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SEASONAL DYNAMICS OF MARUCA VITRATA (GEYER) AND HELICOVERPA ARMIGERA (HÜBNER) ON BLACKGRAM IN RELATION TO WEATHER

Shreya Soneshwar[1], D.V. Singh[2], Hem Singh[3], Prashant Mishra[4], Bhim Singh [5], Manoj Kumar Singh[6], Deepali Vishwakarma[7*]

[1]PhD Scholar, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, 250110
[2,3]Professor, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, 250110
[4]Professor, Department of Plant Pathology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, 250110
[5]Professor, College of Basic Science, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, 250110
[6]Professor, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, 250110
[7]Deepali Vishwakarma, Guest Faculty, Department of Entomology, College of Agriculture, Jabalpur, (Jawaharlal Nehru Krishi Vishwa Vidyalaya), 482004, (M.P.)
***Corresponding Author:** Deepali Vishwakarma, Email Id: 97deepalivishwakarma@gmail.com

ABSTRACT
A field experiment was conducted during Zaid seasons of 2025 and 2026 at the Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, to assess seasonal incidence of Maruca vitrata and Helicoverpa armigera on blackgram in relation to prevailing weather conditions. Blackgram variety Pant Urd-31 was grown in a randomized complete block design, and weekly pest observations were recorded from untreated control plots along with temperature, relative humidity, and rainfall. During 2025, M. vitrata attained its peak population of 9.85 larvae plant^{-1} in the 21st standard meteorological week (SMW), whereas H. armigera peaked at 8.36 larvae plant^{-1} in the 22nd SMW. In 2026, M. vitrata again peaked in the 21st SMW at 10.56 larvae plant^{-1}, while H. armigera reached 9.65 larvae plant^{-1} in the 20th SMW. Correlation analysis showed that evening relative humidity was significantly associated with M. vitrata in 2025, while minimum temperature was significantly associated with H. armigera. In 2026, M. vitrata showed significant positive correlations with minimum and average temperature, whereas no weather variable was significantly associated with H. armigera. Peak pest activity between the 20th and 22nd SMWs highlights the need for intensified surveillance during the reproductive stage of blackgram to support timely and need-based integrated pest management interventions.

KEYWORDS: Blackgram; Maruca vitrata; Helicoverpa armigera; seasonal incidence; weather parameters

1. INTRODUCTION
Pulses occupy an important position in food and nutritional security because they provide substantial quantities of plant protein, dietary fibre, complex carbohydrates, minerals, vitamins, and other health-promoting constituents. They are used in various forms in India and also form a significant part of the predominantly cereal-based diet, which can help to enhance the nutritional balance and nutritional quality of the diet in terms of protein quality (Gurusamy et al., 2022). In addition to their nutritional benefits, pulse crops have been shown to provide a range of other benefits to sustainable agricultural production, such as their ability to fix nitrogen in the soil, improve soil fertility, diversify cropping systems, and use land and water resources more efficiently, especially in rain-fed environments (Kumar et al., 2023).
Vigna mungo (L.) Hepper is an important short duration pulse crop grown in different agro-ecological zones of South and South East Asian countries. It is well adapted to diverse production systems, including sole, sequential, catch, and intercropping systems, and is valuable for intensifying pulse-based production systems. The crop also contributes soil nitrogen enrichment and is an important crop in agriculture especially in India where significant genetic and breeding efforts have been made to make it more productive, adaptable and resistant to biotic and abiotic stresses (Nair et al., 2024). The nutritional value of blackgram seeds is high in terms of protein, carbohydrates, minerals, amino acids and phytochemicals, which further strengthens the nutritional and economic significance of blackgram crop (Hadi et al., 2025).
Blackgram is an agronomically and nutritionally valuable crop, but suffers from a number of insect pests attacking it from vegetative growth to flowering and pod formation. Of these, the spotted pod borer Maruca vitrata (Geyer), is a destructive lepidopterous pest of urdbean and other grain legumes. The larvae damage reproductive structures by webbing flowers, buds and pods, as well as feeding within protected webbed area, making infestation difficult to detect and control once established. The seasonal occurrence of M. vitrata is closely associated with crop stage and environmental conditions, with substantial infestation commonly developing during the reproductive growth stage (Ramu et al., 2018). The intimate relationship of larval feeding with the floral structures is also reflected in the observation that various floral features of legume flowers affect the level of M. vitrata infestation (Nasiya-Beegum & Subramanian, 2018).

Helicoverpa armigera (Hübner) is another pod borer that is economically significant and has an extremely wide-host range, and is highly attracted to the reproductive parts of the plants (flowers, pods, developing seeds). It has a high reproductive capacity, mobility, and utilizes many cultivated host plants, which makes it of great importance in agriculture (Haile et al., 2021). Insecticides have been used extensively for the control of H. armigera in the past, but resistance, resurgence, detrimental effect on beneficial organisms and concern about residues following repeated use of insecticides have stressed the need for integrated and surveillance based management methods (Patil et al., 2017).
Environmental conditions affect abundance and seasonality of these insect pests. Temperature is especially significant as it influences insect development, survival, reproduction, phenology and population expansion, and precipitation and humidity may also influence pest activity and host-pest interactions. Changes in temperature regimes have been shown to alter the phenology and population performance of H. armigera across geographical regions (Huang, 2021). More broadly, climatic and meteorological variability can alter pest development rates, seasonal occurrence, distribution, and the timing of crop-pest interactions, making local weather-based surveillance increasingly relevant for pest management (Skendžić et al., 2021).
However, information on the comparative seasonal dynamics of M. vitrata and H. armigera during the Zaid season and their associations with prevailing weather conditions under western Uttar Pradesh agro-climatic conditions remains limited. Understanding the timing of pest appearance, population build-up, peak activity, and weather relationships can provide a stronger basis for timely monitoring and need-based management in blackgram.
Accordingly, the present investigation was undertaken with the following objectives:
1.To determine the seasonal incidence and population dynamics of M. vitrata and H. armigera on blackgram during the Zaid seasons.
2.To assess the relationships of both pod borers with major meteorological parameters, including temperature, relative humidity, and rainfall.
3.To identify the period of maximum pest activity to support timely surveillance and need-based pest management under western Uttar Pradesh conditions.

2. MATERIALS AND METHODS

The experiment was conducted at the Crop Research Centre (CRC) of SVPUA&T, Meerut (U.P.), during Zaid seasons of 2024–25 and 2025–26 to study the seasonal incidence of Maruca vitrata (Geyer) and Helicoverpa armigera (Hübner) on blackgram. Blackgram variety Pant Urd-31 was used for experiment, which was laid out in a Randomized Complete Block Design (RCBD) comprising nine treatments and three replications. Seasonal-incidence observations used in the present analysis were recorded from the untreated control plots. Each experimental plot measured 4 m × 3 m (12 m2), with spacing of 30 cm between rows and 10 cm between plants. Recommended agronomic practices were followed throughout crop period. The incidence of M. vitrata and H. armigera was recorded at weekly intervals throughout the observation period. At each observation, 10 randomly selected plants from the untreated control plots were examined, and populations of both pod borers were recorded. Weekly meteorological data on maximum temperature, minimum temperature, morning RH, evening RH and rainfall were obtained from the Department of Soil Science, SVPUA&T, Meerut. Average temperature was calculated from the maximum and minimum temperatures, while average relative humidity was calculated from the morning and evening relative humidity values. Pearson's simple correlation analysis was used to examine the relationship between weekly pest populations and meteorological parameters separately for each season, following Gomez and Gomez (1984). Correlations were evaluated using 13 weekly observations per season, with statistical significance considered at $p < 0.05$. The observations recorded during both years were used to characterize seasonal fluctuations and the associations between weather parameters and incidence of major pod borers of blackgram.

3. RESULTS AND DISCUSSION

3.1 Seasonal Incidence during Zaid 2025

The seasonal incidence of Maruca vitrata and Helicoverpa armigera during Zaid 2025 is presented in Table 1. M. vitrata was absent up to the 15th standard meteorological week (SMW) and first appeared during 16th SMW at 0.46 larvae plant^{-1}. Its population subsequently increased, with a marked build-up from the 19th SMW onwards, and attained maximum of 9.85 larvae plant^{-1} during 21st SMW (21–27 May). Thereafter, the population declined progressively and reached 0.29 larvae plant^{-1} by the 25th SMW. H. armigera also appeared during the 16th SMW at 0.62 larvae plant^{-1}, increased through the subsequent weeks, and reached its seasonal maximum of 8.36 larvae plant^{-1} during the 22nd SMW (28 May–3 June). The two species therefore showed overlapping periods of population build-up but differed in the timing of peak abundance.
This temporal separation in peak activity is consistent with earlier observations that M. vitrata and H. armigera do not necessarily attain maximum abundance simultaneously on blackgram (Kapoor & Shankar, 2019). Variation in peak occurrence among regions and production seasons has also been reported for M. vitrata under pre-kharif blackgram conditions, indicating that crop phenology and local environmental conditions can modify the timing of pest build-up (Kundu et al., 2021).

Table 1. Seasonal incidence of M. vitrata and H. armigera and associated weather parameters during Zaid 2025

SMW	Date	M. vitrata (larvae plant⁻¹)	H. armigera (larvae plant⁻¹)	Tmax (°C)	Tmin (°C)	Avg. Temp. (°C)	RH1 (%)	RH2 (%)	Avg. RH (%)	Rainfall (mm)
13	Mar 26–Apr 1	0.00	0.00	33.1	16.9	25.0	89.6	28.4	59.0	0.0
14	Apr 2–Apr 8	0.00	0.00	35.7	17.6	26.6	81.6	30.0	55.8	0.0
15	Apr 9–Apr 15	0.00	0.00	34.8	19.5	27.1	76.8	30.5	53.6	14.7
16	Apr 16–Apr 22	0.46	0.62	36.2	22.2	29.2	76.0	33.1	54.5	33.4
17	Apr 23–Apr 29	1.39	0.90	37.4	22.4	29.9	65.6	30.7	48.2	0.0
18	Apr 30–May 6	1.95	1.84	33.1	22.1	27.6	87.0	87.6	87.3	38.1
19	May 7–May 13	4.85	3.45	35.5	24.0	29.7	73.6	73.6	73.6	1.0
20	May 14–May 20	4.15	6.94	35.6	24.4	30.0	67.0	67.1	67.0	40.2
21	May 21–May 27	9.85	5.86	33.5	23.8	28.7	76.7	76.7	76.7	53.8
22	May 28–Jun 3	6.15	8.36	35.7	25.2	30.4	74.9	59.4	67.2	0.0
23	Jun 4–Jun 10	3.20	5.30	37.6	25.1	31.3	69.0	43.4	56.2	0.0
24	Jun 11–Jun 17	1.55	3.10	36.8	28.1	32.5	76.9	53.7	65.3	7.8
25	Jun 18–Jun 24	0.29	1.15	34.4	27.1	30.8	89.4	69.0	79.2	1.4

Note: Tmax = maximum temperature; Tmin = minimum temperature; RH1 = morning relative humidity; RH2 = evening relative humidity.

3.2 Relationship with Weather Parameters during Zaid 2025

The relationships between pest abundance and meteorological variables during 2025 are summarized in Table 2. M. vitrata showed significant positive correlation with evening relative humidity ($r = 0.598$, $p < 0.05$), whereas its relationships with maximum temperature, minimum temperature, average temperature, morning RH, average RH, and rainfall were non-significant. The positive relationship with evening RH suggests that comparatively humid evening conditions coincided with higher M. vitrata abundance during this season. Humidity-related variation in M. vitrata incidence has also been reported under rice-fallow blackgram conditions, although the particular humidity component and magnitude of association differed from those observed here (Swathi et al., 2019).

For H. armigera, minimum temperature was the only weather variable showing a significant positive correlation during 2025 ($r = 0.575$, $p < 0.05$). Maximum and average temperatures, evening and average RH, and rainfall showed positive but non-significant relationships, while morning RH was negatively associated with pest abundance. Similar variation in the response of H. armigera to individual meteorological factors has been reported across seasons, suggesting that the relative importance of temperature, humidity, and rainfall is not constant among production environments (Mehra & Singh, 2023).

Table 2. Correlation of M. vitrata and H. armigera populations with weather parameters during Zaid 2025

Weather parameter	M. vitrata (r)	H. armigera (r)
Maximum temperature (°C)	−0.110 NS	0.160 NS
Minimum temperature (°C)	0.387 NS	0.575*
Average temperature (°C)	0.274 NS	0.521 NS
Morning relative humidity (%)	−0.359 NS	−0.479 NS
Evening relative humidity (%)	0.598*	0.521 NS
Average relative humidity (%)	0.417 NS	0.308 NS
Rainfall (mm)	0.442 NS	0.244 NS

* Significant at $p < 0.05$; NS = non-significant; n = 13 weekly observations.

3.3 Seasonal Incidence during Zaid 2026

The seasonal population pattern during Zaid 2026 is shown in Table 3. M. vitrata first appeared during the 15th SMW at 0.59 larvae plant^{-1} and increased steadily thereafter. The population reached 7.50 larvae plant^{-1} during the 20th SMW and attained its maximum of 10.56 larvae plant^{-1} during 21st SMW. Following the peak, population density declined progressively to 0.62 larvae plant^{-1} by 25th SMW.

In contrast, H. armigera appeared one week earlier, during the 14th SMW, at 0.34 larvae plant^{-1}. Its population increased rapidly through the subsequent weeks and reached the seasonal maximum of 9.65 larvae plant^{-1} during the 20th SMW (14–20 May). A consistent decline was observed thereafter, with the population decreasing to 0.45 larvae plant^{-1} during the 25th SMW. Thus, unlike the 2025 season, H. armigera reached its maximum population one week before M. vitrata during 2026.

The shift in peak timing between seasons demonstrates that pod-borer incidence is dynamic rather than fixed to a single meteorological week. Seasonal differences in M. vitrata occurrence and peak abundance have likewise been documented in blackgram under different cropping environments, where changes in sowing season and prevailing weather altered the timing and intensity of infestation (Praveenkumar & Kandibane, 2025). Seasonal succession of insect pests on blackgram has also been reported to vary with crop development and environmental conditions, supporting the importance of local monitoring rather than reliance on a fixed calendar schedule (Sreedhar et al., 2024). The comparative seasonal population trajectories of M. vitrata and H. armigera during Zaid 2025 and 2026 are illustrated in Figure 1.

Table 3. Seasonal incidence of M. vitrata and H. armigera and associated weather parameters during Zaid 2026

SMW	Date	M. vitrata (larvae plant^{-1})	H. armigera (larvae plant^{-1})	Tmax (°C)	Tmin (°C)	Avg. Temp. (°C)	RH1 (%)	RH2 (%)	Avg. RH (%)	Rainfall (mm)
13	Mar 26–Apr 1	0.00	0.00	32.9	19.1	26.0	65.9	43.9	54.9	0.0
14	Apr 2–Apr 8	0.00	0.34	33.8	18.4	26.1	68.4	40.3	54.4	2.6
15	Apr 9–	0.59	1.25	31.5	17.4	24.4	59.3	42.7	51.0	10.4

	Apr 15									
16	Apr 16– Apr 22	1.92	2.60	39.7	21.2	30.4	41.7	23.9	32.8	0.5
17	Apr 23– Apr 29	2.65	3.50	41.7	25.3	33.5	34.1	20.0	27.1	0.0
18	Apr 30– May 6	4.80	6.50	34.7	21.7	28.2	68.3	42.1	55.2	9.8
19	May 7– May 13	5.69	7.30	33.9	21.7	27.8	61.8	45.1	53.5	2.8
20	May 14– May 20	7.50	9.65	38.5	24.9	31.7	47.7	33.6	40.7	17.6
21	May 21– May 27	10.56	6.52	43.1	27.7	35.4	30.0	22.3	26.2	0.0
22	May 28– Jun 3	7.25	4.30	37.5	23.8	30.7	56.3	41.9	49.1	0.0
23	Jun 4– Jun 10	4.30	2.12	38.4	26.2	32.3	52.9	41.9	47.4	7.4
24	Jun 11– Jun 17	1.25	1.20	37.0	25.0	31.0	63.3	47.9	55.6	43.6
25	Jun 18– Jun 24	0.62	0.45	37.7	26.4	32.1	55.3	42.9	49.1	0.0

Note: Tmax = maximum temperature; Tmin = minimum temperature; RH1 = morning relative humidity; RH2 = evening relative humidity.

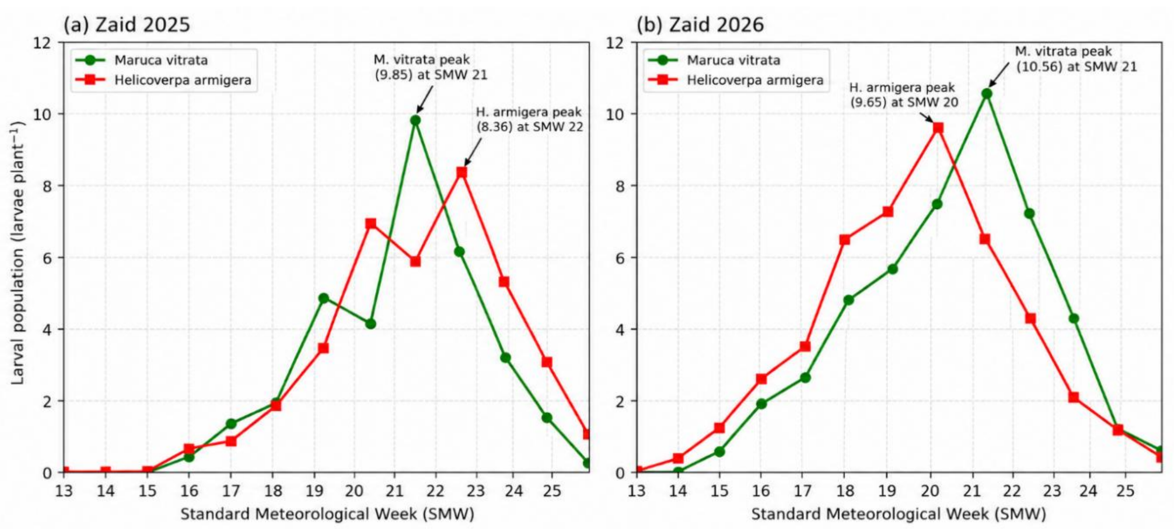

Figure 1. Seasonal population dynamics of Maruca vitrata and Helicoverpa armigera on blackgram during Zaid 2025 and 2026

3.4 Relationship with Weather Parameters during Zaid 2026

As presented in Table 4, M. vitrata showed significant positive correlations with minimum temperature ($r = 0.556$, $p < 0.05$) and average temperature ($r = 0.566$, $p < 0.05$) during 2026. Maximum temperature was positively but non-significantly associated with pest abundance, whereas morning, evening, and average relative humidity and rainfall showed negative but non-significant relationships. The shift from a significant association with evening relative humidity in 2025 to significant associations with minimum and average temperatures in 2026 indicates substantial interannual variation in the meteorological correlates of M. vitrata. Comparable season-dependent responses have been documented in other legume production systems, where the strength and direction of relationships between M. vitrata and weather parameters varied with host crop and season (Jayabal & Kennedy, 2022).

No meteorological variable showed a statistically significant relationship with H. armigera during 2026. Maximum, minimum, and average temperatures exhibited positive but non-significant correlations, while all relative humidity measures were negatively associated with population abundance. Rainfall showed an almost negligible positive relationship ($r = 0.009$). The contrast between the significant minimum-temperature relationship observed in 2025 and the absence of significant associations in 2026 indicates that the seasonal abundance of H. armigera cannot be explained by a single weather variable across years.

Table 4. Correlation of M. vitrata and H. armigera populations with weather parameters during Zaid 2026

Weather parameter	M. vitrata (r)	H. armigera (r)
Maximum temperature (°C)	0.526 NS	0.308 NS
Minimum temperature (°C)	0.556*	0.330 NS
Average temperature (°C)	0.566*	0.333 NS
Morning relative humidity (%)	−0.486 NS	−0.317 NS
Evening relative humidity (%)	−0.341 NS	−0.287 NS
Average relative humidity (%)	−0.434 NS	−0.311 NS
Rainfall (mm)	−0.111 NS	0.009 NS

* Significant at $p < 0.05$; NS = non-significant; n = 13 weekly observations.

3.5 Comparative Seasonal Pattern and Implications

Comparison of Tables 1 and 3 shows that M. vitrata exhibited relatively stable peak timing across the two seasons, attaining maximum abundance during the 21st SMW in both 2025 and 2026, with peak populations of 9.85 and 10.56 larvae plant^{-1}, respectively. In contrast, the timing of the H. armigera peak varied between years, occurring during the 22nd SMW in 2025 and the 20th SMW in 2026. These observations indicate that the seasonal dynamics of the two pod borers overlap but are not completely synchronized.

The correlation patterns in Tables 2 and 4 further demonstrate that the weather variables associated with pest abundance differed both between species and between seasons. Evening relative humidity was significantly associated with M. vitrata in 2025, while minimum and average temperatures were significant in 2026. For H. armigera, only minimum temperature showed a significant association in 2025, and no significant meteorological relationship was detected in 2026. Similar year-to-year and species-specific differences in the influence of abiotic factors on blackgram pod borers have been reported under western Uttar Pradesh conditions (Yadav et al., 2023). The species- and season-specific relationships between pod-borer populations and meteorological variables are further illustrated in Figure 2.

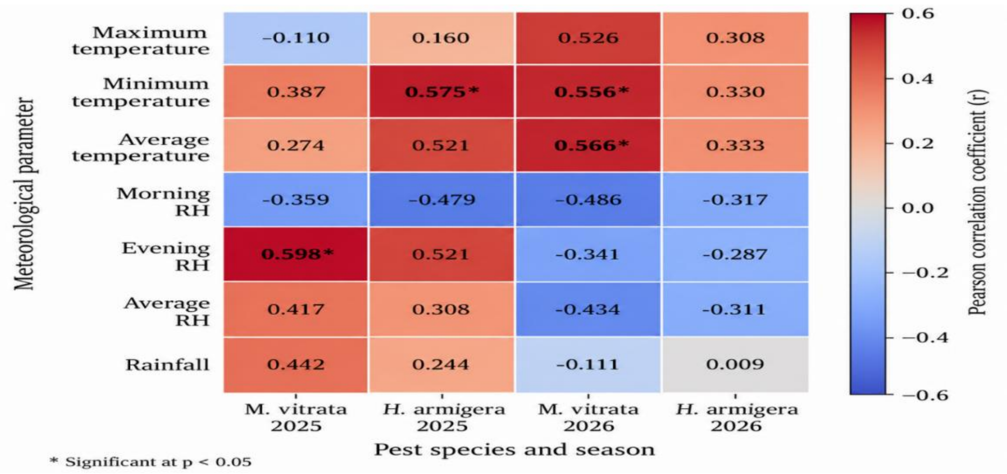

Figure 2. Correlation of Maruca vitrata and Helicoverpa armigera populations with meteorological parameters during Zaid 2025 and 2026

The results suggest that pest occurrence is influenced by the interaction of both crop phenology and multiple environmental factors, and not by any one meteorological factor alone. The maximum population of these two species occurred from the 20th to 22nd SMW which coincides with the reproductive stage of blackgram, in which flowers and growing pods are suitable feeding sites for both species. This means that monitoring should start before the large-scale population increase and continue through the flowering phase and pod development. In fact, regular field monitoring, in combination with current weather conditions, is likely to offer a better basis to determine management needs and start management actions at the appropriate time based on the need, rather than on a specific calendar week.

4.CONCLUSION

The present investigation revealed that there is a distinct seasonality of Maruca vitrata and Helicoverpa armigera on blackgram under the condition of western Uttar Pradesh (WUP) during Zaid seasons 2025 and 2026. Pod borers exhibited a progressive population build-up during crop development, with maximum numbers occurring at different times between the two species and seasons. M. vitrata showed its highest population during the 21st standard meteorological week (SMW) in both years, with 9.85 and 10.56 larvae plant^{-1} in 2025 and 2026, respectively. H. armigera peaked later in 2025, during the 22nd SMW (8.36 larvae plant^{-1}), but reached its peak earlier in 2026 during the 20th SMW (9.65 larvae plant^{-1}). The differences suggest that these two pests have overlapping but not identical seasonalities.

The relationships between pest populations and weather parameters were also species- and season-specific. Evening relative humidity had a significant positive correlation with M. vitrata in 2025 and minimum temperature had a significant positive correlation with H. armigera in 2025. In 2026, M. vitrata had significant positive correlations with minimum and average temperature but none of the meteorological variables were significantly correlated with H. armigera. No one weather variable consistently accounted for fluctuations in both pests in either season and the rainfall was not significantly correlated with either.

The most intense pest activity occurred during the 20th to 22nd SMWs which indicate the reproductive stage of blackgram as a time to be kept under surveillance. Early detection through regular monitoring before this period and continuing through flowering and pod development can support timely and need-based IPM under western Uttar Pradesh conditions.

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