International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Beneficial Role of Rhizosphere Mycoflora in the Field of Agriculture: An Overview

Prakash Deshmukh, Sheela Shinde

Department of Botany
Late. Shankarrao Gutte Gramin
Arts, Commerce and Science College, Dharmapuri.
Tq. Parrli (V.), Dist. – Beed. Pin-431515 [M.S.]

Abstract: ***Plant rhizosphere soil microorganisms are immersed in a framework of interactions known to affect plant fitness and soil quality. They are involved in fundamental activities that ensure the stability and productivity of both agricultural systems and natural ecosystems. Strategic and applied research has demonstrated that certain co-operative microbial activities can be exploited, as a low-input biotechnology, to help sustainable, environmentally-friendly, agro-technological practices. Much research is addressed at improving understanding of the diversity, dynamics, and significance of rhizosphere microbial populations and their cooperative activities. This paper deals on an analysis of the co-operative microbial activities known to affect plant development is the general aim of this review.***

Keywords: Rhizosphere soil, Rhizosphere Mycoflora, Beneficial, Agriculture, Plant growth etc

1. Introduction

According to a general view, the rhizosphere includes plant roots and the surrounding soil. This is a wide and wise definition, already coined more than hundred years ago by Hiltner in 1904. The rhizosphere inhabiting microorganisms compete for water, nutrients and space and sometimes improve their competitiveness by developing an intimate association with plant **[14]**.These microorganisms play important roles in the growth and ecological fitness of their host. An understanding of the basic principles of rhizosphere microbial ecology, including the function and diversity of microorganisms that reside there, is necessary before soil microbial technology can be applied in the rhizosphere. Here we review different mechanisms commonly used by the beneficial rhizosphere bacteria to influence plant-growth and health in the natural environment.

Fungi, bacteria and actinomycetes are known to colonize diverse habitats and substrates they are known to play substantial role in plant health and productivity besides producing diseases. The specialized ecological niches where the microbial association and their activity amply evidence are soil, rhizosphere, rhizoplane and phylloplane. These microbes may interact with the same plant simultaneously independently, synergistically and/or antagonistically resulting sometimes in beneficial effect and at other times in harmful consequences. The microbes living in the complex region of rhizosphere influence the crop health and yield. The fungal biotechnologists have forgotten that soil, rhizosphere, rhizoplane and phyllosphere are the natural resources for microbial metabolites, products and other of biotechnological importance **[10].**

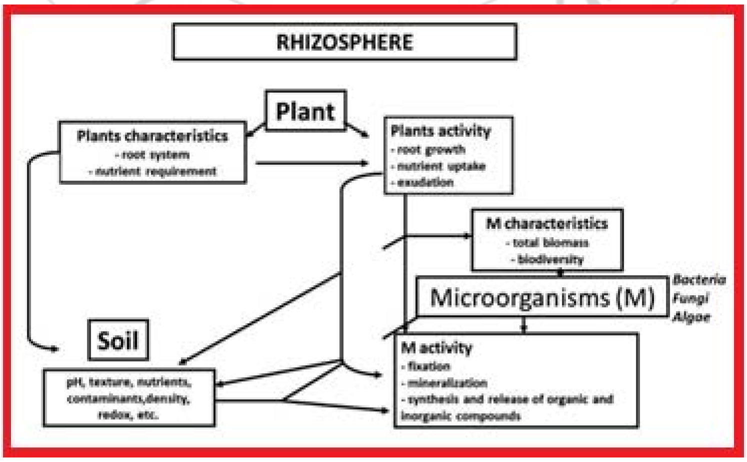

Figure 1: Component present in Rhizosphere soil and Plant Activity

Microorganisms in the soil are in constant state of flux and play an active role in recycling of organic wastes, nitrogen, phosphorus cycle and mineralization and other phenomenon and also produce several metabolites useful for humans. **[1].**

There are three separate interacting components recognized in the rhizosphere i.e., rhizosphere (soil), the rhizoplane, and the root itself. The rhizosphere is the zone of soil influenced by roots through the release of substrates that affect microbial activity. The rhizoplane is the root surface, including the strongly adhering soil particles. The root itself is a part of the system, because certain micro-organisms, the entophytes, are able to colonize root tissues **[4, 18] [Figure 1].** Microbial colonization of the rhizoplane and/or root tissues is known as root colonization, whereas the colonization of the adjacent volume of soil under the influence of the root is known as rhizosphere colonization. The use of molecular techniques to identify micro-organisms is currently a key tool to study rhizosphere ecology **[23]**.

Many studies have demonstrated that soil-borne microbes interact with plant roots and soil constituents at the root–soil interface **[4, 3, 11, 19, 20, and 21].** The great array of root–microbe interactions results in the development of a dynamic environment known as the rhizosphere where microbial communities also interact. The differing physical, chemical, and biological properties of the root-associated soil, compared with those of the root-free bulk soil, are responsible for changes in microbial diversity and for increased numbers and activity of micro-organisms in the rhizosphere micro-environment (Kennedy, 1998).

RhizosphereSoil

The rhizosphere may be defined as that portion of the soil which is adjacent to the root system of a plant and is influenced by the root exudates **[Figure 3]**. The area of this zone depends on the soil type and host plant under study and soil environment conditions. The roots exert influences on various types of microorganisms. The stimulatory effect on microorganisms is known as the "Rhizosphere effect" as indicated by the interaction of soil and rhizosphere microbes and their ratio. The chemical and physical nature of the root zone is quite different from the soil away from the root zone and the biology of this complex zone has been studied extensively **[2, 4][Figure 2]**.

Rhizosphere is a soil ecological region where soil is subjected to specific influence by plant root due to the exudates from root cells and sloughing of root tissue **[5, 12].** The rhizosphere represents a poorly defined zone of soil with a microbiological gradient in which maximum changes in the population of microflora in soil is evident adjacent to root and decline with distance away from it **[29].**

The phenomenon of accumulation of microorganisms around the root zone was reported by a number of earlier workers **[16, 17, 24, 32, and 33]**. Various compounds such as amino acids, vitamins, sugars, tannins etc. are exuded by the roots. Some root exudates are also known to affect certain microbial species adversely leading to their decrease in the root zone and, in return, microorganisms are known to exert profound influence on the plant itself by decomposition, affecting nutrient uptake, antagonistic effect on other microbes and parasitism.

Figure 2: Rhizosphere soil attached on the root of Plant

Factors such as soil type, soil moisture, pH, temperature, plant age, relative humidity and several other factors are known to influence the rhizosphere effect. The rhizosphere effect is expressed in terms of R/S ratio **[17].** The term „rhizoplane was referred to the immediate surface of plant roots together with any closely adhering particles of soil or debris. Using different isolation techniques microorganisms were isolated and identified by a number of workers.

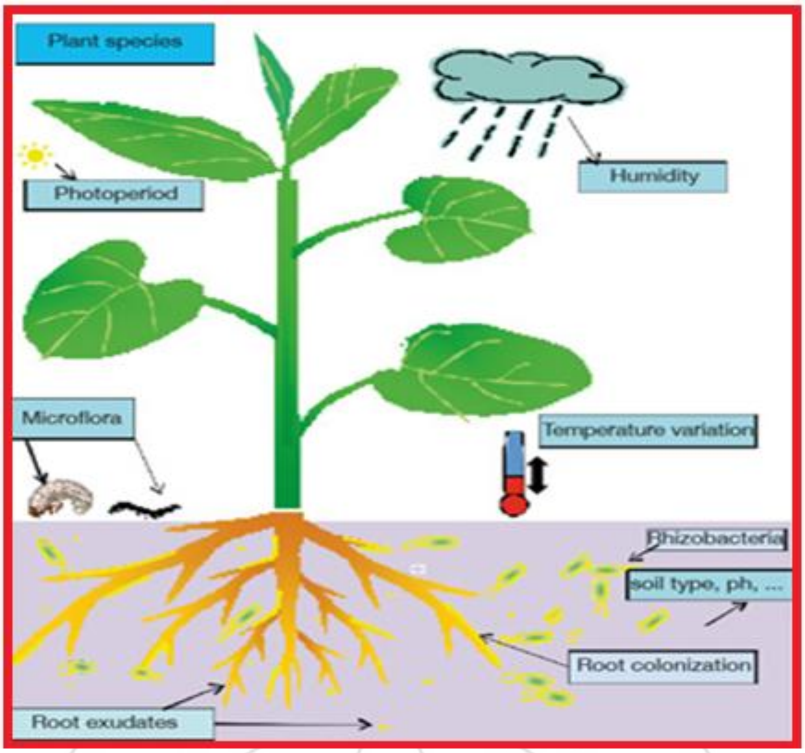

Figure 3: Ecological factors influencing Root Exudation process

Many have emphasized the importance of rhizosphere in plant-microbe interaction **[29]**.It has been documented by several researchers that microorganisms are stimulated in the rhizosphere **[17]**. Significant differences in the rhizosphere effect have also been reported. The metabolic state of the plant and the nature of soil appear to influence the extent of the rhizosphere effect (Rovira 1991). There is a need to learn more about the beneficial rhizosphere microorganisms. Ultimately the work on rhizosphere microbes has to aim at augmenting the biomass production **[36]**.

Rhizosphere studies are fascinating and interesting leading to many beneficial consequences though some microbes have harmful effects. Some microbial metabolites like antibiotics and toxins, are crucial factors in determining plant-microbe relations. Microbial enzymes also play an effective role. The interesting relationship between plant root and microbes has attracted the attention of molecular biologists, microbiologists and biochemists throughout the world. Interestingly different types of microbes like fungi, bacteria, nematodes and viruses may interact with the same plant simultaneously either independently, synergistically or antagonistically **[15]**.

In recent studies on rhizosphere, the emphasis was laid on interactions of microflora in the root zone due to effect of systemic or aerial sprays of herbicides or insecticides or fungicides on rhizosphere microflora. Data on microflora in Relation to various economically important crop plants or medicinal plants, studies on root diseases soil environment and various factors of biotic, edaphic, environmental variations on the rhizosphere microflora and Dynamics of Microorganisms in the rhizosphere are meager. **[24]**.

Using soil biology methods on rhizosphere soils of six different plant species grown in four different soils and combinations of species were studied to get information on organic metabolites and their origin in the rhizosphere. The amounts of sugar, amino acids and enzyme activity of some metabolites suggested a closer interrelationship with the involved organisms. Sometimes the nature of the soil was the dominating factor while it was host plant species which played a major role. Recently plant growth promoting rhizobacteria (PGPR) were isolated from a number of economically important plants such as barley, bean, cotton, maize, groundnut, rice, various vegetables, wheat and wood species. In addition to increasing crop yield the strains of PGPR can also affect pathogenic fungi in reducing population densities **[21]**.

Molecular cross talk seems to be the prerequisite mechanism for most root microbial infections. Just as the rhizodeposition can affect the composition of rhizosphere microflora, microbial metabolites can also affect the rhizosphere deposition. Rhizobacteria promote plant growth due to the production of plant growth regulators like auxin derivatives. The most studied molecular cross talk has been between rhizobia and the leguminous and non-leguminous host plant. The root exudates or chemical composition of rhizosphere solution can affect plant growth. It is very much the case that uptake of nutrients may be considerably influenced by the ionic concentration of the rhizosphere solution. However, we do not have the complete picture that takes into account the relative weight of each factor regarding molecular analysis of the interaction between plants, microbes and soil components **[29]**.

2. Beneficial effect of Rhizosphere Microorganisms in Agriculture

Plant-beneficial microbial interactions can be divided into following three categories.

- Firstly group is the microorganism that, in association with plants, is responsible for its nutrition (*i.e.*, microorganisms that can increase the supply of mineral nutrients to the plant).

- Second group is the microorganisms that stimulate plant growth indirectly by preventing the growth or activity of pathogens. Such microorganisms are referred to as biocontrol agents, and they have been well documented.
- A third group involves those microorganisms responsible for direct growth promotion, for example, by production of phytohormones.

The activity and effects of beneficial rhizosphere microorganisms on plant growth and health are well documented for bacteria belonging to the Proteobacteria (noticeably *Pseudomonas* and *Burkholderia*) and Firmicutes (*Bacillus* and related genera), and for fungi from the Deuteromycetes (e.g. *Trichoderma*, *Gliocladium* and non-pathogenic *F. oxysporum*). In the remainder of this section, these beneficial microorganisms will be referred to as biocontrol microorganisms or biocontrol agents. Biocontrol microorganisms may adversely affect the population density, dynamics (temporal and spatial) and metabolic activities of soilborne pathogens via mainly three types of interactions, which are competition, antagonism and hyperparasitism.). In the case of biocontrol bacteria, production of several antagonistic traits and compounds is subjected to cell-density dependent regulation or quorum sensing **[26,27]**. In addition, competition can in itself be a biocontrol mechanism, often for organic compounds necessary for reactivation of propagules and/or subsequent proliferation and root colonisation by the pathogen **[9, 28, 29, and 34]**.Competition can also take place for micronutrients, especially iron, that are essential for growth and activity of the pathogen. Competition for soluble ferric iron is based on production and/or utilisation of high-affinity chelators termed siderophores **[22]**. Once complexed with iron, siderophores are taken up via specific membrane receptors. Competition for iron as well as competition for carbon are documented as important modes of action for several biocontrol bacteria and fungi **[6,8]** with iron competition being particularly significant in calcareous soils where high pH leads to low iron solubility **[2]**.

In addition to competition and antagonism, direct biocontrol effects on rhizosphere pathogens can result from hyperparasitism. This is mainly documented for *Trichoderma* and *Gliocladium*, and it affects various fungal pathogens, such as *Rhizoctonia*, *Sclerotinia*, *Verticillium* and *Gaeumannomyces* [**13, 14**]. Hyperparasitism by *Trichoderma* involves secretion of chitinases and cellulases, which release small molecules from the target pathogen and trigger chemotropism towards the latter **[37]**. Contact is followed with coiling of hyphae around the hyphae of the pathogen, further enzymatic digestion of its cell wall, and penetration by *Trichoderma* **[7, 35]**. Cell wall damage caused by endochitinases was also shown to play an important role in the activity of *Gliocladium virens* against *Botrytis cinerea* **[6]**. Hyperparasitim enables also the Firmicute *Pasteuria penetrans* to control the plant parasitic nematode *Meloidogyne***[8]**, but the mechanisms involved are still poorly understood.

3. Conclusion

The rhizosphere is the zone of soil surrounding a plant root where the biology and chemistry of the soil are influenced by the root. As plant roots grow through soil they mostly release water soluble compounds such as amino acids, sugars and organic acids that supply food for the microorganisms. High levels of exudates in the rhizosphere attract a plethora of microorganisms to a larger extend than elsewhere in the soil. The composition and pattern of root exudates affect microbial activity and population numbers. Plant species, plant developmental stage and soil type have been indicated as major factors determining the composition of rhizosphere microbial communities As shown in many studies, there is no general decision about the key player: the diversity and predominance of rhizosphere microbial population depend on a number of abiotic and biotic factors of a particular ecological niche.

A better understanding of the basic principles of the rhizosphere ecology, including the function and diversity of inhabiting microorganisms is on the way but further knowledge is necessary to optimize soil microbial technology to the benefit of plant-growth and health in the natural environment. In sum, this can constitute overwhelming evidence indicating that an ever exploitation of plant growth promoting rhizobateria (PGPR) can be a true success story in sustainable agriculture. As a consequence, current production methods in agriculture, *e.g.*, the improper use of chemical pesticides and fertilizers creating a long list of environmental and health problems, will reduce.

References

[1] **Agrios GN (2005),**Plant pathology, 5th edn. Elsevier, New York.

[2] **Alabouvette C, Olivain C, Steinberg C (2006),** Biological control of plant diseases: the European situation. Eur J Plant Pathol 114:329–341

[3] **Barea JM, Werner D, Azco´n-Aguilar C, Azco´n R. 2005b.**Interactions of arbuscular mycorrhiza and nitrogen fixing simbiosis in sustainable agriculture. In: Werner D, Newton WE, eds. Agriculture, forestry, ecology and the environment. The Netherlands: Kluwer Academic Publishers.

[4] **Bowen G. & Rovira A., 1999.** The rhizosphere and its management to improve plant growth. *Adv.Agron*., **66**, 1-102.

[5] **Curl, E. A., Truelove, B. 1986.** *TheRhizosphere.* Berlin/Heidelberg/NewYork/Tokyo: Springer-Vedag

[6] **Di Pietro A, Lorito M, Hayes CK, Broadway RM, Harman GE (1993),**Endochitinase from *Gliocladium virens*: isolation, characterization, and synergistic antifungal activity in combination with gliotoxin. Phytopathol 83:308–313

[7] **Djonović S, Pozo MJ, Kenerley CM (2006),**Tvbgn3 a b-16-glucanase from the biocontrol fungus *Trichoderma virens* is involved in mycoparasitism and control of *Pythium ultimum*. Appl Environ Microbiol 72:7661–7670

[8] **Duponnois R, Bâ AM, Mateille T (1999),**Beneficial effects of *Enterobacter cloacae* and *Pseudomonas mendocina* for biocontrol of *Meloidogyne incognita*

with the endospore-forming bacterium *Pasteuria penetrans*. J Nematol 1:95–101

[9] **Fravel D, Olivain C, Alabouvette C (2003)**. *Fusarium oxysporum* and its biocontrol. New Phytol 157:493–502

[10] **Gerretsen, F. C. 1948.** The influence of microorganisms on the phosphate intake by the plant. Plant and Soil 1:51-81.

[11] **Glick B.R. 1995.** The enhancement of plant growth by free-livingbacteria. Canadian Journal of Microbiology 41, 109–117.

[12] **Harley, J.L. and Smith S.E, 1983**. Mycorrhizal Symbiosis.London /New York, Academic Press.

[13] **Harman GE, Petzoldt R, Comis A, Chen J (2004),** Interactions between *Trichoderma harzianum* strain T22 and maize inbred line Mo17 and effects of these interactions on diseases caused by *Pythium ultimum* and *Colletotrichum graminicola*. Phytopathol 94:147–153

[14] **Hartmann A., Schmid M., van Tuinen D. & Berg G., 2009.** Plant-driven selection of microbes. *PlantSoil*, **321**, 235-257.

[15] **Hiltner L., 1904.** Über neuere Erfahrungen und Probleme auf dem Gebiete der Bodenbakteriologie unter besonderer Berücksichtigung der Gründüngung und Brache. *Arb. Dtsch. Landwirtsch. Ges*., **98**, 59-78.

[16] **Jackson R.M. 1960.** Soil fungistatis and the rhizosphere.In.D. Parkinson and J.S.Waid (Editors). Ecology of Fungi. University of Liverpool Press,168-181.

[17] **Katznelson, H., Lochhead, A.G., and Timonin, M.I., 1948.** Soil Microorganisms and the Rhizosphere, Bot. Rev. 14: 543.

[18] **Kennedy AC. 1998.** The rhizosphere and spermosphere. In: Sylvia DM, Fuhrmann JJ, Hartel PG, Zuberer DA, eds. Principles and applications of soil microbiology. Upper Saddle River, New Jersey: Prentice Hall, 389–407.

[19] **Linderman RG. 1992.** Vesicular–arbuscular mycorrhizae and soilmicrobial interactions. In: Bethlenfalvay GJ, Linderman RG, eds.Mycorrhizae in sustainable agriculture. Madison, Wisconsin:ASA Special Publication, 45–70

[20] **Lynch J (1990),**The rhizosphere. Wiley, London, UK, p 458

[21] **Lynch,J. M.1982,** Interactions betweenbacteria and plants in the root environment. In *Bacteria andPlants, Soc. Appl.Bacteriol. Symp. Set. 10,* ed. M. E.Rhodes-Roberts, F. A. Skinner, pp. 1-23. London: Academic

[22] **Neilands, J.B. (1981).** Microbial iron compounds. *Annul. Rev. Biochem*., 50: 715-731.

[23] **O'Gara F, Dowling DN, Boesten B. 1994.** Molecular ecology of rhizosphere micro-organisms. Weinheim, Germany: VCH, 173. Okon Y. 1994. Azospirillum/plant associations. Boca Raton, FL, USA: CRC Press.

[24] **Parkinson, G., Taylor G. S., and Pearson, R.,** 1963. Studies on fungi in the root region. The development of fungi on the root surfaces of crop plants Pl. Soil. 19:332-349.

[25] **Paulitz TC, Anas O, Fernando DG (1992).** Biological control of Pythium damping-off by seed treatment with *Pseudomonas putida*: relationship with ethanol production by pea and soybean seeds. Biocontrol Sci Technol 2:193–201

[26] **Pierson LS III, Pierson EA (2007).** Roles of diffusible signals in communication among plant-associated bacteria. Phytopathol 97:227–232

[27] **Pierson LS III, Wood DW, Pierson EA (1998),** Homoserine lactone-mediated gene regulation in plant-associated bacteria. Ann Rev Phytopathol 36:207–25

[28] **Pinton, R., Varanini, Z. and Nannipieri, P., 2001.** The Rhizosphere:Biodiversity and Organic Substances at the Soil–Plant Interface,*Marcel Dekker, New York.*

[29] **Pinton R., Veranini Z. & Nannipieri P., 2007.***The rhizosphere. Biochemistry and organic substances at the soil-plant interface*. New York, USA: Taylor & Francis Group, LLC. *Review of Microbiology* 19: 241-266.

[30] **Rao, N. S. 1992**. Biofertilizers in agriculture. Rotterdam: AA Balkema. 188 p.

[31] **Rovira, A. D.,** 1965. Interactions between plant roots and soil microorganisms. *Annual*

[32] **Sadashivan, S., and Manickam, A.,** 1997. Biochemical methods II[nd] edition published by new Age international publisher.

[33] **Starkey, R.L.,** 1958. Bacterial Rev. 22:154.

[34] **Van Dijk K, Nelson EB (2000),** Fatty acid competition as a mechanism by which *Enterobacter cloacae* suppresses *Pythium ultimum* sporangium germination and damping-off. Appl Environ Microbiol 66:5340–5347

[35] **Woo SL, Scala F, Ruocco M, Lorito M (2006),** The molecular biology of the interactions between *Trichoderma* spp. phytopathogenic fungi and plants. Phytopathol 96:181–185.

[36] **Yang C.-H. & Crowley D.E., 2000.** Rhizosphere microbial community structure in relation to root location and plant iron nutritional status. *Appl. Environ. Microbiol*., **66**, 345-351.

[37] **Zeilinger S, Galhaup C, Payer K, Woo SL, Mach RL, Fekete C, Lorito M, Kubicek CP (1999)** Chitinase gene expression during mycoparasitic interaction of *Trichoderma harzianum* with its host. Fungal Genet Biol 26:131–140.