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Biopesticide: A Green Step towards Sustainable Agriculture

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Synthetic pesticides are being used indiscriminately and incessantly, which is becoming a growing global concern. The use of traditional synthetic pesticides has undoubtedly improved the quality and quantity of agricultural products but their injudicious usage has left us with no other option than to develop agro-food systems that not only produce more from less, but also do so sustainably. Biopesticides, which include a wide range of microbial agents, biochemicals generated from microorganisms and other natural sources, and methods involving the genetic incorporation of DNA into agricultural commodities, are an environmentally benign alternative to chemical pesticides. Biopesticide is a formulation made from naturally occurring compounds that uses nontoxic processes to manage pests in an environmentally safe manner, gaining popularity around the world.

What are biopesticides?

In broad terms, biopesticides are pesticides derived from natural materials, such as, animals, plants, bacteria, and minerals according to the US Environmental Protection Agency (USEPA). They also include living organisms that destroy agricultural pests. Biopesticides are living organisms (natural enemies), their products (phytochemicals, microbial products), or byproducts (semiochemicals) derived from animals (e.g. nematodes), plants (e.g. Chrysanthemum, Azadirachta), and microorganisms (e.g. *Bacillus thuringiensis*, *Trichoderma*, nucleopolyhedrosis virus) that can be used.

Types of biopesticides:

I. **Microbial pesticides**: Also known as biocontrol agents (BCAs). They are active-ingredient microorganisms (bacteria, fungus, viruses, or protozoans) that have been successfully utilised to manage insect pests. Microbial pesticides can control a wide range of pests, despite the fact that each microbial active component is generally specialised for its target pest. For example, variations of the bacterium *Bacillus thuringiensis* (*Bt*), which may control some insects in cabbage, potato, and other crops, are the most well-known microbial pesticides. *Bt* produces a protein that is poisonous to a certain type of insect pest. Other microbial insecticides work by displacing pest organisms.

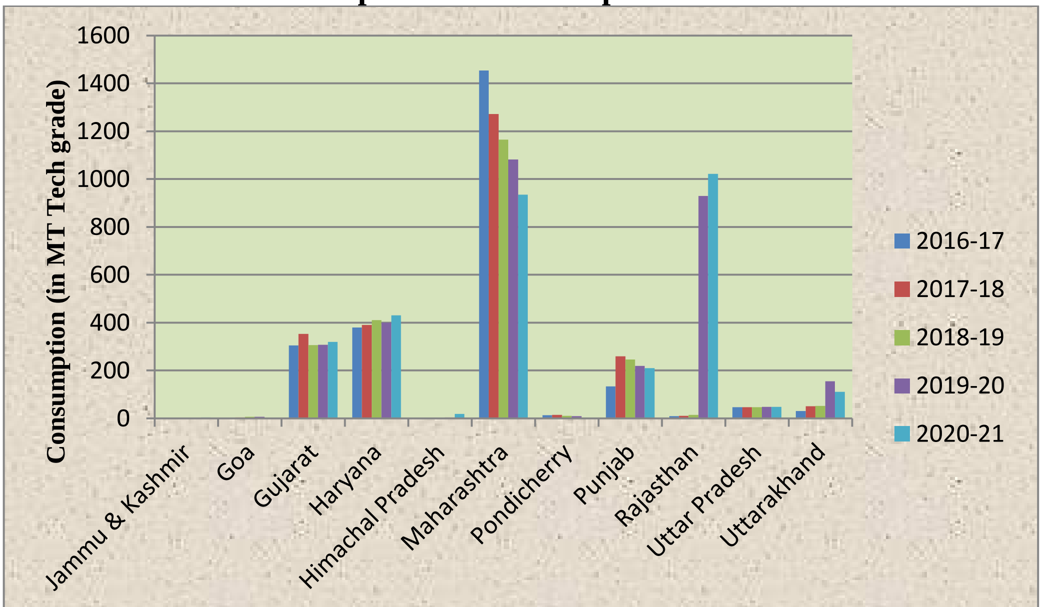
II. **Plant- Incorporated-Protectants (PIPs)**: PIPs are pesticidal compounds produced by plants from genetic material introduced to the plant. Scientists can, for example, extract the gene for the *Bt* pesticidal protein and insert it into the genetic material of the plant. The plant, rather than the *Bt* bacteria, then produces the chemical that kills the pest. The EPA (Environment Protection Agency) regulates both the protein and its genetic material, but not the plant itself.

III. **Biochemical pesticides:** Plant extracts, fatty acids, and pheromones are examples of naturally occurring compounds that use harmless processes to keep pests at bay (Verma *et al.* 2021).

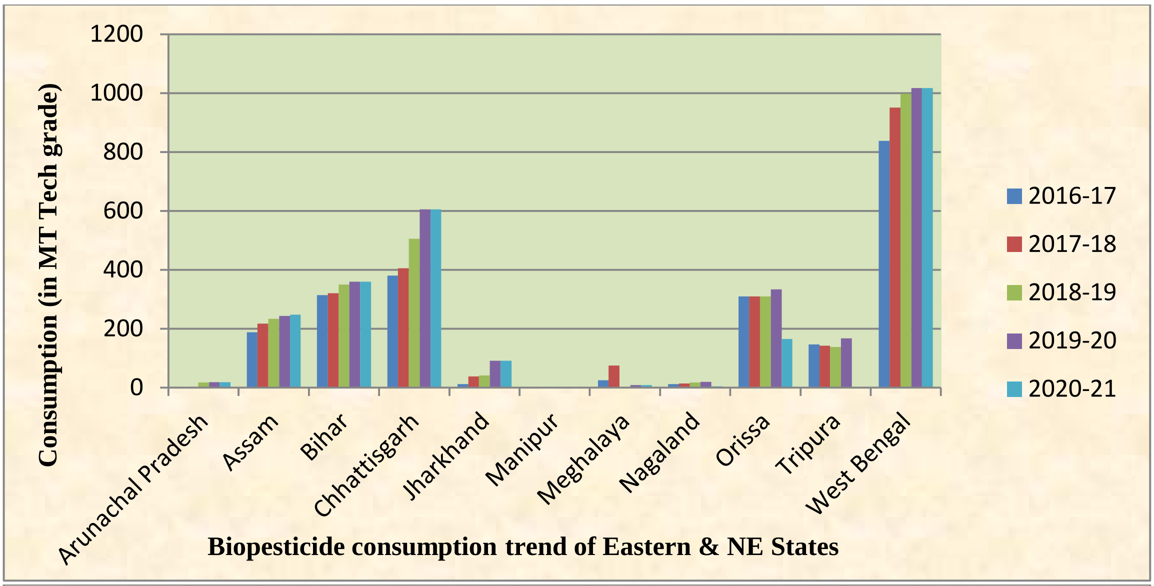
Registered formulations of biopesticides with their target pests (Kapila and Singh 2021):

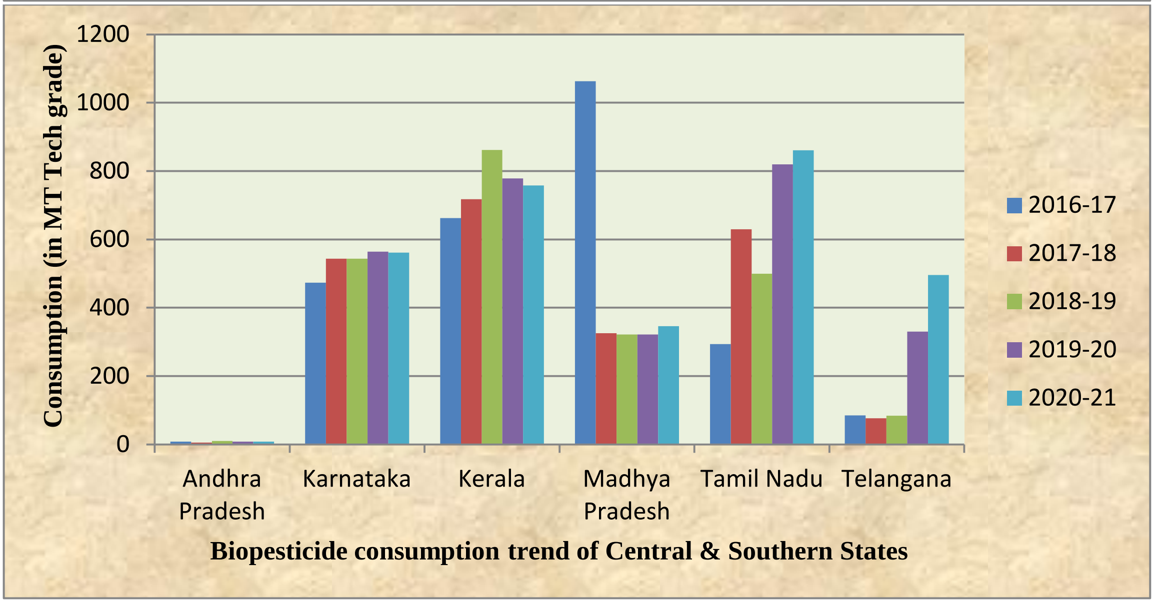
Origin	Agent	Used against
Bacteria	*Bacillus thuringiensis var. tenebrionis* strain Xd3 (Btt-Xd3)	Alder leaf beetle (*Agelastica alni*)
Bacteria	*Burkholderia rinojensis* A396 (heat killed)	Broad spectrum insecticide / acaracide
Bacteria	*Bacillus thuringiensis subsp. Galleriae* SDS 502	Beetles
Bacteria	*Lactobacillus casei* strain LPT-111	*Xanthomonas fragariae*
Bacteria	*Bacillus thuringiensis subsp. tenebrionis* SA-10	Colorado potato (*L. decemlineata*) and elm leaf *(P. luteola*) beele larva
Fungus	*Trichoderma harzianum*	*Fusarium* root rot
Fungus	*Beauveria bassiana* combination GHA + neem oil	Whitefly, aphids, thrips, scales and other leaf feeding insects
Fungus	*Talaromyces flavus* SAY-Y-94-01	*Glomerella cingulata* and *Colletotrichum acutatum*
Virus	Nucleopolyhedrovirus (NPV). *Spodoptera exigua* SeNPV	Beet armyworm, *S. exigua*
Plant	Stilbenes from grapevine extracts	*S. littoralis*
Plant	*Clitoria ternatea*	*Helicoverpa spp.*
Plant alkaloid	Oxymatrine	*Spodoptera litura*, *Helicoverpa armigera*, *Aphis gossypii*

Statistics of biopesticides consumption in Indian states



Biopesticide consumption trend of North & Western States





(Source: **http://ppqs.gov.in**)

Potential benefits of using Biopesticides in Agriculture:

1. Specificity of the host.
2. When used in little amounts, it can be quite effective.
3. Decomposes naturally and fast.
4. There are no harmful residue issues. Cross resistance isn't an issue.
5. Effect that lasts for a long time. Most other plant protection strategies used in an IPM programme can be easily integrated with this one.
9. There is no worry of contamination, making it environmentally beneficial.

Constraints in popularization of biopesticides

1. From the screening stage to the selection of prospective strains for sale, packaging, storage, and distribution, biopesticide production requires a large initial financial commitment.
2. The selling of substandard or fake biopesticides, as well as biopesticides tainted with chemical pesticides not permitted by the Central Insecticide Board and Registration Committee, is the main impediment to its development and expansion (CIBRC).

3. Farmers are also concerned about their short shelf life. Temperature variations, humidity, and ultraviolet light diminish the efficacy of biopesticides, which are mostly made up of living bacteria. Furthermore, any contamination lowers its usefulness in real-world situations.
4. Biopesticides are likewise dose-dependent, and their efficacy changes depending on the climate.

Conclusion:

Pesticides have long been utilised as a necessary tool for controlling pests and contributing to the refinement of agriculture, but their overuse has posed real security risks to people and the environment. Biopesticides have emerged as a safe substitute for chemical pesticides. We recognise that the application of biopesticides to manage insect pests may play a critical role in sustaining food quality for human and livestock health, as well as environmental protection for long-term development. Recent potential biopesticides include betaproteobacteria products and entomopathogenic fungi and baculovirus based products. Another biopesticides which are on development are phytochemicals. Currently, biopesticide research is in its early stages, but with the identification of isolates, improvements in formulations, and advancements in methodologies that reduce costs and extend product life, the research has been rapidly changing and increasing. However, there are still many hurdles to be overcome, and fundamental questions about cost viability and storage stability remain unanswered. Nanotechnology has also provided solutions to a number of challenges relating to the advancement of biopesticides. However, there is still a dearth of detailed information on factors linked with toxicity and dangers connected with the release of these compounds into the environment. As a result, future research should focus on these strategies.

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