

## **SOIL HEALTH ASSESSMENT AND MANAGEMENT: MEASUREMENTS AND RESULTS**

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For the past four years, the Cornell Soil Health PWT has been working to develop a holistic approach to soil management. As we discussed in the March-April issue of What's Cropping Up, soil health emphasizes the integration of physical, chemical and biological soil properties for the purpose of sustainable agricultural management. In this article we will discuss some of the results from the recent research efforts and discuss the proposed soil health testing that we intend to offer to complement the existing soil chemical tests offered by Cornell Nutrient Analysis Laboratory.

In this 3-years project we have analyzed over 700 soil samples across New York State for physical, chemical and biological soil properties. We collected samples from three types of farms:

1. Research farm experiments: to help establish useful indicators from long-term soil management experiments under controlled conditions.
2. Growers' on-farm experiments: to have field demonstrations and document soil health improvements from alternative management practices.
3. Commercial farm samples: To provide perspective under a range of soil health conditions in the real world.

Thirty-one properties were measured, as listed in Figure 1. The chemical properties are those associated with the standard soil test, while the physical and biological properties are newly-established or existing methodologies that allow for fairly rapid soil testing.

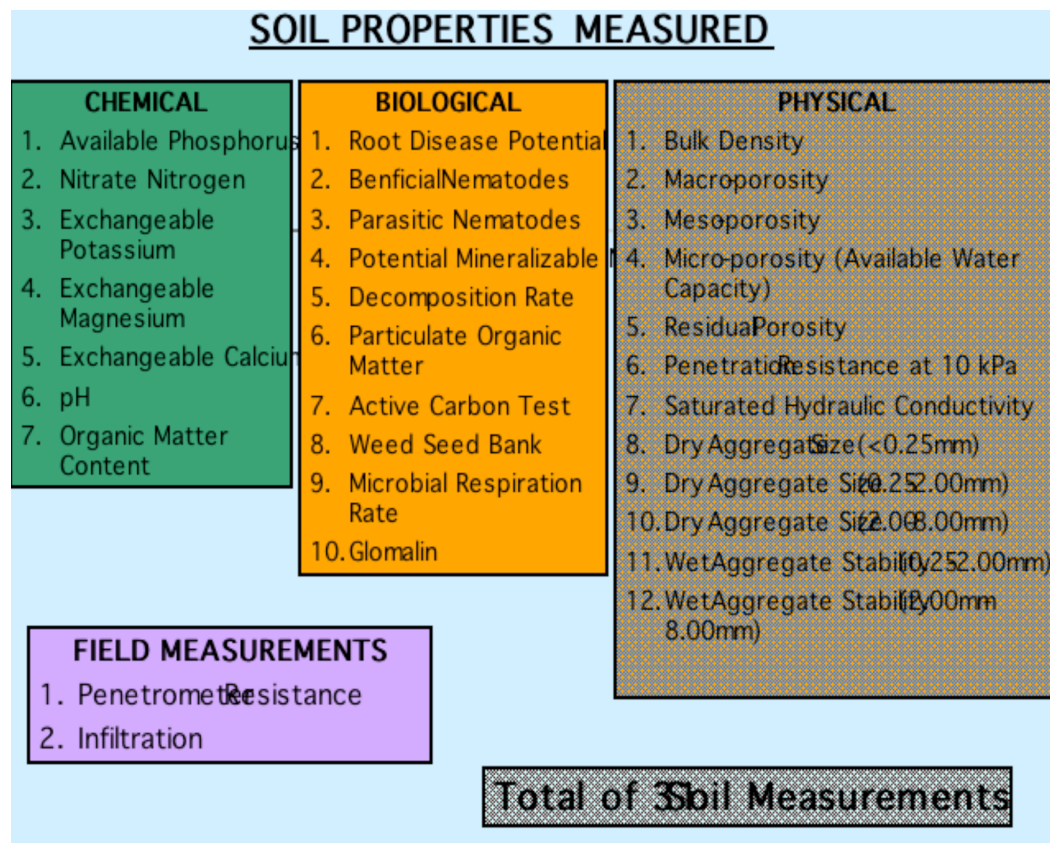


Figure 1. Chemical, Biological and Physical properties measured for Soil Health Assessment

### Results

Table 1 show some results on soil physical indicators from two tillage experiments in Aurora and Willsboro, New York comparing conventional tillage (Plow Till) and no tillage (No Till).

Table 1. 13 Year Tillage Experiments in Aurora and Willsboro, NY (ns=non-significant)

Soil Health Indicator	Silt Loam (Aurora)		Clay Loam (Willsboro)	
	Plow Till	No Till	Plow Till	No Till
<b>Bulk Density (g/cm<sup>3</sup>)</b>	ns	ns	1.21	1.03
<b>Pores &gt;30 microns (%)</b>	13	17	12	16
<b>Pores &gt; 0.1 microns (%)</b>	ns	ns	29	34
<b>Available Water Capacity (%)</b>	12	16	ns	ns
<b>Water Stable Aggregates- 0.25-2mm (%)</b>	20	41	30	68

Although a few comparisons were non-significant (ns), most indicators show more favorable values (lower bulk densities, and high numbers for all others) for the no-till than the plow-till treatments. Notably, aggregate stability had more than doubled under 13 years of no-tillage, indicating that

these soils are less susceptible to slaking, sealing, hardsetting and runoff. Higher values for porosity indicators indicate that the no-till soil is more resilient to extreme wetness (when aeration is critical) and drought (when water retention is critical). Lower bulk densities generally indicate a better rooting environment. The no-till treatment in general showed more favorable soil properties compared to plow till.

Table 2. Rotation Experiment in Willsboro, NY (ns=non-significant).

Indicators showing management difference	Loamy Sand (Willsboro)		Sandy Clay (Willsboro)	
	Corn after Grass	Continuous Corn	Corn after Grass	Continuous Corn
<b>Bulk Density (g/cm<sup>3</sup>)</b>	1.31	1.36	ns	ns
<b>Pores &gt;30 microns (%)</b>	ns	ns	10	16
<b>Pores &gt; 0.1 microns (%)</b>	42	38	ns	ns
<b>Available Water Capacity (%)</b>	28	23	24	20
<b>Water Stable Aggregates- 0.25-2mm (%)</b>	34	10	ns	ns

Table 2 shows some results from a rotation experiment on loamy sand and sandy clay soils in Willsboro, NY, comparing corn after eight years of orchard grass with continuous corn. In general, soil health indicators were better for the corn after grass, supporting the notion that rotation of corn with sod crops results in better soil health. Available water capacity was significantly different for both soil types. These indicators are useful in assessing soil health but they must be considered and interpreted separate for each soil type.

Another experiment was recently established at the Gates farm in Geneva, NY and compares the effects of three tillage systems, three cover cropping conditions and two rotations on soil health and crop growth. Figure 2 shows the effect of these treatments on root disease potential, an integrative biological indicator that is especially important in vegetable systems. Reduced tillage, combined with cover crops, led to a gradual but significant reduction in root disease potential as measured by the root bio assay. No-till with vetch cover crop had the least root disease potential over the past two years of measurement.

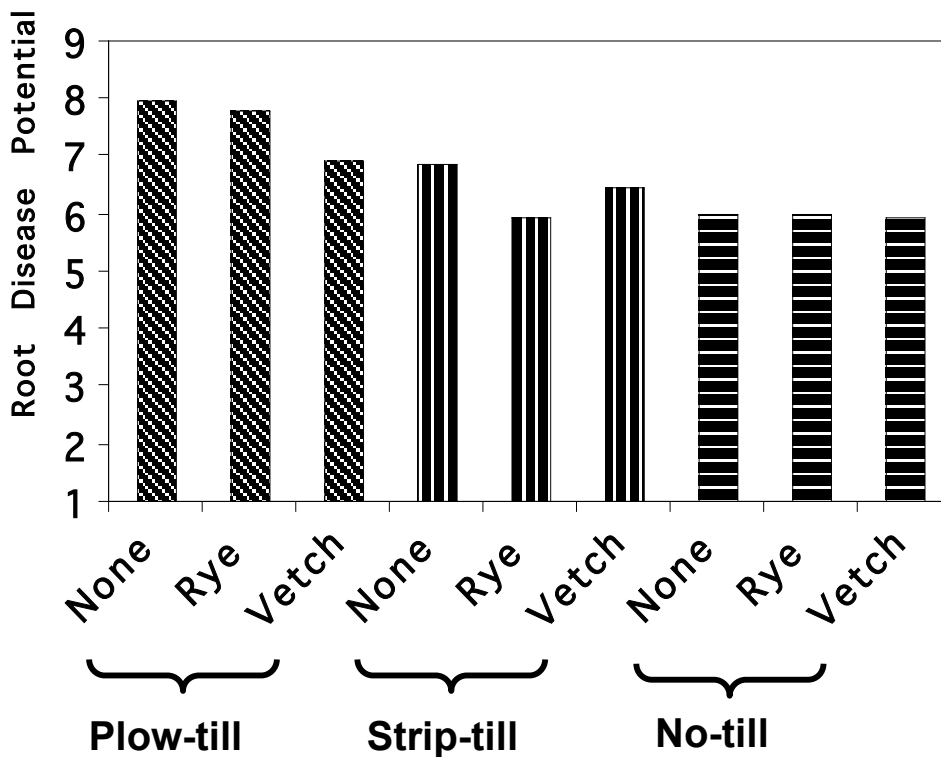


Figure 2. Tillage and cover crop system experiment at Gates Farm, Geneva, NY

Figure 3 shows the distribution of root disease potential for commercial vegetable grower field samples measured as part of the project during 2004 and 2005. There is a shift in the distribution towards lower root disease potential for organic production systems compared to conventional systems. This was expected as previous studies have shown root disease suppression in systems with high organic matter inputs.

The appropriate time for soil sampling was also evaluated. It was determined that the results of several of the tests depended on whether the soil was sampled during either the early, middle, or late part of the growing season, or whether it occurred prior or after tillage. We therefore concluded that meaningful results can only be obtained from samples that are collected during the early-season pre-tillage period.

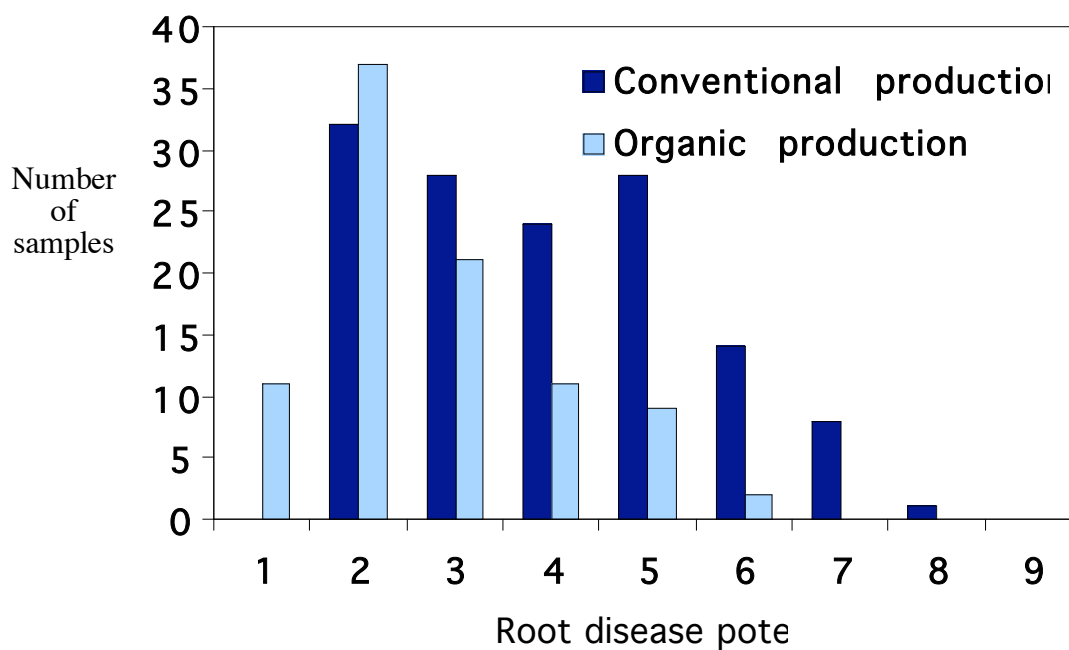


Figure 3. Organic versus Conventional Vegetable Production Systems (New York Commercial Vegetable Growers 2004 and 2005)

### Selection of Indicators

One of the purposes of the project was to identify soil health indicators that were most useful for adoption as part of routine soil health testing. Some criteria for selection of indicators were:

1. Sensitivity to management
2. Functional relevance
3. Consistency and reproducibility
4. Ease and cost of sampling
5. Cost of laboratory analysis
6. Opportunity to be estimated by regression methods

Based on the above criteria, we tentatively developed a two-tiered approach for soil health assessment in New York. Tier 1 consists of indicators which can be measured or estimated rapidly and are fairly inexpensive to process (Table 3). These indicators have the potential of being measured and/or estimated rapidly, are relatively inexpensive to process, and Tier 1 rely on sampling methods that are similar to those used for standard chemical test.

Table 3: Proposed Tier 1 indicators for soil health assessment.

Physical	Biological	Chemical
<ul style="list-style-type: none"> <li>• Bulk density (Composite 6 cores in a plastic bag)</li> <li>• Aggregate Stability (2 - 0.25 mm)</li> <li>• Available Water Capacity (by measurement and estimation)</li> <li>• Textural class (by feel)</li> <li>• Field Penetration Resistance</li> </ul>	<ul style="list-style-type: none"> <li>• Potentially Mineralizable Nitrogen</li> <li>• Active Carbon</li> <li>• Root Rot Assay</li> <li>• Weed assay</li> </ul>	<ul style="list-style-type: none"> <li>• Standard Chemical Test</li> </ul>

Tier 1 indicators include bulk density, wet aggregate stability, available water capacity, soil texture by feel, field measured penetration resistance, potentially mineralizable nitrogen, active carbon/organic matter, root rot assay, weed assay and the standard soil chemical test. We are still continuing to test the indicators and plan to start offering the tests on a commercial basis by the end of this year, in time for spring sample submissions.

Tier 2 analyses consist of a wide variety of “a la carte” measurements (as listed in Figure 1) from which selections can be made based on the interest of the client. In a future issue of “What’s Cropping Up”, we will discuss further details on the new soil health tests, including associated sampling protocols and interpretation of results, as well as planned training programs.