



Biopesticide- An Eco-Friendly Way of Diseases Control

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Plant diseases are the main reason behind pandemic and yield losses in the agricultural. The average annual loss of 10 to 15% in major crops of world due to plant diseases is (Chatterjee et al. 2016). Chemical fungicides are majority used for controlling the plant diseases but chemical fungicide have negative effect on human health, non-target useful organisms and environment. Biofungicide have been emerged as alternative of chemical fungicides. Biofungicides are formulations of living organisms (usually fungus or bacterium or actinomycetes or plant extract) as active ingredient to prevent, stop, or control pathogenic fungal or bacterial infections in plants in an eco-friendly manner. European Union (EU) defined biofungicides as a form of pesticides based on microorganisms or natural products (European Commission). According to Environmental Protection Agency (EPA, 2012) of USA biofungicides include-

- 1) Naturally occurring substances that control fungi (biochemical fungicides)
- 2) Microorganisms like fungi, bacteria etc. that control fungi (microbial fungicides)
- 3) Fungicidal substances produced by plants containing added genetic material (plant-incorporated protectants)

Biofungicides are usually occurring naturally in soil or on plant surfaces and making them an environmentally friendly alternative to chemical fungicides. Additionally, using biofungicides in disease management program reduces the risk of pathogens becoming resistant to chemical fungicides. The mechanism of action of biofungicide is by various ways like antibiotic substances production, plant growth promotion, compete with other fungi, induce localized or systemic resistance in plants etc.

Direct competition: Biofungicide is more effective than the pathogen to compete for critical nutrients or space and, therefore, inhibits pathogens establishment. Biocontrol agents also metabolize seed and root exudates that normally stimulate pathogen germination and competition of glucose in soil also suppress disease development. E.g.

Antibiosis - Antibiosis is defined as 'the antagonism resulting from the toxicity of secondary metabolites produced by one microorganism for other microorganisms'. Streptomycin antibiotic is produced by *Streptomyces* bacterial species which are classified as actinomycetes.

Mycoparasitism: Mycoparasitism is the ability of a species to withdraw some or all of its nutrients from the fungal host. Weindling (1934) first described the mycoparasitism potential of *Trichoderma viride* to control plant-pathogenic fungi.

Induced plant resistance: Some microorganisms have the ability to induce metabolic changes in plants that increase their resistance towards plant pathogenic fungi and bacteria. Induce systematic resistance (ISR) is similar to systemic acquired resistance (SAR) induced by the infection of pathogens without hypersensitive response (HR) and visible symptoms (Liu et al. 2007)

Plant growth promotion: Some beneficial root-colonizing microorganisms promote plant growth and decrease the harmful effects of pathogens. Biofungicides direct stimulation of plant growth by the action of phytohormones or the production of metabolites and also enhance the nutrient uptake of roots.

Biofungicide commercial availability

The global biofungicides market is projected to reach \$4.06 billion by 2029. Some of the most common biofungicides includes *Bacillus*, *Trichoderma*, *Streptomyces* and *Pseudomonas* formulation of species. Details of the commercially available biofungicides listed in the Table 1. The major companies operating in the biofungicides market in the world include Bayer AG (Germany), Marrone Bio Innovations, Inc. (U.S.), Certis USA L.L.C., Andermatt Biocontrol AG (Switzerland), BASF SE (Germany), Som Phytopharma India Limited (India), Syngenta AG (Switzerland), International Panaacea Ltd (India), The Stockton (STK) Group (Israel), BioWorks, Inc. (U.S.), Novozymes A/S (Denmark), W. Neudorff GmbH KG (Germany), Valent (U.S.A.), FMC Corporation (U.S.), and Gowan Company, LLC. (U.S.).

Table 1: List of biofungicide commercially available in the market

Microorganism	Trade name	Target pathogens/diseases
<i>Agrobacterium radiobacter</i>	Galltrol	<i>Agrobacterium tumefaciens</i>
<i>Ampelomyces quisqualis</i>	Biodewcon	Powdery mildew
<i>Bacillus subtilis</i>	Companion Liquid, Cease, Kodiak, Rhapsody, Serenade	Leaf spots, Powdery mildew, Botrytis, bacterial disease, Fire blight, <i>Botrytis</i> , <i>Fusarium Rhizocotonia</i> , <i>Pythium</i> , <i>Phytophthora</i> ,
<i>Bacillus amyloliquefaciens</i>	Serifel	<i>Botrytis cinerea</i> , <i>Sclerotinia sclerotiorum</i> , <i>Trichoderma aggressivum</i>
<i>Chaetomium globosum</i>	Ketmium	Soil-borne pathogens
<i>Gliocladium virens</i>	SoilGard, WRC-AP-1, WRC-GL-21	<i>Rhizoctonia</i> , <i>Pythium</i>
<i>Gliocladium catenulatum</i>	Prestop WP	<i>Botrytis</i> , <i>Fusarium</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Verticillium</i>
<i>Pythium oligandrum</i>	Polyversum	Root rots
<i>Pseudomonas fluorescens</i>	ABTEC Pseudo, Bio-cure-B, Biomonas, BrightBan A 506, Esvin Pseudo, Phalada 104PF, Sudo, Sun Agro Monus	Fireblight, Plant soil-borne disease
<i>Streptomyces lydicus</i>	Actinovate, Actono-iron	<i>Botrytis</i> , Downy mildew, <i>Fusarium</i> , <i>Pythium</i> , <i>Phytophthora</i> , <i>Rhizoctonia</i> , Powdery mildew
<i>Streptomyces griseoviridis</i>	MycoStop	<i>Alternaria</i> , <i>Botrytis</i> , <i>Phytophthora</i> , <i>Pythium</i> , <i>Rhizoctonia</i>

<i>Trichoderma viride</i>	Bioderma, Biovidi, Bip T, EswinTricho, Biohit, Defense SF, NIPROT, Ecoderm, Phalada 106TV, Sun Agro Derma, Tricontrol	Soil-borne pathogens
<i>Trichoderma harzianum</i>	Biozim Soil-borne pathogens, F-stop, Phalada 105, Plant Shield, Root Shield, Sun Agro Derma H, T-22 Planter Box, T35	Soil-borne pathogens like <i>Cylindrocladium</i> , <i>Fusarium</i> , <i>Pythium</i> , <i>Rhizoctonia</i> , <i>Thielaviopsis</i> etc.

Advantages of biofungicide

- 1) they help reduce the risk of developing pathogen resistance to traditional chemicals
- 2) They are safer and has less impact on non-target organisms.
- 3) They are less phytotoxic therefore impact on the ecological environment is small.
- 4) are easily decomposed by sunlight, plants, or various soil microorganisms, therefore minimize residue levels on crops.
- 5) The production of biofungicides generally does not use of non-renewable energy resources for its production.

Disadvantages of biofungicide

- 1) Biofungicide are not broad spectrum as they have narrow target range.
- 2) Biofungicide may not work as fast as chemical fungicide
- 3) Biofungicide may not be compatible with the use of other chemical fungicides.
- 4) Biofungicide have to use before onset of disease.

Conclusion

Biofungicides are most important alternative of chemical fungicide in the agriculture as these not only control the diseases but also promotes growth of the plants. Biofungicide are also eco-friendly and therefore a good option for sustainable cropping and increase in crop yields.

References

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