Cornell University
School of Integrative Plant Sciences

Soil Health Manual Series Fact Sheet Number 22-08b

Total Carbon, Soil Organic Carbon and Total N

Total Carbon (Tot C)

Tot C is a measure of the sum of both organic and inorganic forms of carbon in the soil. Soil carbon that is bound in organic matter is referred to as soil organic carbon (SOC). Whereas, the soil carbon bound in inorganic carbonate minerals (e.g. calcium carbonate or lime) is referred to as soil inorganic carbon (SIC).

Soil Organic Carbon (SOC)

Soil organic carbon consists of relatively available organic carbon such as fresh plant residues and more stable organic carbon that is protected in the soil. In soils with a pH below 6.5, soils are presumed to have no soil inorganic carbon (SIC), and Tot C is equivilent to SOC. However, in soils with a pH above 7.2, a significant portion of Tot C may be in the inorganic form, i.e. as SIC, which doesn't provide the same benefits as organic carbon. The Cornell Soil Health Laboratory measures the SIC of samples that have a pH above 6.5. The SOC is determined by subracting the SIC from the Tot C. Important differences exist between measuring Tot C and measuring the percent organic matter (% OM) of a soil sample using the loss-on-ignition (LOI) % OM procedure (CASH_Manual_Fact_Sheet_Number_08_OM). The Tot C method directly measures the CO_2 released as the soil sample is combusted and is subject to less error than the LOI procedure.

How SOC relates to soil function

Soil organic carbon impacts the biological, physical, and chemical functioning of the soil. Both Tot C and SOC are more precise indicators for the total organic matter or soil organic matter (SOM) in a soil sample. Carbon is the main element found in soil organic matter, comprising 48-58% of its total dry weight. SOM acts a long-term carbon sink and a slow release pool for nutrients. Therefore, soils with higher SOC, Tot C, or SOM tend to require fewer off-farm inputs and are more resilient to drought and extreme rainfall events.

Total Nitrogen (Tot N)

Tot N is a measure of the total quantity of nitrogen in a sample and consists of organic and inorganic (or mineral) forms such as plant available ammonium (NH_4^+) and nitrate (NO_3^-). The vast majority of Tot N is bound in soil organic matter (generally greater than 90%). Proteins and amino sugars are the most important group of nitrogen containing organic compounds in the soil.

How Tot N relates to soil function

Soil microorganisms decompose soil 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 (DNA, ATP, 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 in a process called *immobilization*. Conversely, if the organic matter contains sufficient nitrogen to satisfy microbial requirements, excess inorganic N is *mineralized* and released to crop plants.

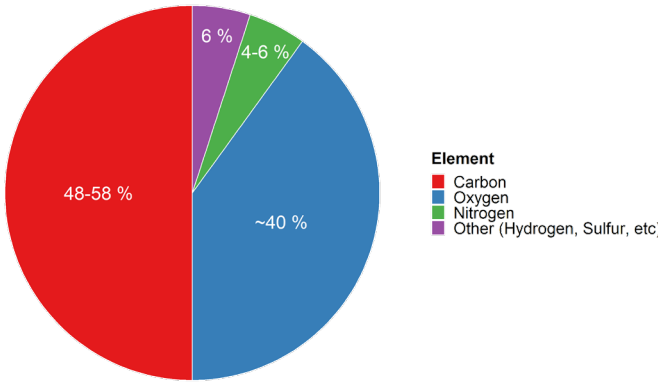

FIGURE 1. Average carbon, nitrogen, and oxygen composition of soil organic matter..

Total Carbon, Soil Organic Carbon and Total N

Maintaining optimal Tot C and N content

Sustainable soil management seeks to increase the quantity and quality of the pool of total C and N. Building Tot C and N can be accomplished through incorporating organic matter in the forms of cover crops, crop residues, and manures. Maintaining a living cover of adapted species sustains plant input above and belowground year-round. Retention of crop debris and reduced tillage have been shown to increase storage of carbon and nitrogen in the soil.

Basic Protocol

Precise measurement of carbon and nitrogen in soil samples is accomplished using a temperature regulated dry combustion furnace (Figure 2). Batches of oven dried crucibles containing approximately 0.3 g of soil are delivered by the autosampler to the analyzer. The Tot C in a sample is obtained with the complete oxidation of sample carbon into CO_2 using high temperature combustion (1100°C) and CO_2 measurement using Non-dispersive infrared (NDIR) detection. The soil inorganic carbon (SIC) is measured using an additional pressure calcimeter methodology (Fonnesbeck et al., 2013) on samples with a pH above 6.5. The Tot N in a sample is quantified by the C and N analyzer with the Dumas methodology. Specifically, all sample nitrogen is converted to N_xO_y gases in the combustion furnace. Then, the effluent gas is moved to the reduction furnace where all nitrogen is reduced to N_2. The N_2 gas is measured by thermal conductivity detection (TCD).

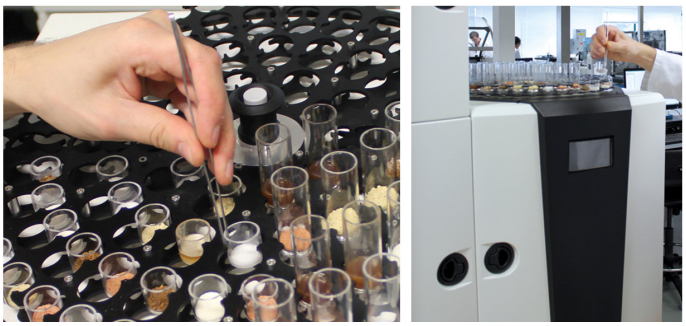

FIGURE 2. Primacs SNC-100 Carbon and Nitrogen Analyzer measures Tot C and N in soil and plant samples.

Scoring functions

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. Tot C and N use more is better scoring functions. 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.

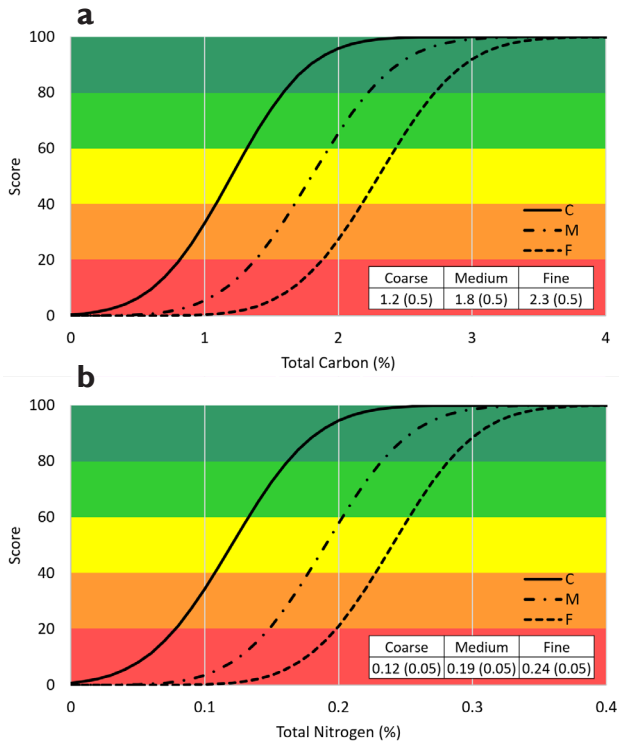

FIGURE 3. Tot C and Tot N scoring functions for Coarse (C), Medium (M), and Fine (F) texture groups. Mean and standard deviation (in parenthesis) are provided for each

Note: The accompanying % OM by LOI laboratory methodology is available in Fact Sheet Number 08.

Acknowledgement

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This fact sheet represents the best professional judgment of the authors and

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