Total Carbon (Tot C)

Total Carbon (Tot C) is a measure of both the organic and inorganic forms of carbon in soil. Carbon that is bound in soil organic matter is referred to as soil organic carbon (SOC), which includes relatively available organic carbon such as in fresh plant residues and more stable organic carbon that is protected in the soil. Carbon can also be found in inorganic form as carbonate minerals such as calcium carbonate (lime). When soils have no carbonate minerals, Tot C is equivalent to SOC. However, in soils containing high levels of carbonates, a significant portion of Tot C may be in the inorganic (mineral) form. Soils with high levels of carbonates tend to have a soil pH above 7.2.

Important differences exist between measuring Tot C and measuring the percent organic matter (% OM) of a sample using the loss-on-ignition (LOI) procedure. The Tot C method directly measures the CO₂ released as the soil sample is combusted and is subject to less error than the LOI procedure. On the other hand, estimation of the % OM in a soil sample from Tot C may not be completely accurate if the soil contains large quantities of carbonates.

How Tot C relates to soil function

Organic carbon greatly impacts the physical, biological and chemical properties of the soil. The Tot C measurement is an indicator of the OM in the soil sample. The total amount of all organic material in soil is commonly called soil organic matter (SOM). Carbon is the main element found in soil organic matter, comprising 48-58 % of its total dry weight (Nelson and Sommers, 1996). SOM acts as a long-term carbon sink, and as a slow-release pool for nutrients. Soils with high Tot C tend to require lower farm inputs, and to be more resilient to drought and extreme rainfall events.

Total Nitrogen (Tot N)

Total Nitrogen (Tot N) exists in organic forms and inorganic (or mineral) forms such as plant available ammonium (NH₄⁺) and nitrate (NO₃⁻). The majority of Tot N is bound in soil organic matter. Inorganic nitrogen is liberated from organic nitrogen sources in the soil, particularly proteins and amino sugars. This complex group of organic compounds accounts for roughly 30 % of the total nitrogen found in soil but this number can vary greatly based on soil management practices: crop rotation, tillage operations, and application of animal manures.

How Tot N relates to soil function

Soil microorganisms decompose organic matter to liberate energy stored in chemical bonds to fuel their activity and to harvest carbon and nitrogen to build their biomass. Soil biota require nitrogen for the synthesis of their own proteins and other nitrogen containing organic molecules (ATP, DNA, etc.). As dynamic microbial populations grow, if there is insufficient nitrogen in the organic matter they are decomposing they can out-compete crop plants for inorganic nitrogen. This is called immobilization. Conversely, if the organic matter contains sufficient nitrogen to satisfy microbial demands, excess inorganic N is released to crop plants.

FIGURE 1. Example of soil with (a) low SOM and (b) high SOM from Tall Grass Prairie USA.
Managing constraints and maintaining optimal total C and total N content

Sustainable soil management seeks to increase the size and quality of the pool of total carbon and total nitrogen. Building Tot C and Tot N can be accomplished through incorporating organic matter in the forms of cover crops, crop residues, and manures. Retention of crop debris and reduced tillage practices have been shown to increase storage of carbon and nitrogen in the soil.

Basic protocol

Precise measurement of the carbon and nitrogen in soil samples is accomplished using a temperature regulated dry combustion furnace with automatic control of gas flow and pressures (Figure 2).

After oven drying batches of crucibles containing about 0.3 g of soil, the autosampler delivers each sample in turn to the analyzer. The Tot C in a sample is obtained with the complete oxidation of carbon to CO₂ using a high temperature combustion (1100 °C) and CO₂ measurement using Non Dispersive Infrared Detection (NDIR).

The Tot N in a sample is obtained following the Dumas Methodology. In this analysis, the sample is moved into the combustion furnace where all the Nitrogen is converted to N₂O using oxygen. Then the effluent gas is moved to the reduction furnace where all nitrogen is reduced to N₂. The N₂ gas is measured by Thermal Conductivity Detection.

Scoring function

Figure 3 below depicts the (a) Total Carbon and (b) Total Nitrogen scoring functions and upper value limits for coarse, medium, and fine textured soils. The red, orange, yellow, light green and dark green shading reflects the color coding used for the ratings on the soil health report summary page.

![Figure 3. Tot C and Tot N scoring functions and upper value limits for Coarse (C), Medium (M) and Fine (F) textural classes. Mean and standard deviation (in parenthesis) for each class are provided. In this case more is better.](image)

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