Indian Journal of Fertilisers **19** (4) : 270-271, April, 2023

Carbon Management for Sustainable Soil Health and Environment

Frank Notes

Arvind Chaudhary

Carbon is the key element for living beings including soil for agriculture. Soil carbon is a major determinant of soil health and crop productivity. It is intrinsically connected with all the soil physicochemical, biological and biochemical properties. Soil organic carbon (SOC) helps in soil aggregation that directly improves the physical properties of soil including soil structure, soil water holding capacity and soil porosity. It is the key energy source for the soil microbes. The increased population and activity of microbes in soil improves the soil nutrient contents which improve soil fertility and crop yields.

The organic carbon status of Indian soils is in low to very low category and it is mainly due to sub-tropical climate, long history of cultivation and poor farm management. Conventional farming practices, particularly tillage and crop residue burning, have substantially degraded the soil resource base and crop production capacity. Widespread soil erosion, nutrient mining, depleting water table and eroding biodiversity are posing a threat to soil carbon management.

Mineralization of soil organic carbon, accentuated by agricultural intensification, besides releasing nutrients to meet the nutritional requirement of growing crops leads to carbon dioxide (CO_2) emissions to the atmosphere. Thus, carbon has importance in the sustainability of both food security and environmental quality and its management is critical. The continuous rise in the concentration of carbon dioxide in the atmosphere alters the source-sink chemistry. The sudden and sharp rise in carbon equivalent emissions create extreme weather events affecting crop production.

Global warming, caused by more greenhouse gases in the atmosphere, has become the serious environmental problem. Burning of fossil fuels such as coal, natural gas and oil for power generation and transportation, land use changes, decomposition of organic matter and forest fires are the major contributors to CO_2 emissions. More than 80% of world's energy comes from fossil fuels, which has increased CO_2 level in the atmosphere. The CO_2 concentration in the atmosphere has risen from 278 ppm in 1750 to 420.41 in 2023. Capturing the CO_2 from the air and storing inside the soil or in plant biomass which is scientifically termed as carbon sequestration is vital to solve climate change and land degradation issues.

Carbon sequestration has gained much attention in the last few years in view of the importance of soil organic carbon (SOC) and its close relationship with soil fertility, nutrient use efficiency, crop productivity, and environmental sustainability. Restoration of SOC not only enhances crop production and livelihood security but also contributes to Sustainable Development Goals. Making appropriate use of carbon sequestration practices that involve effective soil, water and crop management strategies help in storing maximum amount of carbon in the soil besides achieving enhanced soil fertility, improved soil water storage, higher crop yields and environment sustainability.

The management of carbon or carbon equivalent emission is vital to sustain the environment and food security. A number of practices/approaches have been developed in India and abroad in the field of carbon management. The important approaches used for carbon management include carbon farming; micro-irrigation/sensor-based irrigation management; conservation agriculture; crop residue management; integrated nutrient

Carbon farming needs to be encouraged with appropriate policies including financial support. There is a need to strengthen linkages between government and other stakeholders to promote carbon farming at local, state and national scale.

management; mulching; crop diversification; and integrated farming systems.

Carbon farming practices are regenerative agricultural practices which improve soil health, reduce GHGs and sequester carbon. Conservation agriculture is a proven practice for soil carbon management. It not only adds carbon to the soil directly but also reduces fossil fuel CO_2 emission and oxidation of soil organic carbon. Crop diversification is beneficial for healthy aboveground and belowground biomass production which improve organic carbon content in soil. Legume in a crop rotation supports aggregate formation and stabilization and ultimately protects the aggregate-carbon through chemical polymerization and physical occlusion. Integrated nutrient management is beneficial for augmented carbon inputs and increased biomass productivity.

Mulching of organic nutrient sources that are rich in carbon also helps in improving the soil organic carbon. Mulching brings multiple advantages to the soil ecosystem like protecting the soil surface, soil temperature balance, moisture conservation, congenial environment for the plant growth, and carbon source for microbial activity. Similarly, biochar, made through pyrolysis method in absence of oxygen or low oxygen, is rich in carbon and plays a crucial role in increasing soil carbon stocks. Use of biochar can result in several environmental and ecological benefits like minimizing GHGs and nutrient leaching in addition to improving soil organic carbon, water retention and soil structure, thus enhancing crop productivity. The Intergovernmental Panel on Climate Change (IPCC) has recognized biochar as a sustainable land management response option to mitigate climate change.

To guarantee soil quality, productivity, and sustainability, carbon stocks in soil must be preserved or increased. The dry environment will continue to be a problem as it leads to soil deterioration through the loss of organic carbon. The fast oxidation of organic matter under the prevailing high temperatures makes sustaining or improving organic carbon levels in tropical/subtropical soils more challenging. For managing carbon, it is essential to estimate carbon footprint of an activity, measured in tonnes of CO_2 emissions. The quantitative predictions of SOC sequestration rates will always entail a large degree of uncertainty due to the complex nature of agriculture and hence proper modeling for a specific agro-ecosystem is necessary.

Carbon management in India needs affordable technologies, investments, and enabling policy. Creating an enabling environment is necessary to address the critical issues hindering the adoption of carbon farming technologies. Carbon farming needs to be encouraged with appropriate policies including financial support. Further, there is a need to strengthen linkages between government and other stakeholders to promote carbon farming at local, state and national scale. Widespread awareness among farmers is needed to adopt SOC sequestration practices. Strict legal /administrative actions should be taken to reduce crop residue burning, supported by technological innovations and investments. Farmers need to be enabled to shift to low carbon agriculture by adopting appropriate carbon management practices.

This special issue on carbon management is an initiative of FAI to present the developments in this emerging field and underlines the need of carbon management for sustainable soil health and environment. The issue includes six papers covering important aspects of soil carbon management. We hope that all those concerned with agriculture will find the contents of this special issue relevant and useful.■