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Ecological study on pest dynamics and *Helicoverpa armigera* (Hub.) activity in gram under varying weather conditions

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Abstract

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in India; however, its productivity is constrained by several insect pests, particularly the gram pod borer, *Helicoverpa armigera* (Hubner). Understanding seasonal pest dynamics and their relationship with weather parameters is essential for developing effective forecasting and integrated pest management (IPM) strategies. *Helicoverpa armigera* was the predominant insect pest during both cropping seasons. Larval infestation commenced during the 50th Standard Meteorological Week (SMW) and reached its peak during the 12th SMW, recording 8.20 and 7.70 larvae plant⁻¹ during 2022–23 and 2023–24, respectively, with seasonal mean populations of 2.38 and 2.31 larvae plant⁻¹. Other insect pests, namely *Autographa nigrisigna*, *Spodoptera litura*, and *Aphis craccivora*, occurred at comparatively lower population levels. Adult moth catches in pheromone traps closely followed the seasonal build-up of larval populations, demonstrating the utility of pheromone-based surveillance for early pest detection. The abundance of natural enemies, particularly *Coccinella septempunctata* and *Mantis religiosa*, increased following pest establishment, indicating their contribution to natural biological control. Correlation analysis revealed that fluctuations in *H. armigera* populations were significantly influenced by prevailing weather variables, particularly temperature and relative humidity, confirming the importance of meteorological factors in determining seasonal pest incidence.

Keywords: *Cicer arietinum*, *Helicoverpa armigera*, chickpea, population dynamics, pheromone trap, weather parameters, natural enemies, integrated pest management

Introduction

Chickpea (*Cicer arietinum* L.) is the second most widely cultivated grain legume after common bean and constitutes an important component of sustainable agricultural systems worldwide. It is an excellent source of plant protein (18–24%), carbohydrates, dietary fibre, vitamins, and essential minerals, making it a vital crop for nutritional security, particularly in developing countries. Besides its nutritional significance, chickpea improves soil fertility through symbiotic nitrogen fixation, contributes to carbon sequestration, and enhances the sustainability of cereal-based cropping systems. Despite remarkable progress in varietal development and crop management practices, the average productivity of chickpea remains considerably lower than its attainable potential due to several biotic and abiotic constraints, among which insect pests constitute one of the most important yield-limiting factors.

More than 60 insect species have been reported infesting chickpea under different agro-ecological conditions; however, only a few attain economic importance. Among these, the gram pod borer, *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae), is recognized as the most destructive pest of chickpea throughout South Asia. A single larva can damage several pods during its development, resulting in substantial reductions in grain yield and quality. Although *H. armigera* remains the principal insect pest, chickpea fields harbour a diverse complex of other insect species, including the semilooper, *Autographa nigrisigna* (Walker), tobacco caterpillar, *Spodoptera litura* (Fabricius), and aphid, *Aphis craccivora* Koch. Individually, these pests may not always exceed economic threshold levels, but their combined infestation can adversely affect crop growth, reduce photosynthetic efficiency, impair pod development, and ultimately lower grain yield.

Consequently, effective pest management requires continuous monitoring of the entire insect pest complex rather than focusing exclusively on *H. armigera*. Pheromone-based monitoring has emerged as an effective, species-specific, and environmentally benign technique for surveillance of *H. armigera*. Synthetic sex pheromone traps attract male moths and provide an early indication of pest activity before significant larval infestation occurs in the field. Regular monitoring of adult moth catches facilitates the identification of seasonal flight peaks and enables timely implementation of control measures. When combined with weather observations, pheromone trap catches improve the accuracy of pest forecasting and support decision-making in integrated pest management programmes. Consequently, pheromone-based surveillance has become an indispensable component of modern IPM strategies for *H. armigera* in several agricultural cropping systems.

Natural enemies also play a vital role in regulating insect pest populations in chickpea ecosystems. Predators such as the seven-spotted ladybird beetle (*Coccinella septempunctata* Linnaeus), praying mantid (*Mantis religiosa* Linnaeus), spiders, dragonflies, lacewings, and ground beetles contribute significantly to the suppression of aphids and lepidopteran larvae under natural field conditions. Although several investigations have been conducted on chickpea insect pests in different agro-climatic regions of India, the seasonal incidence of major insect pests and their association with weather parameters vary considerably with geographical location, sowing time, cropping pattern, and climatic conditions. Information generated under one agro-ecological region cannot be directly extrapolated to another.

In the Vindhyan Plateau of Madhya Pradesh, comprehensive information regarding the seasonal dynamics of major chickpea insect pests, adult activity of *H. armigera*, associated natural enemies, and their relationship with weather parameters remains limited. Such region-specific information is indispensable for developing reliable pest forecasting models and location-specific integrated pest management strategies. Therefore, the present investigation was undertaken to study the seasonal population dynamics of major insect pests and associated natural enemies on chickpea during two consecutive Rabi seasons, and monitor the adult activity of *Helicoverpa armigera* using species-specific pheromone traps, with determine the influence of prevailing weather parameters on pest incidence under the agro-climatic conditions of the Vindhyan Plateau of Madhya Pradesh.

Materials and Methods

Field investigations were conducted during two consecutive Rabi seasons (2022–23 and 2023–24) at the Instructional-cum-Research Farm, Faculty of Agriculture, Rabindranath Tagore University, Raisen, Madhya Pradesh, India. Seasonal incidence of major insect pests and associated natural enemies was monitored in unsprayed chickpea plots through weekly observations, while adult activity of *H. armigera* was assessed using species-specific pheromone traps. Concurrent meteorological data comprising maximum and minimum temperature, morning and evening relative humidity, rainfall, wind speed, and bright sunshine hours were collected to determine their influence on pest incidence through correlation analysis. *Helicoverpa armigera* was the predominant insect pest during both cropping seasons. Larval infestation commenced during the 50th Standard Meteorological Week (SMW) and reached its peak during the 12th SMW, recording 8.20 and 7.70 larvae plant⁻¹ during 2022–23 and 2023–24, respectively, with seasonal mean populations of 2.38 and 2.31 larvae plant⁻¹. Other insect pests, namely *Autographa nigrisigna*, *Spodoptera litura*, and *Aphis craccivora*, occurred at

comparatively lower population levels. Adult moth catches in pheromone traps closely followed the seasonal build-up of larval populations, demonstrating the utility of pheromone-based surveillance for early pest detection.

The abundance of natural enemies, particularly *Coccinella septempunctata* and *Mantis religiosa*, increased following pest establishment, indicating their contribution to natural biological control. Correlation analysis revealed that fluctuations in *H. armigera* populations were significantly influenced by prevailing weather variables with the study establishes that integration of weather-based surveillance with pheromone trap monitoring provides a reliable approach for forecasting *H. armigera* outbreaks in chickpea

Results and Discussion

The seasonal incidence of major insect pests on chickpea was monitored during the Rabi seasons of 2022–23 and 2023–24 under unsprayed field conditions. Four major insect pests, namely *Helicoverpa armigera* (Hübner), *Autographa nigrisigna* (Walker), *Spodoptera litura* (Fabricius), and *Aphis craccivora* Koch, were recorded during the crop growth period. Among these, *H. armigera* was the dominant and most destructive pest in both years, whereas the remaining species occurred at comparatively lower population levels. The present findings are in agreement with earlier reports of Ghosh *et al.* (2013), Sharma (2016), and Jat and Ameta (2019) [8], who also identified *H. armigera* as the most serious pest of chickpea across different agro-climatic zones of India. Similar observations were made by Singh *et al.* (2020), who reported that pod borer incidence remains consistently higher than other insect pests during the reproductive stage of chickpea.

Incidence of *Helicoverpa armigera*

The larval population of *H. armigera* first appeared during the 50th SMW in both cropping seasons and increased with crop development. Population density was low during the vegetative stage but increased sharply during flowering and pod initiation, reaching a peak during the 12th SMW, with 8.20 and 7.70 larvae plant⁻¹ in 2022–23 and 2023–24, respectively. Thereafter, the population declined towards crop maturity. The seasonal mean was 2.38 and 2.31 larvae plant⁻¹, respectively, indicating a consistent seasonal pattern across years.

The higher larval abundance during flowering and pod formation was likely due to the availability of succulent reproductive tissues that favour oviposition and larval feeding. The subsequent decline may be associated with crop senescence, reduced food availability, and increased natural-enemy activity. Similar peak activity during flowering and podding has been reported by Lal *et al.* (2015), Patel and Yadav (2018) [11], and Kumar *et al.* (2021). Comparable seasonal trends, with maximum populations during February followed by a decline towards maturity, were also reported by Singh and Singh (2014), Sharma *et al.* (2017), and Reddy *et al.* (2020). The consistent population pattern observed over two years confirms that crop phenology strongly influences *H. armigera* abundance under the agro-climatic conditions of the Vindhyan Plateau. These findings highlight the importance of focused pest surveillance during flowering and pod development for timely implementation of IPM measures and reduction of unnecessary insecticide applications.

Incidence of *Autographa nigrisigna*

The semilooper, *Autographa nigrisigna*, was recorded from the vegetative stage and persisted up to the reproductive stage of chickpea. Its population remained considerably lower than that of

H. armigera during both cropping seasons, with only occasional foliage damage and no economically significant infestation. The low and sporadic occurrence observed in the present study agrees with the findings of Verma and Singh, who reported *A. nigrisigna* as a minor pest of chickpea. Therefore, routine monitoring appears sufficient, with management interventions required only when favourable conditions result in an unusual increase in population.

Incidence of *Spodoptera litura*

The tobacco caterpillar, *S. litura*, occurred at low population levels, mainly during the vegetative stage of chickpea. Larvae fed on tender foliage and caused characteristic irregular defoliation. Population density showed slight seasonal fluctuations but remained below the economic threshold throughout both years. Thus, *S. litura* appeared to be an occasional defoliator of chickpea under the climatic conditions of the Vindhyan Plateau. Similar observations were reported by Patel; Gupta and Sharma, who noted that *S. litura* generally attains economic importance under humid conditions or during outbreak years in pulse crops.

Incidence of *Aphis craccivora*

Colonies of *A. craccivora* appeared mainly on tender shoots and young leaves during the vegetative stage. Population density increased under cool conditions but declined with rising temperature and crop maturity. Infestations remained localized, with no severe outbreaks in either season. Similar seasonal trends have been reported by Singh; Kumar and Singh. The association of aphid populations with coccinellids and chrysopids suggests an

important role of natural enemies in regulating aphid abundance, as reported by Sharma.

Among the recorded pests, *H. armigera* was the predominant species and posed the major threat to chickpea production, while other pests occurred at comparatively low levels. Similar pest incidence across both seasons indicates that chickpea pest dynamics are largely influenced by crop phenology and weather conditions. These findings support timely pest surveillance and weather-based IPM strategies for sustainable chickpea production. The present study provides comprehensive information on the seasonal dynamics of major insect pests, natural enemies, and adult activity of *Helicoverpa armigera* in chickpea under the agro-climatic conditions of the Vindhyan Plateau of Madhya Pradesh. Among the insect pests recorded, *H. armigera* was the predominant and most destructive species, with peak larval populations occurring during the flowering and pod formation stages of the crop. The incidence of *Autographa nigrisigna*, *Spodoptera litura*, and *Aphis craccivora* remained comparatively low and did not attain economically damaging levels during the study period.

The populations of natural enemies, particularly *Coccinella septempunctata* and *Mantis religiosa*, increased following pest establishment, suggesting their role in natural pest regulation. Integrating weather-based surveillance, pheromone trap monitoring, conservation of natural enemies, and need-based interventions can enhance the effectiveness of IPM in chickpea. The findings provide a basis for developing location-specific pest forecasting and sustainable crop protection strategies for the Vindhyan Plateau and similar agro-ecological regions.

Table 1: Population dynamics of insect pests and natural enemies in chickpea and weather parameters during Rabi 2022-23

SMW	<i>Helicoverpa armigera</i>	<i>Autographa nigrisigna</i> (Walker)	<i>Aphis craccivora</i> (aphids/plant)	<i>Spodoptera litura</i>	<i>Coccinella septempunctata</i> (adults/plant)	<i>Mantis religiosa</i> Linnaeus
48	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
49	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
50	1 (1.22)	0 (0.71)	2 (1.58)	0 (0.71)	0 (0.71)	0 (0.71)
51	0.3 (0.89)	0 (0.71)	1 (1.22)	0 (0.71)	0.6 (1.05)	0.4 (0.95)
52	0.2 (0.84)	0 (0.71)	0.8 (1.14)	0 (0.71)	1 (1.22)	0.6 (1.05)
1	2.3 (1.67)	0.1 (0.77)	5 (2.35)	0.2 (0.84)	1 (1.22)	0 (0.71)
2	2 (1.58)	0.1 (0.77)	0.8 (1.14)	0 (0.71)	1.3 (1.34)	0.6 (1.05)
3	2.1 (1.61)	0.3 (0.89)	3 (1.87)	0.4 (0.95)	1.2 (1.30)	0.2 (0.84)
4	2 (1.58)	0.2 (0.84)	3.1 (1.90)	0.2 (0.84)	0.8 (1.14)	0.6 (1.05)
5	2.6 (1.76)	0.1 (0.77)	2.8 (1.82)	0.4 (0.95)	1.1 (1.26)	1 (1.22)
6	2.8 (1.82)	0.3 (0.89)	2.4 (1.70)	0.2 (0.84)	1 (1.22)	0.6 (1.05)
7	2.8 (1.82)	0.7 (1.10)	2 (1.58)	0.8 (1.14)	1 (1.22)	2 (1.58)
8	2.6 (1.76)	1.1 (1.26)	3.2 (1.92)	0.6 (1.05)	1.8 (1.52)	2 (1.58)
9	3.9 (2.10)	1.2 (1.30)	1.9 (1.55)	0.8 (1.14)	2 (1.58)	1 (1.22)
10	4.6 (2.26)	1.3 (1.34)	1.8 (1.52)	0.6 (1.05)	2.4 (1.70)	1.4 (1.38)
11	3.1 (1.90)	1 (1.22)	1.7 (1.48)	0.6 (1.05)	2.6 (1.76)	2 (1.58)
12	8.2 (2.95)	1.2 (1.30)	2.1 (1.61)	0.6 (1.05)	2.7 (1.79)	2.6 (1.76)
Mean	2.38	0.45	1.98	0.32	1.21	0.88

Figures in parentheses are $\sqrt{(X+0.5)}$ transformed values

Table 2: Correlation of weather parameters with insect pest and natural enemies during Rabi 2022-23

Sr. No	Weather parameter	<i>Helicoverpa armigera</i>	<i>Autographa nigrisigna</i>	<i>Aphis craccivora</i>	<i>Spodoptera litura</i>	<i>C. septempunctata</i>	<i>Mantis religiosa</i>
1	Maximum temperature (°C)	-0.69 (SN)	-0.52 (MN)	-0.61 (SN)	-0.48 (MN)	-0.42 (MN)	-0.39 (MN)
2	Minimum temperature (°C)	-0.71 (SN)	-0.55 (MN)	-0.58 (SN)	-0.46 (MN)	-0.44 (MN)	-0.41 (MN)
3	Morning RH (%)	+0.42 (MP)	+0.36 (MP)	+0.49 (MP)	+0.33 (LP)	+0.47 (MP)	+0.51 (MP)
4	Evening RH (%)	+0.41 (MP)	+0.34 (LP)	+0.46 (MP)	+0.31 (LP)	+0.45 (MP)	+0.48 (MP)
5	Rainfall (mm)	-0.46 (MN)	-0.29 (LP)	-0.38 (MN)	-0.26 (LP)	-0.22 (LP)	-0.25 (LP)
6	Wind speed (km h ⁻¹)	-0.33 (LP)	-0.21 (LP)	-0.27 (LP)	-0.18 (LP)	-0.16 (LP)	-0.19 (LP)
7	Bright sunshine (h)	-0.58 (SN)	-0.44 (MN)	-0.53 (SN)	-0.41 (MN)	-0.39 (MN)	-0.37 (MN)

Table 3: Population dynamics of insect pests and natural enemies in chickpea and weather Parameters during Rabi 2023-24

SMW	<i>Helicoverpa armigera</i>	<i>Autographanigrisigna</i> (Walker)	<i>A. craccivora</i> (aphids/plant)	<i>Spodoptera litura</i>	<i>C. septempunctata</i> (adults/plant)	Praying mantis
48	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)
49	0 (0.71)	0 (0.71)	2 (1.58)	0 (0.71)	0 (0.71)	0 (0.71)
50	1 (1.22)	0 (0.71)	2 (1.58)	0 (0.71)	0 (0.71)	0 (0.71)
51	0.6 (1.05)	0 (0.71)	3 (1.87)	0 (0.71)	0.6 (1.05)	0.2 (0.84)
52	0.2 (0.84)	0 (0.71)	5 (2.35)	0 (0.71)	1 (1.22)	0.6 (1.05)
1	1.6 (1.45)	0.1 (0.77)	2 (1.58)	0.2 (0.84)	1 (1.22)	0 (0.71)
2	2.1 (1.61)	0.2 (0.84)	1.2 (1.30)	0 (0.71)	1.3 (1.34)	0.6 (1.05)
3	2.4 (1.70)	0.3 (0.89)	2 (1.58)	0.4 (0.95)	1 (1.22)	0.4 (0.95)
4	2.2 (1.64)	0.2 (0.84)	1.5 (1.41)	0.2 (0.84)	0.8 (1.14)	0.6 (1.05)
5	2.1 (1.61)	0.1 (0.77)	2.2 (1.64)	0.6 (1.05)	1.1 (1.26)	1 (1.22)
6	2.4 (1.70)	0.4 (0.95)	3 (1.87)	0.2 (0.84)	1 (1.22)	0.6 (1.05)
7	2.6 (1.76)	1.6 (1.45)	2 (1.58)	1 (1.22)	1 (1.22)	2 (1.58)
8	2.4 (1.70)	2.2 (1.64)	2 (1.58)	0.6 (1.05)	1.8 (1.52)	2 (1.58)
9	4.2 (2.17)	1.4 (1.38)	2.4 (1.70)	0.8 (1.14)	2 (1.58)	1 (1.22)
10	5.6 (2.47)	1.3 (1.34)	2.2 (1.64)	0.6 (1.05)	2.1 (1.61)	1.4 (1.38)
11	5.6 (2.47)	2 (1.58)	1.1 (1.26)	0.6 (1.05)	2.6 (1.76)	2 (1.58)
12	7.7 (2.86)	1.4 (1.38)	1.2 (1.30)	0.8 (1.14)	2.7 (1.79)	2.4 (1.70)
Mean	2.51	0.66	2.05	0.35	1.18	0.87

Figures in parentheses are $\sqrt{(X+0.5)}$ transformed values

Table 4: Correlation of weather parameters with insect pest and natural enemies during Rabi 2023-24

Sr. No.	Weather parameter	<i>Helicoverpa armigera</i>	<i>Autographanigrisigna</i>	<i>Aphis craccivora</i>	<i>Spodoptera litura</i>	<i>C. septempunctata</i>	Praying mantis
1	Maximum temperature (°C)	+0.66 (SP)	+0.58 (MP)	+0.61 (SP)	+0.49 (MP)	+0.44 (MP)	+0.42 (MP)
2	Minimum temperature (°C)	+0.58 (MP)	+0.52 (MP)	+0.55 (MP)	+0.46 (MP)	+0.41 (MP)	+0.39 (MP)
3	Morning RH (%)	-0.74 (SN)	-0.62 (SN)	-0.69 (SN)	-0.55 (MN)	-0.51 (MN)	-0.48 (MN)
4	Evening RH (%)	-0.74 (SN)	-0.60 (SN)	-0.67 (SN)	-0.54 (MN)	-0.50 (MN)	-0.47 (MN)
5	Rainfall (mm)	+0.42 (MP)	+0.36 (MP)	+0.39 (MP)	+0.33 (LP)	+0.29 (LP)	+0.27 (LP)
6	Wind speed (km h ⁻¹)	+0.31 (LP)	+0.28 (LP)	+0.34 (LP)	+0.26 (LP)	+0.22 (LP)	+0.24 (LP)
7	Bright sunshine (h)	+0.59 (SP)	+0.48 (MP)	+0.54 (SP)	+0.45 (MP)	+0.43 (MP)	+0.41 (MP)

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