

ROLE OF SOIL FLORA IN SOIL PHYSICAL CONDITION IMPROVEMENT AND THEIR IMPACT ON PLANT GROWTH

Rakesh Giri Goswami ^{1*}, Ashish Kumar Singh² and Thaneshwar Kumar³

^{1&2} Department of Soil Science and Agricultural Chemistry

³Department of Soil Science and Agricultural Chemistry

Indira Gandhi Agricultural University, Raipur -492012 (C.G), INDIA

*Email : rakeshgoswami57@gmail.com

Received-09.01.2015, Revised-18.01.2015

Abstracts: Soil physically supports plants, and acts as a reservoir for storing the water and nutrients required for the plants. Good physical condition facilitates oxygen and water infiltration and can improve water storage, increasing fertilizer use efficiency in plants, ultimately, improves productivity of soil. The soil is teeming with millions of living organisms which make it a living and a dynamic system. These organisms not only help in the improvement of soil physical condition but also carry out a number of transformations, facilitating the availability of nutrients to the plants.

Keywords: Soil, Plant growth, Nutrient

INTRODUCTION

Soil physically supports plant and acts as a reservoir for storing the water and nutrients required by the plants. Soils are complex mixtures of mineral particles of various shape and size; living and dead organic materials including microorganisms, roots, plant and animal residues; air and water (Fig. 1). The physical condition of the soil plays a large role in influencing the nature of biological and chemical reactions. Physical, chemical, and biological reactions occur in the soil continuously and are closely interrelated. The physical form of the soil plays a large role in influencing the nature of biological and chemical reactions. The discussion of soil physical environment begins with the sizes (texture) and arrangements (structure) of individual soil particles. These two characteristics intimately affect the pore space between the particles. The pore space is important as the conveyor of water, dissolved mineral nutrients, and air, as well as for providing space in which roots can grow. Finally, it is important to consider the whole soil mass, and how it changes with depth below the surface. The soil is teeming with millions of living organisms which make it a

living and a dynamic system. These organisms not only help in the improvement of soil physical condition but also carry out a number of transformations, facilitating the availability of nutrients to the plants. The rationale for the use of microbial and biochemical characteristics as soil quality indicators is their central role in cycling of C and N and their sensitivity to change (Nannipieri et al., 1990).

Soil macroflora (plant roots) create voids and macropores in the soil so that air and water can move through the soil. They roots supply food for microorganisms and burrowing soil fauna that also keep the soil from compaction. Bulk density can be increased from 12 to 35% compared with that of the bulk soil due to compressing action of growing root. However, organic residues left behind by the decaying plants are lighter and less dense than clay, silt, and sand particles decreasing the average soil density. Soil microflora plays an important role in improving soil physical condition which can be manifested by aggregate stability, because the size, arrangement and stability of aggregates have a wide influence on soil physical properties and plant growth.

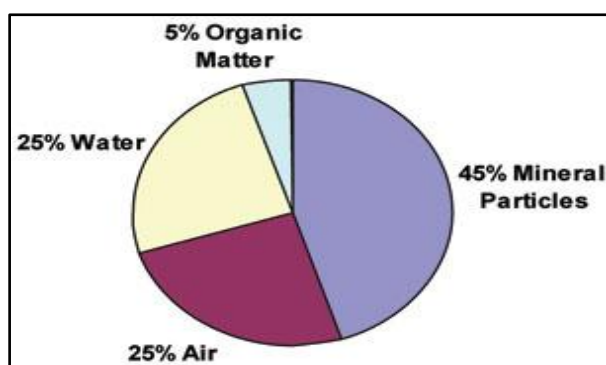


Fig. I: Soil as a three phase system

*Corresponding Author

Bacteria are involved in micro aggregate stabilization of soil particles, while fungi are involved in binding together larger soil particles and aggregate stabilization.

Therefore, soil organisms play very important role in soil physical condition improvement which affects plant growth by influencing root distribution and the ability to take up water and nutrients. Good physical condition facilitates oxygen and water infiltration and can improve water storage, increasing fertilizer use efficiency in plants, ultimately, improves productivity of soil.

Impact of soil organisms on soil physical conditions

A. Soil physical conditions as influenced by soil macroflora

B. Soil physical conditions as influenced by soil microflora

A. Soil physical conditions as influenced by soil macroflora

Root rhizosphere related processes affecting soil physical condition can be grouped into five categories:

- a) Root penetration
- b) Changed soil-water regimes
- c) Root exudation
- d) Dead root decomposition
- e) Root entanglement

a) Root penetration

The compressing action of growing roots decreases soil porosity in the zone between roots and reorientates clay particles along the root surface. Near the root surfaces, bulk density can be increased from 12 to 35% compared with that of the bulk soil. According to Dorioz these modifications occur mostly within a 50—200 μ m zone around the roots, inducing the formation of micro aggregates. In contrast, a decrease in macro aggregation after plant growth is partially due to the penetrating effect of roots into macrospores'. Also found that, even at constant water potentials, roots decreased the proportions of already formed large water stable aggregates by 20—50%.

b) Changed soil-water regimes

Plant roots also influence aggregation through modifying the soil water status in several ways. First, water uptake by plant causes a localized drying of the soil, which promotes the binding of root exudates on clay particles. Second, root exudation reduces the wetting rate by occluding pores or increasing pore tortuosity, thereby reducing slaking of aggregates. Third, water flows preferentially along living roots due to the presence of a saturated film of water along the roots.

c) Root exudation

As plant roots release organic material within the rhizosphere (rhizodeposition), they directly and indirectly affect soil physical condition. Mucilages produced by roots may stick soil particles directly together. Root mucilage such as polygalacturonic acid may stabilize aggregates by increasing bond strength. Roots can also alter the ionic and osmotic balance in the rhizosphere through nutrient uptake and rhizodeposition, which can affect aggregation. The degree of influence by roots on soil structure through root exudation is very variable as production and composition of mucilage's depend on various factors such as water regime, plant species, soil depth and time.

d) Dead root decomposition

During the decomposition of dead roots, soil structure will be promoted, resulting in improvement of soil physical condition, by increasing organic matter soil microbial activity, then decreasing bulk density, compaction thereby increasing soil porosity, water holding capacity or its availability and ultimately, increasing crop productivity.

e) Root entanglement

The entanglement of particles by roots to form and stabilize macro aggregates. However, it is difficult to separate the influence of entanglement versus exudation by roots. In addition, arbuscular mycorrhizal (AM) fungi are often associated with root systems, further complicating the separation of the effects of roots versus AM fungi and their exudates.

B. Soil Physical Conditions as Influenced By Soil Microflora

Soil microflora plays an important role in improving soil physical condition which can be manifested by aggregate stability, because the size, arrangement and stability of aggregates have a wide influence on soil physical properties and plant growth. Microbial and biochemical characteristics are used as potential indicators of soil quality, even if soil quality depends on a complex of physical, chemical and biological properties.

What is aggregate?

A soil aggregate can be defined as “a naturally occurring cluster or group of soil particles in which the forces holding the particles together are much stronger than the forces between adjacent aggregates”.

Why is stable aggregate necessary?

The importance of soil aggregation in crop production lies in its effect on water and air relationships in soil. The size, shape, and stability of soil aggregates control the pore size distribution, which in turn affects many soil physical properties.

How is microflora involved in soil aggregation two major ways?

1. Mechanical binding of soil particles.
2. Influence of microbial product.

Mechanical binding of soil particles

Some organisms may be able to mechanically bind soil particles together. The improvement of soil physical conditions brought about by the addition of organic matter, but organic matter additions have no effect unless soil organisms are present. Bacteria are involved in microaggregate stabilization of soil particles, while fungi are involved in binding together larger soil particles i.e., macroaggregate. The role of fungi may be considered as both aggregate forming and aggregate stabilizing. By ramifying through the fungal hyphae may bring soil particle together and force their contact with binding agents. Lichens and algae also formed surface crusts in sand through mucilaginous sheaths. In low rainfall areas, it was observed that the crust of sand were interwoven with algal filaments that had bacteria and fungi associates with them. Jastrow and Miller suggested that the soil micro flora involved if soil aggregation in several ways (Fig.2). They reported that Microaggregates are 20—250 μm in size and are composed of clay microstructures, silt-size microaggregates, particulate organic matter, plant and fungus debris, and mycorrhizal fungus hyphae: these particles are stable in size. Roots and microbes

combine microaggregates in the soil to form macro aggregates.

Influence of microbial product

Others may produce effective binding agents either by synthesis or through the decomposition of organic materials. These products may remain in close contact with the cell or becomes part of the pool of soil organic matter and subjected to decomposition. Microbial product may be freshly synthesized by soil microorganisms or may be produced after the decomposition of plant residues and other tissues. The end product of decomposition is humus, a dark coloured, heterogeneous colloidal mixture. The humic colloids include polysaccharides, proteins having a large numbers of aromatic rings. Among the various product, polysaccharides were the main factor responsible for aggregate stabilization. Microflora in a soil form part of the biomass and contributes to the reserve of soil nutrients and is generally referred to as the microbial biomass.

Mechanisms involved in binding processes

Soil micro flora involved in aggregate formation mainly through the following three mechanisms.

Polysaccharides produced by microorganisms may absorb to soil surfaces:

By themselves absorbing to soil particles, microorganisms may bind soil particles.

Groups of microorganisms may interact with each other or with root to stabilize aggregate.

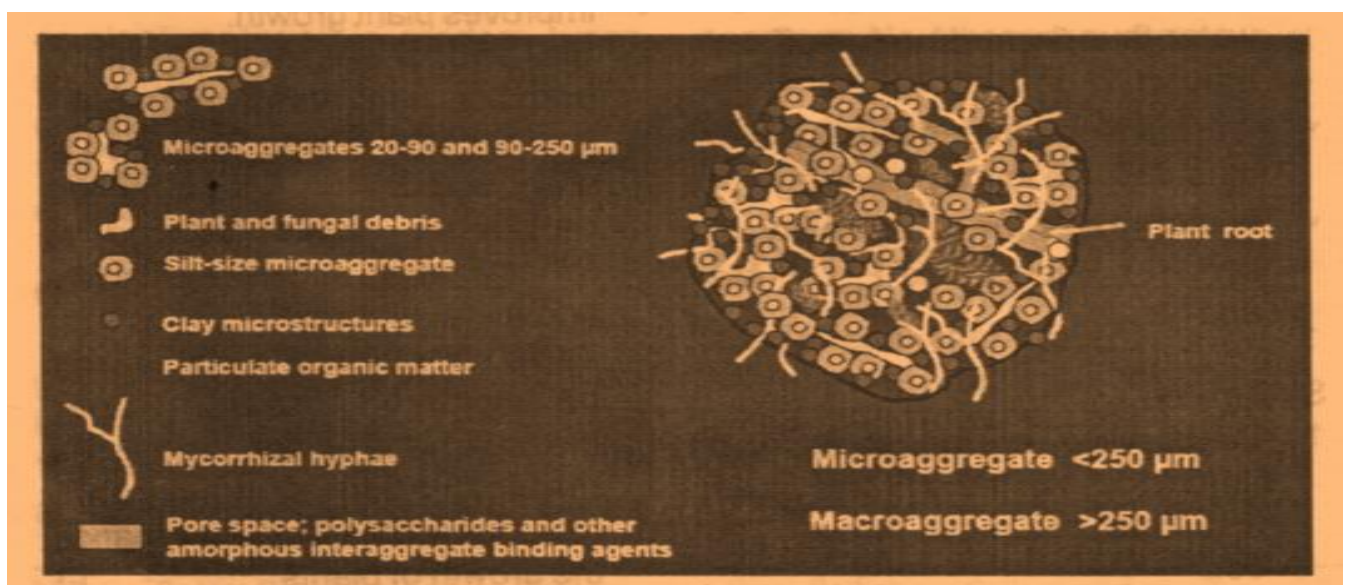


Fig. 2: Mechanism of macroaggregate and micro aggregate form atili

The first two are leading to formation of microaggregates and the third leading to a higher level of organization.

a) Binding activity of polysaccharides:

Martin (1971) summarized the binding activity of polysaccharides as being due to —

The length and linear structure of polysaccharides allow them to bridge spaces between soil particles. Their flexibility, allowing many points of contact so that van der Waals forces can be more effective. The number of acid groups present, allowing ionic bonding through di- and trivalent ions.

b) Adsorption of cells to soil surfaces

There are three interactions between microorganisms and soil particles:

1. Sorption between microorganisms and surfaces of large soil particles.
2. Sportive interactions between cells and soil particles of smaller size.
3. Sorption of very small particles to surfaces of microorganisms.

c) Interactions between groups of microorganisms with roots

The stability of aggregates produced by bacteria increased in the presence of fungi and actinomycetes. The presence of fungi, possibly arbuscular mycorrhiza and saprophytic fungi are the most important microorganism which could mechanically bind soil particles together, with stabilization being enhanced by polymers produced by bacteria associated with the hyphae. Bacteria at the root surface would be in an ideal position to utilize root residues to produce effective soil binding agents. These microorganisms help combine soil particles into stable aggregates around plant roots.

Soil physical conditions as influenced by soil mycorrhizal fungi

The contribution of mycorrhizal fungi to aggregation is a simultaneous process involving four steps (Fig.3):

1. The fungus hyphae form an entanglement with primary soil particles, organizing and bringing them together.

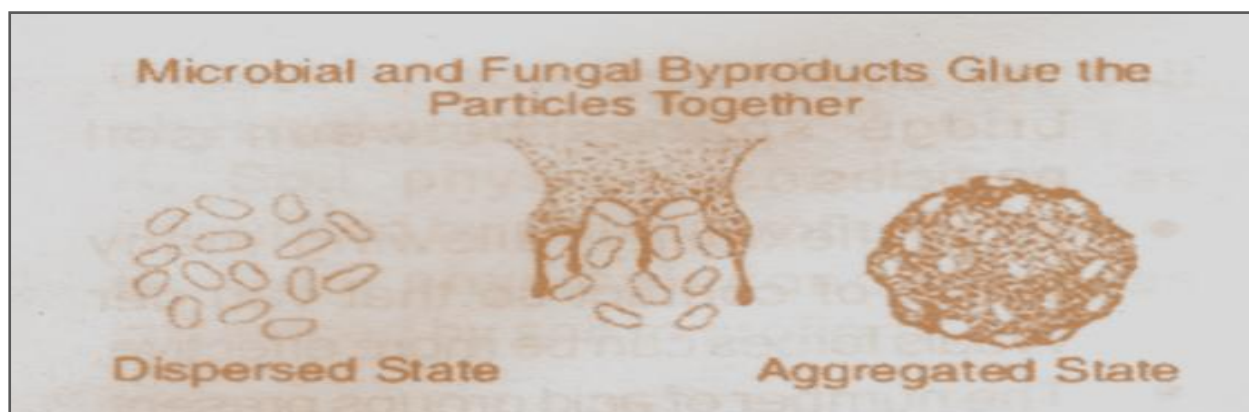


Fig. 3: how are aggregates formed?

2. Fungi physically protect the clay particles and the organic debris that form micro aggregates.
3. The plant root and glomalin formed by fungal hyphae glue micro aggregates and some

Smaller macro aggregates together to form larger macro aggregates.

4. The fungal “root-hyphae-net” holds the aggregates intact and clay particles protect the roots and hyphae from attack by microorganisms. Roots also create other Polysaccharide. Exudates to coat soil particles.

Role of Glomalin

Glomalin is an amino polysaccharide or glycoprotein created by combining a protein from the mycorrhizal fungus.

It is present in soils at high concentrations and is an important factor in stabilizing aggregates, possibly due to its recalcitrant nature and high concentration in some soils and may protect other aggregating agents.

Glomalin initially coats the plant roots and then coats soil particles.

Glomalin acts like a glue to cement micro aggregates together to form macro aggregates and improve soil structure.

Management for improving soil microbial activity

Microbial activity can be increased by-

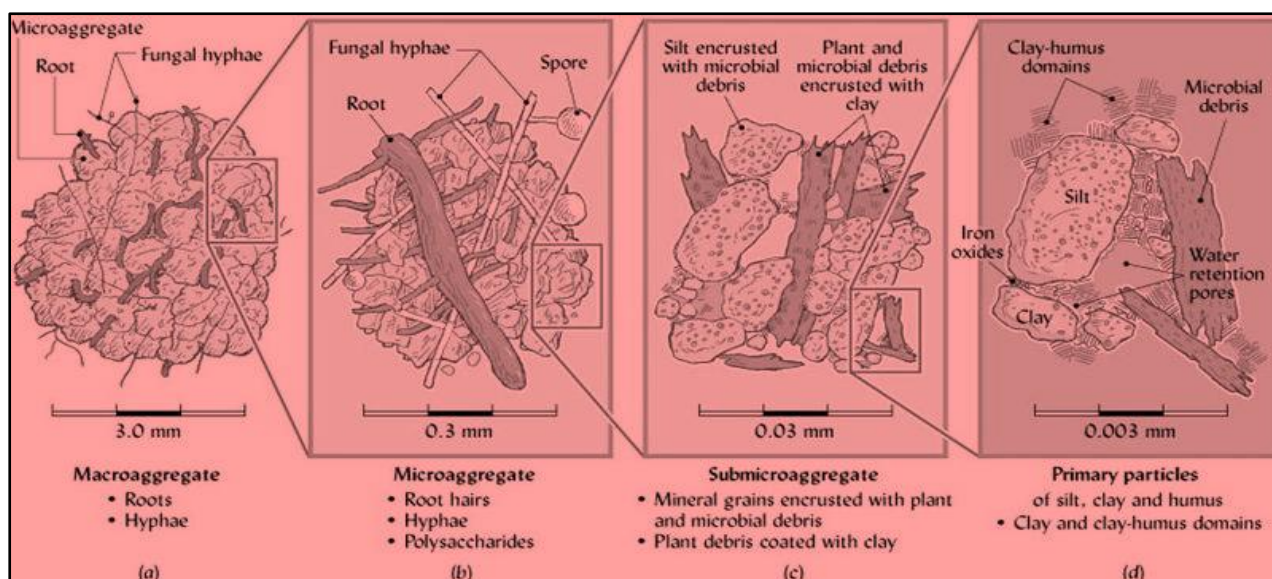


Fig. 4: Macroaggregate model and hierarchy

Application of farm yard manure (FYM), because it causes

The application of FYM increases the percentages of organic matter nutrient levels (providing a slow fertilization action over a long period of time), microbial biomass and improves the soils' physical properties (aeration, water holding capacity, etc.) Bertran *et al.* 2004.

Improvement of soil structure Improvement of water holding capacity.

Improvement of in soil aeration buffering of soil surface temperature.

Reduction of soil losses due to erosion.

Green manuring (GM)

Should be included in cultural practices as it enhances

It adds organic matter to soil. This stimulates the activity of soil microorganisms.

It improves the structure of the soil.

It facilitates the penetration of rain water thus decreasing run-off and erosion.

It holds plant nutrients that would otherwise be lost by leaching.

It increases the availability of certain nutrients, like P, Ca, Mg and Fe.

The soil microbial population is closely associated with organic matter of soil. Immediately after incorporation into soil, plant materials are subjected to the transformation and decomposition process of heterotrophic microflora (Negi *et al.*, 1986, 1987; Rauhe, 1987; Singh and Singh, 1993; Tilak *et al.*, 1995).

Summary

Plant roots create voids and microspores in the soil so that air and water can move through the soil.

Plant roots supply food for microorganisms (especially fungus) and burrowing soil fauna that also keep the soil from compaction.

Organic residues left behind by the decaying plants are lighter and less dense than clay, silt, and sand particles which ultimately, decrease the average soil density.

Soil microflora improves the soil physical condition through contributing to the aggregation of soil particles thereby enhancing cycling of nutrients and their availability to plants and finally improves plant growth.

Soil fauna improve aeration, porosity, infiltration, aggregate stability, litter mixing, improved N and C stabilization, C turnover and carbonate reduction and N mineralization, nutrient availability and metal mobility.

Thus, soil physical condition can be improved through proper management of soil organism through addition of organic manures which ultimately enhance the growth of plants.

REFERENCES

- Bertran, E., Sort, X., Soliva, M., and Trillas, I. (2004). Composting Winery Waste: Sludges and Grape Stalks, *Bioresource Technol*, **95**, 203-208.
- Nannipieri P, Grego S, Ceccanti B (1990). Ecological significance of the biological activity in soil. In: Bollag J-M, Stotzky G (eds) *Soil biochemistry*, vol 6. Dekker, New York, pp 293-355.
- Negi, M., Sadasivam, K. V. and Tilak, K. V. B. R. (1987). A note on the effect of nonsymbiotic nitrogen fixers and organic wastes on yield and nitrogen uptake of barley; *Biological Wastes*; 22:179-185.
- Rauhe, K. (1987). Effects of organic manuring and cropping on soil humus and fertility; in: *Agricultural Waste Management and Environmental Protection*,

edited by Walte, E. and Szaboles, I.; 4th International CIEC Symposium Proceedings, International Science Centre of Fertilizers, Belgrade.

Singh, H. and Singh, K. P. (1993). Effect of residue placement and chemical fertilizer in soil microbial

biomass under tropical dry land cultivation; *Biology and Fertility of Soils*; 16:275–281; 1993.

Tilak, K. V. B. R., Saxena, A. K. and Datt, N. (1995). Dynamics of microbes in agricultural soil with different management practices; *Journal of Soil Biology and Ecology*; 15:117–126.