Xournals

Academic Journal of Microbiological Studies

ISSN UA | Volume 01 | Issue 01 | January-2019

The Relation between Plants and Soil Microorganisms

Ashutosh Kumar[1]

Available online at: www.xournals.com

Received 8th September 2018 | Revised 13th October 2018 | Accepted 16th December 2018

Abstract:

In recent, the use of fertilizers is growing day by day. The usage of fertilizers with an aim is to increase the production of plants with high quality. These fertilizers affect the natural resources such as soil, water and air due to which the pollution is increased and harm the organisms. To reduce the problems related to the fertilizers, the researcher found out the alternative methods of production by which the growth and productivity of plants can be increased. In this alternative methods, one is the use of biomass which is rich in the number of microorganisms. Microorganisms play a dynamic role in the growth of plants. Rather than the biomass, soil also contains microorganisms called soil microorganism in the rhizosphere. The soil microorganisms have an interrelation with the plants. Plants help in the development of these microorganisms and vise verse in the form of growth and productivity. This paper represents the role of plant and microorganism with each other as for how plant contributes in microbe and microbes activities in plant growth.

Keywords: *Fertilizers, Rhizosphere, Soil Microorganism*

Authors:

1. *Marwari Boys' College, Ranchi, Jharkhand, INDIA*

Introduction

From the beginning of 19th century, human population has been grown up to 7 fold that leads to the overexploitation of the natural resources of planets. These natural resource exploitations include loss of biodiversity, change in climate, and disturbance in the nitrogen cycle. For social and political consideration, reduction of biodiversity and changes in climate have become major issues. With these issues, the disturbance in the nitrogen cycle is also a worldwide problem that needs higher consideration. As the demand for food is increasing with the growing population, the revolution in the agriculture has a gigantic influence on the universal biogeochemical cycle. Approximately 10^{11} kg of nitrogen fertilizers is assessed per year. While more than 60% of the fertilizer is not absorbed by the plants and go into the groundwater. For cyano-bacterial and algal blooms are not reached to the plant by the nutrient 'Nitrogen'. And these nutrients released into the groundwater, drifts into the sea where they cause intense variations in marine microbial populations and disturb the whole marine food chain.

In developing countries, the fertilizers are used in excess for enhancing the potential of plants. It is necessary for developing countries to increase their yield per hectare noticeably. Here it becomes difficult to understand how plant growth can be improved without using the costly and environment damaging synthetic fertilizers. According to report, the crop harvest per hectare will be increased by 2050. The deforestation is a temporary solution of the ability of crop yield areas.

The lands which have been converted into fields can be used for increasing the crop yield. Another way for increasing yield is to investigate on to the natural abilities of plants. Before century, it was observed that soil is rich with microbes around the plant roots. This soil was termed as rhizosphere. These soil microorganisms showcase a significant role in plant health and in the procedure that takes place in the rhizosphere. Now, these microorganisms can be utilized to escalate the plant development in a viable manner. The important goal of rhizosphere plant-microbe studies is connecting the capability of microbes to offer plants with vital micro and macronutrients **(Tkacz and Poole, 2015)**. Plant root growth is enhanced by the good soil structure and results in greater extraction of water and nutrients. The fertility of the soil is increased when released organic compound from soil microbes helps in the binding of individual soil particles into aggregates **(Coyne and Mikkelsen, 2015).**

Soil Microbes and Plants

Even though, the soil is a rich source of nutrition to plants for the plant physiologists. But it is also considered a complex ecosystem that contains bacteria, protists, fungi and animals. Soil-dwelling organisms interact with the plants in different ways that have the complete series of ecological prospects such as exploitative, commensal, competitive, mutualistic and neutral. New plant science is engaged in the studies of lessening pathogenic effects like herbivory, infection and attenuating abiotic stress conditions.

The characteristics of positive ecological collaborations that promote plant growth are used from the last era. For example, from the second half of 19th century, mycorrhizal fungi and bacteria, were recognized as root symbionts. These are present in nodulated legumes. In the 1950s, crop seeds were covered with the cultures of bacteria for improving the growth and yield. In the 1980s, a number of different bacterial strains like pseudomonas and Azospirillum were used that give the plant growth promoting effects. From the 2000s, by the use of metagenomics, researchers shifted their focus from specific microbial strains to detailing the diversity and abundance of the root microbiome. Rhizospheric niche is a hotspot of ecological wealth in which plant roots introduce a gigantic collection of microbial taxa. The research has moved toward designed synthetic communities (SynComs), have strains that represent the dominant rhizospheric texa, and have the aim of observing promising microbial functions again under the measured experimental settings.

Environmental Sustainability

The problems are induced due to scale and severity of the fertilizers. To resolve these problems, alternative methods of sustaining plant nutrition are being developed in agricultural science. In these alternative methods, mineral fertilizers are used with lower inputs. The use of mineral fertilizers can be reduced by the input of organic materials and the plant should be supplemented with specific root-associated microbes by which the organic-bound nutrients would be depolymerized and mineralized. The use of organic inputs can be applied easily because innumerable industrial, agricultural and municipal processes generate a large amount of nutrient-rich junk that has been discarded off. These waste material can be used as compost and fertilizers. These organically bound nutrient have more stability in the soil as compare to the inorganic fertilizers due to which they show less leaching and volatilization.

In organic farming systems, bio-fertilizers are used already but the choice of plant cultivars and microbial inoculants is the main areas of research currently. The precision occurs with the deficiency because of two huge gaps in knowledge:

- The strategies plant for recruiting the beneficial microbes and to know the genetic variations of these existing traits is still unclear.
- The knowledge regarding the specific microorganisms which are finest allies for increasing plant nourishment from organic sources of N, S and P is insufficient.

Here the aim is to understand the role of microbe in the plant nutrition and also the role of the plant toward the microbiome to escalate the nutritional benefits of the collaboration **(Jacoby *et al.*, 2017)**.

Role of Microbes in Plants

In the soil, nitrogen and phosphorus are available in the form of various organic compounds that can be taken by the plants directly. Many organic compounds that are composed of the organic portion of nitrogen present in the soil. The soil organic material consists of putrefying plant and animal remains and even products of putrefaction resistant humus and compounds. The numerous mechanisms take place for the microbial conversion of nutrient into a soluble form. There are some nutrients which are increased by microbes **(Singh *et al.*, 2017)**.

The water movement, physical processes, turbation and root growth cause the mixing of soil due to which microbial populations are suited to a different environment and have diverse practices simultaneously. For example, nitrification which is an aerobic process and denitrification, which is an anaerobic process occurs at the same time in the soil **(Powlson, Hirsch and Brookes, 2001).**

Nitrogen

The conversion of dinitrogen gas into chemically reactive forms is called fixation. In this process, nitrogen combines with other elements like oxygen, carbon, and hydrogen. Nitrogen fixation starts by some biochemical communications that occur between two symbionts. Host plant and bacteria produce products such as flavonoids and lipochitin oligosaccharides. The specificity of the process of nitrogen fixation is determined by these products. The significant amount of atmospheric nitrogen can be fixed by the bacteria under optimum conditions. This nitrogen amount is important ecologically and economically because the process of nitrogen fixation is able to decrease the number of chemicals of fertilizers under both conditions (dry and humid). In humid conditions, nitrogen has the high mobility that processes like leaching and denitrification that decrease the nitrogen availability to the plants. There are some soil bacteria like Azospirillum spp., Bacillus spp., and Azotobacter spp.etc. are used to fix atmospheric nitrogen in a non-symbiotic linked with their host plant. With these bacteria, AM fungi normally use their host plants through their extensive network for increasing the uptake of different nutrients **(Singh *et al.*, 2017)**.

After nitrogen fixation, several chemical reactions occur that covert organic to inorganic forms. Microorganism coverts the organic form into inorganic form in the soil called mineralization. This mineralization contains two steps. Aminization is a first step in which the complex proteins are broken down into simpler amino acids, amides and amines by the activity of microorganism (Primary heterotrophs). Another or second step is ammonification in which ammonium is formed from amino groups by the action of the microorganism (primary autotrophic).

By the activity of microbes, Nitrification occurs that controls two steps. Nitrosomonas is an obligate autotrophic bacteria that convert ammonium into nitrite. The function of these bacteria is inhibited by Nitrification inhibitors like nitraphyrin (NServeR) or dicyandiamide (DCD), block the ammonium conversion to leachable nitrate. Another step is occurred by Nitrobacter species that convert nitrite into nitrate. The conversion of ammonium into nitrite, the concentrations of nitrite are low in soils

Phosphorus

In soil, the acquisition and transfer of nutrients are processed by the microorganism. The microorganism is used to solubilize and mineralize phosphorous from inorganic and organic pools of phosphorus in soil. The surface area of roots can be increased by the activity of microorganism. The microbial biomass is also rich in the pool of immobilizing phosphorous required by the plants. The accumulation of phosphorous in soil occurs in the form of organic or inorganic forms. In the solubilization of various form of precipitated phosphorous, an extensive range of soil bacteria and fungi work.

The importance of phosphorus solubilization mechanisms by the direct action of microorganisms in soil has limited attention. The plants are able to acquire the phosphorous from the soil by the symbiotic linkage between plant roots and mycorrhizal fungi. The phosphorous solubility is determined by the source availability (mineral or organic), anions, cations, pH, microbial combination, and host plant etc.

Potassium

The third essential nutrient for plants is potassium. The microorganisms have their part in making non-dissolvable procedures of potassium by the process of mineralization. Potassium is solubilized from a non-dissolvable form like feldspar, mica, and others by the generation of organic acids, siderophores, and capsular polysaccharides. Bacteria B. mucilaginous are used to dissolve rock potassium mineral powder like illite, micas, and orthoclases by the generation of organic acids **(Singh *et al.*, 2017)**.

The contribution of Plants in Microbes

Various compounds are excreted by the plant's parts mainly from roots that create a different environment in the soil around the roots that is known as rhizosphere. Rhizosphere consists of microorganism that has advantageous properties on plant health and growth. These soil microorganisms are mycorrhizal fungi, nitrogen-fixing bacteria, plant growth promoting rhizobacteria (PGPR), protozoa, mycoparasitic fungi, and biocontrol micro-organisms. Some Rhizosphere organisms are also present that gives the deleterious effects to plant growth and health **(Mendes, Garbeva and Raijmakers, 2013).** These organisms are bacteria, pathogenic fungi, nematodes, and oomycetes. These excreted compounds are called as root exudates categorize into three parts according to the weight; volatile organic compounds (VOCs), Low molecular weight, and High-molecular-weight. Low molecular weight compounds contain sugars, amino acids, phenolics, organic acids, vitamins and various secondary metabolites represent the key part of exudates. Mucilage and proteins are high molecular weight compounds whereas carbon dioxide, certain secondary metabolites, aldehydes, and alcohol are the part of volatile organic compounds. These constitutes are contained by various plants species in different quantities and the duration of discharge by the root is also varied. The nature and timing of exudation are affected by the several factors such as soil type, light, age and temperature. The exudation of organic acids like oxalic acid, malic acid, and citric acid is increased in the presence of a toxic concentration of aluminum or growth of plant under low availability of phosphate. These organic compounds are the sources of microbial attraction such as malate and also used as carbon sources for microbial nourishment.

The equilibrium between various compounds discharged, the timing of discharge and exclusive substances produced in an inducible method defines the characteristics of the rhizosphere. These characteristics may be physical, biochemical and ecological. 20 to 40% photosynthetically secured carbon is transported to the soil surrounding the roots of plants. The plants establish beneficial interactions with soil microbial population as the significant influence of plant on the rhizosphere that reverts in the form of plant well-being by bothering processes such as water and nutrient uptake. Various types of microorganisms present in the rhizosphere contain bacteria, fungi, algae, and actinomycetes.

The population of microbe present in the rhizosphere reacts with the exudates that are released by the plant's roots. Microorganism and their products affect the roots of plants in different ways. It may be in negative, positive and neutral ways. Hence, the rhizosphere is a vibrant system in which the communication and interaction among the roots and microorganisms take place. These interactions play a vital role in maintaining the productivity and growth of plants. For biotechnology enhancement that has the target to boost the inherent harvest and biomass manufacture with less use of fertilizers, agrochemicals, and water, the rhizosphere management may be an important area. This can be attained by the inoculation of rhizosphere with beneficial microorganisms or by modifying the level and nature of exudate compounds by the use of engineering plants.

The Plant defense response involves the many molecules in which Elicitors are the molecules that are derived from beneficial and pathogenic microbes. The deposition of a wide range of secondary metabolites such as phytoalexins, indole glucosinolates, and alkamides are induced by the exogenous usage of security signaling molecules like methyl jasmonate, salicylic acid, and nitric oxide. These secondary metabolites may portray a significant role in the communication with the population of microbe **(Castro *et al.*, 2009)**.

Review of Literature

Kertesz and Mirleau (2004) the external source is the main reason for the inputs of organo-sulfur into the soil environments. The conversion of inorganic and organic sulfur present in the soil by the catalytic reaction proceeds by the microbial action. The modern molecular techniques are learned about the composition of soil microbial communities. This paper shows how a specific soil species may play a role in soil Organophosphorous cycle. The soil microbes play a vital role in the plant nutrition.

According to Castro *et al.*, (2009), plants and microorganisms have relationships with each other for the growth of plant and microbes. In their paper, they considered four measure classes of signals which have a participation in interactions. They discussed the different challenges like Chemical communication for inter-kingdom signaling is a challenge. Beside it, the further challenge is to determine the role played by phytohormones and other plant-derived metabolites such as NAEs, alkamides, and VOCs in the physiology of microorganisms.

Marinkovic *et al.*, (2012) analyze the location for the presence of microbes and stated that microbial groups are found in all locations and these are uneven because of the types of soil. In their study, N-fixers and fungi were present in the rich quantity at the location of Petrovaradin and Vršacon cambisol, and a small quantity at these location Morovic –on pseudogley.

Massenssini *et al.*, (2014) in their paper studied about the response of cultivated species in artificial environments with human intervention. They observed that the weed has a great interaction with soil microbes in relation to crops. The microbes help in the interaction of weeds and crops that result in the form of the increased competitive ability of different plants that depend on environmental conditions. They suggested in their paper that the management of soil microbial populations should be taken into accounts for the implementation of sustainable agriculture model. Many questions are given about the microbes and their interaction with the plants. According to them, with less human intervention, new agriculture model can be developed that will have greater productivity by the use of great use of soil microorganism in promoting the plant growth.

Asadu, Nwafor, and Chibuike (2015) Studied on three lands (forestland, fallow land, and cultivated land) in southeastern Nigeria to know the role of microorganism in soil fertility. They observed that organic matter and exchangeable Mg are at a high level in forest land. Follow land are rich in nitrogen and exchangeable acidity whereas cultivated land has the high pH, phosphorous and exchangeable bases except for Mg. The cultivated land has the lowest quantity of microorganisms compared to other lands. This observation shows that soil management practices and tillage operation may be the cause of low contribution of microorganisms in soil fertility on cultivated land. While cultivated land has more nutrients compare to others. This means the interrelation exists between the microorganism and nutrients. By the use accurate soil microbial community analysis like culture-independent techniques (phospholipid fatty acid (PLFA) analysis, nucleic acid techniques, phylogenetic analysis, and fluorescent in situ hybridization (FISH)) with the other microbial analyses like microbial biomass, microbial respiration, and enzyme activity can improve the experiment and better result can be gained in the terms of contribution of microorganisms to soil fertility.

Jacoby *et al.*, (2017) try to find out how agricultural system can be sustainable. The use of fertilizers is very harmful because they affect the environment in an adverse way. In their paper, they discussed the plant microbes which possess a vital role in the plant growth. The soil is a major source of these microbes community that is associated with the roots of the plant. The comparative genetic approaches like GWAS are used to determine the plant genes and procedures for controlling how plants shape the rhizospheric microbiome.

Conclusion

The term 'Soil microorganisms' is defined as the microorganism that is developed in the soil in a unique environment. These soil microorganisms have a great value in the growth of plants as they work as a catalyst in the reactions that maintain the number of nutrients (Nitrogen, Potassium, and Phosphorous) in the plants because the excess amount is also harmful to the plant and less amount inhibits the growth of plants. In the same way, plant excrete many organic compounds in the soil that works for the enhancement of microorganisms in soils. By the study of this phenomenon, this paper concluded that this phenomenon can be defined in the cyclic form. Therefore, a relation can be established between plant and soil microorganism.

The use of fertilizers and management of soil for the cultivation disturb this cycle and the amount of pollutant is increasing that cause the low fertility of soil, water pollution and so on. So there is a need for implementing the advanced techniques in which the less use of fertilizers with high productivity can be achieved. More research should be conducted in the field of soil microorganism to find new techniques for increasing of these soil microorganisms.

References:

Anija, Asadu Charles Livinus, et al. "Contributions of Microorganisms to Soil Fertility in Adjacent Forest, Fallow and Cultivated Land Use Types in Nsukka, Nigeria." International Journal of Agriculture and Forestry, vol. 5, no. 3, 2015, pp. 194–204.

Coyne, Mark S., and Robert Mikkelsen. "Soil Microorganisms Contribute to Plant Nutrition and Root Health." Better Crops, vol. 99, 2015, pp. 18–20.

Jacoby, Richard, et al. "The Role of Soil Microorganisms in Plant Mineral Nutrition—Current Knowledge and Future Directions." Frontiers in Plant Science, vol. 8, 2017.

Kertesz, M. A. "The Role of Soil Microbes in Plant Sulphur Nutrition." Journal of Experimental Botany, vol. 55, no. 404, Feb. 2004, pp. 1939–1945.

MARINKOVIĆ, Jelena, et al. "The Distribution of Microorganisms in Different Types of Agricultural Soils in the Vojvodina Province." Research Journal of Agricultural Science, vol. 44, no. 3, 2012, pp. 73–78.

Massenssini, A.m., et al. "Soil Microorganisms and Their Role in the Interactions between Weeds and Crops." Planta Daninha, vol. 32, no. 4, 2014, pp. 873–884.

Mendes, Rodrigo, et al. "The Rhizosphere Microbiome: Significance of Plant Beneficial, Plant Pathogenic, and Human Pathogenic Microorganisms." FEMS Microbiology Reviews, vol. 37, no. 5, 2013, pp. 634–663.

Ortíz-Castro, Randy, et al. "The Role of Microbial Signals in Plant Growth and Development." Plant Signaling & Behavior, vol. 4, no. 8, 2009, pp. 701–712.

Powlson, David S., et al. "The Role of Soil Microorganisms in Soil Organic Matter Conservation in the Tropics." Managing Organic Matter in Tropical Soils: Scope and Limitations, 2001, pp. 41–51.

Seema, Preeti Singh, et al. "The Role of Soil Microbes in Plant Nutrient Availability." International Journal of Current Microbiology and Applied Sciences, vol. 6, no. 2, Oct. 2017, pp. 1444–1449.

Tkacz, A., and P. Poole. "Role of Root Microbiota in Plant Productivity." Journal of Experimental Botany, vol. 66, no. 8, Jan. 2015, pp. 2167–2175.