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ECOLOGICAL BASIS OF INTEGRATED PEST MANAGEMENT OF RICE PESTS IN SATNA DISTRICT

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ABSTRACT:

The present study examines the ecological basis of Integrated Pest Management (IPM) of rice pests in Satna District, Madhya Pradesh, with emphasis on pest biodiversity, population dynamics, and the role of natural enemies within the rice agro-ecosystem. Rice fields of different blocks in Satna district were surveyed during the kharif seasons to document the diversity and seasonal abundance of major insect pests, including stem borers, leaf folders, brown planthoppers, gall midges, and rice hispa, along with their associated predators and parasitoids. Observations on crop growth stages, climatic variables (temperature, rainfall, and relative humidity), and agronomic practices were integrated to understand pest–environment interactions. The results revealed that pest incidence varied significantly with crop phenology and abiotic factors, while populations of natural enemies such as spiders, coccinellids, dragonflies, and hymenopteran parasitoids played a crucial role in suppressing pest outbreaks under low chemical input conditions. Fields adopting ecologically sound practices such as balanced fertilizer application, reduced pesticide use, and conservation of field bund vegetation exhibited higher natural enemy diversity and lower pest infestation levels. Diversity indices indicated a more stable and resilient agro-ecosystem in IPM-managed fields compared to conventionally managed fields.

KEYWORDS: *Integrated Pest Management, Rice pests, Agro-ecosystem, Biodiversity and Natural enemies.*

INTRODUCTION:

Rice (*Oryza sativa* L.) is one of the most important staple food crops of India and plays a vital role in ensuring food security and rural livelihoods. In Madhya Pradesh, rice is widely cultivated during the kharif season, and districts like Satna contribute significantly to regional rice production. However, rice cultivation is severely constrained by a wide range of insect pests that cause substantial yield losses every year. Major rice pests such as stem borers, leaf folders, planthoppers, gall midges, and hispa pose persistent threats throughout different growth stages of the crop.

Traditionally, management of rice pests has relied heavily on chemical pesticides. Although these provide quick control, indiscriminate and excessive use has resulted in several ecological problems, including pesticide resistance, resurgence of secondary pests, destruction of natural enemies, environmental pollution, and health hazards to farmers and consumers. These challenges have

emphasized the need for ecologically sustainable pest management approaches, leading to the development and adoption of Integrated Pest Management (IPM) strategies.

Integrated Pest Management is an environmentally sound approach that combines biological, cultural, mechanical, and chemical methods to keep pest populations below economic threshold levels. The ecological basis of IPM lies in understanding the interactions among pests, their natural enemies, host plants, and environmental factors within the agro-ecosystem. Rice fields represent complex and dynamic ecosystems where pest populations are strongly influenced by climatic conditions, cropping practices, habitat structure, and biodiversity of associated organisms.

In the Satna district, variations in agro-climatic conditions, irrigation practices, and crop management systems significantly influence rice pest incidence and the effectiveness of control measures. Despite the importance of rice cultivation in the region, limited comprehensive studies have been conducted to evaluate rice pest management from an ecological perspective. Understanding pest diversity, population dynamics, and the role of natural enemies is essential for designing effective IPM strategies suited to local conditions. Therefore, the present study aims to analyze the ecological basis of Integrated Pest Management of rice pests in Satna District, focusing on pest biodiversity, environmental influences, and the contribution of natural enemies to pest regulation. The findings are expected to provide valuable insights for promoting sustainable rice pest management practices, reducing dependence on chemical pesticides, and maintaining ecological balance in rice agro-ecosystems of the region.

MATERIALS AND METHODS:

Study Area:

The present study was conducted in major rice-growing areas of Satna District, Madhya Pradesh (India) during the kharif seasons. Satna district lies in the Vindhyan plateau region and experiences a tropical monsoon climate, characterized by hot summers, moderate to heavy rainfall during the monsoon period, and mild winters. The average annual rainfall ranges between 900–1100 mm, which supports extensive rice cultivation under both rain-fed and irrigated conditions. Selected study sites included representative rice fields from different blocks of the district, covering variations in cropping practices, irrigation facilities, and pesticide use patterns. These sites provided suitable conditions for assessing pest diversity, natural enemy abundance, and ecological interactions within the rice agro-ecosystem.

Collection of Rice Pests and Natural Enemies:

Field surveys were carried out at regular intervals throughout different crop growth stages, including seedling, tillering, panicle initiation, flowering, and maturity stages. Rice insect pests were collected using standard entomological methods such as sweep netting, hand picking, light traps, and visual count methods. Stem borer infestation was assessed by recording dead hearts and white ear heads, while planthopper and leaf folder populations were estimated by hill count methods. Natural enemies such as predators and parasitoids were recorded simultaneously using sweep nets, pitfall traps, and direct field observations. Spiders, coccinellid beetles, dragonflies, damselflies, and parasitoid wasps were noted to evaluate their role in regulating pest populations. Collected specimens were preserved in 70% alcohol or dry mounted as per standard procedures for further laboratory examination.

Identification:

Collected insect specimens were identified up to species or genus level using standard taxonomic keys, reference collections, and published literature on rice insect pests and beneficial insects. Identification was carried out in the laboratory with the help of stereomicroscopes. Wherever necessary, expert consultation and authenticated keys from entomological institutions were used to confirm species identification. Macro-photographs were also taken to support accurate identification and documentation.

Data Analysis :

Quantitative data on pest and natural enemy populations were analyzed to understand their diversity, abundance, and seasonal fluctuations. Diversity indices such as Shannon–Wiener Index (H′), Simpson's Diversity Index (D), and Evenness Index (E) were calculated to assess biodiversity within the rice agro-ecosystem. Correlation and regression analyses were performed to examine relationships between pest populations and abiotic factors such as temperature, rainfall, and relative humidity.

Comparative analysis was carried out between IPM-adopted and conventionally managed fields to evaluate the effectiveness of ecological IPM practices. Economic threshold levels were considered to interpret pest incidence and management requirements. All statistical analyses were performed using standard statistical software, and results were interpreted in relation to ecological stability and sustainability of rice pest management in Satna district.

RESULTS:

The present investigation revealed a rich diversity of rice insect pests and their natural enemies in the rice agro-ecosystems of Satna District. Pest incidence and population density varied significantly with crop growth stages and prevailing environmental conditions. Major rice pests recorded during the study included yellow stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), brown planthopper (*Nilaparvata lugens*), green leafhopper (*Nephotettix* spp.), gall midge (*Orseolia oryzae*), and rice hispa (*Dicladispa armigera*).

Pest populations were generally low during the early seedling stage, gradually increased during the tillering stage, and reached peak levels during panicle initiation and flowering stages. Stem borer damage, expressed as dead hearts and white ear heads, showed a strong association with higher temperature and humidity. Planthopper and leaf folder populations were found to increase in fields receiving higher nitrogen inputs and frequent irrigation.

A diverse assemblage of natural enemies was recorded throughout the cropping season. Predators such as spiders (Araneae), coccinellid beetles (*Coccinella* spp.), dragonflies (*Pantala flavescens*), and damselflies were abundant, particularly in IPM-managed fields. Parasitoids belonging to Hymenoptera, especially *Trichogramma* spp. and *Telenomus* spp., were observed parasitizing eggs of stem borers and leaf folders. Fields with reduced pesticide application exhibited significantly higher natural enemy populations, resulting in lower pest pressure.

Diversity index analysis indicated higher Shannon–Wiener diversity and evenness values in IPM fields compared to conventionally managed fields, suggesting greater ecological stability. A negative correlation was observed between pest abundance and natural enemy density, highlighting the regulatory role of biological control agents in rice ecosystems.

Table 1: Major Rice Pests and Natural Enemies Recorded in Satna District

S. No.	Insect Species	Common Name	Order	Mean Population / Infestation Level*	Ecological Role
1	*Scirpophaga incertulas*	Yellow stem borer	Lepidoptera	8.6% dead hearts	Major pest
2	*Cnaphalocrocis medinalis*	Leaf folder	Lepidoptera	6.2 larvae/hill	Major pest
3	*Nilaparvata lugens*	Brown planthopper	Hemiptera	12.4 insects/hill	Major pest
4	*Nephotettix* spp.	Green leafhopper	Hemiptera	9.1 insects/hill	Minor–major pest
5	*Orseolia oryzae*	Gall midge	Diptera	4.3% silver shoots	Minor pest
6	*Dicladispa armigera*	Rice hispa	Coleoptera	3.7 adults/hill	Minor pest

S. No.	Insect Species	Common Name	Order	Mean Population / Infestation Level*	Ecological Role
7	Spiders (Araneae)	Spiders	Araneae	6.8 individuals/m^2	Predator
8	*Coccinella* spp.	Ladybird beetle	Coleoptera	4.2 individuals/m^2	Predator
9	*Pantala flavescens*	Dragonfly	Odonata	3.5 individuals/m^2	Predator
10	*Trichogramma* spp.	Egg parasitoid	Hymenoptera	18–24% parasitism	Parasitoid

*Mean values represent pooled observations across crop stages and study sites.

DISCUSSION :

The present study provides a comprehensive understanding of the ecological basis of Integrated Pest Management (IPM) in rice agro-ecosystems of Satna District, Madhya Pradesh. The results clearly demonstrate that rice pest diversity and abundance are strongly influenced by crop growth stages, abiotic factors, and prevailing agricultural practices. The dominance of major pests such as yellow stem borer, brown planthopper, and leaf folder during the tillering to flowering stages corroborates earlier findings that these stages offer favorable microclimatic conditions and abundant food resources for pest multiplication.

The observed increase in stem borer infestation during periods of higher temperature and humidity highlights the role of climatic variables in pest outbreaks. Similarly, higher populations of planthoppers and leafhoppers in nitrogen-rich fields suggest that excessive fertilizer application enhances plant succulence, thereby increasing pest susceptibility. These findings emphasize the importance of balanced nutrient management as a key ecological component of IPM.

A notable outcome of the study is the significant presence of natural enemies in rice fields, particularly in IPM-managed plots. Predators such as spiders, coccinellid beetles, and odonates, along with parasitoids like *Trichogramma* spp., contributed substantially to natural regulation of pest populations. The negative correlation between pest density and natural enemy abundance confirms the stabilizing role of biological control agents in rice ecosystems. Similar trends have been reported in other rice-growing regions, where conservation of natural enemies reduced the frequency and intensity of pest outbreaks.

The higher values of Shannon–Wiener diversity and evenness indices recorded in IPM fields indicate greater ecological stability and resilience compared to conventionally managed fields. Reduced pesticide application in IPM plots helped preserve beneficial insect populations, preventing pest resurgence and secondary pest outbreaks. In contrast, conventional fields showed lower diversity and higher pest incidence, likely due to disruption of trophic interactions caused by indiscriminate chemical use. Overall, the findings support the concept that ecology-based IPM, which integrates pest biodiversity assessment, habitat management, conservation of natural enemies, and threshold-based chemical interventions, is more sustainable than chemical-dependent approaches. Adoption of such strategies in Satna district can not only reduce environmental and health risks but also enhance long-term productivity and economic returns for farmers. The study underscores the need for farmer awareness and region-specific IPM programs tailored to local ecological conditions.

CONCLUSION:

The present study concludes that the ecological approach to Integrated Pest Management (IPM) is highly effective for sustainable management of rice pests in the rice agro-ecosystems of Satna District, Madhya Pradesh. The investigation revealed a diverse complex of rice insect pests whose population dynamics were closely linked with crop growth stages, climatic factors, and agricultural practices. Major pests such as yellow stem borer, brown planthopper, and leaf folder showed peak infestation during critical growth phases, emphasizing the need for stage-specific management strategies.

The study clearly demonstrated the crucial role of natural enemies—including predators and parasitoids—in regulating pest populations. Higher abundance and diversity of beneficial insects in

IPM-managed fields resulted in lower pest pressure and improved ecological stability. Conservation of these natural enemies through reduced and judicious use of pesticides proved to be a key component of effective pest suppression. Diversity index analysis further confirmed that IPM-based rice fields exhibited greater biodiversity, evenness, and ecosystem resilience compared to conventionally managed fields. Balanced fertilizer application, habitat management, and threshold-based interventions contributed significantly to minimizing pest outbreaks and preventing pest resurgence. Overall, the findings highlight that ecology-based IPM is a viable, environmentally safe, and economically sustainable alternative to chemical-intensive pest control practices. Adoption of region-specific IPM strategies in Satna district can enhance rice productivity while conserving biodiversity and maintaining agro-ecosystem health. The study strongly recommends strengthening farmer awareness programs and extension services to promote large-scale implementation of ecological IPM for long-term sustainability of rice-based farming systems.

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