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Carbon Sequestration in Relation to Crop Production

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World hunger is an overarching issue and will remain a major concern during most of the 21st century. Soil organic matter (SOM) is one of the most important constituents of soils due to its capacity in affecting plant growth indirectly and directly (Bongiovanni and Lobartini, 2006). Indirectly, it improves the chemical and physical conditions of soils by increasing cation exchange capacity, termed buffering effect, and enhancing aggregation, aeration and water retention. Improvement of soil biological properties affects soil microbial diversity and population, thereby creating a suitable environment for root growth of plants and soil microbes (Senesi and Loffredo, 1999). The most observable functions of SOM include changes of soil physical properties such as bulk density, aggregate stability, porosity and water holding capacity when applied for long periods (Edwards and Lofty, 1982).Generally, increasing the organic carbon content of soils results in an increase in stability, irrespective of the origin of the stress. The sound structure of well managed soils can support sustainable production and yield of crops. Soil degradation and subsequent crop yield decline are major agricultural and economic problems in the intensive farming lands. Intense soil cultivation causes several alterations to soil physical properties, resulting in structural degradation (Tisdall and Oades, 1982).

In cultivated soils, one soil management technique considered to be promising is organic resource input with various sources. Carbon sequestration (CS) is the process of capture and secure storage of carbon in soils, plants, geologic formations and ocean. Conservation agriculture (CA) is one concept for resource conservation and mitigation of adverse climatic impacts. Globally CA was estimated to be practiced over an area of 124.8 Mha, of which India contributes about 1.5 Mha only. Decline in agronomic productivity of soils in developing countries is partly attributed to human-induced soil degradation and the attendant decline in soil quality (Lal, 2004). There is a strong link between soil quality and agronomic productivity on the one hand, and soil organic carbon (SOC) and soil quality on the other. Extractive practices widely used by resource-poor farmers in developing countries deplete the SOC pool, degrade soil quality and adversely affect agronomic productivity. Thus, agricultural sustainability is contingent upon land use and management systems that enhance and maintain high levels of SOC pool. This manuscript collates and synthesizes existing information linking the SOC pool and the agronomic yields of important food crops in developing countries. In these areas, crop yields are low, and productivity must be increased to meet the food demands of the growing population. Higher C content and stable C pool in the 0–15 and15–30 cm soil layers in CA-based zero-till (ZT) and permanent bed (PB) plots compared to the CT plots indicated that CA practices were effective in stabilizing SOM (Parihar *et al.* 2018). Thus, adoption of CA in place of conventional tillage helps in carbon sequestration and mitigating climate change.

Carbon Sequestration

Carbon Sequestration refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans so that the buildup of carbon dioxide concentration in the atmosphere will reduce or slow down (Lal, 1995). It is process of transferring CO_2 from atmosphere into the soil through crop residues and other organic solids, and in a form that is not immediately reemitted.

Soil Carbon Sequestration

Sequestration : $C_{input} > C_{output}$

Depletion : $C_{input} < C_{output}$

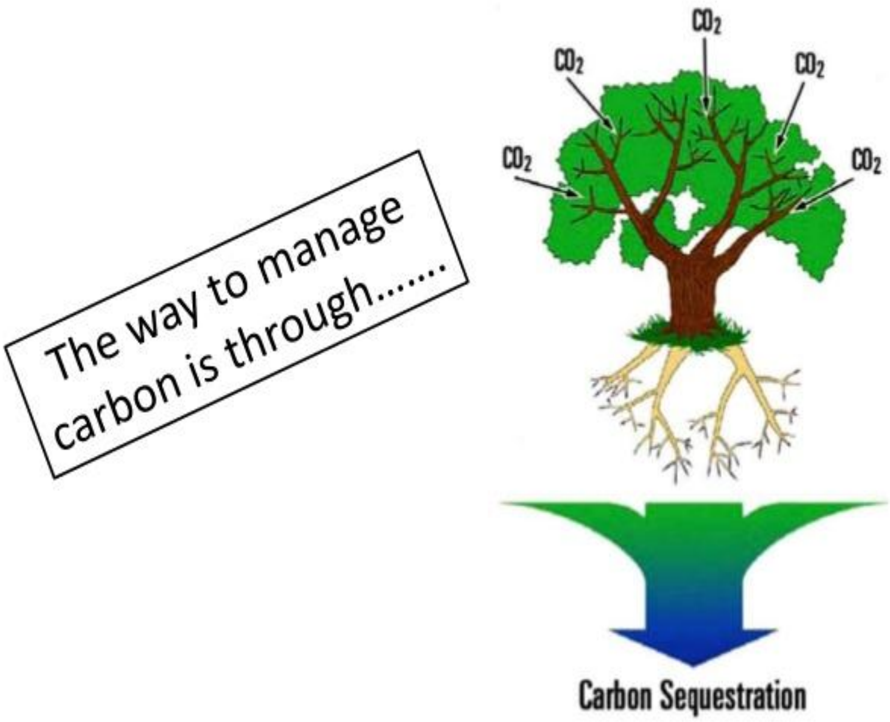


Fig.: Carbon Sequestration

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).

1. Mechanism of Soil Carbon Sequestration

Enhancing non-labile C pool in soil

A. Strategies Increasing Deep incorporation

Micro-aggregation of SOC in sub-soil

B. Techniques Organic amendments Enhance activity of soil fauna

Soil conditioners deep-rooted plants

Conservation tillage vertical mulching

Cover crops

Mulch farming

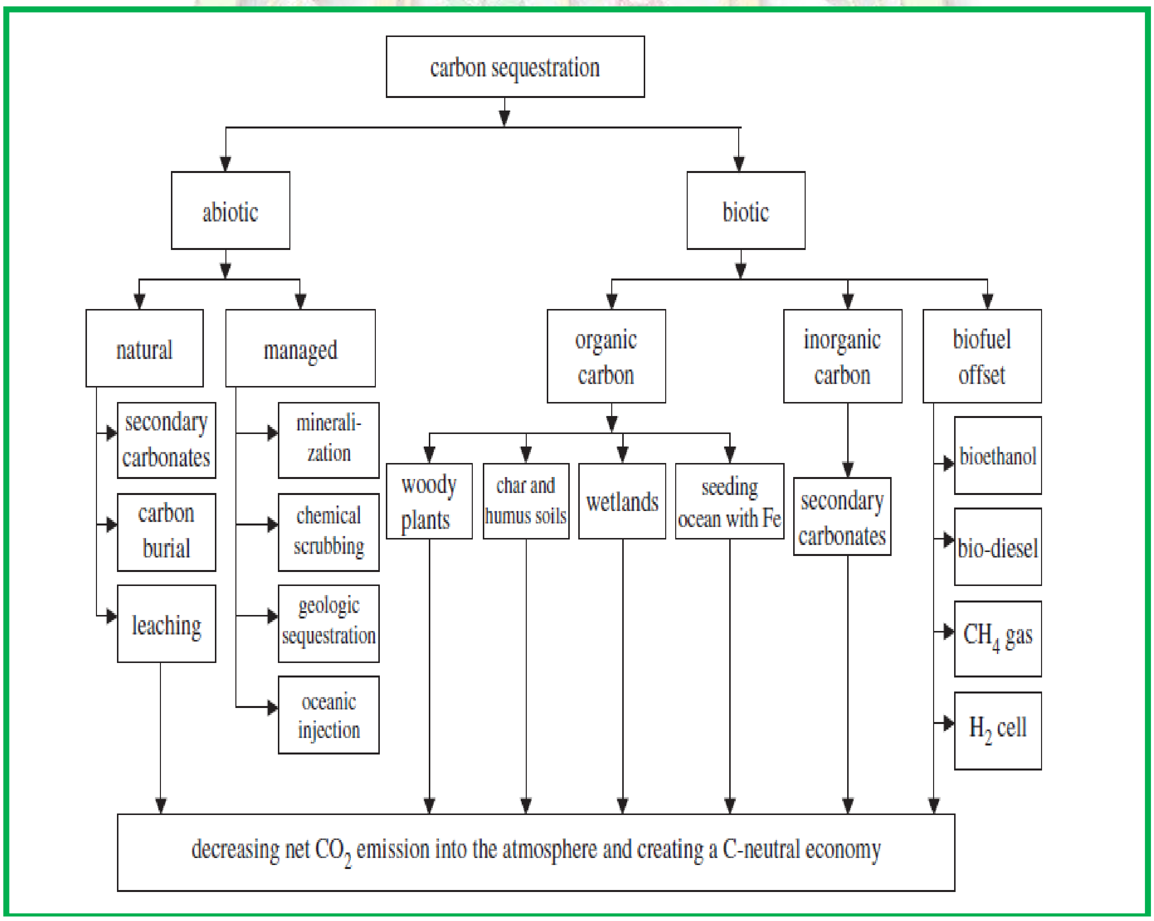
2. Carbon Cycle Between the Atmosphere, Plants and Soil

The global soil carbon (C) 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.

3. Top CO_2 Emissions Nations

Rank	Countries
1.	CHINA
2.	USA
3.	INDIA
4.	RUSSIA
5.	JAPAN

4. Types of Carbon Sequestration



Conclusion

- Traditional methods have been shown to be exhaustive, laborious, and eco-unfriendly
- Modern green extraction techniques tend to be rapid, convenient, economical, sustainable, and eco-friendly
- Positive impact on climate change by reducing carbon dioxide emission and toxic solvent usage.
- Combination of methods can possibly improve these processes.
- New concept to protect both the environment and consumers, and enhance competition of industries to be more ecologic, economic and innovative.

Future Aspects

- Investigations of modern extraction methods at pilot scales.
- Need for mechanistic studies in order to thoroughly understand the mechanisms governing the extraction kinetics of green extraction methods.
- Removal of technical barriers in the designs and processes of these techniques for future scaling up of extraction processes to the industrial level.

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