International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; 9(9): 29-32
www.biochemjournal.com
Received: 02-07-2025
Accepted: 06-08-2025

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Seasonal incidence of major defoliators and their natural enemies in soybean [*Glycine max* (L.) Merrill]

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i9a.5483

Abstract
Field experiments were conducted during *Kharif* 2024 at the Research Farm, R.A.K. College of Agriculture, Sehore (M.P.), to investigate the seasonal incidence of major defoliators and their natural enemies in soybean (*Glycine max* L.) variety NRC-152. The crop was sown in 40 cm spaced rows with seeds placed 4-5 cm deep using a hand liner. Three main defoliators *i.e.*, green semilooper (*Chrysodeixis acuta*), tobacco caterpillar (*Spodoptera litura*) and gram pod borer (*Helicoverpa armigera*) were seen at different crop stages, along with spiders as a natural enemy. The green semilooper appeared at the vegetative stage, persisting from the 2nd last week of July to the last week of September, with peak population (4.44 larvae/mrl) in the 3rd week of September. Tobacco caterpillar and gram pod borer also emerged at the vegetative stage, with activity recorded between the 30th and 38th Standard Meteorological Weeks, both peak in the 34th SMW with 2.89 and 3.78 larvae/mrl, respectively, coinciding with higher temperatures and lush vegetative growth. Spider populations were recorded from 28 days after sowing until crop maturity, ranging between 0.22 and 1.44 spiders/plant. Correlation analysis revealed that green semilooper and tobacco caterpillar populations had significant positive associations with relative humidity (r = 0.652 and r = 0.669, respectively; $p<0.05$), while spider populations showed a significant positive correlation with maximum temperature (r = 0.733, $p<0.05$).

Keywords: Soybean, defoliators, correlation analysis, natural enemy

Introduction
Soybean [*Glycine max* (L.) Merrill], recognized as the "wonder crop" of the 20th century, is also referred to as the yellow jewel or miracle bean. It is a predominant *kharif* oilseed crop in Madhya Pradesh, belonging to the Fabaceae family and Papilionaceae sub-family. In the Indian context, soybean holds significant value as both a major oilseed and an important pulse crop. Due to its exceptional nutritional composition, it is often called the "poor man's meat" and the "golden bean." The crop contributes to soil enrichment by fixing atmospheric nitrogen through its symbiotic relationship with Rhizobium bacteria in root nodules, earning the title "gold of the soil." Soybean grains comprise nearly 40% high-quality protein enriched with essential amino acids, 20% oil, 6-7% minerals and 17-18% carbohydrates (Chauhan & Joshi, 2005) [5]. Its oil is extensively used in the manufacture of vanaspati ghee and a range of industrial products such as antibiotics, protein supplements, soy milk and soy sauce.

Soybean is predominantly cultivated in nations including Brazil, the United States, China, India, Canada, Russia, Mexico, and Japan. Among these, Brazil ranks as the largest producer, accounting for nearly 40% of global output, followed by the United States with about 28%. Worldwide, soybean occupies approximately 136.9 million hectares, producing an estimated 428.9 million metric tonnes, with an average productivity of 3.13 metric tonnes per hectare. In India, the crop covers around 13.5 million hectares, with an annual production of nearly 12.8 million tonnes. Madhya Pradesh holds the leading position in soybean cultivation, covering about 53.48 lakh hectares and contributing approximately 55.39 lakh tonnes to the national output. The state records an average yield of around 1,125 kilograms per hectare (Anonymous, 2023) [2].

In India, about 20 insect species are recognized as major pests of soybean (*G. max*) (Singh & Singh, 1990) [7], with the tobacco caterpillar (*Spodoptera litura*), green semilooper

(*Chrysodeixis acuta*), and gram pod borer (*Helicoverpa armigera*) being the most destructive defoliators during the vegetative stage. Severe infestations may cause complete defoliation and substantial yield losses, with *S. litura* also inflicting direct pod damage (Patil, 2002) [8]. Other important pests include the girdle beetle (*Obereopsis brevis*), Bihar hairy caterpillar (*Spilarctia obliqua*), whitefly (*Bemisia tabaci*) and stem fly (*Melanagromyza sojae*), which together account for 15-20% yield reduction in India. The *S. litura* occurs regularly in both *kharif* (August-October) and *rabi* (November-March) seasons, feeding on leaves, tender shoots, and 30-50% of pods, while heavy leaf miner infestations stunt growth, reduce pod set, cause shriveling of grains and lower yields by up to 50% (Biswas, 2013) [3]. The success of any integrated pest management programme depends on a thorough understanding of the seasonal incidence of targeted pests. Therefore, the present investigation was carried out to study the seasonal incidence of major defoliators in soybean.

Material and Methods

The field experiment was conducted during the *kharif* season of 2024 at the Research Farm of R.A.K. College of Agriculture, Sehore, Madhya Pradesh, using soybean (*Glycine max*) variety NRC-152. Sowing was done on 1 July 2024 in furrows 4-5 cm deep with a row spacing of 40 cm and plant spacing of 10 cm, in plots measuring 15 × 15 m². The population of defoliator larvae was recorded from one meter row length (mrl) by shaking plants onto a muslin cloth at three locations per plot and calculating the mean. Natural enemy populations were recorded weekly from ten randomly selected plants, starting from their initial appearance until crop maturity. The recorded data on insect pests and natural enemy populations were correlated with meteorological parameters prevailing during the crop growth period. The data of weather parameters were collected from the Department of Agrometeorology, R.A.K., College of Agriculture, Sehore, Madhya Pradesh. The weather parameters and insect pests seasonal incidence correlations were calculated by using OPSTAT software.

Results and Discussion

Weekly monitoring data on the seasonal incidence of major defoliators and their natural enemies in soybean are presented in Table 4.1. The observations indicated the presence of four defoliator species along with their associated natural enemies at different growth stages of the crop during the *Kharif* season of 2024. The recorded defoliators included the green semilooper, tobacco caterpillar and gram pod borer.

The green semilooper (*Chrysodeixis acuta*) first appeared during the 29th Standard Meteorological Week (SMW) with an initial mean population of 0.56 larvae per meter row length (mrl) and gradually increased, reaching a peak of 4.44 larvae/mrl (34th SMW) (Table 1). Correlation analysis revealed a positive but non-significant relationship with maximum (r = 0.52) and minimum (r = 0.62) temperatures, a non-significant negative correlation with rainfall (r =-0.39) and a significant positive correlation with relative humidity (r = 0.65*), indicating that higher humidity favored the population build-up of this pest (Table 2 and Figure 1). The findings agree with earlier reports by Ahirwar *et al*. (2014) [1], Brahman *et al*. (2018) [4] and Sapekar *et al*. (2020) [10], who also identified *Chrysodeixis acuta* as a pest of soybean flowers and pods.

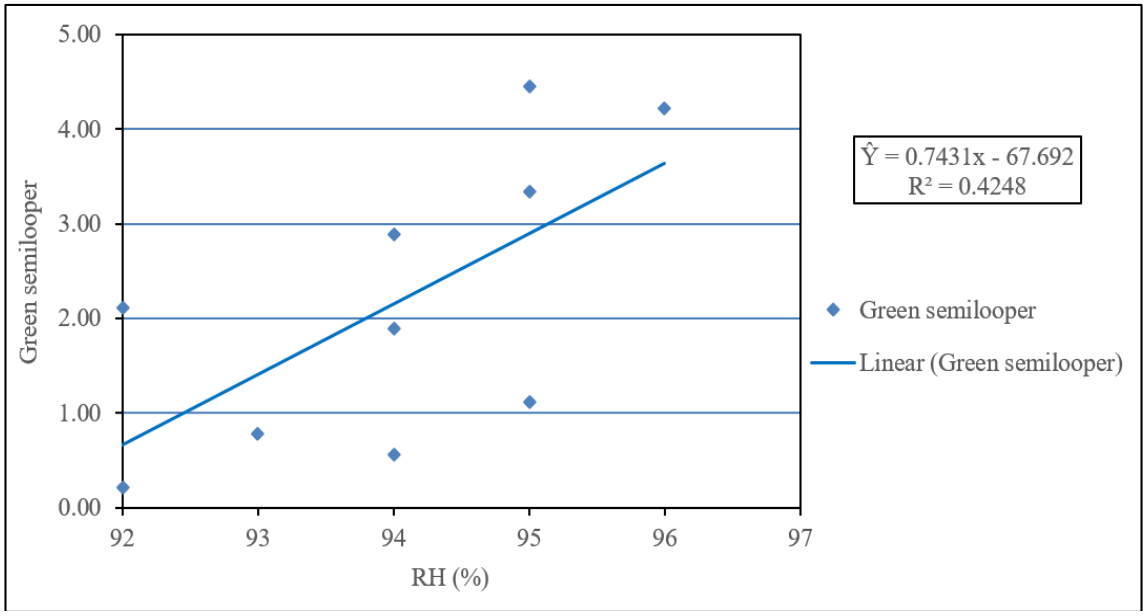

Fig 1: Effect of relative humidity (%) on Green semilooper larval population in soybean

The infestation of the tobacco caterpillar (*Spodoptera litura*) on soybean started during the 30th SMW and persisted until the 38th SMW, with larval populations ranging from 0.78 to 2.89 per mrl. The peak population of 2.89 larvae/mrl (34th SMW) (Table 1). Correlation analysis indicated a positive but non-significant relationship with maximum (r = 0.48) and minimum (r = 0.59) temperatures, a non-significant negative correlation with rainfall (r =-0.10) and a significant positive correlation with relative humidity (r = 0.67*), suggesting that higher humidity favoured larval build-up (Table 2 and Figure 2). The present findings align with Ahirwar *et al*. (2014) [1], Brahman *et al*. (2018) [4] and Sapekar *et al*. (2020) [10], who also reported *Spodoptera litura* as a serious phytophagous pest of soybean.

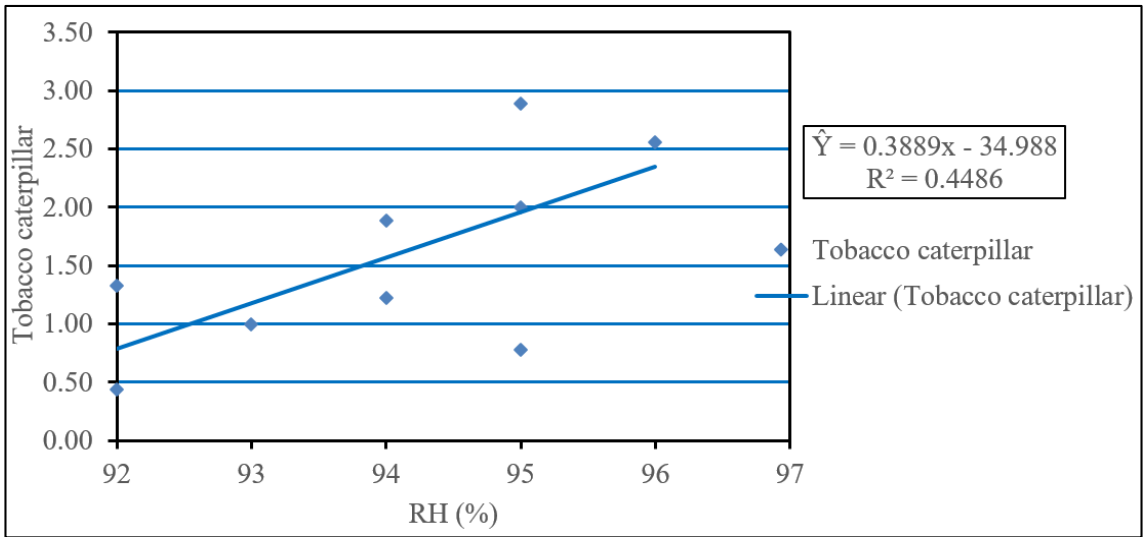

Fig 2: Effect of relative humidity (%) on Tobacco caterpillar larval population in soybean

The population of the gram pod borer (*Helicoverpa armigera*) began building up during the 30th SMW with an initial mean of 0.44 larvae per mrl and gradually increased, reaching a peak of 3.78 larvae/mrl (34th SMW) (Table 1). Correlation analysis showed a positive but non-significant relationship with maximum (r = 0.56) and minimum (r = 0.66) temperatures, a positive non-significant correlation with relative humidity (r = 0.55) and a negative non-significant correlation with rainfall (r =-0.22), indicating that temperature and humidity moderately influenced larval populations (Table 2). The present findings are in agreement with Karam *et al*. (2014) [1], Brahman *et al*. (2018) [4] and Sarvesh *et al*. (2018) [4], who also reported *Helicoverpa armigera* as a pest of soybean flowers and pods.

The spider population, a natural enemy of soybean pests, first appeared during the 30th SMW with an initial mean of 0.22 spiders per plant, coinciding with the emergence of host insects, and continued until the 38th SMW. Peak abundance was recorded in the 34th SMW, reaching 1.44 spiders per plant (Table 1). Correlation analysis showed a positive but non-significant relationship with minimum temperature (r = 0.48) and relative humidity (r = 0.35), a negative non-significant correlation with rainfall (r =-0.17) and a significant positive correlation with maximum temperature (r = 0.73*), indicating that higher temperatures favoured spider activity (Table 2 and Figure 3). Ahirwar *et al*. (2014) [1], Kushram (2016) [6], Sable *et al*. (2018) [9] and Patel *et al*. (2019) [7] reported spiders as natural enemies of insect pests in soybean.

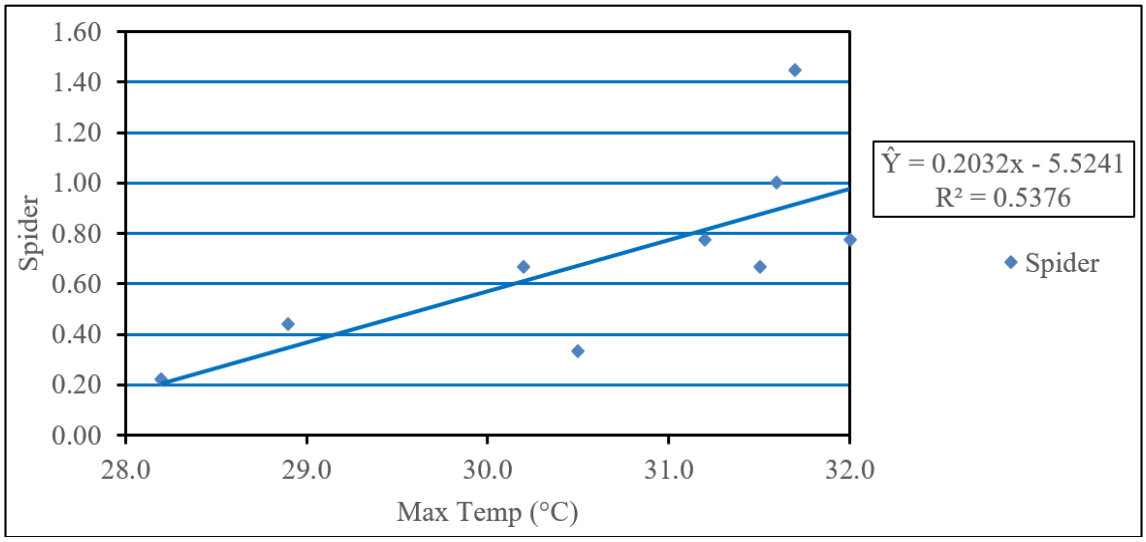

Fig 3: Effect of maximum temperature (^{0}C) on spider per plant population in soybean

Table 1: Seasonal incidence of major defoliators and their natural enemy on soybean crop during *kharif* season 2024

SMW	Meteorological data				Population of defoliators (No. of larvae/mrl)			Population of natural enemy/plant
	Max Temp (°C)	Min Temp (°C)	RH (%)	Rainfall (mm)	Green semilooper	Tobacco caterpillar	Gram pod borer	Spider
29	27.4	23.3	94	189.7	0.56	0	0	0
30	28.2	23.5	95	45.5	1.11	0.78	0.44	0.22
31	28.9	23.8	94	27.4	1.89	1.22	1.56	0.44
32	30.2	24.0	95	83.0	3.33	2.00	2.78	0.67
33	31.6	24.0	96	30.2	4.22	2.56	3.56	1.00
34	31.7	23.9	95	50.5	4.44	2.89	3.78	1.44
35	31.2	23.2	94	45.6	2.89	1.89	2.33	0.78
36	32.0	24.1	92	9.2	2.11	1.33	2.33	0.78
37	31.5	23.6	93	55.3	0.78	1.00	1.00	0.67
38	30.5	22.0	92	74.5	0.22	0.44	0.22	0.33

SMW: Standard Meteorological Week; Max Temp: Maximum Temperature; Min Temp: Minimum temperature; RH: Relative humidity; mrl: Meter Row Length

Table 2: Correlation between weather parameters and population of defoliators and their natural enemy in soybean crop during *Kharif* season 2024

S. No.	Metrological parameter		Defoliator's larvae/mrl			Population of natural enemy/plant
			Green semilooper	Tobacco caterpillar	Gram pod borer	Spider
1.	Max Temp	r	0.52^{NS}	0.48^{NS}	0.56^{NS}	0.73*
		byx	-	-	-	0.20
2.	Min Temp	r	0.62^{NS}	0.59^{NS}	0.56^{NS}	0.48^{NS}
		byx	-	-	-	-
3.	RH	r	0.65*	0.67*	0.55^{NS}	0.34^{NS}
		byx	0.74	0.39	-	-
4.	Rainfall	r	-0.39^{NS}	-0.10^{NS}	-0.22^{NS}	-0.17^{NS}
		byx	-	-	-	-

SMW: Standard Meteorological Week; Max Temp: Maximum Temperature; Min Temp: Minimum temperature; RH: Relative humidity; mrl: Meter Row Length; NS= non-significant; * = significant at 5%

Conclusion

The investigation indicated that green semilooper, tobacco caterpillar and gram pod borer were the major defoliators affecting soybean, with peak larval populations recorded around the 34th Standard Meteorological Week. Relative humidity significantly influenced the population build-up of green semilooper and tobacco caterpillar, whereas temperature and humidity moderately affected gram pod borer populations. The spider, serving as an important natural enemy, appeared concurrently with the pests and reached maximum abundance during the same peak period, with higher temperatures enhancing its activity.

Acknowledgment

The author expresses sincere gratitude to the Chairman of the Department of Entomology at R.A.K., Sehore, M.P., India, for their indispensable assistance and support in the successful culmination of this research endeavor. The author would also like to extend they're thanks to all coworkers, field assistants and laborers for their contributions.

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