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Role of Carbon Sequestration in Agriculture

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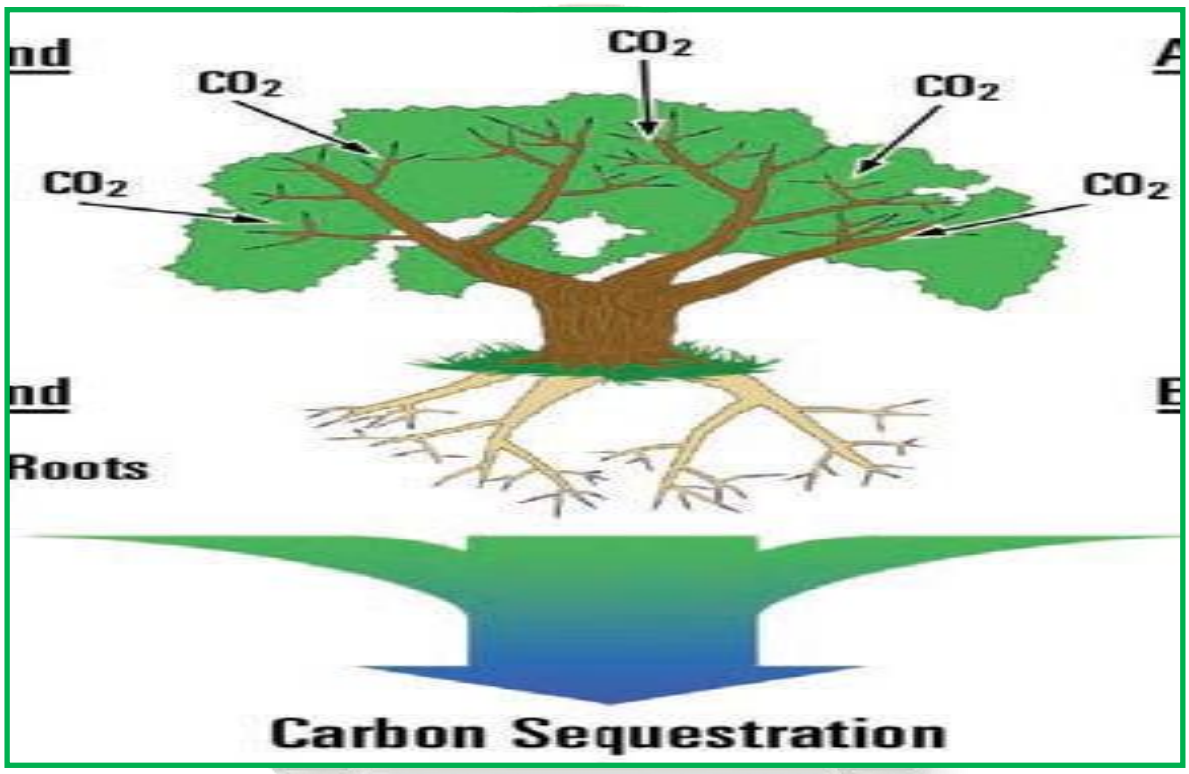
Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide to mitigate global warming and to avoid dangerous impacts of climate change. In other words, it also refers to the process of removing carbon from the atmosphere



and depositing it in a reservoir. This carbon storages or reservoirs are also known as carbon pools. Carbon pool refers to a system or mechanism which has the capacity to accumulate or release. It can be natural or human induced. Examples are forest biomass, wood products, soils, and the atmosphere. Carbon pools in a forest are a complex mix of live and dead organic matter and minerals. Human induced carbon pools are geological storages of carbon dioxide. The quantity of carbon in a pool is known as carbon stock and any change may be expected as stock change. The use of forest is also a financially viable technique to reduce emission from atmosphere. It could also bring significant benefits to the local communities involved and consequently helps in reducing poverty at the same time. Forestry projects can bring social, economic and local environmental benefits to millions of people.

Necessity

- C in excess amount in atmosphere is dangerous
  - Causes global warming
  - May causes productivity losses in agriculture
- C in excess amount in soil is beneficial
  - Improves soil quality & crop productivity
  - Mitigates global warming

  Hence carbon sequestration is important.

Major Ways of Carbon Sequestration

Ocean Sequestration

"Carbon is naturally stored in the ocean via two pumps, solubility and biological, and there are analogous man-made methods, direct injection and ocean fertilization, respectively. Eventually equilibrium between the ocean and the atmosphere will be reached with or without human intervention and 80% of the carbon will remain in the ocean. The same equilibrium will be reached whether the carbon is injected into the atmosphere or the ocean. The rational behind ocean sequestration is simply to speed up the natural process." Carbon sequestration by direct injection into the deep ocean involves the capture, separation, transport, and injection of CO_2 from land or tankers. 1/3 of CO_2 emitted in a year already enters into the ocean. Ocean has 50 times more carbon than the atmosphere.

Geological Sequestration

Storing of CO_2 underground in rock formations able to retain large amounts of CO_2 over a long time period. Held in small pore spaces (have held oil and nat. gas for millions of years).

Terrestrial carbon sequestration

The process through which CO_2 from the atmosphere is absorbed naturally through photosynthesis & stored as carbon in biomass & soils. Tropical deforestation is responsible for 20% of world's annual CO_2 emissions, though offset by uptake of atmospheric CO_2 by forests and agriculture. Carbon seq. rates differ based on the species of tree, type of soil, regional climate, topography & management practice

- Pine plantations in SE United States can accumulate almost 100 metric tons of carbon per acre after 90 years (~ 1 metric ton/1 year)

Soil Carbon Sequestration

Soil carbon sequestration refers to the process of transferring carbon from the atmosphere into the soil through plant residues where it is retained for a substantial period of time.

Natural Carbon Sequestration

Natural areas of C_{seq} are natural grasslands, wetlands, organic soils even with lightning induced fires, C can be stored in great amounts

- Environmental factors that naturally promote carbon sequestration
- Soils in cool climates with high moisture contents store lots of C because of slow oxidation rates.

Benefits of Adding Carbon for Soil and Plants

- OM increases soil aggregation
- Reduces soil erosion
- Increases plant available water

- Decreases mechanical impedence
- Decreases bulk density over time
- Increases CEC and buffer capacity
- Can increase crop yields over time
- Keeps nutrients in the soil instead of running off or leaching

Methods of Carbon Sequestration in Agriculture

a) Conservation agriculture
- Minimal soil disturbance
- Residue retention
- Minimal soil compaction.
- Cropping sequences
- Crop rotation

Intercropping for *Kharif* season (Shallow to medium deep soil):
2:1 Proportion - Pearlmillet + Pigeonpea, Sunflower + Pigeonpea, Pearlmillet + Mothbean, Clusterbean + Pigeonpea,
1:2 Proportion - Castor + Mothbean, Castor + Clusterbean
Intercropping - Castor + Ridge gourd
- Intercropping for *kharif* season (Medium deep to deep soil):
Soybean + Pigeonpea, Sorghum + Pigeonpea, Maize + Soybean, Cotton + Blackgram
- Three tier intercropping for *kharif* season (Medium deep to deep soil):
6:1:2:1 proportion - Cotton+Sorghum+Pigeonpea+Sorghum
- Relay Cropping for *kharif* season (Medium deep to deep soil):
Soybean – Gram, Greengram – Sorghum, Greengram-Safflower, Soybean – Wheat

Strip cropping for *Rabi* season (Medium to deep soil):
6:3 Proportion - Chickpea + Safflower, Sorghum + Safflower
Crop rotation for deep soil
Kharif-Rabi - Pearlmillet-Chickpea, Soybean-Chickpea, Blackgram / Greengram / Cowpea-Rabi Sorghum

Sole cropping for shallow soils *Kharif*
Kharif - Stylo / Horsegram / Mothbean / Pearlmillet

Year to year crop rotation for medium to deep soil
Kharif-Rabi - *Pigeonpea-Sorghum*
Rabi-Rabi - Sorghum-Chickpea, Sorghum-Safflower, Safflower-Chickpea

Alley Cropping
Incorporation of Leucaena loppings in 9m width allays in sorghum, sunflower and pigeon pea.

b) Agro forestry in carbon sequestration-Direct role: Carbon sequestration rates ranging from1.5 to 3.5 Mg C ha^{-1} yr^{-1} in agroforestry systems.
- Indirect role: Agroforestry has also some indirect effects on C sequestration since it helps to reduce pressure on natural forests
- Neem + Cowpea
- Guava + stylo

- Mango + Greengram
- Leucaena + sunhemp
- Sequestration by AM fungi
- Biochar application

c) Forest management practices -Tree plantings have the advantage of accumulating carbon in perennial biomass of above- and below-ground growth, as well as in soil organic matter.

d) Organic farming in Carbon sequestration

- C-sequestration through plant rootsThe ability of regenerative organic agriculture to be a significant carbon sink
- Organically improved healthy soil develops high levels of complex organic compounds which are not readily water soluble yet create micro pores that help to manage water better than non-organic soils.

e) Green manure

Non-legumes: supply OM

Legumes - Both OM and fix N

- Legumes add 25-70 lbs N/ac

Advantages of green manure crops

1. Positive influence on physical and chemical properties of soil.
2. Maintain the organic matter and carbon status of soil.
3. Serves as a source of food and energy for the soil microbial population.
4. Enhanced the activities of soil organisms.
5. Improves aeration.

Build up soil structure and tilth.

f) Improved Grassland Management

- Degradation of permanent grasslands can occur from accelerated soil erosion, compaction, drought, and salinization.
- Strategies to sequester carbon in soil should improve quality of grasslands.

Strategies for restoration should include:

- Enhancing soil cover
- Improving soil structure to minimize water runoff and soil erosion

g) Biochar - carbon-rich solid- a by product of low-temperature pyrolysis of biomass also known as charcoal, biomass derived black carbon, Agrichar. formed under complete or partial exclusion of oxygen at low temperatures between about 400 and 500º C.

Benefits of Carbon Sequestration

- Improve structural stability
- Increase plant available water
- Reduce soil erosion
- Affecting thermal properties
- Storing and cycling of nutrients
- Contribute to cation exchange capacity
- Sustaining biological activity, diversity and productivity
- Increase agronomic productivity and brings sustainability in production system
- Reduces atmospheric CO_2 concentration thus helpful to mitigate the global warming issue.