OPPORTUNITIES AND CHALLENGES: USING SOIL HEALTH INDICATORS TO GUIDE ON-FARM MANAGEMENT

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SUMMARY

The USDA Natural Resources Conservation Service (NRCS) was founded in 1935 as the nation grappled with drastic depletion of soil resources in the Dust Bowl era. Initially called the Soil Conservation Service, the NRCS is a non-regulatory federal agency that offers technical and financial assistance to support conservation on private working lands. In August 2012, the agency rededicated itself to its roots in soil conservation by launching a Soil Health Initiative.

Healthy soils are a fundamental underpinning to successful agricultural production; they minimize input costs (e.g. fertilizer, pesticides, tillage costs) and maximize benefits of inputs used. In addition, healthy soils can contribute to broad landscape scale conservation benefits such as clean air and water, and intact and diverse habitat to support wildlife.

When NRCS Conservation Planners work with farmers, they conduct a thorough inventory of a farming operation to identify resource concerns. They then develop a plan with the land owner/manager to address the identified concerns. Soil organic matter (SOM) content, soil tilth, compaction, erosion, crop vigor and other easily measured or observed properties of a production system have been the primary indicators of soil health for NRCS Conservation Planners, as well as for many farmers. More recently a variety of tests offer a quantitative assessment of soil health based on a range of soil properties. For example, the Cornell Soil Health Test Indicators include Physical Indicators (Available Water Capacity, Surface Hardness, Subsurface Hardness, Aggregate Stability) and Biological Indicators (SOM, ACE Soil Protein Index, Root Pathogen Pressure, Respiration and Active C) (Odowu et al., 2009). The Cornell tests and accompanying interpretive information offer management guidance to address identified problem areas (See: http://soilhealth.cals.cornell.edu/extension/planning.html). Another test developed by USDA Agricultural Resource Service (ARS) scientists is focused on rapid assessment of microbial respiration and predicted N release (Haney et al., 2008). This test is currently being evaluated using soil samples collected on hundreds of farming operations across the nation.

All NRCS work on private lands occurs by invitation from the land owner or land manager, and relies upon a perceived value of the services offered by NRCS. In many settings, management shifts that address soil health have created dramatic results and enthusiastic farmer endorsement of practices such as reduced or no-till management, diverse cover cropping, conservation crop rotations, and reduced reliance on synthetic fertilizers. Many of these success stories are described in a series of videos found here: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/health/?cid=stelprdb1083183.

Where farmers perceive the examples to be similar to their own systems, these videos may be very compelling. However, the majority of the videos describe soil health successes in rain-fed, commodity crop farming operations that include a winter fallow period. Where farmers are managing different types of systems, or in different growing environments, it may be necessary to discuss adaptations to achieve similar benefits of management changes in their own systems. For example, use of cover crops, a common practice to build soil health, is challenging in regions

where there is a very short winter fallow or no winter fallow. Where winter rains may not reliably germinate cover crop seeds, and pumped or delivered water is costly to apply (and in some cases may not be available), it may be particularly hard to effectively engage farmers with a dialogue about soil health focused on cover crop use.

With regard to reduced or no-till practices, there may also be challenges. Many irrigated row crops rely on a finely tilled seed bed, and minimal partially decomposed organic debris for good seed/soil contact and limited rot disease pressure during germination and establishment. Extensive tillage activity and vehicle traffic on these soils can lead to significant compaction problems, however, reducing tillage operations, or shifting to no-till is challenging given generally accepted management practices. Successful adoption of new tillage practices may require adapting existing equipment or designing new implements. These kinds of considerations create unique challenges for NRCS planners as they dialogue with the farmer to understand what key soil health concerns are, and how they might best be addressed.

To effectively engage farmers in a soil health focused management review, it is essential to focus on the concerns that are most salient for the farmer. For example, if disease and pest pressure are problematic, a discussion of the benefits of diverse, abundant and active soil microbial populations and the role of cover crops in supporting them may be an effective way to enter a dialogue about use of cover crops to increase soil health (Abawi and Widman, 2000). Where extensive tillage leads to the need to deep rip ground each season, consideration of the benefits of reduced tillage or deep rooted cover crops may be a good starting point (Chen and Weil, 2010). Often a practice that benefits soil health is of interest to a farmer because it confers benefit in some other management dimension. For example, farmers face increasing market and regulatory pressure to demonstrate limited movement of nitrogen off the farm, either to surface or ground waters. Use of cover crops to scavenge residual nitrogen may have multiple benefits, including improved physical, biological and fertility parameters of soil health (Dabney et al., 2001).

Typically farmers adopt new management practices incrementally, testing them to see how they work in their own systems before adopting them across the entire operation, and often gradually adding individual elements of a new management approach. Adoption of no-till and cover cropping are among the key strategies to promote soil health, as they address two central tenets --- keep the soil covered with living vegetation as much as possible and reduce disturbance of the soil. A recent review of over 610 studies of yield in no-till vs. conventional till paired comparisons revealed that adoption of a single soil health focused practice (no-till) may reduce yields if not paired with accompanying practices addressing residue retention and crop rotation (Pittelkow et al., 2014). Thus, there is an inherent challenge in demonstrating success of changed management, as gradual adoption may mask benefits in the initial stages of adoption. Even when more comprehensive suites of practices are applied to a farming operation, there may be considerable lag time before benefits are measurable (Meals et al., 2010).

The development of soil health indicator tests may prove helpful if these indicators can be linked to measurable impacts on crop yield and quality, pasture performance, and other factors that capture farmer attention. Some soil health indicators provide quantifiable measures of properties that farmers already observe. For example, in the Cornell Soil Health Indicators, surface and subsurface hardness, aggregate stability and root pathogen pressure are all factors that a farmer can observe, although perhaps not quantify, without a laboratory analysis. While not directly observable, the effects of differing SOM content and available water holding capacity can likewise be noted by a farmer with experience on a particular piece of land.

Much emphasis has been placed on predicting N release from SOM using measurements

such as ACE Soil Protein Index, microbial respiration, C:N, active C, etc. These all require some laboratory analysis and are not directly observable. If the indicators are found to be reliable predictors of N mineralization capacity and other beneficial soil properties, they may be a powerful motivator to manage soils to achieve a target value. It is important to recognize that soil, climate, and cropping system characteristics have a significant impact on many of these measures. For example, SOM levels in arid regions and light textured soils are typically lower than those found in humid regions and heavier textured soils. In addition, nitrogen mineralization rates are dependent on soil type and climate as well as other edaphic and cropping system conditions. To be meaningful, estimates of N mineralization and subsequent anticipated N fertility benefit, require field calibration in a wide range of systems. For any soil health indicator to have meaning in practical applications, it is critical to have reasonable target values in specific cropping systems and soil and climate conditions.

Focus on soil health is not new (National Resource Council, 1993; van Bruggen and Semenov, 2000; Wander and Drinkwater, 2000). The renewed focus on it may reflect increasing market, regulatory and conservation pressures for farmers to demonstrate effective stewardship, often in quantifiable terms. If the emerging soil health tests are able to reliably and accurately predict agronomic and environmental benefits of improvement in specific soil health parameters (e.g. increased water holding capacity and drought resiliency, reduced disease pressure, and fertility benefits) in a wide range of cropping systems, they may help energize the focus on soil health and drive new management approaches.

REFERENCES

Abawi, G.S. and T.L. Widmer. 2000. Impact of soil health management practices on soilborne pathogens, nematodes and root diseases of vegetable crops. *Applied Soil Ecology*, 15:37-47.

Chen, G., and R.R. Weil. 2010. Penetration of cover crop roots through compacted soils. *Plant and Soil* 10.1007/s11104-009-0223-7.

Dabney, S.M., J.A. Delgado, D.W. Reeves. 2001. Using winter cover crops to improve soil and water quality. *Communications in Soil Science and Plant Analysis*, 32(7&8):1221–1250.

Haney, R.L, W.H. Brinton & Eric Evans (2008) Estimating Soil Carbon, Nitrogen, and Phosphorus Mineralization from Short-Term Carbon Dioxide Respiration, *Communications in Soil Science and Plant Analysis*, 39:17-18, 2706-2720, DOI: 10.1080/00103620802358862

Idowu, O.J., H.M. van Es, G.S. Abawi, D.W. Wolfe, R.R. Schindelbeck, B.N. Moebius-Clune, and B.K. Gugino. (2009) Use of an integrative soil health test for evaluation of soil management impacts. *Renewable Agriculture and Food Systems* 24(3):214-224.

Meals, D.W., S.A. Dressing and T.E. Davenport. 2010. Lag time in water quality response to best management practices: A review. *Journal of Environmental Quality*, 39: 86-96.

National Research Council. 1993. Soil and water quality: An agenda for agriculture. National Academy Press. Washington, D.C.

Pittelkow, C.M., X. Liang, B.A. Linquist, K.J. van Groenigen, J. Lee, M. Lundy, N. van Gestel, J. Six, R.T. Venerea and C. van Kessel. 2014. Productivity limits and potentials of the principles of conservation agriculture. *Nature.*

Van Bruggen and Semenov. In search of biological indicators for soil health and disease suppression. *Applied Soil Ecology*, 15:13-24.

Wander, M.M. and L.E. Drinkwater. 2000. Fostering soil stewardship through soil quality assessment. *Applied Soil Ecology*, 15: 61–73.

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