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REVIEW ARTICLE

A Review on Integrated Pest Management in Rice in India and traditional Practices in North East India

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ABSTRACT
Integrated Pest Management (IPM) has emerged as a crucial strategy for sustainable agricultural practices, particularly in rice cultivation, which serves as a staple food for a significant portion of the global population. This review explores the development and implementation of IPM in rice cultivation in India, focusing on various strategies and practices employed to manage insect pests effectively. It also examines the challenges encountered in adopting IPM techniques and discusses traditional pest management practices prevalent in North East India. Through secondary sources of information including academic literature, government reports, and field studies, this review underscores the importance of IPM in enhancing agricultural productivity while minimizing environmental and health risks associated with chemical pesticides. Key IPM approaches discussed include host plant resistance, cultural controls, chemical controls, biological controls, and mechanical practices. Moreover, the review highlights the necessity for location-specific IPM modules, community participation, and continuous technological advancements to address evolving pest challenges. Traditional pest management practices in North East India reflect indigenous knowledge and resourcefulness, offering insights into sustainable pest management methods. Overall, the review emphasizes the dynamic nature of IPM and the need for collaborative efforts among researchers, policymakers, and farmers to ensure its successful implementation and long-term sustainability in rice cultivation.
Keywords: *Integrated Pest Management (IPM), Rice, Pest Management Strategies, Traditional Pest Management, North East India*

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INTRODUCTION

As an agrarian nation, over 70% of the rural population in India depends on agriculture and its associated activities for their livelihood. Since 1966, the agricultural sector in India has experienced remarkable growth. Rice stands as the most crucial food crop globally, serving the largest population of both consumers and farmers(1). Countries such as India, China, and Japan boast the largest areas of rice cultivation, production, and productivity respectively (2).

India, specifically, holds the largest area under rice cultivation worldwide, covering 44.6 million hectares, and ranks second in rice production, with 117.94 million tonnes recorded in the 2019-20 period. The diverse agro-ecological conditions across India—ranging from waterlogged and deep-water areas to hilly terrains, high humidity, high temperatures, saline, alkaline, and flood-prone regions—lead to varying cropping intensities. Fertile regions can support up to three rice growing seasons annually. However, rice crops face significant threats from various pests, including insects, weeds, and rodents. Over 100 insect species have been identified as rice pests globally, with about a dozen posing substantial threats in India(3). Pest-related yield losses in India range from 21% to 51%(4).

Coordinated network trials across different centres in India have demonstrated that controlling insect pests alone can increase yields by approximately 1 ton/ha. Integrated Pest Management (IPM) strategies offer an optimal solution to these pest challenges. IPM, as defined by various government bodies, research organizations, NGOs, and universities, is a pest management system that, within the context of the associated environment and pest population dynamics, employs all feasible techniques and methods in a compatible manner to maintain pest populations below economically harmful levels. Rice IPM provides a comprehensive framework for integrating knowledge, skills, and information on rice pest management.
This paper aims to review the development of IPM in rice cultivation in India, incorporating traditional pest management practices used by farmers in Northeast India.

Integrated Pest Management in Rice Cultivation in India

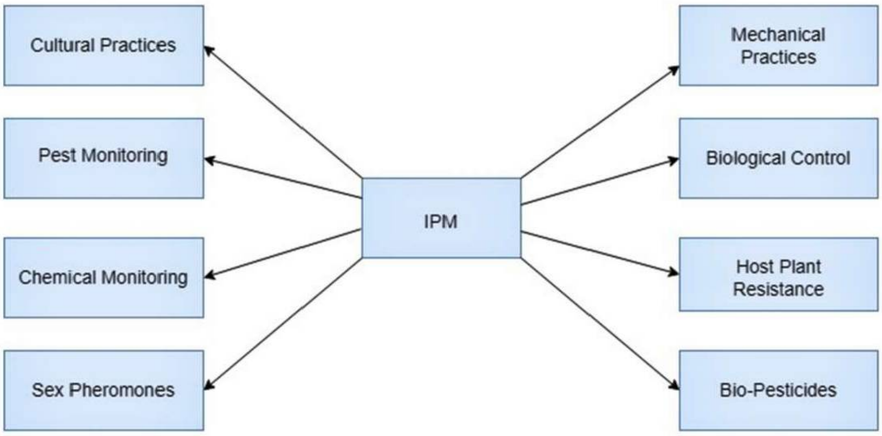

Fig.1: Different approaches of IPM in rice.

Integrated Pest Management (IPM) has been pivotal in managing pest damage and maintaining pest populations below economic threshold levels in rice cultivation in India. Numerous strategies have demonstrated success in controlling insect pests in rice fields.

Host Plant Resistance

Developing rice varieties resistant or tolerant to insect pests and diseases is a critical component of Integrated Pest Management (IPM). India has released over 550 commercial rice varieties, with 51 resistant to gall midge, 25 to brown plant hopper, 3 each to stem borer and green leafhopper, and 2 to white-backed plant hopper (5). These varieties are not only pest-resistant but also exhibit high yield and desirable agronomic. Host plant resistance is a highly effective, economical, and easy-to-implement IPM strategy, extensively used in pest-endemic areas. These resistant varieties are often developed through genetic modifications, such as incorporating genes from *Bacillus thuringiensis*, which make plant tissues toxic to pests (4).
However, pests can co-evolve with their host plants, leading to the emergence of new biotypes. For instance, in the case of gall midge, three biotypes were initially identified, but another three have evolved in different parts of India due to the cultivation of resistant varieties like Surekha and Phalguna. This co-evolution highlights the ongoing challenge in developing and maintaining effective resistant varieties.

Cultural Control

Cultural control practices involve standard farming techniques manipulated to reduce or eliminate insect pest populations in crops. These practices can directly affect pest growth and multiplication or decrease host plant susceptibility, making the environment less favourable for pests and more favourable for their natural enemies. Cultural practices are compatible with other pest management strategies and can target multiple pests simultaneously (3–5) (Table 1). Key cultural control practices include:

1. Early and synchronous planting to prevent overlapping pest infestations.
2. Inter-planting nectar-producing plants and diverse crops to support beneficial insects.
3. Destroying old crop stubble to prevent pest carryover.
4. Crop rotation to interrupt pest life cycles and habitats.
5. Fertilizer management, such as using cover crops as green manure or splitting nitrogen application into 2-3 doses.
6. Manipulating row spacing, like creating alleyways every 2-3 meters, to reduce pest infestations.

7. Water management, including flooding, draining, and ploughing with rotators to expose and kill hibernating larvae and pupae.

Cultural practice	Effected Insect pest
Synchronous planting	YSB,GM,BPH,GLH
Synchronous harvesting	YSB,BPH,CW
Early trans planting	YSB,GM,BPH
Formation of alleyways	BPH
Fertilizer management	GM,LF,BPH,GLH
Draining off water	GM,BPH
Flooding	CW
Stubble management	YSB

Table 1: Various cultural practices useful in pest management of rice
(YSB-Yellow stem borer,GM-Gall midge, BPH-Brown plant hopper, GLH-Green leaf hopper, CW- Case worm,LF- Leaf folder.)

Chemical Control

Synthetic pesticides are often used when other pest control methods fail, especially during the early or later stages of crop growth. These pesticides are fast-acting, relatively inexpensive, and easy to use. However, the success of chemical control relies heavily on choosing the right pesticide, understanding the most vulnerable stage of the pest, and considering the environmental and economic impacts of pest populations. The formulation and application technique also significantly influence the pesticide's effectiveness (6). Awareness of potential hazards to users, consumers, and the environment is essential.

Biological Control

Biological control uses living organisms to suppress pest populations, making them less harmful to crops. These natural enemies, which include predators and parasites, kill pests, reduce their reproductive potential, or compete with them for host plants. Biological control offers a promising alternative to chemical methods, effectively managing major pests in India through the inundative and inoculative release of natural enemies (3). This approach is particularly effective against yellow stem borer, leaf folder, gall midge, and plant hoppers.

Studies in India and abroad indicate that native natural enemies can be effectively used in pest management(7). While not precisely estimated, biological control in paddy fields primarily occurs through natural processes, with several natural enemies identified across the country. These enemies have been studied for their abundance and relative occurrence in various rice-growing ecosystems.

In India, the inundative release of natural enemies has been primarily limited to egg parasitoids, especially *Trichogramma japonicum* and *T. chilonis*, due to their ease of mass multiplication. The release of *Trichogramma spp.* has been useful against pests like *S. incertulas* and rice leaf folder complexes(8). Across the country, the inundative release of *Trichogramma spp*. is practiced to control stem borers and leaf folders in rice fields. Success has been reported with egg parasitoids such as *T. japonicum*, *T. brasiliensis*, *T. chilonis*, and *T. exigua* in controlling stem borer(9).

Studies under the All India Coordinated Rice Improvement Program have shown that egg parasites like *Tetrastichus, Telenomus*, and *Trichogramma* spp. thrive better in natural biocontrol plots (NBC) with higher parasitism rates compared to need-based protection (NBP) and schedule-based protection (SBP)(10). However, the major parasite of the gall midge, *Platygaster oryzae*, has not significantly impacted field parasitism. In the case of leaf folders, schedule-based protection increased pest infestation and adversely affected larval parasitism.

Insect	Natural enemies	Stage parasitized
Stemborer	*Telenomus*spp., *Tetrastichus*spp., *Trichogramma* spp.	Egg
Gall midge	*Platygasteroryzae*	
Plant hopper	*Anagrus* spp. *Oligostia* spp *Gonatopas*spp. *Crytorhinuslividipennis Lycosa* spp. And other Spiders	Egg, Nymph, Adult
Leaf folder	*Trichogramma* spp., *Apanteles* spp., *Tetrastichus* spp.	Egg, Larva, Pupa
Hispa	*Apanteles* spp., *Bracon* spp.	Egg, Larva

Table:3. Important natural enemies of rice pest

Predators

Among predators, spiders, mirid bugs, and coccinellids are more common and dominant, while dragonflies, damselflies, ground beetles, staphylinids, and earwigs are observed at low to moderate levels.

The predator population remains higher in natural bio-control plots due to reduced pesticide application. Studies have shown that need-based pesticide application results in higher profits compared to other strategies (10). This approach maintains low pest populations, allowing natural enemies to thrive. Quantifying natural bio-control in different rice agroecosystems and demonstrating the effectiveness of natural enemies could help reduce insecticide use. Conventional practices often destroy certain predatory fauna when used indiscriminately, causing pest outbreaks. However, insecticides like carbofuran, phorate, and granular formulations are safer for natural enemies compared to spray formulations like monocrotophos and chlorpyriphos. Neem formulations such as Rakshak, Econeem, Neemax, Neemazal, and Neem Gold are safer for major natural enemies(11).

Use of Biopesticides

Microbial Pesticides

Microbial pesticides, like *Bacillus thuringiensis* (Bt) formulations with endotoxins, are another useful pest management approach. They are natural enemies to insect pests and other non-target organisms, specific to pests, and harmless to humans. They are highly effective against leaf folder pests and moderately effective against stem borers. Fungal pathogens such as *Beauveria bassiana* against rice hispa and *Pandora delphacis* against BPH have also shown promise(12).

Botanical Pesticides

Neem formulations represent a novel approach to pest management as they are safe for humans and the environment. Unlike traditional insecticides, neem formulations do not outrightly kill insect pests but incapacitate them through repellence, feeding deterrence, reproductive inhibition, and oviposition deterrence. Studies have shown that neem formulations are moderately effective against BPH, WBPH, GLH, and leaf folder.

Insect sex hormones

Sex pheromones are effective tools for managing insect pests like the yellow stem borer. They can be utilized in two main ways:

a. Pest Surveillance and Behavioral Manipulation

1) Mating Disruption: Introducing synthetic pheromones into the environment to mask natural pheromones, preventing mating by disrupting communication between male and female insects.
2) Mass Trapping: Using pheromone-baited traps (e.g., funnel traps) to attract and kill pests in large numbers. This method is economical, non-pollutant, ecologically acceptable, and species-specific. However, its specificity can be a disadvantage when multiple pests are present simultaneously.

b. Pest Surveillance/Monitoring

Pest surveillance is crucial in Integrated Pest Management (IPM). It involves regular monitoring of pest and disease occurrence, population development, and damage, providing the basis for control decisions using economic thresholds as guidelines.

Survey/Field Scouting: Surveys monitor pest development in endemic areas at the start of the crop season. Roving surveys help determine focus areas for state extension functionaries, who then concentrate efforts at the block and village levels for detailed field scouting. The plant protection measures are required to be taken only when insect pests and diseases cross Economic Threshold Level (ETL) as per results of field scouting(13)(14).

Pest monitoring through pheromones/light traps:

Majority of insect's population can be monitored by fixing or positioning of pheromones or light traps at appropriate stage of crops.

1) Pheromone trap monitoring-5 traps per ha may be used to monitor yellow stem borer and moth population.
2) Light trap-Chinsurah light trap or any other light trap can be operated for two hours in the evening to observe photo-tropic insect pests.
3) Sweep nets- water pans–Besides visual observations sweep nets and water pans may also be used to assess the population of insect pests and bio-control agents to determine the type of pesticides to be recommended or used. Traditionally, light traps are used for in direct assessment for the presence or development of insect pest populations. However, pheromone baited traps have been successfully utilized for monitoring stem borer and leaf borer (15).

Mechanical practice

In this method, pests are destructed or damaged by manual labour. This includes-

- Removal or destruction of pest in fested plant parts.
- Use of rope dipped in kerosene in rice crop field.
- Clipping of rice seedling tips before transplanting.

- Collection of egg masses and larvae.

Discussion and Recommendation

Investment concessions encourage farmers to adopt IPM for pest control. The cost of technology is crucial in farmers' decision-making. Currently, IPM programs offer bio-pesticides at subsidized prices, supported by public sectors. Studies indicate that the benefits of conventional chemical pest control are slightly lower than those of IPM adoption (4). However, the economics of IPM can be disrupted by rising bio-pesticide prices due to cost considerations or subsidy withdrawal. Given the considerable social and environmental benefits of bio-pesticides, the government should consider subsidizing them, facilitating wider IPM distribution. Another approach could be making chemical pesticide production and use less attractive through taxes and excise duties. Historically, heavy taxes on the pesticide industry led to a decline in pesticide use in the early 1990s(16). Encouraging pesticide industries to produce safer pesticides and bio-pesticides, coupled with withdrawing subsidies for chemical pesticides and linking agricultural credit and insurance to IPM adoption, would further motivate farmers to switch from conventional methods to IPM.

On-Farm Implementation of IPM

Large-scale IPM implementation requires collective action, involving government agencies, industries, and farmers. ICAR initiated Operational Research Projects on IPM for rice, supervised by the Directorate of Rice Research (DRR), Hyderabad, Kerala Agricultural University, and the Department of Agriculture, West Bengal. Successful IPM implementations are observed in districts of Haryana, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Kerala, Madhya Pradesh, and Punjab(5). The current trend in IPM emphasizes a 'bottom-up' or participatory approach, combining control tactics for better yield, profit, and environmental safety. In areas with long-term pesticide use, the goal is to minimize their use while maximizing biological and cultural methods, including host plant resistance and biological control agents. Understanding farmers' perceptions and conditions within their farming systems, rather than focusing solely on the rice crop, is essential.

Essentials for Implementation

Successful IPM programs require development, support, and implementation through various organizations. Key points for program implementation include:

1. Availability of location-specific IPM modules that are ecologically sound, viable, and socially acceptable.
2. High-level target group participation.
3. Widespread dissemination of IPM strategies.
4. Removal of obstacles to IPM dissemination.
5. Measuring, evaluating, and publicizing IPM impacts.
6. Prioritizing the augmentation and preservation of natural enemies to maintain ecological balance and manage pests using bio-agents and bio pesticides/botanicals.

Traditional Pest Management in Rice in North-East India

The agricultural landscape in north-east India differs significantly from mainland India due to varying climatic conditions and physiography. Indigenous communities in the north-east have unique traditions and customs, with shifting cultivation being the main form of agriculture(14). Agricultural support systems often fail to reach upland farmers, who then rely on traditional pest management practices based on empirical experience. Common traditional practices are detailed in Table 4 (17–19).

Traditional Practices	**Target pests**
Erection of bamboo (*Bambusa indica)* branches or other stick in the rice field.	Rice stem borer
Steam decoction of neem (*Azadirachta indica*) leaves and seeds and spraying the extract onto the rice crop. The extract is prepared by mixing 1to 3 gm of ground neem seed or leaf in 1 liter of waterfor12hours.	
Keeping slices of pumalo (*Citrus grandisosbeck*) in the paddy field.	
Introduction of grounded khira leaf in Irrigation channel.	
Placing chopped leaves of Indian Rhododendron or phutuka in paddy field.	
Placing of grounded bark of drumstick (Moringa *oleifera*) into the rice field.	
Placing few branches of fern (Cybotiumspp.)	
Burying the puthi or barb fish (*Puntius* spp.) into the soil for 15-20 days and spraying the water extract of them into the rice field.	
Placing citrus or sakala tenga (*Citrus sinensis*os beck) peels in the rice fields	
Erecting or pegging branches of *Cymbopogon khasianum* or S*accharum spantaneum*.	

Spreading of grounded pulp of khira leaves in water.	
Placing of branches of Calotropis process in paddy fields.	stem and root borer
Removal of grasses around the bund of paddy fields.	Rice leaf folder
Placing of well fermented wine pomace (wine residue) usually made up of millets in source of irrigation canal	Rice leaf folder
Spraying of aqueous suspension of cow-dung in the nursery.	Rice thrips
Dragging of rope impregnated with kerosene with standing water	Rice case worm
Rearing duck near the paddy field	Rice hispa
Mixing cow dung with water in paddy fields	
Placing of nishinda plant twigs (*Vitexnegunda*)in the infected rice fields	
Burning of bicycle tyres near the rice field before panicle initiation	Gundhi bug
Placing rotten crab or frogs in plastic trapsat1trap/10m^{2}area	
Placing the leaves *Calotropisprocera* in paddy fields.	Rice aphids
Placing grounded oak tree bark in the source of irrigation canal	Brown plant hopper
Keeping tree boles/trunk and partially cut alder trees amidst jhum field.	Rice grass hopper
Growing of inter crops such as maize and Sorghum long duration pigeon pea etc. with jhum rice	Several pests of rice
Indigenous repeated ploughing technique for getting rid of soil borne insects and their diapausing stages	Several pests of rice

Table 4: Common Traditional Pest Management Practices in Rice in North East India

CONCLUSION

The literature on the impact of rice IPM on farmers is extensive but sparse in published data, reflecting technical and financial challenges in conducting such studies. Longitudinal studies in agriculture are particularly challenging due to seasonal variations, while horizontal studies face difficulties in finding comparable IPM and non-IPM controls across diverse and socially varied settings. Despite these methodological limitations, strong evidence supports the benefits of IPM for rice farmers. IPM is a dynamic process requiring continuous technological updates to adapt to evolving pest scenarios. Farmers must adopt modern and intensive agricultural practices to enhance productivity and meet future demands. The practices observed in Table 5 highlight the Northeast Indian communities' profound knowledge of local plant resources and their sustainable utilization.

REFERENCES

1. Zeigler, R.S., Barclay, A.(2008). The relevance of rice. Vol. 1, Rice. Springer. p. 3–10.
2. Gadal, N., Shrestha, J., Poudel, M.N., Pokharel, B. (2019). A review on production status and growing environments of rice in Nepal and in the world. Archives of Agriculture and Environmental Science; 4 (1) : 83–87.
3. Pathak, M.D., Jayaraj, S., Rao, Y., Kameshwar Rao, K., Mukhopadhyay, S.K. (1996). Integrated pest management in rice. In: International Symp on Rainfed Rice for Sustainable Food Security, Central rice Research Institute, Cuttack. p. 295–300.
4. Sehgal, M., Malik, M, Singh, R.V., Kanojia, A.K., Singode, A. (2018). Integrated pest management in rice and its future scope. International Journal of Current Microbiology and Applied Sciences; 7(6) : 2504–2511.
5. Pasalu, I.C., Mishra, B., Krishnaiah, N.V., Katti, G. (2004). Integrated pest management in rice in India: Status and prospects. In: Proceedings; p. 237–245.
6. Arora, S., Mukherji, I., Kumar, A., Tanwar, R.K. (2014). Pesticide residue analysis of soil, water, and grain of IPM basmati rice. Environmental monitoring and assessment; Vol. 186 (12) : 8765–8772.
7. Huffaker, C.B., Ridgway, R.L., Vinson, S.B. (1976). Biological Control by Augmentation of Natural Enemies.
8. Mathur, K.C. (1983). Biological control in pest management. In: Proceedings Annual rice workshop.
9. Gupta, M., Rao, P.P., Pawar, A.D. (1987). Role of parasites and predators in rice ecosystem. In: National symposium on integrated pest control-progress and perspectives, Trivandram, (Eds. N. Mohan Das and George Koshy). p. 15–17.
10. Katti, G., Pasalu, I.C., Varma, N.R.G., Dhandapani, N. (2001). Quantification of natural biological control in rice ecosystem for possible exploitation in rice IPM; In: Proc. of the eighty eighth session of the Indian Science Congress, New Delhi, Abstract No. 60, p45.

11. Jhansilakshmi, V., Katti, G., Krishnaiah, N.V., Kumar, K.M. (1998). Safety of neem formulations vis-à-vis insecticides to *Cyrtorhinus lividipennis* Reuter (Hemiptera: Miridae), a predator of brown planthoppers, *Nilaparvata lugens* (Stal) in rice crop. Journal of Biological Control; 12(2) : 119–22.
12. Hazarika, L.K., Puzari, K.C. (1997). Field efficacy of white muscardine fungus (*Beauveria bassiana*) on rice hispa (*Dicladispa armigera*). The Indian Journal of Agricultural Sciences; 67(10): 463-465.
13. Misra, R.P., Arasumallaiah, L., Ravi, K., Diwakar, M.C. (1994). Integrated pest management approach for rice-a case study in Karnataka. Plant Protection Bulletin 46(1): 6-10.
14. Prakash, A., Bentur, J.S., Prasad, M.S., Tanwar, R.K., Sharma, O.P., Bhagat, S., et al. (2014). Integrated pest management for rice. National Centre for Integrated Pest Management, New Delhi, India; 43, p.1-19.
15. Krishnaiah, K., Zainulabeuddin, S., Rao, A.G., Kumar, D., Verma, N. (1998). Pheromone monitoring system of rice yellow stem borer, *Scirpophaga incertulas* Walker. Indian Journal of Plant Protection; 26(2) : 99–106.
16. Birthal, P.S., Sharma, O.P., Kumar, S. (2000). Economics of integrated pest management: Evidences and issues. Indian Journal of Agricultural Economics; 55(4) : 644–659.
17. Deka, M.K., Bhuyan, M., Hazarika, L.K. (2006). Traditional pest management practices of Assam. Indian Journal of Traditional Knowledge, pp 75-78
18. Srivastava, S.K., Babu, N., Pandey, H. (2009). Traditional insect bio-prospecting–As human food and medicine. Indian Journal of Traditional Knowledge, p 485-494.
19. Bhattacharjee, P.P., Ray, D.C. (2010). Pest management beliefs and practices of Manipuri rice farmers in Barak Valley, Assam. Indian Journal of Traditional Knowledge, p 673- 676.