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Role of Beneficial Microbes in Organic Farming

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SUMMARY

Beneficial microbes have emerged as an inevitable component in present-day agriculture in the context of the worldwide importance of organic farming. As an alternative to chemo-centric agriculture, the use of biological agents not only helps to fight against various harmful insect pests, weeds, and disease-causing pathogens but also in sustaining agricultural productivity of soil and maintains the natural integrity of the environment. Under such situations, microbial biodiversity plays a vital role in their utility in various activities like biopesticide and biofertilizer production, enrichment, and acceleration of composting techniques, for sustaining soil health and plant health. Various beneficial microorganisms, viz., Trichoderma spp., pseudomonads, Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii, Bacillus spp., Rhizobium spp., Azotobacter sp., Azospirillum sp., etc. can be successfully incorporated in the agricultural production system to manage various pest, diseases and improving plant and soil health.

INTRODUCTION

In agriculture, microbes play a pivotal role, being beneficial or pathogenic to our crops. Beneficial microbes are involved in various activities like microbial pest and disease management, biological nitrogen fixation, phosphate solubilization, potash mobilization, agricultural waste and residue decomposition, mineralization, cycling nutrient, plant growth promotion, etc. In organic agriculture, since the use of synthetic fertilizer, chemical pesticides are restricted, microbe-based biopesticides and biofertilizers have a very important role to play. Eco-friendly and non-toxic management of pest and diseases, plant growth, and soil health enhancement activities no only helps in sustaining agricultural productivity, but also maintains the integrity of the environment. In this context, both in plant and soil health, beneficial microbes play a very important role. Biological management of plant pathogens attempts at reduction of pathogen population by one or more organisms accomplished naturally through manipulation of the environment, host or antagonists or by mass introduction of one or more antagonist. Various beneficial microorganisms that are playing important role in this regard include *Trichoderma* spp. (*T. harzianum*, *T. viride*, *T. virens*, *T. koningii*, *T. pseudokoningii*, *T. roseum*, *T. polyporum*, *T. piluliferum*, *T. hamatum* etc.), Pseudomonads (*P. fluorescens*, *P. putda*, *P. aureofaciens*, *P. aeroginosa*, *P. chloraphus*, *P. syringae*), *Beauveria bassiana*, *Metarhizium anisopliae*, *Lecanicillium lecanii*, *Bacillus* spp. (*B. thuringensis*, *B. subtilis*), *Rhizobium* sp., *Azotobacter* sp., *Azospirillum* sp., etc. Some of them are discussed below.

Trichoderma spp.

Trichoderma is one of the potential biocontrol agents and used extensively for the management of various plant diseases, mainly soil-borne. It has been used successfully against pathogenic fungi belonging to various genera, like *Pythium*, *Phytophthora*, *Sclerotinia*, *Sclerotium*, *Rhizoctonia*, *Fusarium*, *Botrytis*, *Ralstonia*, etc. causing diseases like damping off, root rot, dry rot, seedling blight, collar rot, loose smut, karnal bunt, black scurf, foot rots, capsule rot, silver leaf of plum, peach, fungal and bacterial wilt, etc. *Trichoderma* was also found to have the ability to solubilize phosphates and other micronutrients. *Trichoderma* applied alone or in combination with other plant growth-promoting microbes increases the number of deep roots and thereby increases the plant's ability to resist drought. An increase in shoot length and plant height could increase yield and improves the quality of plant products. *Trichoderma* species are common inhabitants of the rhizosphere and contribute to the control of many soil-borne plant diseases through antibiosis, lysis, competition, and mycoparasitism.

Pseudomonas fluorescens

One of the major bacterial antagonists *Pseudomonas fluorescens* under fluorescent pseudomonads group is also known as plant growth-promoting rhizobacteria (PGPR) has been reported to manage several seeds, soil, and airborne crop diseases caused by various pathogens. Pseudomonads are also having abilities to solubilize phosphorus and potassium by the production of various organic acids and hence improve soil health and can successfully use in integrated nutrient management strategy. Fluorescent pseudomonads exhibit diverse mechanisms of biocontrol which include antibiosis, cyanide production, siderophore production, competition for space and nutrients, and induced systemic resistance.

Metarhizium anisopliae

Metarhizium anisopliae, formerly known as *Entomophthora anisopliae*, is a widely distributed soil-inhabiting fungus. A member of the Hyphomycetes class of fungi, *M. anisopliae* is categorized as a green muscardine fungus due to the green color of the sporulating colonies. It has been reported to infect approximately 200 species of insects and other arthropods. Although *M. anisopliae* is not infectious or toxic to mammals, inhalation of spores could cause allergic reactions in sensitive individuals.

Lecanicillium lecanii

Lecanicillium (Verticillium) lecanii formerly, is a cosmopolitan fungus found mainly in association with soft-bodied insects. It is also known as a “white-halo” fungus because of the white mycelial growth on the edges of infected insects. The main insect host of this fungus includes whiteflies, thrips, aphids, mealybugs, and a few other sucking pests. The fungus usually uses mechanical pressure and release of mycotoxins (cyclodepsipeptide, dipocolinic acid, cyclosporine, etc.) to kill the insect host.

Bacillus thuringiensis

Bacillus thuringiensis (or Bt) is a Gram-positive, soil-dwelling bacterium, commonly used as a biological pesticide. *B. thuringiensis* also occurs naturally in the gut of caterpillars of various types of moths and butterflies. *B. thuringiensis* (Bt) is an entomopathogenic bacterium, use to manage various insect pests - mainly caterpillars of the Lepidoptera (butterflies and moths). Bt products represent about 1 percent of the total ‘agrochemical’ market (fungicides, herbicides, and insecticides) across the world. When Bt bacteria are ingested by the insects, the crystal protein present in the bacterial cell is dissolved in the midgut of the insect body and subsequently causes the insect to stop feeding within one day. The infection causes death within 2-3 days.

Bacillus subtilis

Many fungal and bacterial plant diseases can be effectively controlled by using *Bacillus* sp. It is an endospore-forming bacteria, and the endospore can withstand extreme temperatures as well as dry environments. It plays an important role in developing resistance to various phytopathogenic organisms through production of antibiotics, toxins, enzymes, etc. Some of the common diseases that can be effectively managed by *B. subtilis* are wilt, seedling rot, blight, leaf spot, stem rot et., caused by various pathogens, viz., Alternaria, Xanthomonas, Rhizoctonia, Sclerotinia, etc. *B. subtilis* also plays an important role solubilize the unavailable forms of Inorganic-P like tricalcium, iron, aluminum, and rock phosphates into soluble forms by the release of a variety of organic acids.

Azotobacter chroococcum

The *Azotobacter* is an aerobic, cyst forming, heterotrophic, free-living nitrogen-fixing bacteria. Besides their nitrogen-fixing ability, they have also been noted for their ability to produce different growth hormones (IAA and other auxins, such as gibberellins and cytokinins), vitamins, and siderophore. *Azotobacter* is capable of converting nitrogen to ammonia, which in turn is taken up by the plants for their growth and development.

Table 1: Role of beneficial microbes as Biopesticide, Biofertilizer, and Phytostimulator

Category	Definition	Mechanisms
Biopesticide	Microorganisms are used to manage various phytopathogenic agents and insect pests.	Antibiosis, lysis, competition, mycoparasitism, production of antibiotics, siderophore, HCN, antifungal metabolites, enzymes,

		acquired systemic resistance, and induced systemic resistance
Biofertilizer	Beneficial microorganisms, when applied on the seed, plant surface, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth through increased supply or availability of primary and secondary nutrients to the host plant.	Nitrogen fixation, Utilization of insoluble forms of phosphorus, potassium, Availability of micronutrient
Phytostimulator	Microorganism with the ability to produce or change the concentration of growth regulators such as indole acetic acid, gibberellic acid, cytokinins, and ethylene	Production of various phytohormones, viz., auxins, cytokinins and gibberellins, etc. and regulating plant ethylene level

CONCLUSION

To combat the limitation of chemicals, an environmentally safe and economically feasible biological management strategy has been recently receiving significant attention since it promises to offer a more sustainable food supply. The beneficial microbiomes can be successfully used as single or in combination for suppression or management of single or complex plant diseases, insect pests. These can also be successfully used as a potential component for plant growth promotion, in organic farming and integrated nutrient management approach. So, incorporating efficient and aggressive microbes in the agricultural production programme by developing various biopesticides, biofertilizers will significantly help in days to come.

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