MARUMEGH

Kisaan E- Patrika

Available online at www.marumegh.com

 ISSN: 2456-2904

BIO-PESTICIDES AND THEIR ROLE IN AGRICULTURE

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Agriculture has been facing the destructive activities of numerous pests like fungi, bacteria, insects, plant parasitic nematodes and weeds from time immemorial, leading to radical decrease in yields. Pests are constantly being introduced to new areas either naturally or accidentally or in some cases, organisms that are intentionally introduced become pests. Chemical pesticides are extensively used in all countries of the world but they are regarded as ecologically unacceptable. Therefore, there is an increased social pressure to replace them gradually with biopesticides which are safe to humans and non-target organisms. The harmful environmental implications of the synthetic chemicals have compelled to search for some alternative methods. This leads to increased development of compounds based on the models of naturally occurring toxins of biological origin, having various biological activities. Bio-pesticides include a broad array of microbial pesticides, bio-products and bio-chemicals derived from micro-organisms and other natural sources.

Bio-Pesticides:

Bio-pesticides are biochemical pesticides that are naturally occurring substances that control pests by nontoxic mechanisms. Bio-pesticides are living organisms (natural enemies) or their products (phytochemicals, microbial products) or by-products (oil & extract) which can be used for the management of pests that are injurious to plants. Bio-pesticides have an important role in crop protection, although most commonly in combination with other tools including chemical pesticides as part of Bio-intensive Integrated Pest Management. Biopesticides based on pathogenic microorganisms specific to a target pest offer an ecologically sound and effective solution to pest problems. They pose less threat to the environment and to human health (Kandpal, 2014).

(1.) Botanicals As Biopesticides:

Phytochemical are classified as either primary or secondary plant metabolites. Of the estimated 3,08,800 plant species very few have been surveyed and most remained unexploited and unutilized for pesticidally active principles. Till date, about 2400 plant species have been reported to possess pesticidal perties belonging to 189 families among which about 22 families contain more than 10 plant species in each family with anti insect properties. Approximately, more than 350 insecticidal compounds, >800 insect feeding deterrents and quite a good number of insect growth inhibitors and growth regulators have been isolated from various plant species but apparently only few have achieved the commercial status.

Neem based pesticides: Maximum number of pesticidal plants belong to family Meliaceae. Among this neem, *Azadirachta indica* has been found to be promising. Neem based

pestidcides are marketed in India in different trade names containing 300, 1500, 3000, 5000, 10000 and 50000ppm of azadirachtin in it. Some of them are Ozoneem Trishul, Margocide OK, Godrej Achook, Nimbicidine, Bioneem, Neemark, Neem gold, Neemax, Rakshak, Econeem, Limnool and Repelin containing 300ppm of azadirachtin. Besides neem seed kernel extract (NSKE) 5%, neem leaf extract, neem cake powder is also used for pest and nematode control.

Almost all parts of neem tree, viz., leaf, drupes, bark and seed contain approximatelly 40 types of biologically active constituents, including the triterpenoids, azadirachtin, salanin and meliantriol. These compounds give protection against more than 100 species of insects, mites and nematodes including economically important pests like desert and migratory locusts, lepidopterian insects (Pod borer, tobacco caterpilar, rice and maize borers etc.), plant hoppers of rice, pulse beetle and grain weevil, rootknot and reniform nematodes, and citrus red mite. Modes of pest control by neem include antifeedant, growth regulatory, repellent, hormonal or pesticidal action in larva and adult stages of these pests.

Pest control action of neem:

The farmer of rural India traditionally mix 2-5 Kg of shade dried neem leaves with 100 Kg grain or they soak empty sacks overnight in water containing 2-10Kg of neem leaves per 100 litres of water and then dry these sacks before filling them with grain to get rid of stored grain insects. For locust control spraying with 0.1% neem-kernel suspension @ 300-600 litres per hectare.

Pyrethrum:

From the flowers of *Chrysanthemum cinerariaefolium*, two formulations of Pyrethrum i.e. Pyrethrum 0.2% dust and Pyrethrum 1% EC are registered for use against insect pests in vegetables and Pyrethrum is also used in combination with other insecticides as synergists for the control of household pests.

Nicotine Sulphate:

Nicotine is the extract from tobacco. Two formulations i.e. nicotine 40% solution and 10% DP are registered in India.

***Parthenium hysterophorous* (Gajar grass):**

The extract of this plant contains parthenin, pyroparthenin, anhydroparthenin and photoparthenin. These are sesquiterpene lactones which exercise cytotoxic, antitumour, allergic, antimicrobial, antifeedant, phytotoxic, insecticidal actions.

Catharanthus roseus* (Sadabihari)*:

Leaf extract in water is a phagodeterrent against *S.litura* and aqueous leaf extract has toxicant action against YSB. The root extract acts as antifeedant against *S .litura.*

***Pongamia glabra* (Karanja):**

The oil extracts have been reported to be repellent for BPH, WBPH, Epilachna beetle, maize borer, citrus butterfly etc, and oil cake also used against soil born insects and nematodes.

(2.) Microbials as Biopesticides:

Fungal bioagents:

Over 750 fungal species belonging to 100 genera are entomopathogenic. There are many examples where fungal pathogens have been used for the control of crop pests in India.

The important genera are *Coelomomyces, Entomophthora, Massospora* belonging to Mastigomycotina; *Cordyceps, Tricoderma, Podonectria, Torrubiella* belonging to Ascomytina; and *Aspergillus, Beauveria, Fusarium, Hirsutella, Metarhizium, Nomuraea, Paecilomyces* etc. belonging to Deuteromycotina. The development of fungal infections in terrestrial insects and nematodes is largely influenced by terrestrial conditions. High humidity is vital for germination of fungal spores and transmission of the pathogen from one pest to another. Mode of action of fungal bioagents is mycoparasitism, antibiosis, competition for food and space with pathogen, tolerance, induced resistance and enhanced plant growth. The dust/WP form is applied @ 1-2 kg/ha (2×10^6 cfu/g).

Viruses:

Viruses are submicroscopic, obligate, intracellular pathogenic entities. Many viruses are active against insects. Approximately 60% of the 1200 known insect viruses belong to baculoviridae that can be used against 30% of all major pests of food and fibre crops. Majority of the baculoviridae those have been developed as bio-pesticide are bacilliform or rod shaped and include Nuclear Polyhedrosis Viruses (NPVs) and to a lesser extent Granulosis Viruses (GVs). Upon ingestion by the larvae the protein coat dissolves in the mid gut and the virions enter the epithelial cells of mid gut. Later they infect fat body, epidermis, tracheal matrix, muscle, gonads, haemocytes, nervous and endocrine system. After an incubation period of 5-7 days (sometimes 20 days) the larvae becomes sluggish, yellowish or pinkish in colour, swell slightly and then become limp and flaccid. Shortly before death the integument becomes very fragile. The dead larvae found hanging by their pro-legs from the top of the host plant. Finally they dry up and look like a dark brown or black cadaver. Presently, NPV's for *Helicoverpa* (Helicide, Heliocel, Biovirus H) and *Spodoptera* (Spodocide, Litucide, BiovirusS) are available in India and used @ 250-500LE/ha for control of these two polyphagous pests infesting tomato, tobacco, arhar, cotton, vegetables, oilseeds etc. The need for propagating these in live organism and costs involved in producing have limited viruses as products of significant commercial importance. GV of *Chilo infuscatellus*, codling moth, potato tuber moth, cabbage butterfly are widely used for control of vegetable and field pests in advanced countries and some parts of India.

Bacterial bioagents:

Biopesticides based on bacteria have been used to control plant diseases, nematodes, insects, and weeds. Bacteria are present in all soils and are the most abundant micro-organisms in soil samples. Many spore forming and non-spore forming bacteria are known to be effective against a wide spectrum of insects and diseases. The most well-known and widely used of all biopesticides are insecticides based on *Bacillus thuringiensis*, commonly referred to as "Bt." During spore formation, Bt produces insecticidal proteins (know as delta-endotoxins) that kill caterpillar pests, fly and mosquito larvae, or beetles (depending on the subspecies and strain of Bt) that ingest them through feeding in Bt-treated areas. The highly specific delta-endotoxins bind to and destroy the cellular lining of the insect digestive tract, causing the insect to stop feeding and die.

Some other important bacteria are used for the control of plant pathogens, nematodes etc. and also increased plant growth and yield. They are *Pasturia penetrans, Pseudomonas*

spp., Bacillus subtilis, Bacillus pumilus, and Streptomyces spp. found in the rhizosphere producing anti-fungal compounds. The dust/WP form is applied @ 1-2 kg/ha (2.5×10^9 cfu/g).

Entomopathogenic Nematodes:

Biological control of pests using entomopathogenic nematodes (EPNs) may prove to be an ideal alternative to other bioagent earlier used they have long term effect, without any harmful effect on non target organisms. EPNs are potential agents as they serve as vectors of bacteria (*Xenorhabdus* and *Photorhabdus*), achieve a quick kill of target insect pests within 24-48 hrs, have broader host range, highly virulent, possess chemoreceptor's and can be cultured easily *in vitro* and *vivo*. They infect 10 different orders of insects. One of its strains DD-136 is used extensively for control of insect pests of orchards, vegetables, field crops, forests and turf crops. EPNs can be easily applied using standard application equipments and are compatible with many chemical pesticides. The EPNs of the families Steinernematidae and Heterorhabditidae are potentially useful for biological control in agriculture systems. The infective juveniles (IJs) of these families are free living, non-feeding and have the ability to search out their hosts. They have the potential for long term establishment in soil through recycling on infected insects larvae. The importance of entomopathogenic nematode as a key component for the management of lepidopteron, coleopteran, dipterans etc pests (Bhati *et al.* 2016).

Biopesticides in India:

Bio-pesticides represent only 2.89% (as on 2012) of the overall pesticide market in India and are expected to exhibit an annual growth rate of about 2.3% in the coming years. In India, so far only 12 types of bio-pesticides have been registered under the Insecticide Act, 1968. Neem based pesticides, *Bacillus thuringensis*, NPV and *Trichoderma* are the major bio-pesticides produced and used in India. Whereas more than 190 synthetics are registered for use as chemical pesticides. Most of the bio-pesticides find use in public health, except a few that are used in agriculture. Besides, i) transgenic plants and ii) beneficial organisms called bio-agents: are used for pest management in India (Mazid *et al.*2011).

Biopesticide regulation structures in India:

Biopesticides fall under the Insecticide Act (1968). Central Insecticides Board (CIB) and the Registration Committee (RC) are two "high-powered" bodies under this Act. CIB is the Apex Advisory. It comprises eminent scientists of all disciplines/fields concerned. Whereas, the RC grants registrations to the persons desiring to import or manufacture insecticides, after scrutinizing their formulae and verifying claims with respect to their bio-efficacy and safety to human beings and animals.

Table-1: Microbial pesticides registered in India

S. No.	Microbial pesticide	Formulations	No. of products
Bacteria			
1.	*Bacillus thuringiensis* var. *israelensis*	5.0%WP, 5.0%AS	6
2.	*Bacillus thuringiensis* var. *kurstaki*	0.5%, 5.0% & 7.5% WP	18
3.	*Pseudomonas fluorescens*	0.5%, 1.0% WP	93
4.	*Bacillus subtilis*	1.5 % AS	2

Fungi			
5.	*Ampelomyces quisqualis* Ces.	2.0%WP	1
6.	*Beauveria bassiana*	1.0%,1.15% or 2.15%WP, 10.0%SC	62
7.	*Metarhizium anisopliae*	1.0%, 1.5%WP	13
8.	*Paecilomyces lilacinus*	1.0% WP	7
9.	*Trichoderma harzianum*	0.5%, 1.0%, 2.0% WP	19
10.	*Trichoderma viride*	1.0%WP	184
11.	*Verticillium chlamydosporium* Godd.	1.0% WP	2
12.	*Verticillium lecanii*	1.15% WP	51
Virus			
13.	NPV of *Helicoverpa armigera*	0.43%, 0.5%, 0.64%, 2.0%	18
14.	NPV of *Spdoptera litura*	0.5%, 2.0%	3

Source: CIB and RC website

Table-2: Commercial products of different bioagents

S. No.	Bio-agents	Commercial product	Used Against
1.	*Trichoderma viride*	Monitor, Trichoguard	Soil-borne pathogens (Both fungal and nematodes), Insects etc.
		NIPROT	
		Bioderma	
		Biovidi	
		Eswin Tricho	
		Biohit	
		Tricontrol	
		Ecoderm	
		Phalada 106TV	
		Sun Agro Derma	
		Defense SF	
2.	*Trichoderma harzianum*	Biozim	Soil-borne pathogens
		Phalada 105	
		Sun Agro Derma H	
		Trichosan	
		Binap vector	
		TRI002,003	
		Biofungus	
		Trichodex	
		Rootpro	
		Trichopel	
		Canna	
3.	*Paecilomyces lilacinus*	Yorker	Whitefly, Nematodes etc.
		Biomycel	
		ABTEC	
		Paceilomyces	
		Paecil	
		Pacihit	
		ROM biomite	
		Bio-Nematon	

	BIO-ACT(r)	
4. *Pseudomonas fluorescens*	ABTEC Pseudo	Plant soil-borne diseases and nematodes
	Biomonas	
	Esvin Pseudo	
	Sudo	
	Phalada 104PF	
	Sun Agro Monus	
	Bio-cure-B	
5. *B. thuringiensis* subsp. israelensis *B. thuringiensis* subsp. kurstaki	Tacibio, Technar	Lepidopteran pests
	Bio-Dart	
	Biolep	
	Halt	
	Taciobio-Btk	
6. *Helicoverpa armigera* NPV	Helicide	*H. armigera*
	Virin-H	
	Helocide	
	Biovirus-H	
	Helicop	
	Heligard	
7. *Spodoptera litura* NPV	Spodocide	*S. litura*
	Spodoterin	
	Spodi-cide	
	Biovirus-S	

Advantages

The potential benefits to agriculture and public health programmes through the use of bio-pesticides are considerable.

- ✓ Bio-friendly/eco-friendly organisms and bio products help to maintain ecological balance.
- ✓ Identification of indigenous/native isolates of bioagents would be less expensive compare to chemicals.
- ✓ Problems of resurgence can be minimized.
- ✓ Help to achieve pollution free environment.
- ✓ Reduce residues and health hazards.
- ✓ Easy marketability.
- ✓ Long persistence- Once established they remain effective over long periods especially for perennial crops.

Limitations:

- ✓ Non-availability in large quantity.
- ✓ Non-identification of native isolates.
- ✓ Slow process.
- ✓ Lake of standardized techniques for isolation and mass multiplication of biopesticides.
- ✓ Non-adaptability and establishment of the introduced bioagents in the given locality.

- ✓ Variation in performance due to environmental conditions.
- ✓ Lack of awareness.
- ✓ Less compatibility with other management practices.

CONCLUSION

However, bio-pesticides and natural enemies of pests are likely to play an important role in IPM in modern agriculture for controlling pests of field, vegetables and fruit crops. The biopesticides appear to have a promising role of the dovelopment of future commercial pesticide not only for agriculture crop productivity but also for the safety of the enviorment and public health. Biopesticides being the only alternative to chemicals which will also bring sustainability to agriculture as it involves integration of cultural, biological and natural inputs for the management of pests. Because of their slow active nature, we need to develop effective strategies for using them in agriculture. Extension workers and farmers need to be educated for encouraging their use in agriculture to safeguard human health.

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