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Ecological Pest Management – An Overview

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SUMMARY

Ecological pest management (EPM) is an integrative approach that seeks to control pest populations through environmentally sustainable and ecologically balanced methods. This strategy emphasizes the understanding of pest ecology, natural enemies and ecosystem dynamics to minimize reliance on chemical pesticides and reduce adverse environmental impacts. EPM utilizes a combination of biological control agents, habitat manipulation, cultural practices and mechanical methods to manage pest populations effectively. By fostering biodiversity and promoting ecological resilience, EPM aims to achieve long-term pest management solutions that enhance agricultural productivity and preserve ecosystem health. This paper explains the principles and methodologies of EPM highlighting the key points over conventional pest control methods.

INTRODUCTION

Of the total crop production, yield loss by both field and storage pests accounts 20 to 30%. Indiscriminate use of chemical pesticides has resulted in environmental pollution and ecological imbalance causing insecticide resistance, pest resurgence and pesticide residue in food and environment. Hence, insect pest management is necessary to ensure food security. Integrated pest management (IPM) is an ecologically and environmentally friendly approach which integrates different practices and strategies for pest control to below economic injury level (EIL). EIL refers to the lowest population density which causes economic damage. According to FAO, IPM analysis the agro-ecosystem to manage it's different elements for control of pests and keeping them at acceptable level with respect to economic, health and environmental requirements. Integrated Pest Management (IPM) employs a combination of cultural, mechanical, physical, biological, and chemical techniques to control pests. Cultural methods aim to make crops less appealing to pests through practices such as mixed cropping, crop rotation, and the use of trap crops to divert insects from the main crops. Mechanical methods, based on soil management principles, include tillage, mowing, cutting, mulching, and organic soil coverage to create an unfavourable environment for weeds and disrupt pest life cycles. Physical methods involve the use of pheromone traps, light traps, and sticky traps. Biological methods control insect pests and diseases using natural predators, parasitoids, and pathogens. Chemical methods, involving the use of pesticides, are employed when other measures are insufficient. There has been a shift to more ecologically sustainable strategies and Bio-intensive IPM viz., Agro Eco System Analysis (AESA) based IPM and Ecological Engineering for Pest Management. AESA is a situation in which decisions are made based on field observations. Ecological Engineering is a new emerging technique to increase the natural enemies of pests in an agro ecosystem and relies on use of cultural techniques to bring about habitat manipulation pests in the crop micro and macro environment.

Agro-Eco System Analysis (AESA) based Plant Health Management:

In Agro-Ecosystem Analysis (AESA), farmers observe their crops, analyze field conditions, and make crop management decisions based on these observations. AESA-based IPM emphasizes the dynamics between pests and their natural defenders, the plant's ability to compensate for pest damage, and the impact of abiotic factors on pest populations. A plant's health is influenced by its environment, which includes abiotic factors (such as sunlight, rainfall, wind, and soil nutrients) and biotic factors (like pests, diseases, and weeds). These factors contribute to the balance between insects and their natural enemies, and understanding these interactions aids in effective pest management.

Principles of AESA based Integrated Pest Management (IPM):

Grow a healthy crop:

Choose a variety that is resistant or tolerant to major pests. Treat seeds, seedlings, and planting materials with recommended pesticides, particularly biopesticides. Ensure the selection of healthy seeds, seedlings, and planting materials. Enhance soil health through nutrient management, especially using organic manures and biofertilizers, based on soil test results. Applying too much nitrogenous fertilizer can make crops overly succulent and susceptible to insects and diseases, while too little can stunt crop growth. Therefore, farmers should apply an adequate amount for optimal results. Phosphate fertilizers do not need to be applied every season, as the residual phosphate from the previous season will be available for the current one. Additionally, proper irrigation and crop rotation are essential.

Observe the field regularly:

Farmers should monitor field conditions at least once a week, including soil, water, plants, pests, natural enemies, weeds, and weather factors. Based on these observations and the Pest: Defender (P:D) ratio, they should make informed decisions and take necessary actions, such as removing infested plants.

Plant Compensation Ability:

Compensation refers to the replacement of plant biomass lost to herbivores, often involving increased photosynthetic rates and the mobilization of stored resources, such as those from roots and remaining leaves.

Understand and Conserve defenders:

Learn about natural enemies to understand their role in the agroecosystem through regular observations, and avoid using chemical pesticides. The concept of an "Insect Zoo" can enhance farmers' ability to identify beneficial and harmful insects. Various types of insects are present in the field, some beneficial and some harmful, but farmers often lack awareness of this. In the Insect Zoo method, unknown predators are collected in plastic containers from the field. Each predator is placed inside a plastic bottle with parts of the plant and some known insect pests. By observing the insects in the bottle, farmers can determine whether the test insect is a pest (feeds on plants) or a predator (feeds on other insects).

Pest: Defender ratio (P: D ratio):

Natural enemies of crop pests include parasitoids, predators, and pathogens. Identifying these pests and beneficial insects helps farmers make informed pest management decisions. Techniques such as sweep netting and visual counts can be used to determine the numbers of pests and defenders. The Pest: Defender (P:D) ratio may vary based on the feeding potential of the natural enemies and the type of pest.

Ecological Engineering for Pest Management

Ecological Engineering (EE) for pest management is an emerging approach aimed at enhancing the natural enemies of pests within an agroecosystem. It is regarded as a crucial strategy for promoting Bio-Intensive Integrated Pest Management (BIPM). This method relies on cultural techniques to manipulate habitats and enhance biological control. The primary goal of Ecological Engineering is to create an agroecosystem environment conducive to the enhanced survival of natural enemies of pests. Habitat manipulation involves providing natural enemies with nectar, pollen, physical refuge, alternate prey, alternate hosts, and suitable living sites. This can be achieved through planting suitable companion plants such as floral trap crops and repellent crops, which can bolster populations of pollinators, predators, and parasitoids for effective management of herbivorous insect pests. Ecological Engineering (EE) strategies address pest management both below and above ground. They focus on enhancing soil health below ground by promoting soils rich in organic matter and microbial activity, and on improving plant health above ground through habitat manipulation to increase the biodiversity of beneficial natural enemies.

EE for Pest Management – Above Ground

The focus is on creating habitats less favourable for pests and more attractive to natural enemies. Planting flowering crops along the borders involves arranging shorter plants near the main crop and taller ones towards the border to attract natural enemies and deter invading pest populations. Intercropping, border-cropping, and mixing flowering plants provide nectar and pollen as food for various bio-control agents. Trap crops and repellent crops are also intercropped with the main crop. Naturally growing weed plants like *Tridax procumbens*, *Ageratum* sp., *Alternanthera* sp., which serve as nectar sources for natural enemies, are not removed. Chemical pesticides are withheld when the Pest: Defender (P:D) ratio is favourable. Additionally, the plant's ability to compensate should be considered before applying chemical pesticides.

Different types of Plants used in Ecological Engineering:

These can be classified into 4 categories.
1. Attractant Plants - Attract the Natural Enemies of pests
2. Trap plants - Trap the crop pests
3. Repellent plants - Repel the crop pests
4. Barrier/Border plants - Prevent the entry of pests.

EE for Pest Management – Below Ground:

This approach focuses on enhancing soil health by maintaining year-round soil cover with living vegetation and/or crop residues. It involves enriching soil with organic matter such as farmyard manure (FYM), vermicompost, and crop residues to enhance underground biodiversity. Reduced tillage intensity helps preserve hibernating natural enemies. Nutrients are applied in balanced doses using biofertilizers, including mycorrhiza and plant growth-promoting rhizobacteria (PGPR). Seed, seedling, and nursery treatments include applications of *Trichoderma* spp. and *Pseudomonas fluorescens*. These practices strengthen crop resilience against pests while enhancing soil fertility and crop productivity. Biodiversity plays a crucial role in crop defenses: a diverse array of plants, animals, and soil organisms in farming systems supports a variety of beneficial organisms that combat pests effectively.

Biological Control:

Biological control is a fundamental aspect of Integrated Pest Management (IPM), focusing on the management of insect pests and diseases using natural means. It employs natural enemies or biological control agents such as predators, parasitoids, and pathogens. Predators are natural enemies that consume crop pests and significantly contribute to reducing insect populations. Parasitoids lay eggs inside or on their insect hosts, completing their life cycles by ultimately killing the host. Pathogens encompass disease-causing microorganisms like bacteria, fungi, viruses, and certain nematodes, which either kill or weaken their hosts. Biological control strategies include protecting and promoting natural enemies, introducing and augmenting specific parasitoids and predators, and propagating and dispersing specific bacterial, viral, fungal, and protozoan diseases.

Biological control Strategies

There are three types of strategies in Biological control:

Classical biological control: This method involves introducing natural enemies into a new area by importing and releasing them to control insect pests. For instance, *Acerophagus papayae*, a parasitic wasp, was imported to India to manage papaya mealybug infestations.

Augmentation: This encompasses activities aimed at increasing the population of locally occurring natural enemies. It includes Inoculative release, where small numbers of natural enemies are released into a crop cycle to establish and provide long-term pest control, and Mass release, which involves mass production and release of natural enemies to suppress pest populations. For example, *Trichogramma* egg parasitoids, predators like green lacewings, and ladybird beetles are mass-released. Modifying the cropping system to favor natural enemies also falls under this category.

Conservation: This strategy involves preserving and enhancing natural enemies by safeguarding them from harm and implementing measures to extend their lifespan and reproduction. Methods include:

- Preservation of Inactive Stages: For example, leaving pupae of *Epipyrops* (a parasite moth) in sugarcane leaf trash after harvesting to boost natural enemy populations before the monsoon season, targeting pyrilla pests.
- Maintaining Diversity: Providing alternate hosts as sources of food and shelter for natural enemies.
- Protection from Pesticides: Using pesticides selectively to avoid harming natural enemy populations.

These biological control strategies may not always be effective when used individually, but when integrated, they form a potent tool in Integrated Pest Management (IPM).

CONCLUSION

Ecological pest management represents a progressive shift towards more sustainable and environmentally responsible pest control practices. It offers a holistic approach that reduces reliance on chemical interventions. Adopting and advancing EPM practices will be crucial for achieving long-term pest management goals and maintaining the integrity of our natural ecosystem.

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