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Ecology of rhizosphere mycoflora in organic matter amended soil: A review

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Abstract
The root surface itself and the rhizosphere may be used in studying the rhizosphere phenomenon, since they are more sensitive index of the specific qualitative effects of roots on soil microorganisms. They influence the greater number and activity of soil micro-organisms in that region. It has become evident that the metabolic activities of the microbes in the root region are of vital importance for the development of the plant. It was observed that the root microflora exerts a beneficial effect on plant growth. The decomposition of the organic matter helps in alternation of the physical, chemical and biotic conditions of the soil. The altered conditions reduce the inoculum potential of the pathogens. In addition, it improves soil structures which promotes root growth of the host and also used as alternate strategy for management of soil borne pathogens.

Keywords: Rhizosphere, soil, mycoflora, organic amendment

Introduction
Hiltner (1904) [6] first used the term rhizosphere to describe that part of the soil in which roots generally induce a proliferation of microorganisms. Since then, many studies, both qualitative and quantitative have been carried out and it has become evident that the metabolic activities of the microbes in the root region are vital importance for the development of the plant. The rhizosphere phenomenon has been reviewed and its salient features described earlier (Starkey, 1958; Lochhead, 1959; Katznelson, 1961) [17, 10, 9]. It is always important to consider the antagonistic and associative biotic events occurring in the rhizosphere and how they may be influenced to create an environment that is unfavourable for a pathogen. The rhizosphere effect is the resultant of two major forces – the plant root and the microorganisms that grow on and around it.

Nature of the rhizosphere effect
The primary biological fact of the rhizosphere or zone of root influence is the greater number and activity of soil micro-organisms in this region than in root – free soil. It is generally accepted that the term rhizosphere soil refers to the thin layer adhering to a root after the loose soil and clumps have been removed by shaking. The rhizosphere offers a distinct advantage in study of root fungi in that vegetatively active forms rather than rapidly sporing types may be isolated and studied (Warcup, 1960) [21].
Different seed borne and soil borne mycoflora cause various types of damage to seeds and seedlings under congenial condition in storage and field. Many other microorganisms are also associated with the seeds which although may not be pathogenic to the host and play an important role in seed germination, plant stand and initial health of the plant.
Seed, soil and plant treatments with different chemicals are usual practices in the control of soil borne as well as seed borne plant pathogens that cause seedling blights, seed decays or other diseases. All these type of treatments have their influences in the rhizosphere population. In recent time, attention has been paid to the role of rhizosphere population in disease development. Root exudation has an important role on the qualitative and quantitative nature of rhizosphere mycoflora. This is called rhizosphere effect. Legume supports larger rhizosphere population than non-legume. According to most of the relevant literature, the rhizosphere effect starts to increase just after germination, reaches its peak during flowering and fruiting and then declines sharply as root senescence begins.

Interaction of rhizosphere organisms

Once the root has began to exert its influence on the microbial population of the soil, a multiplicity of associative and antagonistic interactions occur which complicate the entire rhizosphere picture. The root exudates of crop plants have immense role in the development of rhizosphere microflora and in disease control (Funck-Jensen and Hocken Hall, 1984) [4]. Roots provide energy and nutrients for microorganisms in the rhizosphere. The rate of exudation is influenced by age of the root, environmental factors, cultural factors and the presence of micro-organisms. Root exudates may contain compounds which especially influence processes such as spore germination etc. Difference in the exudates composition between resistant and susceptible cultivars have been found. Such difference may lead to change in the composition of microflora in the rhizosphere. Resistant cultivars have been noted to support greater population of antagonistic microorganisms than the susceptible cultivars. Plant genotypes have been shown to be of importance in this respect and the deliberate selection of resistant cultivars on the basis of root exudation, is a possibility worthy of serious consideration. The increased rhizosphere effect during active plant growth and the enhancement of this effect as the root is approached, indicate that it exerts a continuing influence. This, however, is modified microbial interactions which are intensified by the dense population in this zone.

Importance of the rhizosphere phenomenon

Phytohormones play an important role for enhancement of plant growth in a direct way. It produces indole-acetic acid, cytokinins, gibberellins and ethylene. Indole-3-acetic acid is known to be involved in root initiation, cell division, and cell enlargement (Salisbury, 1994) [14]. It was observed that the root microflora exerts a beneficial effect on plant growth by increased amount of microbial CO_2 in the root zone, more solubilisation of mineral nutrients, synthesis of vitamins, amino acids, auxins and gibberellins which may stimulate the plant and of antibiotics, which will protect it, and so on. Soil organisms in general effect transformations of organic and inorganic materials with production of CO_2 and liberation of ammonia, minerals and organic substances on the one hand and with consumption of CO_2, denitrification, immobilization of nitrogenous materials and of minerals etc. on the other.

Organic amendment in soil

One of the cheapest and effective methods of alteration of soil environment is amendment of soil with decomposable organic matter. This has been considered as one of the methods of biological control of plant diseases. The materials used in amendments include dry or green crop residues (including green manure crops), oil cakes, meals, saw dust, wood shavings, compost etc. These materials are allowed to decompose in the field itself where the pathogen is supposed to be present. The decomposition of the organic matter helps in alternation of the physical, chemical and biotic conditions of the soil (Hulugalle *et. al.,* 1986) [8]. The altered conditions reduce the inoculum potential of the pathogens. In addition, it improves soil structures which promotes root growth of the host. Various bio-chemicals are released during decomposition, which may include antibiotics and phenols released by decomposition of lignin- containing materials, increase disease resistance on the root surface as well as in the tissues when absorbed. Completely decomposed material ultimately serves as nutrient for the plant and favourably affects the yield. Fungi participate in decomposition of organic matter and deliver nutrients for plant growth. Their role is very important in plant protection against pathogenic microorganisms as biological agents, which influences soil health (Frąc *et. al.*, 2015) [3].

The application of organic amendments has been proposed as a strategy for the management of diseases caused by soil-borne pathogens (Shafique *et. al.,* 2015; Hoitink and Boehm, 1999) [15, 7]. There are many examples of soil borne pathogens controlled effectively by the application of organic amendments: like *Gaeumannomyces graminis* f. sp. *tritici*, *M. phaseolina*, *R. solani*, *Thielaviopsis basicola*, *Verticillium dahliae*, *Sclerotinia sclerotiorum*, Streptomyces scabies species of *Fusarium*, *Phytophthora*, *Pythium* and *Sclerotium* (Bonanomi *et. al.,* 2007; Gupta *et. al.,* 1986; Singh, 1983; Mandal and Pal, 2015) [1, 5, 16, 11].

Neem (*Azadirachta indica*) seed cake, when added to the soil, not only improves the soil with organic matter, but also lowers nitrogen losses by inhibiting nitrification. The material left after oil is squeezed out from seeds and is popularly known as the seed cake; it acts as a bio fertilizer and helps in providing the required nutrients to plants. It is widely used to ensure a high yield of crops. Neem is used as a fertilizer both for food crops and cash crops, particularly rice and sugarcane crop. Neem seed cake performs the dual function of both fertilizer and pesticide, acts as a soil enricher, reduces the growth of soil pest and bacteria, provides macro nutrients essential for all plant growth, helps to increase the yield of plants in the long run and is bio degradable, eco-friendly and excellent soil conditioner (Subbalakshmi *et. al*., 2012) [18].

Among the four oil cakes (ground nut, mustard, sesamum and *binola*/cotton seed), groundnut and mustard at 2 per cent concentration of soil (w/w) were most effective in reducing pathogen population (>70%) and disease incidence. However, groundnut cake was found superior to mustard as it not only reduced higher disease index (77.1%) but improved plant growth also (Raj and Kapoor, 1996) [13].

FYM is partially composed of dung, urine, straw etc. Dung comes mostly as undigested material and the urine from the digested material. More than 50 percent of the organic matter that is present in dung is in the form of complex products consisting lignin and protein which are resistant to further decomposition and therefore the nutrients present in dung are released very slowly. The nutrients from urine, becomes readily available. FYM contains approximately 5 - 6 kg nitrogen, 1.2 - 2.0 kg phosphorus and 5 - 6 kg potash per tonne (Chandra, 2005) [2].

Vermicompost has also been found to have a wide range of indirect effects on plant growth such as the mitigation or suppression of plant diseases. Suppression of plant diseases has been extensively investigated in other organic amendments such as manure and compost (Noble and Coventry, 2005) [12]. Likewise, some studies have shown that vermicompost can suppress a wide range of microbial diseases, insect pests and plant parasitic nematodes. The addition of solid vermicompost to tomato seeds significantly reduced infection caused by *Fusarium lycopersici* (Szczech, 1999) [20] and *Phytophthora nicotianae* (Szczech and Smolinska, 2001) [19].

Conclusion

The study of rhizosphere is essential for a critical evaluation of the biological environment in which the pathogen is to act and may be helpful in designing suitable control measures particularly for soil borne plant pathogens. From the many experiments a common fact emerges: reduction in the activity of a pathogen is often correlated with an increase in the population of antagonistic microorganism as assessed in the soil. Thus, this correlation suggests the role of antagonists in biological control and advocates their use to eliminate pathogens in the soil. Soil amendment with organic and inorganic materials is also play an important role for suppression of the pathogen.

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