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Biological Control of Insect Pests: A Sustainable Approach

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INTRODUCTION

Agriculture plays a vital role in ensuring food security and supporting livelihoods worldwide. However, crop production is continuously threatened by insect pests, which cause significant yield losses and reduce the quality of agricultural produce. Farmers often rely heavily on chemical pesticides to manage these pests. While chemical control methods provide quick results, their excessive and indiscriminate use has led to several problems such as environmental pollution, pesticide resistance, resurgence of pests and adverse effects on non-target organisms, including beneficial insects.

Biological control has emerged as a sustainable and eco-friendly alternative to chemical pest management. It involves the use of natural enemies such as predators, parasitoids and pathogens to regulate pest populations. This approach is based on ecological principles and aims to maintain pest populations below economic threshold levels rather than completely eliminating them.

Concept of Biological Control

Biological control refers to the use of living organisms to suppress pest populations. These organisms are known as natural enemies and include predators, parasitoids and microorganisms. The concept is based on the natural interactions that occur in ecosystems. In a balanced ecosystem, pest populations are regulated by their natural enemies. However, agricultural practices and environmental changes often disrupt this balance, leading to pest outbreaks. Biological control seeks to restore this balance by introducing or enhancing the population of natural enemies.

Types of Biological Control

Biological control can be classified into three main types based on the method of application.

1. Classical Biological Control

This involves the introduction of natural enemies from the native habitat of the pest into a new environment where the pest has become problematic. Once established, these natural enemies provide long term control.

2. Augmentative Biological Control

In this method, natural enemies are mass produced and released in large numbers to control pest populations. It includes two approaches:

- Inoculative release where small numbers are released at critical times
- Inundative release where large numbers are released for immediate control

3. Conservation Biological Control

This approach focuses on protecting and enhancing the existing natural enemies in the environment by modifying agricultural practices.

Agents of Biological Control

1) Predators

Predators are organisms that consume multiple prey individuals during their lifetime.

Examples: Ladybird beetles feed on aphids. Lacewings feed on soft bodied insects

2) Parasitoids

Parasitoids are insects that lay their eggs on or inside a host insect. The developing larvae feed on the host and eventually kill it.

Examples: Trichogramma wasps attack the eggs of many crop pests

3) Pathogens

Pathogens include bacteria, fungi, viruses and protozoa that infect and kill pests.

Example: *Bacillus thuringiensis* is widely used against caterpillars

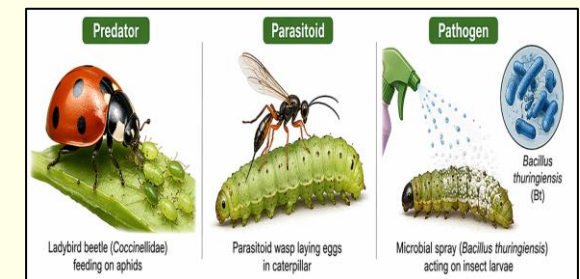


Figure 1. Major biological control agents including predators, parasitoids and pathogens used for the management of insect pests in sustainable agriculture.

Table 1: Major Biological Control Agents

Agent Type	Examples	Target Pests
Predators	Ladybird beetles	Aphids
Parasitoids	Trichogramma spp.	Lepidopteran eggs
Pathogens	Bacillus thuringiensis	Caterpillars

Advantages of Biological Control

- ✓ Biological control offers numerous advantages over chemical methods.
- ✓ It is environmentally friendly and does not pollute soil or water.
- ✓ It is target specific and does not harm non-target organisms.
- ✓ It reduces pesticide resistance in pest populations.
- ✓ It provides long term and sustainable pest control.
- ✓ It helps conserve biodiversity and ecological balance.

Limitations of Biological Control

- Despite its advantages, biological control has some limitations.
- It may take time to establish and show results.
- Effectiveness can be influenced by environmental conditions.
- It requires proper knowledge and management.
- Mass production and storage of natural enemies can be challenging.

Role in Integrated Pest Management

Biological control is a key component of integrated pest management systems. It works in combination with cultural, mechanical and chemical methods to achieve effective pest control. In integrated pest management, chemical pesticides are used only when necessary and in a manner that minimizes harm to natural enemies.

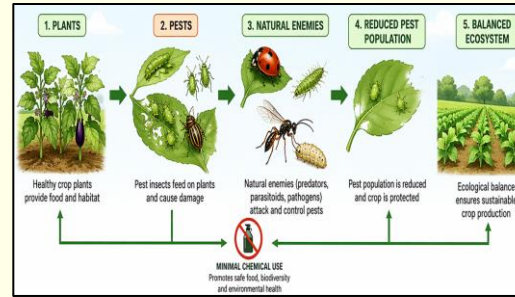


Figure 2. Biological control in a crop ecosystem showing interaction between plants, pests and natural enemies leading to sustainable pest regulation.

Techniques for Enhancing Biological Control

- Farmers can adopt several practices to enhance biological control in their fields.
- Planting flowering plants to provide nectar and pollen for natural enemies.
- Reducing pesticide use to protect beneficial organisms.
- Maintaining habitat diversity to support natural enemies.
- Using selective pesticides when necessary.

Application in Different Crops

- Biological control is widely used in various crops.
- In vegetable crops, parasitoids and predators are used to control pests like aphids and caterpillars.
- In fruit crops, biological control helps manage pests such as fruit flies.
- In field crops, microbial pesticides are used against major insect pests.

Table 2: Applications of Biological Control in Crops

Crop Type	Pest	Control Agent
Vegetables	Aphids	Ladybird beetles
Fruits	Fruit flies	Parasitoids
Field crops	Caterpillars	Bacillus thuringiensis

Environmental Impact

- Biological control contributes to environmental protection by reducing chemical inputs.
- It helps maintain soil health and water quality.

- It supports biodiversity by conserving beneficial organisms.
- It reduces greenhouse gas emissions associated with pesticide production and application.

CONCLUSION

Biological control of insect pests represents a sustainable and environmentally sound approach to managing agricultural pests in modern farming systems. By utilizing natural enemies such as predators, parasitoids and pathogens, this method provides an effective alternative to chemical pesticides, which are often associated with environmental degradation, health risks and the development of pest resistance. Biological control works in harmony with natural ecological processes, helping to maintain a balance between pests and their natural enemies while ensuring long term pest suppression. Although it may require careful planning, knowledge and time to achieve desired results, its benefits in terms of sustainability, biodiversity conservation and reduced chemical inputs make it an essential component of integrated pest management. The successful implementation of biological control depends on awareness, proper management practices and support from research and policy frameworks. As agriculture continues to face challenges from climate change and increasing demand for food, biological control offers a viable and sustainable solution for protecting crops and ensuring food security while preserving environmental health.