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Role of Microorganism in Mineral Nutrition

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INTRODUCTION

Microorganisms represent largest and most diverse biological group in soil, with estimates one million to one billion microorganisms per gram of cultivated topsoil. Soil health is defined as the ability of a soil to function as a vital living system, by recognize that it contains biological elements that important for ecosystem function within land use ranges. In the context of agriculture, it can refer to its ability to maintain productivity. Microorganisms have the potential to provide an integrated measure of soil health, aspect that cannot be obtained from physical - chemical measures or analysis of the diversity of higher organisms. Microorganisms are major role in the cycle of nitrogen, sulfur and phosphorus and micronutrients because macro- and micronutrients are essential for plant growth and reproduction. These nutrients are supplemented in inorganic or organic forms and taken up with water by the plant's roots. Soil microorganisms play an important role in mobilizing and absorbing nutrients for plants. In recent decades, several bacterial strains designed as bio-fertilizers have been introduced to improve NPK nutrition and decomposition of organic residues. Whereby they also affect water holding capacity, infiltration rate, crusting, corrosion, and susceptibility to compaction. Changes in microbial populations or activity may precede detectable changes in soil physical and chemical properties, providing early indication of soil improvement or an early warning of soil erosion.

1. What are Microorganisms and their Classification

A microorganism or microbe is a microbe which can be a single cell or multicellular organism. Soil is the habitat of a large number of organisms and organisms in the soil is classified as:

1. Soil plant kingdom 2. Soil animal kingdom soil microorganisms

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A. Bacteria

The most predominant group of microorganisms in the soil and equal to half of the microbial biomass in the soil. They are found in neutral to slightly alkaline soils. Bacillus, Clostridium, Pseudomonas is different bacterial genera. The genus Bacillus has the largest representation in soil in terms of species. Soils with low organic matter and sandy texture have very low populations.

B. Actinomycetes

Actinomycetes are an intermediate group between bacteria and fungi and belong to the genera streptomyces, nocardia. 70% of soil actinomycetes are Streptomyces. Found in neutral to slightly alkaline soils. Generally found in dry soils and less in lowlands.

C. Fungus

They are numerous in the surface layers of well aerated and cultivated soils. common species in soil are Aspergillus, Mucor, Penicillium, Alternaria and Rhizopus. Soil fungi can grow in a wide range of soil pH but their populations are higher in acidic conditions.

D. Algae

Abundant in habitats exposed to light and sufficient moisture. important species are Anabaena, Nostoc, Auloseira.

E. Protozoa

Found in the top layer of soil and get their nutrition by feeding on soil bacteria. They are controlling the biological balance in the soil. Their population is high in soils containing organic matter.

2.Decomposition and Nutrient Mineralization: A Two-Step Process

2.1 Soil Biota Involved in the Decomposition Process:-

Organic residue inputs in agro ecosystems originate from many sources. Virtually all agro ecosystems will have an input of non harvested crop components roots, above - ground residues (mostly leaves, stems, and husks) of grain crops, the above-ground biomass of cover crops, green manure crops, and fallow crops and may also receive organic materials like forestry residues, animal wastes, compost from various feed stocks and bio solids from municipal water treatment facilities. Further, the action of the soil organisms is strongly controlled by oscillations in soil moisture, which is linked to rainfall, irrigation, and snowmelt patterns as well as evapo - transpiration, transpiration, and drainage of water through the soil profile.

2.2 Soil Biota Involved in the Mineralization Process

The decomposition process liberates monomer compounds that can diffuse through the soil pore water and be absorbed through the membrane of microbial cells for further hydrolysis *in vivo*, releasing energy and precursors for metabolic processes. As precursors for protein synthesis and other metabolic pathways, these soluble ions could be immobilized in the microbial cell or released into the soil pore water if microbial requirements were already met.

3. Synchronizing the Decomposition and Nutrient Mineralization Processes with Crop Nutrient Requirements

Crops require N to synthesize proteins, chlorophyll, and other N - rich compounds, P for energy relations and cell division, and S for protein synthesis, glucosinolate synthesis as an anti-herbivore defense, and production of organosulfur compounds that gives food their distinctive odors and flavors. There is a constant but variable requirement for these nutrients during the growing season.

4. Microorganisms Responsible for Nutrient Mobilization

A. Rhizobium

Rhizobium belongs to the family Rhizobiaceae, symbiotic in nature, fixing nitrogen 50 - 100 kg/ha. Rhizobium has the ability to fix atmospheric nitrogen in a symbiotic association with legumes and some non-legumes such as Persona. It is useful for pulse legumes such as chickpea, red gram, pea, etc., oil-seed legumes such as soybean and groundnut, and fodder legumes such as berseem and lucerne. It colonizes the roots of

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specific legumes to form tumors called root nodules, which act as factories of ammonia production. This symbiosis provides a specialized niche for bacteria and, in return, plants obtain an individual nitrogen source (Andrew *et al*., 2006). The net reduction of molecular nitrogen to ammonia usually results in the following equation:

N2 + 16Mg ATP + 8e- + 8H+ g 2NH3 + H2 + 16Mg ADP + 16Pi

B. Azotobacter

Azotobacter belongs to the family Azotobacteriaceae, free-living and heterotrophic in nature. It is a bound aerobe, although it can grow under low oxygen concentration. It is a free living nitrogen fixer. Azotobacter is present in neutral or alkaline soils and Azotobacter crococum is the most commonly occurring species in arable soils. Azotobacter vinlandii, A. beijerinckii, A. insignis and Azotobacter macrocytogenes are the other reported species.

C. Azospirillum

Azospirillum belongs to the family Spirilaceae, heterotrophic and cooperative in nature. In addition to their nitrogen fixation capacity of about 20-40 kg/ha, they also produce growth inhibitors. Although there are several species under this genus, e.g., A. Amazons, a. halopreferens, A. brasiliens, however, the benefits of worldwide distribution and vaccination are mainly due to A. lipoferum and A. Proven with Brasilance. Azospirillum species belong to the group of facultative endophyticdiazotrophs that colonize the surface and interior of roots and such association is considered the starting point of most ongoing biological nitrogen fixation programs with nonlegume plants worldwide.

D. Azolla Anabaena

These belong to eight different families, phototrophic in nature, fixing 20–30 kg N/ha in water-submerged rice fields as they are abundant in paddy, hence making less land available for rice production. Also in large quantities. Soil N and BNF by associated organisms are major sources of N for lowland rice (Wani and Lee, 1995). BGA forms symbiotic associations with fungi, liverworts, ferns and flowering plants capable of fixing nitrogen, but the most common symbiotic association has been found between Azolla and Anabaena azolla (BGA), a free-floating aquatic fern. Azolla contains 4-5% nitrogen on dry basis and 0.2-0.4% on wet basis and can be a potential source of organic manure and nitrogen in Rice Production.

6. The Role of Microbes to Improve Crop Productivity and Soil Health

Application of beneficial microbes may be a potential alternative to harmful chemical fertilizers and pesticides. Microbes stand an important role in improving crop productivity and soil management. Plant-associated soil microbes play a crucial role in plant growth and development such as nutrient cycling and crop productivity (Yan *et al.* 2015).

7. Microbial Mechanism of Plant Growth Promotion

Microbes can we use in different way for plant growth promotion required plant growth promoting rhizobacteria (PGPR). Two major ways to promote plant growth are direct and indirect mechanism. The indirect mechanism includes reduction of some of the negative impact of pathogens by different mechanism. For example, siderophore reduces availability of iron for pathogens and reduces their growth. Plant growth promoting microbes that enhance plant growth process includes (1) increase availability of nutrient, (2) production of plant growth regulator (Auxin, Cytokine, and Gibberellins), (3) metabolites such as hydrogen cyanide (HCN), 1-amino cyclopropane-1-carboxylate (ACC) deaminase, siderophore, and antibiotics, (5) induction of systemic resistance (Duan *et al*. 2013).

7.1 Phosphate Solubilization

Phosphorus is essential micronutrient and most vital element for plant growth and development. Plants acquire phosphorus in the form of phosphate ions from soil. Plant growth promoting rhizobacteria (PGPR) having phosphate solubilization ability, available phosphorus to plant through mineralization, and solubilization. Phosphorus solubilizing microbes govern biogeochemical cycle in natural agriculture system. It is responsible for normal functioning of living organism. However, most of phosphorus present in soil in insoluble form and unavailable to plant. It plays a major role in sugar transport and stimulates root development and physiological process of plants and animals. The bioavailability of phosphate to plant depends on plants, microbes, and surrounding environment. The association of plant microbes could enhance the mobilization of phosphorus in soil and available to plants (Mehta et al. 2013). Phosphate solubilizing microbes (PSM) such as bacteria and fungi mobilizes it by producing organic acid and phosphatase. Many genera of bacteria and fungi are described as phosphate solubilizing microbes (Yadav *et al.* 2014).

7.2 Indirect Mechanism of Plant Growth Promotion

The indirect effect of plant growth promoting bacteria occurs when they either decrease or inhibit deleterious consequence of pathogen through various mechanisms. The application of microorganism to control disease in plants is known as biocontrol. It is an environmentally sustainable and cost-effective approach to ameliorate deleterious effect of pathogens.

CONCLUSION

Mineralization of nutrients by microorganisms proves beneficial and economical due to the high cost of chemical fertilizers and the increasing gap between supply and demand. Microbial inoculants are eco-friendly and environmentally safe with low cost technology, improve productivity, reduce environmental pollution. Microorganisms play an important role as organic fertilizers in facilitating the absorption of nutrients in a crop. They are beneficial in maintaining the physical, chemical and biological components of the soil.

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