SEMESTER-3
SEC-A: Unit - 5
BIOINSECTICIDES

❖ Bioinsecticides:

The world's population heavily depends on the agricultural production of plants and animals for food. Without this food source, many of us would be unable to survive. However, humans aren't the only organisms who enjoy eating these products; agricultural pests are common, and we use special substances called pesticides to control or kill them. Based on the types of pest we are trying to control, pesticides come in many forms. An insecticide is a type of pesticide that specifically targets insects that harm animals or agricultural crops.

Unit 5 Syllabus: Bioinsecticides

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, Bacillus thuringiensis, production, Field applications, Viruses – cultivation and field applications.

For the purpose of this lesson, we are specifically interested in learning about biological insecticides, also known as biopesticides, which are pesticides made from natural materials that are meant to kill or control insects. These natural source materials may include animals, plants, bacteria, or minerals. Simply biopesticides are composed of living things, made by living things, or are found in nature.

- **Types of Biological Insecticides:**

There are three main categories of Biopesticides. They are:

1. Biochemical pesticides: this type uses substances that are naturally found in nature. Generally speaking, biochemical pesticides control pests through non-toxic mechanisms.

2. Microbial pesticides: this type uses microorganisms as the active ingredient. These microorganisms are usually bacteria or fungi but can also be viruses, protozoa, or oomycetes.

3. Plant-Incorporated Protectants (PIPs): this type uses substances that are produced by plants after genetic material, such as genes or proteins, has been added to the plant by humans. Plants are modified in this way so that they are naturally resistant to insect pests, and different types of genes and proteins can enhance a plant's resistance to different types of pests.

- **Uses and Advantages:**

In brief, biopesticides are used to control or kill some type of pest. This lesson focuses on insects that harm the agricultural production of animals or plants. Biopesticides can control insect pests by disrupting their mating patterns, attracting them to traps, or being sprayed on the crop as a pest repellent. There are several advantages to using biopesticides instead of conventional pesticides. While biopesticides are made from naturally occurring substances, conventional pesticides are made from synthetic chemicals or agrochemicals. Typically, conventional pesticides are used to directly kill pests rather than control them. In contrast, most biopesticides are used as one component of an integrated pest management approach that enables the gradual control of an insect pest over time. Control is usually accomplished through indirect mechanisms instead of by directly killing the insect.

Biopesticides are usually less toxic than conventional pesticides. Most are capable of affecting only the target species or closely related species instead of broadly killing all organisms that come into contact with them. Additionally, biopesticides are often effective at low doses, and they decompose quickly. This means that the exposure time is lowered and less pollution is produced. As a result, biopesticides are often approved for use faster than conventional pesticides because they pose fewer safety risks.

- **Bioinsecticides fall into three major classes:**

1. Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances that interfere with mating, such as insect sex pheromones, as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.

2. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bt ingredients control moth larvae found on plants, other Bt ingredients are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve.

3. Plant-Incorporated-Protectants (PIPs) are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

- **Advantages of using Bioinsecticides:**

- Biopesticides are usually inherently less toxic than conventional pesticides.

- Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects and mammals.

- Biopesticides often are effective in very small quantities and often decompose quickly, resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.

- When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly reduce the use of conventional pesticides, while crop yields remain high.

In order to use biopesticides effectively (and safely), however, users need to know a great deal about managing pests and must carefully follow all label directions. **How does EPA encourage the development and use of bioinsecticides?**

In 1994, the Biopesticides and Pollution Prevention Division was established in the Office of Pesticide Programs to facilitate the registration of biopesticides. This division promotes the use of safer pesticides, including biopesticides, as components of IPM programs. The division also coordinates the Pesticide Environmental Stewardship Program (PESP). Since biopesticides tend to pose fewer risks than conventional pesticides, EPA generally requires much less data to register a biopesticide than to register a conventional pesticide. In fact, new biopesticides are often registered in less than a year, compared with an average of more than three years for conventional pesticides. While biopesticides require less data and are registered in less time than conventional pesticides, EPA always conducts rigorous reviews to ensure that registered pesticides will not harm people or the environment. For EPA to be sure that a pesticide is safe, the agency requires that registrants submit the results of a variety of studies and other information about the composition, toxicity, degradation, and other characteristics of the pesticide.

- ***Bacillus thuringiensis*:**

The bacterium, *Bacillus thuringiensis* (B.t.), reproduces by spores. The spores are produced in the bacterium cell along with a crystalline protein called an endotoxin. The endotoxin, with or without the spores must be ingested by the target insect in order to be effective. Once ingested, the endotoxin is activated by the alkaline conditions in the insect's stomach. The toxin attaches to specific receptors on the gut wall, causing the gut lining to break down. This method normally allows the spores to enter the host's blood (hemolymph) where the bacterium can proliferate. Different species and strains and *Bacillus* bacteria are known to affect different groups of insect pests, primarily due to differences in endotoxin receptor sites on the gut wall:

- *Bacillus thuringiensis* var. *kurstaki* – caterpillars of moths and butterflies
- *Bacillus thuringiensis* var. *israelensis* – larvae of flies such as fungus gnats
- *Bacillus thuringiensis* var. *san diego* – larvae of beetles such as elm leaf beetles and Colorado potato beetles

Another species, *Bacillus popollia*, or milky spore disease has been marketed for controlling Japanese beetle larvae. Occasionally, this product is marketed in Texas for white grub control. For most effective use, *B.t.* products must be applied when insects are in their early larval stages (first or second) and are actively feeding. Several days may be required for larvae to die, although feeding usually stops soon after ingestion. For foliar applications, additives such as feeding stimulants and stickers are often added to the spray mixture to ensure that target pests rapidly ingest the treated leaves and that rain does not wash treated surfaces. On foliage, *B.t.* treatments degrade rapidly. Applications are most effective when made in the evening or on cloudy days.

B.t. is formulated in liquid concentrates, wettable powders, dusts and granules. One product, MPV®, has been developed by inserting the genes that code for the *B.t.* endotoxin into another hard bodied microorganism. The microorganism is then killed and used as a capsule in which the endotoxin is protected. These endotoxin genes have also been genetically engineered into several plants, including tobacco, tomatoes and cotton. These plants have been shown to be resistant to caterpillars. Unfortunately, there have been several documented cases of insect pests becoming resistant to *B.t.* endotoxins.

- **Toxicology of *Bacillus thuringiensis*:**

The varieties of *Bacillus thuringiensis* used commercially survive when injected into mice, and at least one of the purified insecticidal toxins is toxic to mice. Infections of humans have been extremely rare (two recognized cases) and no occurrences of human toxicosis have been reported. From studies involving deliberate ingestion by human subjects, it appears possible, but not likely, that the organism can cause gastroenteritis. B.t. products are exempt from tolerance on raw agricultural commodities in the United States. Neither irritative nor sensitizing effects have been reported in workers preparing and applying commercial products.

Viruses and biological pest control

Viruses can also be used to control damaging pests. Traditionally this has been used in agriculture, but applications exist in the control of agents important to human health as well. The types of agents used for this purpose may prey on the target species, may be parasites on the target pests, are pathogens or cause disease in the target species or may be competing species. Viruses used for pest control are commonly pathogens causing disease of the target species. Although they account for a small amount of total pesticide use, viruses are used for the control of multiple species of insects and also for rabbits.

Biological agents can produce long-lasting effects and in some cases are able to spread among the target population. They have also been recognized as inherently less toxic than conventional pesticides by the US Environmental Protection Agency (EPA). Their disadvantages include:

1. limited range of action,
2. slow effects compared to chemical agents,
3. high costs of initial treatment,
4. low environmental stability, particularly in sunlight etc.

Microbes include fungi, bacteria and viruses. Farmers and ranchers often think of microbes as pests that are destructive to their crops or animals (as well as themselves), but many microbes are beneficial. Soil microbes (bacteria and fungi) are essential for decomposing organic matter and recycling old plant material. Some soil bacteria and fungi form relationships with plant roots that provide important nutrients like nitrogen or phosphorus. Fungi can colonize upper parts of plants and provide many benefits, including drought tolerance, heat tolerance, resistance to insects and resistance to plant diseases.

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