Promoting and Measuring a Soil Health Management System (SHMS)

Background and Purpose

Soil health is “the capacity of a soil to function”. Soil is a habitat for a highly productive visible and invisible life that needs food, water and shelter to provide food, water and shelter for crops that grow in it. Managing for soil health goes far beyond soil texture identification, nutrient management, and soil erosion prediction.


Stable aggregates that hold and release water more efficiently can only be formed in a healthy soil. Sustainable plant production, energy savings, less nutrient inputs, less pesticide use and less water quality degradation are benefits of achieving a healthy soil. Also soil that is healthy will store more Carbon in both microbial populations and in humic substances.

A Soil Health Management System (SHMS) is the highest level of soil conservation because it is regenerative and it improves the plant-soil ecosystem. Conservationists should encourage cooperators to adopt the following SHMS strategies:

- **Decrease tillage to improve soil aggregate stability and enhance the soil food web habitat**
  
  Tilling the soil is the equivalent of an earthquake, hurricane, tornado, and forest fire occurring simultaneously to the world of soil organisms. Simply stated, tillage is bad for the soil. Physical soil disturbance, such as tillage with a plow, disk, or chisel plow, that results in bare or compacted soil is destructive and disruptive to soil microbes and creates a hostile, instead of hospitable, place for them to live and work. The soil may also be disturbed chemically or biologically through the misuse of inputs, such as fertilizers and pesticides. This disrupts the symbiotic relationship between fungi, microorganisms and crop roots. By reducing nutrient...
inputs, we can take advantage of the nutrient cycles in the soil to supply crop nutrients and allow plants to make essential associations with soil organisms.

- **Keep the soil covered as much as possible with residue and diverse cover crops**
  Soil should always be covered by growing plants and/or their residues, and soil should rarely be visible from above. This is true regardless of land use (cropland, hayland, pasture, or range). Soil cover protects soil aggregates from ‘taking a beating’ from the force of falling raindrops. Even a healthy soil with water-stable aggregates (held together by biological glues) that can withstand wetting by the rain may not be able to withstand a ‘pounding’ from raindrops. A mulch of crop residues on the soil surface suppresses weeds early in the growing season giving the intended crop an advantage. They also keep the soil cool and moist which provides favorable habitat for many organisms that begin residue decomposition by shredding residues into smaller pieces.

- **Plant diverse crops to increase diversity in the soil food web**
  Sugars made by plants are released from their roots into the soil and traded to soil microbes for nutrients to support plant growth. The key to improving soil health is assuring that the food and energy chains and webs includes as many different plants or animals as practical. Biodiversity will ultimately be the key to success of any agricultural system. Lack of biodiversity severely limits the potential of any cropping system and disease and pest problems are increased. A diverse and fully functioning soil food web provides for nutrient, energy, and water cycling that allows a soil to express its full potential.

- **Keep living plants growing throughout the year to feed the soil food web.**
  There are many sources of food in the soil that feed the soil food web, but there is no better food than the sugar exuded by living roots. Soil organisms feed on sugar from living plant roots first. Next, they feed on dead plant roots, followed by above-ground crop residues, such as straw, chaff, husks, stalks, flowers, and leaves. Lastly, they feed on the humic organic matter in the soil. Healthy soil is dependent upon how well the soil food web is fed. Providing plenty of easily accessible food to soil microbes helps them cycle nutrients that plants need to grow.

- **Incorporate livestock grazing into the crop rotation if possible.**
  Grazing animals can be incorporated into a cropping system in a rotation. Herbivores add another aspect of organic nutrient cycling by stimulating plant growth and adding nutrients through manure in addition to beneficial hoof action under the right conditions. It is critical to closely manage livestock grazing to maintain healthy and productive plants through prescribed grazing.

**Achieving a SHMS requires a long term commitment.**

The SHMS strategies are interconnected and inseparable. To achieve soil health all of the strategies must be used. A piecemeal approach will not be effective.

Adaptive nutrient management and the 4 Rs, (Right source, rate, time and placement), is a strategy designed for conventional, high nutrient input crop production. It has a role in a SHMS
but it is not the central focus because it places too much emphasis on chemical nutrient-plant relationships and too little emphasis on soil-plant microbiological processes and interactions. As the health of the soil improves, essential plant nutrients will become more abundant as part of a balanced system and will be available for plant use from the soil food web. The need for imported nutrients identified in a standard soil test will be reduced.

Conservationists should encourage Cooperators to begin adopting SHMS on a small field or on part of a field. The conservationist and cooperator can both gain confidence through experience using new approaches with diverse crop rotations, cover crops, roots in the ground all year, less tillage and the use of livestock if possible.

Questions about types of crop rotations to use, nutrients, cover crops, no till strategies, economics, etc. will be asked by the cooperator. Achieving soil health is a complex undertaking so conservationists must educate themselves on its principles and benefits. Ongoing support is essential.

- [http://aces.nmsu.edu/pubs/_a/A148/welcome.html](http://aces.nmsu.edu/pubs/_a/A148/welcome.html)

Several producers in New Mexico have already adapted SHMS. For details contact the NM state Agronomist [Rudy.Garcia@nm.usda.gov](mailto:Rudy.Garcia@nm.usda.gov)

**Tools for Soil Health**

The following four tools should be used with the cooperator to establish a baseline condition on which to build and measure progress towards a Soil Health Management System.

1. A Slake test for aggregate stability
2. A Soil Respiration or active CO₂ test
3. A Soil Food web Analysis
4. A Standard soil test for N,P,K, Micronutrients, pH, Electrical Conductivity(EC) and Sodium Adsorption Ratio(SAR)

### 1. Slake test For Aggregate Stability

1. Acquire two glass jars approximately 10" high x 3" wide.

2. Acquire screen with ¼ to ½" square slots. Hardware cloth works well. Cut two sections of screen approximately 8" long x 2.5" wide, resulting in one section of screen for each jar. Form the screen sections so they overlap by approximately 1" on two sides of the jar and dip approximately 2.5" into it.
3. Randomly collect soil aggregates approximately 2.5" in diameter from two locations in the same field to show contrast in management. Aggregates should be from a heavily disturbed field, such as with conventional tillage where tillage history is known. To show the contrast collect aggregates of the same soil type from the edge of the field where the soil is undisturbed. Remove and discard litter and roots.

4. Dry all collected soil clods in a microwave or allow it to air dry.

5. Fill jars with water.

6. Choose two soils aggregates which you suspect will have different organic matter contents (annual vs. perennial, no-till crop field versus conventional tilled crop field). Place them in the water. Observe the different stability of the soil material. A soil aggregate high in organic matter will stick together. The water will be clearer (left). An aggregate low in organic matter will fall apart or “slake” rapidly. The water will soon be cloudy (right). Use this demonstration to explain the importance of building organic matter and especially the importance of Glomalin that glues micro-aggregates together.
2. Soil Respiration test

The Solvita® Test is a simple test to measure soil respiration. It is available as a field test kit or upon request from some soil testing labs. http://solvita.com/

Testing soil Respiration: The release of Carbon Dioxide, CO₂, from the soil due to biological activity is a basic dynamic of the earth. It reflects the interplay of added and sequestered organic matter and the fraction that is being biologically decomposed. By evaluating this turnover of organic matter via respiration, important biological aspects of soil fertility are revealed. The rate of CO₂ release is generally regarded as an indicator of soil health and may be used to estimate potential release of nutrients such as Nitrogen. -Solvita® Version 2013 Official Solvita®

Guideline Soil CO₂ Respiration Test

BASAL RESPIRATION (fresh soil) METHOD

Solvita Basal Respiration* is performed with undisturbed or fresh, moist soil that has not been adjusted or pre-dried. The test may also be performed directly in the field with a cylindrical chamber inserted into the soil. This method gives results typical of actual field conditions but tend to be inherently more variable than lab results.

1. SAMPLING: Soil should be freshly sampled in a normal moist condition shortly before the test is performed. Take at least 6 random samples 0 - 3’ (0 - 7.5cm) depth from various locations and mix thoroughly, removing stones, roots and organic debris.

2. IDEAL SOIL MOISTURE: For this test the soil should be sampled moist as would be normal for optimal growing conditions. If moisture is added to a very dry soil, the sample should be allowed to equilibrate for 24 hours before testing. If performing in-situ (field) tests, soil is tested in the as-is condition.

3. PUT SAMPLE IN SOLVITA® JAR: Put the fresh, moist soil in the jar up to the fill line. A natural soil profile or turf plug may also be inserted in the jar to reproduce actual field conditions. Alternatively, a 3’ (7.5cm) cylinder may be inserted into the field soil for in-situ testing as per the USDA-NRCS instructions*. If a scale is available, the soil should weigh 100-110 grams (3.5 - 4 oz).

4. START THE TEST: When you are ready to start the test, open the Solvita foil pouch and carefully remove the probe. Do not touch the gel surface, and don’t allow soil to touch it. The fresh gel should appear to be close to color #0 (blue).

5. INSERT PROBE: Push the probe into the soil. Do not jostle or tip the jar. Screw the lid on tightly, and record the start time. Keep the jar at 68 - 75°F/20-24°C out of sunlight for 24 hrs.

6. READ THE GEL COLOR: At 24 hours compare the color of the probe to the Color Key chart provided. Alternatively, a DCR may be used in the ALT mode (Model 700 only). For visual readings note that the printed color key has two charts, one for fluorescent/daylight, and the other incandescent lighting.

7. INTERPRETATION: See Table 2 for guidelines on the results.

3. Soil Food Web Analysis

As soil health becomes more widely accepted more labs will likely offer soil food web analysis. Current testing capabilities available from http://www.earthfort.com/lab-services.html can quantify a number of microorganisms such as:

- Mycorrhizal Colonization
- E. coli
- Active Bacteria
- Total Bacteria
- Active Fungi
- Total Fungi
- Protozoa
- Nematodes

Increasing numbers in each category will show how that the numbers and diversity of microorganisms in the soil is increasing which will show that soil is getting healthier.

4. Standard soil test

A standard soil test is a snapshot of essential plant nutrients, pH and salts in a soil. Guidance is in the 590 Nutrient Management Standard. http://www.nm.nrcs.usda.gov/technical/fotg/section-4/std-specs.html. Baseline and subsequent tests should be used to show changes in levels of nutrients and salts over time as the soil becomes healthier.

“An understanding of soil health is creating a new approach to agriculture. This new approach is looking at the soil for what it is; a biological system where plants and other living organisms work together in webs and cycles to produce the food we eat. The old approach to agriculture is one of using the soil merely as a medium for inputs of production... Purchased inputs = crop yield + profit. The soil health approach to agriculture recognizes the soil as a biological system where the capacity of the soil to function = crop yield + profit. Both systems produce food. Both systems produce profits for the farmer or rancher. One system continues to degrade the soil and its capacity to function while the other system restores and builds the soils capacity to function. One system is fraught with symptoms of soil erosion, water runoff, sedimentation, surface and groundwater pollution. The other system relieves those symptoms by curing the disease of soil dysfunction. The difference between the two systems is an understanding of how the soil functions. An understanding of soil health changes the way folks view and manage the soil. We are at a crossroads in agriculture. The road to the future is the road of understanding and applying the principles of soil health. The path of agriculture that disregards the soil as a living ecosystem is quite likely a dead end.” -Jon Stika Soil Scientist NRCS North Dakota https://connections.usda.gov/blogs/54ff94be-4a42-4e69-9ba3-a3099f85768d/entry/crossroads_in_agriculture?lang=en_us