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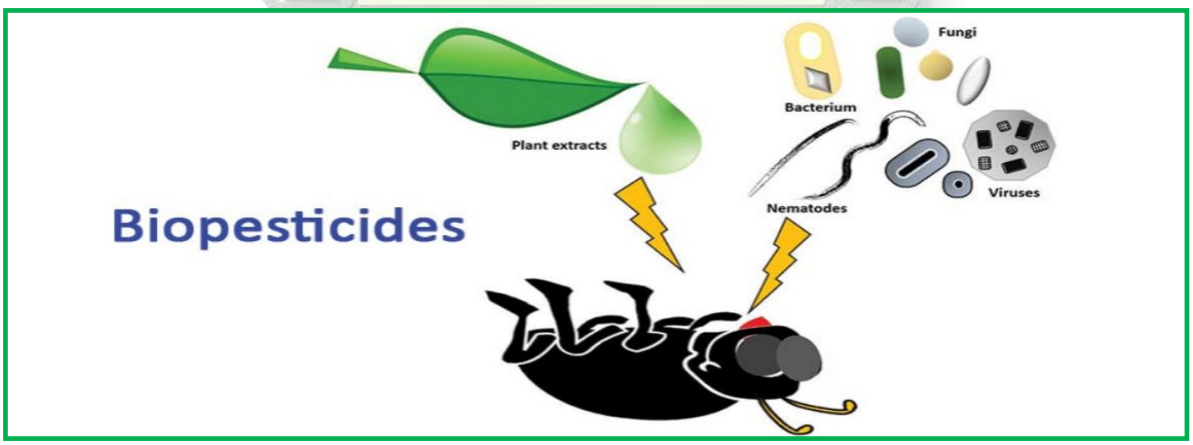
Biopesticides: An Environmentally Acceptable and Long-Term Pest Management Solution

(Neeraj Kumar[1], Sakshi Saxena[2], *Naveen[2] and Shivani Suman[2])
[1]Ph.D. Research Scholar, Department of Entomology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh
[2]Ph.D. Research Scholar, Department of Entomology, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh
*jangir000naveen@gmail.com

Biopesticides are pesticide derivatives of natural origin like plants, animals, microbes, and certain minerals used to control insect pests. It is an emerging sustainable approach to managing proliferating insect pest population. An ever-increasing population is building massive pressure on farmers to increase production to serve the growing needs and demand for food. As per UN projections, the population will rise from 7.5 billion to 9.7 billion by 2050, and accordingly, food production will have to increase by 60% to feed an additional 2 billion population. Indeed, achieving something comes with many challenges, and so does agriculture. Long-term shifts in temperature (global warming) and random weather patterns drive severe pest outbreaks regularly. According to FAO estimates, we lose 20-40 percent of crop production annually due to insect pests. A quick way to address this problem is pesticides, which are used indiscriminately by farmers due to their immediate effects. However, their over and indiscriminate use has led to great concern and severe environmental issues. It has contaminated soil and water, causing ecosystem imbalance and severe health issues of high risk such as cancer, organ deformities, and reproductive failures, which is alarming to switch over to new approaches to pest control, and biopesticides are one of them.

Biopesticides

Microbial biopesticides:
These incorporate small tiny microbes like bacteria, fungi, baculoviruses, protozoa, and nematodes, which use a specific mechanism to kill target insects.



A. Entomopathogenic bacteria:

Bacillus thermogenesis (Bt) is the most widely exploited species of bacteria. When ingested by insects, it gets activated due to the alkaline pH of the insect gut and kills the host by producing protein crystals or toxins. These toxins bind to a larval gut receptor, causing ionic imbalance leading to septicemia or making insect larvae starve or die due to a sudden drop of oxygen. Several species of soil-borne bacteria, Bacillus and Paenibacillus, are pathogenic to coleopteran, dipteran, and lepidopteran insects. *Bacillus thuringiensis* subsp. *aizawai*, *Bt* subsp. *kurstaki*, *Bt* subsp. *israelensis*, *Bt* subsp. *sphaericus*, and *Bt* subsp. *Tenebrionis* is an efficient microbial biopesticide that may be used to control a variety of target insects. For example, *Bt* subsp. *Aizawai* and *Bt* subsp. *kurstaki* are effective against caterpillars, *Bt* subsp. *Israelensis* and *Bt* subsp. *sphaericus* target mosquito larvae, and *Bt* subsp. *tenebrionis* is effective against some coleopterans.

B. Entomopathogenic fungi:

Entomofungal pathogens cause infection when they contact the host, as fungal spores can directly penetrate through the integument via enzymatic activities and mechanical pressure. These invade host tissue and body cavity, and mycelium and spores proliferate and cover the host's body, produce toxins and cause them to starve and eventually kill them. Entomofungus *Beauveria bassiana* is known to cause white muscardine, targeting various sucking pests. *Metarrhizium anisopliae* causing green muscardine is effective against soil-dwelling insects.

C. Entomopathogenic viruses:

Baculoviruses with sub-group Nuclear Polyhedrosis Virus (NPV) and Granuloviruses (GVs) are the most known viruses exploited for lepidopteran larvae. Viruses gain entry by ingestion and are mainly used against insect pests with chewing mouthparts. After gaining entry into the host, viruses integrate their nucleic acid with host genomic machinery, take charge of the cell metabolic system, and replicate using cell content starving it to die. *Spodoptera exigua* multi-enveloped Nucleo Polyhedron Virus (SeMNPV), *Helicoverpa zea* single-enveloped Nucleo Polyhedron Virus (HzSNVP), and *Cydia pomonella* granulovirus (CpGV) are some of the commercially available viruses.

D. Entomopathogenic nematode:

EPNs such as Steinernema and Heterorhabditis are mainly used against soil-dwelling insect pests and tissue borers. In association with bacterial symbionts, endoparasitic nematodes invade insect hosts via natural openings such as the mouth, spiracles, and anus or through intersegmental membranes. Infective juvenile (IJ) once inside the host, release symbiont in the host, bacteria propagate inside and kill host through bacterial septicemia.

E. Protozoans:

Protozoan either directly kills the insects or reduces the fecundity of adults. They are known to cause debilitating infections as their effect is chronic. Also, they prolong the larval life in the field, thus exposing them longer to predators and parasitoids. They are exploited by lepidopterans, locusts, grasshoppers, and beetles.

Entomophagous Insects:

These are important bio-control agents as they consume other insects, and they may do so by predation or parasitizing them.

1. Predators:

Predatory mites are extensively used for controlling other phytophagous mites in several crop ecosystems. These are free-living insects that devour other insects smaller than themselves

and require more than two prey in their lifetime. Many Coccinelid and ground beetles are known voracious feeders on small sucking insects such as aphids, mealybugs, mites, and scale insects. Some syrphid or hoverflies are also important predators of aphids of several crops. Other examples of insect predators are- Spiders, predatory bugs, predatory mites, lacewings, beetles and hoverflies.

2. Parasitoids:

These are insects whose larvae develop in the host into a free adult and eventually kill it. Most parasitoids fall in hymenopteran order (Wasps) and dipteran order (order). They are categorized as egg parasitoids, larval parasitoids, pupal parasitoids, and adult parasitoids based on their attack stage. For Example- A tobacco hornworm that has been killed by *Cotesia* larvae which have pupated outside the host.

Plant-based Insecticides

Neem is one of the oldest known plants exhibiting agro-medicinal properties conferring insecticidal property, having azadirachtin as an active ingredient which acts as an antifeedant, repellent, and repugnant agent and induces sterility in insects.

Benefits of biopesticides

- ✓ Environmentally friendly as having no problem with toxic residuals,
- ✓ Gives long and permanent control of pests,
- ✓ Host-specific,
- ✓ Effective in tiny quantities and is biodegradable,
- ✓ Safe to non-target insect pests and natural enemies.

Conclusion

With the advent of the latest technologies like Artificial Intelligence and genetic mutations, various innovations in the domain of biopesticides are astounding. Pest-specific action of biopesticides is a promising step towards achieving the goal of sustainable agriculture. Various kinds of biopesticides like Bacterial, microbial, fungal, protozoan, and predators are all particular in their pest-killing action, harmless for humans. They are in sync with the natural processes of the food chain and crop production.