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Variability in diamondback moth larval abundance: A seasonal and geographic perspective

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Abstract

Jammu and Kashmir supports a flourishing vegetable cultivation sector, with cruciferous vegetables playing a vital role in the regional economy and dietary habits. In the year 2022, an experiment was conducted to monitor the population dynamics of diamondback moth larvae at different locations in the region during the *Kharif* and Rabi seasons. Our findings revealed that during the *Kharif* season, the larval population commenced its rise from mid-May and peaked towards the end of June to early July. In contrast, during the Rabi season, larval activity began in September, with the maximum population observed in early to mid-October. Furthermore, correlation studies revealed intriguing relationships between weather parameters and larval population dynamics. In the *Kharif* season, maximum temperature exhibited a positive and non-significant correlation with the larval population, while in the *Rabi* season; it displayed a negative and non-significant correlation. Conversely, minimum temperature showed a positive and highly significant correlation during *Kharif* but a negative and non-significant correlation during Rabi season. Rainfall and morning relative humidity displayed positive and non-significant correlations in both seasons, while the evening relative humidity exhibited negative and non-significant correlations. These insights enhance our understanding of the seasonal patterns of diamondback moth infestations in cruciferous vegetable crops in Jammu and Kashmir, providing valuable information for the development of effective pest management strategies and crop protection measures in the region.

Keywords crucifers, diamondback moth, infestation, weather parameters

Introduction

Jammu and Kashmir, renowned for its picturesque landscapes and rich agricultural heritage, boosts a thriving vegetable cultivation across an expansive area of 60 thousand hectares with an annual production of 13.8 thousand metric tons [1]. Amid the diverse range of crops cultivated, cruciferous vegetables hold a significant place in the region's economy and diet [2]. However, the cole crop productivity faces significant challenges, primarily attributed to various factors (climate change, inadequate irrigation, pests and diseases, post-harvest losses, pesticide misuse, etc), with insect pests emerging as the predominant concern and hence jeopardizing the livelihood of the farmers and the food security of the inhabitants [3].

Among the various pests attacking these crops, the diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae) is found to be most persistent and highly destructive in nature, wreaking havoc on Brassica crops [4, 5]. The pest exhibits a brief life cycle, and displays remarkable adaptability to adverse weather conditions, coupled with its excellent capacity of disperse; moreover, its quick generation turnover further contributes to its persistence [6-7]. The diamondback moth has national importance in India due to its substantial impact on cabbage production, leading to a drastic reduction of marketable yields by an annual range of 50 to 80 percent [8]. However, reports highlight severe diamondback moth outbreaks in Southeast Asia and the Uttar Pradesh region of India, resulting in catastrophic Brassica crop losses exceeding 90 and 100 percent, respectively [9-10]. A single *P. xylostella* larva can feed up to 62 to 78 percent leaves, which not only stunts plant growth but severely lowering both the quantity and quality of marketable produce [11]. According to Uthamasamy et al., [12], the projected annual crop losses attributable to this pest in India amount to a staggering US $16 million, while the expenses associated with control measures and productivity losses are estimated to reach US $4–5 billion on a global scale [13]. In the gut lumen of the diamondback moth, an enzyme known as "glucosinolate sulfatase" is present, which possesses the capability to desulphate glucosinolates via hydrolysis, thereby rendering these compounds inert and ineffective in deterring larval feeding [14]. Diamondback moth has a holometabolous development with four life stages; egg, larva, pupa, and adult. The larvae of diamondback moths possess chewing mouthparts and exhibit a voracious feeding behaviour, continuously devouring plant leaves, thus resulting in extensive defoliation [5, 15]. Initially, first and early second instar larvae tunnel the leaves, while successive instars create numerous small biting holes, leading to the destruction of the crop and thus to a significant reduction in both yield and overall crop quality by contaminating the edible portion with its excrement [16]. The number of *P. xylostella* generations varies from region to region, to about four in temperate conditions and nearly 20 generations in tropical regions [17-18].

The small size of diamondback moth larvae and its propensity to hide within the heart of leaves and curds makes its collection further challenging, hence, a concerted effort was initiated to gather additional valuable insights into diamondback moth larval population through the utilization of monitoring tools, with a particular emphasis on visual scouting, to enhance our comprehension of this elusive pest's behaviour and distribution. Monitoring larval infestations of the diamondback moth in Kashmir is thus a critical endeavour to optimize pest management strategies and ultimately ensure the region's agricultural prosperity and ecological sustainability.

Methodology

An experiment trial was conducted across three distinct locations viz; Vegetable Experimental Field, Faculty of Horticulture, SKUAST-K, Shalimar; Urban Technology Park, SKUAST-K, Habbak; and commercial farmer's field in Budgam, with plots measuring 9×9 m2. Observations were systematically recorded on a weekly basis throughout the crop growth phase, focusing on ten randomly selected plants from each plot. The trial encompassed both the Kharif and Rabi seasons of the year 2022. The primary objective was to monitor the presence of diamondback moth larva and to estimate its larval population; a direct visual counting method was employed Lal [19]. Weekly data of temperature (maximum and minimum), relative humidity (morning and evening), and rainfall were collected from the Meteorological Observatory, Department of Meteorology, SKUAST-K, Shalimar. The population data of the diamondback moth thus acquired were subjected to statistical analysis to find out the correlation coefficient and consequently, determine the impact of above mentioned abiotic factors on the population dynamics of this pest.

Results and Discussion

Plutella xylostella larval population during Kharif 2022

The diamondback moth larval population initiated from 20th SW (third week of May) as 1.46+ 0.13, 2.93 + 0.12, 1.79 + 0.17 larvae at Shalimar, Budgam and Habbak, respectively. Over the following weeks, the population gradually increased and peaked at 8.33 +0.15, 13.86 + 0.24, 10.60 + 0.22 larvae per plant during the 23rd SW at each respective location. However, in the subsequent weeks, the *P. xylostella* population declined, followed by another increase to a maximum of 11.93 + 0.15 larvae at Shalimar and 13.73 + 0.12 larvae at Habbak during the 27th SW; while the highest larval count of 15.53 + 0.16 was recorded during the 26th SW at Budgam (Table 1). Our findings are in similar line with the research conducted by Rasool et al., [20] who also reported the maximum larval population of diamondback moth during the end of June to the first week of July (26th and 27th SW).

Table 1. Larval population of *P. xylostella* at different locations during *Kharif* 2022

Standard Week (SW)	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)		Number of Diamondback moth larvae per plant (Mean + S.E)		
	Maximum	Minimum		Morning	Evening	Shalimar	Budgam	Habbak
20	26.28	10.57	0.00	68.85	53.00	1.46 + 0.13	2.93 + 0.12	1.79 + 0.17
21	25.01	10.07	3.31	73.71	51.00	2.93 + 0.15	5.73 + 0.12	3.46 + 0.22
22	24.92	11.67	1.68	68.28	46.57	4.86 + 0.16	8.796 + 0.17	5.66 + 0.27
23	29.85	12.05	0.57	57.57	37.57	8.33 + 0.15	13.86 + 0.24	10.60 + 0.22
24	28.714	13.78	1.28	69.14	40.14	6.40 + 0.16	13.33 + 0.10	7.79 + 0.30
25	19.34	12.14	14.94	85.28	81.28	5.60 + 0.16	12.26 + 0.19	7.66 + 0.23
26	32.64	17.51	0.00	75.71	44.00	9.13 + 0.16	15.53 + 0.16	10.86 + 0.13
27	31.31	20.32	1.25	77.42	58.00	11.93 + 0.15	15.06 + 0.26	13.73 + 0.12
28	26.21	17.28	13.77	88.57	67.85	8.4 + 0.16	11.66 + 0.23	10.72 + 0.16

Plutella xylostella larval population during Rabi 2022

The *P. xylostella* population as monitored at different locations commenced from 36th SW, gradually increased in successive weeks, and peaked at a maximum larval population of 11.73 + 0.26 in Budgam and 7.73 + 0.12 in Habbak during 40th SW; whereas at Shalimar, the peak of larval population was recorded as 6.93 + 0.18 during 41st SW (Table 2). The present findings align with the work of Ahmad et al., [21] who also observed the larval peak of diamondback moth between mid-August to mid-October, with a maximum persistence occurring at the end of September.

Table 2. Larval population of *P. xylostella* at different locations during *Rabi* 2022

Standard Week (SW)	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)		Number of Diamondback moth larvae per plant (Mean + S.E)		
	Maximum	Minimum		Morning	Evening	Shalimar	Budgam	Habbak
36	30.00	15.42	1.00	78.00	46.14	1.06 + 0.18	2.66 + 0.29	1.00 + 0.10
37	28.57	13.07	1.05	77.71	52.14	2.13 + 0.19	3.40 + 0.12	2.98 + 0.14
38	28.42	11.71	0.68	74.28	45.85	3.73 + 0.18	4.66 + 0.14	3.93 + 0.19
39	26.92	11.85	0.11	85.42	46.71	4.33 + 0.15	6.86 + 0.25	4.86 + 0.17
40	26.57	7.92	0.00	84.85	40.57	6.60 + 0.19	11.73 + 0.26	7.73 + 0.12
41	24.72	7.30	0.00	75.28	48.42	6.93 + 0.18	9.26 + 0.12	7.39 + 0.12
42	20.07	4.571	5.71	92.85	53.85	4.13 + 0.21	8.06 + 0.16	6.53 + 0.16
43	19.95	2.428	0.00	91.14	70.14	2.26 + 0.18	6.12 + 0.20	4.60 + 0.12
44	18.85	3.50	0.57	90.14	62.14	1.80 + 0.17	4.40 + 0.12	2.73 + 0.19

Correlation matrix of abiotic factors with Plutella xylostella larval population during Kharif and Rabi 2022

A simple correlation analysis (Tables 3 and 4) was computed between important weather parameters and *P. xylostella* larval population in both seasons. During the *Kharif* season, the maximum temperature exhibited a positive but non-significant correlation (r = 0.59, 0.53, 0.47) with the larval population of diamondback moth across all the locations. In contrast, during the Rabi season, a positive but non-significant correlation was observed at the Shalimar location (r = 0.042), while at both Habbak (r = -0.25) and Budgam locations (r = -0.21), a negative and non-significant correlation was found. Similarly, the minimum temperature had a positive but highly significant correlation (r = 0.88, 0.85, 0.71) with the larval population during the *Kharif* season, while it displayed a negative but non-significant correlation (r = -0.15, -0.44, 0.41) during the *Rabi* season. In both the seasons and across all the locations, the relationship with rainfall and morning relative humidity was non-significant and positively correlated; however, an exception to this trend was observed during the Rabi season at Shalimar, where a negative and non-significant correlation (r = -0.08) was observed. However, the evening relative humidity exhibited a consistent negative and non-significant correlation throughout both seasons. The present findings are in accordance with Bhagat et al., [22] observations, which also reported a negative correlation (r = - 0.005) between maximum temperature and larval population, however, in the subsequent year, a positive correlation (r = 0.19) was computed. Similarly, Venkateswarlu et al., [23] also observed a positive correlation of the diamondback moth population with the maximum and minimum temperature. This finding resonates with the results of Aysheshim et al., [24], who found a positive and non-significant correlation between maximum temperature and larval population, contrasting with Mane et al., [25] study, who found a negative and non-significant correlation, partially converging with our present findings.

Table 3. Correlation between *P. xylostella* larval population and abiotic factors during *Kharif* 2022

Weather Parameters	Locations		
	Shalimar	**Budgam**	**Habbak**
Maximum Temperature	0.59	0.47	0.53
Minimum Temperature	**0.88 ****	**0.71***	**0.85****
Rainfall	0.02	0.77	0.11
Morning Relative Humidity	0.19	0.13	0.22
Evening Relative Humidity	- 0.09	-0.05	0.04

**Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table 4. Correlation between *P. xylostella* larval population and abiotic factors during *Rabi* 2022

Weather Parameters	Locations		
	Shalimar	**Budgam**	**Habbak**
Maximum Temperature	0.42	- 0.21	- 0.25
Minimum Temperature	- 0.15	- 0.41	- 0.44
Rainfall	- 0.08	0.17	0.11
Morning Relative Humidity	- 0.14	0.22	0.17
Evening Relative Humidity	- 0.50	- 0.29	- 0.22

Additionally, Meena and Singh [26] reported a positive association between minimum temperature and the larval population of the diamondback moth, further corroborating our present findings. Rainfall, however, exhibited a positive and non-significant correlation, consistent with the findings of Bhagat et al., [22] and Rajput et al., [3], though the positive relationship between rainfall and the larval population also finds support from the various studies [25-27]. On the other hand, the negative correlation between rainfall and the diamondback moth population observed at Shalimar during the *Rabi* season is in agreement with research conducted by Ahmad et al., [21]. The present findings also demonstrate a non-significant relationship between the diamondback moth population and relative humidity, consistent with the observations reported by Bana et al., [22]. Further, Ahmad et al., [21] also reported a positive and non-significant correlation of relative humidity. Moreover, Bhagat et al., [22] two-year study found both negative (r = -0.26) and positive (r = 0.11) relations between relative humidity and diamondback moth larval population, but a non-significant effect on the pest population. These results further support our findings of non-significant positive and negative correlations of relative humidity observed during the present research pursuit.

Regression analysis

Regression equations (Table 5) of *P. xylostella* during the *Kharif* 2022 season revealed that weather parameters influenced population variations by 75.08% at Shalimar, 78.98% at Habbak, and 81.65% at Budgam. Similarly, during *Rabi* 2022 season, a 76.02% variation was observed at Budgam, while Shalimar and Habbak exhibited variations of 94.58% and 94.60%, respectively. Consequently, the combined effect of weather parameters on *P. xylostella* populations across both seasons ranged from 75% - 94% (R^2). These findings aligns with the results reported by Ahmad et al., [21], who also documented variations in this range.

Table 5. Multiple regression equation for *P. xylostella* at different locations during the *Kharif* and *Rabi* seasons 2022

***Kharif* Season**		
Locations	**Multiple Regression equation**	**R^2 Value**
Shalimar	Y= 23.91-0.04X1-0.34X2-0.01X3-0.08X4-0.17X5	75.08%
Budgam	Y= 6.67+0.42X1-0.81X2+0.02X3+0.08X4-0.21X5	81.65%
Habbak	Y= 8.11+0.41X1-0.72X2+0.26X3-0.01X4-0.11X5	78.98%
***Rabi* Season**		
Locations	**Multiple Regression equation**	**R^2 Value**
Shalimar	Y= 14.30-0.10X1+1.20X2+0.33X3-0.30X4-0.01X5	94.60%
Budgam	Y= 36.00-0.46X1+1.66X2+0.64X3-0.39X4-0.17X5	76.02%
Habbak	Y= 16.52+0.01X1+1.33X2+0.55X3-0.39X4-0.006X5	94.58%

Conclusion

The period from the second fortnight of June to the second fortnight of July during the *Kharif* season and the early part of October during the *Rabi* season is of utmost significance for crop management. This is when pest populations peak, making it a critical time for crop protection. Further, the correlation analysis between the diamondback moth population and various weather parameters yielded statistically non-significant results. These findings provide valuable insights for farmers, enabling them to formulate effective strategies for mitigating *P. xylostella* infestations in cole crops and thereby reducing potential losses.

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