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Role of Soil Microorganisms in Soil Fertility and Crop Production

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Abstract

Soil represents a medium or substrate in which numerous microorganisms live and bring about a great variety of processes which are responsible for continuation of the cycle of life in nature. The numerous living forms spend all or part of their life in soil ranging from sub microscopic forms to the lower animal forms. With the growing recognition of the numerous processes carried out by the microorganisms in the soil there gradually emerged a branch of microbiology, which came to known as Soil microbiology. It is a branch of soil science concerned with soil inhabiting microorganisms and their functions and activities.

Introduction

Since soil microbiology concerns with soil microorganisms and their processes it is closely associated with soil biochemistry. Medical bacteriologists were interested in the soil as a medium for the growth and survival of disease producing organisms. Agricultural chemists are also interested in the soil processes that result from the activities of microorganisms. General bacteriologist, zoologist, botanist were interested in certain special group of organisms found in soil. Recently, soil microbiology has expanded to include the study of the role of soil microorganisms in genetic engineering, in the biological control of pests and diseases, the degradation of pollutants, production and destruction of radioactive gases and its transfer. Thus microbial participation in several important processes highlight that soil microbiology has become a global science.

Soil is an Excellent Culture Media for Living Organism

Soil may harbor or inhabits a diverse group of organisms, both micro flora (fungi, bacteria, algae and actinomycetes) and micro fauna (protozoa, nematodes, earthworms, moles and ants). Top soil, the surface layer contains greater number of microorganisms because it is well supplied with oxygen and nutrients. Lower layer (sub soil) is depleted with oxygen and nutrients; hence, it contains fewer organisms. Soil ecosystem comprises of organisms which are both, autotrophs (algae, BGA) and heterotrophs (fungi, bacteria). Autotrophs use inorganic carbon from CO_2 and are primary producers of organic matter, whereas heterotrophs use organic carbon and are decomposers/ consumers.

Soil Microbes and Plant Growth

Soil microbes serve as a best medium for plant growth. Soil fauna and flora convert complex organic nutrients into simpler inorganic forms which are readily absorbed by

the plant for growth. They produce variety of substances like IAA, gibberellins, antibiotics *etc*. which directly or indirectly promote the plant growth.

Soil Microorganism and Soil Structure

Soil structure is dependent on stable aggregates of soil particles. Soil organisms play an important role in soil aggregation. The soil binding or aggregation properties are graded in the order as fungi > actinomycetes > gum producing bacteria > yeasts. There are two ways that bacteria could be involved in soil aggregation. One way is by producing organic compounds called polysaccharides (Costa *et al*., 2018). Bacterial polysaccharides are more stable than plant polysaccharides, resisting decomposition long enough to be involved in holding soil particles together in aggregates. The other way bacteria are involved in soil aggregation is by developing a small electrostatic charge that attracts the electrostatic charge on clay surfaces, bringing together small aggregates of soil. Examples are Fungi - *Rhizopus, Mucor, Chaetomium, Cladosporium, Rhizoctonia, Aspergillus* and *Trichoderma.* Bacteria - *Azotobacter, Rhizobium, Bacillus* and *Xanthomonas*.

Soil Microbes and Organic Matter Decomposition

Microorganisms play an important role in the process of decomposition of organic matter and release of plant nutrients in soil. The organic matter serves as food and supplies energy for the vital process of metabolism. Organic matter added to the soil is converted by oxidative decomposition to simpler nutrients (Swaminathan *et al*., 2021).

Soil Microbes and Humus Formation

Humus is the organic residue in the soil resulting from decomposition of plant and animal residues in soil. It is the highly complex organic matter in soil which is not readily degraded by microorganisms (Jan *et al*., 2020). It is the soft brown or dark brown coloured amorphous substance composed of residual organic matter along with dead microorganisms.

Soil Microbes and Cycling of Elements

Life on earth is dependent on cycling of elements from their elemental states. The biogeochemical process through which organic compounds are broken down to inorganic compounds or their constituent elements is known as mineralization. Soil microbes play an important role in the biochemical cycling of elements in the biosphere (Gougoulias *et al*., 2014). Through the process of mineralization organic C, N, P, S and Iron *etc*. are made available for reuse by plants.

Soil Microbes and Biological N_2 Fixation

Conversion of atmospheric nitrogen into ammonia and nitrate by microorganisms is known as Biological Nitrogen Fixation (BNF). Two groups of microorganisms involved in the process of BNF are Free living (Non-symbiotic) and Symbiotic (Wagner, 2011).

Soil Microbes as Biocontrol Agents

Several ecofriendly bioformulations of microbial origin are used in agriculture for the effective management of plant diseases, insect pests, weeds. Nuclear polyhydrosis virus (NPV) is used for the control of Heliothis or American boll worm. Bacteria (*Bacillus thuringiensis* and *Pseudomonas*) are used as a biocontrol agent for cotton boll worms and angular leaf spot. *Trichoderma* sp. and *Gleocladium* sp. are used for bio-control of seed and soil borne diseases. Fungi (*Entomophthora, Beauveria* and *Metarrhizium*) and Protozoa (*Maltesiagrandis* and *Malamebalocustiae*) *etc*. are used in the management of insect pests.

Degradation of Pesticides in Soil by Microorganisms

Soil receives different toxic chemicals from weedicide and pesticide application. It causes adverse effects on beneficial soil micro flora/ micro fauna, plants, animals and human beings. Various groups of microbes present in soil act as the scavengers of these harmful chemicals in soil. They are degraded into non-toxic substances and thereby minimize the damage caused by the pesticides. For example, bacteria (*Pseudomonas, Clostridium, Bacillus, Thiobacillus, Achromobacter etc*.) and fungi (*Trichoderma, Penicillium, Aspergillus, Rhizopus* and *Fusarium*) are playing important role in the degradation of the toxic chemicals or pesticides in soil.

Biodegradation of Hydrocarbons

Natural hydrocarbons in soil like waxes, paraffin's oils *etc*. are degraded by fungi, bacteria and actinomycetes. *E.g.*, Ethane (C_2H_6) a paraffin hydrocarbon is metabolized and degraded by *Mycobacteria, Nocardia, Streptomyces, Pseudomonas, Flavobacterium*.

Conclusion

The soil fertility and health are very important for plant growth and development; the primary supplement needs of the yields production are satisfied by mineral manures. In this regard, soil microorganisms are the main

retreat liable for various soil measures influencing the change of supplements and consequently affecting the resulting accessibility to plant foundations of these nutrients. The capacity for microorganisms to solubilize and mineralize nutrients from inorganic and organic pools is now very much seen, and their utilization could open another skyline for better harvest creation and profitability with improved soil fertility. Improving soil productivity by adding beneficial microbes and enzymes without disrupting the ecological structure of the soil is also one of the main challenges in the current scenario, as different anthropogenic activities contributing to environmental problems increased.

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