Soil Protein

The Autoclaved Citrate Extractable (ACE) Protein Index is an indicator of the amount of protein-like substances that are present in the soil organic matter. ACE represents the large pool of organically bound nitrogen (N) in the soil organic matter, which microbial activity can mineralize, and make available for plant uptake. Protein content is well associated with overall soil health status because of its indication of biological and chemical soil health, in particular, the *quality* of the soil organic matter (SOM).

How soil protein relates to soil function

Plant residues are ultimately the source of much of the SOM. Microbial biomass builds up as plant residues and other organic matter amendments decompose in the soil. Residues are made up of several types of compounds that are largely similar in composition (Fig. 1). Of these compounds, protein contains the largest fraction of N.

Protein content, as organically bound N, influences the ability of the soil to store N, and make it available by mineralization during the growing season. Soil protein content has also been associated with soil aggregation and thus water storage and movement.

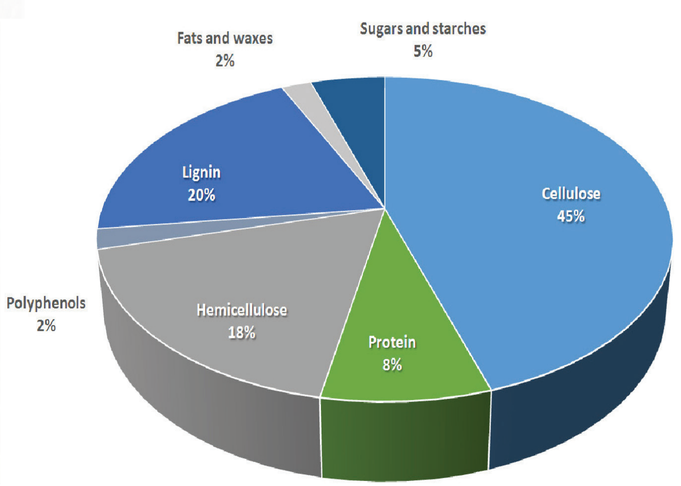

FIGURE 1. Types of compounds in plant residues. Proteins are found in high abundance and contain the largest N fraction.

Managing constraints and maintaining optimal soil protein content

To store and maintain N in SOM, we need to accumulate compounds that are relatively stable, rich in N (low C:N ratio), microbially degradable, and potentially abundant in amendments, crops, cover crops, or residues. Building and maintaining healthy, biologically active soil with large reserves of decomposting plant tissue in organic form is a good approach to provide a crop with its N needs over time as opposed to applying soluble forms of N that plants may not use immediately and be lost. Organic forms of N reserves are built over years and should be maintained to the extent possible.

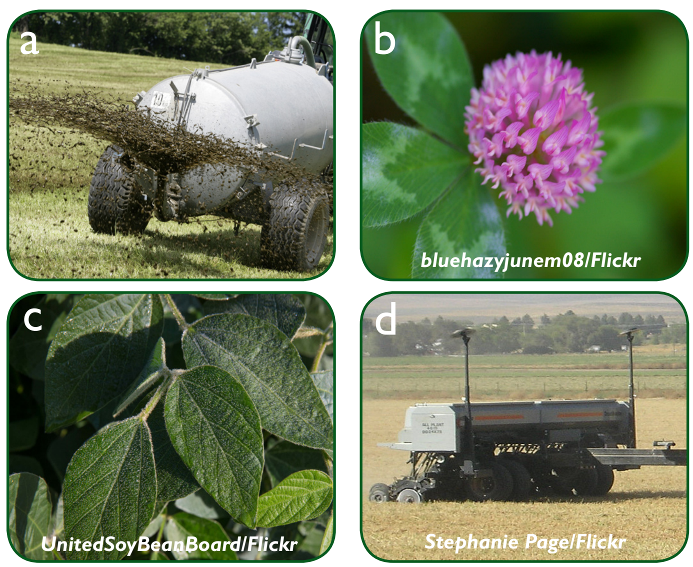

FIGURE 2 a - d. SOM building practices. (a) Manure (amendment), (b) Red clover (green manure), (c) Soybeans (crop rotation), (d)No-till drill (reduced tillage).

Protein content can be increased by adding biomass such as manure, fresh green biomass, well finished compost high in N, and by growing biomass in place to maintain the presence of living, actively growing roots – particularly legumes that are well nodulated – and soil microbes (Fig. 2). Most of these sources are slow to release N over time. Protein content tends to decrease with increasing soil disturbance such as tillage.

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Basic protocol

- Proteins are extracted from sieved, well-mixed, air-dried soil, using a protocol modified from Wright and Upadhyaya (1996) and Clune (2008).
- 3.00 g of soil are weighed into a pressure- and heat-stable glass screw-top tube, with 24.00 ml of sodium citrate buffer (20 mM, pH 7.0), and the mixture is shaken to disperse aggregates and mix well (5 min at 180 rpm) (Fig. 3a).
- The tubes are autoclaved for 30 min (121° C, 15 psi) and then cooled (3b).
- 2 ml of the slurry is withdrawn to a smaller micro-centrifuge tube, and centrifuged at 10,000 x gravity to remove soil particles.
- A small subsample of this clarified extract is used in a standard colorimetric protein quantification assay (BCA), to determine total protein content of the extract.
- The Cornell Soil Health Lab uses the Thermo Pierce BCA protein assay, miniaturized for use in 96-well microplates, incubated at 60° C for uniform response to different protein types, and read color development in a BioTek spectrophotometric plate reader (3c).
- Extractable protein content of the soil is calculated by multiplying the protein concentration of the extract by the volume of extractant used, and dividing by number of grams of soil used.

FIGURE 3 a - c. Lab procedure for the Autoclaved Citrate Extractable (ACE) Protein Index.

Scoring function

Figure 4 below depicts ACE Soil Protein Index scoring functions and upper value limits for coarse, medium, and fine textured soils. It is important to note that extremely high N mineralization could increase losses of N to the environment and thus harm air and water quality.

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.

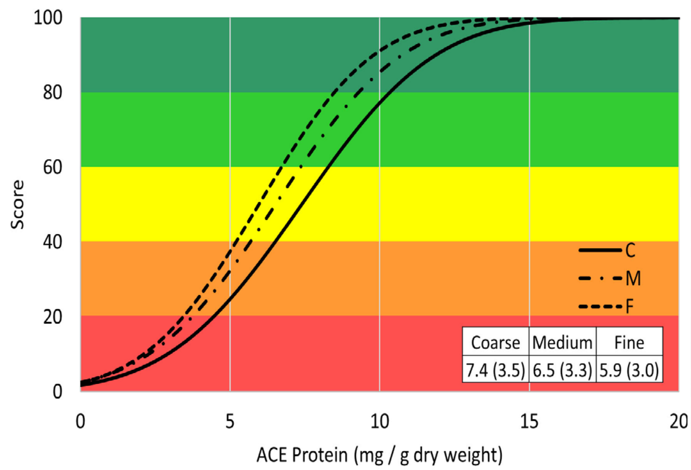

FIGURE 4. ACE Soil Protein Index scoring functions and upper value limits for Coarse (C), Medium (M) and Fine (F) textural classes. Mean and standard deviation (in parenthesis) for each class are provided. In this case more is better. Higher protein index scores indicate a larger pool of organically-bound soil N..

Cornell Soil Health Laboratory ACE Protein Standard Operating Procedures (CSH 07) can be found under the 'Resources' tab on our website.

For a more comprehensive overview of soil health concepts including a guide on conducting in-field qualitative and quantitative soil health assessments, please download the Cornell Soil Health Manual at bit.ly/SoilHealthTrainingManual.

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