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M. Vassanda Coumar
Senior Scientist
Division of Environmental Soil Science
Indian Institute of Soil Science
Berasia Road
Nabibagh
Bhopal
India

J. K. Saha
Principal Scientist and Head
Division of Environmental Soil Science
Indian Institute of Soil Science
Berasia Road
Nabibagh
Bhopal
India

Corresponding Author
M. Vassanda Coumar
vassanda.coumar@gmail.com

Soil Management for Sustainable Crop Production and Soil Health

Importance of soils to human well-being and cultural enrichment is glorified in the ancient Indian scriptures dating back to the drawn of civilization. In the developing countries like India, a large proportion of the land area shows clear evidence of advanced and continuing degradation seriously affecting the country's productive resource base. As ecosystem consist of soil, plant, animal and human, an adverse impact on any of the component is likely to have various effects on the other component of system. Continuous adoption of conventional farming practices based on intensive tillage, especially when combined with crop residue burning or removal have exaggerated soil erosion losses and degraded the soil resource base steadily. Soil carbon changes of a crop production system are a very important aspect as it indicates whether a production system is a C restorative process or not. Hence, the need to protect our soil environment against degradation will necessarily involve the knowledge and the use of natural soil functions so as to ensure higher quality soils and better produce quality through the appropriate management of soils.

INTRODUCTION

Soil is a resource which helps to sustain life on Earth. Soil supports growth of plants and provides habitat for a variety of living organisms. Soil helps purify, or clean, water as it seeps or drains through the ground and into rivers, lakes, and oceans. Decomposers and soil microbes help recycle nutrients by breaking down the remains of plants and animals, releasing nutrients for growth and development of green plants. The importance of soils to human wellbeing and cultural enrichment is glorified in the ancient Indian scriptures dating back to the drawn of civilization. As ecosystem consist of soil, plant, animal and human, an adverse impact on any of the component is likely to have various effects on the other component of system. Thus the importance of soil, its quality and the immediate environment as a core element in the issues related to sustainability and society.

SOIL DEGRADATION

In the developing countries like India, a large proportion of the land area shows clear evidence of advanced and continuing degradation seriously affecting the country's productive resource base (Abrol and Sehgal, 1994). Soil degradation (~ 57% of the cultivated area) both in irrigated and rain-fed agro-ecosystems is a major threat to agricultural sustainability and environmental quality in India. With increasing demographic pressure, intensive land use and improper management, soil is subjected to severe degradation leading to deterioration in its quality. Soil erosion, water logging, salinity/alkalinity, soil acidity etc are the most important soil degradation types in India. In the recent past, soil degradation has also become a major global concern and since soil is one of the precious natural resources, it should be protected from all forms of degradation (Physical, chemical and biological). Soil degradation may occur naturally as well as anthropogenically. The human induced soil disturbances further accelerate and aggravate the soil pollution/degradation problems. Hence, the need to protect our soil environment against degradation will necessarily involve the knowledge and the use of natural soil functions so as to ensure higher quality soils and better produce quality through the appropriate management of soils.

SOIL QUALITY CONCEPT AND ITS APPLICATION

As a result of increasing demographic pressure, intensive land use and improper soil management, soils encounter diversity of constraints broadly on account of physical, chemical and biological soil health leading to deterioration in soil quality (AQ) ultimately end up with poor functional capacity (Sharma et al., 2007). Decline in SQ will have adverse impact on surrounding environment, ecosystem productivity, food security and livelihoods. Soil quality term and concept was proposed by different scientists and in general it is viewed as "fitness for use" or "capacity of the soil to function". Karlen et al. (1997) defined soil quality as "The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation."

The Capacity of soil to perform various function varies naturally and hence soil quality is specific to each kind of soil. Traditionally, soil quality has been mainly related with its productivity, while more recently, it has been defined as the capacity of a soil to function within ecosystem environmental quality, and promote plant and animal health. Soil quality depends on chemical, physical and biological soil properties, and its characterization requires the selection of the properties which are mostly sensitive to changes in soil management practices. Soil quality includes both inherent and a dynamic component (Carter, 2002). With respect to inherent properties, a soil is a result of the factor of soil formation- climate, topography, vegetation, parent material, and time. Each soil has an inherent capacity to function like some soil type will be intrinsically more productive or some soil type will be capable to partition water much more efficiently than others. This view of the definition is useful for comparing the abilities of one soil against another, and is often used to evaluate the worth or suitability of soil for specific uses. For example, a loamy soil will have a higher water holding capacity than a sandy soil; thus, the loamy soil has a higher inherent soil quality. Dynamic SQ, however, refers to changes in soil quality in a short period as a result of human and management intervention (Carter, 2002). Some management practices like cover crops, organic matter addition may have a positive effect on soil quality. On the other hand, management practices like tilling the soil when wet will adversely affect soil quality by increasing compaction. This view of soil quality requires a reference condition for each kind of soil with which changes in soil condition are compared, and its currently the focal point for the term "soil quality".

SUSTAINABLE SOIL MANAGEMENT FOR MAINTAINING SOIL QUALITY

Soil organic carbon content and pools has been recognized as one of the important indicators of soil quality and crop productivity. Soil management practices like tillage, crop cultivation and residue burning or removal may results in SOC changes (Srinivasarao et al., 2012). Soil carbon changes of a crop production system are a very important aspect as it indicates whether a production system is a C restorative process or not. A study conducted by Coumar et al. (2020) revealed that the C balance sheet under different crop rotation (soybean- wheat, soybean- chickpea and rice-rice) in Vidisha and Sehore district indicates that the annual soil carbon loss from soil was much less than the annual biomass C input into the soil supplementary through FYM and left over plant biomass, thereby, maintaining a positive carbon balance in soil profile under soybean- chickpea system in Sehore districts and soybean- wheat system in Vidisha district of Madhya Pradesh.

Among the cropping system practiced in Sehore district, SOC pools values are relatively higher under legume based cropping system (soybean- wheat and soybean- chickpea) than cereal-cereal cropping system (rice-wheat). The carbon loss from passive pool of carbon is relatively less in soybean- wheat and soybean chickpea system (legume based cropping system) and any management practices that conserve slow C-pool or passive pool in soil for longer period should be implemented. Hence it could be concluded that growing soybean– wheat and soybean – chickpea rotations in Vertisol as compared to rice-wheat system are not only soil organic C restorative process but also help to sequester C into the soil. Several authors also reported that long-term fertilizer experiments in India indicate the declining trends in the soil organic carbon under cereal-cereal system and highlighted that inclusion of legumes in the cropping system helps in maintaining soil organic carbon, soil quality and crop productivity (Newaj and Yadav, 1994; Ghosh et al., 2006; Ganeshamurthy, 2009). Continuous adoption of conventional farming practices based on intensive tillage, especially when combined with crop residue burning or removal have exaggerated soil erosion losses and degraded the soil resource base steadily (Montgomery, 2007). In recent years, farmers interested in sustainable crop production systems have begun to adopt and adapt improved crop management practices, a step toward conservation agriculture (CA), which may be considered the ultimate solution. Conservation agriculture (CA) including reduced or no-tillage and crop residue retention,is being widely accepted as an important component of the overall strategy for enhancing productivity, improving environmental quality and maintaining natural resources. Zero till systems with surface residue management/retention improves soil health (Sharma et al., 2008) and reduces GHG emission globally (Friedrich, 2009). Soil organic matter in the surface soil is increased considerably under cover crop combined with no-till system (Roldan et al. 2003; Alvear et al. 2005; Diekow et al. 2005; Madari et al. 2005; Riley et al. 2005). Soil mulch with legume crop will help in recycling of plant nutrients through the association with below-ground biological component and by providing carbon and energy source for microbial populations. A few comparative studies have been conducted to look at soil quality changes under conventional and conservation agricultural systems. Somasundaram, et al. (2019) reported that soil microbial biomass C (SMBC) concentration in the surface soil was significantly higher in reduced tillage than conventional tillage system in a Vertisol of a semiarid region of central India. Crop residues and manures promote microbial activity as a measure of soil microbial biomass (SMB) while burning and removal of residues decrease SMB (Doran, 1980; Collins et al. 1992; Heenan et al. 2004; Alvear et al. 2005).

CONCLUSION

Crop production in the next decade will have to produce more food from less land by making more efficient use of natural resources and with minimal impact on the environment. To attain this target, crop and soil management systems that help improve soil health parameters (physical, biological and chemical) and reduce farmer costs are essential. Despite of growing concern of threat from land degradation on land productivity and ecosystem sustainability, only few studies have been made to evaluate and monitor soil quality. Therefore, understanding the response of soils to agricultural management practices over time helps to evaluate whether the investigated practices maintain or improve soil quality. Such management practices like conservation agriculture, legume based cropping, organic matter addition, green manuring, soil test based balanced fertilizer application coupled with periodic assessment and monitoring of soil quality will ensure sustainable crop production and soil health improvement without degrading the surrounding environment.

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