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Soil Physical and Chemical Properties in Relation to Plant Growth

S. Arunkumar
Ph.D. Scholar, Department of Soil Science and Agricultural Chemistry, School of Agriculture, Lovely Professional University, Jalandhar, Punjab

SUMMARY

Soil is a dynamic natural body developed as a result of pedogenic processes through weathering of rocks, consisting of mineral and organic constituents, possessing definite chemical, physical, mineralogical and biological properties, having a variable depth over the surface of the earth, and providing a medium for plant growth (Velayutham and Bhattacharyya, 2000). Soil supports terrestrial life through five processes like biomass productivity, restoration and resilience of ecosystems, purification of water, detoxification of pollutants, and cycling of C, N, P, S, and H2O.

INTRODUCTION

The natural resources of any country are the national treasure and there is need for proper planning to make best use of them. Soil resources of the world are finite, easily degraded by misuse and mismanagement, nonrenewable over the human time frame, and shrinking because of degradation and conversion to nonagricultural uses (Lal, 1998). Most of these degradative processes are more severe in the tropics than in the temperate climate, in marginal rather than prime agricultural lands, and in resource-based and subsistence agriculture rather than science-based or commercial farming (Brady, 1998). There is need of judicious and scientific management of soil resources. Degraded soils and ecosystems must be ameliorated, and the depleted organic carbon pool restored so that soil can respond to the use of yield –enhancing input (e.g., fertilizers, improved varieties) and can meet the current and future food demand.

Soil Properties in relation to plant growth

Physical properties

The physical properties of a soil are important since they determine the manner in which it can be used either for agricultural and non-agricultural purposes. Properties viz. infiltration rate, water-holding capacity, permeability, aeration, plasticity and nutrient-supplying ability, are influenced by the size, proportion, arrangement and mineral composition of the soil particles

Particle shape and size: The soil particles differ in shape like spherical to angular. They differ in size also from gravel (>2mm) and sand (2-0.02mm) to fine clay (<0.002mm). The International System is commonly used to designate textures while the USDA system in used for classifying soils according to Soil Taxonomy which is officially used for grouping soils in the soil-survey organizations all over India.

Colours: Colour of soil is probably the first soil property for the human perception. Even today soil is described by its colour, such as black, red and yellow soil. A soil attains certain colour depending on pedo-chemical reactions. For example, different degrees of oxidation, hydration and diffusion of iron oxides in the soils may bring either red, yellow or brown colour.

Density: Larger particles in soils are heavier in weight per unit volume than the smaller particles. Particle density of a soil is based on the individual densities of soil constituents and according to their proportionate contribution. The bulk density on the other hand, is the weight per unit volume of dry soil including the particles and pore space and hence it is lower than the particle density.

Pore space: The portion of soil occupied by air and water is pore space which is largely governed by structural conditions. Low pore space of about 30 per cent is common for sands, whereas clays may have a pore space of as much as 50-60 per cent.

Plasticity and cohesion: Plasticity is a soil property which enables a moist soil to change shape on an applied force and retain this shape even when the force is withdrawn. Thus sandy soils are considered as non-plastic and clayey soils as plastic. Cohesion, on the other hand, is a property of the particles to stick to one another by cohesive force.

Soil temperature: Soil temperature is an important factor affecting seed germination, plant growth and micro-biological activity. Germination has been found to be a slow process in a cold soil. For germination and root

growth the required temperature varies with crops and varieties. The winter crops viz. wheat, barley and oat require low temperature for germination as compared to the summer crops like cotton and sorghum.

Soil air: It is an established fact that restricted soil aeration affects root development, respiration and other biological processes and can thus change the soil environment. The pore space, not filled by water, is occupied by space (macropores) that generally constitutes the air space, the capillary pore space (micropores) being occupies by water. Normally if one-third of the pore space in the soil is filled by air and two-third of by water, the plant growth is assumed to be optimum.

Soil water: The maximum influence on the growth and yield of a crop depends on the availability of soil water since it is required in larger quantity than any other substance contributing to the growth and yield.

Soil structure: Soil structure is defined as the arrangement of primary and secondary soil particles. Soil structure is recognised as one of the most important properties since it influences aeration, permeability and water capacity. In the field, the structure is described in terms of (i) type (shape and arrangement), (ii) class (size), and (iii) grade (degree of aggregation).

Chemical properties

The chemical properties of soils largely depend on the soil collides. It is, therefore, important to know about the soil colloids and their nature to have an insight into their influence on various chemical properties of soils.

Soil colloids and their nature: Soil colloids refer to the most reactive part of the soil solids. Soil colloids can roughly be grouped into two phases namely organic and inorganic phase. The organic phase consists of either fresh of decomposed residues of plant, animal, and microbial residues which may remain associated with inorganic phase or may be present in free form. The inorganic phase of soil colloids is dominated by the clay which governs almost all the soil properties.

Nutrient elements in soils: The soil supplies all the essentials minerals elements required by the plants. Depending on their requirements by plants these elements are grouped into two types viz.

- **Macro elements:** These are nitrogen, phosphorus, potassium, calcium, magnesium and sulphur.
- **Micro elements:** these include iron, manganese, zinc, copper, molybdenum, boron, cobalt and chlorine.

Cation and anion exchange properties of soils: Ion exchange is a reversible process which involves both cations and anions. The exchange takes place between solid and liquid phases and between solid phases which are in close contact with other. The exchange of cations and anions is termed cation exchange and anion exchange, respectively. Ion exchange is the most important of all the processes occurring in a soil. Soil colloids, are the seat of ion exchange processes.

Organic matter: Although organic matter is a small part of mineral soil, it plays a vital role in the productivity and conditioning of soils. Organic matter act as a source of food for soil bacteria and fungi, which are responsible for converting complex organic materials into simpler substances, which are easily available to the plants. The presence of organic matter also helps to improve the physical conditions of the soil in terms of its working quality. Presence of organic matter, clay and Ca in right proportion may form a good soil physical condition for better crop performance. Organic matter can also be used as mulch and can prevent the soil from losing moisture by evaporation.

Soil properties and soil quality: Soils have chemical, biological and physical properties that interact in a complex way to give a soil its quality or capacity to function. Soil function describes what the soil does. Five soil functions as described by karlen *et al.,* (1997) are:

- Sustaining biological activity, diversity and productivity;
- Regulating and partitioning water and solute flow;

- Filtering, buffering, degrading, immobilizing and detoxifying organic and inorganic materials, including industrial and municipal by–products and atmospheric decomposition;
- Storing and cycling nutrients and other elements within the earth's biosphere; and
- Providing support of socioeconomic structures and protection for archeological treasures associated with human habitation.

CONCLUSION

World soil resources being finite, intensive land use is inevitable to meet the global demands for food and fiber. Intensification of agriculture on existing arable land increases risks of soil and environmental degradation. Establishment of such functional relationships involves identifying criteria for quantitative assessment of sustainability and soil quality (Lal, 1998; Lal, 2001; Lal, 2007). Soil resource of the world are adequate to meet the needs of the present and future population. Soil scientists can play a key role in achieving food security and enhancing environmental quality by improving/ restoring soil quality through development of multidisciplinary and holistic approaches to natural resources management.

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