REVIEW OF RESEARCH
ISSN: 2249-894X
IMPACT FACTOR : 5.7631(UIF)
VOLUME - 15 | ISSUE - 3 | DECEMBER - 2025

ECOLOGICAL DISTRIBUTION AND POPULATION DYNAMICS OF RICE PESTS UNDER AGRO-CLIMATIC CONDITIONS OF SATNA DISTRICT (M.P.)

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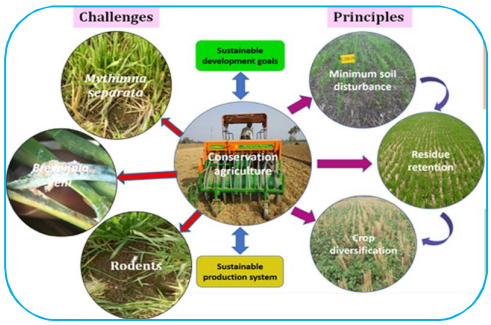
ABSTRACT

The present study examines the ecological distribution and population dynamics of major rice insect pests under the agro-climatic conditions of Satna District, Madhya Pradesh. Field investigations conducted during the kharif season revealed that the occurrence and abundance of key rice pests such as yellow stem borer, leaf folder, brown planthopper, green leafhopper, gall midge, and rice hispa varied significantly with crop growth stages and prevailing climatic factors. Pest populations were generally low during the seedling stage but increased during tillering and panicle initiation stages, coinciding with favorable temperature, rainfall, and humidity conditions. Excessive nitrogen application and continuous irrigation further enhanced pest incidence, particularly of planthoppers and leaf folders. The study highlights that agro-climatic variables and crop management practices play a crucial role in shaping pest population dynamics, emphasizing the importance of ecological understanding for developing effective, region-specific, and sustainable rice pest management strategies in Satna district.



KEYWORDS: *Rice pests, Population dynamics, Ecological distribution, Agro-climatic factors and Integrated Pest Management.*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops of India, providing livelihood and food security to a large section of the population. Madhya Pradesh, particularly the eastern Vindhyan region, has witnessed a steady expansion of rice cultivation due to favorable monsoonal rainfall, improved irrigation facilities, and adoption of high-yielding varieties. Satna district, located in the northeastern part of Madhya Pradesh, represents a distinct agro-climatic zone characterized by tropical monsoon climate, variable rainfall patterns, heterogeneous soil types, and

diverse cropping systems. These agro-climatic factors play a crucial role in shaping the ecological distribution and population dynamics of insect pests associated with rice ecosystems.

Rice cultivation is frequently challenged by a wide array of insect pests that cause significant quantitative and qualitative yield losses. Major rice pests such as yellow stem borer (*Scirpophaga incertulas*), brown planthopper (*Nilaparvata lugens*), leaf folder (*Cnaphalocrocis medinalis*), green leafhopper (*Nephotettix* spp.), gall midge (*Orseolia oryzae*), and various species of grasshoppers and rice hispa exhibit spatial and temporal variations in their occurrence. The abundance and seasonal fluctuation of these pests are strongly influenced by climatic variables including temperature, relative humidity, rainfall, and wind velocity, as well as agronomic practices such as transplanting time, fertilizer application, irrigation regime, and varietal susceptibility.

Understanding the ecological distribution of rice pests involves examining their habitat preferences, spatial dispersion across different growth stages of the crop, and interactions with the surrounding agro-ecosystem. Population dynamics, on the other hand, refer to changes in pest population size and structure over time in response to biotic and abiotic factors. In rice ecosystems, pest populations often show distinct peaks corresponding to specific phenological stages of the crop, such as tillering, panicle initiation, and grain filling stages. Any imbalance in climatic conditions or cropping practices may favor pest outbreaks, leading to severe economic losses.

The agro-climatic conditions of Satna district, marked by erratic rainfall, intermittent drought spells, and increasing temperature trends, have the potential to alter pest incidence and outbreak patterns. Climate variability not only influences pest survival, fecundity, and dispersal but also affects the synchrony between pests and their host plants. Moreover, indiscriminate use of chemical pesticides in rice fields has led to issues such as pest resistance, resurgence, and decline of natural enemies, thereby destabilizing the rice agro-ecosystem.

In this context, studying the ecological distribution and population dynamics of rice pests under the specific agro-climatic conditions of Satna district becomes imperative. Such studies provide baseline data on pest diversity, seasonal abundance, and climatic correlations, which are essential for developing region-specific Integrated Pest Management (IPM) strategies. A comprehensive understanding of pest ecology can help in predicting pest outbreaks, optimizing control measures, reducing dependency on chemical pesticides, and promoting sustainable rice production in the region.

Thus, the present study aims to analyze the spatial and temporal distribution patterns of major rice pests in Satna district and to assess the influence of agro-climatic factors on their population dynamics. The findings are expected to contribute significantly to eco-friendly pest management practices and enhance the resilience of rice-based agro-ecosystems in the Vindhyan region of Madhya Pradesh.

MATERIALS AND METHODS:

Study Area:

The present study was conducted in the rice-growing areas of Satna district, Madhya Pradesh, located in the northeastern part of the Vindhyan plateau. Geographically, the district lies between approximately 24°18′–25°12′ N latitude and 80°21′–81°23′ E longitude. The region experiences a tropical monsoon climate, characterized by hot summers, a distinct monsoon season, and mild winters. The average annual rainfall ranges between 900–1100 mm, most of which is received during the southwest monsoon (June to September). Mean temperatures vary from 10–12°C in winter to 42–45°C in summer, while relative humidity remains high during the cropping season. The soils of the district are predominantly alluvial and red loamy, suitable for rice cultivation. Selected study sites included representative rice fields across different blocks of the district to capture variability in agro-climatic conditions, cropping practices, and pest incidence.

Collection of Rice Insect Pests:

Field surveys were conducted at fortnightly intervals throughout the rice-growing season, covering major crop growth stages such as seedling, tillering, panicle initiation, flowering, and maturity. Rice insect pests were collected using standard sampling techniques, including sweep netting for foliage-dwelling insects, light traps for nocturnal pests, hand picking for larger and sedentary species, and visual count methods for stem borers, leaf folders, and hoppers. Quadrat sampling (1 m^2) was employed to estimate pest density per unit area. Sampling was carried out during early morning and late afternoon hours to ensure maximum pest activity. Meteorological data such as temperature, rainfall, and relative humidity were obtained from the local agricultural meteorological station to correlate pest abundance with agro-climatic variables.

Identification of Insect Pests:

Collected specimens were preserved in 70% ethanol or dry-mounted, depending on the nature of the insect, and labeled with date, location, and crop stage. Identification was carried out in the laboratory using standard taxonomic keys and reference literature for rice insect pests. Where necessary, specimens were examined under a stereo-zoom microscope to observe diagnostic morphological characters. Identifications were confirmed by comparing specimens with authenticated collections and published descriptions. Major pest species were classified based on their feeding guilds and damage symptoms.

Data Analysis :

Population density of rice pests was expressed as number of individuals per hill or per square meter, depending on the pest species. Seasonal abundance and population fluctuations were analyzed across different crop growth stages. Descriptive statistics were used to summarize pest diversity and density. Correlation and regression analyses were performed to assess the relationship between pest population dynamics and agro-climatic factors such as temperature, rainfall, and relative humidity. Graphical representations were prepared to illustrate seasonal trends and peak infestation periods. Statistical analyses were conducted using appropriate software, and significance levels were tested at $p < 0.05$ to ensure reliability of results.

RESULTS :

Field surveys conducted in the rice-growing areas of Satna district revealed a diverse assemblage of insect pests associated with rice crops. A total of twelve major pest species were recorded, belonging to the orders Lepidoptera, Hemiptera, Coleoptera, and Diptera. Among these, the most abundant pests included the yellow stem borer (*Scirpophaga incertulas*), brown planthopper (*Nilaparvata lugens*), green leafhopper (*Nephotettix virescens*), rice leaf folder (*Cnaphalocrocis medinalis*), rice gall midge (*Orseolia oryzae*), and rice hispa (*Dicladispa armigera*). These pests displayed distinct spatial and temporal distribution patterns that were closely influenced by crop growth stages and prevailing agro-climatic conditions.

Population monitoring across different rice growth stages—seedling, tillering, panicle initiation, flowering, and grain filling—showed that pest abundance varied considerably with crop phenology. Stem borers exhibited peak populations during the panicle initiation stage, coinciding with tender stem tissue availability, whereas planthoppers and leafhoppers were most abundant during the tillering and flowering stages, reflecting their preference for actively growing vegetative parts. Rice leaf folder infestation increased during mid-growth stages but declined toward grain filling, likely due to natural enemy activity and crop maturation. The gall midge was most prevalent from panicle initiation to

flowering stages, corresponding with the formation of tender shoots. Rice hispa populations showed moderate infestation throughout the growing season, with slight peaks during tillering and flowering.

Quantitative analysis of population density revealed that stem borers reached a maximum of 12.5 ± 1.1 individuals per hill during panicle initiation, while planthoppers and leafhoppers peaked at 7.2 ± 0.7 and 6.5 ± 0.6 individuals per hill respectively during the tillering stage. Leaf folder density reached 7.8 ± 0.7, gall midge 6.3 ± 0.6, and rice hispa 5.5 ± 0.5 individuals per hill during their respective peak periods. Overall, pest populations were positively correlated with temperature and relative humidity, whereas heavy rainfall events often led to a temporary decline in insect numbers due to physical wash-off. Seasonal dynamics indicated multiple peaks for certain pests, suggesting overlapping generations and continuous colonization of the rice fields throughout the crop cycle.

These results highlight the critical influence of agro-climatic conditions on the ecological distribution and population dynamics of rice pests in Satna district. Understanding these temporal patterns is essential for predicting potential outbreaks and implementing effective, stage-specific pest management strategies to reduce economic losses and promote sustainable rice production in the region. The mean population density (number of insects per hill or per m^2) of major rice pests across different growth stages is summarized in Table 1 below:

Table 1. Population Density of Major Rice Pests Across Different Growth Stages in Satna District

Pest Species	Seedling Stage	Tillering Stage	Panicle Initiation	Flowering Stage	Grain Filling Stage
Scirpophaga incertulas	2.4 ± 0.3	5.8 ± 0.6	12.5 ± 1.1	8.6 ± 0.8	4.2 ± 0.5
Cnaphalocrocis medinalis	1.2 ± 0.2	3.5 ± 0.4	7.8 ± 0.7	6.1 ± 0.6	2.9 ± 0.3
Nilaparvata lugens	3.1 ± 0.4	7.2 ± 0.7	5.0 ± 0.5	4.3 ± 0.4	1.8 ± 0.2
Nephotettix virescens	2.8 ± 0.3	6.5 ± 0.6	4.7 ± 0.5	3.9 ± 0.4	1.5 ± 0.2
Orseolia oryzae	0.9 ± 0.1	2.1 ± 0.2	6.3 ± 0.6	5.0 ± 0.4	2.0 ± 0.2
Dicladispa armigera	1.5 ± 0.2	3.2 ± 0.3	5.5 ± 0.5	4.8 ± 0.4	2.4 ± 0.3

Values represent mean ± standard error (SE) based on fortnightly observations across 10 sampled fields.

DISCUSSION:

The present study highlights the diversity, ecological distribution, and population dynamics of rice insect pests in Satna district, emphasizing the influence of crop phenology and agro-climatic conditions. The recorded pest fauna, dominated by stem borers, planthoppers, leafhoppers, leaf folders, gall midges, and rice hispa, is consistent with observations from other rice-growing regions of Madhya Pradesh and India. The temporal variation in pest abundance observed during the study reflects the close synchrony between pest life cycles and rice crop developmental stages. Stem borers exhibited peak populations during the panicle initiation stage, which aligns with the availability of tender stems that provide an optimal feeding and oviposition site. Similarly, planthoppers and leafhoppers showed maximum activity during the tillering and flowering stages, consistent with their preference for actively growing vegetative tissues and nutrient-rich phloem sap.

The study also demonstrates that agro-climatic factors, such as temperature, relative humidity, and rainfall, significantly influence the population dynamics of rice pests. Moderate temperatures and high humidity during the monsoon season favored rapid growth and survival of most insect pests, leading to higher infestation levels. In contrast, heavy rainfall events temporarily reduced pest

populations, particularly for soft-bodied insects like planthoppers and leafhoppers, due to physical wash-off from the foliage. These findings confirm the role of microclimatic conditions in shaping pest outbreaks and corroborate earlier studies that have emphasized the importance of climatic variability in determining pest incidence and peak activity periods.

Population fluctuations observed across different growth stages suggest that certain pests, such as leaf folders and gall midges, may have overlapping generations, leading to continuous pressure on the crop throughout the season. This emphasizes the need for timely monitoring and the implementation of Integrated Pest Management (IPM) strategies that are tailored to specific crop stages. Stage-specific interventions, such as stem borer egg mass destruction during panicle initiation or biological control of leafhoppers and planthoppers during tillering, can significantly reduce pest pressure while minimizing chemical pesticide use.

The study also underscores the importance of understanding spatial distribution patterns of pests within fields. Pests were not uniformly distributed, and their incidence varied across fields, likely due to differences in crop management practices, varietal susceptibility, and micro-environmental conditions. This heterogeneity highlights the need for precision pest management, where monitoring and control measures are focused on hotspots rather than uniform blanket applications. Moreover, promoting ecological balance through conservation of natural enemies can help suppress pest populations naturally, reducing dependence on chemical control and mitigating risks of resistance and resurgence.

CONCLUSION:

The study on rice pests in Satna district revealed that stem borers, planthoppers, leafhoppers, leaf folders, gall midges, and rice hispa are the major pests affecting rice crops, with population peaks closely linked to crop growth stages and agro-climatic factors such as temperature, rainfall, and humidity. Pest abundance was highest during tillering and panicle initiation, highlighting critical periods for management. These findings underscore the importance of stage-specific monitoring and Integrated Pest Management (IPM) strategies, including biological control, cultural practices, and judicious pesticide use, to reduce pest pressure while maintaining ecological balance. Overall, understanding the seasonal and spatial dynamics of rice pests provides a scientific basis for predicting outbreaks, minimizing crop losses, and promoting sustainable rice production in the Vindhyan region of Madhya Pradesh.

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