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Integrated Pest Management Strategies for Sustainable Crop Protection

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ARTICLE ID: 30

Abstract

Integrated Pest Management (IPM) stands as a successful and environmentally conscious strategy for pest control. As per the United States Environmental Protection Agency (2012), alternate interpretations of IPM underscore its efficiency and environmentally friendly characteristics, hinging on a combination of practical methods. This understanding, in conjunction with various pest control techniques, is implemented to reduce pest damage by employing the most cost-effective and least hazardous methods, benefiting both crops and the environment.

Introduction

Integrated Pest Management (IPM) is an effective and environmentally responsible approach to pest control that utilizes a comprehensive strategy involving cultural, mechanical, biological, and chemical methods. The concept, initially termed 'integrated control' by Bartlett in 1956, was further developed by Stern and his collaborators in 1959. IPM involves the optimal combination of control strategies tailored to a specific pest issue, considering factors such as crop yield, profitability, and safety compared to alternative options (Kenmore et al., 1985). According to the United States Environmental Protection Agency (2012), alternative definitions of IPM emphasize its efficiency and environmentally conscious nature, relying on a blend of practical methods. In an IPM program, management decisions are based on a thorough understanding of the pest, including its life cycle and interactions with the environment (Parsa et al., 2014). This knowledge, coupled with a range of pest control techniques, is applied to minimize pest damage using the most cost-effective and least hazardous methods for both crops and the environment.

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Principles and strategies of IPM

a. **Monitoring of pest population:** Pest monitoring, pest identification, and predictive analysis are essential tools in the context of Integrated Pest Management (IPM), playing a crucial role in shaping strategic management decisions. By actively monitoring and identifying pests, the risk of unnecessary pesticide use or the application of unsuitable pesticides can be significantly reduced.

b. **Concepts of injury levels:** The incorporation of Economic Threshold Level (ETL) and Economic Injury Level (EIL) concepts is designed to minimize the use of harmful pesticides and reduce their environmental impact. The establishment of injury and action thresholds is crucial in determining the appropriate timing for addressing pest issues, providing essential guidelines in this regard.

c. **Integration of pest control tactics:** Choosing appropriate strategies and integrating them in a manner where each component amplifies the effectiveness of the others.

Tools of pest management

Different strategies, practices, and techniques employed to manage individual insect pest species are conveniently organized in ascending order of complexity as.

1. Cultural practices:

a. Use resistant plant variety for particular insect species.
b. Crop rotation is very effective techniques for pest management.
c. Summer tillage serves to expose various life stages of soil-borne insects and diminishes the population of soil-dwelling insect pests.

2. Mechanical methods:

a. The manual removal and elimination of pests can also prove effective against larger-sized insect pests.
b. Employing diverse trap crops can shield the primary crop from attacks by insect pests. Example: In cabbage field marigold used as a trap crop to attract *Helicoverpa armigera* (Cabbage borer).

3. Physical methods:

a. A light trap is effective against various insect pests such as the Rice stem borer, hairy caterpillar, and bollworm.

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b. Heat treatment and moisture reduction are highly effective methods against stored insect pests.

4. Biological control: The use of living organisms to maintain pest populations below economic injury levels involves three main categories of natural enemies for arthropods: parasitoids, predators, and pathogens. (Hajek and Eilenberg**,** 2018).

a. Parasitoids: They do not directly consume their host but instead lay their eggs inside or on the host insect. Upon hatching, the immature stages utilize the host as their source of nourishment.

Example: Egg parasitoids: *Trichogramma chilonis* against cotton bollworm, *Trichogramma japonicum* against rice yellow stem borer.

Larval parasitoids: *Campoletis chloridae* targets *Helicoverpa armigera* larvae, *Bracon hebetor* against coconut black headed caterpillar.

Larval pupal parasitoids: *Isotima javensis* attacked on prepupal parasite of top shoot borer of sugarcane.

Adult parasitoids: *Encarsia Formosa* attacking cotton whitefly, *Aphelinus mali* effective against apple wooly aphid.

b. Predators: A predator is an organism that maintains independence and a free-living existence throughout its entire life cycle. Generally, it hunts and kills prey, typically larger than the predator itself, and often requires multiple prey items to complete its development.

Example: Various ladybird beetle species exhibit predation on different aphid species.

c. Pathogens: Various entomopathogenic bacteria, viruses, fungi, and nematodes are employed for the control of different insects.

Example: Entomopathogenic bacteria: *Pseudomonas* spp., *Bacillus thuringiensis*.

Entomopathogenic Virus: Nuclear polyhedrosis virus, Granulosis virus.

Entomopathogenic fungus: *Beauveria bassiana, Verticillium lecanii*

Entomopathogenic nematode: *Steinernema feltiae, Rhabditis sp.*

5. Chemical control:

a. The use of diverse semiochemicals, including pheromones and kairomones, is effective in controlling various insect pests, and insects cannot develop resistance to these compounds.

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Example: Helilure is the term for the sex pheromones employed to combat *Helicoverpa armigera*, Grandlure used against cotton boll weevil.

b. The effective use of repellents, such as neem seed extract and tobacco leaf extract, proves highly successful in preventing pest infestations.

c. Uses of insecticide: Insecticides are utilized in the event of a pest outbreak when none of the other techniques proves effective. In such cases, insecticides provide swift and effective control against various insect pests.

Once you have identified the pest and defined your management objectives, this information becomes crucial for the selection of insecticides. There are four fundamental pathways through which the poison enters the insect.

i. Stomach poison: The insect needs to ingest it.

Example: Indoxacarb, Spinosad, Emamectin benzoate, Flubendiamide etc.

ii. Contact poison: It merely needs to make contact with them.

Example: Cypermethrin, Chlorpyriphos, Chlorfenapyr etc.

iii. Systemic poison: Taken up by the plant and subsequently consumed by the insect.

Example: Acephate, Imidaclorprid, Thiomethoxam, Fipronil etc.

iv. Fumigant: Fatality occurs through respiration or absorption of vapors across membranes.

Example: Ethylene dichloride, Carbon tetrachloride, Methyl bromide.

Advantages of Chemical Pesticides

- Quick action.
- Easy to apply.
- Readily available.
- Has the potential to protect against vector-borne diseases transmitted by insects.

Disadvantages of chemical pesticides

- Potential hazard to human health.
- Impact on non-targets pest.
- Probable negative environmental effects.
- Pest resistance.

Conclusion

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Integrated Pest Management (IPM) embodies a comprehensive and environmentally sound strategy for pest control. By integrating a variety of approaches ranging from cultural and mechanical methods to biological and chemical strategies IPM strives to enhance pest management effectiveness while mitigating environmental consequences. The prioritization of well-informed decision-making, taking into account factors like crop yield, profitability, and safety, underscores IPM's dedication to sustainable agricultural practices. Through the adoption of this integrated and adaptable methodology, IPM not only successfully manages pest challenges but also fosters enduring resilience and balance within agricultural ecosystems.

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