

## Biopesticides: The Future of Agricultural pest Management

Manoj Kumar Jena<sup>1</sup> and Satikanta Sahoo<sup>2</sup>

<sup>1</sup>PG Research Scholar, Dept. of Entomology, Navsari Agriculture University, Navsari

<sup>2</sup>Jr. Lecturer, Department of Botany, N.C. (Autonomous) College, Jajpur, Odisha

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### Abstract

The excessive use of chemical pesticides pollute the environment and leads to pest resurgence, pest resistance, secondary pest outbreak, kills natural enemies, earthworms and other useful microbes present in the soil. Due to these problems, the crop production is not profitable and fails to meet the growing demand of increasing population. There is the need for the development of eco-friendly strategies to mitigate these problems. Viewing these problems, the various naturally occurring active ingredients of biological origin called as biopesticides must be developed. Biopesticides are broad array of microbial pesticides, biochemicals derived from micro-organisms, phytochemicals and other natural sources, and processes that involve the genetic modification of plants to express genes encoding insecticidal toxins. The use of biopesticides for pest control is an evolving field in pest management.

### Introduction

Destructive activities of numerous pests like plant pathogens (fungi, bacteria, nematodes *etc.*), insects and weeds have plagued agriculture leading to drastic decrease in yields (Saima and Jogen, 2011). About 40 per cent reduction in the worlds crop yield due to pests has been estimated (Oerke *et al.* 1994). Management of these pests to increase food security in order to meet the needs of increasing human population is imperative without causing any adverse effects on human health, public goods and environment (Bastianns *et al.* 2008). Over the past half of the decade, crop protection against pests depend solemnly on chemical pesticides and new legislations on chemical usage and the evolution of resistance in pest populations has resulted in their declining usage. Besides this, the use of synthetic pesticides is significantly becoming more difficult due to a number of factors, such as, pest

resurgence, the development of heritable resistance, expensive costs and their effect on target organisms. Looking these incessant problems or drawbacks associated with the use of synthetic chemicals to control pests, it is imperative to look for eco-friendly method that will serve as an alternative to chemicals (biopesticides). Biopesticides are effective, biodegradable with no residues in the environment. Due to the adverse effects of chemicals, biopesticides development is increasing and that their efficiency against pests is significant (Salma and Jogen, 2011).

### **What are biopesticides?**

Bio-pesticides are naturally occurring substances obtained from living organisms (natural enemies) or their products (microbial products, phytochemicals) or their by-products (semiochemicals) that can control pest by nontoxic mechanisms. Biopesticides are also defined as manufactured mass produced agents derived from natural sources living micro-organisms and sold for use to control pests.

### **Types of Biopesticides**

#### **1. Microbial Pesticides**

These consist of microorganisms such as bacterium, virus, fungi and protozoan as active ingredients which are used for the biological control of plant pathogens, insect pests and weeds. It includes Nuclear Polyhedrosis Virus (NPV), Cytoplasmic Polyhedrosis Virus (CPV), Granulosis Virus (GV), *Metarrhizium anisopliae*, *Verticillium lecanii*, *Beauveria bassiana*, *Bacillus thuringiensis*, Rickettsia like Organisms, Rhabditids, Heterorhabditids, *Pseudomonas spp.*, *Streptomyces spp.*, *Trichoderma spp.*, *Coniothyrium minitans* and bacteriophages *etc.* The most widely used microorganism in the development of biopesticide is the insect pathogenic bacterium *Bacillus thuringiensis* (Bt). This bacterium serves as an insecticide for most of the Lepidopterans, coleopterans and dipterans. *B. thuringiensis* produces protein crystals or toxin during spore formation of the bacterium that is active at alkaline P<sup>H</sup> and capable of lysis of gut cells when consumed by a specific or susceptible insects.

#### **2. Biochemical Pesticides**

They are also known as herbal pesticides which are naturally occurring substances used for controlling pests through a non-toxic mechanism. Plants that produced secondary

metabolites are also considered as biopesticides. It includes Azadirachtin, Nicotene, Rotenone and Pyrethrum *etc.*

### 3. Plant-Incorporated-Protectants (PIP)

PIPs, also known as Genetically Modified Crops, are the substances produced by plants from genetic material that have been added or incorporated into their genetic makeup. A typical example of this is the use of Bt protein to develop PIP in a process called genetic engineering. The Bt toxin is host specific and is capable of causing death within a short time, usually 48 hours and safe to beneficial organisms, human, environment and it does not harm vertebrates.

### 4. Semiochemicals

A semiochemical is a chemical signal produced by one organism, usually insects which caused a behavioural change in an individual of the same or different species. For crop protection, the most widely used semiochemicals are the insect pheromones which serve as a signal to communicate with others in their species for a number of reasons which are synthesized for pest control by mating disruption, Lure-and-Kill systems and mass trapping.

### Status of Biopesticide in India

Biopesticides are registered under section 9(3)b of Insecticide act, 1968 and contribute 3% of the pesticides registered. These are *Ampelomyces quisqualis*, Azadirachtin, *Bacillus sphericus*, *Bacillus thuringiensis var. israelensis*, *Bacillus thuringiensis var. kurstaki*, *Bacillus thuringiensis var. galleriae*, *Beauveria bassiana*, *Metarrhizium anisopliae*, NPV<sub>Ha</sub>, NPV<sub>Si</sub>, *Pseudomonas fluorescens*, Pyrethrins, *Trichoderma harzianum*, *Trichoderma viridae* and *Verticillium lecanii*.

### Biopesticide Formulations

Depending on the physical states, biopesticides are formulated as dry or liquid forms. The active ingredients are produced by addition of stabilizers, synergists, spreaders, stickers, surfactants, colouring agents, anti-freezing compounds, additional nutrients, dispersants and melting agents. In general, biopesticides are usually formulated as dry formulation (for direct applications) and liquid formulations.

### Dry formulation for direct application

1. Dustable Powders (DP)

2. Granules (GR)
3. Seed Dressing(SD)
4. Wettable Powders (WP)
5. Water Dispersible Granules (WDG)

### **Liquid formulations**

1. Emulsion (E)
2. Suspension Concentrate (SC)
3. Suspo-Emulsion (SE)
4. Oil Dispersion (OD)
5. Capsule Suspension (CS)
6. Ultra-Low Volume Liquids (ULV)

### **Biopesticides Application Technology/Methods**

1. Seed Treatment
2. Foliar Application
3. Seedling Dipping

### **Mechanisms of Action of Biopesticides for Pest Control**

#### **1. Antibiosis**

This occurs as a result of an interaction with other microbes (microorganisms) mediated by specific metabolite of microbial origin, by volatile compounds, lytic enzymes or other toxic substances. The microorganisms produce antibiotics, bacteriocin, volatile compound and metabolite production. E.g. *Bacillus spp.*, *Pseudomonas spp.*, *Trichoderma spp.*, *Gliocladium spp.*, *Streptomyces spp.* etc.

#### **2. Competition**

It is the ability to compete aggressively, that they grow rapidly and colonize substrate to exclude pathogens. E.g. *Trichogramma spp.* are aggressive competitors of *Fusarium spp.*

#### **3. Hyperparasitism**

Hyperparasitism is the lysis or death by other microorganisms or direct parasitism. E.g. *Trichogramma lignorum* is found to be parasitizing the hyphae of *Rhizoctonia solani* and therefore soil inoculation with *Trichoderma* spores help to control damping off disease in citrus seedlings.

#### **4. Synergism**

The ability of some bioagent to combine actions of hydrolytic enzymes and antibiotic secondary metabolites. *E.g.* the effectiveness *Trichogramma spp.* as a biocontrol agent and its fitness in the environment is as a result of synergistic effects of antimicrobial compounds, pyrones, coumarins *etc.*

### **Advantages of Biopesticides**

- Biopesticides are usually inherently less harmful/toxic to non-target organisms and cause less environmental load or pollutions.
- Designed to only one specific pest or, in some cases, a few target pests as opposed to chemical that have a broad spectrum activity.
- Cost of developing biopesticides is significantly lower than those of synthetic chemical pesticides.
- The nature of control is preventive not curative and their effects on flower is less.

### **Disadvantages of Biopesticides**

- Sppecificity is high which may require an exact identification of the target pest/ pathogen.
- Because of their slow speed of action, biopesticides are often unsuitable if a pest outbreak is an immediate and becomes a threat to crops.
- Biopesticides are not suited for a standalone treatment rather they have to be with a compatible method for high efficacy.
- Living organisms evolve and increase their resistance to biological, chemical, physical and any other form of control.

### **Challenges in Commercialization of Biopesticides**

- Maintenance of quality, non-availability of bioagents unlike chemical pesticides and storability.
- Many countries amended their policies to reduce the use of chemical pesticides and encourage the use of biopesticides.
- Need for fast-track registration of biopesticide products based on justified regulations, promoting the adoption of safer technologies in the development of commercial products.
- Policy measures need to be strengthened in order to reduce excessive use of chemical pesticides and to promote the use of biopesticides.
- Need for quality audit of biopesticides and establishment of separate enforcement department with adequate manpower for quality control of biopesticides.



- Role of states in registration and quality assurance. States are responsible for enforcing standards and quality.
- Separate team of inspectors to curb the sale of spurious/ counterfeit pesticides needs to be brought in by state governments.
- Separate legal department to look after cases related to the violation of the act.
- Bio-pesticides, botanicals, PGRs and pheromones are safer to the environment. Registration of such products along with chemical pesticides under section 9 of the insecticides Act 1968 seems unjustified.
- A separate section under the Insecticides Act 1968 may be created through amendments for quick and easy registration of such eco-friendly products.
- Generating Expensive biosafety data: ICAR institutes & SAUs with NABL accreditations can be selected to generate bio efficacy data.

### Conclusion

The increasing concern about the problems associated with synthetic chemicals for pest control and on food safety has led growers to find new eco-friendly methods to replace the current chemical-based practices. The use of biopesticides as supplement has emerged as promising alternative to chemical pesticides and their demand is rising steadily in all parts of the world. Biopesticides serve as a very effective alternative method for pest control as well as good component of integrated pest management.

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