Microbial Pesticide: A Boom for Sustainable Agriculture

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Abstract: Microbial pesticides now a day became most important practices in integrated pest management. A vast use of chemical pesticide degrading soil structure and its health also. So application of microbial pesticides becoming one the popular and demanding method by the farmers and researchers in a sustainable agriculture system. A wide range of Microorganism viz bacteria, fungi and viruses are now a day being used to control the different groups of insects and pests. They are specific in nature and do not have harmful effect on other beneficial microorganism. They act on the target organism directly by killing them by producing crystal proteins or indirectly by making unavailable certain ions or minerals by secreting siderophore. They are users as well as environment friendly. The present review article focused on the different microbial group with their effects and mode of action on the target species. All these bio control agent by acting as a herbicides, fungicides or insecticides depending upon their special ability to produceor secrete substances like parasporal bodies, crystal protein and other.

Index Terms: Biocontrol agent, Crystal proteins, Integrated pest management, Parasporal bodies, Pesticides, Sustainable Agriculture, Siderophores.

1. Introduction

Chemical pesticides and fungicides have been is use since long period to protect the crops from diseases. Ultimate use of these chemical substances, pollute our ground water, drinking water and the environment and interfere the different ecosystem(1). Thus it seems to urgent need to think seriously about the environmental issue and find alternative means. In the current and modern agricultural trends of crops production bio-control agent are snowing promising result to protect the crops from diseases and thus it may become an important component in sustainable agriculture (2). These agents provide the protection as well as nutrients to the crop (3,4). There are many microbial genera (Table. 1) have been described as potential bio-control agent several plant diseases. Microbial pesticides (Also known as bio-pesticides) are certain type of pesticides derived from living organisms like bacteria, fungi, protozoa etc (5). For example, *Bacillus thuringiensis* has pesticidal effect against Lepidoptera and Coleopteran and are considered bio-pesticides.

2. Classification of microbial pesticides

The term biopesticide is used for all kind of biocontrol agents like microbial pesticides, microbial herbicides, while the microbes used for insect control of often called bioinsecticides and use of microbes or its secretion to kill the weeds is microbial herbicides. Microbes or its secretion used for the agent are bacteria, fungi, protozoa and viruses. Biocontrol agents have been in use to control mostly insects, pests and occasionally for weeds and diseases .

Microbial pesticides fall into following categories :

(1) Bacteria
(2) Fungi (Entomopathogenic fungi)
(3) Protozoa
(4) Virus

2.1. Bacterial insecticide or pesticide

To use bacteria as biological control agent was necessitated by an increasing number of pests and insects. Some of the bacteria which are being used as bacterial insecticides are given (7)

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2.1.1. Pseudomonas spp.

These suppress plant diseases owing to secretion of siderophores or antibiotics and or aggressive root

colonization by organisms that displace or exclude deleterious rhizosphere microbes. *Pseudomonas fluorescence* is one of the most important biological central agents for many plant disease causing microbes. *P. cepacia* is a broad spectrum antagonist to plant pathogens through the production of various types of antibiotics such as pyrrolinitrin. Siderophores are secreted under iron limiting conditions as means to secure available iron present at low concentration in soil. The ability of *certain* Pseudomonads to utilize a wide range of ferric siderophore as a source of metabolic iron, may contribute to their competitiveness and survival in the soil. Other pseudomonads may be used as biological agents are *P. maltophila, P. acidovorans and P. alcaligen*

Seed inoculation with these agents is one of the most powerful methods to control the specific disease. Target disease: *P. fluorescense* is being applied against plant disease, leaf-roller gypsy moth locusts, berry borer of the rice and vegetable crops.

2.1.2. ***Bacillus thuringiensis***

It is a spore farming, rod shaped gram positive bacterium which produces a crystal protein as a parasporic inclusion in the vegetative cell containing the spore. The crystal protein as a protoxin which is converted into a toxin in alkaline mid-gut of insect which lead to the death of insect.

2.1.3. Target organism

Caterpillar pests like Lepidoptera and diptera, mosquitoes like culex and anopheles, backflies,bulworms and cockroachers are the targeted organism. These organism harm the crops like cotton, tobacco, maize, citrus plants and many vegetable crops. Some other Bacillus sp. are *B. subtilis, B. sphaericus. B. popillae. B. lentimorbis* are effective against several beettles *B. sphaericus* is effective against mosquito larvae like culex. Use of *B. subtilis* is effective against *Macrophomina phasecolina* of sesame rot, *Pythium* infection of tomato, *Rhizoctina solani* infection of tubers. Other bacteria are also encountered as biocontrol agent. *Agrobacterium radiobacter* is found effective against the *Agrobacterium tumefaciens,* which for the crown gall disease of dicot plants *Azotobacter chroococcum* is effective against *Rhizoctina solani* infection of tuber crops.

2.2. Entomopathogenic fungi :

Beauveria species: *B. bassiana* and *B. bronriatii* are accounted for the insect killer fungus. They produced the bassianin and tanellin in *vitro,* and remain concentrated in the mycelium.

2.2.1. Trichoderma: Several species of *Trichoderma* have been successfully used to control important soil borne root pathogens viz; *Fusarium* spp., *Pythium aphanidermatium, Rhizoctonia batalicola. R. solani* and *Sclerotium rolfsii.* These pathogens cause damping off, root rot, collar rot and wilts in several field. Oilseeds and vegetable crops.

T. viride and *T. harzianum* are utilized as a promising biocontrol agents. *T. viride* is also a promising biocontrol agent against sisam wilt caused by *Fusarium solani f.* spp. *Dalbergi.*

2.2.2. ***Hirsutella thompsonii-*** *It is found very effective against citrus rust mites (Phylloucoptrula oleivora) of citrus crops. It is also a promising biocontrol agents against citrus bud mite (Eriophyes sheldone) and coconut flower mite (Eryophyes guerreronis).*

2.2.3. ***Verticillium lecanii-*** *It is non-fasticidous fungi which frequently infect the seal insects and aphids. Using V. lecanii conidia or blastospores, seals and aphids can be controlled. Conidia or blastospores are suspended in phosphate buffer in 0.02%, wetting agent triton x- 100 is mixed.*

2.2.4. ***Numeraea rileyi-*** *This ascomycetous fungus is entomopathogemic agent against caterpillar pests on cabbage, clover, soybean, and valvet beans.*

2.3. Protozoa

Malameba locustae and Mattesia spp. are found antagonist against insects like grass hopper, Lepidoptera, coleopteran, while mite *(Hypoaspis miles*) are very effective against Sciarid larva and other invertebrates.

2.4. Some insecticides

Some viruses or their products are utilized as insecticides in place of chemical insecticides. There are many viruses which proliferation and plant growth by way of encouraging the soil microflora. It increases the crop yield also. It helps in volatilization and sequestration of certain inorganic nutrients (10) . For e.g. *Bacillus subtilis* soubilizes the elemental phosphorus and make it available to the plant.

- These are very easy to handle and be applied to the target.
- Bio-pesticides may be used with bio-fertilizer.
- They are easy to manufacture.
- They do not harm non-targeted species.

It is expected that insect/pest are not able to develop resistance against bio-pesticides.

Table: 1 Important bio-control agents to control of insect/ pests/ pathogens and weeds.

Biocontrol agent	Suppressed agent	Crop	Disease /Host/Remarks
Bacteria			
Pseudomonas fluorescens	*Phytophthora infestans*	Potato	Fireblight
Erwinia herbicola	*Erwinia amylovara*	Pear, apple and other rosaceous plants	
B. subtilis	*Uromyces sp.*	Bean	Beanrust
S. griseoviridis	*Agrobacterium brasicicola*	Cruiciferae	Damping off of crufifers
P. fluorescens	*Rhizoctotnia solani P. ultimum*	Cotton	Damping off of cotton
P. fluorescens	*Pythium ultimum*	Mushroom	Brown blotch of mushrooms
A.Radiobacter	*Agrobacterium tumefaciens*	Several crops	Crown gall
Bacillus thuringiensis	Heliothis and other Lepidoptera and coleopteran	-	Cotton, chickpea, maize, tomato, groundnut etc.
Fungi			
Hirsutella thompsonii	Citrus mites	Citrus fruits	
Verticillium lecanii	Aphids, white, Lies		Citrus fruit
Trichoderma viride	*Macrophomina phaseolina*	Groundnut, chickpea	
Rhizoctonia solani	*Pythium ultimum*	Cotton legume	Damping off of cotton
T. viride	*F.* solani	Sisam	Sisam wilt
Viruses			
Nucleopoyhedrosis virus	Rice borer	Rice	Asiatic rice borer
Nucleopoyhedrosis virus	Cotton leaf worm	Cotton	Cotton leaf worm
Chilo Granulosis virus	*Chilo infuscatellus*	Sugarcane	
Nucleopoyhedrosis virus (NPV)	Asiatic rice borer, cabbage looper	Cotton, rice cabbage	Commercially used in USA
Granulosis viruses (GV)	Codling moth, tuber worm rice borer	Potato, rice	
Bioherbicides			
Phytophthora citrophora	Milk weed	-	-
Colletrotrichum gloecosproioides	*Aeschynomene verginica*	-	-
Protozoa	-	-	-
Malameba locustae	Grass hoper, Lepidoptera	-	-

2.5. Bio-herbicides: Fungal pathogens are attractive and effective agent for weed control in view of their host specific(8) . *Phytophthora citrophthora* and *Colletotrichum gloeosporioides* control milk weed vine (*Morreria odorate), Aesehynomene virginica* respectively. Such type of weedicides need a close cooperation .

3. Why microbial pesticides (biological control)

- Biological control is cheaper and less costly than other means.
- Protect the crops throughout the crop period unlike chemical pesticides.
- These are highly effective against specific plant disease.
- They do not cause toxicity to the plants.
- Practice of bio-pesticides is safer to the environment as well as person who applies them.
- They multiply easily in the soil and leave no residual problem.
- Bio-control agent eliminate pathogens from the site of infection.

- Some of the bio-pesticides like *Pseudomonas* sp; *Bacillus subtilis* etc. do not only control the disease but also enhance the root proliferation and plant growth by way of encouraging the soil microflora. It increases the crop yield also. It helps in volatilization and sequestration of certain inorganic nutrients (10) . For e.g. *Bacillus subtilis* soubilizes the elemental phosphorus and make it available to the plant.
- These are very easy to handle and be applied to the target.
- Bio-pesticides may be used with bio-fertilizer.
- They are easy to manufacture.
- They do not harm non-targeted species.
- It is expected that insect/pest are not able to develop resistance against bio-pesticides.

4. Mode of application

Most of the bio-pesticides are available in talc powder from , which may be utilized as follow:

(1) **Seed treatment** - @ 30.0g/kg inoculants containing 10^8 viable cells/g carrier seed is treated with the product. Wet the seed and mix with interest of products.

(2) **Spraying –** About 50.0gram of the product is mixed with 10.0 L: water and spray on the crop of interest.

(3) **Soil treatment –** About 1.5-2.0 kg of the powdery talc product of the desired microbe (s) mixed with dried, cow dung and use it in one hectare. Application is preferred in moistened soil.

5. Characteristics of an ideal bio-control agents.

It is very difficult to select the criteria for a potential bio-control agent that can function effectively under variable condition prevailing during the plant growth. Willson and Weishiwski have presented some criteria for an ideal antagonists for the biological control for various plant diseases. These are (a) Genetic stability (b) ability to survive in adverse and variable environmental stress (c) shows higher consistent efficacy (d) must be effective against wide range of pathogens like a variety of fruits as well as vegetables (e) strain resistant to standard fungicides (f) metabolites or end products most be stable during the storage.

6. Limitations: Due to high specificity, correct pest identification is essential. Two or more bio-pesticides are necessary due to their high specificity(9). Various biotic and abiotic factors influence the efficacy of the bio-pesticides due to their living characteristic feature.

7. Future prospects : Biological control agents or bio-pesticides offer an environmentally sustainable approach to increase crop production and health. The application of biotechnological (11) and molecular tools is encouraging our ability to understand and manage the rhizosphore. It will lead to new products with improved effectiveness.

Conclusion: By using microbial rather than chemical pesticides, farmers can avoid harming the environment. Many chemical insecticides, such as DDT, remain in the soil as toxic pollutants. These are eventually incorporated into the food chain, unlike microbial pesticides. Due to the specific nature of microbial pesticide most experts feel that they are useful component of IPM but generally they are not as widely used as they should be. So, it is a problem of expectation. Although microbial pesticides look like a chemical pesticides but feel like biological agents.

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