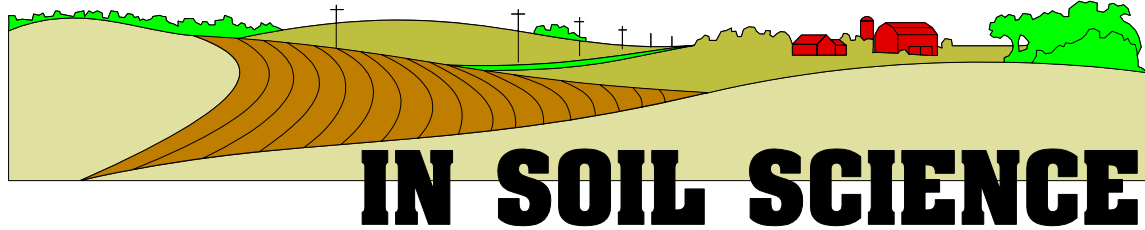


NEW HORIZONS



November 2005

Issue #2 – 2005

Soil Quality and Crop Production Systems

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Soil quality is a general term that describes the overall condition of the soil with respect to its intended use. It integrates soil physical, chemical, and biological properties and reflects the effects of management. Some use the term “soil health,” which provides a medical context to an evaluation. Presumably an “unhealthy soil” could be nursed back to health with improved management. The quantification of soil quality is typically more subjective than analytical, and often reflects the characteristics of a particular use or user group. Within an agricultural context a high quality soil would be productive and be sustainable over generations of producers. It would have characteristics of good natural fertility, water holding capacity, resilience to tillage or other disturbances to permit profitable crop production possible. Visible traits could include the evidence of earth-worm activity, good infiltration and internal drainage with adequate water storage, good structure and tilth, and low salt content. A consumer from an urban area may have a different view of soil quality. They would regard it as being important for the establishment of an attractive landscape for their home and a healthy, high-quality, and low-cost food source for their family. An environmentalist or naturalist would consider soil quality to be part of a diverse ecosystem that helps to maintain air and water quality and an aesthetically pleasing landscape.

Assessing soil quality is affected by the type of soil, management, location in the world, and ultimate use. For example the coarse-textured soils of central Wisconsin may not have high apparent quality, but with irrigation, fertilization, and proper management they can be highly productive. The soil quality characteristics of a soil with respect to road or building construction are different than those for crop production and likely different from those necessary for maintaining a diverse landscape.

Simple efforts to rate or assess soil quality have been made in many states. Most employ a relative ranking of soil properties related to crop production. An example of soil health score card developed by the NRCS is shown in Table 1. This card rates some

easily assessable characteristics of the soil to help a producer or crop advisor rate a field. It is suggested that the assessment be done under adequate moisture conditions at a consistent time each season. This evaluation allows the opportunity to assess other characteristics that may be of local importance. The USDA-NRCS offers further information on soil quality at Soil Quality Institute website (<http://soils.usda.gov/sqi>).

The University of Wisconsin, Center for Integrated Agricultural Systems offers a Soil Health Scorecard for Wisconsin at its website (<http://www.cias.wisc.edu/>). This rather comprehensive scorecard was developed by UW Soil Science Professor Robin Harris and his students about 10 years ago. They worked with a group of southeastern Wisconsin farmers to develop a tool that assesses 43 different factors under the broad categories of soil, crops, animal interactions, and water quality. Each is assigned a rating on a four point scale with 3–4 being healthy, 1.5–2.5, impaired, and 0–1 being unhealthy. It is recommended that the assessment be conducted at harvest, but before tillage. The authors recognize that not all factors may relate to a given field, so an average rating of the pertinent questions is calculated to determine areas in which corrective action should be taken. The farmer group prioritized the soil quality factors with the top 10 being:

1. Organic matter
2. Crop appearance
3. Earthworms
4. Erosion
5. Tillage ease
6. Drainage
7. Soil structure
8. Soil pH
9. Soil test P and K
10. Yield

More quantitative soil quality assessment tools have been developed that mathematically integrate measured factors. Andrews et al. (2004) used data from Georgia, Iowa, and the Pacific Northwest to develop a three-step method that first determines which soil quality indicators to select for a site, creates an interpretation for the indicators, and integrates the interpretations into an index that can be used over a range of soils and climactic conditions. Their method shows relative concurrence over locations for factors such as water-stable aggregation, soil bulk density, microbial biomass, soil pH, potentially mineralizable N, and organic carbon. Comparisons between tillage systems showed small, but significant differences related to tillage intensity, with reduced tillage having a higher soil quality index.

While it may be interesting to discuss the merits of soil quality, the important question is whether it has any practical value in production agriculture. Improvements in soil quality would be expected to increase infiltration and reduce runoff and erosion. A soil with a high quality index should also producer a better root bed and supply adequate water and nutrients to crops. RUSLE2 has been introduced as the official soil erosion prediction tool for use by agencies of the USDA. Concepts of soil quality have been integrated into RUSLE2 based upon comprehensive research conducted at various institutions. Specifically these are the Soil Conditioning Index (SCI) and the Soil Tillage Intensity Rating (STIR). These are stand-alone calculations that are reported along with sediment loss in the RUSLE2 report.

The SCI incorporates research that has demonstrated the value of the cropping system management and tillage on soil organic matter with respect to the soil condition. The goal of management should be to increase soil organic matter because of its importance in forming and maintaining soil structure, biological activity, and productivity. SCI scores range from -2 to +2, with positive numbers being better, with the ultimate goal being the reduction of soil loss. Producers are encouraged to increase their SCI by implementing the following practices:

- Raising crops that produce and retain large amounts of residue in a field
- Using cover crops whenever possible
- Applying manure
- Reducing the number and intensity of tillage operations
- Minimizing wind and water erosion
- Using production techniques that increase crop and residue production

The STIR value reflects the overall type and intensity of the disturbance caused by tillage. Components of the STIR value include tillage type, operating speed, depth, and percent of the soil surface disturbed by tillage. Values range between 0 and 200, with most no-till production systems having a value of 30 or less. Including forage crops in a rotation will also reduce STIR values. In reality the manipulation of management to obtain a low STIR value replaces the age-old ideal of maintaining a certain level (e.g. 30%) of surface crop residue. Some states are offering CSP Enhancement payments for management within a specific range of STIR values. For example, Colorado has a program that offers a \$0.50, \$1.00, or \$2.00/acre payment for operating with STIR values 31–60, 16–30, or less than 16, respectively. The payments double if a GPS guidance system is used in the production system. The practices are intended to reduce or confine compaction, thereby improving the condition of the soil within the field, which would benefit from being un-trafficked. STIR values can be calculated for a specific area (based on zip code) by accessing the following website: (<http://stir.nrcs.usda.gov/>).

Researchers have linked the effect of agricultural management systems on soil quality. Lower disturbance systems, such as no-till generally resulted in improved soil quality characteristics. Karlen et al. (1994) compared data collected from the Lancaster Agricultural Research Station from plots that had been in long-term continuous corn using moldboard, chisel, or no-till for the previous 12 years. Surface samples collected from the no-till had higher aggregate stability, total carbon microbial activity, and earthworm populations. Estimated soil loss measured by simulated rainfall collection was two to four times greater in the moldboard plow compared to no-till.

Buman et. al. (2004) examined data collected from 13 standardized Midwest on-farm tillage trials for the corn-soybean rotation. Recent trend have shown a reduction in the adoption of no-till and other low disturbance tillage systems. This study compared no-till, strip-till, and conventional tillage. Some sites included a “stale seedbed” treatment that consisted of the fall conventional tillage treatment with no further spring tillage prior to planting. Several soil quality parameters were measured including earthworm populations, bulk density, crop residue, infiltration, and soil temperature. Few differences in soil quality measurements were found at the sites, but no-till and strip-till

showed greater profitability in 4 of the 5 years of the evaluation, mainly due to lower input costs and yields similar to those observed in the conventional or stale seedbed treatments.

Hess et al. (2000) include the evaluation of soil quality as part of an overall evaluation of the sustainability of an agroecosystem. They define an agroecosystem as the particular field, pasture, orchard, etc. and its associated border areas. Their efforts assumed that sustainable management, as assessed by certain soil quality parameters, benefits society and should be encouraged in governmental programs.

Wisconsin crop production in 2005 was unique, as in mid-summer the fear of drought was pervasive, but when yields were measured many producers reported an excellent crop. Regardless there was considerable variability within fields due to moisture stress. It would be expected that improvements in soil quality of the low yielding could have reduced the yield penalty. Green Lake County UWEX Agricultural Agent Carla Heiman provided some aerial images taken prior to harvest and the yield map for these fields. These are shown along with the soil survey and yield maps for a field in Figures 1-3. The drought stressed area was associated with the eroded, more steeply sloped portion of the field and yielded approximately half of the relatively level, non-eroded areas. This phenomenon was repeated throughout Wisconsin and cause one to wonder if modifications in management intended to improve water holding capacity might have ameliorated some of the yield loss in the eroded portion of the field. The field was second-year no-till corn following alfalfa. Manure was not part of the recent field history.

Soil quality is a reflection of both inherent soil properties and the effects of management. Its interpretation can be highly relative and is associated with the intended use of the soil. Crop production practices that improve structure are parameters that can often be controlled within management systems. Practices to improve structure include the addition of organic residues, the reduction of tillage intensity, and controlling traffic. Some adjustments in management will result in immediate returns and others would be expected to require more time. It is apparent that soil quality management will be both directly and indirectly associated with future NRCS cost-sharing programs. Selected Wisconsin watersheds offer incentives for increasing the Soil Conditioning Index as part of the CSP program. Many of the practices promoted to improve soil quality involve the addition of organic residues (e.g., manure) with a concurrent reduction in tillage intensity. Additional work will be needed to determine the best balance of these practices for a given field and operation.

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Figure 1. Image of a Green Lake County field prior to corn harvest, 2005. (Note: View is from west to east.)

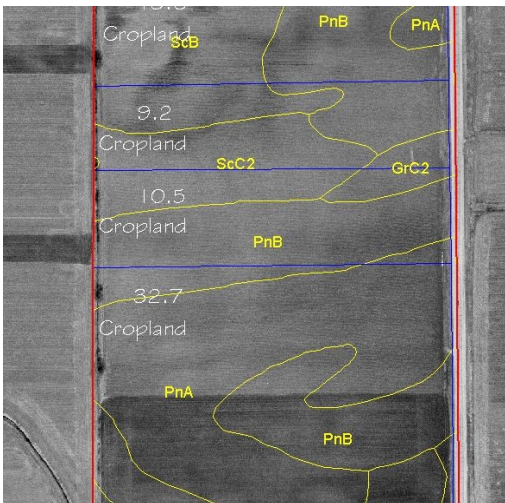


Figure 2. Soil survey map of a Green Lake County field. (North at top).

GrC2 = Griswold silt loam, 6-12 %
 PnB = Plano silt loam, 2-6%
 ScC2 = St. Charles silt loam, 6-12%

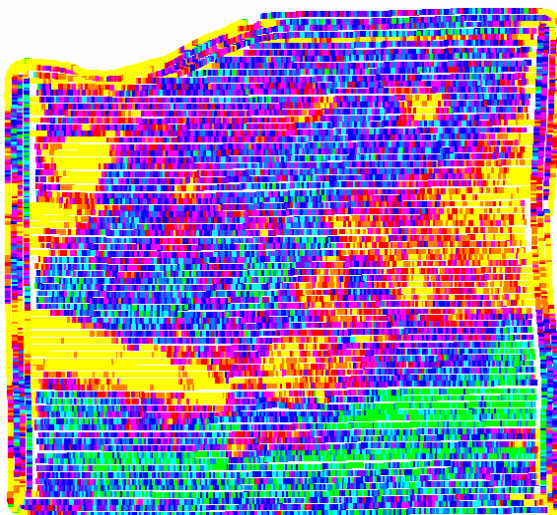


Figure 3. Corn yield map of a Green Lake County field for 2005. (North at top).

Green = greater than 160
 Light Blue = 150-160
 Dark Blue = 120-140
 Pink = 100-120
 Red = 80-100
 Yellow = less than 80

Table 1. Example Soil Health Card (Adapted from the NRCS).

Assessor name:		Date of assessment:		Farm and field ID:		
Indicator	Ranking			Rating		
	Low (1)	Medium (2)	High (3)	Circle one		
Earthworms/organisms	Few worms, holes, casts; organisms visible	Moderate worms, holes, casts; organisms visible	Many worms, holes, casts; organisms visible	1	2	3
Surface organic matter	No visible roots or crop residue	Some roots or crop residue	Many roots and residue	1	2	3
Smell	Swampy odor	Little or no odor	Fresh, earthy smell	1	2	3
Compaction	Tight soil, layers, contorted roots	Firm soil, some resistance to penetration	Loose, not restricted, good rooting	1	2	3
Workability	Multiple passes and horsepower needed	Soil works up with some difficulty	Tills easy and requires minimal power	1	2	3
Tilth	Firm clods, powdery when dry	Some crusting, small clods	Soil friable and porous	1	2	3
Residue decomposition	Very slow or rapid decomposition	Some non-decomposed residue	Residue at various stages of decomposition	1	2	3
Porosity	Few channels visible	Some channels visible	Many root and worm channels	1	2	3
Crusting	Soil surface sealed, emergence problems	Some surface crusting	Surface porous throughout season	1	2	3
Water infiltration	Wet spots, ponding, root diseases	Some poorly drained areas	Water drains well after rain, no disease	1	2	3
Water retention	Plants stressed, requires watering often	Some drought stress, irrigation needed	Deep soil, crops weather dry periods	1	2	3
Erosion	Obvious soil movement, gullies, rills	Some soil movement, sediment in runoff	No visible soil movement	1	2	3
Crop appearance	Stunted uneven growth, discolored	Some discoloration, stress, stunting	Healthy, vigorous, uniform growth	1	2	3
Roots	Poor development, brown or mushy	Some fine roots, uneven distribution	Vigorous growth, many fine roots	1	2	3
Salts	Salt on surface, dead plants	Stunted, evidence of leaf burn	No visible salts or plant damage	1	2	3
Other (specify)				1	2	3
Other (specify)				1	2	3
				Total Score		

Note: Evaluate during times of adequate moisture. Some factors will be affected by tillage, so assess before major tillage operations. Attempt to make measurements at the same time each year.