Educational Material Series # 2 **Soil Carbon Cycle and Management**

Introduction

Carbon (C) is the most common element in the universe and is found in all living organisms. Plants use C in the form of carbon dioxide (CO_2) for photosynthesis. When plants grow, they create aboveground and belowground components. After harvest, roots and plant residue on the ground transform into different types of soil C. The added C provides food for microbes, which respire CO_2 back into the atmosphere. This movement of the C through soil from decomposition of organisms and organic matter is called the soil carbon cycle (Fig. 1). This fact sheet describes the benefits of soil C, factors that influence soil C, and management practices that could improve C accumulation in the soil.

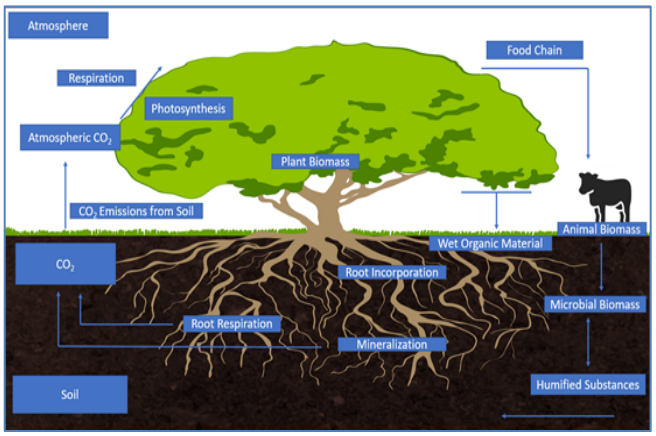

Fig. 1. Soil Carbon Cycle (Adapted and modified from Institute for Radiological Protection and Nuclear Safety (IRSN)).

Benefits of Soil Carbon

Soil C has several benefits including improving soil structure, soil aeration, water retention, biological soil activity, reducing the risk of soil erosion and nutrient leaching; all of which could increase crop yield, benefit the environment and improve growers' income. Soil C benefits are briefly explained below:

- ***Soil Structure:*** An increase in soil C often provides food for earthworms and other beneficial organisms, resulting in increased soil aggregation, better soil structure and physical stability leading to improved soil conditions for crop growth.
- ***Soil Aeration:*** Soils with higher organic C are generally well aerated which allows for exchange of oxygen in soil and promotes root development.
- ***Water Retention:*** Soils with high C content generally show higher water retention which is more apparent in sandy and silt-loam soils.
- ***Soil Biological Activity:*** An increase in C presence in the soil will often result in an increase in soil biological activity, which promotes nutrient cycling and provides potential for increased crop yield.
- ***Soil Pollution Reduction:*** More soil organic C in an agricultural setting encourages a stable C cycle, which decreases soil pollution.
- ***Nutrient Preservation:*** In soils with high C content, improved structure and aeration decrease the risk of surface runoff and leaching which subsequently increases the nutrient avaiablity for agricultural productivity.

Growers are increasingly interested in improving and protecting soil C. Storing C in the soil is called "carbon sequestration". Increases in organic soil C result in a stable C cycle. It is important to know what factors influence C storage/losses to implement best management practices for protecting and improving soil C.

Natural Factors that Influence Soil Carbon

Several inherent factors influence soil C including soil temperature and moisture, soil texture, and soil drainage.

- ***Soil Temperature:*** Warm temperatures can generally speed-up soil C mineralization and therefore, soil C is often higher in cooler regions than in warm and humid regions.
- ***Soil Moisture:*** Soil C mineralization is slower in dry conditions.

- ***Soil Texture:*** Generally, soils with finer texture (higher clay content) have higher soil C content than coarse textured soils.
- ***Soil Drainage:*** High oxygen levels in well-aerated soils increase soil C mineralization and saturated soil conditions decrease the mineralization process.

Management Practices that Increase Soil Carbon

- ***Conservation Tillage Practices:*** One way to prevent C loss is through shifting from high intensity tillage that disturbs the soil and results in loss of C as CO_2 to less intense tillage practices including no-till, strip-till and mulch-till. No-till in particular does not disturb the soil excluding planter disturbance and therefore, keeps the soil intact from rapid C mineralization, preventing C losses.
- ***Crop Residue:*** Leaving crop residue on the soil surface (1) protects the topsoil from erosion losses and (2) adds to the soil organic matter accumulation. Presence of crop residue on the soil surface helps to hold soil moisture and improve overall soil quality.
- ***Cover Crops:*** Cover crops can help provide extra soil support as well as physically covering the soil. They can also improve soil structure through the addition of organic materials to the soil via decomposition of both roots and shoots.
- ***Manure and Compost:*** Adding organic amendments such as manure or compost can increase soil C, soil aggregation and aggregate stability. Stable aggregates allows for soil C to become more complex over time and this would help with soil C stabilization and sequestration.
- ***Crop Selection:*** Planting crops that require less disturbance during management, have higher root biomass, including perennial grasses and alfalfa, typically increase soil C by (1) preventing soil loss through soil disturbance and (2) the decomposition of root biomass which adds organic matter to the soil and improves soil aggregation, protecting soil C.
- ***Buffers:*** Buffers are generally perennial grasses which could slow down the flow of run-off, decreasing soil loss, and therefore, preventing C loss. Similar to other perennials, buffers can also add soil C through root decomposition. They also do not require tillage and therefore can improve soil aggregation, aggregate stability and as a result, soil C stabilization.
- ***Prescribed Grazing:*** Grazing can improve the soil by the additions of organic materials (feces and urine), reducing machinery operation, and trampling down crop residue. It should be noted that prescribed grazing takes into account the number of animals in a unit of land and considers soil moisture to avoid soil compaction.

Summary

Soil C has several benefits including improving soil structure, soil aeration, water retention, biological soil activities, reducing the risk of soil erosion and nutrient leaching, all of which could increase crop yield, benefitting the environment and improving growers' income. Management practices that decrease soil disturbance, increase organic matter accumulation and protect the soil from erosion all contribute to soil C accumulation. Examples of these practices are conservative tillage practices, leaving behind crop residue, application of cover crops, adding manure or compost, proper crop selection of crops with higher root biomasses, use of buffers, and the use of prescribed grazing.

Additional Information:

The carbon cycle and soil carbon: http://nmsp.cals.cornell.edu/publications/factsheets/factsheet91.pdf

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