On The Soil Horizon

Dr. Anthony Fulford

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Meet the New Advisor of Nutrient Management and Soil Quality

My name is Anthony Fulford, and I am a newly appointed Nutrient Management and Soil Quality Advisor. My office is located in Stanislaus County, but I will also be serving San Joaquin and Merced Counties. Currently, I am developing the direction of my research and extension program and welcome your feedback on knowledge gaps and research priorities for nutrient management and soil quality. I hope to hear from many of you in the coming months, but until then I wanted to tell you who I am, where I have been, and how I found myself in California.

I grew up in Illinois with a desire to understand the interconnectedness of natural ecosystems. Ultimately, my passion led me west to Colorado where I studied forestry at Colorado State University. My experience in Colorado convinced me to enroll in graduate school where I studied soil remediation and reclamation of urban soils in Illinois and soil fertility of rice cropping systems in Arkansas. It was during graduate school that I realized I wanted to understand how effective nutrient management could sustain and improve ecosystem services. I continued my postgraduate research, where I focused on soil health testing and nutrient management practices for corn, soybeans, and wheat in Ohio.

In This Issue

Anthony Fulford, PhD

UCCE Nutrient Management and Soil Quality Advisor

amfulford@ucanr.edu

(209) 525-6825

My general interest in soil health and nutrient management continues to expand, but my previous research has focused on the development of rapid and cost-effective nitrogen soil test methods. One of the questions we wanted to address during my graduate research in Arkansas was: "Can we identify a soil nitrogen test capable of accurately predicting the yield-maximizing fertilizer nitrogen rate for rice at the beginning of the growing season?" This project led us to discover that by quantifying soil nitrogen from a 0 to 12-inch sampling depth, we could improve our prediction of mineralizable nitrogen and ultimately the accuracy of our recommended fertilizer nitrogen rate. The question we wanted to ask during my postgraduate work in Ohio was: "Does extractable soil protein nitrogen represent a significant fraction of organic nitrogen?" The main result of this project was that we were able to provide evidence that the method used to extract soil protein does not quantify nitrogen derived from a specific organic nitrogen source (for example fungal nitrogen) but instead extracts nitrogen derived from diverse organic matter sources. This result has led us to consider soil protein as a suitable indicator of soil organic nitrogen across a wide range of soil types and cropping systems in Ohio.

I am excited by the opportunity to work in California to advance soil health and nutrient management. There is a good deal of interest in establishing practices at the farm level that will improve soil health while simultaneously maintaining productivity and profitability. I would like to build on this interest and bring practical information about soil health testing and nutrient management to Stanislaus, San Joaquin, and Merced Counties. I hope you will join me in addressing some of the emerging questions surrounding nutrient management and soil health in California.

Anthony can be contacted at *(209) 525-6825* or amfulford@ucanr.edu

Profile

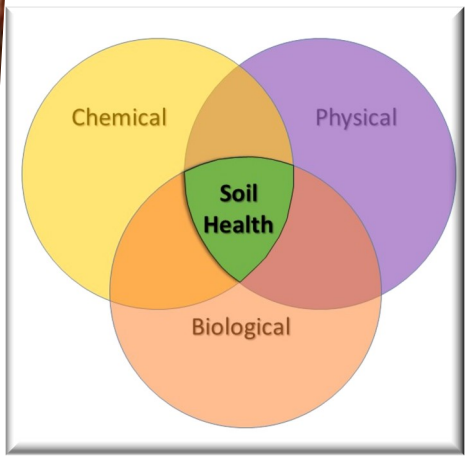
- Soil health conceptually integrates chemical, physical, and biological soil properties
- Soil health testing services differ among laboratories
- Identifying suitable soil health indicators is crucial to managing soil health

What is soil health? How do you measure soil health? What management practices affect soil health? These questions, along with many others, are routinely asked by those new to the idea of soil health and the answers are not always clear. Every field and production system is unique, and therefore what defines a "healthy soil" changes with the landscape. However, despite these unique features, there are common indicators that can be evaluated to determine soil health. Understanding soil health begins with knowing what these indicators are and how they respond to management practices.

What is soil health?

One common definition of soil health is, "the ability of a soil to function." At first, this definition appears to be very simple and easy to understand, but when you consider what it means for a soil to function you notice the complexity underlying this seemingly simple definition of soil health. The ability of the soil to function cannot be determined simply by isolating one aspect of soil. The soil's nutrient availability, for example, contains factors other than the soil's chemical properties that indirectly impact nutrient availability. To properly address soil function, it is necessary to begin thinking about the chemical, physical, and biological processes that occur in soil. **These three processes are connected and when considered together represent soil health.**

Diagram 1



Chemical, physical, and biological constraints can affect soil health, and the goal of soil health management is to implement practices that target those limitations.

How do you measure soil health?

Soil health assessment can be done in the field or in the laboratory. Qualitative soil health assessments are generally conducted in the field using observational indicators, while quantitative assessments are typically conducted in soil testing laboratories using analytical indicators. The focus for part one of this series will be on quantitative soil health indicators.

Currently, there is no standard set of soil health measurements offered by all soil testing laboratories. The methods used to quantify soil health indicators, the number of soil health indicators evaluated, and the analysis cost per sample differ among soil testing laboratories. The *Comprehensive Assessment of Soil Health, Haney Soil Health Test,* and *Solvita Soil Health Suite* are three commonly used and nationally available soil health testing services. An example of the soil health measurements provided by *The Comprehensive Assessment of Soil Health* (CASH) are shown in **Table 1**. The 10 soil health indicators of CASH were selected from among a much larger set of potential soil health indicators based on their ability to respond to different management practices and represent important soil processes. Additional considerations included sampling logistics, cost of soil sampling and analysis, and how easy the results were to interpret.

Quantifying soil health can be done by integrating the results of different chemical, physical, and biological soil tests into a single number, the soil health index. To generate the soil health index provided by CASH, each of the soil health indicators are first evaluated based on their value relative to all other values derived from soil of similar texture. The relative values then receive a rating from 0 to 100 and are assigned to one of five categories: very low (0 to 20), low (20 to 40), medium (40 to 60), high (60 to 80), or very high (80 to 100). For a given soil textural class, the soil health index is then determined by calculating the average score of the CASH indicators. Representing soil health as a single number allows for a quick and easy comparison of soil health indices among different management and production systems.

What management practices affect soil health?

The goal of soil health management is to establish conditions necessary for proper soil function. This goal can be achieved by implementing management practices that overcome chemical, physical or biological limitations and improve the soil's resilience to environmental stress. Organic matter regulates multiple functions in soils including nutrient storage and cycling, water holding capacity, structural stability, and resource provisioning to the soil food web. **Organic matter connects different soil functions, much like the hub of a bicycle tire connects individual spokes, thus integrating the chemical, physical, and biological properties of soils.** (See Diagram 2)

Consequently, soil health management practices generally focus on ways to increase the quantity, or

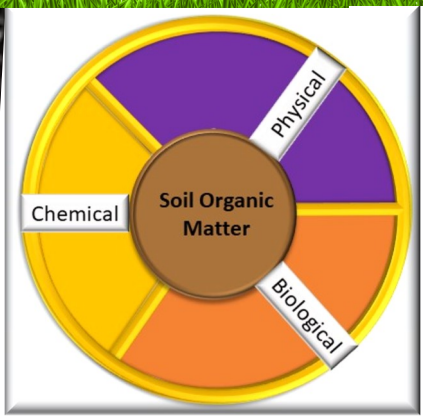


Diagram 2

improve the quality, of soil organic matter. Management practices that build, maintain, or improve the quality of soil organic matter are shown in **Table 2**. The addition of stabilized organic matter, such as mulch and compost, builds soil organic matter by increasing the fraction of soil organic matter that is resistant to rapid microbial decomposition. Building soil organic matter can alleviate physical constraints on soil health by improving structural stability and decreasing bulk density. Diversifying crop rotations and leaving the soil surface covered with crop residues after harvest can maintain soil organic matter by improving soil aggregation and limiting soil erosion. Additionally, optimizing soil fertility can avoid under- or over-fertilization and ensure a consistent amount of above- and belowground biomass will be returned to the soil at the end of the growing season, thus sustaining organic matter inputs. Incorporating crop residues with a low carbon-to-nitrogen ratio or using plants as green manure can improve soil organic matter quality by providing nitrogen-rich organic matter to decomposers, thus improving microbial nutrient cycling of organic matter. Similarly, cover crops capture residual soil nutrients not used by the preceding crop and return these nutrients to the soil organic matter during decomposition.

Summary

The concept of soil health provides a useful way of describing the integrated chemical, physical and biological constraints on soil function. An important point to keep in mind when evaluating soil health is that, currently, soil health testing services are not standardized among different soil testing laboratories. Therefore, knowing which indicators are evaluated by a laboratory and how they are interpreted are critical to understanding soil health. Ultimately, soil management practices that influence the quantity or quality of soil organic matter will have the greatest impact on soil health by augmenting the soil's chemical, physical, and biological functions.

To simplify information, trade names of products have been used. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

Table 1. Chemical, physical, and biological soil health measurements provided by the *Comprehensive Assessment of Soil Health* (CASH).

Soil Health Indicators†		
Chemical	**Physical**	**Biological**
pH	Wet aggregate stability	Soil respiration
Extractable nutrients	Available water capacity	Organic matter
	Penetration resistance	Protein-nitrogen
	Soil texture	Active carbon

†The indicators listed in the table are from the *Standard Soil Health Analysis Package* of CASH (http://soilhealth.cals.cornell.edu/testing-services/). The exact method and number of soil health indicators evaluated differ among laboratories. It is important to know what soil health indicators a laboratory measures when consideringsoil health testing services.

Table 2. Soil health management practices that can build soil organic matter (SOM), maintain SOM, or improve the quality of SOM.

Soil Health Management Practices†		
Build SOM‡	**Maintain SOM**	**Improve SOM**
Apply mulch	Diversify crop rotation	Incorporate nitrogen-rich crop residues
Apply composts	Leave soil surface covered	Incorporate green manures
Adopt no-tillage	Optimize soil fertility	Establish cover crops

†This table is not intended to be a comprehensive list of soil health management practices but rather to serve as an example of management practices that influence soil organic matter;

‡SOM, Soil Organic Matter.

Soil Health Resources

Soil health testing services:

Comprehensive Assessment of Soil Health (http://soilhealth.cals.cornell.edu/)

Haney Soil Health Test (https://www.wardlab.com/)

Solvita Soil Health Suite (https://woodsend.com/)

Soil Health News:

University of California Agriculture and Natural Resources – Solution Center for Nutrient Management (http://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Soil_Health_894/)

Natural Resource Conservation Service – Soil Health Division (https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/)

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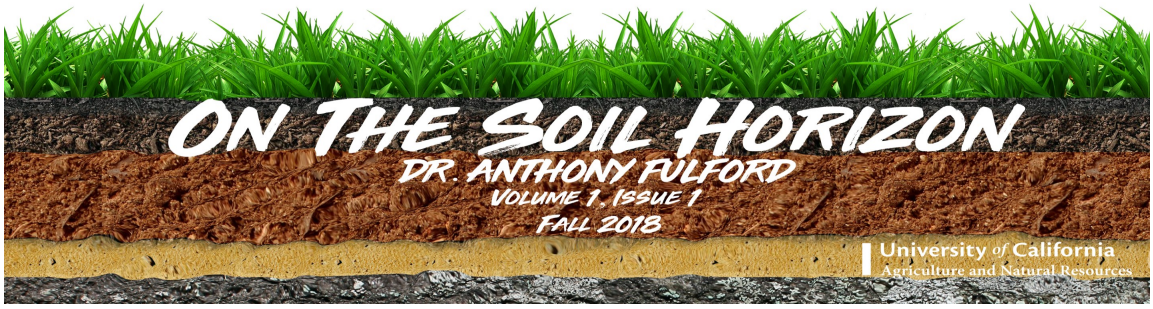

Anthony

Anthony Fulford,
Nutrient Management and Soil Quality Advisor
UCCE Stanislaus County

Current resident or:

University of California
Cooperative Extension
3800 Cornucopia Way, Suite A
Modesto, CA 95358

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