Soil Quality and Enhanced Productivity through Soil Organic Matter

P. Chandrasekhar Rao* and G. Padmaja

Dept. of Soil Science & Agriculture Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad (500 030), India

Corresponding Author

P. Chandrasekhar Rao
e-mail: rao_palli@yahoo.com

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Abstract

Soil quality and health of the soil is a very important factors for growing of crops. The accelerated decomposition of soil organic carbon due to agriculture, resulting in loss of carbon to atmosphere and its contribution to greenhouse effect is a serious problem. Important factors controlling soil SOM status include climate, especially rainfall and temperature hydrology, parent material, soil fertility, biological activity, vegetation and land use. Assessment of soil quality, which is 'the capacity of the soil to produce safe and nutritious food, to enhance human and animal health and overcome degradative processes" is thought to be a means to maintain soil health and quality. There is no doubt that agricultural management practices such as crop rotations, inclusion of legumes in cropping systems, addition of animal based manures, adoption of soil water conservation practices, various permutations and combinations of deep and shallow tillage, mulching of soils with insitu grown and external plant and leaf materials were part and parcel of agriculture in India. Despite all these efforts, the concept of conservation farming could not be followed in an integrated manner to except greater impact in terms of protecting the soil resource from degradative processes. One of the approaches could be better land husbandry (BLH). It is an integrated and synergistic resource management. Components of BLH are Build up SOM and related biological activity, Integrated plant nutrition management, Better crop management, Better rainwater management, improved soil structure for better rooting depth and permeability, adoption of people centred learning approach and community based participatory approaches.

Keywords: Soil quality, productivity, organic matter, soil health

1. Introduction

The accelerated decomposition of soil organic carbon due to agriculture, resulting in loss of carbon to atmosphere and its contribution to greenhouse effect is a serious problem. The contribution of soil to improving soil physical, chemical and biological properties and maintaining soil, integrity sustaining soil productivity is well known. Important factors controlling soil SOM status include climate, especially rainfall and temperature hydrology, parent material, soil fertility, biological activity, vegetation and land use.

Soil supporting good crops are under stress because of consistent intensive cultivation and other demographic pressures. These stresses ultimately lead to declined productivity of crops even under best management practices and make the soil "Sick" and unresponsive to fertilizer application and other inputs.

2. Soil Quality

Assessment of soil quality, which is 'the capacity of the soil to produce safe and nutritious food, to enhance human and animal health and overcome degradative processes" is thought to be a means to maintain soil health and quality. Soil quality has been defined by many scientists differently. Some have defined it as "fitness for use", while other as "capacity of the soil to function". In soil quality assessment, we consider different attributes of soil viz., physical, chemical and biological and also the nutritional quality of the produce grown on the soil. A schematic framework of soil quality assessment is given in Fig 1. Again, within each category of attributes, we analysed a number of parameters, such as – bulk density, maximum water holding capacity, mean weight diameter under physical – pH, organic carbon available N, P and K, micronutrient, heavy metals under chemical, and microbial biomass C and N, soil enzymes, mineralizable C and N, soil biodiversity, soil fauna under biological. These attributes are selected based on a few scientific principles viz., i) encompass ecosystem process, ii) sensitive to variations in management practices, iii) easily measurable and reproducible, iv) a component of existing soil database, and v) integrate soil physical chemical and biological properties.

2.1. Causes of land degradation and soil quality deterioration

The predominant process or factors which degrade land, and

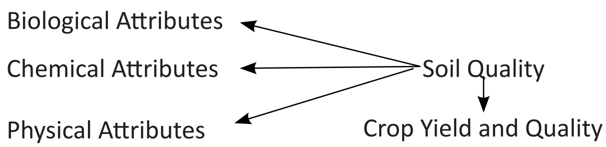

Figure 1

deteriorate soil quality and its productive capacity could be enumerated as:

i. Washing away of topsoil and organic matter associated with clay size fractions due to water erosion resulting in loss of soil fertility.
ii. Intensive deep tillage and inversion tillage with moldboard and disc plough resulting in
iii. Dismally low levels of fertilizer application and widening of removal addition gap in plant nutrients
iv. Mining and other commercial activities such as use of top soil non-agricultural purpose,
v. Mono cropping without following any suitable rotation,
vi. Nutrient imbalance caused due to disproportionate use of primary, secondary and micronutrients
vii. No or low use of organic manures such as FYM, compost, vermicompost and poor recycling of farm based crop residues because of competing demand for animal fodder and domestic fuel,
viii. No or low green manuring as it competes with the regular crop for date of sowing and other resources
ix. Poor nutrient use efficiency due to nutrient losses through leaching volatilization and denitrification
x. Indiscriminate use of other agricultural inputs such as herbicides, pesticides, fungicides, etc., resulting in poor soil and water quality

xi. Water logging, salinity and alkalinity and acidity.

There is no doubt that agricultural management practices such as crop rotations, inclusion of legumes in cropping systems, addition of animal based manures, adoption of soil water conservation practices, various permutations and combinations of deep and shallow tillage, mulching of soils with insitu grown and external plant and leaf materials were part and parcel of agriculture in India. Despite all these efforts, the concept of conservation farming could not be followed in an integrated manner to except greater impact in terms of protecting the soil resource from degradative processes.

Once the attributes are chosen, they are integrated into an index called soil quality index after rigorous screening of the attributes using rationale and appropriate statistical tools to assess the system for its fitness status.

3. Better Land Husbandry

One of the approaches could be better land husbandry (BLH). It is an integrated and synergistic resource management. Components of BLH are Build up SOM and related biological activity, Integrated plant nutrition management, Better crop management, Better rainwater management, improved soil structure for better rooting depth and permeability, adoption of people centred learning approach and community based participatory approaches.

It was pointed out that sustainable food production is feasible through tapping the synergies between crop-tree (Agro-forestry) and crop-tree livestock production systems. Such systems have been in existence in India. To name a few: Zabo in Nagaland, Apatani in Arunchal Pradesh, Paddy-cum-fish or duck farming in east India, Alder based cropping system in NE India and Khejri – based cropping in NW India (Table 1 and 2).

With large land area and diverse eco-regions, there is a

Table 1: Nutrient additions through different systems and sources

Sl.No.	System	Nutrient additions as N equivalent (kg ha^{-1})
1. Agro-forestry		
	a) Khejri based	250
	b) Alder based	150
2. Ley farming		
	a) Sewan grass 2 years followed by pearlmillet	25
	b) Stylosahthes 2 years followed by sorghum	20
3. Mixed or inter cropping		
	a) Cowpea in castor	30
	b) Pigeonpea in sorghum	30
	c)	
4. Green leaf manuring		
	a) Sesbamia (per tonne)	4.4
	b) Subabool (per tonne)	5
5. Green manure		
	a) Sesbamia	55
6. Micro-organisms		
	a) Rhizobia	19-22
	b) Azotobactor	20
	c) Azolla	25
7. Livestock based		
	a) 10 cents fish pond + 20 fowls	34
	b) 3 bovines + 2 calves	113 (as FYM) 157 (as Bio-gas)
	c) 20 small ruminants under deep litter system	

Table 2: Integrated farming systems and nutrient management benefits

Sl.No.	Systems	Nutrient management
1.	Rice based farming system in Apatani plateau in Arunachal Pradesh. It is growing rice in terraces in the Apatani Valley	Rice straw @ 10 t ha^{-1} allowed to decompose *in situ* Pig and poultry droppings, rice husk, kitchen waste, ash and weeds are incorporated After harvest of rice crop, cattle are allowed to graze, thereby adding dung and urine to the fields
2.	Paddy-cum-brackish water fish and prawn culture. It is practiced in West Bengal and Kerala. Fish-cum-farming is practiced in parts of NE India	The pond mud of 0.3-0.6 m depth is a good sediment containing 0.32 to 4.77% organic-C and is used as a valuable manure The sediment is also rich in adsorbed NH4-N and available P.
3.	Fish-cum-duck poultry culture is also practiced in parts of NE India. The ducks are reared adjacent to ponds	The duck or poultry droppings amount to 10 t ha^{-1} yr^{-1}, contributed by 300 layer birds or 150-200 broiler birds reared in cages This nutrient mass is a good feed for the fish
4.	Silvi-horti-livestock integrated system. The system was proposed by the National Pulses Research Centre and internalized. It includes fruit trees and MPTs along with fodder crop in the alleys. A goat unit of 1 buck an 5 does and a dairy unit of one milch cattle are integral in the system	The loppings and leaf litter of the MPTs are the nutrient supplying system.\ The dung of the milch animal is used as manure, besides the excreted of the small ruminants.

considerable potential for soil carbon sequestration and improved soil health. The results suggest that long term application of inorganic fertilizers along with organic manures in integrated manner plays a vital role in not only obtaining higher crop yields but also to sustain soil fertility and to sequester high amounts of organic carbon n long run under scarce, medium and high rainfall regions. The results also suggest that cropping systems like rice-maize if continued for long term may deplete soil organic carbon. Recommended Management Practices (RMPs) like conservation tillage, erosion control and residue recycling are suggested. In rice-rice cropping system, prior rising of sunhemp or green gram is found to be best option for sequester organic carbon and to bring sustainability. Since significant reduction is observed in seasonal CH4 emission, scientific irrigation practices like SRI cultivation and aerobic rice are better options in tank fed and bore or well irrigated areas. In Nalgonda district most of the area comes under carbon density ranges of 3.5 – 5.5 kg m-2. The highest SOC is observed in Agri-sylviculture system followed by Sylvi-pasture and Agri-Sylvi-horti system. Regular additions of nutrients through fertilizers along with organic manures are found necessary for carbon sequestration, particularly in soil with nutrient deficiencies. With the introduction of carbon trading, agro-forestry systems may become more attractive. In crop husbandry as well as agro-forestry, research addressing both biophysical and socio-economic issues, identifying, developing and bringing out best management practices (BMPs) with reference to carbon sequestration and sustainable production needs to be intensified.

4. Conclusion

It can be pointed out from the above discussed matter that sustainable food production is feasible through tapping the synergies between crop-tree (Agro-forestry) and crop-tree livestock production systems. Such systems have been in existence in India. To name a few: Zabo in Nagaland, Apatani in Arunchal Pradesh, Paddy-cum-fish or duck farming in east India, Alder based cropping system in NE India and Khejri – based cropping in NW India.