*Indian J. Plant Genet. Resour. 35(3): 369–374 (2022)*
DOI 10.5958/0976-1926.2022.00102.4

# Current Status and Recent Developments in Microbial Pesticide Use in India

**HB Singh**
*Department of Biotechnology, GLA University, Mathura-281406, Uttar Pradesh, India*

For ensuring sustainable food security scientists are working hard to develop alternative eco-friendly technologies for crop protection to combat the ill effect of chemical pesticides. A large number of agriculturally important microorganisms (AIMs) are being used as biopesticides or biostimulants for the management of plant diseases. Despite extensive research on biopesticides globally their reach to end-users i.e. farmer is very low. The main barrier to not accepting biopesticides is poor quality products available in the Indian market. Issues related to commercialization, regulatory requirements in India, slow market growth and less acceptance of biopesticides by the farmers in India are discussed.

## Introduction

In order to effectively manage plant diseases and stimulate plant growth, microbial pesticides and bio pesticides (PGPR, bio stimulants) based on living microorganisms and their bioactive components have been extensively studied, published, and promoted. They have, however, typically been consigned to niche items due to their lack of efficacy, uneven field performance, short shelf lives, and stringent regulation requirements by Central Insecticide Board and Registration Committee (CIBRC). Despite significant market penetration gains, bio-pesticides still only account for a small portion of Agri-bio input goods. Numerous microorganisms associated with plants are known to suppress pathogenic organisms, produce hormones that stimulate plant development, and increase plant health and resilience to disease. To safeguard crop production and boost output, managing pests and illnesses in agriculture is crucial. The awareness and demand for AIMs used as biopesticides, biofertilizers, and bio stimulants is rising slowly all over the world. Microbial pesticides are based on bacteria, fungus, viruses, nematodes, protozoa, and other microorganisms. *Bacillus subtilis, Gliocladium* spp., *Trichoderma, Pseudomonas fluorescens, Beauvaria bassiana*, and *Metarrhizium anisopliae* are among the nine microbes included in a schedule that was published in the Gazette of India on March 26, 1999, as an amendment to the Insecticides Act, 1968 for the commercial production of biopesticides. The Insecticide Act of 1968 added 26 new microorganisms to its agenda for the manufacture of microbial biopesticides.

In India, the biocontrol agents *Trichoderma viride, T. harzianum, P. fluoroscens, B. bassiana, M. anisopliae*, and *B. subtilis* have carved out a place for themselves as crucial components in the management of numerous pests and illnesses (Singh *et al.* 2016). Its reach is still confined to a few specific states in our nation, though. The proliferation of low-quality producers of biopesticides is the main cause of this situation. In our opinion, biopesticides have a possible role to play in the creation of a future integrated pest management program. Hopefully, the government will soon adopt a more sensible stance regarding microbial biopesticides.

The research on microbial pesticides would be beneficial only if the product based on novel strains is commercialized and registered. To accomplish this, it is necessary to adhere to the Central Insecticide Board's standards. Technology advancement also heavily depends on the mass manufacture of formulations based on microorganisms. These CIB-set parameters will be discussed in this manuscript, along with other aspects of the marketing and registration of biopesticides (Singh *et al*., 2016).

## Need for Commercialization of Microbial Pesticides in India?

Prior to independence, our research in plant disease management was primarily theoretical and exploratory in nature. Biological control agents seem to be the same. To combat disease in micro-plots, scientists have tested a vast number of antagonists, narrowed them down to a few that were effective, and then put them to the test in

**Author for Correspondence: Email-hbs1@rediffmail.com*

the field. The most effective antagonists were produced in this way. Commercialization of biocontrol products would have been the next obvious step in this sequence. Biocontrol products make up less than 1-2 % of the crop protection market, according to estimates from a firm. About 80 biocontrol products have crossed the finish line to become commercial merchandise worldwide. The products have a confined range of applications because they have only been assessed on a small range of crops and can only control one or two infections. Additionally, there hasn't been a lot of investment in the development of commercial formulations of biocontrol-active microbes, perhaps as a result of the high costs associated with creating, testing, registering, and selling these products. Based on both the growing degree of complexity and the declining potential for repeat sales, the efforts made in the direction of the commercialization of biocontrol agents may be divided into three groups. As with the application of soothing balm in medicine, the first group suggested applying the antagonist precisely and directly to the infection site as needed. This is done to prevent or overwhelm the pathogen by applying a large population of antagonist organisms, such as antagonists applied to seeds to protect germination against damping-off, antagonists applied to fruits to prevent fruit decay in storage, and bacteria growing at temperatures below 0°C to protect plants from frost damage. With the exception of *Gliocladium virens* GL-21, which is placed in the soil near seeds or plants with a sufficiently high inoculums density to ensure an initially high population in the infection court, nearly all microorganisms that have been commercially available to date fall into this category. This collection of bioagents is crucial as it represents the first logical step in their commercialization for use against plant diseases and because it makes a substantial contribution to raising awareness of microbes among business people, farmers, and society at large. The second group, which contains antagonists administered to seeds or other single points with the intention of spreading with plant growth and defending roots and shoots, is supported by Plant Growth Promoting Rhizobacteria (PGPR). This group of antagonists may include examples of the inundative and augmentative application strategy, where the antagonist is expected to multiply, persist for some or all of the plant's life, and boost the population of an insufficient supply of a linked or pretty close antagonist already present in the rhizosphere. For instance, colonized wheat grains strewn on the soil surface were employed to spread an oxygenic *Aspergillus flavus*, which prevents the growth of toxic strains of *A. flavus* on the floral portions of cotton plants. Due to the antagonists' increased susceptibility to the impacts of competition and environmental factors, this category of examples presents a more difficult biocontrol approach. At this time, there are no commercially available alternatives in this group.

The following are examples of biological control failure or variable performance in the rhizosphere with introduced microbes:

a. Low disease pressure for an effective test
b. Very poor carbon content in the soil
c. Heavy dosage of chemicals used in the field prior to use of biologicals
d. The use of biopesticides encourages the expansion of non-target disease harm
e. Variable colonization of the transplanted strain's impacted roots or loss of the strain's ecological competency
f. Wherever it is required for the efficient action of an antagonist, the expression of antibiotic synthesis occurs perhaps too late or insufficiently to actively control the disease.

However, these restrictions can be overcome by choosing efficient antagonist strains and enhancing their activity using cutting-edge biotechnological techniques. A combination of institutional issues, technical constraints, and unreasonably high expectations for these goods are some of the additional difficulties associated with the commercialization of biocontrol products. But if we're serious about creating marketable biological control products, we'll have to get over these challenges. As a result of years of research, the formulation's rhizosphere competency varies with shifting soil conditions. All research must move in the direction of the creation and commercial manufacturing of the unique superior train after isolating a rhizosphere competent strain of an efficient biocontrol agent or antagonist. In order to develop a broad-spectrum product that can effectively control a large number of pathogenic fungi and bacteria under different conditions, field trials are essential for the development of a product. These trials must be executed under varied soil conditions in various fields, on crop varieties, and also with multiple pathogenic fungi or bacteria. In order to help prevent illnesses, biocontrol fungi offer other advantages, such as reducing the physiological stresses that seedlings experience naturally and boosting resilience to abiotic pressures (Singh *et al.,* 2017). Another restriction is selecting an appropriate substrate for the creation of an efficient formulation. The development of biocontrol formulations has utilized a variety of substrates. Utilizing agricultural wastes, such as wheat bran, coffee and tea grounds, rice hay, distilled waste from oil-producing plants, and rice waste would be financially viable. For use in the field, we have created a cheap technology for mass-producing biocontrol fungi. Different substrates, such as powdered rye grass seed, Diatomaceous earth granules and molasses, wheat bran formulations, wheat bran sawdust formulations, molasses-yeast medium, and others, are employed in laboratories to mass-produce biocontrol fungi. Many commercially viable products for disease management are either region- or disease- or both-specific. Therefore, it is imperative to go forward with the selection of the most efficient strains of biocontrol fungus and their production as broad-spectrum formulations for use against a variety of soil-borne illnesses under various soil conditions. The essential factor in the commercialization of microbial agents for use in agriculture, as well as a significant barrier, is cost. Another significant barrier is that most nations lack the infrastructure needed to scale up and commercialize biocontrol products. It is necessary to create a framework for the commercialization and distribution of biocontrol agents to farmers that is akin to the one used by breeders to release breakthrough varieties.

The optimum parameters for the commercialization of a biocontrol agent are as follows:

- Appropriate and suitable strain selection.
- Prolong shelf life and storage of bioformulations at room temperature.
- Novel application technology viz., seed biopriming.
- Scale up and quality control at production and distribution sites.
- Registration of bioformulation with regulatory body.

Registration of the organisms used to produce biocontrol products is one of the biggest obstacles that must be overcome during the commercialization process. Through Directive 91/414/EEC, which is "Concerning the Placement of Plant Protection Products on the Market," an effort has been made in the European countries to offer a uniform legislative framework throughout the European Union. However, there has been much discussion on this matter and it is still not completely settled, so there remains uncertainty in the domain. The EPA maintains four levels of testing for possible adverse impacts of microbial pesticides in the USA. These include adverse impacts on plants and animals that are pathogenic or poisonous but not targeted. The Insecticide Act of 1968 now requires that antagonistic organisms, including *Trichoderma* species, *Gliocladium* species, *Bacillus* species, *Pseudomonas* species, etc., be listed in the schedule. This regulation was put into effect by the Indian government in March 2009. India has a completely different situation as the market for crop protection has been monopolized by the chemical pesticide business. It is also discouraging to see how the administration is acting. A paradigm shift in business practices is required to establish a market for biocontrol products in India. Any microbiological product must be registered in accordance with specific legal requirements before it can be sold. The Insecticides Act of 1968 and its implementing regulations govern the import, manufacturing, sale, transportation, and distribution of biopesticides in India (Singh *et al.,* 2016). The following are the key components of this requirement:

The Central Insecticides Board approved adding more microorganisms to the schedule of the Insecticides Act to control production and use in India (Table 1).

After inclusion of an organism in the schedule, an applicant can submit Form I along with prescribed fees to the Registration Committee (RC) under Section 9(3B) as per the guidelines of data generation. Permanent certification is issued under section 9(3) as per guidelines.

## Data Requirements

Usually, the CIB-RC allows commercialization in terms of import, manufacture, sale, transport, and distribution of biopesticides only after the grant of regular registration. The data requirements for all microbes to be registered are provided at http://www.cibrc.nic.in. Currently, 970 microbial pesticides are registered with CIBRC for commercial production and use by farmers (Fig. 1). There are 355 products based on *Trichoderma* spp. manufactured in India by several companies (Fig. 2).

Table 1. **Microbes listed in Gazette of India in the 1968 Insecticide Act's for production of biopesticides**

| | | |
|---|---|---|
| *Agrobactarium radiobacter* strain 84 | *Fusarium oxysporum* (non pathogenic) | *Paeciliomyces lilanicus* |
| *Agrobactarium tumefaciens* | *Gliocladium* spp. | *Photorhabdus luminescens* akhurustii strain K-1 |
| *Alcaligenes* spp. | *Grannulosis* viruses | *Piriformaspora indica* |
| *Ampelomyces quisqualis* | *Hirsutella* spp. | *Serratia marcescens* GPS5 |
| *Aspergillus niger* – strain 27 | *Metarrhizium anisopliae* | *Streptomyces griseoviridis* |
| *Bacillus subtilis* | *Myrotheium verrucaria* | *Streptomyces lydicus* |
| *Beauvaria bassiana* | Nuclear Polyhedrosis Viruses (NPV) | *Trichoderma* spp. |
| *Burkholderia cepacia* | *Nomurea rileyi* | *Verticillium chlamydosporium* |
| *Candida oleophila* | *Pseudomonas fluorescens* | *Verticillum lecanii* |
| *Chaetomium globusum* | *Penicillium islanidicum* (for groundnut) | VAM (fungus) |
| *Coniotyrium minitans* | *Pythium oligandrum* | |
| *Erwinia amylovora* (hairpin protein) | *Phlebia gigantean* | |

In India, we have 361 biocontrol laboratories/units for the production of biocontrol agents (Fig. 3) with annual production and consumption of 7203 Metric Tons during 2018-19 (Fig. 4).

## Why AIMs Are Not So Popular in India?

In India, a large number of academic institutions, universities, ICAR Institutes, CSIR Institutes are working on agriculturally important microorganisms (AIMs) for management of pests and diseases, plant growth promotion, bioremediation etc., but there is no connectivity among academia, industry, and regulatory bodies (Fig. 5). Therefore, a very strong bond is to be developed among these three partners so that the microbes get a substantial place in agriculture and the environment.

## Future Prospects

What is the outlook for biological management of plant pathogens that are responsible for various diseases around the globe? The main issue is how to get the technology from the lab to the commercial growers in order to change the outlook for biological control. More scientific efficacy trials in commercial or almost commercial contexts are required, along with thorough replication and statistical analysis. Biocontrol products are either sold separately or blended with other microbial metabolites when they are formulated. However, extensive research needs to be done in order to create mixes that might lead to greater success. The biopesticide Industry Alliance is building a certification method to guarantee industry standards for efficacy, quality, and consistency in order to aid in improving the global market perception of biopesticides as efficient products. The availability of all these facts to growers and extension agents will make a stronger impression than relying just on company advertisements. Discovering the causes of the dearth of biological control data is not that tricky anymore.

A few are mentioned below:

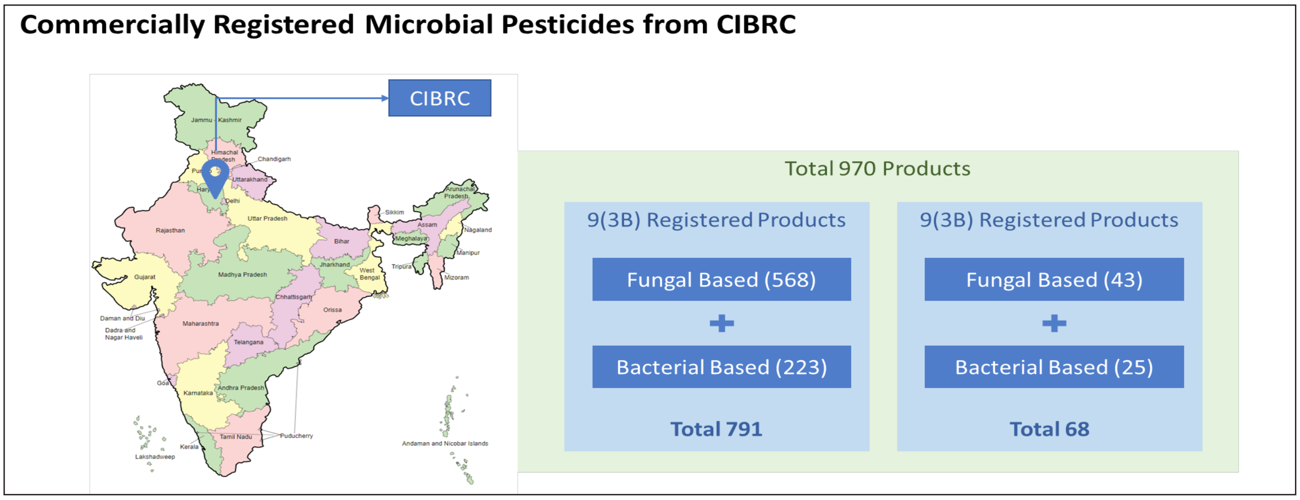


**Fig. 1. Commercially Registered Microbial pesticides from CIBRC**

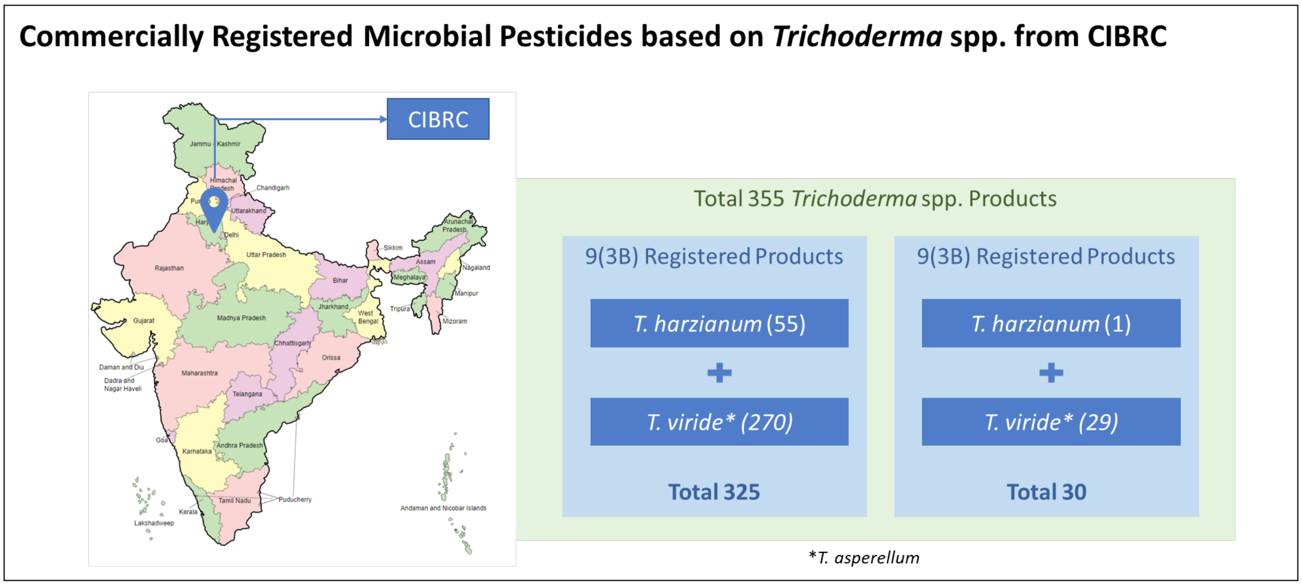


**Fig. 2. Commercially Registered Microbial pesticides based on Trichoderma spp. from CIBRC**

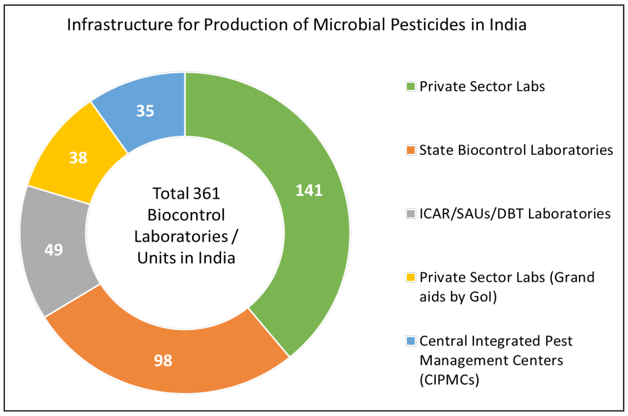


**Fig. 3. Infrastructure for production on Microbial pesticides in India**

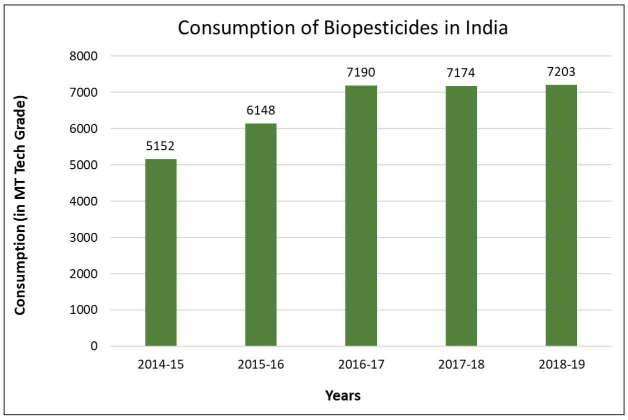


**Fig. 4. Consumption of Biopesticides in India**

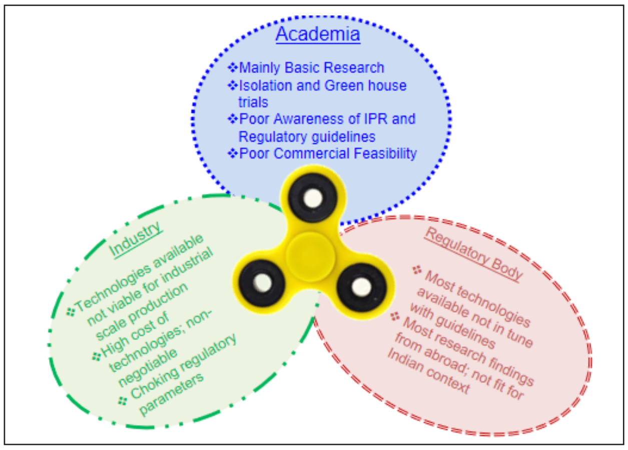


**Fig. 5. Gap areas between academia, industry and regulatory body**

1. A lot of the information is confidential and is only available in corporate reports or in registration dossiers submitted to regulatory bodies.
2. Universities and research institutes no longer test products on a regular basis; instead, findings are reported in research station bulletins, which are not indexed by citation databases.
3. Many trials may demonstrate a lack of efficacy and are not published.
4. Scientific publications do not publish biocontrol product effectiveness studies due to deficit innovative ideas.

More research is needed on the pathogen's ecology and epidemiology, which are particularly understudied for diseases that are soil-borne. Before extolling the virtues of biological control over chemical control techniques, a number of additional issues also need to be addressed.

For example:

a. How is the pathogen introduced and how does it spread?
b. How does the connection exist between damage and population density?
c. How do different environmental factors affect the effectiveness of newly introduced microorganisms?

Every change we make has an impact on the environment, including the one of doing nothing. But we need to find a way out of this mess so that we may presume that the main qualities of our commercial products for the biocontrol of plant diseases are safety and effectiveness. Only then can it be anticipated that the marketing of biocontrol agents will be effective. The idea that the disease should be managed rather than entirely controlled must be ingrained in end users' minds for biocontrol to be more widely accepted. Additionally, commercial companies are hesitant to finance ongoing efforts in biocontrol research because of the market size, variability, and methods of production, formulation, and distribution. For the development of next-generation goods with longer shelf lives, recent research methods on *Trichoderma*, in particular genomics, transcriptomics, proteomics, and metabolomics, can be applied. To get over these challenges, more research must be done across all aspects of biocontrol.

## References

Singh HB, BK Sarma and C Keswani (Eds.) 2017. Advances in PGPR Research. CABI-UK. 408 pages, ISBN-9781786390325.

Singh HB, BK Sarma and C Keswani (Eds.) (2016) Agriculturally Important Microorganisms: Commercialization and Regulatory Requirements in Asia. Springer, Singapore. 336 pages, ISBN-**13**: 978-9811025754.