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Ampelomyces quisqualis

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Special issue on Biopesticide

Editorial:

Pests are a special category of animals and plants those destroy our crops and biological products and include several insects, nematodes and weeds. With increasing agriculture, insects become more and more important competitors of human food damaging or even destroying the crops. To reliance on chemical pesticides, a burst of research activities have done over the last decades devoted to biological control of insect pests in agricultural ecosystems.

Biological control may be defined as the destruction or suppression of undesirable insects, other animals or plants by the introduction, encouragement or artificial increase of their natural enemies, that include both macro and micro organisms. The natural enemies include predators, parasites, parasitoids and pathogens.

One of the biological control methods is the use of biopesticide. Biopesticides made from biological sources, that is from toxins which occur naturally. Naturally occurring biological agents used to kill pests by causing specific biological effects rather than by inducing chemical poisoning. The idea is based on mimicking processes that arise naturally and is argued to be favorable to conventional chemical pesticides as it is more easily biodegradable and more target specific. A pesticide in which the active ingredient is a virus, fungus, or bacteria, or a natural product derived from a plant source. Therefore the use of biopesticide become a safe-eco friendly control alternatives which has been prompted with the great progress in biotechnology.

Prof. S. C. Santra
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Grasshopper control

Larva of pest attack by fungus

Entomophagous fungus in pest management

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Recent development in pest control research have proves the urgent need for developing biological control methods with use of microbial pathogens in the control of several pests that cause serious crop degradations year after year. Among microorganism entemopathogenic fungi constitute the largest single group of insect pathogens. Such insect killing fungi are very fast micro-organisms to be recognized as disease causing agent in insects. Entomogenous fungi are promising biocontroling agent for a number of crop pests. Several species belonging to order Lepidoptera, Coleoptera, Homoptera, Hymenoptera and Diptera are susceptible to various fungal infections.

Fungal pathogens particularly *Beauveri bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii*, and *Nomuraea rileyi* have found to be promising in the control of several agricultural pests.

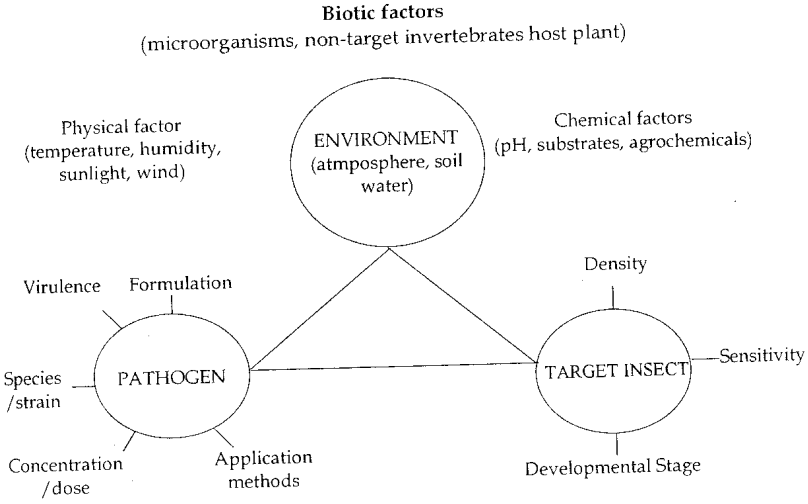

Fig. 1 Interaction involved in efficacy of fungal pathogens in the field

Mode of action of Entomopathogenic fungi:

Among the entemopathogens, fungi are important as they are virulent, infect by contact, persists in environment for long and many of them can be mass produced in liquid or solid media. Most of the entomopathogenic fungi are facultative parasites which also exists as saprotrophs and therefore can be grown apart from living hosts. Only a few groups are obligate parasites which must be reared in living hosts. Fungal epizootics ususlly occur after considerable pest damage has been done. The initiation of artificial epizootics has been accomplished for long term control especially in areas where high humidity condition prevail. By introducing the fungal pathogens into the host population early the epizootic is initiated earlier and prevents or reduces damage by the pest.

There are several defense mechanism in insect also which should prevent the penetration and the growth of the fungus. The most common is melanisation of the cuticle at infection site.

Again when the fungal hyphae has reached the hemolymph, the further defense mechanisms have to be overcome

Entomopathogenic fungi display either a very broad host spectrum like *Metarhizium anisopliae, Beauveria bassiana* or have a very narrow host range like *Aschersonia* spp. Which can only infect scale insects and white flies (Samson *et al.*, 1988).

Life-cycle and infection process

The infection process of entomopathogenic fungi is divided into

a) parasitic phase and
b) saprophytic phase

The infection process comprises of the following steps:

i. Attachment of the infective units, e.g., conidia or zoospores to the cuticle.
ii. Germination of the infection unit on the cuticle.
iii. Peneration of the cuticle either directly by germ tubes or by infection pegs from appressoria.
iv. Multiplication of the yeast phase-hyphal bodies in the haemocoel.
v. Death of the host.
vi. Growth in the mycelial phase with invasion of virtually all the host.
vii. Penetration of hyphae from the interior through the cuticle to the exterior of the insect.
viii. Production of infective units on the exterior of the insect.

The parasitic phase starts with the adhesion of the conidia to the cuticle. The entemopathogenic fungi invade their hosts by direct penetration of the host exoskeleton or cuticle.

The penetration of the insect cuticle can be performed in different ways. *Verticillium lecanii* is capable of penetrating the insect cuticle only with its germtube while *Metarhizium anisopliae* and *Beauveria bassiana* produce specific infection hyphae originating at appressoria. After the successful penetration the fungus then distributed into the haemolymph by formation of blastospores.

The saprophytic phase starts with the death of insect which is performed by a number of mechanisms. Viz.

i) Mechanically by growth of the fungus in the insect body & by retrival of nutrients from the insect body.
ii) Mechanically by growth of the fungus in the insect body & by toxins produced by the fungus (Gillespie and Claydon, 1989).

Commercial uses of entomopathogenic fungi

Among 800 species of entomopathogenic fungi only six species are commercially available for field application (Table-1)

Table: Commercial formulations of entomopathogenic fungal pesticides

Fungus	Product and Company	Formulation
Aeschersorzia aleyrodis	Koppert/ Holland	Wettable powder
Beauveria bassiarza	Naturalis^{TM}, Troy Bio- Science, USA.	Liquid formulation
Beauveria bassiarza	Conidia, AgrEvo, Germany, Columbia	Suspendible granules
Beauveria bassiana	Brocaril^{TM}, Laverlam, Columbia.	Wettable powder
B.bassiana	Boverol/ Czech Republic	Wettable powder and dry pellets
B.bassiana	Mycontrol-WP /Mycotech Corp/USA	Wettable powder
B.bassiana	Ostrinil/ Natural Plant Protection / France	Microgranules of mycelium
B. *brongniarti*	Betel/ Natural Plant Protection/France	Microgranules of mycelium
B. *brongniartii*	Engerlingspilz /Andermatt - Biocontrol/ Switzerland	Barley kernels colonised with the fungus.
Metarhizium anisopliae	Bio-path^{TM} / Eco Science/OSA	Conidia on a medium placed in trap/chamber
Metarhizium anisopliae	Biogreen/ Biocare Technology Pvt. Ltd./ Australia	Conidia produced on grain
Metarhizium anisopliae	Biologic Bio1020 / Bayer AG Germany	Granules of mycelium
Paceilomyces fumosoreseus	Pfr 21 / WR Grace USA.	Wettable powder
Verticillium lecanii	Mycotal/ Koppert/ Netherlands	Wettable powder
Verticillium lacanii	Vertalec/ Koppart/ Netherlands	Wettable powder

Conclusion:

The entomophagous fungi are one of the important, organisms as there are several advantages of using these fungal pathogens as pest control agent. Most of these are host specific and less toxic to mammal having a wide host range. But in most of the cases the success has been limited where the ambient environmental conditions can be very accurately controlled. For the future it seems likely that developments in biotechnology may be used to manipulate desirable traits to improve the field activity of many fungi.

BIOPESTICIDE RESEARCH

The following are the major activities of Department of Science & Technology (DST), Govt. of India on biopesticide research.

a. Development of cost effective and commercially viable mass production technologies of various(24) candidate biocontrol agents / biopesticides.

b. Demonstrating the field efficacy of biocontrol agents / biopesticides under different ecosystems in various economically important regional crops grown in various agroclimatic zones throughout the country covering about 1,35,000 ha.
c. About 50 production cum demonstration units were set up in various states for mass production of biocontrol agents / biopesticides and their subsequent efficacy demonstration at multilocation in different agroecological regions.
d. Two repository centres were also set up at TNAU, Coimbatore and PDBC, Bangalore for collection, maintenance and supply of Nucleus cultures of biocontrol agents and host insects to various production units.
e. Several capable IPM modules were developed for various economically important crops which are cost effective, sustainable and eco-friendly in various ecosystems. In addition, sustained preservation of ecosystem was also demonstrated in adopted villages.
f. The cost effectiveness of biopesticide technology in IPM and non-IPM plots of various crops was established by working out the authenticated cost of production of biocontrol agents produced in different units at various states.
g. The Department also took an initiative in streamlining the guidelines for generation of toxicological data for registration purpose. In order to promote and facilitate commercialisation of the biopesticides, Department has played a catalytic role and taken suitable measures for the generation of toxicological data of potential biopesticides for the purpose of registration etc.
h. Intensive promotion programmes were launched for popularization and adoption of IPM and IPNM techniques through trainings and extension activities for farmers and extension workers throughout the country.
i. These programmes have resulted in conservation of ecosystem and environmental protection leading to sustainable agriculture and income generation.

Table: Technologies/Products availability

Name of the Centres/State	**Technology**	**Status**
RRL Jammu Jammu & Kashmir	Fermentation based (500 :1 scale) *Trichoderma viride* *Trichoderma virens*	Fermentor based technology packaged 3 packages transferred to industries viz., 1. M/s Pratishtha Industries Ltd. in Nalgonda, A.P. and 2. M/s Javeri Agro-Industries & Investment Company Ltd. in Amrawati, (Maharashtra) 3. M/s Haryana Biotech., Gurgaon 4. Negotiations on for more transfers
TNAU, Coimbatore, Tamil Nadu	Trichogramma, Heliothis NPV	Transferred to: Crop Health Products Ltd., Ghaziabad
	Trichoderma	-do-
		Hoechst AgrEvo, Bombay
		Maharashtra Cooperaticve Oil seed federation, Jalgaon
	Pseudmonas flurescence	Already transferred to Several industries through TNAU
IARI, New Delhi	*Aspergillus Niger* (strain AN 27)	Transferred to Cadila Pharma
IISR, Calicut, Kerala	Solid state fermentation of *T. harzianum*	Technology transferred to 10 private entrepreneurs in the states of Tamil Nadu, Karnataka and Andhra Pradesh
MPKV, Rahuri	HaNPV(Heliokill), SlNPV (Magic),	Formulated, branded, being produced and supplied to farmers in large quantities for demonstration.

	SoNPV (Spilocide), *Trichoderma*, *Trichogramma*	

New initiatives for the 10th Plan by DST, Govt. of India.

Following are the identified thrust areas:

- Strengthening and consolidation of the existing programmes and studies on revalidation and fine tuning of the technologies and their subsequent transfer to industries would be a priority task.
- Demonstration activities would include: Technology upgradation and Demonstration through Farmer Participating programmes on a large scale to create the awareness among farmer on the benefits of biopesticides and IPM technologies ; Popularization of Biopesticide Technology by organizing training workshops, training of NGOs, extension functionaries, entrepreneurs and farmers on the production and use of biological control agents and IPM Technologies and establishment of some biopesticides Pilot Plants to demonstrate the commercial viability of the units and to promote entrepreneurial development.
- Research on molecular aspects (mainly genetic engineering of biocontrol agents) viz., *Bacillus thuringiensis* (Bt), *Baculoviruses*, nematodes, plant pathogens and antagonists and in insect biotechnology, areas like neuroendocrine research, sex specific selection using chimeric genes, pheromones, kairomones, insect tissue culture and genetic engineering of *baculoviruses* would be supported.
- Projects would be taken up for improvement of fungal and bacterial antagonists for disease management: stability of formulations; and biological control of nationally important weeds (*Parthenium, Cyperus, Orobanche, Salvinia*) – by development of suitable Mycoherbicides with fungi safe for crops.
- Use of botanical pesticides, by identifying newer molecules responsible for insect disease control and large-scale use against different pests and diseases, more efficient formulations of neem and the plant products with in-built stabilizers antioxidants UV protectants surfactants etc will be developed.
- Large scale demonstrations would be done for biological control of insect pests in forest ecosystem; and
- Biological control of crops having export potential e.g. plantation crop (Coffee, tea, Cashewnut), fruits (Mango, Apple, *Citrus*, Grape), vegetables (Tomato, Cabbage/Cauliflower, Okra), spices (Pepper, Cardamom, Ginger and Turmeric), rice (Basmati and fine grain) and cotton (Green/organic).
- Modules and package of practices integrated with IPM and INM would be developed for farmers use.

Current News on Biopesticide use and Integrated Pest Management :

Environmentally friendly weapon against locusts proves effective

For the first time, an environmentally friendly weapon against Desert Locusts has been successfully tested under large-scale field conditions. During a field trial organized jointly by the

plant protection authorities of Algeria and FAO near El Oued in eastern Algeria, the biopesticide, called Green Muscle®, was sprayed on more than 1 400 hectares of land infested by Desert Locust larvae. Locusts were clearly weakened and started moving slowly after four days and were then eaten by birds, lizards and ants. The new control method uses a natural fungus, called *Metarhizium anisopliae*, which infects locust hoppers in such a way that they stop feeding and die in one to three weeks.

(***FAO, June 2005***)

AgraQuest biopesticide clears EPA

AgraQuest Inc., the Davis biotech company has won EPA approval for the company's fifth organic product in 12 months -- Sonata Biopesticide. The substance helps control downy mildew, powdery mildew and rusts on fruits and vegetables, giving farmers an alternative to chemical pesticides. AgraQuest makes and sells environmentally friendly, natural products for farm, home and public health pest management, basing its science on biological or naturally derived chemistry. The privately held company says it awaiting approval from the Environmental Protection Agency for two other products, Arabesque Biofumigant and Virtuoso Bioinsecticide. The company's home-garden biopesticide, Serenade Garden-Ready To Use, sells through Wal-Mart.

(***2004, American City Business Journals Inc***.)

Metarhizium-based biopesticide

GREEN GUARD™ is a new Metarhizium-based biopesticide developed by CSIRO Entomology and has been licensed to an Australian Company SGB Ltd for locust control. Metarhizium fungus is a native strain that was originally collected from the spur-throated locust. Because the Metarhizium fungus is a non-chemical product, it cannot cause residue problems and reduces the hazard to users and the environment. The formulation is currently produced by SGB and is applied under direction by APLC. Its application is from aircraft as a spray of dry spores suspended in oil. Locusts are infected either by direct contact or by picking up spores from the vegetation. The spores penetrate the locust cuticle and grow into its body, killing young locusts in the second week after infection. Metarhizium biopesticide is also effective in the control of grasshoppers and termites.

(***August, 2005, CSIRO Australia***)

Integrated Pest Management

This pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in a compatible manner as possible and maintain the pest population at levels below those causing economic injury. IPM is thus a plant protection in the overall crop protection programme which is environ-friendly, economically viable and socially acceptable because the plant protection strategy is not oriented to the flat killing of organisms by synthetic pesticides. The advantages of IPM schedule in agriculture lies in the facts are:

- it provides planned diversification of control methods so as to checkmate the pest, as in warfare,
- it protects and conserves the environment including biodiversity
- it checks adverse side effects to target and non-target organisms of ecosystem and thus checks upsetting the balance of nature,

- it provides efficient and cheaper control and thus makes plant protection feasible, safe and economical even for small farmers,
- it fits well with national economy of any country.

The following commercial formulations are available in India for field application

Table: Commercial biopesticide manufactured in India:

Product name	Controlling agent	Target organism	Formulation	Manufacturing company
BIOVERT RICH	Entomopathogenic fungi *Verticillium*	Control sucking and chewing insects, Nematodes	Powder formulation having high cfu of 109 / mlgm	PLANTRICH Industrial Estate, Manarcadu P. O. Kottayam - 686 001, Kerela (India)
PACIHIT RICH	*Paecilomyces* sp	Control of larvae of thrips, white flies and nematodes.	Foliar spraying	Do
BIOGUARD RICH	*Beauveria bassiana* an entomopathogenic fungus.		Foliar application	Do
RHIZOME		Control of Coffee berry borer, Root grubs, Cotton leaf roller, White flies, Aphids, Thrips, Cotton pests and other sucking and chewing pests.	Seed treatment, Soil Application	Do
BIOMET RICH	entomopathogenic fungus, *Metarhizium* sp	Control of Jassids, Fruit borers, White grub, Termites, Leaf miners and coconut beetles	Soil application, Soil drenching, Foliar spray	Do
BIOTRIS RICH		Recommended for Pepper, Cardamom, Ginger, Turmeric, Vanilla Coconut, Arecanut, Rubber, Tea, Rice, Vegetables, Pulses, Betel vines, Garden Plants.	Pseudomonas fluorescence liquid formulation	Do
MITEHIT	*Hirsutella thompsonii*	Controls coconut eriophyid mite and other red mites.	Liquid formulation	Do
Neem Oil, Cake, Bioinsecticide Biopesticide, Azadirachtin, Urea-Coating	Neem	Bioinsecticide & Biopesticide	Oil, Cake, liquid	AAZADIRACHTIN Block 94, Sanjay Place, Agra, Uttar Pradesh

Forth-coming events

Events	Date	Place
9th International Conference on Environmental Science and Technology - 2005	September 1, 2005	Rhodes island, Greece
BIOFORUM 2005	September 28, 2005	Milan, Italy
International Workshop on Biosensors for Food Safety and Environmental Monitoring	November 10, 2005	Agadir, Morocco
3rd International conference on Plants and Environmental Pollution	29th November 2005	Locknow, India

National seminar on urban industrial pollution	December, 10	Kolkata, India
2nd International Congress of Chemistry and Environment	December 24, 2005	INDORE, India

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