Chapter 8 Applying the Cornell Soil Health Test to Berry Production- *Robert Schindelbeck, Cornell University*

Introduction

The Cornell soil health test (CSHT) has been available to researchers and the general public since 2007. Thousands of samples have been done on both research and commercial farms in NY and throughout the entire country and Canada. The CSHT was originally designed for use in commercial vegetables crops but has utility for other crops as well; work is now underway to tailor the CSHT more specifically to perennial crops like berries.

This chapter discusses using the Cornell soil health test to understand and evaluate soil processes important in general crop growth and production including berries. It builds upon and complements some of the ideas presented by Harold van Es in Chapter 1 "Introduction to Soil Management in Berry Production".

Acknowledgements

The Cornell soil health "team approach" to understanding real life soil/plant issues has been highly effective. The team leaders from various disciplines (Crop and Soil Science, Horticulture, and Plant Pathology) help balance the focus of the investigations by bringing expertise from their discipline. Collaborating growers, extension educators and field staff force the discussion back to "on the ground" issues facing growers. This work would not have been possible without their input or the support of the Cornell Soil Health program sponsors: Northeast Region SARE, the Northern NY Agricultural Development Program, the NYS IPM Program, the NY Farm Viability Institute and Cornell University Cooperative Extension.

Soil health is...

Doran and Parkin (1993) define soil health as, "the capacity of the soil to function ... chemically, biologically and physically". These are qualitative characteristics. Soil quality can't be measured directly but we can indirectly measure the functions that make up soil quality by measuring important indicators in the chemical, biological and physical arenas of soil function.

Characteristics of healthy soils

Healthy soils are easy to spot from a distance- the crops growing on them look uniform and vigorous. Closer inspection allows us to list important features of the soil. These features highlight soil processes and functions that benefit vigorous plant growth and support resiliency through balanced functional behavior. Characteristics of a healthy soil are 10-fold and include things like having good soil tilth (physical structure), having sufficient rooting depth, good water storage and drainage, containing sufficient (but not excessive) nutrients, free of chemicals that might harm plants, containing low populations of plant disease and parasitic organisms, having high populations of beneficial organisms, having low weed pressure, showing high resistance to being degraded and exhibiting resiliency (the ability to recover quickly from adverse events). More and more extreme weather events are occurring; a healthy soil has the resilience needed to recover from the effects of these types of events quickly.

Conversely, signs of poor soil health would include cloddy and hard soil at planting, poor seedbeds, rapid onset of stress or stunted growth during dry or wet periods, poor growth of plants, declining yields, high disease pressure and signs of runoff and erosion. Our experience

with healthy, productive soils allows us to recognize degraded soils.

Soil behavior is dynamic - we understand that any single measure of soil behavior must also be considered in an ecological context of interaction (Figure 31). This complexity is what we hope to understand using the information we obtain from soil health testing. As scientists, we are reductionists, first de-constructing and learning about the parts, then putting the information back together towards a whole understanding- this is the holistic approach to soil health testing. The soil health team approach is to identify which soil functions are impaired through testing and then adapt field management to address them.

Figure 31. *Soil health is an expression of the physical and chemical properties of soil in conjunction with soil biology. These soil properties interact with the growth of plants to create a complex soil ecology.*
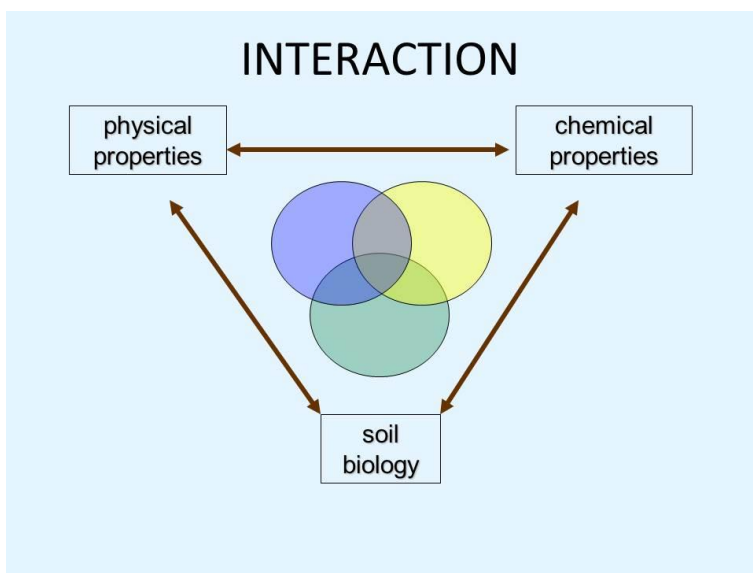
Soil interactions – an example

Why does hard soil reduce rooting? It is not a straightforward simple effect. The answer is complicated due to the interaction of many factors. Ultimately, we can use this information to our advantage as we measure and understand the parts of the whole. Below is an example. Blue text indicates physical properties affected; orange indicates biological processes.

Hard soil reduces rooting:
- **Compacted, dense soil layers restrict rooting volume to exploit water and nutrients**
- **Compacted soil suppresses beneficial biological processes**
- **Poor drainage reduces rooting and aerobic biological processes**
- **Compaction increases root diseases and denitrification losses**

Soil problems on NYS farms (and other farms in the NE region) are not only nutrient concentration issues but often fall into what is called "sick soil syndrome". One commercial vegetable farm in NY was evaluated using the Cornell soil health test and found to be suffering from this syndrome. The field tested very high in nutrients but as you can see from the photo montage (*Figure 32*) it has very poor stands. Key issues discovered on this intensely used soil were low organic matter content, soil compaction increasing and with that decreased water infiltration. The soil began exhibiting reduced water holding capacity and became drought prone. There was more going on in

this field than a simple lack of soil fertility; the Cornell soil health test was developed to further elucidate what is happening in soils like these. Simply adding more fertilizer nutrients would not help the plants to grow.

Figure 32. *A field exhibiting "sick soil" syndrome is being discussed by Extension Vegetable Specialist Carol MacNeil, Cornell Cooperative Extension Vegetable Program.*

Let's look at soil chemical testing. Soil lime requirements and nutrient recommendations have been developed for all major crops. Growers also test for foliar nutrient levels in berries and other high value commodities. Thus much progress has been made to determine nutrient sufficiency levels in the soil (and the plant) and we can even provide recommendations of how much of each nutrient to add to achieve non-limiting soil and foliar test levels. This technology has been developed to become the standard for soil chemical nutrient assessment since World War II. We now recognize that we need to measure soil physical and soil biological parameters in addition to chemical levels. The "three-legged stool" is a useful analogy to describe the strategy of measuring soil parameters in more than just the single chemical arena. If any one of the stool "legs" is weak, the stool can tip over; if all legs are strong, the stool is stable and balanced. A healthy soil is also <u>balanced</u> and therefore provides for crop resiliency to stress. If we can 1) measure soil indicators to identify constraints, then we can 2) optimize our soil management.

After identifying essential soil functions a testing strategy was developed to quantify these parameters. This was the first step in developing a means to evaluate and manage soil health. The second step involved how to use the

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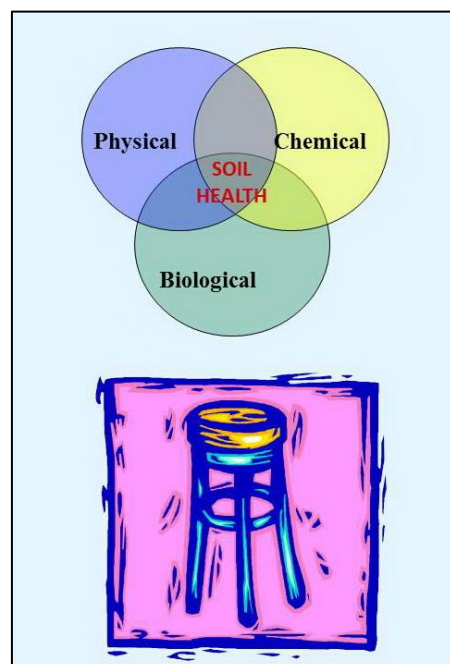
information collected to manage soils in such a way as to address measured constraints.

To understand the whole soil ecology, we first de-constructed the soil chemistry by listing the processes which it governs (Figure 33). Much work has been done in the last 75 years to understand nutrient requirements for maximizing growth of various plant types. In the holistic context, we must recognize that chemical storage and release (availability) is also mitigated by soil biological processes. Each of the soil biological functions listed here are key functions to understand and measure. The soil physical structure is often called the "house" for microbes and plant roots to live and function in. Robust tilth allows air and water exchange and subsequent water storage. Roots must be able to penetrate soil layers to obtain water and nutrients there for resiliency to drought.

As previously mentioned, soil chemistry involves nutrient release and storage; this function is mediated to a greater degree by soil pH but is also strongly influenced by both the physical structure as well as soil biology.

Soil biology encompasses support of a beneficial microbial community contributing to organic matter decompositions and nitrogen mineralization leading to the biological release of nutrient leading to plant growth. This beneficial microbial community also lends itself well to suppression of pests.

Figure 33. *Processes governing physical, chemical and biological aspects of soil.*
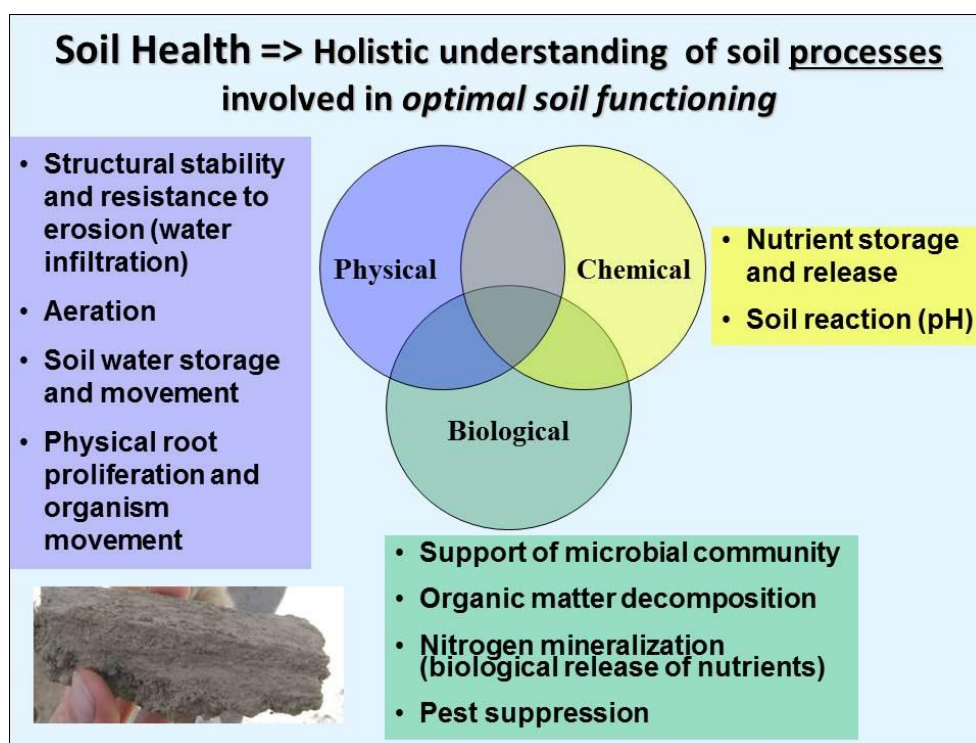
The Cornell soil health test (CSHT)

The Cornell soil health test in use today was derived from an elaborate suite of 39 potential soil health assessment indicators. What follows below (*Figure 34*) is the suite of physical and biological indicators selected from among those 39 (along with chemical tests) that comprise the Cornell soil health assessment. These final indicators were selected based on their sensitivity to changes on soil management practices, relevance to soil process and functions, consistency and reproducibility, ease and cost of sampling and finally, cost of analysis.

Soil physical tests appear in blue across the top of the photomontage; these are all laboratory tests apart from the field penetration test. Biological tests appear in green across the bottom. The chart below the photomontage lists the indicator tests along with their related soil processes.

A Modified Morgan extracting solution is used to determine soil nutrient levels. Soil texture determination is used to categorize test results. Each test will now be examined in detail.

**Figure 34**. *Measured CSHT indicators and their related soil processes.*

Indicators		Soil processes
PHYSICAL	Aggregate stability (%)	Aeration, Infioltration, Rooting, Erosion, Crusting
	Available Water Capacity (m^3m^{-3})	Water retention
	Surface hardeness (PSI)	Rooting, Water transmission
	Subsurface Hardness (PSI)	Subsurface pan/deep compaction
BIOLOGICAL	Total Organic Matter (%)	Energy storage, Carbon sequeatration, Water retention
	Active carbon (ppm)	Soil biological activity
	Potentially mineralizable nitrogen (PMN)	Nitrogen supply capacity
	Root health rating (1-9)	Soil-borne pest pressure/disease suppressiveness
CHEMICAL	pH	Nutrient availability toxicity
	Extractable phosphorus (ppm)	Phosphorus availability/run off potential
	Extractable Potassium (ppm)	Potassium availability
	Minor elements	Minor element availability/toxicity

## Soil Physical Indicators

The "Soil House"

Soil aggregates (or crumbs) are made up of very small soil particles held together by cementing agents and biological glues. Robust soil biological activity produces compounds and by-products ("glues") which contribute to this aggregation. A medium sized soil crumb can be made up of many smaller ones. In a well aggregated soil these different sized crumbs allow for a range of pore sizes (*Figure 35*). The different sized pores perform different functions. Large pores (macropores or biopores) allow for rapid air and water transfer while smaller pores store water over time. Soil inhabitants of all sizes live and travel through the water stored in these different sized pores.

Figure 35. *A medium sized soil crumb made up of many smaller ones. Very large pores can occur within and between the medium size aggregates.*
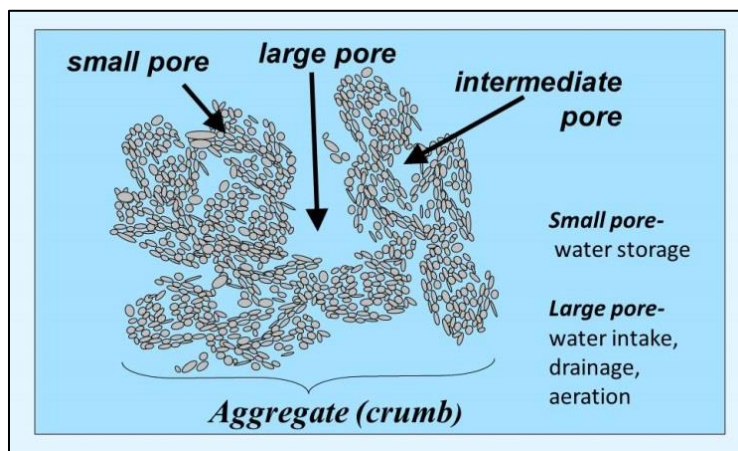
As water infiltrates rapidly between the large particles in the well-aggregated soil structure shown on the left in Figure 36 stale air is forced out of the pores. As the water continues to percolate down, fresh air is drawn into the soil from the atmosphere. This is the desired fate of water reaching the soil. However, as these aggregates break down they become "self-clogging" and the soil closes up, causing soil crusts to form. This crust inhibits air exchange which can lead to the soil becoming anaerobic. The right side of Figure 36 shows a crusted soil surface where the compacted zone facilitates surface water run-off. The water that runs off the field can erode the soil and transport large quantities of topsoil to ditches and streams.

Figure 36. *Model of soil structural breakdown*.
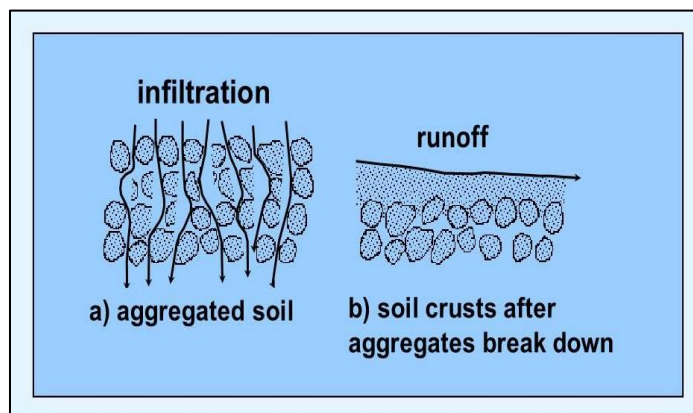
Maintaining good soil aggregation allows not only rain capture but also facilitates drainage via the large pores between crumbs. This "open soil" is widely recognized as a key indicator of good soil quality. Soil surface crusting is surface compaction with destruction (or infilling) of the large pores which impairs water and air movement.

Soil structure affects many soil processes which are facilitated by an open aggregated soil. Note that as soil becomes compacted the large pores are destroyed first. Resulting dense, compacted soil often leads to sluggish plant growth. Soil crusts (surface compaction) reduce infiltration leading to runoff and erosion. Decreased infiltration means less water storage and air exchange. Reduced root penetration reduces the soil volume explored for water and nutrients. It is important to note that plants *can* overcome hard soil but must expend extra energy to do so at the expense of shoot growth and/or fruit production.

**Figure 37.** *An example of soil structural breakdown.*

Figure 37 above details some field examples of soil structure break down. On the bottom left is a photo of a vineyard in California where managers are experimenting with various surface maintenance strategies between rows of grapes. Note in the standing water to the left of the photo where the soil is crusted; in the middle row where soil has been loosened using various techniques water is infiltrating better. The photos just above it are of a potato field. This intensively cultivated field shows signs of surface crusting and sealing that lead to erosion. Digging into the soil at right we see that there is also a dense subsoil layer caused by excessive use of a disk cultivator.

From this photoset it can be seen that in field crop production we typically manage the entire soil area, whereas in a vineyard or berry field we may manage the row area differently than the between row area.

CSHT wet aggregate stability test

The CSHT aggregate stability test is a way of testing soil stability in the lab using simulated rainfall. Aggregate stability, by definition, is a measure of the extent to which soil aggregates resist falling apart when wetted and hit by rain drops. It is measured using a rain simulation sprinkler that steadily rains on a sieve containing a known weight of soil aggregates between 0.25mm and 2.0mm. Unstable aggregates fall apart and pass through the sieve. The fraction of soil remaining after the water drops are applied during the test interval determines the percent aggregate stability. Pictured in Figure 38 are results from a CSHT wet aggregate stability test which delivers 1.25cm (1/2 inch) of simulated rainfall in 5 minutes on to the sample crumbs. The results pictured are from a long-term tillage research study (14 years of continuous corn) that compares fall moldboard plowing with no-till. On the left is the 14-yr continuous plow till soil; on the right a no-till production system. Qualitatively (and visually) it is clear that starting with the exact same soil in both cases, the soil from the no-till soil on the right under continuous corn production has a much higher stability value (72%) vs. the plow till soil on the left (22%). The long-term plow till soil with the low soil stability result in the laboratory test (22%) would be susceptible to the surface sealing and crusting discussed above.

Figure 38. *CSHT Wet Aggregate Stability testing using the Cornell Sprinkler to simulate rainfall.*
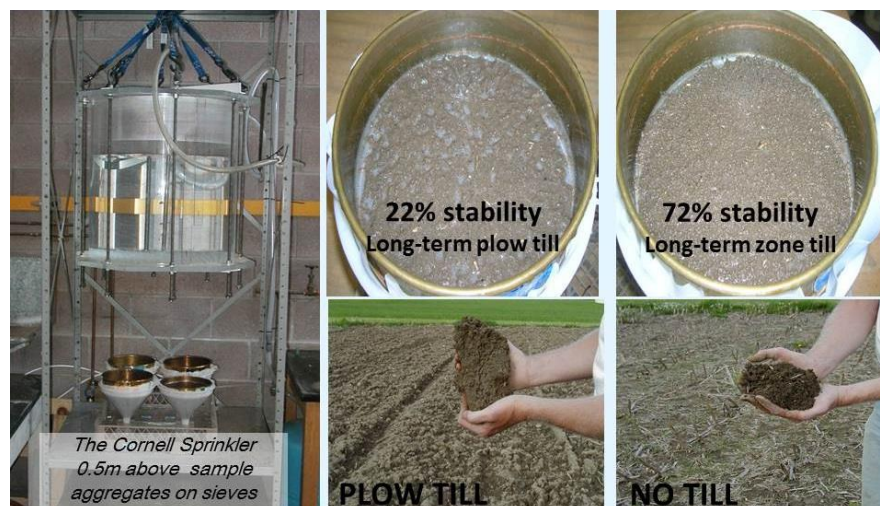

CSHT available water capacity test (AWC)

Available water capacity, or AWC, is defined as the difference in water content of soil at 0.1 bars (field capacity) and 15 bars (permanent wilting point). Water storage is influenced by texture, organic matter and soil structure. The field capacity measurement corresponds to pores 30 microns in diameter (the diameter of the average

human hair.) The pores larger than 30 microns are emptied into gravity in 2 days (Figure 39). Field capacity is defined then as the upper limit of water storage. The 15 bar soil water content is the lower limit of water storage, corresponding to pores 0.2 microns in diameter. At the permanent wilting point, or PWP, these tiny pores hold water more strongly so most plants can overcome.

Figure 39. *Available water capacity operatus and schematic of gravitational pore draining.*
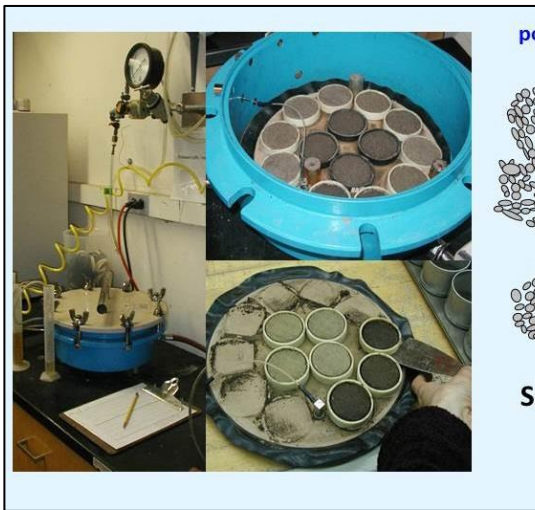
CSHT field penetration test

Our one field measurement in terms of physical soil properties is the soil compaction test. When each soil sub-sample is collected we also record the greatest soil hardness encountered through the two depth intervals using a soil penetrometer. Determining where compaction zones occur gives us information to target our soil management (*left in picture*). The 0 to 6" depth is referred to as the plow layer or surface or active layer; the 6 to 18" layer is referred to as the subsoil. It is important to isolate these 2 depths to better plan for soil management.
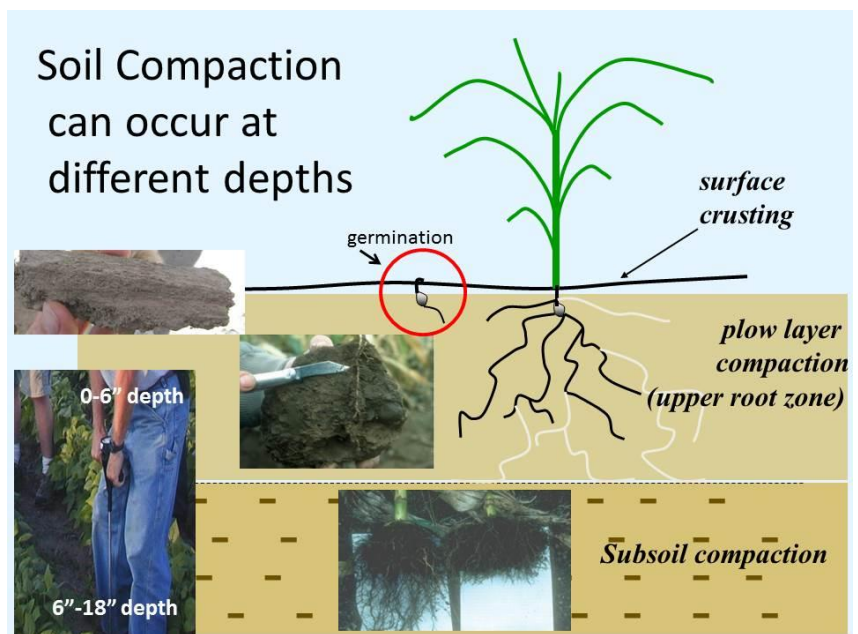

Soil biological indicators

These indicators take us back to the soil ecology with organic matter (food) as the driver of these essential soil processes. Each process is important as a link in the chain leading to resilient soil supporting healthy plants.

The addition of organic materials can contribute to enhanced soil physical processes just discussed (*Figure 40*). Now we'll move to a discussion of the biological processes.

Figure 40. *Adding organic matter (OM) affects soil processes (modified from Oshins, 1999).*
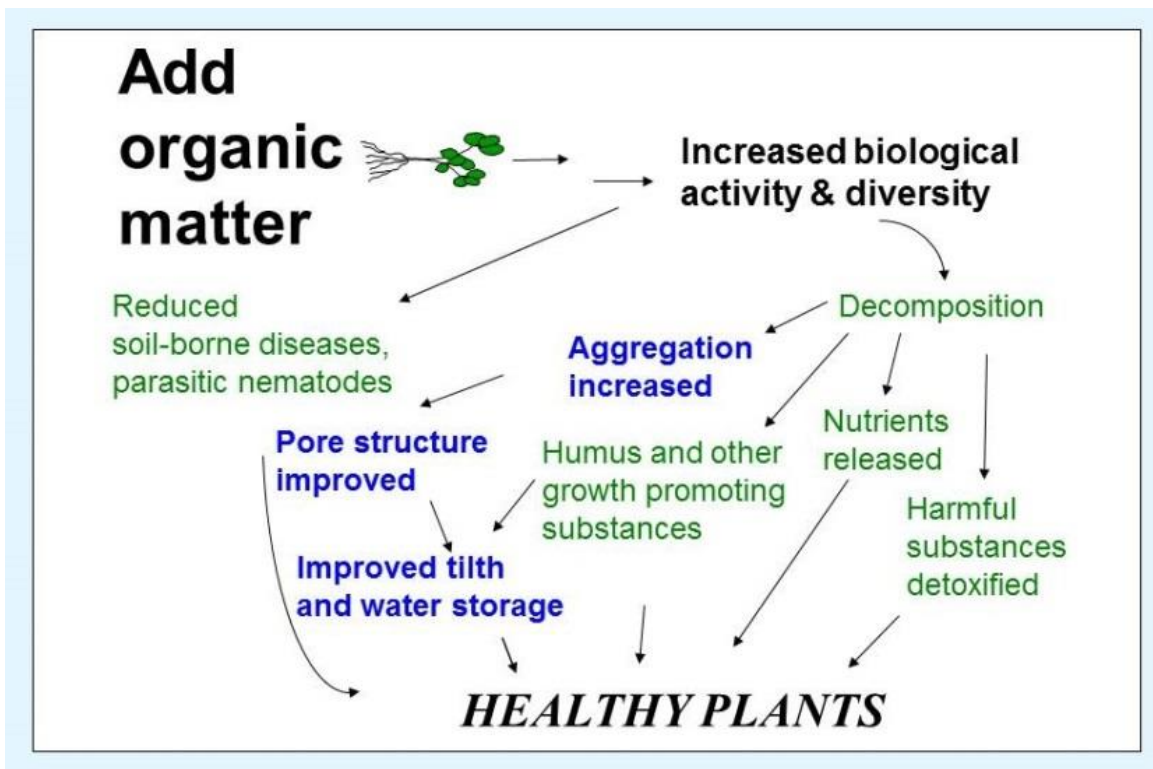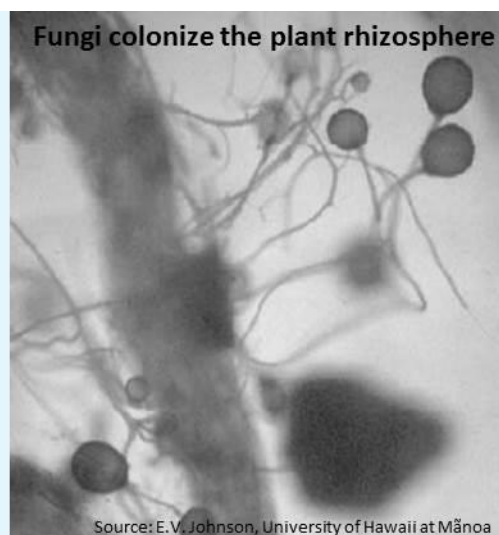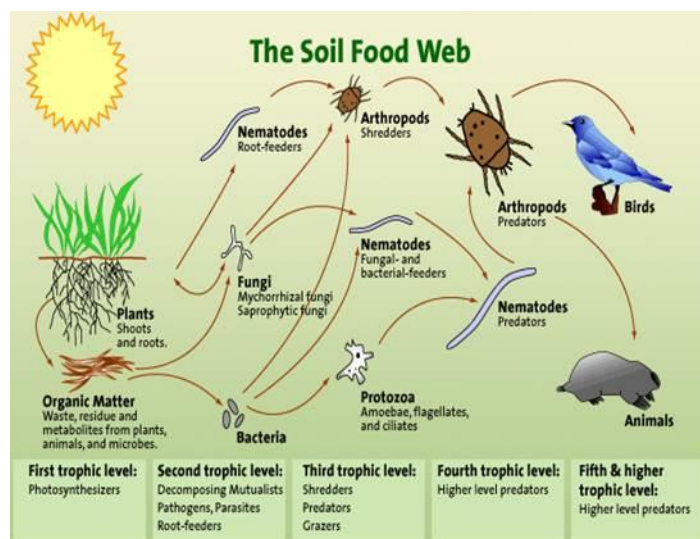

As mentioned in Chapter 1, there are three general "types" of organic matter in soils:

➢ *Living* - soil organisms and plant roots.
➢ *Dead* - recently dead soil organisms and crop residues provide the food (energy and nutrients) for soil organisms to live and function. Also called "active" or "particulate" organic matter.
➢ *Very Dead* - well decomposed organic materials, also called humus. Humus contains very high amounts of negative charge and has high water-holding capacity.

These categories of organic matter are used to simplify a very complex subject- soil organic matter. Some living organisms perform vital functions for plants and others can cause damage. The useful competition between living organisms can be mitigated by the food available for them. Complex humic substances can be long lived and perform vital water storage, loosening/ lightening functions and nutrient storage. All three types of soil organic matter play important roles in helping produce high yields of healthy crops.

The soil biological life cycle is a battleground among the creatures found there (*Figure 41*). Many of the nutrients bound up in the soil biota become available upon death to other organisms or plant roots.

Figure 41. *Living (and dying) soil organisms.*

Upper right- Fungi colonize roots and provide benefits to the plant- increased nutrient uptake, protection against other soil microbes. Microbe glues and earthworm "slime" (lower right) bind soil particles. Important soil processes are mediated by these organisms and we measure a chosen group.

CSHT potentially mineralizable nitrogen test (PMN)

PMN is an indicator for the capacity of soil microbes to convert nitrogen tied up in complex organic residues into plant-available forms (ammonium and nitrate). This test reveals the ammonium liberated from soil organic nitrogen over a one week incubation period. High values suggest a robust population of organisms which contribute to this conversion as well as a food source for them. This is not a test to determine the nitrogen supply levels of the soil but instead it is an indicator of activity with high numbers suggesting the presence of useful organisms and substrate for them to use. The technique used requires soil be measured for ammonium-N at sampling (time zero) and again after a 7-day incubation period.

CSHT soil bioassay with bean test

Another test done with living organisms is the root bioassay with a green bean variety highly susceptible to soil pathogens. This assay is used to evaluate the soil disease suppression index. Each soil sample is planted out in replicate with the susceptible bean variety and allowed to grow for 4 weeks in the greenhouse. Plants are removed from their containers and soil is washed away form the roots. Roots are then rated on

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a score of 1 to 9 (*Figure 42*). A robust soil will have biota which outcompete disease producing organisms with the result of "clean" roots. Note the bean seeds are treated with a combination of fungicides prior to planting to prevent seed decay and/or seedling diseases that might have an impact on test results.

Figure 42. *Root health rating scale for soil bioassay with bean.*
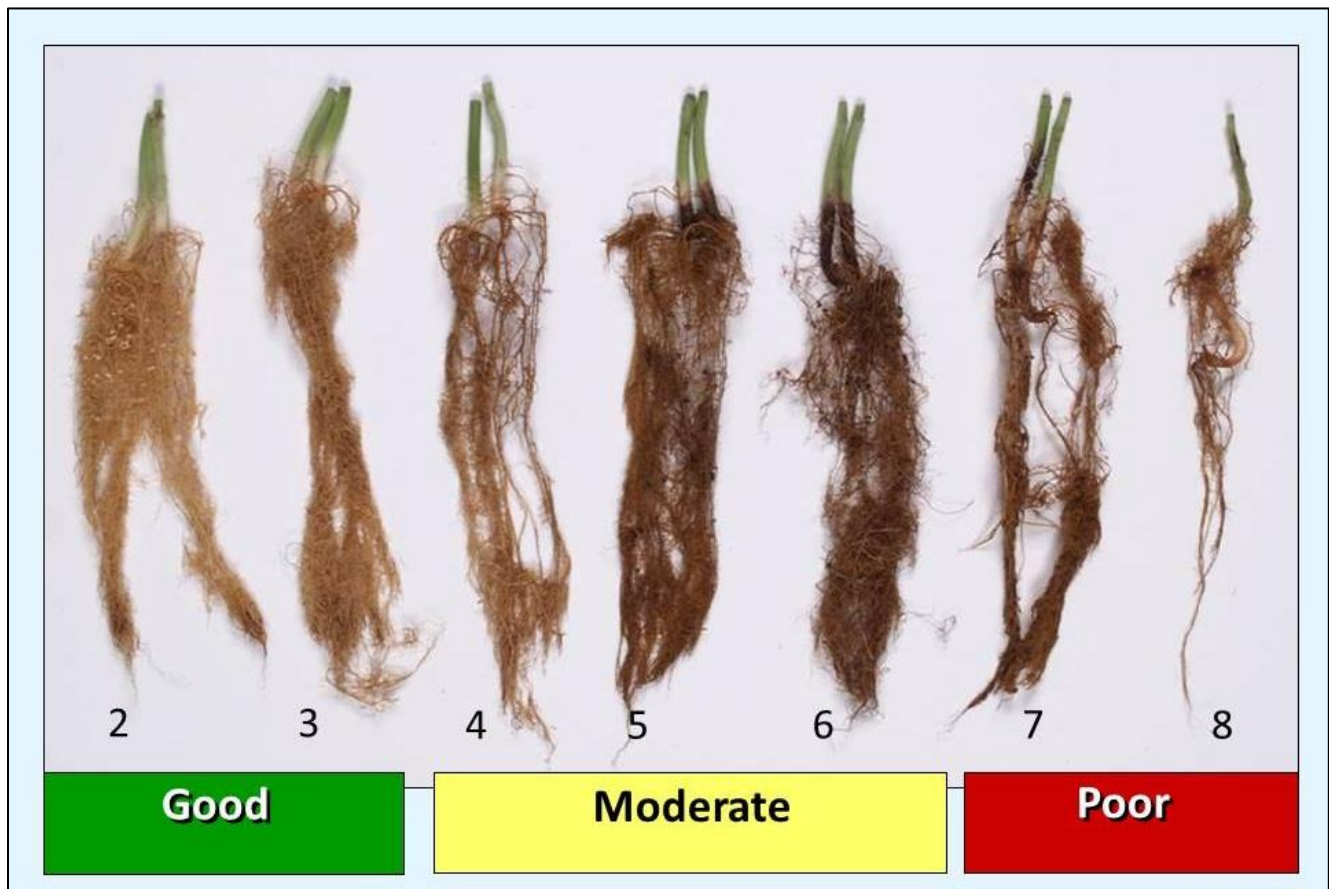
Active carbon test

The recently "dead" portion of soil organic matter is measured using the active carbon test. The active carbon test (*Weil et. al., 2003*) is an indicator for the fraction of carbon and nutrients in total organic matter that is actually available for use by the soil food web and plants. This indicator shows a response to soil management sooner than total OM% changes. The "recently dead" soil life becomes food and energy for other soil life. The material that is available for soil organisms to use can be quantified when chemically "burned" with purple potassium permanganate. A high level of oxidizable material reduces the amount of purple color in the permanganate test solution which we can read with a colorimeter (*right*).

The very dead humic fraction of soil represents a "black box" of compounds. These complex materials really are the long-lasting "house" of soil structure. Moderate amounts of humic substances benefit all soil types. These substances do not

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typically provide significant energy to the soil biota as does the smaller compounds revealed through active carbon testing. Humus, like clay, can hold a lot of cations; it also increases soil water holding capacity. Clay soils are "loosened" and soften by organic residues (humus).

Back to the soil ecology with organic matter (food) as the driver of these essential soil processes. Each process is important as a link in the chain leading to resilient soil supporting healthy plants. Note that these processes occur at different rates and times based on the composition of the initial food source. These issues (and more) will be discussed in the next chapter which focuses on how to maximize these positive processes using various organic materials and composts.

Figure 43. *An update of Figure 40 showing where the Cornell Soil Health Assessment test indicators are used to evaluate these soil processes.*

Note that the boxes in red in Figure 43 list the Cornell soil health tests just discussed for use in soil health assessment. The easily measured indicators listed represent these essential processes. From these indicators, we can determine sub-optimal or constrained levels of soil function.

CSHT rapid soil texture test

The rapid soil texture test is used to determine the soil's textural class as a percentage of sand, silt, and clay. Soil textural class is used

to aid in interpretation of the above mentioned indicators. The test used is one developed by *Kettler, Doran and Gilbert (2001)* where soil is oven dried and sieved; a sample of known weight is then vigorously shaken for 2 hours in a tube with a 3% soap solution. The samples are then rinsed onto another sieve where the material is rinsed through the sieve using fingers or a rubber policeman; sand remains in the sieve and is collected for drying. The water and silt and clay particles passing through the sieve is collected in a large beaker. This mixture is stirred and then allowed to settle for 2 hours, the liquid with its suspended clay particles is poured off and the settled silt is collected and weighed.

For a more in-depth understanding of the development and use of the Cornell Soil test see *Cornell Soil Health Assessment Manual, 3ʳᵈ edition.*
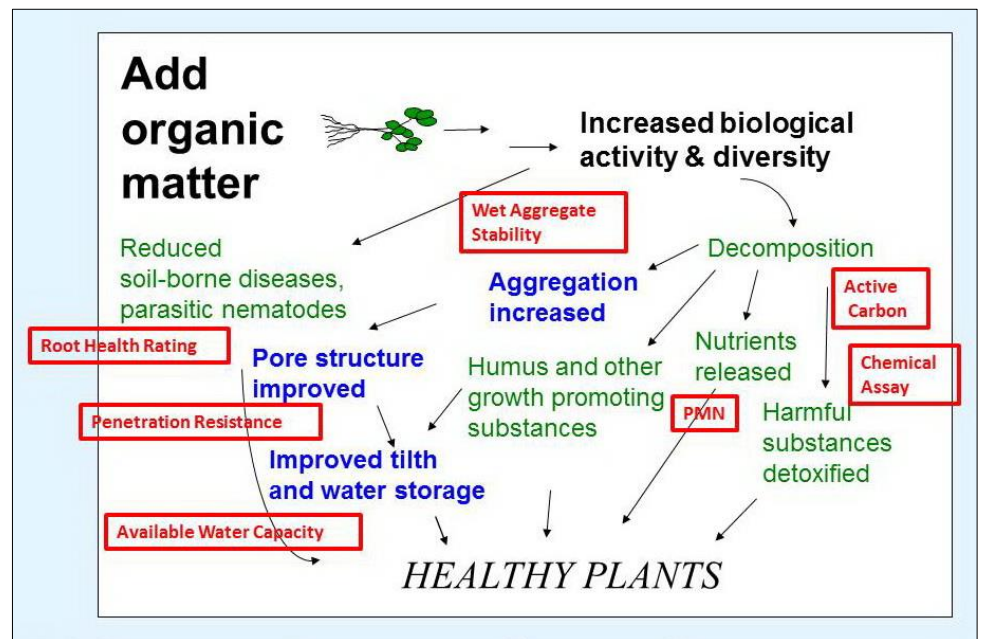
The Cornell soil health test report

The product of the above testing is contained in the Soil Health Test Report (below *left*). The reported test values are taken to a database and sorted by soil textural class for interpretation. The rating column to the right of the reported values shows where the values falls in the data distribution (out of 100). Color coding of red, yellow and green represent the lowest 30% of the distribution, the middle 40% and the upper 30%, respectively. For values in the lower 30% of the distribution (coded in red), the soil functional constraints are listed. To develop a deeper understanding of the CSHT scoring functions see "*Cornell Soil Health Assessment Manual, 3rd edition*".

CORNELL SOIL HEALTH TEST REPORT				
Indicators		**Value**	**Rating**	**Constraint**
PHYSICAL	Aggregate Stability (%)	22.3	10	aeration, infiltration, rooting
	Available Water Capacity (m/m)	0.13	25	water retention
	Surface Hardness (psi)	42	94	
	Subsurface Hardness (psi)	390	1	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	3.9	42	
	Active Carbon (ppm) [Permanganate Oxidizable]	614	27	Soil Biological Activity
	Potentially Mineralizable Nitrogen (μgN/ gdwsoil/week)	6.3	2	N Supply Capacity
	Root Health Rating (1-9)	3.2	75	
CHEMICAL	pH (see Nutrient Analysis Report)	6.1	67	
	Extractable Phosphorus (see Nutrient Analysis Report)	2.6	44	
	Extractable Potassium (see Nutrient Analysis Report)	78.8	100	
	Minor Elements (see Nutrient Analysis Report)		100	
OVERALL QUALITY SCORE (OUT OF 100):		48.9	**Low**	
Soil Textural Class:==> clay loam				
SAND (%): 21.0		*SILT (%): 42.0*		*CLAY (%): 37.0*

The utility of soil health evaluation

Soil health testing investigates the complex interaction between physical, biological and chemical processes. The CSHT suite of indicators allows for the comprehensive, quantitative assessment of a soil's health status. Note that no direct management recommendations accompany the CSHT results; rather management tactics are tailored to individual crops, farms, and circumstances. Results from the soil health test allow for 1) education about soil health concepts, 2) monitoring effects on soil health due to management (e.g., NRCS Conservation Security Program), and 3) targeting of management practices.

Information from the measured indicators in the CSHT gives us a broader suite of data to evaluate soil performance. Understanding the utility of each of these measured parameters singly and together respects the holistic nature of soil ecology. Now we must use the information to develop a management scenario that fits the needs of the grower and available resources.

In terms of berry crops utility of soil health evaluation has just begun to be explored; growers considering establishment of new plantings are likely to benefit most at present from use of this test. The perennial nature of berry crops makes it critical to have the best possible soil health *prior to planting* as mitigation of problems after planting can be extremely difficult. That being said, there is also utility for this test in terms of its use in established plantings as a diagnostic tool for discovering production issues as they relate to soil health. What still remains to be determined are potential management practices that may be implemented post-plant that will have positive impacts on sub-optimal or constrained levels of soil function. As we introduce a soil management

strategy for berry crops using the information obtained in the Cornell Soil Health Test we will focus on agronomic approaches to soil building in "off-berry" years on the field rotation.
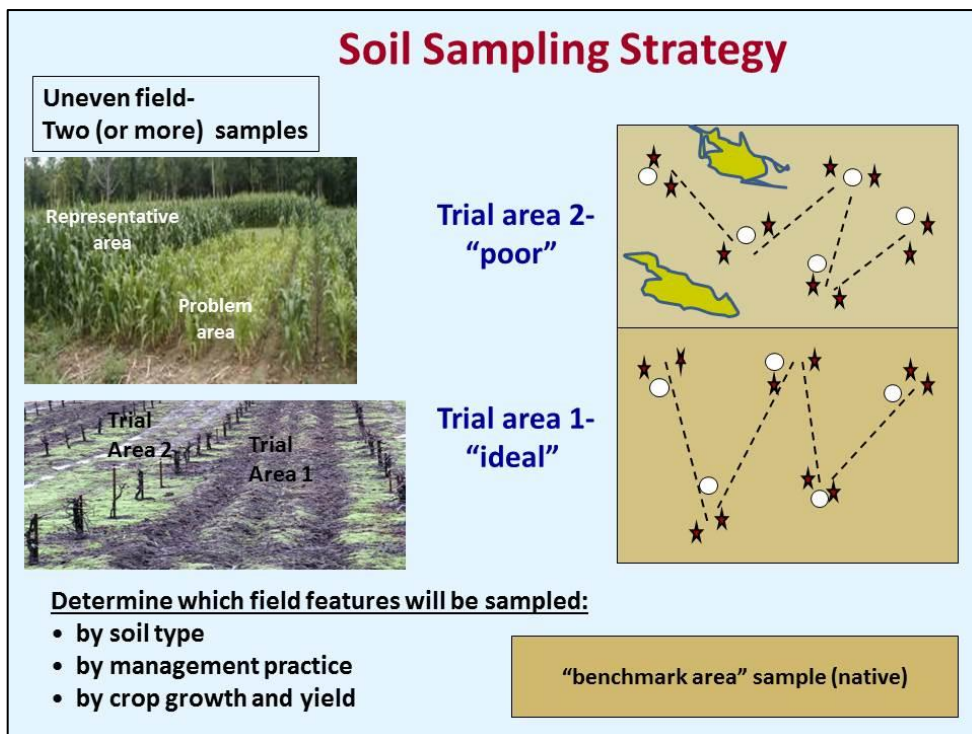
Collecting a CSHT sample

The best time to collect a soil sample for submission to the soil health testing lab is when the soil is in a fully functional or active condition. Sampling a soil when frozen or hard during an extended drought period is not recommended. It is important that the soil be at field capacity when sampling so that meaningful soil penetration data may be collected. Sample only the surface soil from 0-8" deep, scraping away any loose organic debris from the top of the sample. Remember that when you collect the subsamples which comprise a sample that you are asking a question for which you will receive an answer. So sampling the entire field randomly will give values representing the gross mean of that field for each parameter (*right*). Trial area #1 in the figure indicates a uniform field where only one sample would be collected; this sample would be comprised of several unbiased, representative sub-samples which are then combined into one composite sample. White circles indicate sub sample collection points; red stars indicate associated penetrometer reading sites. At each stop in the field one soil subsample is collected and 2 penetrometer readings are recorded. At each stop, with one smooth push, penetrate through to a depth of 18" record the highest penetrometer reading (value) encountered for the 0 to 6" and 6 to 18" depth. Soil could also be collected for Trial area #2 in the figure as a separate sample to determine possible soil health factors causing the poor plant performance. Also, a benchmark sample taken just off the production area can be used to determine the "natural" or background soil parameter values to compare to the values obtained under production in the poor and ideal areas.

Contrasting soil types, soil management, crop growth or yield can be evaluated by collecting 2 (or more) separate soil samples. In the figure at left, we might collect 2 separate soil samples from management zone A and management zone B. In bedded situations like some berry production scenarios, we might want to collect one sample near the plants in the beds versus

Determine which field features will be sampled:
• by soil type
• by management practice
• by crop growth and yield

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another sample collected next to the bed further from the plants.

An example from real life

Back to the long-term research corn grain trial with moldboard plow tillage versus no-till soil management. By submitting samples from contrasting areas of interest we can learn from the Cornell Soil Health Test Report the effects of applied management. We can see differences in soil appearance in these samples taken from our tillage research plots at Cornell's Baker Research Farm in Willsboro, NY. Let's sample these plots and look at the Cornell Soil Health Test Reports (*Figure 44)*.

Figure 44. *CSHT test results for plow till vs. no-till corn research project, Willsboro, NY.*

Here we learn the effects of long term moldboard plowing for grain corn versus no till on this clay loam. In the long-term plow example on the left, we see that the soil physical properties have been negatively affected compared to the no till soil management as have the biological properties. Note however that even in the no till plot the "steady diet" of corn stover has maintained soil organic matter but impaired active carbon levels. This field started out as alfalfa hay- we see that no-tilling maintained a healthy soil (high score) while the continuous moldboard tillage had several measureable negative effects on soil processes (low score).

Developing a management scenario

A four-step process for interpreting and using the information from the CSHT report has been developed (*Figure 45*).

Figure 45. *Cornell Soil Health Test Report Field Management Planning Sheet.*

Cornell Soil Health Test Report Field Management Sheet

Step 1. Identify constraints, prioritize

Information taken from CSHT Report

Step 2. List management options

Collect agronomic options from local experience,
CSHT Training Manual (Table 5, pg. 52), workshops, web sources..

Step 3. Determine site history/ farm background

Note here situational opportunities and limitations-
site history, equipment availability, labor, field location

Step 4. Management Strategy 2012

Adapt field management options to the capacities and
needs of the grower

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The **first step** in Soil Health Management Planning involves defining the grower's background, desires and resource options. **Step Two** asks the grower to combine their knowledge of the field with the information on soil functional performance provided in the Cornell Soil Health Test Report to identify field management targets. This sets the context for **Step Three** where different management options to address the identified targets are weighed (Figure 46). This aspect of examining the information provided requires considerable attention and thought to be of the most value. In addition, agricultural professionals (Extension specialists, consultants, growers, researchers) can bring many ideas to the table here and this is a great forum for brainstorming a management scenario. Reliable advances in soil improvement in berry crops have been made by applying sound agronomic practices well known to field crop growers to fields that are in the "off-berry" phase of the rotation.

Ideas from field days, conferences, the media and other growers can be discussed to arrive at a meaningful strategy for the grower. **Step Four** puts the three steps above together to provide an action plan for the grower to move forward with a management objective derived from an adaptive strategy of information gathering (see Chapter 9).

Soil management options for annual crops can be different than those suitable for more perennial plants such as berries due to row spacings, soil bedding designs, placement of mulches, etc. Ag consultants and educators, as well as growers, must continue to learn of the latest technologies and principles available to accomplish field objectives.

Differing commodities or production systems (organic vs conventional, bedded vs flat) require expertise to be shared between the consulting Ag professionals and the grower. Progressive producers rely on sound advice to continue to adapt the soil management to changing markets and the uncertain climate. How to deal with measured soil constraints has to be addressed on a CASE BY CASE, FIELD BY FIELD, GROWER BY GROWER basis.

Summary

The Cornell Soil Health Test was developed by a diverse group of Cornell University faculty, research staff and Extension personnel. Each person brought to the team an expertise that was felt to be incomplete to understand field situations where plant performance was poor even when soil fertilizer nutrients were not limiting. The consensus of the group was a need to identify and measure a broad suite of soil functional processes to understand the soil ecology. A holistic approach to soil process testing to find limitations to soil performance was developed.

Indicator tests were devised or adopted to measure the essential soil physical processes of aeration, water infiltration and retention, soil hardness in the surface and subsurface. Soil biological function was evaluated from total organic matter content, readily oxidizable organic material to fuel the soil biota and a measure of microbial activity via transformation of organic nitrogen material to plant available ammonium. A measure of root disease suppressiveness by the soil microbial community established. The standard plant-available nutrient extraction and quantification test rounds out the soil measurements.

After these processes are measured in the lab, they are scored against a database and the results are returned in the Soil Health Report. The Report uses a color coding to highlight in red the soil processes values that are in the lowest 30% of the values in the database. This information on the Report is then used in the context of developing a soil management plan to holistically approach the constraining soil processes. The grower compares the information returned in the Report to then prioritize management efforts. Knowledge of the best management tools to use to address the identified concerns requires a capacity to obtain information from various sources. This adaptive strategy of soil management is best served with a system of trial application of soil management practices and observation of the results.

Further reading

1. Gugino, B.K., Idowu, O.J., Schindelbeck, R. R., van Es, H.M., Wolfe, D.W., Moebius-Clune, B.N., Thies, J.E., and Abawi, G.S. 2009. *Cornell Soil Health Assessment Manual, 3rd edition*. Cornell University, Geneva, NY.
2. Cornell Soil Health web site: http://soilhealth.cals.cornell.edu/