Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 23(2) May-August 2025]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

G.B. Pant University of Agriculture & Technology, Pantnagar

PANTNAGAR JOURNAL OF RESEARCH

Vol. 23(2) May-August, 2025

CONTENTS

Population dynamics of brown planthopper and mirid bug in relation to weather factors in the *Tarai* region

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ABSTRACT: The brown planthopper (*Nilaparvata lugens*, BPH) is a major pest of rice that causes significant yield loss, while the mirid bug (*Cyrtorhinus lividipennis*, MB) serves as an important natural enemy of BPH by feeding on its eggs and nymphs. A field study was conducted during *Kharif* 2023 and 2024 at the Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, to assess the population dynamics of BPH and MB in relation to weather parameters. Weekly observations were recorded from 10 days after transplanting (DAT) till harvest on rice variety Pant Dhan 12. In 2023, BPH appeared in the 35th standard week with a population of 1.8/hill and reached a peak of 20.8/hill during the 41st week. MB appeared in the 36th week (0.2/hill) and peaked at 6.9/hill in the 40th week. In 2024, BPH was first recorded in the 32nd week (1.2/hill) and reached the highest population of 20.5/hill during the 37th week, while MB first appeared in the 33rd week (0.2/hill) and peaked at 6.8/hill in the 38th week. Multiple linear regression analysis showed that 87.6% and 97.2% of the variation in Brown Planthopper population in 2023 and 2024, respectively, could be predicted using weather parameters. This indicates the strong predictive power of the developed regression models for forecasting BPH populations.

Keywords: Abiotic factor, brown planthopper, correlation, mirid bug, rice

Rice (*Oryza sativa* L.) stands as one of the most vital cereal crops worldwide, serving as the principal staple food for over half of the global population. It plays a crucial role in food and nutritional security, especially across Asian nations (Mohidem *et al.,* 2022). According to Childs and Abadam (2025), global rice production in the 2025–26 season is expected to reach a record 538.7 million tonnes (milled basis). This is slightly higher than the previous year by about 1 million tonnes. The two largest rice-producing countries are India and China, which produce more than half of the world's total rice. Rice crops are frequently subjected to a range of biotic and abiotic stresses, both of which can significantly compromise plant health, development, and productivity. Abiotic stresses result from non-living environmental factors like drought, salinity, extreme temperatures (both high and low), flooding, excessive light, ozone exposure, nutrient deficiency, heavy metal contamination, pollution, wind, and mechanical injury and biotic stresses are caused by living organisms such as insect pests, fungi, bacteria, viruses, and even toxicity from herbicides (Anami *et al.,* 2020). Collectively, these stresses pose a serious challenge to sustainable rice production, in which insect pests causing about 25% losses, amounting to some Rs.240 billion, almost 30 billion USD (Chintalapati *et al.,* 2023). These pests affect rice plants throughout different stages of crop growth by feeding, breeding and completing their life cycles on the host. Insect pests of major economic importance in rice include the brown planthopper, rice stem borer, rice leaf folder, green leaf hopper, white backed plant hopper and rice gundhi bug. These pests not only reduce yield directly through feeding but also act as vectors for disease transmission, thereby posing a severe threat to rice cultivation. Among them, the brown planthopper (*Nilaparvata lugens* Stål; Delphacidae: Homoptera) is considered a principal pest, especially in the major rice-growing regions of Asia (Horgan *et al.,* 2021), where its outbreaks frequently lead to hopper burn and virus transmission, causing widespread crop damage (Dyck and Thomas, 1979). In the rice ecosystem, predators are more prominent than parasitoids in controlling planthoppers and leafhoppers. Among these, the green mirid bug, (*Cyrtorhinus lividipennis* Reuter, Miridae: Hemiptera) is widely distributed and an effective biocontrol agent against both leafhoppers and planthoppers. It searches for hosts randomly, with rice volatiles influencing its foraging behavior. *C. lividipennis* feeds on eggs and nymphs of hoppers and is the dominant predator in irrigated rice fields. A predator nymph consumes about 7.5 eggs or 1.4 hopper nymphs daily for 14 days, while adults consume approximately 10.2 eggs, 4.7 nymphs, or 2.4 adults daily for 10 days. Over its 24-day lifespan, a single bug can consume up to 66 brown planthopper (BPH) nymphs (Preetha *et al.,* 2010). Hence, studying the population dynamics of brown plant hopper and mirid bug in relation to weather parameters is essential to understand the influence of climatic factors on pest and predator interactions.

MATERIALS AND METHODS

The current study was conducted during the *Kharif* seasons of 2023 and 2024 at the Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar. The rice variety used was Pant dhan 12, transplanted at a spacing of 20 cm × 15 cm. The experiment was laid out in a Randomized Complete Block Design (RBD). Observations on the population of BPH and MB were recorded weekly from 10 days after transplanting (DAT) until harvest. Insect populations were counted on 15 hills per plot. Concurrently, weather parameters such as maximum and minimum temperature, morning and afternoon relative humidity, rainfall, number of rainy days, sunshine hours, wind velocity, and evaporation were recorded daily. Correlation coefficients were computed to assess the relationship between pest/predator populations and weather variables. Population dynamics of BPH and MB were represented by taking weekly mean population against weekly weather data, whereas for the calculation of the correlation coefficient, daily insect population data were plotted against daily weather data throughout the study season and is represented using bars and line graph in figure 1 and figure 2. Multiple linear regression was also performed on the daily data in Microsoft Excel software to establish a predictive relationship between insect population and weather parameters. The following is a standard multiple linear regression equation:

$$Y = B0 + B1\,X1 + \ldots\ldots. + Bn\,Xn$$

Where, Y = Predicted or expected value of the dependent variable,

X1 to Xn = n distinct independent or predictor variables,
B0 = value of Y when all of the independent variables (X1 through Xn) are equal to zero,
B1 to Bn = estimated regression coefficients.

RESULTS AND DISCUSSION

Impact of weather factors on the population dynamics of Brown plant hopper and Mirid bug in 2023

The weekly mean population of BPH and MB on rice crop during *Kharif* season 2023, along with corresponding meteorological parameters is presented in Table 1 and Fig.1. The insect population was absent during the initial weeks from the 31st to 34th Meteorological Standard Week (MSW) (30th July to 26th August), coinciding with high humidity (morning RH 89.4%–92.4%), moderate to high rainfall (11.8–251.2 mm), and minimum temperatures above 25°C.

The initial occurrence of BPH was observed during the 35th MSW (27th August–2nd September) with a count of 1.8 BPH/hill, under conditions of 34.0°C maximum temperature, 91.3% morning RH, and absence of rainfall. This was followed by a gradual rise in population with 5.4 BPH/hill in 36th MSW, 9.5 BPH/hill in 37th MSW, 13.9 BPH/hill in 38th MSW, and 16.5 BPH/hill in 39th MSW. The peak BPH incidence (20.8) was recorded during the 41st MSW (8th–14th October) at 33.0°C/19.3°C temperature, 79.6% morning RH, and zero rainfall. A subsequent decline was observed in the following weeks, with 18.0 BPH/hill in 42nd MSW and 11.4 BPH/hill in 43rd MSW.

Table 1: Population dynamics of Brown Planthopper (BPH) and Mirid Bug (MB) in relation to Weekly Weather Parameters during *Kharif* 2023

MSW	Date	Tem (^oC) (Max.)	Tem (^oC) (Min.)	Relative Humidity (%) (712 am)	Relative Humidity (%) (1412 pm)	Sun-Shine Hrs.	Rainfall (mm)	Wind Velocity (Km/hr.)	Evap. (mm)	BPH	MB
31	30th July 5th August	32.9	26.9	89.4	75.1	6.9	22.2	1.1	3.2	0	0
32	6th–12th August	32.2	25.7	92.4	76.0	6.0	251.2	3.6	3.6	0	0
33	13th–19th August	32.4	26.1	89.7	69.4	4.5	11.8	1.7	3.4	0	0
34	20th–26th August	30.6	25.5	91.6	80.1	3.2	110.0	2.2	3.9	0	0
35	27th August-2nd September	34.0	25.6	91.3	62.1	6.5	0.0	2.5	5.2	1.8	0
36	3rd–9th September	34.3	25.4	88.4	67.6	4.3	42.0	1.5	3.8	5.4	0.2
37	10th–16th September	31.0	25.4	91.1	74.6	8.4	152.2	1.1	3.1	9.5	3.8
38	17th–23rd September	32.6	24.6	90.4	69.7	6.0	47.4	1.0	3.4	13.9	4.3
39	24th–30th September	32.9	23.5	88.6	57.9	4.5	60.2	0.3	3.1	16.5	3.1
40	1st–7th October	33.6	22.8	88.7	51.7	5.8	0.0	0.3	3.7	19.6	6.9
41	8th–14th October	33.0	19.3	79.6	46.7	5.2	0.0	0.4	3.2	20.8	5.5
42	15th-21th October	30.2	16.3	84.1	48.6	7.8	7.4	0.8	3.2	18	3.6
43	22th-27 th October	30.9	14.3	88.9	36.9	8.5	0.0	0.2	2.9	11.4	1.5
	Correlation (BPH)	-0.034	-0.636	-0.682	-0.721	0.209	-0.387	-0.780	-0.405	-	-
	Correlation (MB)	0.006	-0.393	-0.521	-0.496	0.197	-0.254	-0.677	-0.338	0.915	-

Table 2: Population Dynamics of Brown Planthopper (BPH) and Mirid Bug (MB) in Relation to Weekly Weather Parameters during *Kharif* 2024

MSW	Date	Tem (^oC) (Max.)	Tem (^oC) (Min.)	Relative Humidity (%) (712 am)	Relative Humidity (%) (1412 pm)	Sun-Shine Hrs.	Rainfall (mm)	Wind Velocity (Km/hr.)	Evap. (mm)	BPH	MB
29	16th–22nd July	33.9	27.3	85.4	69.0	75.4	6.9	5.7	5.2	0	0
30	23rd–29th July	34.4	22.8	87.3	70.4	58.6	6.0	3.8	5.1	0	0
31	30th July5th August	32.9	26.3	86.7	74.6	110.0	4.5	4.3	5.0	0	0
32	6th–12th August	30.8	25.6	91.9	83.3	145.2	3.2	6.9	4.4	1.2	0
33	13th–19th August	32.6	26.6	90.4	75.0	46.8	6.5	5.1	5.8	4.5	0.2
34	20th–26th August	31.5	25.1	89.3	76.7	121.4	4.3	3.1	4.5	7.7	0.8
35	27th August2nd September	33.6	25.7	86.7	66.6	62.0	8.4	4.7	5.4	11.6	2.7
36	3rd–9th September	32.8	25.7	88.7	70.7	40.4	6.0	2.6	4.5	15.7	3.6
37	10th–16th September	30.3	24.2	92.4	75.6	274.0	4.5	5.3	4.6	20.5	6.3
38	17th–23rd September	32.4	25.1	90.7	68.1	0.0	5.8	2.5	3.6	19.5	6.8
39	24th–30th September	32.4	24.5	90.4	73.0	8.8	5.2	3.2	3.8	15.7	5.8
40	1st–7th October	33.1	22.8	86.7	60.0	0.0	7.8	1.7	3.9	14.1	4.1
41	8th–14th October	32.3	20.1	88.6	51.7	0.0	8.5	1.5	4.0	11.5	3.4
	Correlation (BPH)	-0.368	-0.294	0.423	-0.288	-0.059	0.162	-0.495	-0.599	-	-
	Correlation (MB)	-0.313	-0.329	0.408	-0.305	-0.102	0.131	-0.473	-0.686	0.959	-

Table 3: Regression equations for estimating the dependency of pest population on weather parameters in rice ecosystem in 2023 and 2024

Insect name	Regression equation	R^2
BPH (2023)	$Y= 89.269 + 0.010 X_1 -0.037 X_2 -0.959 X_3 -0.177 X_4 +0.082 X_5 -0.085 X_6 -9.156 X_7 +6.926 X_8$	0.876
BPH (2024)	$Y= -459.011+ 3.439 X_1 + 2.125 X_2 +3.053 X_3 +0.656 X_4 +0.106 X_5 + 6.993 X_6 -3.936 X_7 -10.363 X_8$	0.972

X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Maximum relative humidity, X_4 = Minimum relative humidity, X_5 = Rainfall, X_6 = Sunshine hours, X_7 = Wind velocity and X_8 = Evaporation

The mirid bug population first appeared in the 36th MSW (0.2) and showed an increasing trend up to 6.9 MB/hill in the 40th MSW (1st–7th October). Thereafter, a gradual decline was recorded: 5.5 MB/

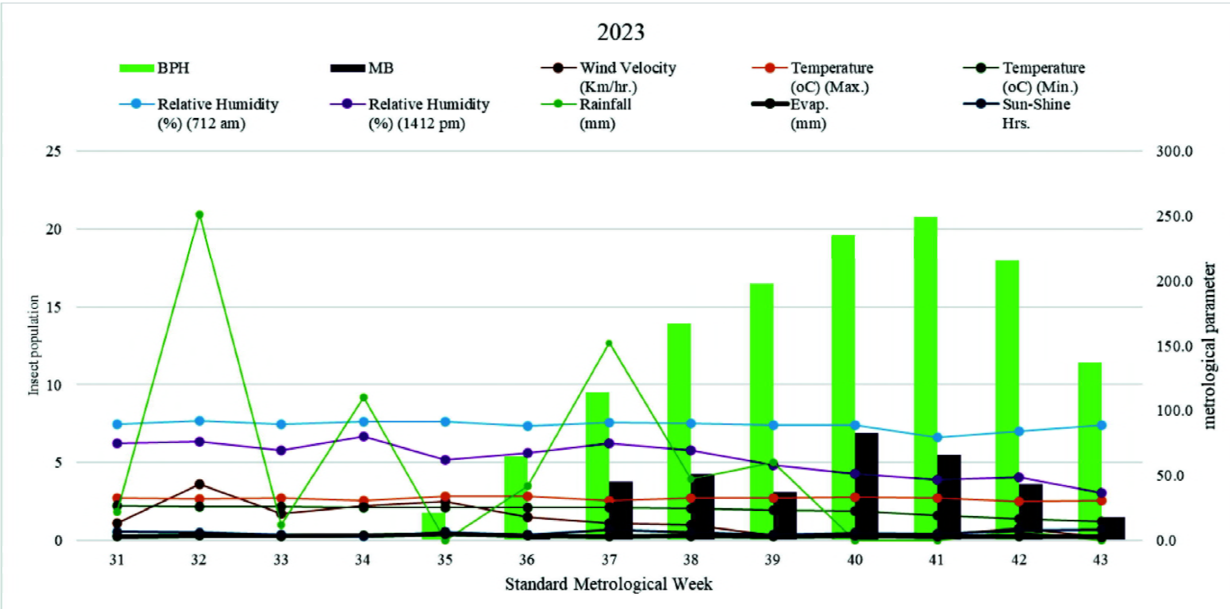

Fig.1: Effect of weather parameters on the population of brown planthopper and mirid bug during *Kharif* 2023 in Pantnagar

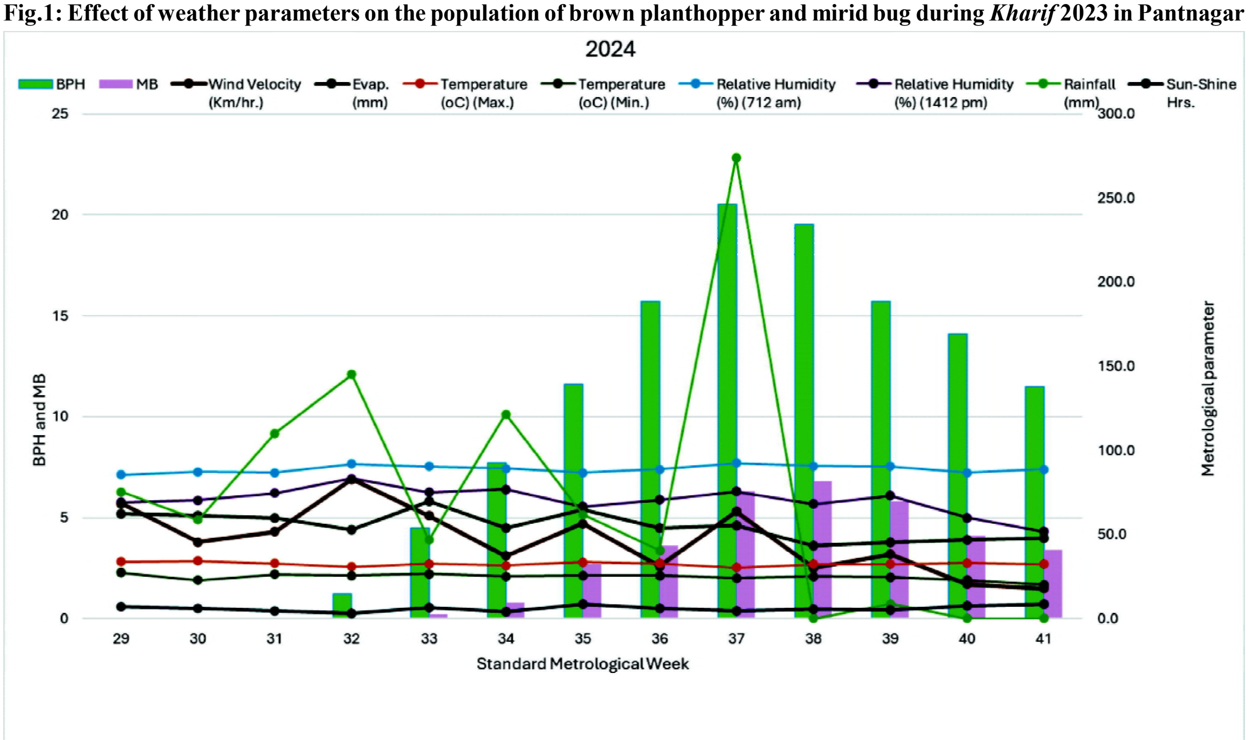

Fig.2: Effect of weather parameters on the population of brown planthopper and mirid bug during *Kharif* 2024 in Pantnagar

hill in 41st MSW, 3.6 MB/hill in 42nd MSW, and 1.5 MB/hill in 43rd MSW.

Correlation analysis revealed that the BPH population had significant negative correlations with minimum temperature (r = -0.636), afternoon relative humidity (r = -0.721), rainfall (r = -0.387), wind velocity (r = -0.780), and evaporation (r = -0.405). Similarly, MB population was also negatively correlated with most weather parameters. A strong positive correlation (r = 0.915) between BPH and MB indicated that their population dynamics followed a similar trend during the season.

Impact of weather factors on the population dynamics of Brown plant hopper and Mirid bug in 2024

In 2024, the first appearance of BPH was recorded during MSW 32 (6th–12thAugust) with a mean population of 1.2 hoppers/hill, whereas MB were first observed in MSW 33 (13th–19th August) with a mean population of 0.2 bugs/hill. The maximum BPH population was observed in MSW 37 (10th–16th September) with 20.5 hoppers/hill, followed by MSW 38 (17th–23rd September) with 19.5 hoppers/hill. The minimum BPH population were recorded in MSW 32 (1.2 hoppers/hill). For mirid bugs, the highest population were recorded in MSW 38 (17th–23rd September) with 6.8 bugs/hill, while the lowest population were in MSW 33 (0.2 bugs/hill).

The correlation analysis revealed that the BPH population showed a negative correlation with maximum temperature (-0.368), minimum temperature (-0.294), afternoon relative humidity (-0.288), rainfall (-0.059), wind velocity (-0.495) and evaporation (-0.599) while a positive correlation was found with morning relative humidity (0.423) and sunshine hours (0.162). Similarly, the mirid bug population exhibited a negative correlation with maximum temperature (-0.313), minimum temperature (-0.329), afternoon relative humidity (-0.305), rainfall (-0.102), wind velocity (-0.473) and evaporation (-0.686) but a positive correlation with morning relative humidity (0.408) and sunshine hours (0.131). Notably, the population of mirid bugs had a strong positive correlation with BPH population (r = 0.959) (Table 2 and Fig.1). These results are supported by several other studies, Tetarwal *et al*. (2016) found a negative correlation with minimum temperature (r = -0.844) and rainfall (r = -0.674) during *Kharif* 2011 and 2012, while noting a strong positive correlation with mirid bugs (r = 0.955). The positive relationship with mirid bugs is further reinforced by Prashant and Naveena (2012) who reported a significant positive correlation (r=0.856) and by Kamboj *et al*. (2025) who found highly significant positive correlations (r = 0.972 and r = 0.963) during *Kharif* 2019 and 2020. However, a key difference emerged in the present findings regarding temperature and humidity supported by Chaudhary *et al.* (2014) who reported that temperature and humidity had a positive effect on the BPH population, the present study found a negative relationship with these parameters.

Regression equations for estimating the dependency of pest population on weather parameters in rice ecosystem in 2023 and 2024

The multiple regression analysis revealed a significant influence of weather parameters on the population dynamics of Brown Planthopper (BPH) during the cropping seasons of 2023 and 2024. In 2023, the regression model accounted for 87.6% of the variation in BPH population (R^2 = 0.876), indicating a strong correlation between pest incidence and the selected abiotic factors. In contrast, during 2024, the model demonstrated a higher coefficient of determination (R^2 = 0.972), explaining 97.2% of the variability in BPH population (Table 3). The increased R^2 value in 2024 suggests a more pronounced and consistent impact of meteorological variables on BPH population dynamics. These findings emphasize the critical role of climatic factors such as maximum and minimum temperatures, relative humidity, rainfall, sunshine hours, wind velocity, and evaporation in influencing the seasonal abundance and outbreak patterns of BPH in rice agro-ecosystems.

CONCLUSION

The present study focused on the population dynamics of the Brown Planthopper (BPH) and its relationship with abiotic factors and population of natural enemy (mirid bug). The analysis revealed a negative correlation between the BPH population including minimum temperature, rainfall, and wind velocity. Conversely, certain conditions like morning relative humidity and sunshine hours showed a positive correlation, suggesting that a specific combination of environmental factors influences pest abundance. Furthermore, a highly significant positive correlation was observed between the BPH population and the MB population. This highlights a strong interdependence between the pest and its predator. The predator population is generally dependent on the pest population.

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Received: August 14, 2025
Accepted: August 25, 2025