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Population Dynamics of Pod Feeders of Green Gram under Red and Lateritic Zone of West Bengal

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***Abstract*:** Pod feeders such as pod bug (*Clavigralla gibbosa* Spinola), flea beetle (*Madurasia obscurella* Jacoby), pod borer (*Helicoverpa armigera* Hubner), and blue butterfly (*Lampides boeticus* Fabricius) cause substantial damage to green gram crops in eastern India. This study quantified their population dynamics across two consecutive pre-kharif seasons (2023 and 2024) within the red and lateritic soils of West Bengal, alongside evaluation of key abiotic factors. Peak populations were observed between 15 and 16 weeks , with pod bug 3.37 and 3.40 individuals per plant, flea beetle 1.84 and 1.90, pod borer larvae 1.28 and 1.20, and blue butterfly adults 3.43 and 3.20 in 2023 and 2024, respectively. Pearson's correlation analysis revealed a strong positive relationship between minimum temperature and pest populations (r = 0.53 to 0.74), whereas rainfall and relative humidity had weak or non-significant effects. Linear regression analyses underscored minimum temperature as the dominant explanatory factor, especially for pod borer populations (R^2 = 0.72 in 2023). These findings provide vital insights for climate-informed integrated pest management strategies in West Bengal's green gram agroecosystem.

***Keywords*:** Abiotic factors, Green gram, Pod feeders, Population dynamics, West Bengal

Green gram (*Vigna radiata* (L.) Wilczek) is a vital pulse crop valued for its nutritional quality and nitrogen-fixing capabilities that contribute to sustainable agriculture. Despite its economic importance, green gram productivity is frequently compromised by an array of insect pests, among which pod feeders pose a significant threat by damaging pods, leading to yield loss and reduced seed quality (Mahesh et al., 2021). The pod feeders of primary concern include pod bug (*Clavigralla gibbosa* Spinola), flea beetle (*Madurasia obscurella* Jacoby), pod borer (*Helicoverpa armigera* Hubner), and blue butterfly (*Lampides boeticus* Fabricius), all of which infest the crop during critical reproductive stages (Dutta and Ghosh 2019, Mehendra et al., 2019). Abiotic factors such as temperature, rainfall, and relative humidity profoundly influence the population dynamics of these pests. Temperature, especially minimum temperature, notably affects development rates and survival while rainfall and humidity can either suppress or facilitate pest outbreaks depending on intensity and timing (Sharma et al., 2019, Singh et al., 2019). Although several studies have focused on pod feeders in varying agroclimatic conditions, specific data for West Bengal's red and lateritic soils remain limited (Meena et al., 2021, Kundu et al., 2021). These soils possess distinctive properties affecting microclimate and pest ecology, warranting localized studies to enable precise pest forecasting and management planning (Umbarkar et al., 2010, Chaudhuri et al., 2020). The aim was to understand environmentally driven pest dynamics and support development of efficient and sustainable integrated pest management interventions appropriate for the regional pulse production system.

MATERIAL AND METHODS

Field trials were conducted at the Agricultural Farm of Seacom Skills University, Kendradangal, Birbhum district, West Bengal (latitude 23.70°N, longitude 87.64°E). The experimental site is characterized by sandy loam, acidic red lateritic soils and experiences a dry sub-humid subtropical climate with an annual average rainfall of approximately 1000 mm predominantly received during monsoon months. Green gram (cv. *Samrat*) was sown during the last week of February in 2023 and 2024 in a randomized complete block design with three replicates with spacing 30cm X 10cm in a plot size of 4m X 3m. Standard cultivation practices, including recommended fertilization and weed management, were implemented (Samant 2014). Weekly pest sampling occurred from 9th to 19th standard meteorological week (SMW) during both years. Five randomly selected tagged plants per plot within each replication were surveyed. Pod feeders, pod bug (*Clavigralla gibbosa* Spinola), flea beetle (*Madurasia obscurella* Jacoby), pod borer (*Helicoverpa armigera* Hubner) larvae, and blue butterfly (*Lampides boeticus* Fabricius) adults, were counted manually on three pods per plant across canopy layers during early morning hours. Daily meteorological parameters including minimum and maximum temperatures (°C), rainfall (mm), and relative humidity (RH) (%) were recorded onsite from a campus weather station to capture accurate microclimatic conditions concurrent with pest sampling.

Statistical analysis: Mean weekly pest populations were computed by averaging counts across replications. Pearson's correlation coefficients quantified relationships between pest populations and individual weather parameters for both years separately. Linear regression analyses were performed to model pod feeder population responses to minimum temperature. Statistical significance was determined at $p < 0.05$ with SPSS version 26.

RESULTS AND DISCUSSION

Climatic trends showed increasing minimum temperatures from early March (SMW 9) with maxima of 24.5 °C around mid-April (SMW 16), followed by gradual decrease toward May (SMW 19) (Table 1). Rainfall was generally low in early weeks and increased modestly following pest population peaks. Population trends for all major pod feeders during both 2023 and 2024 are indicating clear seasonal synchrony of pest peaks across years, typically between SMW 15 and 16 (Fig. 1).

Pod Borer: Pod borer populations began appeared in early reproductive weeks, rapidly rising to maxima of 1.28 larvae per plant in 2023 and 1.20 larvae per plant in 2024, before subsiding as crop maturity approached (Fig. 1). Correlation analysis revealed a strong positive relationship between minimum temperature and pod borer density (r = 0.71 in 2023, r = 0.70 in 2024), with maximum temperature also showing moderate, but weaker positive correlation (Table 2). Rainfall showed a marginal effect, and relative humidity fluctuations were not significantly associated with population changes. The resultant multiple regression equations indicate that minimum temperature exerts the strongest positive influence on larval abundance, in line with findings from Mahesh, Kumar, and Reddy (2021), and similar to reports in related cropping systems (Bera et al., 2023). The high R^2 demonstrates robust explanatory power for temperature variables, suggesting thermal cues are key for forecasting pod borer outbreaks in this zone (Table 3).

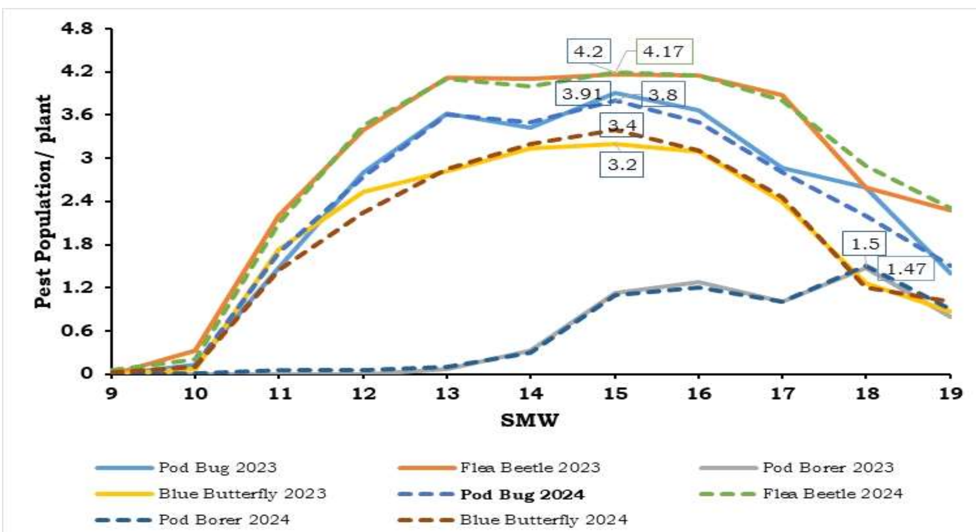

Fig. 1. Population dynamics of pod feeders of green gram in 2023 and 2024

Table 1. Weekly meteorological data for pre-*kharif* (2023 and 2024)

SMW	Min temp (°C) 2023	Max temp (°C) 2023	Rainfall (mm) 2023	RH (%) 2023	Min temp (°C) 2024	Max temp (°C) 2024	Rainfall (mm) 2024	RH (%) 2024
9	16.5	29.8	3.4	65.2	16.2	30.0	4.1	64.5
10	17.2	30.1	2.7	63.7	17.5	30.3	5.0	63.2
11	18.8	31.2	1.5	59.8	18.4	31.5	0.9	60.6
12	20.1	32.0	0.0	56.1	19.3	32.2	0.0	56.0
13	21.5	33.0	0.0	49.8	21.0	33.5	0.0	48.0
14	22.5	34.0	0.0	38.5	22.3	34.2	0.0	36.5
15	24.0	35.0	0.0	35.0	23.5	35.5	0.0	34.5
16	24.5	35.8	5.0	40.5	24.0	36.1	3.4	40.2
17	23.5	34.2	7.0	45.0	23.8	35.7	6.0	46.0
18	22.0	33.8	12.0	51.2	21.8	33.5	9.0	52.0
19	20.5	32.5	10.5	55.5	20.7	32.0	11.5	56.0

Table 2. Pearson correlation coefficients (r) between pod feeder populations and meteorological parameters (2023 and 2024)

Pest	Year	Min temp (°C)	Max temp (°C)	Rainfall (mm)	RH (%)
Pod bug	2023	0.65*	0.51**	0.15 **	0.17**
	2024	0.63*	0.49 **	0.12 **	0.15**
Flea beetle	2023	0.59*	0.41 **	0.12 **	0.13 **
	2024	0.58*	0.39 **	0.14 **	0.12**
Pod borer	2023	0.74*	0.61*	0.18 **	0.20**
	2024	0.72*	0.59*	0.19 **	0.20**
Blue butterfly	2023	0.62*	0.48 **	0.11 **	0.16**
	2024	0.63*	0.46 **	0.13 **	0.15**

*Significant at $p < 0.05$; ** = non-significant

Table 3. Multiple linear regression equations for pod feeders of green gram (2023 and 2024)

Insect & Year	Regression equation	R^2
Pod Borer (*H. armigera* Hubner), 2023	$Y = -3.40 + 0.07X_1 + 0.11X_2 + 0.01X_3 + 0.02X_4$	0.72
Pod Borer (*H. armigera* Hubner), 2024	$Y = -3.10 + 0.06X_1 + 0.10X_2 + 0.01X_3 + 0.02X_4$	0.71
Pod Bug (*C. gibbosa* Spinola), 2023	$Y = -2.10 + 0.06X_1 + 0.13X_2 + 0.01X_3 + 0.01X_4$	0.43
Pod Bug (*C. gibbosa* Spinola), 2024	$Y = -1.90 + 0.06X_1 + 0.12X_2 + 0.01X_3 + 0.01X_4$	0.42
Flea Beetle (*M. obscurella* Jacoby), 2023	$Y = -0.99 + 0.03X_1 + 0.08X_2 + 0.01X_3 + 0.01X_4$	0.34
Flea Beetle (*M. obscurella* Jacoby), 2024	$Y = -0.93 + 0.03X_1 + 0.07X_2 + 0.01X_3 + 0.01X_4$	0.33
Blue Butterfly (*L. boeticus* Fabricius), 2023	$Y = -1.50 + 0.04X_1 + 0.11X_2 + 0.01X_3 + 0.01X_4$	0.37
Blue Butterfly (*L. boeticus* Fabricius), 2024	$Y = -1.36 + 0.04X_1 + 0.09X_2 + 0.01X_3 + 0.01X_4$	0.36

Y: pest population per plant; X□: max temp (°C); X□: min temp (°C); X□: rainfall (mm); X□: relative humidity (%)

Pod Bug: Pod bug populations peaked at 3.37 per plant in 2023 and 3.40 in 2024, closely following the trends of temperature rise (Fig. 1). Correlation coefficients with minimum temperature were significant in both years while those for maximum temperature, rainfall, and relative humidity were positive but far less significant (Table 2). The moderate R^2 value suggests temperature is the primary, but not exclusive, driver, possibly acting in concert with plant phenology (Sarkar et al., 2019) (Table 3). Mahesh, Kumar, and Reddy (2021), observed that rise in minimum temperature enhances adult and nymph development, leading to high pest loads during pod set and filling stages.

Flea beetle: Flea beetle infestations increased steadily from SMW 10, peaking with 1.84 insects per plant in 2023 and 1.90 in 2024 (Fig. 1). There was significant positive correlation with minimum temperature with negligible impacts from rainfall and humidity (Table 2).

Blue butterfly: Blue butterfly adults appeared late vegetative through flowering stage, peaking at 3.43 (2023) and 3.20 (2024) adults per plant (Fig. 1). Correlation with minimum temperature remained statistically significant whereas other abiotic factors showed no clear trends (Table 2). The study demonstrate that rises in minimum temperature provide the main ecological cue for population expansion of all major pod feeders in green gram, aligning with Mahesh et al. (2021) and Bera et al. (2023). Rainfall and relative humidity, within the experienced typical ranges, present limited limiting force. This confirms the critical importance of climate-driven forecasting for timely, sustainable management against these pests in Bengal's pulse systems.

This detailed two-year investigation demonstrates that pod feeders viz. pod bug, flea beetle, pod borer, and blue butterfly exhibit repeatable seasonal population dynamics in green gram under the red and lateritic zone of West Bengal. Their abundance peaks mid-season in close synchrony with rising minimum temperatures, which strongly predict population surges. Rainfall and humidity provide minor influences. The derived regression models enable timely prediction and management. Integrating these climate-based insights into regional pest management strategies can substantially reduce yield losses, minimize pesticide overuse, and promote sustainable green gram farming in eastern India.

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