



RESEARCH ARTICLE

Influence of sowing windows on pest pressure and crop vulnerability in rice (*Oryza sativa* L.)

Manish Kumar Yadav, Prabhu Prasanna Pradhan*, Nihal Ravindranath, Anirban Das, Mounika Tumma & Ramalakshmi V

Department of Entomology, MS Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi 761 211, Odisha, India

*Correspondence email - prabhu.pradhan@cutm.ac.in

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Abstract

Sowing dates play a crucial role in managing biotic stress and crop susceptibility in rice (*Oryza sativa* L.) under field conditions. A field experiment with six sowing windows, from early June to late August, conducted to observe how pest stress and crop damage changed over time. The findings demonstrated a distinct impact of sowing time on crop vulnerability, characterised by increasing pest pressure and damage in delayed sowing scenarios. Crops that were sown early (1st–10th June) had the least biotic stress, with the minimal pest incidence and crop damage. On the other hand, very late sown crops (15th–25th August) exhibited the highest pest incidence and stress. Statistical analysis revealed significant disparities among sowing windows, while correlation studies illustrated robust positive correlations between pest pressure and crop damage, underscoring the increased susceptibility of late-sown crops. The results revealed that timely sowing enables the crop to partially escape peak pest pressure, thereby reducing infestation and enhancing crop resilience. The study highlights sowing window management as a straightforward, economical and environmentally sustainable agronomic approach to mitigate biotic stress and improve the resilience of rice-based production systems in the face of shifting climatic conditions.

Keywords: climate-resilient agriculture; pest management; pest-weather relationship; rice agroecosystem; sowing date; sustainable crop management

Introduction

Rice (*Oryza sativa* L.) is a cornerstone of food security in India and its productivity is strongly governed by crop establishment practices that determine plant growth, stress exposure and yield stability (1). Among these, sowing time plays a pivotal role in regulating crop-environment interactions, particularly by influencing the degree of biotic stress experienced during sensitive growth stages. Inappropriate or delayed sowing often increases crop vulnerability by synchronising plant phenology with periods of heightened pest pressure, thereby compromising crop health and sustainability. Rice production is highly vulnerable to insect pests, which cause severe yield losses every season (2–4). Among them, the gundhi bug (*Leptocoris acuta*) and leaf folder (*Cnaphalocrocis medinalis*) have emerged as major constraints in both irrigated and rainfed rice ecosystems (5). Gundhi bug causes direct damage by sucking sap from developing grains, leading to chaffy kernels and poor grain quality, whereas leaf folder reduces photosynthetic capacity by folding and scraping the leaves (6). The severity of these pests is often influenced by ecological factors, crop duration and most importantly, sowing time.

Sowing date is a simple yet critical agronomic factor that governs crop growth, synchrony with monsoon rainfall and the pest–host relationship. Early or timely sowing generally enables the crop to escape peak pest incidence, while delayed sowing often coincides

with favourable conditions for pest build-up, leading to heavy infestation (7). In recent years, climate variability and erratic rainfall patterns have further complicated sowing decisions, exposing rice crops to increased pest pressure. Farmers frequently resort to chemical pesticides, which not only increase cultivation costs but also adversely affect beneficial organisms, human health and the environment (8, 9).

Investigating the effect of sowing date on the population dynamics of the gundhi bug and leaf folder is crucial for developing eco-friendly and evidence-based pest management strategies (10, 11). In this context, the present study incorporated measurable sustainability indicators to assess their contribution toward agricultural sustainability. These indicators included (A) reduction in pest incidence (%) across different sowing windows, (B) variation in pesticide application frequency and quantity (number of sprays and active ingredient per hectare), (C) changes in grain yield (kg ha⁻¹) and yield stability and (D) input-use efficiency under varying climatic conditions. By quantifying these parameters, the study directly evaluated improvements in food productivity and resource-use efficiency, reduction in chemical dependency and adaptability of cropping practices to climate variability. Hence, the present investigation was undertaken to generate field-based evidence on how alterations in sowing windows influence pest incidence and associated sustainability indicators, thereby guiding climate-resilient and sustainable rice production systems.

The study aims to provide location-specific recommendations to farmers, extension personnel and policymakers for optimising sowing schedules to minimise pest-related yield losses. By linking agronomic practices with pest ecology, the findings are expected to contribute to integrated pest management (IPM) strategies, reduce dependence on chemical control measures and promote environmentally sustainable rice cultivation. Such scientific insights are crucial not only for improving farmer profitability but also for advancing India's commitment to sustainable agriculture and climate-resilient food systems.

Materials and Methods

The field experiment was conducted during the kharif season at Students' Instructional Farm, Bagusala, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management (CUTM), Odisha (23°39' N latitude, 87°42' E longitude). The experimental site was located in the Gajapati district of Southern Odisha, India, under the Eastern Ghat High Land Zone, characterised by a humid tropical climate with erratic rainfall patterns. The soil of the experimental field was sandy loam with moderate fertility status.

Meteorological data, including daily rainfall (mm), maximum and minimum temperatures (°C) and relative humidity (%), were recorded throughout the cropping period from the nearby agrometeorological observatory. During the experimental season, the crop experienced typical monsoonal conditions characterised by intermittent rainfall and moderate to high temperatures. These weather parameters were considered while interpreting pest population dynamics, as they are known to influence insect development, survival and activity.

The popular high-yielding variety of rice, cv. Swarna was selected for the study owing to its widespread cultivation by farmers in the region. The use of a single cultivar ensured experimental uniformity, however, varietal interactions with sowing window and pest incidence were not evaluated in the present study. The experiment was laid out in a randomised block design (RBD) comprising six sowing windows: early sowing (1st–10th June), normal sowing phase I (15th–25th June), normal sowing phase II (1st–10th July), late sowing phase I (15th–25th July), late sowing phase II (1st–10th August) and very late or contingent sowing (15th–25th August). Each treatment was replicated four times with a plot size of 12 m × 20 m. Standard agronomic practices as recommended for the region were uniformly followed in all plots, including fertiliser application, irrigation and weed management. Observations on the gundhi bug population (per hill), gundhi bug

infestation (%), leaf folder population (per hill) and leaf folder infestation (%) were made at appropriate crop growth stages. Observations were recorded at key crop growth stages, particularly the vegetative and reproductive phases, when pest incidence was more pronounced. Population counts were made through standard hill-counting techniques, while infestation levels were calculated based on the percentage of damage.

The recorded data were subjected to statistical analysis using IBM SPSS Statistics (Version 22) and the OPSTAT package for analysis of variance (ANOVA). Treatment means were compared at 5 % level of significance and the variability in the experimental data was expressed in terms of coefficient of variation and standard error of the mean. Correlation analysis was also performed to establish the relationship between pest population and infestation levels under different sowing windows.

Results

The response of the rice crop to different sowing windows showed marked variation in biotic stress levels as reflected by pest population density and infestation intensity (Table 1). The population of gundhi bug ranged from 4.2 ± 0.4 per hill under early sowing (1st–10th June) to 13.5 ± 0.9 per hill under very late sowing (15th–25th August). Correspondingly, infestation levels increased from 5.6 ± 0.5 % under early sowing to 25.7 ± 1.6 % in very late sowing.

A similar trend was observed for leaf folder incidence. Early-sown rice recorded the lowest population (3.1 ± 0.3 per hill) and infestation (6.8 ± 0.6 %), whereas very late sowing resulted in the highest population (11.1 ± 0.8 per hill) and infestation (25.4 ± 1.6 %). Intermediate sowing windows exhibited a gradual increase in both pest density and crop damage with progressive delay in sowing.

Statistical analysis revealed significant differences among sowing windows for all parameters at the 5 % level of significance. The coefficient of variation ranged from 40.34–51.02 %, indicating moderate variability under field conditions. Correlation analysis showed strong positive associations between pest population and infestation levels, as well as between gundhi bug and leaf folder incidence, indicating a concurrent escalation of biotic stress under delayed sowing conditions (Fig. 1).

The differences between early and very late sowing treatments exceeded the critical difference (CD) values, thereby confirming the statistical significance of the treatment effects.

Table 1. Impact of sowing date alteration on population dynamics and infestation of the gundhi bug and leaf folder

Sl. No.	Sowing date and phase	Gundhi bug population (per hill)	Gundhi bug infestation (%)	Leaf folder population (per hill)	Leaf folder infestation (%)
1	Early sowing (1 st –10 th June)	4.2 ± 0.4	5.6 ± 0.5	3.1 ± 0.3	6.8 ± 0.6
2	Normal sowing - phase I (15 th –25 th June)	5.6 ± 0.5	8.4 ± 0.6	4.7 ± 0.4	10.2 ± 0.8
3	Normal sowing - phase II (1 st –10 th July)	7.8 ± 0.6	12.5 ± 0.9	6.5 ± 0.5	14.6 ± 1.1
4	Late sowing - phase I (15 th –25 th July)	9.4 ± 0.7	16.2 ± 1.1	7.9 ± 0.6	18.3 ± 1.2
5	Late sowing - phase II (1 st –10 th Aug)	11.2 ± 0.8	20.8 ± 1.4	9.4 ± 0.7	21.7 ± 1.4
6	Very late/contingent (15 th –25 th Aug)	13.5 ± 0.9	25.7 ± 1.6	11.1 ± 0.8	25.4 ± 1.6
	CD (5 %)	6.32	13.80	5.40	12.77
	CV (%)	40.34	51.02	41.71	43.41
	SEm (±)	2.01	4.38	1.71	4.05

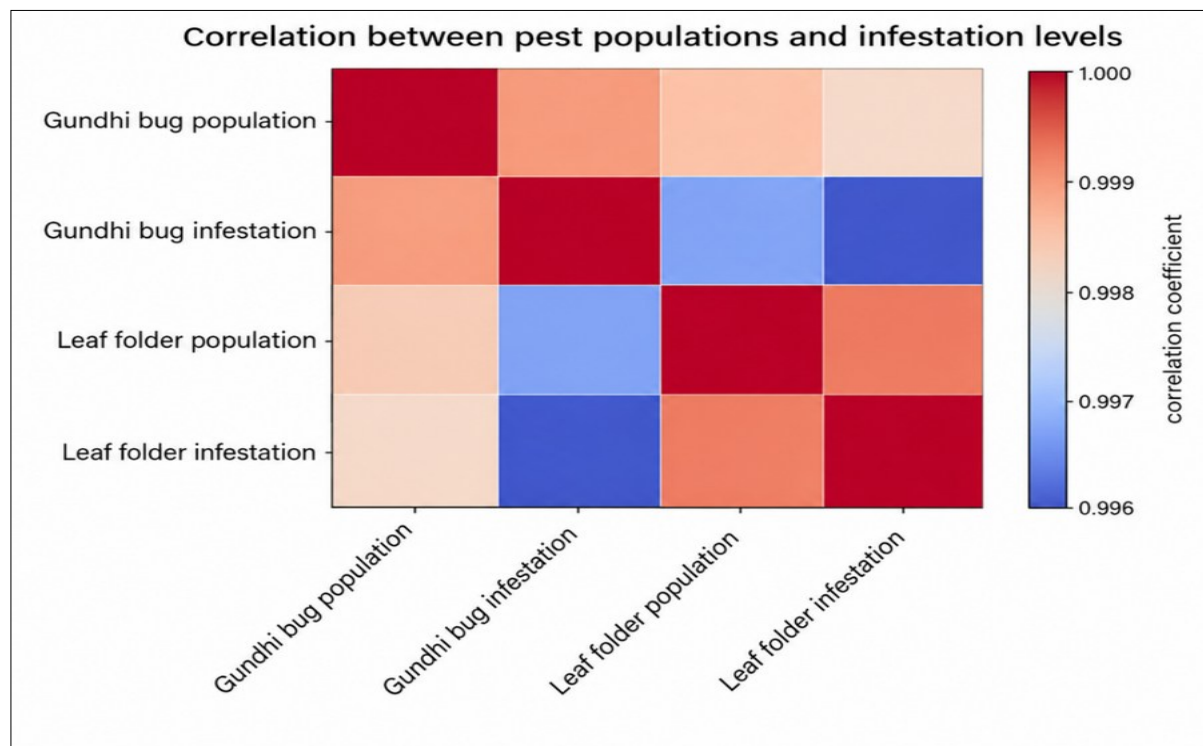


Fig. 1. Correlation between the population of the gundhi bug and leaf folder and the infestation level.

Discussion

The present findings clearly demonstrate that sowing time plays a decisive role in regulating biotic stress in rice, with delayed sowing substantially increasing crop vulnerability to pest pressure. The higher pest population and infestation levels recorded under late and very late sowing windows indicate that crops established during these periods coincided with favourable environmental conditions for pest buildup. Similar trends have been reported previously, where delayed transplanting predisposed rice crops to higher pest incidence (12–16).

The progressive increase in pest pressure with delayed sowing indicates a strong influence of crop phenology and pest synchrony (Fig. 2). Late-established crops tend to coincide with periods of peak pest activity, resulting in prolonged exposure during susceptible growth stages and consequently higher levels of infestation. This elevated pest pressure was reflected in a corresponding decline in grain yield (kilogram per hectare (kg ha^{-1})) and increased need for plant protection interventions, thereby raising the cost of cultivation and reducing net economic returns. The relationship between pest incidence and yield loss highlights the economic implications of delayed sowing beyond mere biological

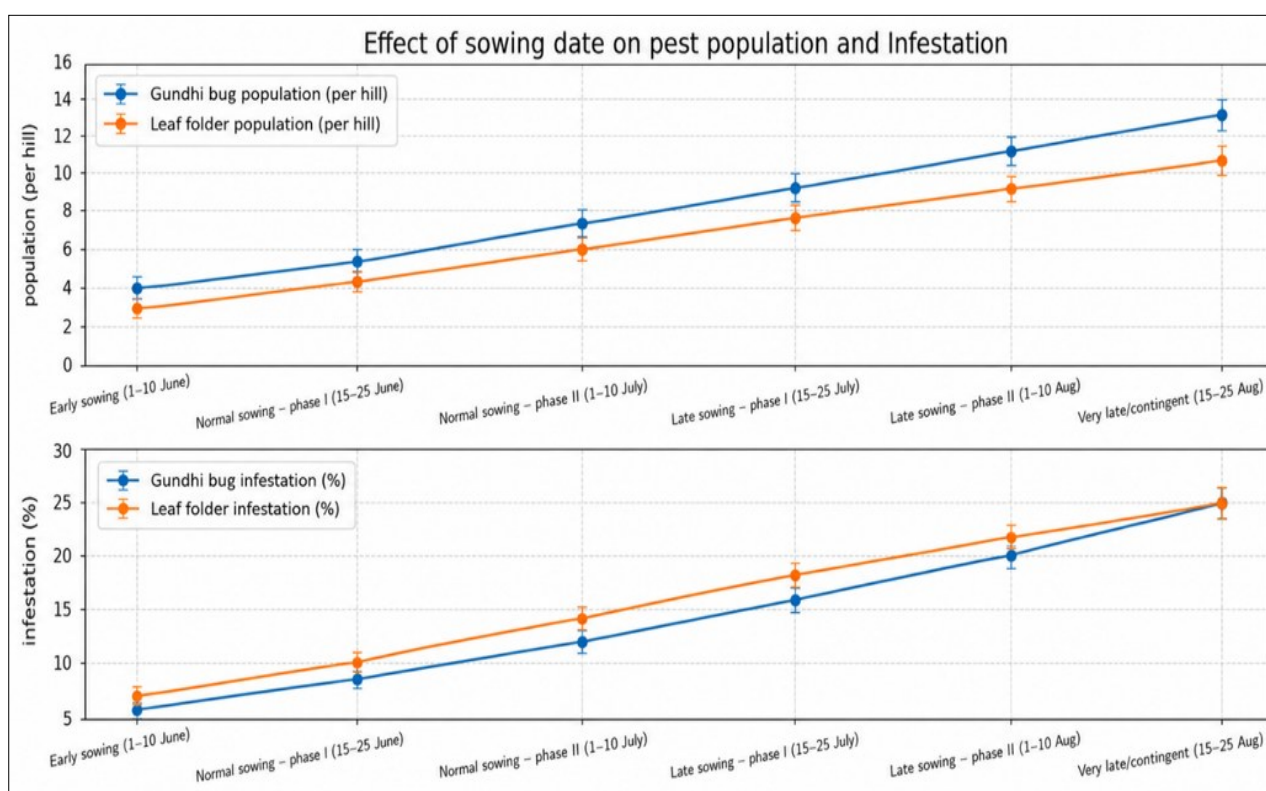


Fig. 2. Impact of sowing dates on population and infestation of the gundhi bug and leaf folder.

observations. However, the magnitude of pest pressure and associated yield reduction exhibited noticeable field-to-field variability, which was likely influenced by differences in microclimatic conditions, soil fertility status, crop management practices and localised pest dynamics. Such variability suggests that while the overall trend of increased pest incidence under delayed sowing is consistent, site-specific factors play a significant role in determining the extent of damage. Therefore, interpretation of the results should consider this inherent field variability and location-specific validation is essential before broader recommendations are made. The observed relationship between pest population and infestation indicates that increased pest density directly translates into higher crop damage, emphasising the importance of timely management interventions (17, 18).

The observed increase in pest incidence under delayed sowing may also be attributed to prevailing meteorological conditions during the later crop growth stages. Higher temperature and humidity levels, coupled with intermittent rainfall, create a favourable microclimate for the rapid multiplication and survival of insect pests. Such conditions are known to accelerate pest life cycles and enhance feeding activity, thereby increasing crop damage. Conversely, early-sown crops may escape peak pest pressure by avoiding synchronisation with these favourable weather conditions. These findings are in agreement with earlier studies highlighting the significant role of temperature and rainfall in regulating pest population dynamics in rice ecosystems (8, 19).

The increased pest pressure observed under delayed sowing was associated with a decline in grain yield and greater economic losses due to increased plant protection requirements. Elevated pest incidence results in direct yield reduction through damage to grains and photosynthetic tissues, while additional pesticide applications increase the cost of cultivation, thereby reducing net returns. However, the magnitude of pest pressure and the associated yield loss exhibited noticeable variability under field conditions. This variability may be attributed to differences in microclimate, soil heterogeneity and localised pest dynamics. Therefore, while the overall trend remained consistent, the results should be interpreted considering this inherent field variability and further multi-location validation is recommended.

It is important to note that the present findings are based on a single rice cultivar (cv. Swarna) and varietal differences may significantly influence pest dynamics and crop responses to altered sowing windows. Variations in plant morphology, growth duration and inherent resistance mechanisms can alter pest colonisation and damage levels among cultivars. Previous studies have shown that rice genotypes differ in their susceptibility to major insect pests due to variations in biochemical and morphological traits (20, 21). Therefore, although the observed trend of increased pest pressure under delayed sowing remained consistent, the magnitude of response may vary among cultivars. Future research should incorporate multiple rice genotypes to validate and generalise these findings across diverse agro-ecological conditions.

In contrast, early sowing enabled the rice crop to partially escape peak pest pressure by disrupting pest-crop synchronisation. This temporal avoidance acts as an effective cultural practice, reducing pest-induced stress without additional inputs. Such findings reinforce earlier reports highlighting the role of crop calendar alignment as an eco-friendly and cost-effective component of sustainable pest management (17, 18).

The simultaneous increase of the gundhi bug and leaf folder incidence under delayed sowing further indicates compounded biotic stress, which may severely affect crop health and productivity if not managed appropriately. Therefore, timely sowing during early to mid-June emerges as a crucial agronomic strategy for minimising biotic stress, reducing dependence on chemical control measures and enhancing sustainability in rice-based production systems.

Conclusion

The present investigation clearly establishes that sowing time exerts a profound influence on the population dynamics and infestation intensity of the gundhi bug (*Leptocorisa acuta*) and leaf folder (*Cnaphalocrocis medinalis*) in rice. Progressive delay in sowing from early June to late August resulted in a steady increase in both pest density and corresponding crop damage. Very late sowing (15th–25th August) recorded the highest pest population and infestation, whereas early sowing (1st–10th June) consistently showed lowest incidence. The strong positive association between pest population and infestation levels indicated that timely sowing acts as a natural cultural control practice by disrupting pest-crop synchrony, thereby reducing the vulnerability of the crop. In contrast, late and contingent sowings not only aggravated pest pressure but also demand higher plant protection inputs, which escalate production costs and increase ecological burden. It may be concluded that early to normal sowing (June 1st–25th) should be advocated as a sustainable and eco-friendly pest management strategy in rice-based production systems. These findings also provide a scientific basis for strengthening integrated pest management (IPM) modules under varied agro-climatic conditions. Future research should focus on validating these findings across multiple agro-ecological regions and diverse rice genotypes to account for genotype and environment interactions. In addition, integrating long-term meteorological data with pest population dynamics can support the development of predictive models for pest outbreaks. Further studies should also evaluate the economic threshold levels and optimise integrated pest management strategies under varying sowing windows to enhance the sustainability and resilience of rice production systems.

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Authors' contributions

MKY conceived the study, developed the overall research design and coordinated the work. PPP contributed to the conceptual framework, supported the finalisation of the methodology and critically revised the manuscript for intellectual content. NR carried out the literature review, interpreted the data and drafted key sections of the manuscript. AD assisted with data curation and compilation, prepared the tables and figures and supported technical editing and formatting. MT and RV provided analytical support, assisted in the preparation of the results section and managed the reference. All authors read and approved the final manuscript.

Compliance with ethical standards

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References

1. Varma P. Rice productivity and food security in India: a study of the system of rice intensification. New York (NY): Springer; 2017. <https://doi.org/10.1007/978-981-10-3692-7>
2. Paroda RS. Priorities and opportunities of rice production and consumption in India for self-sufficiency. In: Dowling NG, Greenfield SM, Fischer KS, editors. Sustainability of rice in the global food system. IRRI; 1998. p. 357–90.
3. Bishwajit G, Sarker S, Kpoghomou MA, Gao H, Jun L, Yin D, et al. Self-sufficiency in rice and food security: a South Asian perspective. *Agric Food Secur.* 2013;2(1):10. <https://doi.org/10.1186/2048-7010-2-10>
4. Abeysekara I, Rathnayake I. Global trends in rice production, consumption and trade. 2024. <https://doi.org/10.2139/ssrn.4948477>
5. Baruah M. Bio-ecological approaches for management of major insect pests in rice ecosystem [thesis]. Jorhat (India): Assam Agricultural University; 2022.
6. Omkar, Tripathi AK. Sucking pests of cereals. In: Omkar, editor. Sucking pests of crops. Singapore: Springer; 2020. p. 3–53. https://doi.org/10.1007/978-981-15-6149-8_1
7. Abbas G, Younis H, Naz S, Fatima Z, Hussain S, Ahmed M, et al. Effect of planting dates on agronomic crop production. In: Hasanuzzaman, editor. *Agronomic crops: Volume 1: Production technologies*. Singapore: Springer; 2019. p. 131–47. https://doi.org/10.1007/978-981-32-9151-5_8
8. Lansigan FP, De Los Santos WL, Coladilla JO. Agronomic impacts of climate variability on rice production in the Philippines. *Agric Ecosyst Environ.* 2000;82(1–3):129–37. [https://doi.org/10.1016/S0167-8809\(00\)00222-X](https://doi.org/10.1016/S0167-8809(00)00222-X)
9. Hussain S, Huang J, Huang J, Ahmad S, Nanda S, Anwar S, et al. Rice production under climate change: adaptations and mitigating strategies. In: Fahad S, Hasanuzzaman M, Alam M, Ullah H, Saeed M, Khan IA, et al., editors. *Environment, climate, plant and vegetation growth*. Cham: Springer; 2020. p. 659–86. https://doi.org/10.1007/978-3-030-49732-3_26
10. Ramesh KC. Population dynamics and management of insect pests of rice and their natural enemies in different rice cultivation systems in Bihar [thesis]. Pusa (India): Dr Rajendra Prasad Central Agricultural University; 2020.
11. Khan M. Influence of transplanting date on growth and yield of boro rice varieties in Lalmai-Hill area [thesis]. Dhaka (Bangladesh): Sher-e-Bangla Agricultural University; 2020.
12. Bentur JS. Insect pests of rice in India and their management. In: Vudem DR, Poduri NR, Khareedu VR, editors. *Pests and pathogens: management strategies*. Boca Raton: CRC Press; 2011. p. 1–42.
13. Behera KS, Jena M, Dhua U, Prakash A. Emerging insect pests and diseases of rice under various rice ecosystems. In: Shetty PK, Hegde MR, Mahadevappa M, editors. *Innovations in rice production*. Bangalore: Aditi Enterprises; 2013. p. 93–103.
14. Yadav M. Management of insect pest complex of rice [thesis]. Ranchi (India): Birsa Agricultural University; 2018.
15. Panse RK. Bio-ecology and management strategies of stem borer and leaf folder in rice ecosystem of Balaghat district. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur; 2021.
16. Humane AN, Undirwade DB, Choudhari BN, Shamkuwar GR, Kulkarni US. Consequences of weather parameters and their correlation with the sucking pests and gundhi bug of *Oryza sativa* L. *Environ Ecol.* 2023;41(3):1317–23. <https://doi.org/10.60151/envec/TCXQ5372>
17. Shyamrao ID, Raghuraman M, Kumar A, Gajbiye R. Population dynamics and management of gundhi bug, *Leptocoris acuta* (Thunberg) in rice ecosystem. *J Exp Zool India.* 2020;23(2):1829.
18. Das K, Nath RK, Sharma P, Upamanya GK, Brahma R. Seasonal incidence of rice gundhi bug *Leptocoris oratorius* Fab. (Hemiptera, Alydidae) and effect of various abiotic factors on their incidence in Dhubri district of Assam. *Pharma Innov J.* 2021;10(12):1968–71.
19. Reddy PP. Emerging crop pest problems: redefining management strategies. Jodhpur: Scientific Publishers; 2018.
20. Heinrichs EA. Genetic evaluation for insect resistance in rice. Los Baños (Philippines): International Rice Research Institute (IRRI); 1985.
21. Pathak MD, Khan ZR. Insect pests of rice. 2nd ed. Los Baños (Philippines): International Rice Research Institute (IRRI); 1994.

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