pest population build up. [3] also observed the population of diamondback moth had positive relation with the maximum temperature and are in agreement with the present findings [14] reported that the minimum temperature showed positive relationship with the larval population of diamondback moth which corroborates the present findings. According to [12] the growth and development of *P. xylostella* is significantly influenced by the prevailing weather variables, especially temperature and rainfall in the field. Temperature has positive correlation with population dynamics of *P. xylostella*, whilst rainfall negatively affects the population build up [1]. Climatic conditions, including higher temperature and lower rainfall are major factors which regulate the population dynamics of *P. xylostella* [7] while hot and dry conditions are known to be conducive for population [16]. The development of larval stages increased with rising temperature upto 30°C thereafter, mortality was absolute at temperatures around 40°C [11, 5]. As incidence of pest depends on host availability and climatic conditions therefore, incidence and peak infestation of pest vary from region to region [15].

Table 1: Influence of abiotic factors on larval population of Diamondback moth on cabbage during 2020

SMW	Temperature (ºC)		Rainfall (mm)	Relative humidity (%)		Larvae/ Plant
	Maximum	Minimum		Morning	Evening	
17	21.8	5.9	3.6	85.28	49.85	0.10*
18	25.8	10.2	1.1	82.14	50.28	0.77
19	23.9	8.3	4.2	86.14	59.42	1.23
20	24	9.3	8.4	84.42	63.71	1.07
21	26	8.2	0.2	73.28	55.42	2.17
22	27.2	10.8	0.8	77.14	56.57	3.13
23	25.4	11.5	2.1	84.71	55.85	2.33
24	27.5	11.5	4.3	84.57	63.57	3.27
25	30.2	11.2	0.1	74.43	45.71	4.53
26	31.1	13.7	0.5	75.14	45.85	7.20
27	31.5	14.1	0.00	73.71	44.43	7.03
28	31.9	14.3	0.8	75.85	53.14	5.43
29	32.2	14.8	0.2	76	54.3	3.20
30	30.2	14.6	1.5	83.42	65	1.53
31	34.5	16.3	1	83.42	57.57	1.23

SMW= Standard meteorological week; * Each value is mean of three replications

Table 2: Influence of abiotic factors on larval population of Diamondback moth on cabbage during 2021

SMW	Temperature (ºC)		Rainfall (mm)	Relative humidity (%)		Larvae/ Plant
	Maximum	Minimum		Morning	Evening	
16	18.21	5.10	9.29	77.00	51.14	0.13*
17	26.00	6.86	0.40	60.71	35.00	0.17
18	23.64	10.50	0.00	76.71	68.43	0.37
19	22.50	9.29	4.74	82.86	54.14	0.57
20	23.29	9.21	2.23	84.29	50.86	0.70
21	28.14	8.64	0.26	75.57	44.43	1.13
22	27.57	13.14	0.46	80.00	55.14	2.03
23	32.64	15.43	1.24	65.14	41.71	2.27
24	26.49	12.43	0.83	76.14	48.86	2.73
25	28.93	12.57	0.54	64.71	42.14	4.43
26	29.57	14.57	1.73	62.86	32.29	6.53
27	31.54	17.07	0.14	64.29	36.14	5.70
28	32.54	15.56	3.57	84.29	69.00	4.37
29	31.1	17.0	2.8	81.4	60.1	3.47
30	30.3	14.6	0.0	84.1	57	2.73

SMW= Standard meteorological week; *Each value is mean of three replications

Table 3: Correlation Matrix of *P. xylostella* on cabbage

Weather parameters	Correlation coefficient (r)	
	2020	2021
Maximum temperature	0.5823	0.7173
Minimum temperature	0.4956	0.7931
Rainfall	-0.5001	-0.259
Relative humidity (morning)	-0.738	-0.339
Relative humidity (evening)	-0.571	-0.288

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