Potential of Biofertilizers and Biopesticides in Indian Agriculture

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Salient Features of Indian Agriculture

- Total Geographical Area - 328 Million hectares
- Net Area sown - 142 Million hectares
- Gross Cropped Area – 190.8 Million hectares
- One of the 12 Bio-diversity centers in the world with over 46,000 species of plants and 86,000 species of animals recorded
- Largest producer of pulses, tea, and milk in the world
- Second largest producer of fruits, vegetables, wheat, rice, groundnut and sugarcane.

Major Causes of Declining Crop Productivity in India

- Imbalanced and indiscriminate use of chemical fertilizers
- Occurrence of multi-nutrients deficiency like-zinc, boron, sulphur etc. besides NPK
- Rain dependent agriculture - about 2/3 area
- Inadequate irrigation facilities
- Continuous fragmentation of land, unfavourable for adoption of technology
- Land holding pattern and Predominance of marginal and small farmers
- Lesser knowledge of modern agricultural technology to majority of farmers
- Inadequate support by the Government

SERIOUS EFFECTS OF CHEMICAL FERTILIZERS

- ***Growth in agricultural production during the last three decades has been accompanied by a sharp increase in the use of chemical fertilizers, causing serious damage to soil fertility.***
- ***Deleterious effect of excessive chemical fertilizers (especially nitrogenous) on the quality of soil and ground water.***
- ***These are expensive***
- ***Health hazards***
- ***Disturbance of Ecosystem***
- ***Pollution***

WHAT ARE BIOFERTILIZERS?

- ***Large populations of a specific or a group of beneficial microbes that enhance soil fertility and the crop productivity***

- ***Preparation containing live microbes which helps in enhancing the soil fertility either by fixing atmospheric nitrogen, solubilization of phosphorus or decomposition of organic wastes or by augmenting plant growth by producing growth hormones with their biological activities.***

TYPES OF BIOFERTILIZERS

1. **Nitrogen fixing** –fix atmospheric nitrogen in readily useable forms by plants. These include Rhizobium, Azotobacter, Azospirillum, blue green algae (BGA) and Azolla. Rhizobium requires symbiotic association with the root nodules of legumes to fix nitrogen while others can fix nitrogen independently.

2. **Phosphate solubilizing-** (PSM) secrete organic acids which enhance the uptake of phosphorus by plants by dissolving rock phosphate and tri-calcium phosphates. PSMs are particularly valuable as they are not crop specific and can benefit all crops

3. **Compost Enhancer** – Lignocarbohydrate degrading microbes (mainly actinomycetes, bacteria, fungi and others)

COMPOST

Vermi Compost- ***Eco-friendly, rich in nitrogen, phosphorus, potassium, organic carbon, Sulphur, hormones, vitamins, enzymes and antibiotics that improve the quality and quantity of yield***

Bio-compost*-sugar industry waste degraded by microbes, rich in nitrogen, phosphate solubilizing bacteria and useful fungi, increase soil fertility , results in good quality products.*

Bokashi*- (Japanese-fermented organic matter) Made with molasses, water, wheat bran and beneficial microbes; also includes manures, spent mushroom compost, forest soil, tea, yeasts, wine and beer*

Major Microbial Products

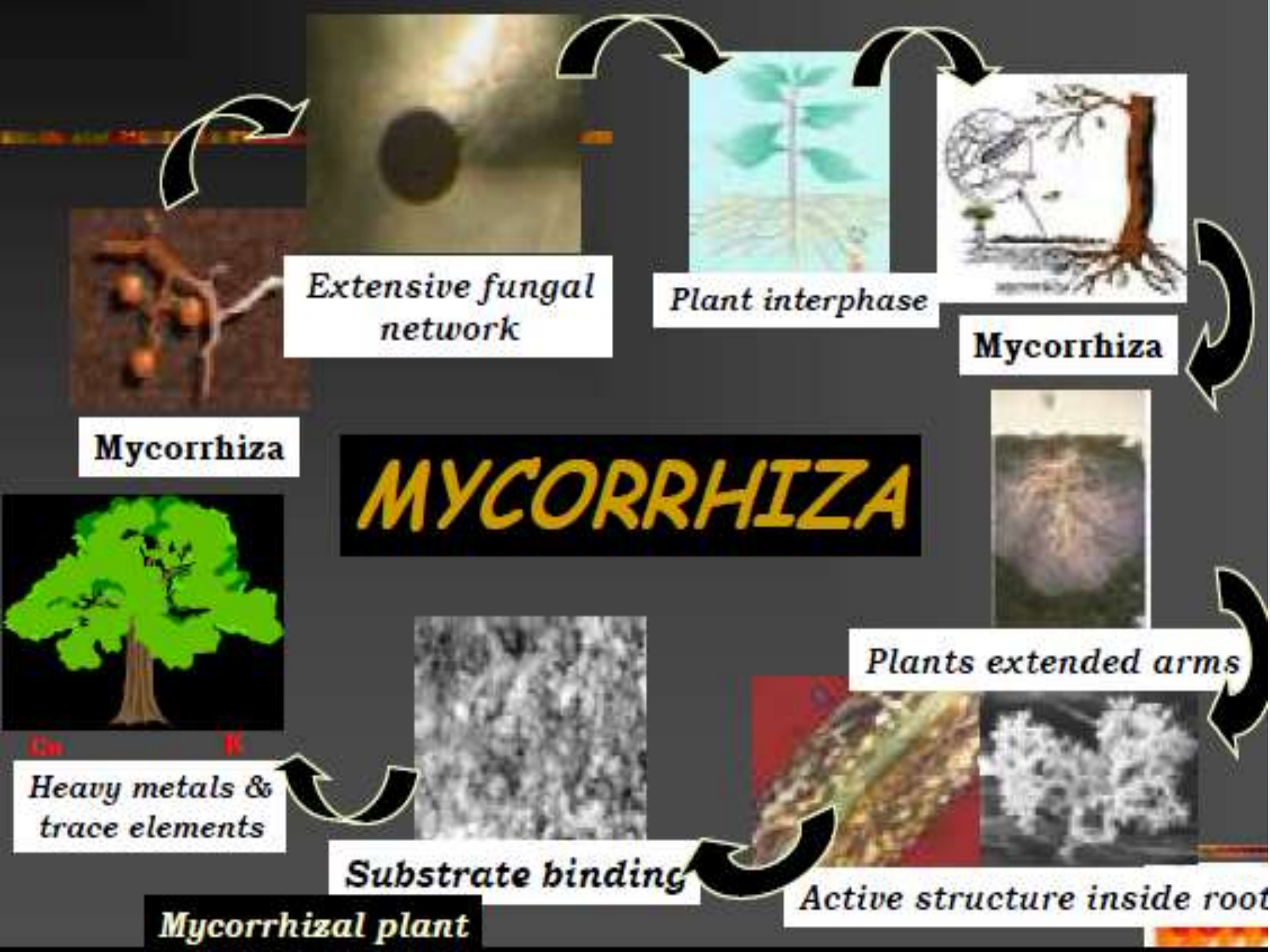
- ***Phospho*: release insoluble phosphorus in soil and fix it which is of great significance**
- ***Rhizo*- induces nitrogen fixation in nodules of legumes**
- ***Azoto*- fixes atmospheric nitrogen and also protects roots from other pathogens**
- ***Tricho*-non-pathogenic, eco-friendly, antagonistic, hyper-parasitic against different pathogens, bio-control agent**

Sugarcane with application of biofertilizer and biopesticides

IPM

Chemical

Control


Extensive fungal network
Plant interphase
Mycorrhiza
Mycorrhiza
MYCORRHIZA
Plants extended arms
Heavy metals & trace elements
Substrate binding
Active structure inside root
Mycorrhizal plant

Major Biofertilizers and Target Crops

Biofertiliser	Target Crop
Rhizobium	Leguminous crops (Pulses, oilseeds, fodder)
Azatobacter	Wheat, rice, vegetables
Azospirillum	rice, sugarcane
Blue green algae (BGA)	rice
Azolla	rice
Phosphate solubilising microorganisms (PSMs)	all

Effect of Azotobacter on Crop yield

Crop	Increase in yield over yields obtained with chemical fertilisers (%)	Crop	Increase in yield over yields obtained with chemical fertilisers (%)
Food grains		Other	
Wheat	8-10	Potato	13
Rice	5	Carrot	16
Maize	15-20	Cauliflower	40
Sorghum	15-20	Tomato	2-24
		Cotton	7-27
		Sugarcane	9-24

Source: Das, 1991

The Potential of Bio-fertilizers

- Bio-fertilizers are considered to be an important alternative source of plant nutrition.
- They are biologically active products that includes bacteria, actinomycetes, algae and fungi with the ability to provide plants with balanced nutrients.
- Promotes germination, flowering, fruiting and ripening in plants

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- ***Improves physical, chemical biological environment of the soil***
- ***Enhances the photosynthetic capacity of crops***
- ***Develops resistance in plants to pests and diseases***
- ***Maintain soil fertility for long time***
- ***Helps in control of soil erosion***
- ***Improves water holding capacity***
- ***Healthy for the consumers***

Use of Bio-fertilizers in Indian agriculture

- ***The green revolution brought impressive gains in food production but with insufficient concern for sustainability.***
- ***In India the availability and affordability of fossil fuel based chemical fertilizers at the farm level have been ensured only through imports and subsidies.***
- ***Dependence on chemical fertilizers for future agricultural growth would mean further loss in soil quality and possibilities of water contamination.***
- ***The Government of India has been trying to promote an improved practice involving use of bio-fertilizers along with chemical fertilizers.***
- ***The role of bio-fertilizers assumes special significance due to increased cost of chemical fertilizers and their ill effects on soil health***

Production of Bio-fertilizers in India

- ***The idea of using micro-organisms to improve land productivity has been around in India for at least 70 years, but it was only in the 1990s that large scale production of various biofertilizers commenced.***

- ***Presently, a number of agricultural Universities, State Agricultural Departments and thousands of Commercial enterprises produce various biofertilizers.***

- ***Farmers also produce a large variety of compost and biofertilizers***

Objectives of Producing Bio-fertilizers in India

- **Promotion of biofertilizers mainly by the National Bio-fertilizer Development Centre (Ghaziabad), which was set up in 1987.**

Major objectives of the National Centre are to:

- **Produce and market bio-fertilizers of required quality;**
- **Isolate and maintain bio-fertilizer strains suitable to various agro-climatic regions;**
- **Train agricultural extension workers;**
- **Promote bio-fertilizers through field demonstrations;**
- **Prepare quality parameters;**
- **To test samples of bio-fertilizers produced by others;**
- **Provide technical and financial assistance to units producing bio-fertilizers.**

Issues of Sustainability and Role of Bio-fertilizers

Land Holding Pattern And Sustainability

80 % of Indian Farmers are Small and Marginal with operational holding of less than 1.4 hectares

Wheat and Rice are the two Major crops grown in India

- ***Average yield for Wheat is 2617 Kg / Hectare***
- ***Average yield for Rice is 2101 Kg / Hectare***

Factors For Sustainability

Raise Farm Income

- Increase crop productivity through balanced use of Fertilizers
- Managing Cost of Inputs Increase fertilizer use efficiency
- Generation of Additional Income to Farmers through allied activities
- Technical knowledge to farmers
- Awareness for use of bio-fertilizers
- Promotion of organic farming
- Minimal support price of agricultural produce (perishable and cash crops)

Estimated Total Potential Demand for Bio-fertilizers in India

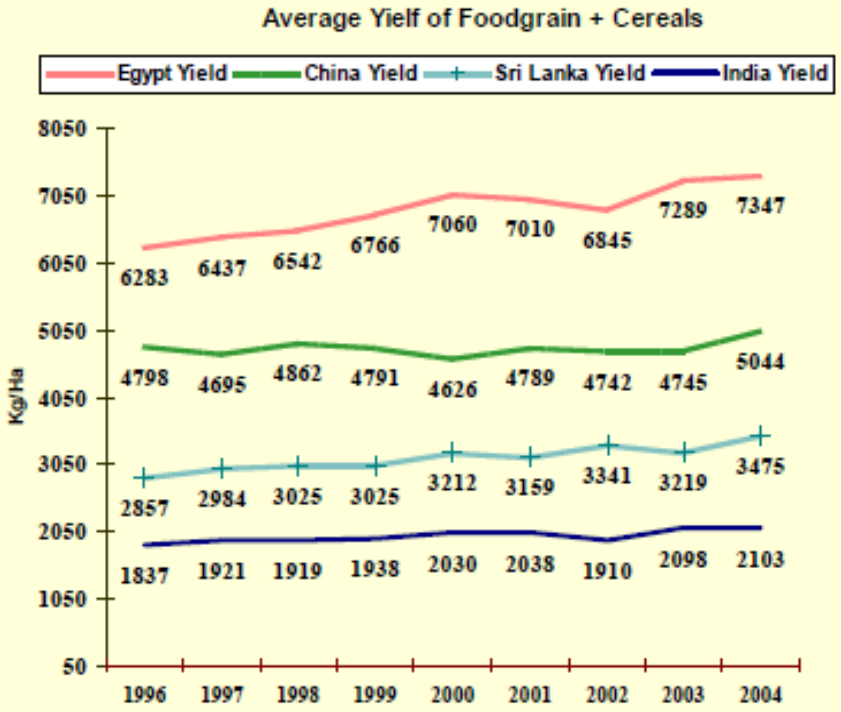
Category of Bio-Fertilizer	Amount in Million Tonnes
Rhizobium	35,730Mt
Azotobacter	162,610Mt
Azospirillum	77,160Mt.
BGA	267,510Mt
Phosphate solubilizer	275,510Mt
TOTAL	818,730Mt

Source: Abhay Phadke, 2001

Comparison to Other Countries

	Country	Fertiliser Uses Kg/Ha
1	India	104.7
2	Pakistan	164.1
3	Bangladesh	188.6
4	France	215.9
5	Sri Lanka	271.8
6	China	275.1
7	United Kingdom	315.1
8	Egypt	471.5
9	N. Zealand	668.5

Due to higher level of consumption, productivity is on rise in Egypt, China, Srilanka



Country	2003 Kg/ha	2004 Kg/ha	Increase in Yield Kg/ha
Egypt	7209	7347	138
China	4745	5044	299
Srilanka	3219	3475	256
India	2098	2103	5

Farmers' Perspectives in Using Bio-fertilizer in Agriculture in India

Problems of Farmers

Availability

- Many farmers have stopped using bio-fertilizers partly because of the unreliable supply. It is largely because biofertilizers are not being sold by most shops.

Quality

- Poor quality and performance of bio-fertilizers is a serious problems.
- Most studies suggest that the bio-fertilizers being sold in the market are contaminated and have a low count of micro-organisms. It is therefore not surprising that the performance is poor and uneven.
- Lesser shelf life

Why Poor performance of Bio-fertilizers in India?

- *Primarily because of inappropriate strains and inefficient production technology.*
- *Agro-climatic conditions and soil characteristics vary*
- *Large range of strains of each bio-fertilizer needs to be isolated for each area.*
- *Until strains which can tolerate wide variations in temperature can be identified, the performance of bio-fertilizers in India will continue to remain poor.*
- *Production of bio-fertilizers is prone to contamination, which reduces the effectiveness of micro-organisms. It is, therefore, vitally important that throughout the process aseptic conditions are required.*
- *Most important problem is that Indian producers do not sterilize the carriers used for mixing the bacterial solution which results in contamination*

Some Commercial Bio-fertilizers in Indian Market

The Potential for Bio-pesticides

- ***About 100,000 tons of pesticides are used in agriculture in India annually***
- ***The intensive use of pesticides in agriculture is a cause of serious concern.***
- ***The problem is especially serious because of the development of resistance to pesticides in important pests and the presence of pesticide residue in food chain (agricultural + dairy products).***
- ***Growing pesticide resistance has meant that a large proportion of agricultural production is lost to pests.***
- ***Hence, alternative, environment friendly methods of plant protection are required, such as integrated pest management (IPM) including the use of bio-pesticides.***

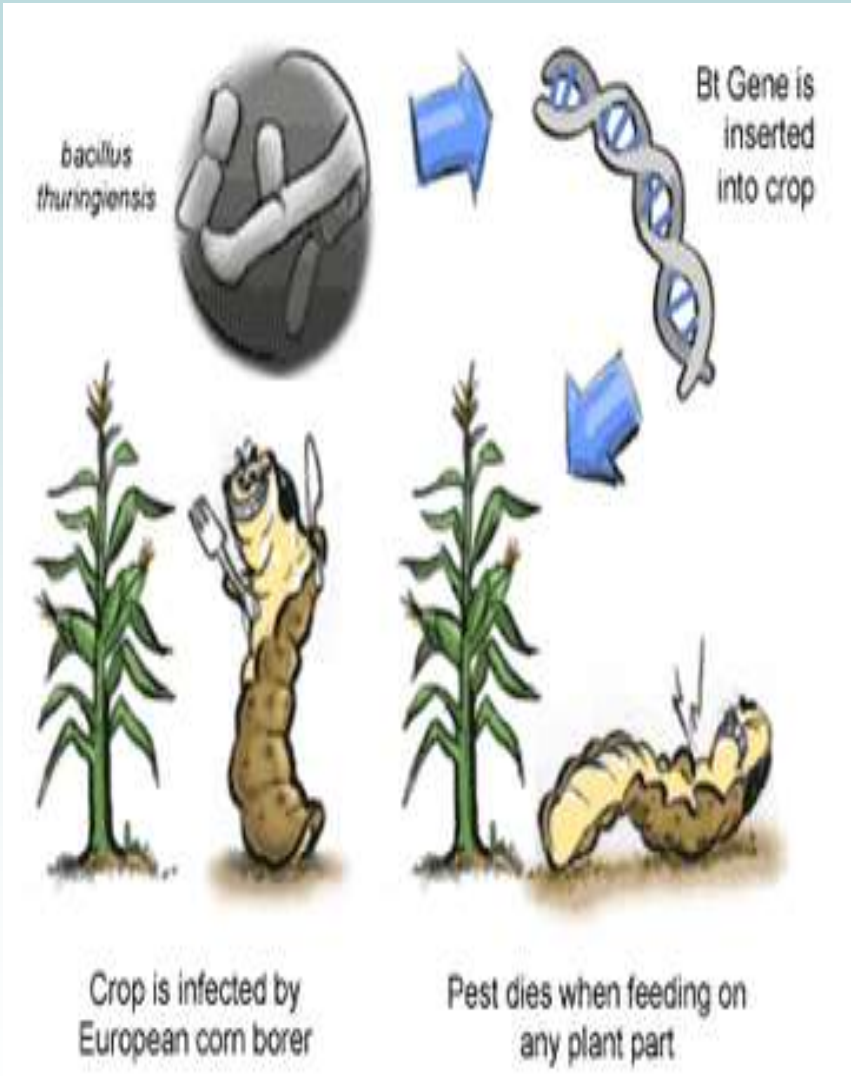
Advantages of using Bio-pesticides and Bio-control Agents

- ***Bio-pesticides are derived from animals, plants and microorganisms such as bacteria, fungi and viruses.***
- ***They are inherently less harmful than chemical pesticides***
- ***They are more target specific than chemical pesticides affecting only the target pests and their close relatives.***
- ***In contrast, chemical pesticides often destroy friendly insects, birds and mammals.***
- ***They are often effective in small quantities. Also, they decompose quickly and do not leave problematic residues.***

Some Important Bio-pesticides and Bio-control Agents

Bacillus thuringiensis (Bt).

- ***Bacillus thuringiensis is the most commonly used bio-pesticide globally.***
- ***It is primarily a pathogen of lepidopterous pests of which some are most damaging.***
- ***When ingested by pest larvae, Bt releases toxins which damage the mid gut of the pest, eventually killing it.***
- ***Bt based pesticides are being marketed by three companies in India. The total sale in 2017 was about 110 tons.***
- ***Not very encouraging***



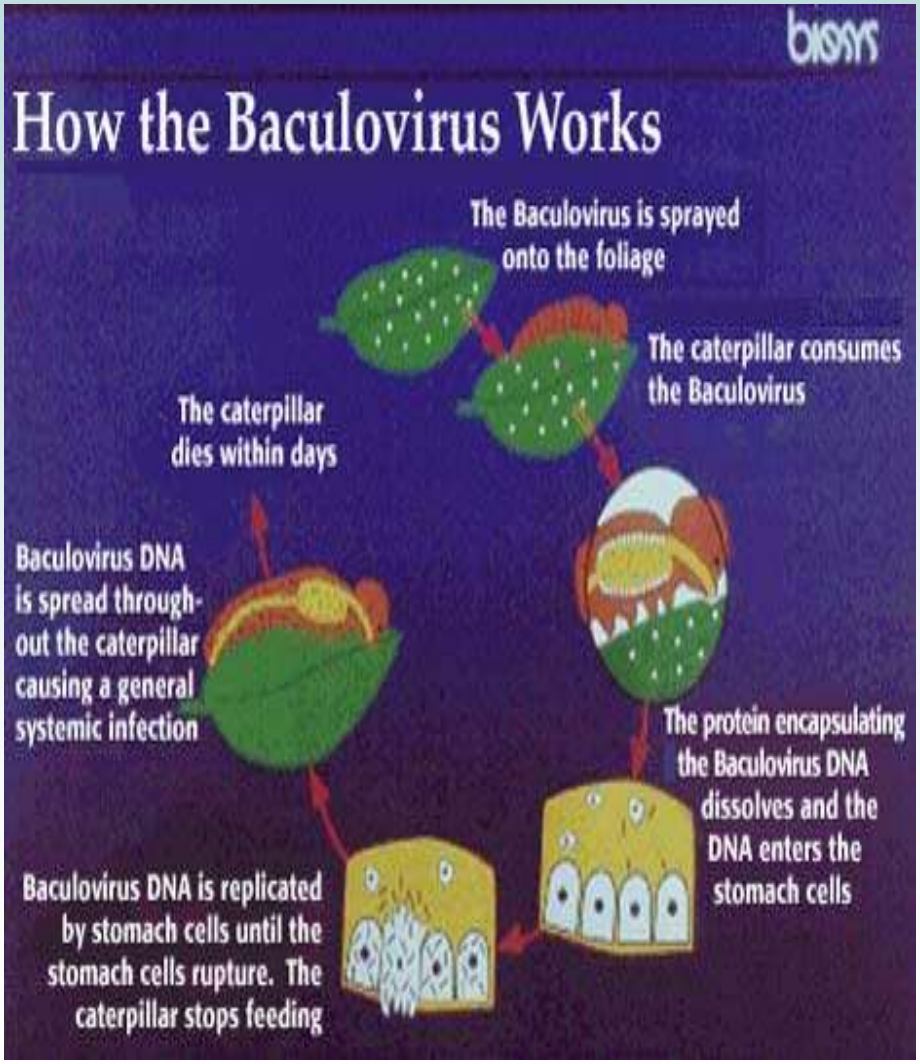
Baculoviruses

These are target specific viruses which can infect and destroy a number of important plant pests.

They are particularly effective against the lepidopterous pests of cotton, rice and vegetables.

Their large-scale production poses certain difficulties, so their use has been limited to small areas.

They are not available commercially in India, but are being produced on a small scale by various IPM centres and state agricultural departments.



Neem.

- **Derived from the neem tree *(Azadirachta indica)*, this contains several chemicals,including ‘azadirachtin’, which affects the reproductive and digestive process of a number of important pests.**

- **Recent research carried out in India and abroad has led to the development of effective formulations of neem, which are being commercially produced.**

- **As neem is non-toxic to birds and mammals and is non-carcinogenic, its demand is likely to increase.**

Trichogramma.

Trichogramma are minute wasps which are exclusively egg-parasites.

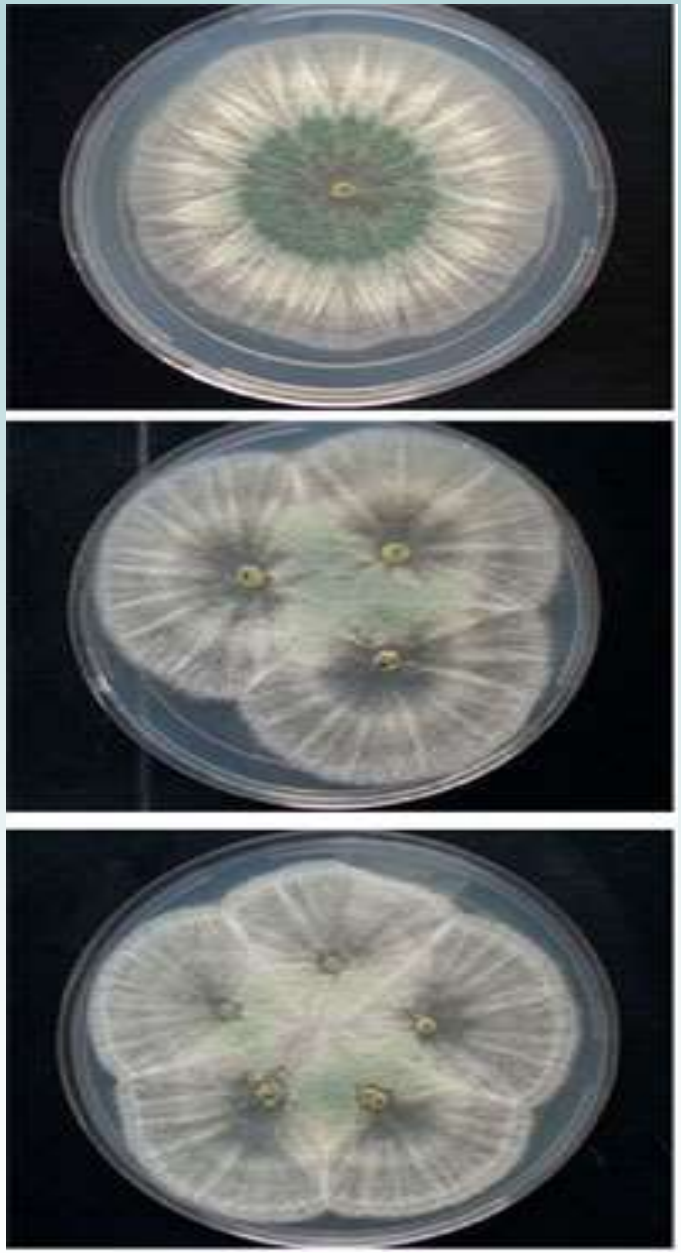
They lay eggs in the eggs of various lepidopteran pests. After hatching, the Trichogramma larvae feed on and destroy the host egg.

Trichogramma is particularly effective against lepidopteran pests like the sugarcane internode borer, pink bollworm and sooted bollworms in cotton and stem borers in rice. They are also used against vegetable and fruit pests.

Trichogramma is the most popular bio-control agent in India, mainly because it kills the pest in the egg stage, ensuring that the parasite is destroyed before any damage is done to the crop.

Trichoderma.

- Trichoderma is a fungicide effective against soil born diseases such as root rot.
- It is particularly relevant for dryland crops such as groundnut, black gram, green gram and chickpea, which are susceptible to these diseases.
- Three companies are marketing trichoderma in India.



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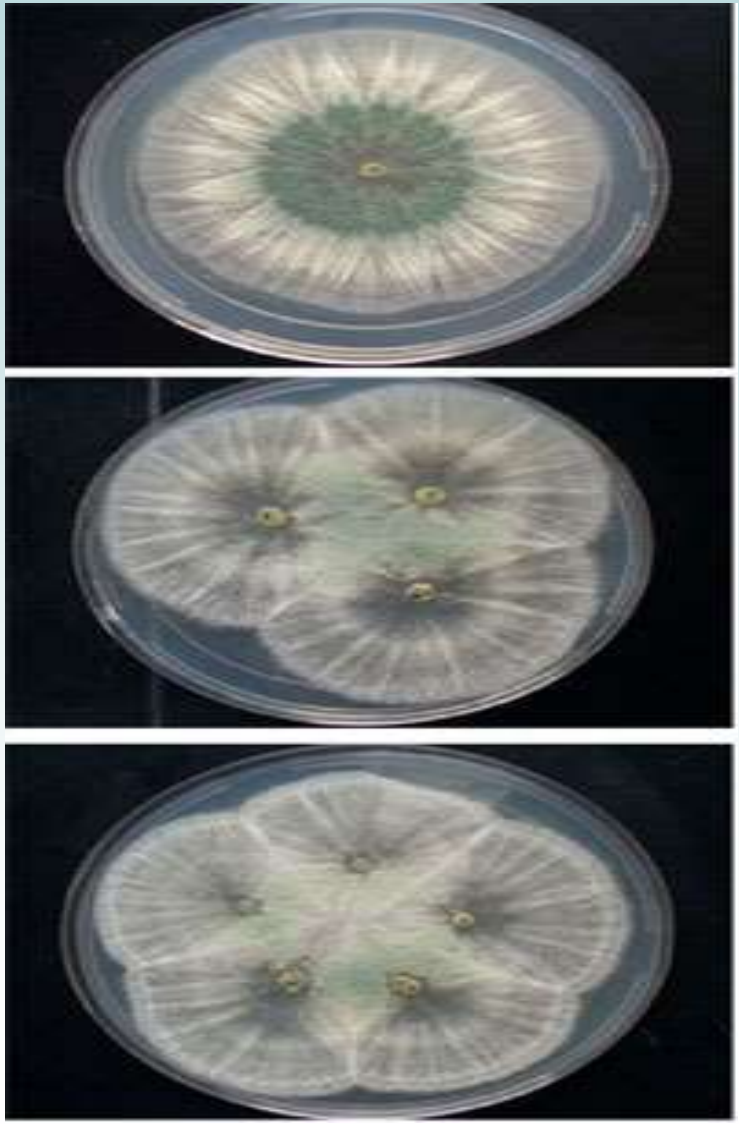
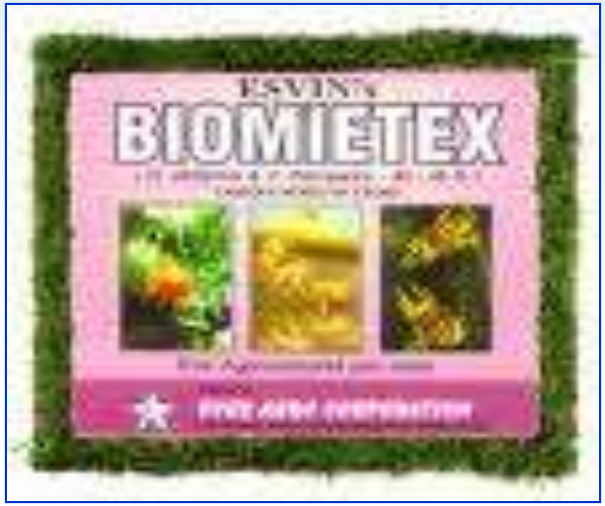


Some Important Plants used for Biopesticides in India

Name of tree	Part or extract of the tree	Chemical(s) extract	Final product
East Indian walnut (Albizia lebbeck)	Seeds, leaves, bark, and roots	Caffeic acid, alkaloids and quercetin	Biopesticide
Cashew (Anacardium occidenatale)	Oil of the shells	Phenolic compounds	Biopesticide
Custard apple (Annona squamosa)	Stems and leaves	Annonine	Biopesticide
Margosa (Azadirachta indica)	Leaves, seeds and seed oil	Azadirachtin, nimbidin, salanin, meliantrol	Antifeedant, insect growth regularor and biopesticides
Flame of the forest (Butea monosperma)	Extract of flowers	Chakcones and aurones	Termiticidal
Anjan (Hardwickia binata)	Heartwood	Mopanol and epicatechin	Antifeedant
Madhuca (Madhuca latifolia)	Seed and seed oil	Saponins	Repellent and biopesticides
China tree (Melia azedarach)	Fruit and seed oil	Meliacin	Antifeedant and biopesticides
Pongam (Pongamia pinnata)	Seed and seed oil	Karanjin	Repellent and biopesticide

Some Commercial Biopescides in Indian Market



Promotion and effectiveness of Integrated Pest Management and Biopesticides

- *The Ministry of Agriculture and the Department of Biotechnology are responsible for promoting bio-pesticides, the former via the Central IPM Centre (Faridabad), the National Centre for IPM (NIPM) under the Indian Council For Agricultural Research (ICAR) and the Directorate of Biological Control.*

- *As a part of the Department of Biotechnology's demonstration programme, biopesticides have been demonstrated on about 55,000 hectares (Wahab, 1998).*

Farmers' Perspectives in Using Biopesticide and Integrated pest Management (IPM) in Agriculture in India

Although bio-pesticides and bio-control agents are important components of IPM being conducted by farmers but very little emphasis on these agents.

The main reasons for this are:

1. ***Lack of awareness.***
2. ***Lack of skills***
3. ***Lack of faith in IPM.***
4. ***IPM practices are difficult and cumbersome***
5. ***Lack of proper training***

Conclusions

Biofertilizers

- ***Despite government's efforts to promote the production and use of bio-fertilizers, various studies found that bio-fertilizers have little acceptance among farmers in India.***

- ***The present policy of providing grants and low interest loans to bio-fertilizer producers should be abolished; this has resulted in the setting up of a large number of inefficient plants producing poor quality bio-fertilizers.***

- ***The policy of marketing bio-fertilizers at very low prices should also be stopped. These prices are too low to attract adequate investment in modern manufacturing facilities.***

- ***The storage and application of bio-fertilizers require special facilities and skills, which most producers, shopkeepers and farmers do not possess.***

- ***It is important that greater R&D efforts are focused on developing bio-fertilizers which are easier to store and apply.***

- ***Research and development to identify more suitable strains, and to develop better production technology and quality control methods are required to be developed.***

- ***Government policy of promoting bio-fertilizers without ensuring good quality and performance has actually harmed their cause, creating a widespread feeling among farmers and extension workers that bio-fertilizers do not work.***

Contd….

- ***It will be better if the production and promotion of bio-fertilizers is suspended until bio-fertilizers of improved quality can be made available in adequate quantity.***

- ***Until then all efforts should be focused on developing technology, setting up modern production facilities and developing infrastructure that will produce and deliver bio-fertilizer of the required quality.***

- ***The producers be brought under control and supervision of trained scientists.***

- ***Well defined parameters of quality be developed and enforced***

Conclusions

Biopesticide

- ***Focus on sustainable agriculture by promoting:***
  - ***a) disease and pest resistant, and especially traditional, varieties;***
  - ***b) judicious inter-cropping and***
  - ***c) reduced crop intensity.***

- ***Improvement in the intensity of training for IPM. Focus should be on the quality of training and not on the number of farmers trained.***

- ***The training should be followed by regular contact with the trained farmers for providing continous support.***

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Contd....

- ***Promotion of the use of bio-pesticides by the state agricultural departments and IPM workers.***
- ***The state agricultural universities, which have decisive influence over what pest control methods are promoted by governmental agencies, should pay greater attention to bio-pesticides***
- ***More researches are required for effective bio-control agents***
- ***Local strains should be promoted for control of local diseases***
- ***Commercial products be under strict quality control***

THANK YOU