Incorporating Soil Biology into Soil Health Assessment

Fact Sheet FS1256

Cooperative Extension

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What is Soil Health?

Soil quality is defined as the capacity of soil to function for different uses, such as a growing medium for plant production (commonly measured as yield), in the regulation of water flow in the environment, and in the recycling of organic residues. Soil quality has intrinsic and dynamic components. Soil mineralogy and soil texture (percentages of sand, silt, and clay) are intrinsic properties that affect a soil's ability to function and are not easily altered. Dynamic characteristics of soil quality, which respond to changes in management, include pH, nutrient status, density, organic matter, and soil biology. Farmers and gardeners commonly manage specific soil amendments by incorporating limestone, humus, compost and cover crops.

Maintenance of the chemical, physical, and biological "health" of the soil is a goal of sustainable soil management. Standard soil fertility assessments involve field sampling with soil probes and laboratory analysis of macro- and micro-nutrients as well as soil pH. Fertilizer recommendations are based upon current soil nutrient levels and estimated crop needs. The ability of farmland or garden soil to produce its own biological nutrients such as nitrogen over the growing season, typically has not been measured due to a lack of economical, practical and/or accurate testing equipment.

The Soil Food Web

Organic matter decomposition through a complex soil food web is the primary nitrogen source in natural, unfertilized ecosystems (Figure 1). Microbial activity is the major contributor to this decomposition, which is essential for nitrogen nutrition of non-legume plants. During this activity, soil microbes release CO_2 through the physiological process of respiration. Measurement of soil respiration from this food web is a method to predict availability of nitrogen, the essential parameter not typically measured in a routine soil test. Farmers with well-balanced, healthy soils have a degree of biological

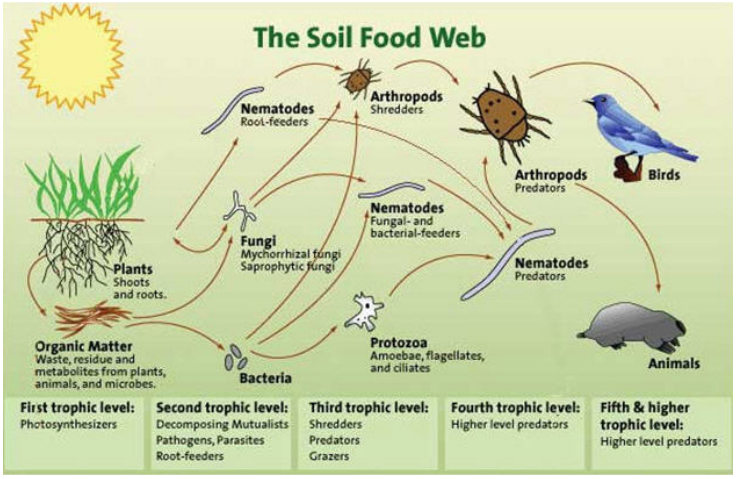


Figure 1 – pictorial diagram of the mineralization process of organic matter through the chain of decomposers and predators. NRCS.usda.gov

soil fertility that can reduce the standard application rates of supplemental fertilizer. The ability to accurately credit nitrogen from microbial conversion of organic matter against the suggested total nitrogen recommendation for plant growth can be a valuable contribution for commercial and residential clients in avoiding excessive application of nitrogen fertilizer.

The Solvita® System

Solvita® is a patented environmental measurement system with applications for soil, compost, manure and grain. The concept is based on color-reactive gels which absorb or react with gases and allow color to serve as an indicator of the gas concentration. One type of Solvita® gel is used to measure carbon dioxide (CO_2) in either low or high ranges, and another type is for ammonia (NH_3) (Haney and Brinton, 2008). For assessment of soil health, the low-level CO_2 gel is used to measure CO_2 emissions from soil, which are primarily due to microbial respiration. The level of microbial activity is indicative of the amount of active organic matter that is being metabolized and nutrients being released simultaneously from the organic matter.

Color 0 - 1 Blue-Gray	1 - 2.5 Gray-Green	2.5 - 3.5 Green	3.5 - 4 Green-Yellow	4 - 5 Yellow
VERY LOW SOIL ACTIVITY Associated with dry sandy soils, and little or no organic matter	MODERATELY LOW SOIL ACTIVITY Soil is marginal in terms of biological activity and organic matter	MEDIUM SOIL ACTIVITY Soil is in a moderately balanced condition and has been receiving organic matter additions	IDEAL SOIL ACTIVITY Soil is well supplied with organic matter and has an active population of microorganisms	UNUSUALLY HIGH SOIL ACTIVITY High/excessive organic matter additions
APPROXIMATE LEVEL OF CO_2- RESPIRATION[a]				
< 300 mg CO_2/kg soil/wk	400 (300 - 500)	750 (500 - 1,000)	1,500 (1,000 - 2,000)	> 2,000 mg CO_2/kg soil/wk
Approximate quantity of nitrogen (N) release per year (average climate)				
< 5 lbs/acre	10-20 lbs/acre	20-30 lbs/acre	30-50 lbs/acre	75-100 lbs/acre

Soil Quality Curve

Figure 2 – scale of microbial soil activity 0 – 5 with associated test colors and predicted nitrogen release.

While the Solvita® soil respiration test can be used in the field, the laboratory method, referred to as the CO_2-Burst Method or Haney-Brinton Protocol, is performed under more controlled conditions and utilizes a drying-rewetting procedure which stimulates a flush of microbial activity to accurately assess biological potential. The visual color chart or an electronic digital color reader provide a 0 to 5 scale of soil health calibrated with the approximate level of CO_2 respiration. This ranking corresponds to the biomass of micro-organisms in the soil. Based on this ranking, an interpretive chart shows the farmer, agent or advisor the amount of additional nitrogen potentially released by soil biology. Soil ratings of low, moderately low, medium, ideal, or unusually high microbial activity provide estimates of 5, 10-20, 20-30, 30-50, or 75-100 lbs. N/acre that could be credited against the total crop needs (Figure 2, Solvita® Guidelines, 2013).

The Laboratory Process, Equipment & Supplies

Under controlled conditions, a standard soil sample (dried, ground, sieved, Figure 3) is analyzed to measure respiration that reveals the relative activity of soil microorganisms through production of CO_2 by biological metabolism. The soil sample is placed in a container with holes in the bottom to allow water to wick up. Placed in an air-tight jar, a paddle with a CO_2-absorbing gel is inserted with the soil to absorb the product of soil respiration as the microbes are revived with the re-wetting step and become biologically active (Franzluebbers, et al., 2000) (Figure 4). The CO_2-sorbing gel changes color as the concentration of CO_2 in the jar increases. After a 24-hour period of incubation, the paddle (gel) is read with a digital color reader or compared to color charts in determining CO_2 production by soil microbes.

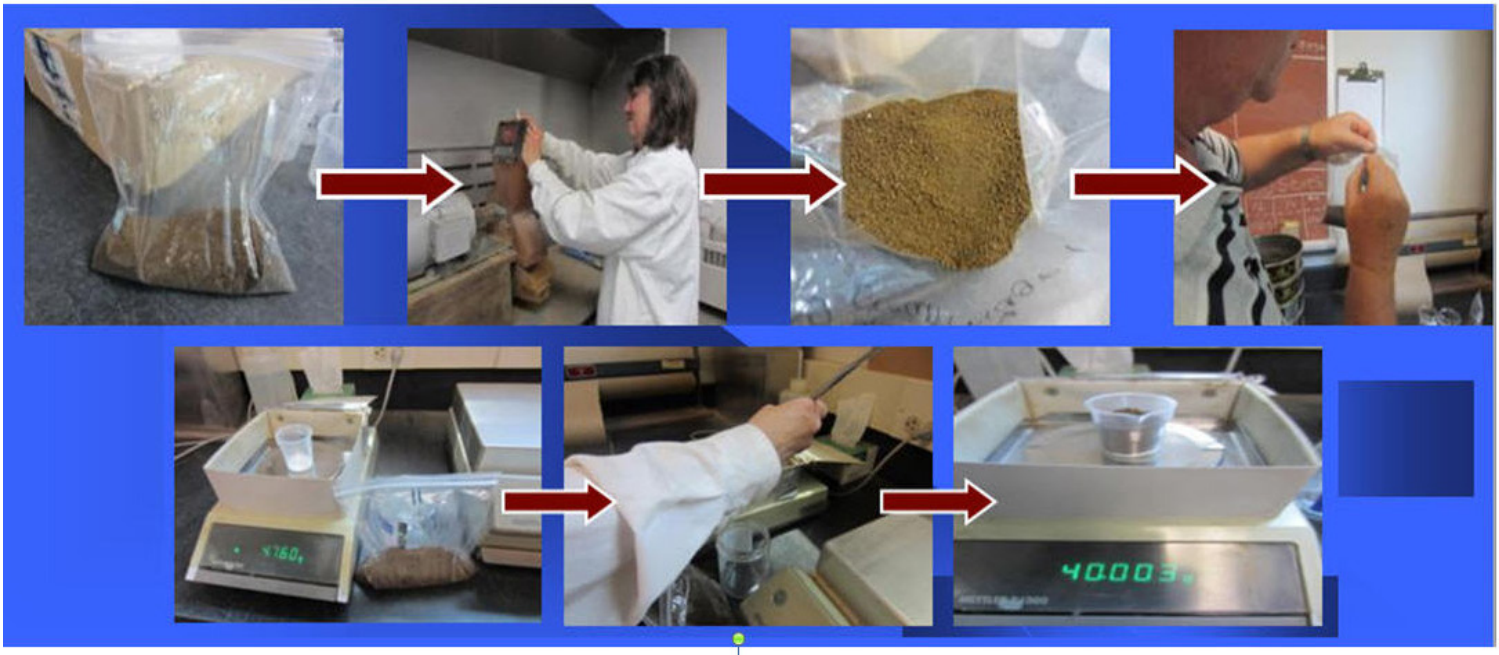


Figure 3 – Rutgers Soil Lab - the laboratory process of receiving soil samples, filtering, drying, weighing and rewetting.



Figure 4 – Solvita® soil test equipment and supplies; color chart, color reader, soil beakers and gel indicators in air-tight jars.

A similar process is carried out for analyzing moist soils directly in the field or compost samples (high CO_2 range) (Brinton, et al., 2007). Recently, a new recommended method of rewetting takes into account soil pore space to achieve 50% soil saturation.

Test Results and Recommendations

Field surveys in central New Jersey assessed farm soils that were nearly level and well drained. Their surface layers were classified as loamy sands, sandy loams, or loams, while the subsoil layers were sandy loams and sandy clay loams (Jablonski & Baumley, 1989). The soil health survey with the Solvita® soil respiration test consistently measured active carbon and microbial biomass which in turn can predict a gain in potential nutrient amounts naturally derived from the soil itself. This research supports the concept that Solvita® works in assessing soil conditions for a diversity of annual and perennial crops (Sciarappa, et al., 2015).

This low-cost, high-tech soil test provided a simple and quantitative means of evaluating the overall status of soil fertility. This tool may be used to measure biological differences between soils under different management or biological changes in a field over time, which is especially important when farmers adopt management practices designed to improve plant and soil health, such as cover cropping, reduced tillage systems, municipal leaves application, fertilizers, compost, and other organic soil amendments. Repeated measurements annually in the same seasons will allow the grower to assess the effects of these various soil management practices, to track changes in biological activity in the root zone, and to make decisions based on this information.

Results and recommendations are given in the 1 to 5 scale system showing low, moderate, medium, and high soil respiration. Higher respiration rates mean more downward adjustment of the total application rate of nitrogen fertilizer. Being able to adjust standard nitrogen recommendations downward by taking natural organic matter mineralization into account would be an economical and environmental contribution to sustainable farming and gardening. The mineralized nitrogen contribution can range from 0 to 75 lbs. or higher per acre depending on the microbial capacity. This site specific information may allow growers with improved, healthier soils to reduce the amount of nitrogen application yet expect the same yield, reduce expenses and avoid excessive nutrient runoff. Rutgers Soil Testing Laboratory performs the Solvita® CO_2-burst test in addition to standard fertility analysis and others. With average sample soil wetness, turn-around time is approximately ten days (Murphy, 2012). The fee structure for Rutgers Soil Testing Laboratory services can be found at njaes.rutgers.edu/soiltestinglab/services.asp.

The Solvita® soil respiration test shows considerable promise in assessing biological soil health and estimating N availability from organic matter decomposition. Farmers, advisors, extension agents and agricultural specialists may add a new assessment method into their technical toolbox. Further research, demonstration and commercial trials can use this regional and seasonal baseline information to compare nutrient recycling from microbial mineralization of organic matter and predict subsequent nitrogen release that contributes to crop nutrition and yield.

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Links

Rutgers – NJAES Soil Testing Lab
njaes.rutgers.edu/soiltestinglab

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