# Biotechnological approaches in IPM and their impact on environment

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**ABSTRACT**

The use of chemical pesticide and other agro chemicals are getting reduced /being banned globally because of their toxic effects on human beings and his live stock, residual toxicity, environmental problems, pest out-breaks and drastic effects on beneficial insects. Therefore, now it is imperative to develop a holistic system of tackling pests to make it more eco-friendly, economically viable and socially acceptable for the farmers. In the WTO regime, it is absolutely necessary to limit the usage of chemicals, to remain in the world market and sustain the competition. In this regard to tackle the major pests and diseases of major crops biotechnological approaches are gaining momentum. Compared with usage of chemical pesticides biopesticides constitute around 2% in the country. The biotechnological approaches of pest control such as use of botanical pesticides, use of microbial pesticides, augmentative biocontrol by inundative releases, pheromones and attractants in pest management and plant incorporated protectants (PIPs) / GM crops which are discussed in detail. Advantages and limitations of biopesticides have been outlined and the future approaches are highlighted.

## INTRODUCTION

The use of chemical pesticide and other agro chemicals are getting reduced / being banned globally because of their toxic effects on human beings and his live stock, residual toxicity, environmental problems, pest outbreaks and drastic effects on beneficial insects. Therefore, now it is imperative to develop a holistic system of tackling pests to make it more eco-friendly, economically viable and socially acceptable for the farmers. In the WTO regime, it is absolutely necessary to limit the usage of chemicals, to remain in the world market and sustain the competition. In this regard to tackle the major pests and diseases of major crops biotechnological approaches are gaining momentum. Crop-wise market share of pesticide usage in India indicates highest use pattern to the extent of 45% in cotton followed by 22% in rice, 9% in vegetables, 7% in plantations, 4% each in wheat and pulses, and 9% constituting others. Compared with usage of chemical pesticides biopesticides constitute around 2% in the country.

### Domestic Market of Organic Products

The current consumption of organically produced fruits and vegetables at the global level is valued at 12,150 crores. To a large extent this sale is also based on individual initiative of the farmers, Non Governmental Organizations and some entrepreneurial traders etc. The Agricultural Products Export Development Agency (APEDA) had proposed to export organically produced fruits and vegetables to a value of Rs. 5,500 crores annually during the Tenth Five Year Plan period. This would require enormous efforts to produce and use biopesticides in the context of IPM.

### Biopesticides: Global Demand/Projection

Biopesticides are likely to have a greater impact on insecticide sector. Some analysts believe that biopesticides would account for 15% of the total insecticide market by the year 2010. Presently, biopesticides represent approximately 4.5% of the world insecticide sales. The growth rate for biopesticides over the next ten years has been forecast at 10-15% per annum in contrast to 2.5% for chemical pesticides.

### Availability of Biopesticides in India

About 700 products of different microbials are currently available worldwide. In India about 16 commercial preparations of *Bacillus thuringiensis*, 38 fungal formulations based on *Trichoderma, Metarhizium, Beauveria, Verticillium* and about 45 baculovirus based formulations of *Helicoverpa* and *Spodoptera* are available.

### The biotechnological approaches include:

I. Use of botanical pesticides
II. Use of microbial pesticides
III. Augmentative Biocontrol by Inundative Releases
IV. Pheromones and attractants in pests management
V. Plant Incorporated Protectants (PIPs) / GM crops

## I. USE OF BOTANICAL PESTICIDES

In general use of neem formulations has been limited as they are moderately effective against a few pests like plant

| III. AUGMENTATIVE BIOCONTROL BY INUNDATIVE RELEASES | |
|---|---|
| **Biocontrol agents** | |
| **Parasitoids** | |
| *Trichogramma chilonis* | *S. incertulas* |
| *T. japonicum* | *Cnaphalocrocis, medinalis, Pectinophora, gossypiella, Chilo infuscatellus Helicoverpa armigera* and other lepidopteran pests |
| *Goniozus nephantidis* | Coconut black headed caterpillars |
| *Trichospilus pupivora* | Coconut black headed caterpillars |
| *Bracon breviconis* | Coconut black headed caterpillars |
| **Predators** | |
| *Cryptolaemus montrouzieri* | Mealy bugs |
| *Crysoperla carnea* | Soft bodied insects |

| **Organism** | **Targetpests** |
|---|---|
| **Virus** | |
| *Nuclear Polyhedrosis Virus* | *Helicoverpa armigera, Spodoptera litura* |
| *Granulosis virus* | *Helicoverpa armigera* |
| **Bacteria** | |
| *Bacillus thuringiensis* | *Helicoverpa armigera* |
| **Fungi** | |
| *Beauveria bassiana* | Lepidopteran and Coleopteran pests |
| *Metarhizium anisopliae* | Lepidopteran and Coleopteran pests, soft-bodied insects like Scales Aphids and Thrips |
| *Verticillium lecanii* | Soft-bodied insects like Scales Aphids and Thrips |
| *Paecilomyces fumosoroseus* | Whiteflies on cotton, mites |
| **Disease control** | |
| **Bacteria** | |
| *Pseudomonas fluorescens* | Sheath blight in rice, Root rot disease in sugarcane<br>Foot rot and slow decline in black pepper, Capsule rot and clump rot in cardamom, Rhizome rot in ginger and turmeric, Fusarial wilt in coriander, Leaf spot in cucumber, Psudostem and leaf spot in banana |
| **Fungi** | |
| *Trichoderma viride* | Quick wilt, Slow wilt, Leaf blight, Anthrocanose, stem rot and root wilt in black pepper, fungal diseases of Cardamom, Ginger and Turmeric |
| | **Nematode control** |
| **Bacteria** | |
| *P. fluorescens* | Inhibits early root penetration of cyst nematode in sugar beet |
| **Fungus** | |
| *Paecilomyces lilacinus* | *Meloidogyne* spp., *R. similis* and *Heterodera* spp. |
| *Myrothecium* sp. | *Meloidogyne* spp., *R. similis* and *Heterodera* spp. |

## IV. PHEROMONES IN PESTS MANAGEMENT

| **Pheromones and attractants** | |
|---|---|
| Species specific sex pheromones | *Helicoverpa armigera, Spodoptera litura, Earias vittella, Rhynchophorus ferrugineus, Pectinophora gossypiella, Cnaphalocrocis medinalis, Scirpophaga incertulus* |
| Methyl eugenol | Fruitflies - *Bactrocera* spp. |
| Cuelure | Cucurbit fruitfly – *B. cucurbitae* |

and leaf hoppers, leaf folders and bollworms. These have limited use due to their lack of quick knock down effect. Thus farmers resort to mixing neem formulations with chemicals and the purpose of reducing insecticides load is defeated. Though a large number of plant products are reported to possess insecticidal, fungicidal and nematicidal effects, still there is lack of proper development of commercial products. It is opined by many that the plant products are safer. It must be kept in mind that the active compounds are chemicals and it is necessary to evaluate the safety of such plant derived chemicals. Another inherent problem is plant extracts if applied as such will not be stable and the stability of the commercial products needs to be looked into.

**II. USE OF MICROBIAL PESTICIDES**

The beneficial and ecofriendly microorganisms of fungi, bacteria, virus and protozoans capable of killing specific disease causing microbes, nematodes and insect pests and also those promoting plant growth are being considered as potential biological alternatives in ecofriendly agriculture. Entomopathogenic virus, bacteria, fungi and protozoans are widely used against lepidopteran pests and specific success has been achieved in case of white grub, stalk borer, sugarcane black bug etc. Similarly the viral pathogens like NPV and GV also viable in controlling *Spilosoma, Amsacta, Spodoptera, Helicoverpa* etc. and bacteria like *Bacillus thuringiensis*, become popular in controlling *Plutella* and *Helicoverpa*. The fungi like *Trichoderma* and the bacteria like *Pseudomonas* are being used as disease control agent of various fungal and bacterial plant diseases (Ramarethinam, 2003). These organisms limit the growth of pathogenic fungi and bacteria by mycoparasitism or by the production of antibiotics. Use of nematophagous fungus and bacteria *P. lilacinus* and *P. fluorescens* are reported as potential nematode control agents of parasitic nematodes in many crops.

Seed treatment with *P. fluorescens* alone or in combination with other microbial and botanical agents such as neem cake has reduced pest and disease problems (Swarnakumari and Lakshmanan, 1999; Swarnakumari *et al*., 1999). Root knot nematodes belonging to the genus *Meloidogyne* viz., *M. incognita, M. graminicola* and *M. javanica* can be controlled by the fungus *P. lilacinus*. Though presently they appear to have less scope in pest management suitable formulations, cost effective production and application technology may lead to success. However the production and marketability of such bio agents are not sufficient even to cover 2% of total consumption of the pesticides in the country.

**III. Augmentative Biocontrol by Inundative Releases**

In India, inundative releases of natural enemies have been restricted to only egg parasitoids, particularly *T. japonicum* and *T. chilonis*, mainly because of their amenability. These parasitoids may be useful against the yellow stem borer (YSB) *S. incertulas* and leaf folder *C. medinalis* of rice, sugarcane shoot borer *C. infuscatellus* and other lepidopteran pests of vegetables. There are several successful reports of the inundative releases of *T. japonicum* and *T. chilonis* against stem borer and leaf folder in rice and sugarcane (Bentur *et al*., 1994; Shrike and Bade, 1997). Studies carried out to test the effectiveness of inundative releases of *T. japonicum* and *T. chilonis* as a component of rice IPM have also been promising (Balasubramanian *et al*., 1994). Gururaj Katti *et al*. (2001), reported that large scale on farm evaluation of *T. chilonis* revealed both the leaf folder as well as stem borer pest could be effectively managed through integration of two non insecticidal components such as parasitoids and pheromones resulting in higher net returns. Weekly release of *T. chil*onis at 2,50,000 adults per hactare from flowering season till the ripening of the boll showed a progressive decline in the infestation of pink bollworm *P. gossipiella* and *H. armigera* on cotton (David, 2003).

**IV. Pheromones and attractants in pests management**

Pheromones in pests management aims at mating disruption by treating the crop with appropriate pheromone to prevent male moths from locating " calling females" and thus suppresses mating. The principle is development of slow release formulations, which maintain relatively high concentration of pheromone for several weeks and thus disrupt mating. Trapping the male moths of the target pest species utilizing the species-specific pheromones facilitates early detection of the pest occurrence. Determination of moth population dynamics through crop seasons helps in formulating pest management strategies and justifying or timing insecticide application. Krishnaiah (1995) reported that the pheromones of the rice the leaf folder *C. medicinalis* viz., Z,11- Hexadecenyl acetate and Z,13- Octadecenyl acetate dispersed from either rubber septa or polythene vials in the ratio of 1:10 were pheromonally active.

Series of attempts made under DRR- National Research Institute, UK project utilizing a controlled release formulation with polyvinyl chloride matrix as base for control of *S. incertulus* the pheromone blend of Z, 9-hexadecenal and Z,11-hexadecenal in 1:10 ratio applied at 40 g a.i./ ha suppressed 98% communication disruption during Rabi 1992 (Ganeswar *et al*., 1994) in on farm trials.

Pheromones applied at 10 DAT equally effective as that applied at 40 DAT in bringing down white ear heads. Similarly species specific lures developed are promising and getting momentum.

**V. PLANT INCORPORATED PROTECTANTS (PIPS) / GM CROPS**

The genetic material, which is responsible for the production of pesticidal substance, is being incorporated into the genome of the target crop plant thus making the plant capable of destroying the pest. For example the gene producing Bt pesticidal protein was introduced in cotton and Brinjal making them resistant to pest attack.

**Advantages of using Biopesticides**

1. Maintains the health of the soil and sustain its life by increasing soil organic matter
2. Generally species specific and are safe to the natural enemies and non target organisms
3. Biopesticides are less toxic than chemical pesticides and safer to the environment
4. Microbial pesticides rely upon the potential biochemicals synthesized by the microbes
5. It requires in small quantities often decompose rapidly, there by avoids pollution problems

**LIMITATIONS**

- Beneficial effects not seen immediately
- Lack of awareness – farmers, dealers etc.
- No standard recommendations
- Short shelf-life
- CIB registration- Expensive & time consuming
- Slow flow of latest research findings
- Problem in price/demand/supply

**FUTURE APPROACHES**

**I. Botanical pesticides**

Large-scale control of agricultural pests and stored grain pests are even today depends mainly on chemical pesticides. There is need to develop new technologies using to minimize the usage of chemicals. Biotechnology based approaches can be tried using available research data.

**II. Biopesticides**

The use of species-specific organisms need to be properly identified, production technology and suitable formulation developed and commercialized. The use of *P. fluorescens* and *P. lilacinus* in nematode management must be given due attention as no safer nematicide is available in the country. There is need for research on nematode problems of major crops and assess the utility of technology.

**III. Biocontrol agents**

Augmentation of biocontrol agents like *Trichogramma* is a proven technology and farmers' response is on the increase. More biocontrol laboratories must be encouraged to popularize the benefits and ensure supply. Though the natural enemy complex of many pest species of rice is known their utility in biocontrol programme by way of mass multiplication and supply to farmers needs a practical approach.

**IV. PHEROMONES**

Though several other natural enemies of many pest species are known their utility in biocontrol programme limited. The concern is tackling when two or three species occur simultaneously. The technology of integration of pheromones with use of biocontrol agents needs to be developed for different agro climatic zones and popularized. Pheromone trap data may be useful for timing the mass multiplication and innundative release of egg parasitoids.

**V. PLANT INCORPORATED PROTECTANTS (PIPS)**

Though biotechnology laboratories because of the environmental concern develop a number of GM crops these crops are not yet popularized and supported legally. In such case the GM crops should be studied thoroughly for the environmental, biodiversity problems etc and those crops found suitable can be encouraged. Small-scale farm trials can be done for satisfactorily long period to ensure the biosafety.

**CONCLUSION**

In fact farmers are now evincing interest in organic farming as pesticide free produce grown under conditions free of pesticide and fertilizer application is the most preferred and fetches premium price. Certifying agencies are now identified and they are certifying the farms and their produce. Though biotechnological approaches are not very popular due to constraints enumerated above in the near future it is likely to have impact in crop protection in the country, creating situation conducive for a safer environment.

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