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Carbon sequestration improves soil health and overcome global warming

Bheru Lal Kumhar
Article ID: 4
College of Agriculture, Jawaharlal Nehru Agricultural University, Jabalpur-482004
Corresponding author: prajapatiagro09@gmail.com

Introduction

Climate change refers to a change in the state of the climate that can be identified (*e.g.*, by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (Kumhar *et al.,* 2019a and Kumar 2019). UNFCCC defines climate change as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.' The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. Global warming, the bitter fruit of industrial revolution has detrimental effects on both biotic as well as abiotic components of the earth. These effects mostly observed as increased average global temperature, unpredictable climate changes, erosion of biodiversity, floods, cyclones, storms etc., and call for immediate strategies to eliminate or reduce the causes responsible for global warming. Since carbon as carbon dioxide (CO_2) is the main player in global warming, so most of the options aimed at addressing the global warming are directed towards trapping of carbon from atmosphere.

Table 1. Present scenario of greenhouse gases

Greenhouse gases (GHG)	**Preindustrial level 1750**	**20th century level 1999**	**Global warming potential**	**Current level** 2018	**Increase (%)**	**Radioactive forcing (W/m^2)**
CO_2	280 ppmv	367 ppmv	1	406 ppmv	41.2	1.46
CH_4	700 ppbv	1745 ppbv	21	1893ppbv	170.4	0.5
N_2O	270 ppbv	314ppbv	310	326 ppbv	20.7	0.15
CFC-12	0	533pptv	10900	-	-	0.17

PPMV= parts per million by volume, Courtesy (IPCC, 2001& 2018)

PPBV=parts per billion by volume,

PPTV= PPMV= parts per trillion by volume

Climate change is poised to have a sharply differentiated effect as between agro-ecological regions, farming systems, and social classes and groups other impacts are. (Singh *et al*., 2017; Agrawal *et al*., 2019).

1. Shift in climatic and agriculture zones
2. Impact on Agriculture soil
3. Effect on soil organic matter and soil fertility
4. Effect on biological health of soil
5. Soil erosion and sediment transport
6. Reduced soil water availability
7. Impact on soil processes
8. Salinization and alkalization
9. Pest, diseases and weeds
10. Impact on plant growth
11. Impact on crop production

Carbon sequestration

Carbon sequestration is the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere. The idea is to prevent carbon emissions produced by human activities from reaching the atmosphere by capturing and diverting them to secure storage, or to remove carbon from the atmosphere by various means and 'storing' it in the soil (Parihar *et al*., 2018). The Department of Energy (2006) refers to carbon sequestration as the provision of long-term storage of carbon in the terrestrial biosphere, underground, or the oceans so that the buildup of CO_2 (the principal GHG) concentration in the atmosphere will reduce or slow." The C sequestration process may be naturally or anthropogenic-driven. The natural process includes terrestrial sequestration in soil (humification and formation of secondary car-bonates) and trees such as biomass production and storage in aboveground and below ground components (Lal, 2004).

Soil carbon sequestration

Soil organic carbon is considered to be one of the largest carbon reservoirs of the terrestrial ecosystems and also plays an important role in the global carbon cycle (Lal, 2004). Ground covers (GC) is an efficient practice to reduce soil and nutrient losses in grass-based cropping system, so they can act as a sink of atmospheric carbon and improve soil fertility, efficient tool for atmospheric carbon sequestration and to protect the soil from erosion. The selection of species with greater biomass in the shoot and root systems usually increases the C input and, therefore, the SOC. Kumhar *et al.,* 2019c.

Conservation agriculture

Principle of conservation agriculture follows the three main processes as described by FAO.

1. Minimal soil disturbance:
2. Soil cover: Ground cover must be more than 30%.
3. Inclusion of legume.

Forms of conservation agriculture

Major forms of conservation agriculture include

- ➢ Minimum, reduced or no tillage
- ➢ Crop and pasture rotation
- ➢ Contour farming and strip cropping
- ➢ Cover and green manure cropping
- ➢ Fertility management
- ➢ Erosion control
- ➢ Agro-forestry and alley cropping
- ➢ Organic and biodynamic farming

- Stubble mulching
- Integrated nutrient management (INM)
- Integrated pest management (IPM)
- Irrigation management

The carbon sequestration under conservation agriculture is possible either by maximizing the carbon input or by minimizing the soil carbon loss. Carbon sequestration rate varies with plant characteristics, rotation sequence, type and frequency of tillage, fertilizer management in terms of rate, timing and placement of fertilizers in the soils and integrated management of pest and nutrients, crop and livestock *etc*. (Kumhar *et al.,* 2019b)

Agroforestry

Agroforestry is a viable alternative to prevent and mitigate climate change. Agroforestry was recognized by IPCC as having high potential for sequestering C as part of climate change mitigation strategies (Watson *et al.,* 2000). It can increase and stabilize agricultural yields and reduce soil erosion (Prinsley, 1990). Agroforestry is ideal option to increase productivity of wastelands, increase tree cover outside the forest, and reduce human pressure on forests under different agro-ecological regions of India. An IPCC special report (IPCC, 2000) indicates that conversion of unproductive croplands and grasslands to agroforestry have the best potential to soak up atmospheric C. In agroforestry, soil restoration process involves recovery of organic based nutrients cycle through replenishment of soil organic matters, about half of which is carbon.

Organic Farming

This compost contains aligned beneficial microbes, where the dry matter is rich in carbon and the green matter is rich in nitrogenous substances. When decomposition of these components takes place the carbon nitrogen ratio in the soil becomes 10:1, ideal for the proliferation of microbes. This type of farming practices not only improve the soil fertility but also increase farmers' income. Hence, we can say organic farming is one of the best ways of improving soil fertility which co-benefited the sequestration of carbon from atmospheric. Organic farming has been shown to increase the SOC contents. Therefore, it is suggested as a measure to improve the overall greenhouse gas balance of agriculture compared to conventional farming. Crop rotation and organic fertilization are both known to exert strong control over SOC in any farming system, but neither of them is uniquely organic farming.

Conclusion

Soil C sink capacity depends on several factors including climate, soil type, crops and vegetation cover, and management practices. Recycling organic resources containing polyphenols and lignin may affect the long-term decomposition dynamics and contribute to the buildup of SOC. Hence, it is important to explore a wide range of adaptation strategies, which could reduce the vulnerability of agriculture to climate change.

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