

India

Neutral (no change)

Chemicals - Overall

Biopesticides to erode chem pesticides biz

- Biopesticides are a greener and cleaner alternative to pesticides because of their natural origin and high specificity.
- The global biopesticides market is currently estimated at US\$3-4bn and is expected to grow at a CAGR of 14.1%.
- The growing prevalence of biopesticides poses an imminent risk to intermediate makers like SRF, Aarti Industries, Jubilant Ingrevia, etc.

Biopesticides tackle the problems caused by chemical pesticides

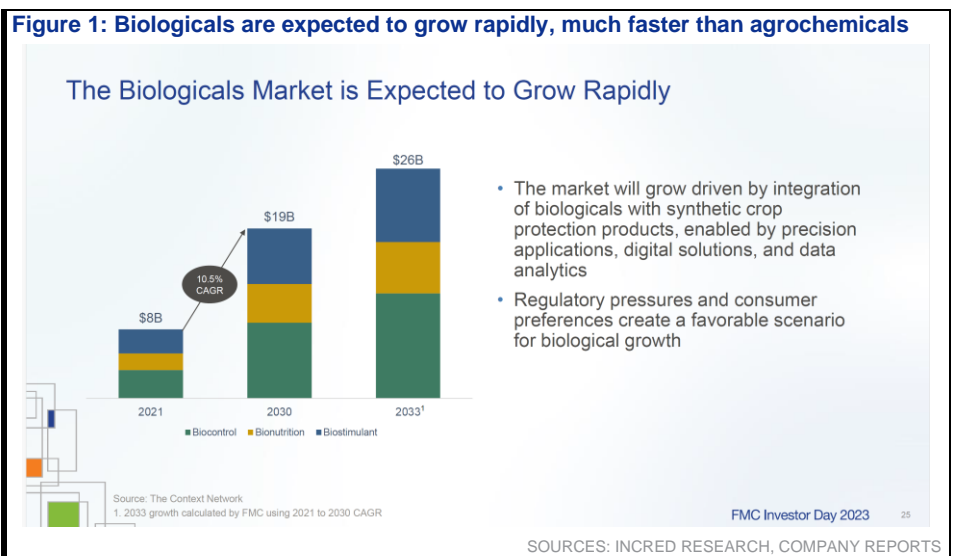
India has lost over 150mt (million tonne) of agricultural crops because of pests. Pests are a heavy burden to the farmers, economy, and agricultural production, thereby making the use of pesticides imperative. However, the overuse of pesticides has caused soil contamination, harm to the ecosystem, and adversely affected human health. A lot of countries have restricted the use of chemical pesticides. Biopesticides are derived from natural organisms like plants, microbes, etc. and do not have detrimental effects on the environment. Additionally, they specifically attack the pests without causing harm to higher organisms and crop yield. Due to the above-mentioned reasons, it is likely that biopesticides will erode the chemical pesticides market in future and that its market share will grow faster.

Biopesticides to capture 50% pesticides biz by late 2040s/early 2050s

Due to their superior properties, it is likely that biopesticides will capture a 50% market share in pesticides. The biopesticides market is currently valued at US\$3-4bn, but it is expected to grow at a CAGR of 14.1%. The US is the biggest market for biopesticides, accounting for 40% of global biopesticides production. The EU market is growing at a slower pace because of strict regulatory policies. India and China, being among the major economies globally, are likely to contribute to the growth of the biopesticides market. In India, out of all the pesticides consumed, approximately 9% comprise biopesticides but it is likely to increase to 50% by 2050F. The National Farmer Policy of 2007 has propelled the growth of biopesticides in India. 12 types of biopesticides and 970 biopesticide products have been registered in India so far.

Biopesticides pose a long-term risk to intermediate makers in India

Biopesticides are increasing their presence in leaps and bounds. They are environmentally friendly, and it takes a fraction of time and money to develop them vis-à-vis chemical pesticides (the costs to develop new biopesticides are 98% lower and the time 50-70% lesser compared to chemical pesticides). Globally, the biopesticides market is likely to grow at a 22% CAGR over the next 10 years. North America is likely to lead global growth and LATAM is projected to grow at a slower pace, at a 10.5% CAGR. All leading global agrochemical companies are shifting to biopesticides, which puts the growth of intermediate makers like SRF, Aarti Industries, Jubilant Ingrevia, etc. at risk.



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What are biopesticides and how do they work?

- Pests cause a huge damage to the food grains produced globally and are a huge economic burden on society. The use of pesticides is imperative to maximize production.
- Even though chemical pesticides are being used until now, society has recognized the heavy burden they pose on the environment and human health, and various countries have started restricting their use.
- Biopesticides are natural alternatives to chemical pesticides that act specifically against the target and do not cause harm to the environment. Due to their beneficial properties, it is likely that the biopesticides market will grow faster than their chemical counterparts.

Why are pesticides used?

- Factors like disease, nematodes, insects, rodents, etc. are detrimental factor to crops and one of the major limiting factors in the growth of agricultural production. The monetary losses that were suffered in major crops in India due to pests have been mentioned in the table below.
- To prevent the losses caused by pests, chemical products such as pesticides, fungicides, and weedicides are used. However, in the past few decades, the usage of these chemical products witnessed an exponential rise in the developed and developing countries alike, and we continue to see an increase in their production.
- After the application of these chemical products, whatever remains in the soil is detrimental to living organisms like human beings, animals, beneficial insects like bees, birds, etc. Moreover, they also contaminate groundwater reserves.
- Biopesticides can help circumvent this problem as they are naturally derived, and act specifically to harm the pests.

Figure 2: Estimated losses suffered in major Indian crops because of pests

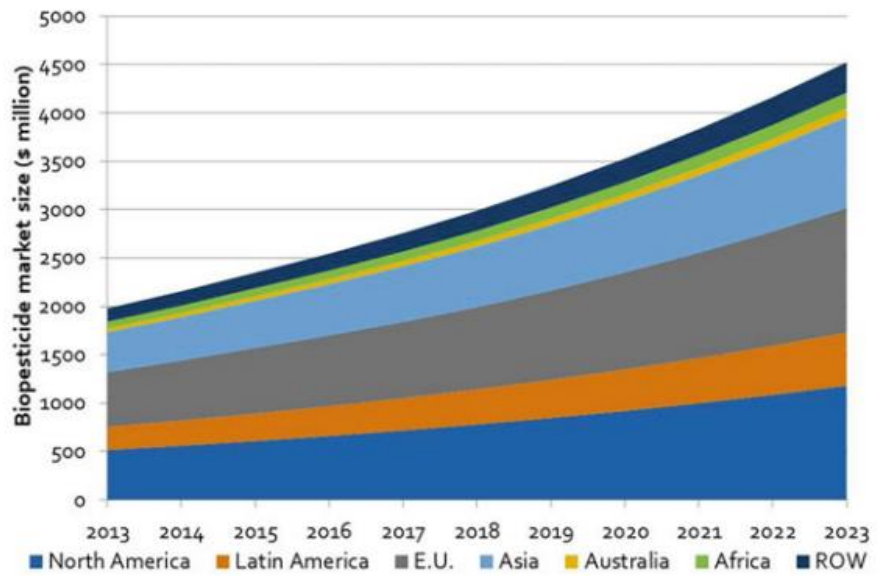
Major agricultural crops of India	Actual production (mt)	Approximate loss in yield due to pests		Hypothetical production in the absence of losses due to insect pests	Monetary value of estimated losses (US\$m)
		%	Total (mt)		
Coarse cereals	19.03	8	1.65	20.68	378.2
Cotton	58.17	30	24.93	83.1	15,767.69
Groundnut	9.71	15	1.71	11.43	1,172.13
Maize	24.26	18	5.33	29.59	1,268.41
Other oilseeds	15.16	12	2.07	17.23	1,215.55
Pulses	19.78	15	3.49	23.27	2,285.29
Rapeseed-mustard	7.88	20	1.97	9.85	1,026.7
Rice	106.65	25	35.55	142.2	8,467.36
Sugarcane	352.14	20	88.04	440.18	3,160.25
Wheat	93.51	5	4.92	98.43	1,135.75
Total/average	706.29		167.95	875.96	35,877.33

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Biopesticides are poised to capture further market share

- Biopesticides offer the promise of protecting crops and increasing their yields without adversely affecting them and the soil quality, in contrast to their chemical counterparts.
- Agrochemicals like pyrethroids and PFAS-related pesticides are now facing scrutiny in European countries as they have off-target effects on other organisms in the ecosystem like bees, birds, etc. Biopesticides have lesser toxicity than chemical pesticides and solely attack the target pests and closely related organisms and hence, they offer a sustainable alternative.
- Biopesticides are likely to capture a larger market share in the coming years because of their superior properties over chemical pesticides. Even at the beginning of this century, there were approximately 195 registered biopesticide active ingredients and 780 products.

Figure 3: Biopesticides are likely to capture a larger market share

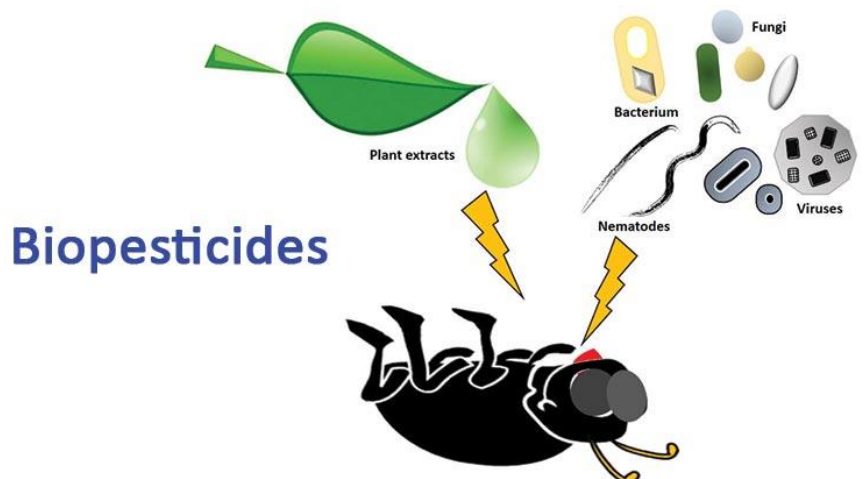


SOURCE: INCRED RESEARCH, COMPANY REPORTS

A quick glance at biopesticides ➤

- Biopesticides are naturally occurring organisms like algae, bacteria, fungi, nematodes, protozoa, and viruses and, in some instances, compounds that are made by these organisms like metabolites.
- A combination of canola oil and baking soda acts as a biopesticide. Biopesticides are used to combat pests, pathogens, and weeds, detrimental to crop yield. The bio fungicide *Trichoderma*, bioherbicide *Phytophthora*, and bioinsecticide *Bacillus thuringiensis* (Bt) are all examples of biopesticides.
- The overall global biopesticides production is more than 3,000t per year. India has huge capacity for growth in this space. Biopesticides such as *Bt*, NPV, neem-based pesticides, *Trichoderma*, etc. have already been registered in India.
- Agriculture plays a significant role in India’s economy. Biopesticides have a lot of room for growth in India as they can help increase the profitability of the agriculture sector in a sustainable manner. *Bt* for diamondback moth control, *Trichogramma* for sugarcane borer control, *Trichoderma* formulation for rot and wilt control in several plants, neem products for whitefly control in cotton, etc. are some biopesticides that are currently used in India.

Figure 4: Biopesticides are plant protection agents derived from naturally occurring organisms

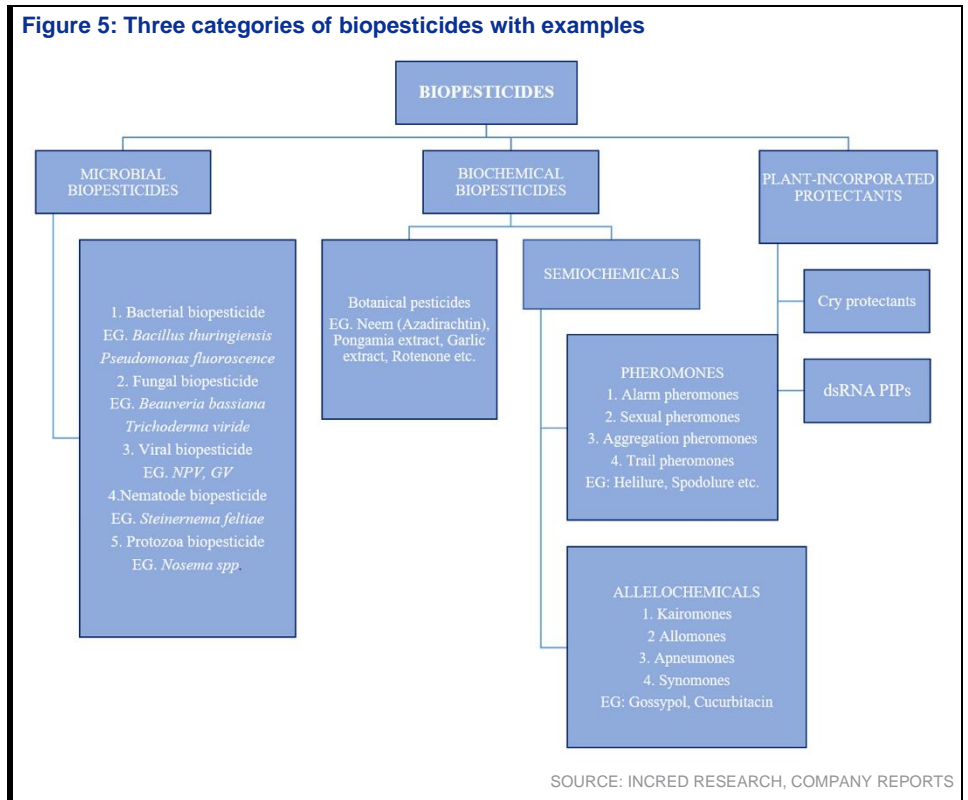


SOURCE: INCRED RESEARCH, COMPANY REPORTS

What are the different types of biopesticides?

- The US Environmental Protection Agency or EPA has characterized three main categories of biopesticides (see Fig. 5).
- Microbial pesticides comprise microorganisms. Biochemical pesticides are organic compounds like pheromones. PIPs are produced by genetically modifying a plant to produce the pesticidal compound and they are the least prevalent ones.

Figure 5: Three categories of biopesticides with examples



Microbial pesticides

- Microorganisms, namely bacteria, fungi, viruses, protozoans, or nematodes are the major ingredients of microbial pesticides. They are effective against weed, plant diseases, and insect pests. They can be administered to the crops as live organisms, dead organisms, and spores.
- These pesticides normally work by generating a toxin against the pest. The microbe enters the insect's body through its skin or gut, multiplies there, and kills the insect's own cells, ultimately causing the insect's death. Generally, microbial pesticides are more potent than chemical pesticides and can easily replace them.
- *Bt thuringiensis* (Bt) is a widely used microbial pesticide. The bacteria produces a crystal protein called Bt-endotoxin. When this is ingested by the insects, it pokes holes in their gut, ultimately leading to their death.

Figure 6: Microbe-based biopesticides with their target organisms

Biopesticide	Category	Targets	Commercial names
<i>Ampelomyces quisqualis</i>	Fungus	Powdery mildew	<i>Bio-Dewcon</i>
<i>Bacillus thuringiensis subsp. kurstaki</i>	Bacterium	Lepidopteran pests	<i>Bio-Dart, Halt, Biolep</i>
<i>Bactericides; B. subtilis</i>	Bacterium	Soilborne pathogens	
<i>Beauveria bassiana</i>	Fungus	Coffeeberry borer, grasshoppers, aphids, codling moth	<i>Myco-Jaal, Bio-larvex, Bio-grubex, ATEC Beauveria</i>
<i>H. armigera</i> (NPV)	Virus	<i>H. armigera</i>	<i>Helicide, Bio-virus H, HeliGuard</i>
Insecticides; <i>B. thuringiensis subsp. Israelensis</i>	Bacterium	Lepidopteran pests	<i>Tacibio, Techna</i>
Nematicides; <i>Verticillium chlamydosporium</i>	Fungus	Nematodes	
<i>Pseudomonas fluorescens</i>	Bacterium	Plant soilborne diseases	<i>Biomonas, Sudo, Sun Agro Monus</i>
<i>Spodoptera litura</i>	Virus	<i>Spodoptera litura</i>	<i>Spodocide, Bio-virus S</i>
<i>Trichoderma harzianum</i>	Fungus	Soilborne pathogens	<i>Biozim, Sun Agro, Derma H</i>
<i>T. viridae</i>	Fungus	Soilborne pathogens	<i>TrichoGuard, Ectoderm, Defense</i>

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Biochemical pesticides

- Biochemical pesticides are organic non-toxic compounds used to control pests. They modify an insect's physiology and behaviour. These compounds can come from insects, animals and plants.
- Plant growth regulators that can prevent population expansion and breeding along with pheromones which can repel or attract pests come under this category.
- Neem oil is derived from neem tree. It is an insecticide which is extracted from neem seeds. Neem tree produces azadirachtin and salanin, the two compounds that kill insects.

Plant-incorporated protectants (PIPs)

- Plants produce compounds that are toxic to pests when you make DNA encoding in them for the desired result. These are called PIPs.
- An example of this is Bt cotton. The Bt gene is inserted in the cotton plant. The crystal toxin that kills the insect is then produced by the plant itself, not by the Bt bacterium.

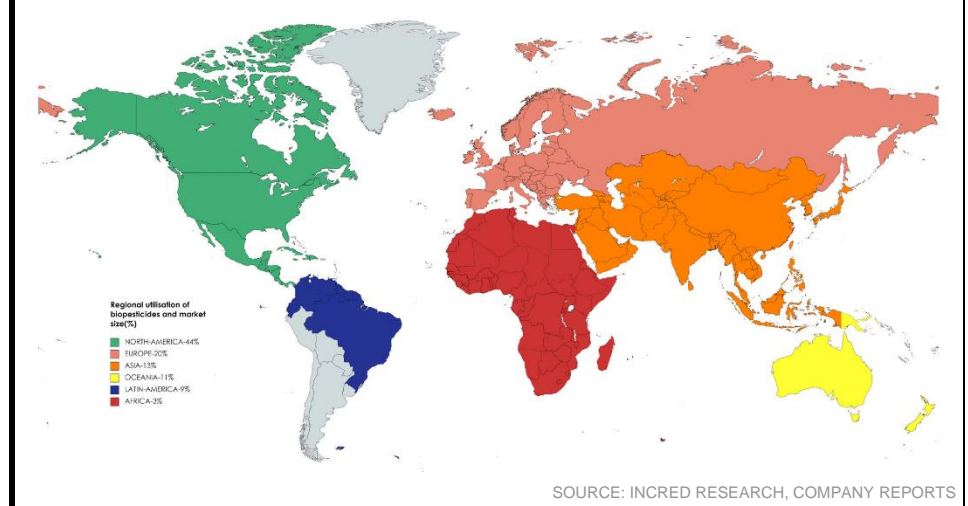
Global & Indian market landscape for biopesticides

- The global biopesticides market is likely to grow at a faster pace than conventional pesticides and it is estimated that they will have an equal market share compared to chemical pesticides by late 2040s and early 2050s.
- The US is the biggest market for biopesticides. India and China are likely to be the major growth contributors. Strict regulations restrict growth in the EU region.
- Public sector companies are responsible for most of the biopesticides production in India. The National Farmer Policy of 2007 has propelled the growth of the biopesticides market. Neem is one of the most prevalently used biopesticides in India.

Global biopesticides market ►

- Out of the global pesticides market of US\$56bn, the biopesticides market is estimated at US\$3-4bn. With a CAGR of 14.1%, it is estimated that the growth of biopesticides will outpace that of conventional pesticides.
- When compared to synthetic pesticides, the biopesticides industry is expected to catch-up in the late 2040s and early 2050s.
- The US biopesticides market is currently valued at US\$205m and is forecast to increase to US\$300m by the end of the decade. North America accounts of 40% of global biopesticides production.
- It is anticipated that the sale of chemical pesticides will decrease and the sale of biopesticides will expand moderately in South and Latin America. This region accounts for 10% of the global biopesticides market.
- Even though the Asian market is currently small, it will provide a significant growth opportunity to biopesticides with their rising usage in China and India. According to India's agricultural ministry, currently 2.89% of the 100,000mt of pesticides sold globally comprise biopesticides, but it is likely to grow to 2.3% annually.
- There are over 200 biopesticides available in the US market and 60 comparable products in the EU market. The EU market has fewer biopesticides when compared to other regions like the US, Brazil, China and India due to the tedious registration process.
- Biopesticides derived from bacteria are commonly used. Bt products are the most prevalently used biopesticides. 200 Bt-based products have a market share of more than 53% of the global biopesticides market.

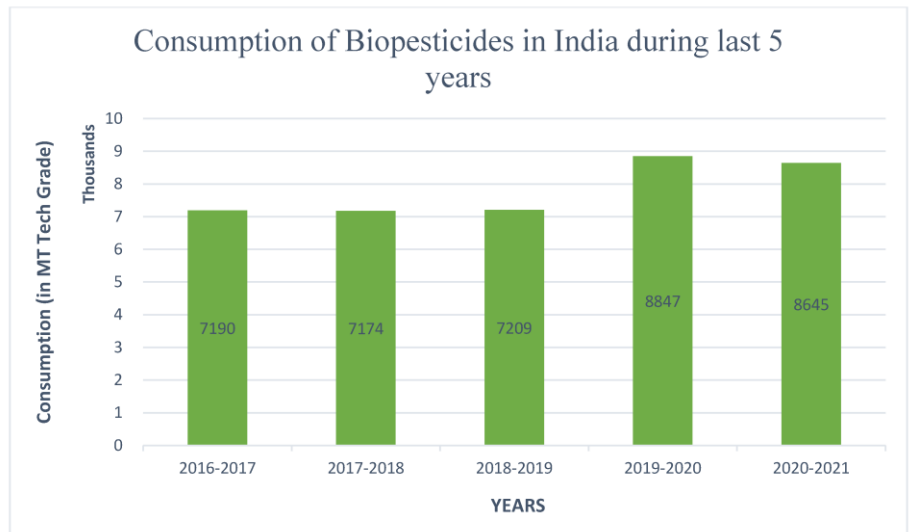
Figure 7: Global biopesticides market



Production and consumption of biopesticides in India ►

- There are 410 production units of biopesticides in India and out of them, 130 are private and 280 are government-owned. Based on estimates, 70% of biopesticides are produced by public sector companies.
- In India, biopesticides account for 9% of total pesticides consumption and it is estimated that by 2050F, it will account for 50% of total pesticides consumption.
- Currently, the biopesticides market is relatively small in comparison with synthetic pesticides. The production is small due to challenges at the policy and industrial level. However, the use of biopesticides is supported by the National Farmer Policy of 2007 and records show that the use of biopesticides has increased in India in the past decade.
- Neem is one of the most prevalently used biopesticides in India. Its consumption increased from 83mt in 1994-1995 to 686mt in 1999-2000. *Bacillus Thuringiensis* (Bt) usage also went up from 40mt to 71mt during this period.
- Biopesticide consumption increased significantly from 123mt in 1994-1995 to 8,110mt in 2011-12. Biopesticides usage in India increased by 40% from 2018-2019 in comparison to the amount used in 2014-2015, and over time touched 8,847mt in 2019-2020 and 8,645mt in 2020-2021. In contrast, the usage of chemical pesticides notably decreased from 56,114mt to 43,584mt (see Fig. 8).
- Biopesticides are registered and regulated in India, according to the Insecticides Act of 1968. Based on it, only the below mentioned 12 types of biopesticides are currently registered in the country:
 - *Bacillus thuringiensis* var. *israelensis*
 - *Bacillus thuringiensis* var. *kurstaki*
 - *Bacillus thuringiensis* var. *galleriae*
 - *Bacillus sphaericus*
 - *Trichoderma viride*
 - *Trichoderma harzianum*
 - *Pseudomonas fluorescens*
 - NPV of *helicoverpa armigera*
 - *Beauveria bassiana*
 - NPV of *spodoptera litura*
 - Neem-based pesticides
 - *Cymbopogon*

Figure 8: Consumption of biopesticides is on the rise in India

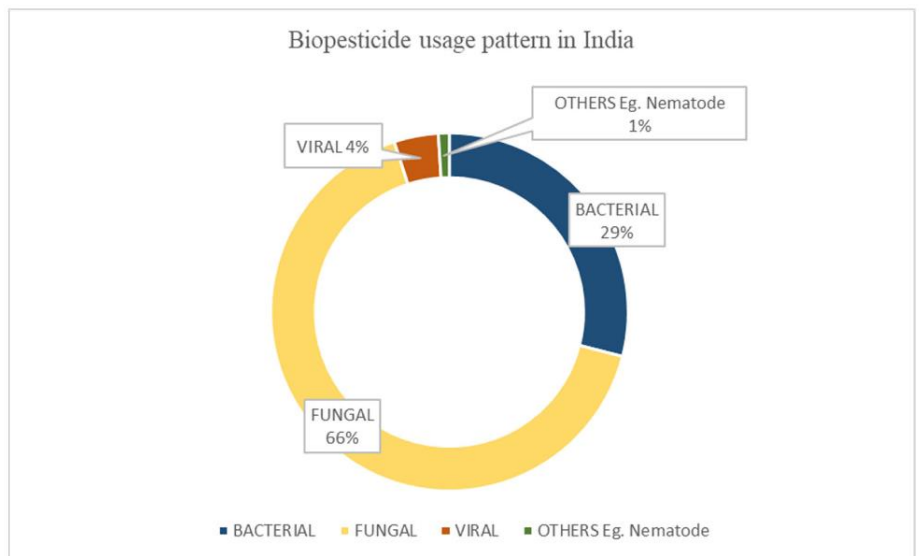


SOURCE: INCRED RESEARCH, COMPANY REPORTS

Biopesticides - usage pattern in India ▶

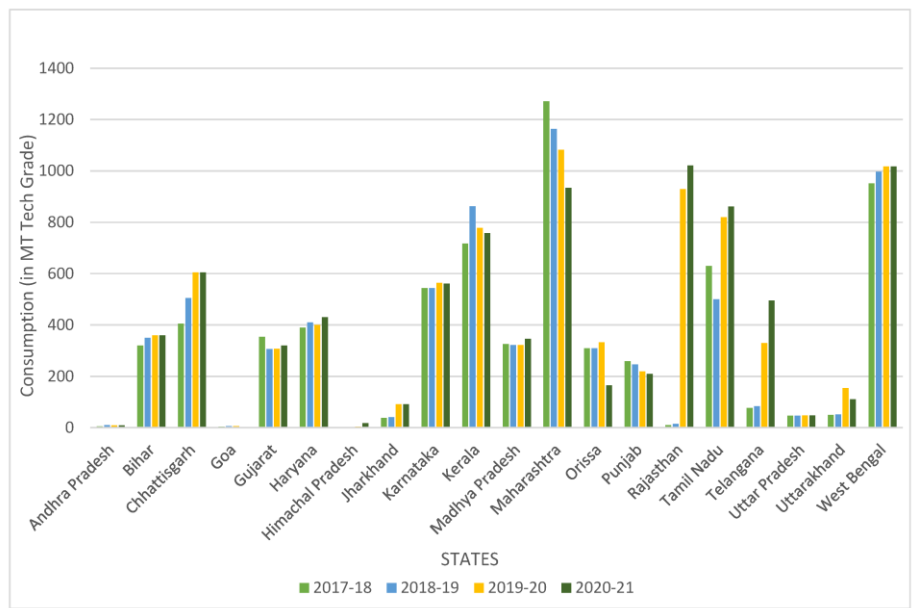
- The Central Insecticides and Registration Committee (CIBR) has 970 biopesticides registered with it. Out of all the different categories, fungal products have the highest share at 66% (Fig. 9).
- Maharashtra has the highest utilization of biopesticides among all Indian states and Goa the lowest. Rajasthan and Andhra Pradesh saw a steep rise while Odisha witnessed the sharpest decline in the usage of biopesticides.

Figure 9: Fungal products have the highest share



SOURCE: INCRED RESEARCH, COMPANY REPORTS

Figure 10: Maharashtra witnessed the highest consumption of biopesticides and Goa the lowest



SOURCE: INCRED RESEARCH, COMPANY REPORTS

Technological advancements in biopesticides

- There are several technological advancements in biopesticides like nanotechnology, recombinant DNA technology, and the discovery of new strains.
- These technological platforms will be used for the discovery of new biopesticides and to improve the efficacy and stability of the existing ones.

Nanotechnology ➤

- Adding nano-polymers to biopolymers improves their properties like penetrability, thermal stability, biodegradability, and solubility.
- Silver nano particles are synthesized using *Trichoderma harzianum*, a pest that causes wilt disease in sweet pepper plants.
- Nano-pesticides can help in the development of biopesticides with lower toxicity, enhanced stability, increased activity in target pests, and adoption by consumers.

New strains ➤

- Various new strains with components that can be used as biopesticides have been discovered, but more testing is required to validate them.

Figure 11: New biopesticides discovered in different strains

Product	Target Pest	Chemical Nature
Products of the fungus <i>Trichoderma harzianum</i>	<i>Fusarium</i> root rot	Fungicide
Strains of the fungus <i>Talaromyces flavus</i> SAY-Y-94-01	Anthraxnose caused by <i>Glomerella cingulata</i> and <i>Colletotrichum acutatum</i>	Fungicide
<i>Bacillus thuringiensis</i> var. <i>tenebrionis</i> strain Xd3 (Btt-Xd3)	Alder leaf beetle (<i>Agelastica alni</i>)	Insecticide
Extract of the species <i>Clitoria ternatea</i> (butterfly pea)	<i>Helicoverpa</i> spp.	Insecticide
Olive mill waste	Various pests	Fungicide and Bactericide
Alkaloid compound oxymatrine	<i>Spodoptera litura</i> , <i>Helicoverpa armigera</i> , <i>Aphis gossypii</i>	Insecticide
Stilbenes isolated from grapevine extracts	<i>Spodoptera littoralis</i>	Insecticide
Fermentation products of the bacterium <i>Lactobacillus casei</i> strain LPT-111	Angular leaf spot caused by <i>Xanthomonas fragariae</i>	Bactericide

SOURCE: INCRED RESEARCH, COMPANY REPORTS

Recombinant DNA technology ➤

- New proteins are being developed to make the next generation biopesticides using recombinant DNA technology.
- A toxic protein is joined to a carrier protein which makes it harmful only for the target pest, not to the higher organisms. When an insect consumes this protein, it dies.

Factors limiting biopesticide usage

- Despite being environmentally friendly and having negligible adverse effects on human health, there are various caveats to the usage of biopesticides, which will end up as growth inhibitors.
- Some of the major disadvantages include high cost of production, activity only against a certain pest, and low stability.

Low efficiency, short shelf life and high development costs to restrict market growth ➤

- The cost of biopesticide production is high due to the investment required for screening, development, and gaining regulatory approval.
- Biopesticides have a short shelf life due to their sensitivity to fluctuations in temperature and humidity.
- Biopesticides have limited field efficacy as they are sensitive to climatic/regional variations in temperature, humidity, soil conditions, etc.
- Due to their high specificity, biopesticides are effective against only the target pests and pathogens. As a result of this, farmers are reluctant to use them as they have to use multiple biopesticides against different pathogens and pests in the field, unlike their chemical counterparts. Overall, currently biopesticides are confusing, costly, and cumbersome. Moreover, they cannot be used for every pathogen and pest.

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