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Influence of Abiotic Factors on Pest Dynamics in Rapeseed Mustard

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Abstract

The study identified four key insect pests in mustard crop, *i.e.*, mustard sawfly, mustard aphid, cabbage butterfly and painted bug. These pests have been shown to cause significant crop loss at different growth phases. During the crop's vegetative stage, the highest prevalence of mustard sawfly was observed at the 47th SMW (2.10 grubs plant^{-1}). There was positive relationship with maximum temperature (r=0.460*) and negative correlation with maximum RH (r=0.568*). The peak aphid population occurred during the 5th SMW (126.90 aphids per 10 cm central twig plant) at siliqua formation stage. Notably, aphids exhibited a positive association with *Coccinella* spp. and syrphid flies (r=0.780** and r=0.805**, respectively). The cabbage butterfly's maximal density was detected during the sixth SMW (2.40 larvae plant^{-1}). It demonstrated a substantial negative association with maximum temperature (r=-0.632*) and a positive correlation with both minimum and maximum RH (r=0.721** and r=0.455*, respectively). The maximum occurrence of the painted bug was observed during the eighth SMW (3.00 bugs plant^{-1}), but no significant link with meteorological factors was found.

Keywords: Abiotic factors, Aphid population, Insect pests, Pest dynamics, Rapeseed mustard

Introduction

Mustard is a crucial oil producing crop primarily cultivated throughout the winter in Northern India. Planting usually begins in late October and extends through late November. By December to January, the crop bursts into vibrant blooms, while the harvesting period mainly spans from mid-February to April. Mustard seeds rank as the third-largest provider of vegetable oil globally, following soybean oil and palm oil. Additionally, they are the second-largest source of protein meal worldwide after soybean meal. The oil percentage in mustard typically varies from 34% to 46%, with an average recovery rate of 32% to 38%.

In India, during 2017-18, rapeseed mustard cultivation covered an area of 6.07 MH, resulting in a production of 7.92 MT and 1,304 kg ha^{-1} productivity (Anonymous, 2018). Notably, U.P. accounted for 0.95 MH dedicated to rapeseed mustard, yielding a production of 2.45 MT, albeit with a lower productivity of 1,155 kg ha^{-1}. In contrast, Gujarat showcased the highest productivity at 1,363 kg ha^{-1} across 0.22 MH, generating a production of 0.30 MT. Within Uttar Pradesh, Mathura district stood out with the largest area of 0.053 MH, producing 0.077 MT and achieving a high productivity of 1,453 kg ha^{-1}. Globally, during the same period, rapeseed mustard covered an expansive area of nearly 36.68 MH, yielding a total production of 70.42 MT and 1,920 kg ha^{-1} productivity (Anonymous, 2018).

Mustard crop faces numerous challenges because of biotic and abiotic stresses, leading to significant disparity between potential yield and actual harvest. Approximately 15 insect pests impact this crop, including mustard sawfly (*Athalia lugens proxima*), painted bug (*Bargrada cruciferarum*), leaf miner (*Phytomyza horticola*), mustard aphid (*Lipaphis erysimi*), Bihar hairy caterpillar (*Spilosoma obliqua*), peach aphid (*Myzus persicae*), cabbage aphid cotton aphid (*Aphis gossypii*), (*Brevicorynae brassicae*), cabbage butterfly (*Pieris brassicae*), whitefly (*Bemisia tabaci*), diamond back moth (*Plutella xylostella*) and cutworm (*Agrotis

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segetum) contributes to substantial damage. The *L. erysimi* is indeed a significant pest in mustard crop. Its impact on seed production can be quite severe. Research has shown that this pest can cause a substantial decrease in produce, ranging 15% to 90%. Additionally, oil content of the harvested seeds may decrease by approximately 5-6% due to the aphid's feeding activity. Managing this pest is crucial for maintaining crop productivity and oil quality (Bakhetia and Sekhon, 1989; Shylesha *et al*., 2006; Sahoo, 2012). Investigating the effect of weather on prevalence of pests in rapeseed mustard is a crucial area of research. Abiotic factors refer to non-living environmental conditions that can influence pest populations. These factors may include temperature, humidity, soil quality and light availability, among others. Understanding how abiotic factors interact with pest populations can help develop effective management strategies. For instance, extreme temperatures or soil moisture levels can directly affect the survival and reproduction of pests. By studying these relationships, researchers can identify patterns and make informed recommendations to farmers.

Materials and Methods

The study was conducted at A.N.D. University of Agriculture and Technology, situated in Kumarganj, Ayodhya, Uttar Pradesh, India (latitude 26.47° N, longitude 82.12° E), during *Rabi* Season of 2021-22. The focus of the study was on the NDR-8501 variety of rapeseed mustard. Insect pest populations were assessed within a plot measuring 10 m × 9 m, with a 1 m border. The spacing between rows and plants was 45 cm and 15 cm, respectively. Researchers observed the mustard aphid population on the top 10 cm central twig of each plant. Additionally, other insects were monitored per plant on a weekly basis from germination until harvesting. Weather parameters, including maximum and minimum temperatures (°C), rainfall (mm) and relative humidity (%) were acquired from the Department of Agricultural Meteorology. Study also aimed to establish correlation coefficients between insect pest populations and these weather parameters.

Results and Discussion

Influence of Abiotic Factors on Pest Dynamics in Rapeseed Mustard

Mustard Sawfly

The incidence of mustard sawfly during *Rabi* 2021-22 was monitored at weekly intervals presented in table 1 and figure 1. The insect appeared early in the crop growth cycle. Initially, population was noted in the 44th Standard Meteorological Week (SMW) at a rate of 0.40 grubs plant^{-1}. By the 47th SMW, this population had increased to 2.10 grubs plant^{-1}. However, after that, the population declined and it was not observed during the 49th SMW. Correlation analysis revealed interesting patterns. The mustard sawfly showed a noteworthy positive correlation with maximum temperature (0.460*), negative association with RH [maximum (-0.568*)] (Table 2). These conclusions closely align with the results reported by Pal and Debnath (2020), who also observed mustard sawfly during the seedling stage. In their study, the minimum population (0.30) occurred in the 48th SMW, while the maximum population (3.60) was observed in the 46th SMW. Additionally, partial agreement was found with the findings of Jat *et al*. (2006), who recorded sawfly infestation from the 1st week after sowing up to the 4th week.

Mustard Aphid

Occurrence of mustard aphid varied across different crop periods, as shown in table 1. It was seen at 50th Standard Meteorological Week (SMW) to the 11th SMW, with the highest population observed during the 6th SMW (126.90 aphids 10 cm of the central twig plant^{-1}). Regarding weather variables, there was a non-significant association with pest (Table 2; Figure 1). Among the biotic factors (Table 3), a positive link with ladybird beetles and syrphid flies (correlation coefficients of 0.780** and 0.805**, respectively). These findings align with the research conducted by Pal and Debnath (2020), who observed mustard aphid from the blooming to pod bearing phase of crop. Similarly, Pradhan *et al*. (2020) reported that aphids appeared during the 51st SMW (*i.e*., the third week of December). Additionally, Chand *et al.* (2022) found that the aphid population showed insignificant connection with maximum temperature and RH. Bavisa *et al*. (2018) also reported a positive effect of temperature and a negative relation to humidity.

Cabbage Butterfly

The manifestation of pest was recorded as of 2nd to the 9th SMW (Table 1; Figure 1). The peak population of cabbage butterfly larvae (2.40 larvae plant^{-1}) was observed during the 6th SMW. Correlation analysis revealed interesting patterns. The incidence of cabbage butterfly larvae showed a significant negative correlation (r = -0.632**) with maximum temperature; whereas, both minimum and maximum RH exhibited positive correlations (r = 0.721** and 0.455**, respectively) (Table 2). These findings align with the research conducted by Patel *et al.* (2019), who observed irregular occurrences and little prevalence of cabbage butterfly. Similarly, Bhati *et al.* (2015) reported that the cabbage butterfly attacked at different crop growth phases. Additionally, Singh *et al.* (2018) found positive association between the cabbage butterfly and maximum temperature.

Painted Bug

The occurrence of the painted bug population was observed from the 4th Standard Meteorological Week (SMW) up to the 8th SMW, with varying populations ranging from 0.40 to 3.00 bugs plant^{-1} (Table 1). The peak population of painted bugs (3.00 bugs plant^{-1}) was observed during the 9th SMW. Correlation analysis revealed interesting patterns. The incidence of painted bugs showed non-significant correlation with meteorological factors (Table 2). These findings partially align with the research conducted by Pal and Debnath (2020), who detected painted bug at the seedling and at maturity stage. Similarly, Patel *et al.* (2019) found painted bugs throughout seedling to maturity period, causing negligible damage. Additionally, Singh *et al.* (2018) noticed negative connection with minimum temperature and RH.

Incidence of Major Predators

Ladybird Beetles

The incidence of ladybird beetles was observed to be active since 2nd to 8th SMW during *Rabi* 2021-22, as shown in table 1. The population of ladybird beetles ranged from 1.00 to 6.50 beetles plant^{-1}. Initially, predator was minimal (1.00 beetle plant^{-1}) in the 2nd SMW and its peak (6.50 beetles plant^{-1}) was recorded in the 8th SMW. These findings align closely with Pradhan *et al.* (2020), who discovered that 4th SMW is time of appearance of ladybird beetles. Additionally, Lal *et al.* (2018) observed that the *C. septumpunctata* active from the 4th SMW and touched its peak during the 9th SMW.

Syrphid Flies

The syrphid fly was observed from 2nd to the 8th SMW during the *Rabi* season of 2021-22, as shown in table 1. The syrphid fly larvae ranged from 0.80 to 6.10 grubs plant^{-1}. Initially, it was low (0.80 grubs plant^{-1}) in the 2nd standard week, but it reached its peak (6.10 grubs plant^{-1}) in the 8th standard week. These findings align with previous research by Pradhan *et al.* (2020), which also identified the syrphid fly as a key hunter.

Table 1: Influence of abiotic factors on pest dynamics in Rapeseed Mustard during *Rabi*, 2021-22

SMW	Abiotic factors					Biotic factors of Mustard Aphid	
	Temperature (°C)		Relative Humidity (%)		Total rainfall (mm)	Lady bird beetles plant^{-1}	Syrphid Fly grubs plant^{-1}
	Minimum	Maximum	Minimum	Maximum			
44	21.90	32.20	48.50	88.10	0.00	0.00	0.00
45	13.70	29.70	56.40	82.40	0.00	0.00	0.00
46	12.30	27.70	69.20	85.40	0.00	0.00	0.00
47	13.50	27.40	64.20	87.80	0.00	0.00	0.00
48	11.40	27.50	68.40	91.20	0.00	0.00	0.00
49	12.60	27.50	57.80	91.70	0.00	0.00	0.00
50	7.90	22.80	66.20	92.50	0.00	0.00	0.00
51	5.80	21.70	62.70	92.00	0.00	0.00	0.00
52	9.90	21.30	68.30	94.60	15.00	0.00	0.00
1	9.30	19.40	69.70	95.40	14.20	0.00	0.00
2	10.60	20.20	78.50	96.00	11.60	1.00	0.80
3	5.70	15.90	79.80	93.50	0.00	1.60	1.20
4	8.30	17.30	80.20	94.50	8.80	3.20	1.80
5	8.80	19.60	78.10	95.20	0.30	3.40	3.90
6	9.00	20.80	76.40	93.50	0.00	4.30	4.80
7	9.90	24.00	71.50	89.20	0.00	5.80	6.10
8	11.30	25.50	63.80	91.50	0.00	6.50	5.90
9	11.40	27.10	68.00	91.20	0.00	4.90	4.50
10	12.50	29.10	64.70	90.00	0.00	3.80	4.00
11	16.50	32.00	57.70	88.10	0.00	2.40	3.10

Table 1: Continue...

SMW	Incidence of Insect Pests			
	Mean No. of Mustard aphids per 10 cm central twig plant	Mean No. of Sawfly grubs plant^{-1}	Mean No. of Cabbage butter fly larvae plant^{-1}	Mean No. of Painted bugs plant^{-1}
44	0.00	0.40	0.00	0.00
45	0.00	1.20	0.00	0.00
46	0.00	1.60	0.00	0.00
47	0.00	2.10	0.00	0.00
48	0.00	1.70	0.00	0.00
49	0.00	1.30	0.00	0.00
50	5.50	0.20	0.00	0.00
51	26.00	0.00	0.00	0.00

Table 1: continue...

SMW	Incidence of Insect Pests			
	Mean No. of Mustard aphids per 10 cm central twig plant	Mean No. of Sawfly grubs plant^{-1}	Mean No. of Cabbage butter fly larvae plant^{-1}	Mean No. of Painted bugs plant^{-1}
52	12.50	0.00	0.00	0.00
1	8.60	0.00	0.00	0.00
2	6.50	0.00	0.80	0.00
3	45.80	0.00	1.50	0.00
4	15.00	0.00	1.80	0.90
5	65.60	0.00	2.00	1.80
6	126.90	0.00	2.40	2.00
7	110.50	0.00	1.20	2.40
8	90.70	0.00	0.90	3.00
9	35.20	0.00	0.20	1.10
10	14.80	0.00	0.00	0.40
11	0.00	0.00	0.00	0.00

[SMW = Standard Meteorological Week]

Table 2: Relationship between abiotic factors and insect pest complex during *Rabi*, 2021-22

Insect Pests	Abiotic Factors				
	Temperature		RH (%)		Rainfall (mm)
	Minimum	Maximum	Minimum	Maximum	
Mustard sawfly	0.325	0.460*	-0.317	-0.568**	-0.302
Mustard aphid	-0.358	-0.348	0.410	0.240	-0.222
Cabbage butterfly	-0.437	-0.632**	0.721**	0.455*	-0.015
Painted bug	-0.186	-0.177	0.297	0.162	-0.216
Painted bug	-0.186	-0.177	0.297	0.162	-0.216

[** Significant at 1%; * Significant at 5%]

Table 3: Relationship between biotic factors and mustard aphid during *Rabi*, 2021-22

	Biotic factors	
	Coccinella spp.	Syrphid fly
Aphid	0.780**	0.805**

[** Significant at 1%; * Significant at 5%]

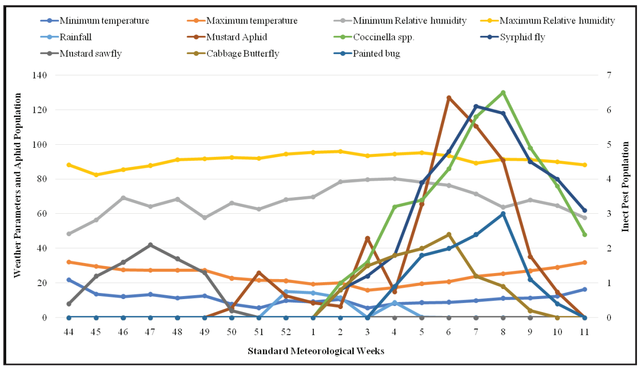

Figure 1: Influence of abiotic factors on pest dynamics in rapeseed mustard *Rabi*, 2021-22

Conclusion

In conclusion, the investigation yielded crucial insights into the prevalence and behaviour of major insect pests. These pests have a significant impact on rapeseed mustard crops at various growth stages. The study revealed distinct correlations between pest incidence and specific weather factors during the crop's development. Notably, temperature, humidity and rainfall played significant roles in influencing pest populations at different stages of crop growth. Armed with this information, researchers and farmers can devise more effective pest management strategies for rapeseed mustard cultivation, ultimately mitigating potential crop damage and losses caused by these prevalent insect pests.

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