Ecological Engineering to manage the Rice Pests: A Sustainable Production Method for restoration of Rice Ecosystem

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Introduction

Rice is a very important crop in India with cultivation dating back for thousands of years. The green revolution in 1960s was aimed at meeting the increasing demsand for food with the rapid population growth. In India, rice is grown over an area of 50 M. ha. with a production of 217.52 M. tonnes (*Anon.,* 2024-25). Karnataka occupies a prominent place in rice map of India accounting for nearly 14.55 Lakh. ha. producing nearly 45.54 Lakh. tonnes (*Anon.,* 2023-24). Rice production increased greatly, with the wide-scale adaptation of high-yielding varieties, extensive use of pesticides and chemical fertilizers. The resulting production system was dependent on high inputs of agrochemicals resulting in a serious threat to the ecological safety of rice, environmental health and the rice grain quality (Heong, 2009). Although rice yields in India continuously increased in recent decades, the outbreak of rice pests has become one of the main obstacles to sustainable production. Large-scale outbreaks of rice planthoppers and the viral diseases they transmit become common in the first decade of the twenty-first century (Xia, 2008). Chemical control has been considered as a key measure to suppress the population of rice planthoppers. The excessive application of chemical pesticides not only led to the development of resistance to insecticides but also negatively affected natural enemies and other beneficial organisms and resulted in unwelcome contamination to the aquatic environment and rice grain. It consequently became essential to minimize the use of chemical pesticides and to guarantee the food safety by developing ecological pest management.

Recent scientific studies have demonstrated that insecticides have a strong collateral effect on both human and other non-target organisms, as well as pests. Therefore, the challenge before the agricultural scientists of today is to identify novel management practices for controlling rice insect pests other than unilateral usage of agrochemicals. Ecological engineering refined version of Integrated Pest Management (IPM) is a potential tool for reducing pesticide use and enhancing yield.

Rice cropping system characters:

Rice cropping systems involve significant levels of disturbance, such as continuous soil tillage, seasonal wetting and drying, transplanting and harvesting, and the use of synthetic pesticides and fertilizers. While pesticides lower populations of natural enemies, which results in reduced biological control (Heong, 2009).

The overuse of chemical insecticides leads to:

Physiological resurgence: The physiological response of the target insect to chemical poisoning, known as hormoligosis, leads to physiological rebound and an increase in fitness. Higher fecundity, enhanced male and female fertility, increased eating, and a larger capacity for dispersal are some of the ultimate reactions observed in planthoppers and other insects.

Ecological resurgence: The insecticides reduce the diversity, abundance or efficiency of the natural enemy component of the rice ecosystem. The negative effects of insecticides on the natural enemies of important pests such as planthoppers and stemborers (Lepidoptera: Pyralidae) have been well documented.

Whereas certain chemicals known to cause physiological resurgence have been banned or are currently restricted for use in rice, most chemicals will still have potential to cause ecological resurgence. Clearly a new strategy around pest management is required.

The need for a new emphasis on rice ecosystem health

Several decades of agricultural intensification and insecticide overuse has resulted in a depletion of natural enemy populations, as well as the development of pest populations that are increasingly resistant to insecticides and more virulent against rice varieties. Rice fields, particularly in the tropics, have a higher diversity of natural enemies than herbivores, resulting in complex food webs. High complexity in food web interactions is predicted to increase the stability and resilience of rice ecosystems.

Ecologically-based pest management methods are one way to achieve these goals while at the same time restoring the ecology of rice landscapes. To achieve efficient rice ecosystems, researchers will need to focus on 'rice ecosystem health' where pesticides are regarded as environmental contaminants that should be avoided as much as possible. Furthermore, natural pest regulation should be optimized and food-webs protected and enhanced by creating conditions that promote biodiversity and the complexity of interspecific interactions. One approach to achieving this is ecological engineering.

Ecological Engineering (EE)

Ecological engineering is an extended and refined version of IPM and selection of appropriate flowering plants for enhancement of biological activity and conservation of natural enemies is important. These have been done in many rice growing countries. The term "ecological engineering" referred to the "environmental manipulation by man using small amounts of supplementary energy to control systems in which the main energy drives are still coming from natural sources." (Odum, 1962). It is a design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both (Mitsch, 2012)."

The Ecological engineering strategy for insect pest management involves the design and management of rice production systems based on ecological principles that will maximize natural ecosystem services, such as biological control and minimize external inputs, like insecticides to conserve biological control. Ecological engineering is the modification of the environment to enhance biological control for sustainable pest management.

Features: Mitsch and Jorgensen, 2004

- ✓ To address pollution issues.
- ✓ Resolve a resource issue
- ✓ Restore an area following a large disturbance.
- ✓ Enhance ecological stability.
- ✓ Improve system functionality for human benefit.

Characteristics

- ✓ Refinement by ecological evaluation
- ✓ Strong reliance on natural processes and a low reliance on synthetic inputs.
- ✓ To adhere to ecological ideals.

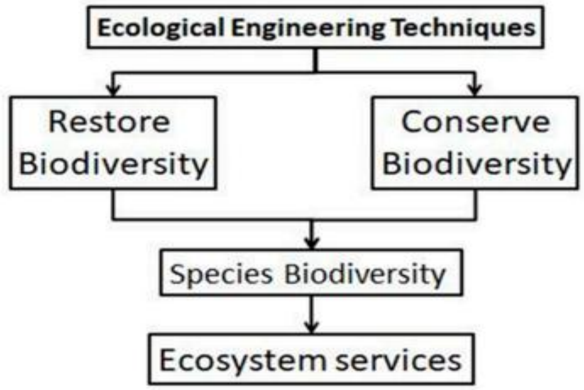

Fig 1. Ecological engineering techniques both restore and conserve biodiversity and ecosystem services

4.3.Goals: The restoration of ecosystems that have been substantially disturbed by human activities, and the development of new sustainable ecosystems have both human and ecological value (Mitsch and Jorgensen, 2004).

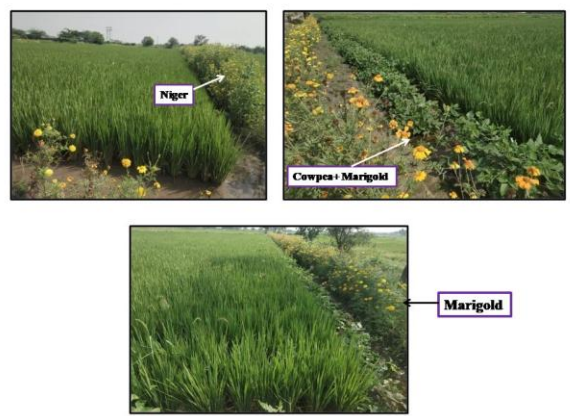

Fig 2: Vegetation diversification to provide resources to natural enemies

Methods of Ecological Engineering

- ✓ Use of cultural practices, usually based on vegetation management, to enhance biological control or the "**bottom-up**" effects that act directly on pests.
- ✓ **No Early Spray**: Insecticide sprays in the early crop stages have no benefits. Instead they cause disruptions to the rice arthropod community and induce BPH development. It was necessary to persuade farmers to stop this practice and adopt "no early spray. The avoidance of insecticides in

the first 40 days was promoted through farmer experimentation in several Asian countries

- ✓ Application of organic manures such as FYM, Compost, Poultry manure etc.
- ✓ **Trap crops**: Use of trap crops that divert pests away from crops and changing monocultures to polycultures to reduce pest immigration or residency. Providing resources such as nectar and pollen to natural enemies promotes biological control (**Top down**). Trap plant like vetiver grass (*Vetiveria zizanioides*) on the rice bunds before the crop was established. The grass would attract the rice striped stem borer (*Chilo suppressalis*) females to lay eggs on the leaves of vetiver grass, but the larvae would not survive on them
- ✓ **Bund crop**: The bund crop may be a vegetable, fodder, pulse or flower crop. Some of the crops tested at IIRR and recommended are African marigold, Blanket flower, Bhendi, Cowpea, Pilipesara, Sun hemp, Coriander, Dill, Fennel and Til/ Sesame. The Crops like Sunflower and Gingelly can be used as border crops in rice ecosystem to enhance the availability and activity of *Cocinella septempunctata*. The natural enemy would play a vital role in the natural suppression of rice insect pests. Sesame and assorted flora on the bunds provided habitats to conserve the natural enemy fauna and associated biological control.
- ✓ Growing flowering plants such as *Eclipta alba* (L.), *Vigna unguiculata* (L.) and *Ageratum conyzoides* were found to increase parasitisation of the green leaf-hopper eggs significantly and were three to four times more than the number of parasitoids emerging without a border crop. The maximum number of parasitoids was observed with a border of cowpea.
- ✓ **Provision of Shelter**: Provide shelter for natural enemies by supplying nectar, pollen, and alternative prey, as well as shelter habitat. In India, it was discovered that spreading straw on bunds provided shelter for epigeal spiders. Pollen sources: During the lean season, many zoophagous carnivores eat pollen as a substitute food and as a supplemental protein source. Other prey: Plants that support other prey, such as predators or parasitoids that do not feed on rice crops, can be recommended as bund planting to increase natural enemy activity. Shelter habitats strive to provide suitable circumstances for overwintering, aestivation, reproduction, and overall safety from human disturbances on farm land.

Entertain Training to farmers: Reaching out to Asia's millions of rice farmers to initiate economic mindset changes is a massive problem. Entertainment-education process of creating and implementing programs that entertain while also educating the audience in order to enhance knowledge, establish favorable attitudes, alter norms, and change behavior towards the sustainable production. Ex: large scale field demonstration to farmers field, the component can be well fitted into integrated pest management systems in rice ecosystem as environmentally safe and cost-effective strategy in small farmer's holdings.

Conclusion

Ecological engineering approaches are economically, biologically sustainable, viable, ecofriendly option as an integral part of rice pest management. Ecological engineering is a low-tech method that rice producers can easily and effectively use, but must be socially acceptable. This requires shifting rice farmers' mindsets from "insecticides are necessary" to "insecticides are only used as a last resort." It will be difficult to establish and sustain such norm adjustments in a region where pesticides are still sold as Fast Moving Consumer Goods and pesticide marketing restrictions are weak. Aside from amending and enforcing pesticide marketing restrictions, efforts must be made to pass environmentally friendly legislation in order to establish a new sustainable foundation for ecological practices.

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