Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 01 (JAN-FEB, 2022)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

# Soil Carbon Sequestration under Conservation Agriculture

(*Siyaram Meena[1], Ravi Saini[1] and Atma Ram Meena[2])
[1]Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi-110012
[2]Department of Horticulture, SKRAU Bikaner, India, 334006
* siyarammeena092@gmail.com

Human efforts to provide more food to feed an ever-increasing population have left their marks on the environment. Soil erosion and degradation have been increased by traditional agricultural techniques, such as extensive tillage based on crop residue removal. The gradual increase in the concentration of greenhouse gases (GHGs) in the atmosphere has prompted global interest in developing several sustainable ways to lower their concentration in the atmosphere in recent years. Carbon (C) stored in soil is two to four times greater than carbon stored in the atmosphere, and four times more than carbon stored in plants. Carbon sequestration (CS) is the process of capture and secure storage of carbon in soils, plants, geologic formations and ocean. The adverse impact of intensive tillage practices on soil physical quality and soil organic carbon (SOC) levels is a major challenge in tropical rice–growing regions. Limited or no use of organic manures/crop residue (Ghosh *et al*., 2017), lack of crop diversification (Hazra *et al*., 2014), imbalanced use of mineral fertilizers (Brar *et al*., 2013) have further aggravated soil quality deterioration.

Conservation agriculture (CA) is the process through which Carbon dioxide ($CO_2$) from the atmosphere is absorbed by various carbon sinks. Agricultural sinks, forests, geologic formations, and marine sinks are all important carbon sinks. CA is one concept for resource conservation and mitigation of adverse climatic impacts that has higher profitability (Das *et al*., 2015). Worldwide, CA was estimated to be practiced over an area of 124.8 Mha, of which India contributes about 1.5 Mha only (Bhan and Behera, 2014). The conversion of conventional tillage to conservation tillage might sequester a considerable quantity of soil organic carbon (SOC). The most essential component of conservation agriculture is that it is expected to increase plant growth and soil health while causing minimal environmental damage. CA is a base for sustainable agricultural production intensification. It opens increased options for integration of production sectors, such as crop-livestock integration and the integration of trees and pastures into agricultural landscapes. Thus, adoption of CA in place of conventional tillage helps in carbon sequestration and mitigating climate change.

## 1. Carbon Cycle Between the Atmosphere, Plants and Soil

The global soil carbon pool of 2500 gigatons (Gt) includes about 1550 Gt of soil organic carbon (SOC) and 950 Gt of soil inorganic carbon (SIC). The soil C pool is 3.3 times the size of the atmospheric pool (760 Gt) and 4.5 times the size of the biotic pool. The SOC pool to 1-m depth ranges from 30 tons/ha in arid climates to 800 tons/ha in organic soils in cold regions, and a predominant range of 50 to 150 tons/ha. The SOC pool represents a dynamic equilibrium of gains and losses. Conversion of natural to agricultural ecosystems causes depletion of the SOC pool by as much as 60% in soils of temperate regions and 75% or more in cultivated soils of the tropics. The depletion is exacerbated when the output of C exceeds the input and when soil degradation is severe. Some soils have lost as much as 20 to 80 tons C/ha, mostly emitted into the atmosphere.

✓ **Soil Carbon Sequestration**

Process of transferring $CO_2$ from the atmosphere into the soil through plants, plant residues, and other organic solids, which are stored in the unit as part of the soil organic matter (humus).

## 2. Mechanism of Soil Carbon Sequestration

| Enhancing non-labile C pool in soil | | |
|---|---|---|
| **A. Strategies** | **Increasing micro-aggregation** | **Deep incorporation of SOC in sub-soil** |
| **B. Techniques** | 1. Organic amendments<br>2. Soil conditioners<br>3. Conservation tillage<br>4. Cover crops<br>5. Mulch farming | 1. Enhance activity of soil fauna<br>2. Deep-rooted plants<br>3. Vertical mulching |
| Lal *et al*., (2004) | | |

## 3. Top Ten $CO_2$ Producing Countries in the World

| | | | |
|---|---|---|---|
| 1. | USA | 6. | Germany |
| 2. | China | 7. | Britain |
| 3. | Russia | 8. | Canada |
| 4. | Japan | 9. | South Korea |
| 5. | India | 10. | Ukraine |
| IPCC (2001) | | | |

## 4. Advantages of Carbon Sequestration

- Stable organic mineral complex
- Improve soil structure
- Improving water and nutrient retention capacity
- Improving soil organic C (SOC) concentration to the threshold level of 1.5– 2.0%
- Improve in soil aggregating process
- Reducing net increase in atmospheric concentration of $CO_2$ (which reached 400 ppm in 2013).
- Enhancing use efficiency of inputs in soils of managed ecosystems
- Increasing and sustaining agronomic productivity, and advancing food and nutritional security etc.

## 5. Impacts of Conservation Agriculture on Soil Carbon Sequestration

Macro-aggregates increased under a ZT rice (direct-seeded or transplanted) and wheat rotation (in 0-5 cm soil) with the 2 to 4 mm fraction greater than that of the 0.25 to 2 mm fraction. Bulk and aggregate associated C increased in ZT systems with greater accumulation in macro-aggregates. Also found that micro-aggregates decrease under a ZT rice (direct-seeded or transplanted) and wheat rotation (in 0-5 cm soil). The intra-aggregate particulate organic matter carbon (iPOM-C) in various size classes of aggregates was perceptively influenced by tillage and was significantly higher in the zero-tillage system (Kumari *et al*., 2011). Nandan *et al*., (2019) observe a study in a cropping system at ICAR–RCER and found that the active and passive carbon pool is highest in the zero-till direct seeded rice followed by zero-till wheat/maize in residue retention condition as compare to puddled transplant rice followed by conventional till wheat/maize. Carbon stabilization is highest in zero-till direct seeded rice followed by zero-till wheat/maize as compare to puddled transplant rice followed by conventional till wheat/maize because of fewer disturbances of soil and less chance of oxidation of organic matter in ZTDSR-ZT cropping systems.

## 6. Conclusions

- ✓ Soil organic carbon which is generally referred as the key indicator of soil quality, it is improved under reduced and no tillage practices.
- ✓ CA has the capacity for short term maximization of crop production as well as the potential for long term sustainability (C storage) at micro site (soil aggregation) and farm level (profitability).
- ✓ Conservation agriculture helps in formation of greater amount of stable aggregates which helps in sequestering carbon.
- ✓ Altering crop rotation can influence soil C stocks by changing quantity and quality of organic matter input.

## 7. Path Ahead

- ✓ Need to develop location specific soil management practices for carbon sequestration and restoring soil fertility
- ✓ Standardized methodologies for estimating above and below-ground C stocks to improve the reliability of data

## References


1. Bhan, S. and Behera, U. K. (2014). Conservation agriculture in India–Problems, prospects and policy issues. *International Soil and Water Conservation Research*, ***2***(4), 1-12.
2. Brar, B., Singh, K., Dheri, G.S. and Balwinder, K. (2013). Carbon sequestration and soil carbon pools in a rice-wheat cropping system: Effect of long-term use of inorganic fertilizers and organic manure. *Soil & Tillage Research*. **128**, 30-36.
3. Das, T.K., Sudhishri, S., Dudwal, B., Sharma, A.R., Bhatia, Arti. and Singh, Geeta. (2015). Conservation agriculture effects on soil organic carbon accumulation and crop productivity under a rice–wheat cropping system in the western Indo-Gangetic Plains. *European Journal of Agronomy*. **70**. 11-21.
4. Ghosh, A., Meena, M.C., Dwivedi, B.S., Singh, G., Agnihotri, R.J. and Sharma, C.M. (2017). Long-term fertilization effects on soil organic carbon sequestration in an Inceptisol. *Soil and Tillage Research*. **177**, 10-1016.
5. Hajra, R.P. and Ghosh, T. (2014). Agricultural productivity, household poverty and migration in the Indian Sundarban Delta. *Elem Sci Anth*. **6**. 3. 10. 15-25.
6. Kumari, M., Chakraborty, D., Gathala, M. K., Pathak, H., Dwivedi, B. S., Tomar, R. K., Garg R. N., Singh R. and Ladha, J. K. (2011). Soil aggregation and associated organic carbon fractions as affected by tillage in a rice–wheat rotation in North India. *Soil science society of America journal*, ***75***(2), 560-567.
7. Lal R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science 304: 1623–1627. Bhan, S. and Behera, U.K. (2014). Conservation agriculture in India–Problems, prospects and policy issues. *International Soil and Water Conservation Research*, **2**, 1-12.
8. Nandan, R., Singh, V., Singh, S.S., Kumar, V., Hazra, K.K., Nath, C.P., Poonia, S.P., Malik, R.K., Bhattacharyya, R. and McDonald, A. (2019). Impact of conservation tillage in rice–based cropping systems on soil aggregation, carbon pools and nutrients. *Geoderma*, **340**, 104-114.