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Spatial And Seasonal Variation In Population Dynamics Of Gram Pod Borer, *Helicoverpa Armigera* (Hübner) Infestations On Chickpea In Tropical Climatic Condition, India

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Abstract

Helicoverpa armigera, commonly known as the gram pod borer, is a major pest that poses a significant threat to chickpea (*Cicer arietinum* L.) cultivation across India, especially in the Rabi season. This study was conducted during the 2023 to 2024 and 2024 to 2025 two consecutive Rabi seasons in Prayagraj, Uttar Pradesh, India, intending to map the temporal and spatial distribution of H. armigera infestations and examine their relationship with key weather variables. Weekly larval counts were recorded from the 5th to the 14th Standard Meteorological Week (SMW). The weather parameters, including temperature, relative humidity and rainfall, were documented and statistically analyzed. The results revealed that *H. armigera* larval activity began in the 5th SMW and peaked consistently in the 12th SMW during both years, coinciding with the flowering and pod-setting stages of the chickpea crop. Correlation analysis indicated a significant positive association between larval population and maximum and minimum temperatures (r = 0.624 to 0.716) as well as relative humidity (r = 0.750 to 0.873). Rainfall showed no significant influence on pest population dynamics, highlighting the dominance of thermal and humidity-related triggers in the Rabi season. These findings underscore the need for early pest surveillance and climate-informed pest management strategies. The study recommends initiating field monitoring from the 5th SMW and implementing timely interventions based on weather trends to minimize crop losses. The insights also support the development of region-specific pest forecasting models, which can empower farmers with early warning tools and improve the precision of integrated pest management (IPM) programs.

Keywords: ***Helicoverpa*** **armigera, chickpea, population dynamics, seasonal distribution, pest forecasting, IPM**

1. Introduction

Chickpea (***Cicer arietinum L.***), often called the poor man's meat due to its high protein content. It is a stable pulse crop with a kind of pulses for millions of people across the Indian subcontinent **(Kumawat et al., 2023; Srivastava et al, 2025).** It contributes not only to food and nutritional security but also enriches soil fertility through biological nitrogen fixation. However, the promise of chickpea as a sustainable food crop is severely threatened by a tenacious pest, the gram pod borer, *Helicoverpa armigera.* Known for its polyphagous feeding habits and wide host range, *H. armigera* poses a significant challenge to chickpea growers, especially small and marginal farmers. This pest is notorious for feeding directly on the economic parts of the plant, flowers, developing pods, and seeds, often leading to yield losses as high as 30–40%, and in some cases, up to 90% if unmanaged **(Sehgal & Ujagir, 1990; Jat & Ameta, 2013, Srivastava, 2024a; Balraj et al. 2025)**. Compounding the problem, its ability to migrate, enter facultative diapause, and develop resistance to multiple insecticide groups makes it a formidable adversary in the field **(Zalucki et al., 1994; Sharma, 2005; Srivastava et al., 2024b).**

Understanding when and where *H. armigera* strikes hardest is essential for crafting timely and location-specific management strategies. While various control measures, ranging from chemical sprays to integrated pest management, are in practice, their effectiveness depends largely on accurate knowledge of the pest's temporal and spatial distribution. Yet, such detailed and localized insights remain scarce in many regions of India, including Eastern Uttar Pradesh, where chickpea is a major Rabi crop.

This study aims to bridge that gap. By documenting the weekly incidence of *H. armigera* across different stages of chickpea growth and correlating it with key weather parameters, we seek to map the pest's seasonal behavior and highlight its environmental triggers. This knowledge can empower farmers and extension workers with predictive tools and early warning signals, enhancing preparedness and reducing crop losses sustainably. In this context, we present findings from a two-season field investigation **(Rabi 2023 to 2024 and 2024 to 2025)** conducted in Prayagraj, Uttar Pradesh, to trace the trail of *H. armigera* across time and temperature, with the goal of informing smarter pest control strategies.

2. Materials and Methods

2.1 Study Area

The present investigation was undertaken during the Rabi seasons of 2023 and 2024 at the Research Farm of Kulbhaskar Ashram P.G. College, Prayagraj, Uttar Pradesh, and nearby farmers' fields to ensure ecological validity under practical conditions. Prayagraj, located in the Central Plain Agro-climatic Zone of Uttar Pradesh, is characterized by a tropical climate with marked seasonal variations, making it suitable for studying pest dynamics in chickpea cultivation. The crop selected for the study was chickpea (*Cicer arietinum* L.), an important pulse crop in the region. The experimental layout followed a Completely Randomized Design (CRD), comprising 17 bioassay treatments and 5 management treatments, each replicated three times to maintain statistical rigour. The trial plots were maintained at a size of 2 × 2 meters, with a spacing of 30 cm between rows and 10 cm between plants, ensuring uniform plant distribution and accurate observation. This setup facilitated a systematic evaluation of *Helicoverpa armigera* infestation patterns and the effectiveness of various bio-rational and management interventions under field conditions.

larvae per meter row length

2.2 Monitoring of *Helicoverpa armigera* Incidence

Systematic field observations were undertaken to record the incidence and population dynamics of *H. armigera* throughout the crop growth period. Weekly larval counts were conducted from the 5th to the 14th Standard Meteorological Week (SMW). For each observation, plants within a 1-meter row length were gently shaken, and the dislodged larvae were collected on a 1 m² white cloth sheet placed beneath the canopy. Observations were made at three randomly selected locations per field to ensure representative sampling. The larvae were subsequently counted and returned to their respective plots to preserve ecological balance.

2.3 Meteorological Data Collection and Correlation Analysis

Meteorological parameters, including maximum and minimum temperatures (°C), relative humidity (%), and total rainfall (mm), were recorded weekly from the nearest agrometeorological observatory. These parameters were analyzed to determine their influence on larval population dynamics. The relationships between weather variables and larval population densities were statistically evaluated using Pearson's correlation coefficient (r), providing insights into climatic factors driving pest incidence.

Formula

- To get the Pooled value, the average of the observations from 2023 and 2024 was calculated for each week:

Pooled Mean= Value in 2023+Value in 2024 / 2

$$\text{Pooled Mean} = \frac{\text{Value in 2023} + \text{Value in 2024}}{2}$$

➢ ® = Correlation coefficient (Pearson's *r*)

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 (y_i - \bar{y})^2}}$$

Where:

- x_i = individual values of the weather parameter (e.g., max temperature)
- y_i = corresponding values of *H. armigera* larval count
- $\bar{x}$ = mean of X values
- $\bar{y}$ = mean of Y values
- r = correlation coefficient ranging from -1 to +1

3. Results and Discussion

The weekly meteorological data was recorded during the Rabi seasons of 2023 to 2024 and 2024 to 2025 at the Research Farm and selected adjoining farmers' fields in Prayagraj district. (Table 1). This data reported in respect of variation in temperature, relative humidity and rainfall during the crucial chickpea growth phase from early vegetative to reproductive stages which also corresponds with the active period of *H. armigera* infestations.

Table 1 Seasonal Incidence of *H. armigera* (larvae per meter row length)

Standard Meteorological Week (SMW)	2023 to 2024	2024 to 2025	Pooled
5	0.17	0.50	0.34
12	5.78	6.86	6.32
14	2.79	3.56	3.18

The data indicates that the larval population was present on chickpea after 4 weeks of sowing and which was exhibiting low numbers during the early vegetative stage. During the 5th SMW, when initial larval presence was reported, average maximum temperatures ranged between 32.7 °C (2023 to 2024) and 36.2 °C (2024 to 2025), with relatively warm nights and moderate humidity. These early-season conditions appear suitable for oviposition and early instar development, although larval numbers remained low. As the season progressed towards the 12th SMW, a noticeable drop in temperature occurred, particularly in the minimum temperature, which dipped to around 10–11 °C, while relative humidity remained consistently high, particularly in the mornings. These environmental conditions mild temperatures with moderate to high humidity appear to be optimal for larval growth and activity, which is reflected in the larval population peak during this period.
Interestingly, rainfall was negligible throughout the season, particularly between the 6th and 13th SMW, confirming that chickpea during Rabi is largely grown under dry land or controlled irrigation conditions. Therefore, temperature and humidity emerged as the more influential environmental drivers during the infestation window. This observation is consistent with earlier findings by **Bajya et al. (2010),** who noted that morning and evening humidity, along with moderate temperatures, positively influenced *H. armigera* activity in pulses.

Table 2. Correlation between Weather Parameters and *H. armigera* Infestation

Parameter	2023 to 2024®	2024 to 2025®
Maximum Temperature (°C)	0.624**	0.716**
Minimum Temperature (°C)	0.587**	0.696**
Maximum Relative Humidity (%)	0.750**	0.840**
Minimum Relative Humidity (%)	0.812**	0.873**
Rainfall (mm)	0.188 NS	0.342 NS

** indicates statistically significant at 1% level;

NS = Non Significant

Table 2 quantifies the strength of association between weather variables and *H. armigera* infestation levels using Pearson's correlation coefficients. The analysis offers valuable insights into the climate-responsiveness of the pest.

- In both 2023 to 2024 and 2024 to 2025, maximum and minimum temperatures showed strong positive correlations with larval population growth. For example, maximum temperature correlated at r = 0.624 in 2023 to 2024 and r = 0.716 in 2024 to 2025, indicating that warmer days promote larval activity and feeding.
- Even more notable was the correlation between relative humidity (RH) and larval population. Maximum RH (morning) had correlation values of r = 0.750 (2023 to 2024) and 0.840 (2024 to 2025), while minimum RH (evening) showed r = 0.812 (2023 to 2024) and 0.873 (2024 to 2025). These strong associations confirm that humidity plays a critical role in larval survival and movement, particularly during the tender stages of chickpea development.
- Conversely, rainfall did not exhibit any significant relationship with larval populations in either season. This is expected given the dry nature of the Rabi season and aligns with findings by Panday et al. (2014), who observed a similar lack of influence from rainfall during *H. armigera* infestations.

In essence, the infestation pattern of *H. armigera* is strongly climate-responsive, with temperature and humidity emerging as reliable predictors of pest outbreaks. These results reinforce the value of integrating weather monitoring into pest surveillance systems — a practice recommended by several researchers (Yadav & Jat, 2009; Ramteke et al., 2014; Sharma et al., 2020) for improving the timing and effectiveness of pest control strategies. Bajya et al. (2022) was observed highest larval population of gram pod borer during the pod formation stage and had significant positive correlation with maximum temperature (r = 0.58*) and non-significant positive correlation with minimum temperature (r = 0.287).

4. Conclusion

The present study sheds light on a critical aspect of chickpea cultivation in Eastern Uttar Pradesh, the seasonal rhythm and climatic preferences of *H. armigera*, a pest notorious for causing devastating losses to pulse crops. Through two consecutive Rabi seasons (2023 to 2024 and 2024 to 2025), the research traced larval population trends and evaluated how they intertwined with key weather variables such as temperature, relative humidity, and rainfall. The findings reveal that *H. armigera* is not a random visitor in chickpea fields; it follows a consistent seasonal pattern. Larval activity began modestly in late January (5^{th} SMW), intensified with warming days and sustained humidity, and reached a peak during mid-March (12^{th} SMW), precisely when the chickpea crop enters its most vulnerable reproductive stage. This synchronization between crop growth and pest build up highlights a window of opportunity for early intervention.
Moreover, the strong positive correlation between larval populations and both temperature and relative humidity underscores the climate-sensitivity of this pest. Rainfall, interestingly, had no significant bearing on infestation levels, suggesting that temperature and humidity are the more reliable climatic indicators in the dry Rabi context. These insights validate and extend earlier findings by researchers such as **Panday et al. (2014)** and **Ramteke et al. (2014)**, and support a growing consensus that weather-based pest prediction tools should be central to integrated pest management (IPM) programs.
In practical terms, this study provides a foundation for developing location-specific pest forecasting calendars, empowering farmers and extension workers with early warning systems. Monitoring larval activity from the 5^{th} SMW, and correlating field observations with real-time weather data, can greatly enhance the precision of insecticide application, reduce overuse of chemicals, and promote ecological balance. Looking ahead, integrating remote sensing, automated pest surveillance, and predictive modelling could further strengthen pest forecasting systems. As climate change continues to alter agroecosystems, such localized, data-driven approaches will be essential for sustaining chickpea productivity and securing farmer livelihoods.

5. Recommendations

- **Begin Monitoring Early**: Start checking chickpea fields for *H. armigera* from the 5th SMW, as early signs of infestation appear around this time.
- **Timely Intervention**: Apply control measures before the 12^{th} SMW, ideally by the 11^{th} week, to manage peak pest pressure.

- **Use Weather as a Guide**: Focus on temperature and humidity trends, warm and humid conditions signal higher pest risk.
- **Ignore Rainfall as a Predictor**: Rainfall had no significant link with infestations; it should not guide pest control timing.
- **Create Local Pest Calendars**: Develop region-specific advisories to help farmers time their interventions effectively.
- **Promote Eco-Friendly Methods**: Encourage biological or botanical controls in early stages to reduce chemical dependence.
- **Integrate Weather Data in IPM**: Link climate patterns with pest forecasting in Integrated Pest Management (IPM) programs.

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