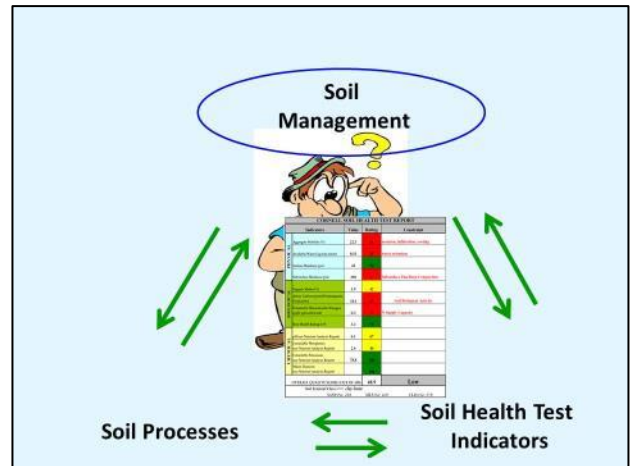


## Chapter 9 Improving Biological and Physical Soil Properties in Commercial Berry Plantings – Robert Schindelbeck, Cornell University

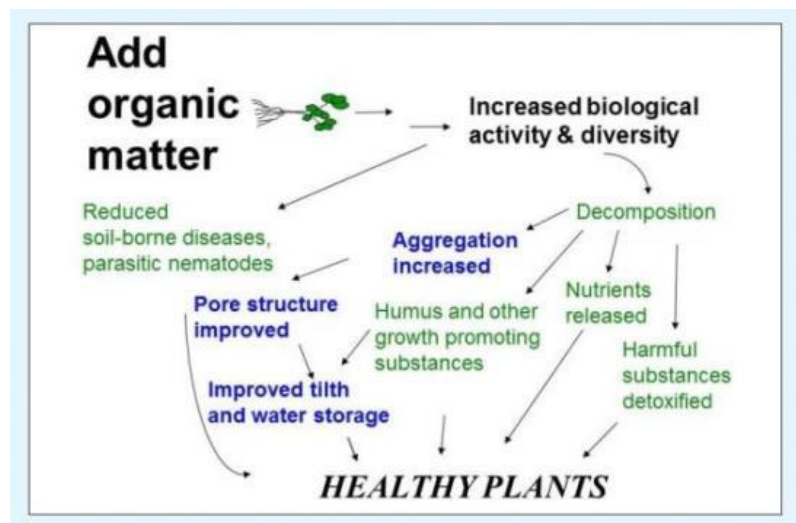
### Let's review

Soil ecology is very complex and full of interaction between the different soil physical and soil biological factors. In order to have some understanding and impact on soil ecology then, it is necessary to take a reductionist approach to the problem, 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. Soil behavior is dynamic- we understand that any single measure of soil behavior must also be considered in an ecological context of interaction.



### Adding organic matter

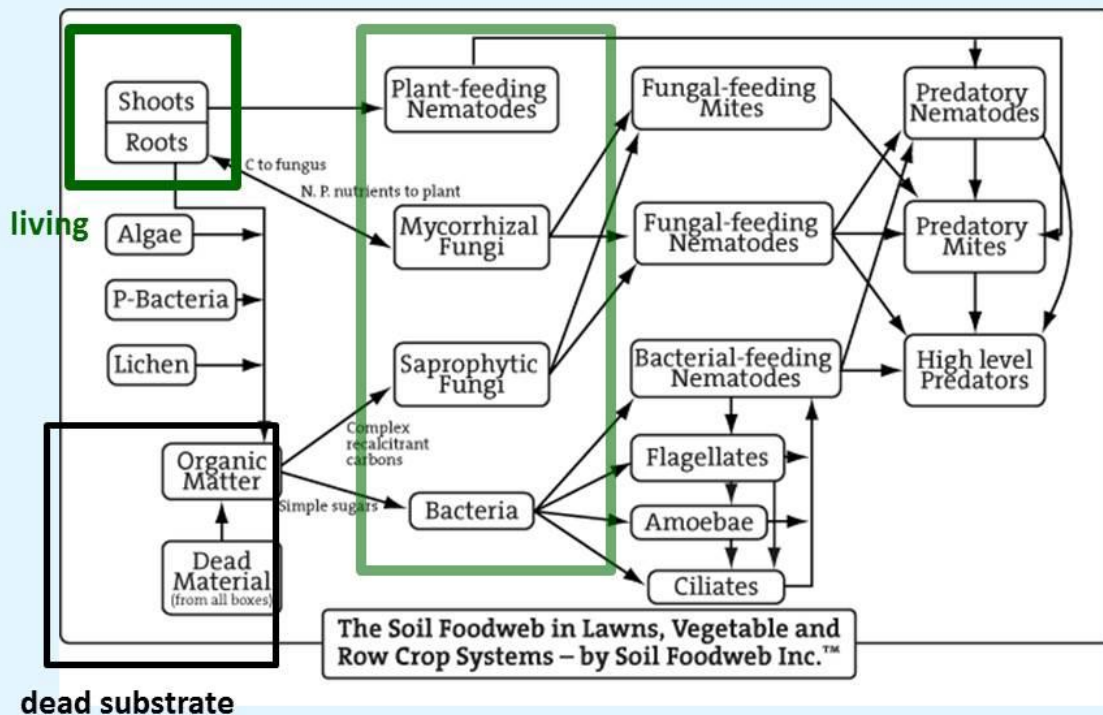
Adding organic matter affects soil processes; these include both physical (blue) and biological (green) processes in soil (*right*). Different types of organic matter affect these processes in different ways. When considering soil health management strategies it is important to take this into consideration. For example, what age organic matter would be best to affect the soil health in the way we need? Should it be applied to the surface, mixed in, grown in?



### Actors in the soil food web

The actors in the soil food web start with organic matter. These include both living organic matter (shoots and roots) and dead substrate. These are quite variable and have different effects on different organisms. Certain organisms then may be promoted or restricted by modifying the living and dead substrates.

## Actors in the Soil Food Web™



### All organic matter is not created equal

**Fresh material (grass clippings, leaves, raw manures).** Green and animal manures provide both nutrients and energy-rich food for microorganisms living in the soil. Composting of this material takes place in situ (in the field). Breakdown products help to 'glue' soil particles together to increase soil tilth. Addition of this type of fresh organic matter also favors the rapid bacterial population increases which can lead to N immobilization, causing plants to be N deficient.

**Composts (biosolids, biochar, municipal stockpiles).** These are long-term, stable materials. Bacteria/bacterial by-products become a food source for next-level organisms. More stable composts can lighten heavier soils and add water and nutrient storage capacity to coarser soils. Potential for nitrate and phosphate runoff losses and leaching losses from concentrated composts may be high.

We recognize that soil biological processes are affected by the mix of active fuel (living or fresh) and passive stable (humus, or very dead) materials, the diversity of soil organisms and their activities. The interaction of these components is controlled by moisture, temperature, mixing, inorganic nutrients (nitrogen), carbon source, etc. We can affect these processes with our crop and soil management.

### Plants and organic debris are part of a dynamic system

Different plants or plant debris composition affect soil biology- note that growing specific plant species can result in introduction of specific compounds into the soil ecology. Healthy soil biotic communities tend to suppress disease causing organisms. Reduced plant stress due to a balanced soil environment reduces plant susceptibility

to disease. Plant shoots and roots are capable of producing plant defensive compounds that stress pests. These plants can also enhance beneficial organisms.

The plant root modifies the rhizosphere environment. Plants contribute nutrients and cellular material to the rhizosphere (estimates up to 20-40% of total plant energy). The root tip loses cells as it passes through the soil. These cells can release their contents and help dissolve nutrients into solution. These cells can also become food for organisms which can provide increased access to nutrients and water protection from disease organisms. Plant roots can singly or symbiotically release compounds which favor the plant needs over competitors' needs.

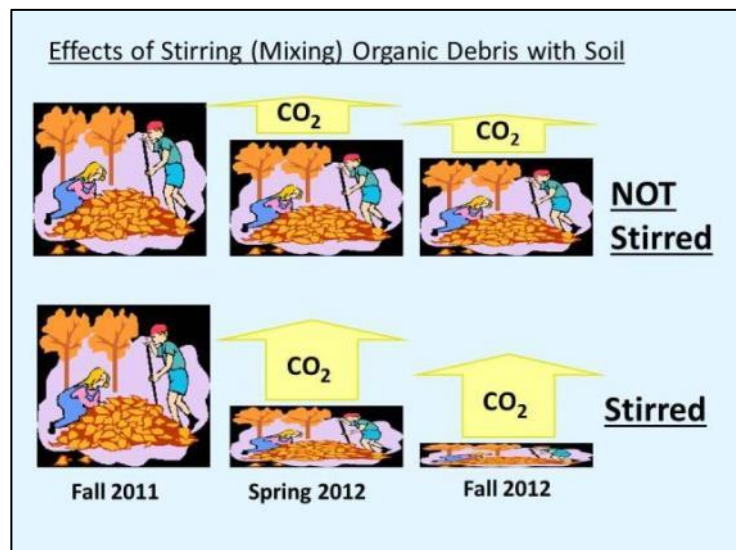
Plants contribute nutrients and cellular material to the rhizosphere zone around the plant roots. Root hairs are short-lived single cells expanding behind the root tip. These hairs can become infected by bacteria (Rhizobia nodulation). These hairs can entwine with fungal mycelium to increase overall surface area for increased capture of nutrients and water. Dead root hairs burst and release compounds which modify the rhizosphere to facilitate new root hair exploration.

### Soil carbon transformations under biologic processes and fungal processes

In a bacterially dominated system, root exudates and plant debris are used as a food source. These bacterial then become a food source for nematodes and actinomycetes. Excess nutrients are mineralized and made available to plants. This is a rapid onset system, characterized by tillage agriculture. Somewhat stable, simple humic carbon compounds can be produced from the transformation of dead organic material or merely remain as recalcitrant cellulose and lignins- compounds that resist further biological use.

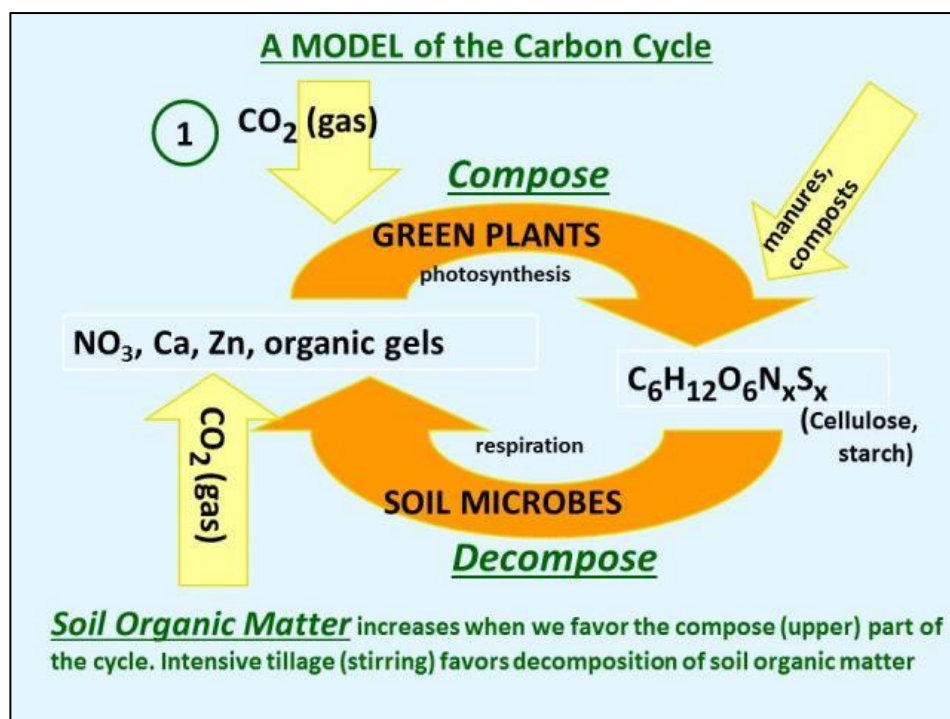
In a fungal dominated system, fungi are the first feeders on rhizosphere compounds and other soil available metabolites. These root associations greatly benefit the plant in water and nutrient uptake and can afford protection against soil-borne disease organisms. These associations develop slowly and are found in undisturbed permaculture environments, such as berry plantings. Complex carbon compounds are sequestered through this "humification" and these durable humic substances can last decades.

The schematic to the right shows the effect of stirring (mixing) organic debris with soil. Across the top leaves are simply collected into a leaf pile in the fall and are not stirred. The following year finds the pile, somewhat compressed by snow and rain, at 2/3 of its previous height but not many leaves have broken down and consequently there is not much carbon dioxide release from this pile. At the bottom, an identical leaf pile has been stirred frequently- turning it provides opportunities to move bacteria into zones of fresh material to break down. Because of that, there is a lot more carbon dioxide release as this occurs. Note that the source of the extra carbon dioxide which diffuses from the bottom pile is the microbial transformation of the organic substrate- the leaves.



## The carbon cycle

The carbon cycle (*right*) can be modeled as a balancing act between composing (top arrow) and decomposing (bottom arrow). Composing involves taking carbon dioxide from the atmosphere and composing it into sugars (cellulose and starch); and then decomposing this organic matter through the respiration of soil microbes turning them back into carbon dioxide. The rapid spinning of this cycle is what's favored by the bacteria. Soil organic



matter increases when we favor the compose part of the cycle; intensive tillage (stirring) favors decomposition of soil organic matter. Different organic matter sources and qualities that are added to this process are going to affect it differently. As discussed in chapter 8, “Applying the Cornell Soil Health Test to Berry Production” living (and dying) soil organisms serve several functions to break down organic debris, to create/ release soil glues, to release nutrients, protect or infect crop plants, and serve as food for other organisms.

## Cornell Soil health Test Indicators (review)

The wet **aggregate stability** test is an indicator for the soil organisms that create and release soil glues; this is accomplished through organic debris breakdown and their subsequent release of compounds which bind soil particles together. Dead roots of crops and cover crops can insert organic matter deep into the soil profile.

The **potentially mineralizable nitrogen** test is an indicator for the soil organisms that release nutrients. It measures the capacity of soil microbes to break down organic soil nitrogen into ammonium.

Soil organisms can protect or infect crop plants. The indicator for this soil health process is the **soil bioassay** using green bean seedlings. Once we have an idea of what micro-organisms are present we can manipulate our soil health management practices to either favor or disfavor them.

The **active carbon** or “kindling” of the soil organic matter is the easily accessible, easily oxidizable, easily available, easily digestible material in soil. This material provides energy to drive the soil biota through their diverse soil functional processes.



## Soil management guidelines

Holistic soil management requires an understanding of soil processes. Soil health testing reveals the capacity of the soil to perform these functions using indicator tests. The soil health management strategy is then tweaked to address any of these identified soil performance constraints. Often a synergistic approach is possible whereby one

management tactic may redress one or more constraints at the same time, saving effort and expenditure.

To review from page 119, the **first step** is to take a look at soil health test results (*left*) and identify any constraints. This is the test results for a two-year old strawberry planting; it had a rye vetch cover the year before it was established; it's on a sandy loam soil.

If we look first at the physical soil characteristics, aggregate stability has a 95% rating, in the green, indicating a very nice soil structure. However, as we move down the list we see there is surface hardness and subsurface hardness so there's some compaction in the soil which will need to be taken into account

Indicators		Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	66.1	95	
	Available Water Capacity (m/m)	0.13	51	
	Surface Hardness (psi)	273	12	rooting, water transmission
	Subsurface Hardness (psi)	375	27	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	2.8	42	
	Active Carbon (ppm) [Permanganate Oxidizable]	365	21	Soil Biological Activity
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	8.0	25	N Supply Capacity
	Root Health Rating (1-9)	3.3	75	
CHEMICAL				
	pH (see Nutrient Analysis Report)	6.0	67	
	Extractable Phosphorus (see Nutrient Analysis Report)	4.5	100	
	Extractable Potassium (see Nutrient Analysis Report)	112.5	100	
	Minor Elements (see Nutrient Analysis Report)		100	
OVERALL QUALITY SCORE (OUT OF 100):			59.6	Medium
Soil Textural Class:==> sandy loam				
SAND (%): 53.0                      SILT (%): 42.0                      CLAY (%): 5.0				





as the grower moves forward. In the biological realm we see there's a decent amount of total organic matter present in the soil (42%); but the fresh organic material (active carbon) is low at 21% and the rate of mineralization of nitrogen (breakdown of organic material into available nutrients) is also low at 25%. Root health is relatively good at 75%.

Soil chemistry is good; soil pH is slightly low at just outside the desired range (6.2 to 6.5). Phosphorus and potassium levels are good, along with minor elements.

The overall score then is 59.6, in the medium range. Now the grower has the option to select some management practices to try on this field to see if they can address the indicated constraints. Once management practices are in place the grower would test again to see what effect these are having on soil health.

The **second step** is to brainstorm management options. Figure 46 lists potential practices that are seen as a starting point in the decision-making process of potential soil remediation practices.

**Figure 46.** Suggested management strategies for addressing soil health constraints

	Short term or intermittent	Long term
<b>Physical Concerns</b>		
<b>Low aggregate stability</b>	Fresh organic materials (shallow-rooted cover/rotation crops, manure, green clippings)	Reduced tillage, surface mulch, rotation with sod crops
<b>Low available water capacity</b>	Stable organic materials (compost, crop residues high in lignin, biochar)	Reduced tillage, rotation with sod crops
<b>High surface density</b>	Limited mechanical soil loosening (e.g. strip tillage, aerators); shallow-rooted cover crops, bio-drilling, fresh organic matter	shallow-rooted cover/rotation crops; avoid traffic on wet soils; controlled traffic 
<b>High subsurface density</b>	Targeted deep tillage (zone building, etc.); deep rooted cover crops	Avoid plows/disks that create pans; reduced equipment loads/traffic on wet soils 
<b>Biological Concerns</b>		
<b>Low organic matter content</b>	Stable organic matter (compost, crop residues high in lignin, biochar); cover and rotation crops	Reduced tillage, rotation with sod crops
<b>Low active carbon</b>	Fresh organic matter (shallow-rooted cover/rotation crops, manure, green clippings)	Reduced tillage, rotation 
<b>Low mineralizable N (Low PMN)</b>	N-rich organic matter (leguminous cover crops, manure, green clippings)	Cover crops, manure, rotations with forage legume sod crop, reduced tillage 
<b>High root rot rating</b>	Disease-suppressive cover crops, disease breaking rotations	Disease-suppressive cover crops, disease breaking rotations, IPM practices
<b>Chemical concerns</b>	<i>See also soil fertility recommendations</i>	
<b>Unfavorable pH</b>	Liming materials or acidifier (such as sulfur)	Repeated applications based on soil tests
<b>Low P, K and Minor elements</b>	Fertilizer, manure, compost, P-mining cover crops, mycorrhizae promotion	Application of P, K materials based on soil tests; increased application of sources of organic matter; reduced tillage
<b>High salinity</b>	Subsurface drainage and leaching	Reduced irrigation rates, low-salinity water source, water table management
<b>High sodium content</b>	Gypsum, subsurface drainage, and leaching	Reduced irrigation rates, water table management

As consultants and educators or growers, we 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. How to deal with measured soil constraints has to be addressed on a CASE BY CASE, FIELD BY FIELD, GROWER BY GROWER basis. Examining the information provided requires considerable attention, thought, and creativity to be of the most value.

We have now added constraints (Step 1) and management options (Step 2) to the field management sheet. For management options we might propose the following (red arrows above): The grower first may want to identify/find the compaction layer(s); options to mitigate these might be to plow, rip, or use an appropriate cover crop to break them up. At the same time, the grower may want to feed the soil with a heavy debris, rich root residual (clover, vetch, or alfalfa), or disease suppressive cover crop (various brassicas) to get their bacterial cycle spinning a little faster to address active carbon and mineralizable nitrogen constraints.

**Step 3** involves an assessment of equipment and labor that may be available to help mitigate the limiting factors, and understanding the history of the field to determine what might have contributed to its current condition. Which options are actually feasible to implement?

**Step 4** is developing a satisfying and workable management plan using the Soil Health Management Toolbox.

## Field Management Sheet

### Step 1. Identify constraints

- Surface and subsurface compaction
- Low available energy for soil biology
- Low conversion rate to NH<sub>4</sub>

### Step 2. List management options

- Find hard layer- plow, rip or use appropriate cover crop
- Feed soil with heavy debris, rich root residual, disease suppressive crop

### Step 3. Determine site history/ farm background

Situational opportunities and limitations- site history, equipment availability, labor, field location

### Step 4. Management Strategy

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

CORNELL SOIL HEALTH TEST REPORT			
RyeVetch/ STW/STW			
Sandy loam			
	Indicators	Value	Rating
PHYSICAL	Aggregate Stability (%)	66.1	95
	Available Water Capacity (m/m)	0.13	51
	Surface Hardness (psi)	273	12
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BIOLOGICAL	Organic Matter (%)	2.8	42
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OVERALL QUALITY SCORE (OUT OF 100):		59.6	Medium
Soil Textural Class:==> sandy loam			
SAND (%): 53.0 SILT (%): 42.0 CLAY (%): 5.0			

## The Soil Health Management Toolbox

1. Crop Rotation/ hybrid choice
2. Growing cover crops
3. Organic/ chemical amendments
4. Reducing or modifying tillage

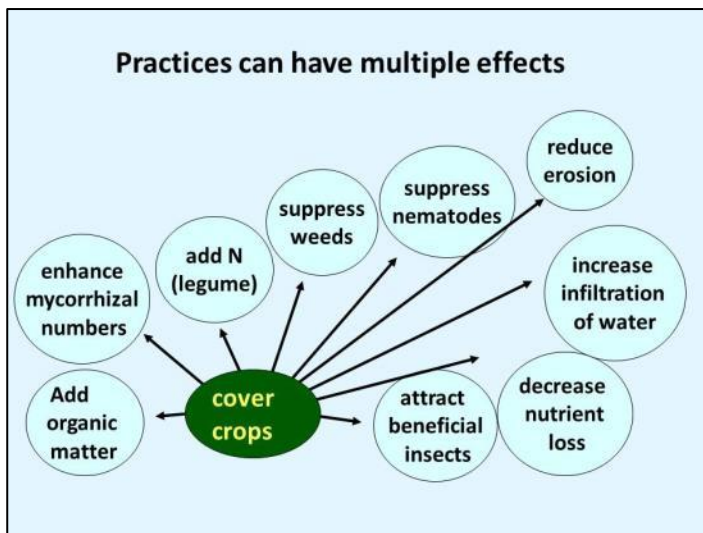
## 1. Crop rotation

Crop rotation is an agronomic approach to soil health management which brings to the table the ability of different plant types to suppress disease, to generally build organic matter and soil health, and smother weeds. It puts a different material there or not there at different times, affecting the soil biology.

Crop rotation is best used with shorter duration berry crops such as strawberries and raspberries. A minimum of a 3 year rotation out of strawberries and raspberries is recommended. Five years is preferable if there is sufficient land to allow for a longer rotation. Strawberries and raspberries share some soil-borne disease and insect susceptibilities with other crops. This is especially true for members of the solanaceous family, such as potatoes, tomatoes, peppers, eggplant and also for some forage crops, such as alfalfa. It is not a good idea to follow these crops with berries for a minimum of 3 years if at all possible. It is during these “off-berry” years that creative attention to crop rotation would be useful. Corn, beans and oats would be examples of crops that could be used in a berry crop rotation.

## 2. Cover crops

If land constraints prevent an adequate rotation time out of berries consider inserting a one or more cover crops into the sequence that has the capacity help mitigate multiple soil constraints at the same time. Other considerations with cover crops include selecting covers that best utilize land/equipment/labor and their ability to be sold in high return markets. The type of cover crop and the qualities it brings to the table in terms of soil health benefits is a major consideration. Another consideration is the timing of its use and how the cover crop may (or may not) fit into the management timetable as they fit in different windows: winter cover crops, summer fallow cover crops, season-long cover crops.



Deciding to grow a cover crop only puts the book on the table; it still needs to be opened and read. It's a brave new world with a wealth of information out there which needs to be considered when making cover crop choices.

Note that each option tested in deciding on a particular strategy is always an iteration towards a final decision- does this work, how does this work? It can always be modified toward what is needed. “Success stories” of the use of different crop/ cover crop combinations from other growers are useful starting points. Growers can “start small” by trying strip trials or half of the field to learn how it will work on their farm before fully committing. Be aware and learn of possible new pest introductions with these new strategies. One needs to be vigilant and ready to learn whatever is necessary to move forward.

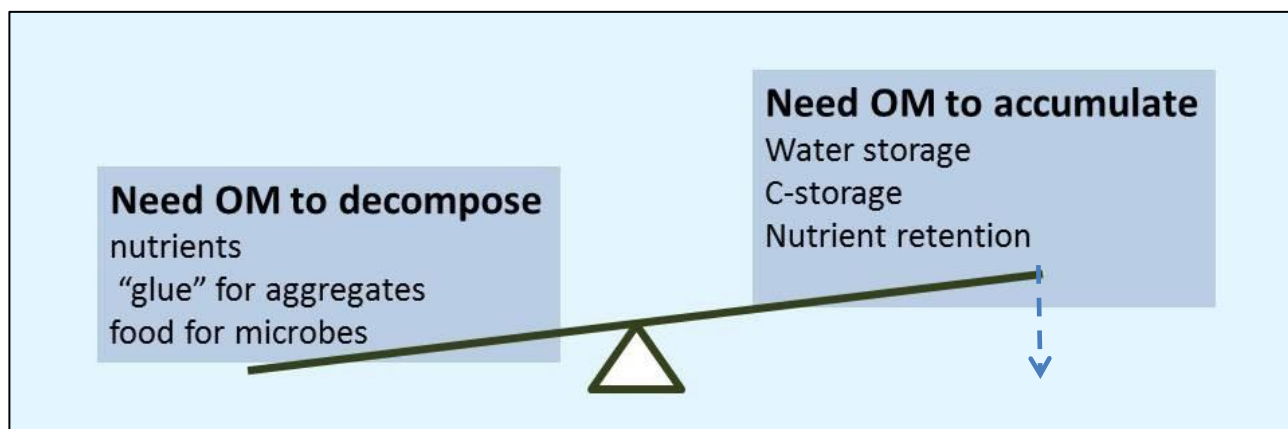
A list of potential cover crops for blueberry plantings is displayed in [Appendix F](#). These specific cover crops will tolerate a lower soil pH which will be necessary in a blueberry site.



### 3. Organic/Chemical Amendments

In terms of amendments, manure and compost as useful candidates for application are deceptively easy to list but the diversity of manures, composts and green manures available and how best to use them require creative thought and decision making on the part of the grower. At the beginning of this chapter we discussed some of the dynamic processes to be considered in making good choices on composition of added materials. We must apply a similar approach to understanding the cycles of breakdown and release of other additions like crop residues and biochar. Don't forget to include the effects of conventional amendments such as fertilizers, pesticides, and herbicides. These organic materials provide not just plant nutrients but active carbon and humic carbon for the soil biota to exploit.

Managing soil organic matter is a balancing act. There is a need for organic matter to decompose in soil at the same time there is a need for organic matter to accumulate. As it decomposes it releases nutrients, "glues" soil aggregates together and feeds important soil biological processes. At the same time we also want organic matter to accumulate to store water, to retain nutrients, to loosen the soil and to store for carbon. The only way to achieve this balance is to literally keep growing and/or adding organic matter because as we decompose it we have less and less. We can only accumulate it by growing or adding more. Regular additions need to be made of diverse kinds of organic matter (manures, composts, cover crops, crop residues, leaves, biochar) to tip the scale the other way allowing us to accumulate on a gross basis even though at times we need to decompose organic matter. These regular and diversified additions also promote a broader base of organic activity in the field.

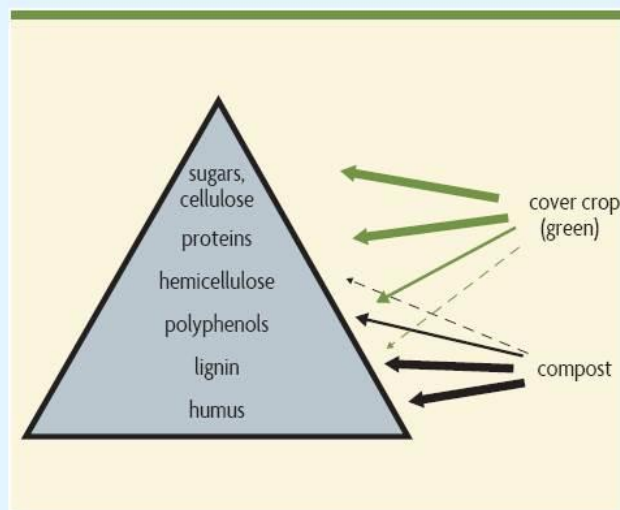


Organic matter losses through excessive decomposition and erosion need to be minimized and crops need to be rotated.

When we add green matter or green manure as a cover crop we are adding sugars, lighter, less complex compounds the bacteria are very hungry for. When we add composts we've moved further down the pyramid in the compost pile into these more complex longer lasting materials.

As portrayed in the schematic below, each of these materials will perform different important roles in the soil: nutrient release, soil aggregation, microbial community diversification, and balance. Buckwheat is an excellent example of a tender green manure crop which decomposes quickly and therefore can have a particularly profound effect on soil aggregation in a very short time.

# All Organic Matter is not Created Equal



**Figure 9.2.** Different types of residues have varying effects on soils (thicker lines indicate more material, dashed lines indicate very small percentage). Modified from Oshins (1999)

Different types of organic matter perform different important roles:

- Nutrient release (N if low C:N ratio)
- Soil aggregation
- Accumulation of OM in soil
- Diversify soil microbial community
- Balanced effects (over-application of same thing can be a problem)

→ **Choice of organic matter depends on constraints...**

## More is not always better....

We have to be particularly careful when applying composts and manure as over-application may generate excess leaching and denitrification losses. In vegetables, too much vigor is undesirable. Excess vegetative vigor and reduced quality can result from too high a supply of soil nitrogen and/or other compounds and compost additions may keep soils too wet during period of fruit set. We need to start from a safe place and modify from there. Use organic application rates based on industry standards and modify after paying close attention to soil and plant response. Appendix B presents various conversions that allow for easier calculation rates.

## 4. Tillage

Tillage assists in breaking up hard soil layers, eliminating ruts caused from heavy traffic, burying residues and preventing compaction. New equipment can allow for innovations in disturbance by using different shapes of shanks, different shapes of coulters. Local wisdom often can be very useful for guidance in the best ways for remediating compaction.

Tillage can also have some adverse effects, however, if used inappropriately or too intensively. Back to our leaf compost pile example offered above- remember stirring of the pile speeds up the bacterial biological processes (mineralization) and the way we do that often is with tillage. Intensive tillage literally results in “burning up” the current store of organic material as the soil biota is able to be mixed into new areas of available material to decompose it to carbon dioxide gas. Moderate amounts of this stirring coupled with timely additions of organic debris can be used to maintain the soil in a balanced condition.

In the top left photo of the photo montage below we see a soil being moldboard plowed a little too wet. Once the soil is flipped over the result is cloddy soil in the top right photo. This does not make for a good seed bed so then the soil is packed/firmed to crush the clods and make a more even surface (*lower right*). This in turn leaves the soil bare and unprotected, setting the soil up for potential crusting. (*lower left*). Admittedly this is a worst case scenario, but tillage is a powerful tool that should be respected in its capacity to degrade soil structure. Intensive tillage can severely affect soil processes, along with soil physical structure.

### **TILLAGE ADDICTION – when tillage is too intensive!!**

**Tillage of plastic soil**



**Underconsolidation (cloddy)**



**Crusting after rain**



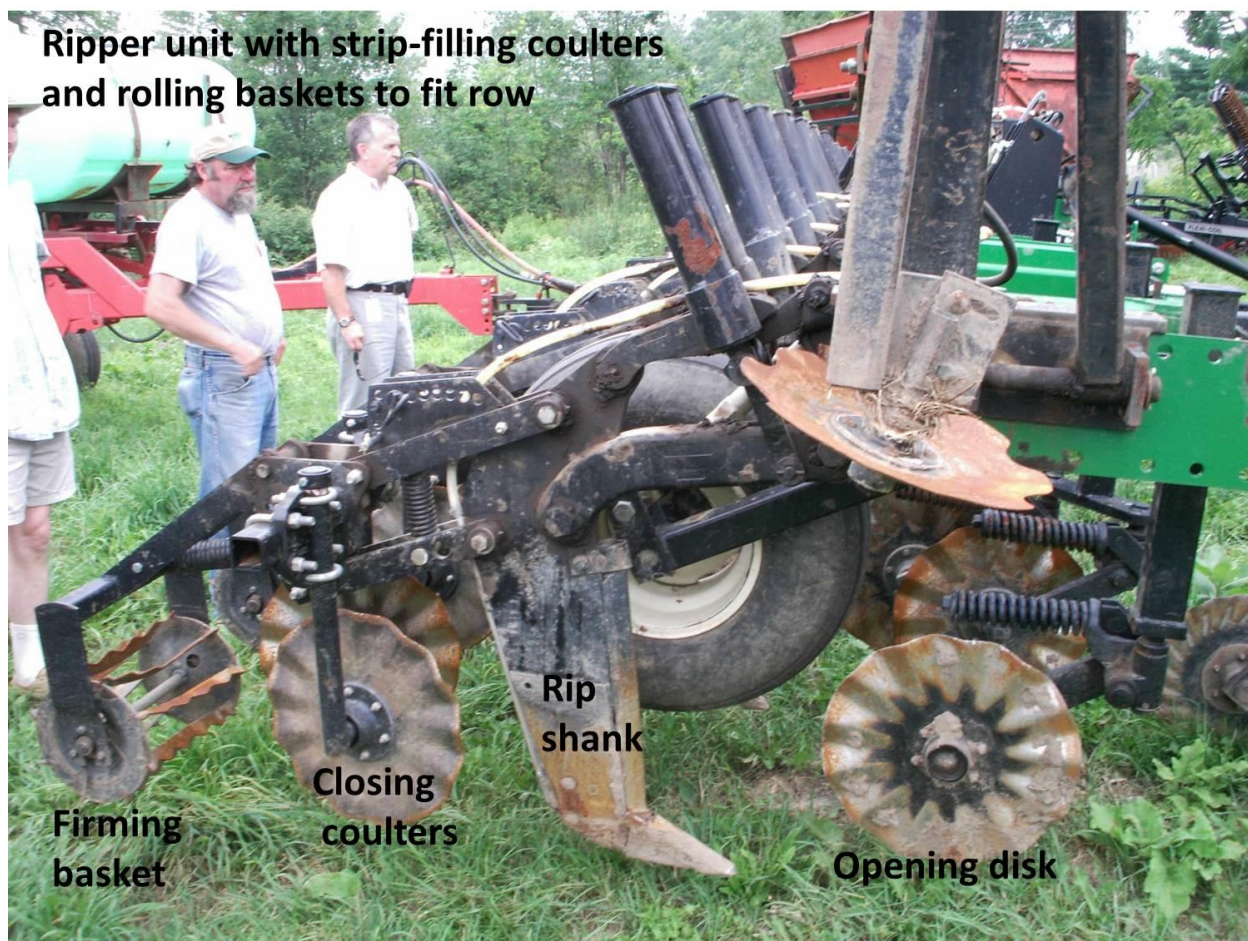
**Packing to crush clods**



A newer strategy than the full width moldboard tillage in the scenario above is a more focused form of tillage. Shown below is a deep ripper tool which is capable of breaking up hard soil layers up to 18" deep. This one is set up for row crop production and has a rather narrow shank typically about 1 inch wide.

To take advantage of the capacity of the ripper to remediate compacted layers we first need to determine the depth in the field where the compacted soil occurs. A field penetrometer can be pushed into the ground when the soil is at field capacity. Soil layers having a resistance over 300 PSI are targeted for loosening. When the soil is friable down to that layer the tool can be set 2" deeper to break through the restrictive layer. A sod forming crop during or following the operation helps to maintain the looseness obtained.





Another feature of this piece of equipment is to focus the tillage right in the vicinity of the rip shank rather than flipping the entire field surface over as in the mold board plow illustration above. This is pictured in the upper left photo in the illustration below-note for the most part there is an undisturbed surface. The rip shank can be set at variety of different depths, whatever is necessary to break up restricted layers, leaving a no-till environment between the rips and a tilled environment where the rips are. By focusing the disturbance we get the best of both worlds in this hybrid system- we plow just where the soil needs to be loosened for successful planting and young seedling growth but we leave the soil covered and undisturbed between the rows. If the weather turns hot and dry the soil surface does not completely dry out as in conventional tilled system. In the strip-till or zone-built tillage area the plant (in this case a row crop) has opportunity for moisture in the no-till zone between the ripped areas where more soil moisture is retained. An ideal time to loosen restrictive soil layers in berry crops is during fallow years in the rotation cycle. Combining this loosening to promote vigorous growth of a rotation crop builds the soil for the subsequent berry crop. Some growers may be interested in preparing ripped zones where the berry plants will be set while other growers may want to focus on the entire field area.



## Strip-till Zone-building

*Multiple – pass planting systems that vary in their **depth** of focused “ripping”*



Progressive Farm Products  
Trash Titans Disc Sealers



Unverferth  
Ripper Stripper Strip-Till



Economic and environmental evaluation suggest focusing disturbance **only in the row** while moving residues to the interrow area

Ripper unit



Restricted-width tillage



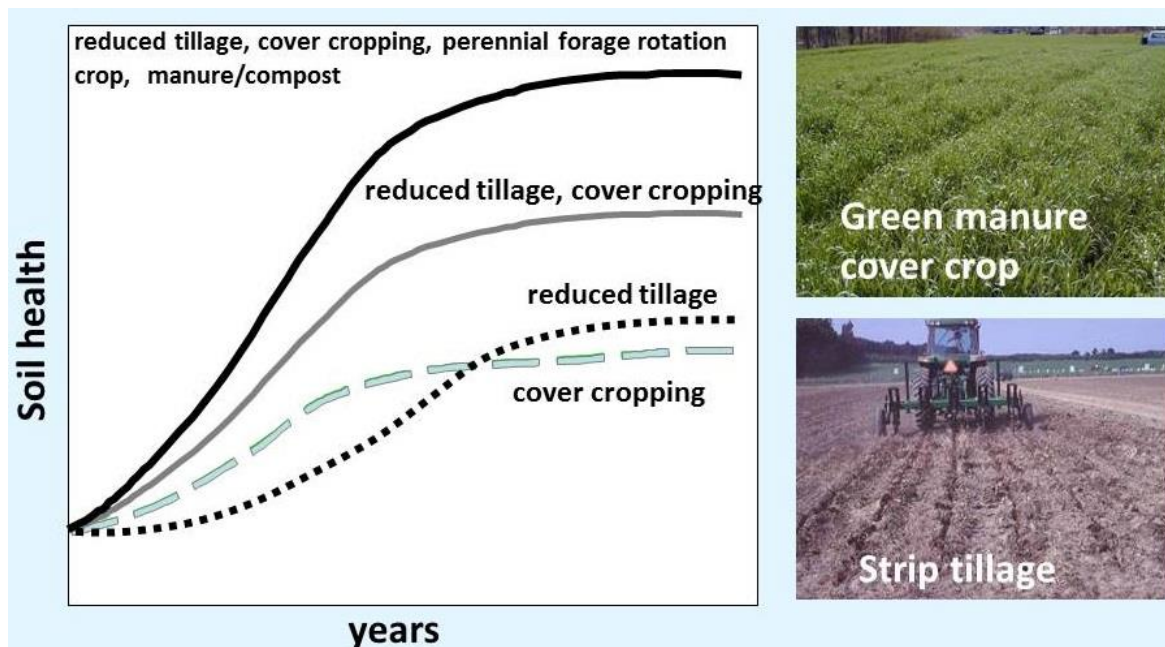
Zone-till planter  
follows ripped strips



### Tips for transitioning to reduced tillage crop production

- **Soil loosening** is the first step in alleviating any soil compaction **SHORT TERM**
- Consider focusing tillage efforts on **specific zones**, looking to minimize stirring effect where not directly necessary
- When limited compaction has occurred, **zone building or strip tillage** will suffice
- Rebuild beneficial microbial communities by **feeding the soil food web**
- Soil structure is additionally improved through **cover crops, rotation, and fresh organic additions** **LONGER TERM**
- Reduced tillage soils are less susceptible to compaction and more resilient due to better soil aggregation **LONGER TERM**
- Healthier, balanced soils respond more favorably to reducing tillage

Combining the various management practices that promote soil health can have a synergistic effect. In the graph below we see soil health on the Y-axis and years on the X-axis. If we modify our management by finding windows for different cover crops or reducing our tillage, these individually applied management choices can increase our soil health. But if we can creatively put them together, and combine them with an overall holistic plan there tends to be a faster and greater overall response.



## Finding Creative Solutions

In our example, a strategy might be to spring plow, lightly disk and then seed with a rye/vetch/mustard mix to get a sod-forming cover crop with the rye. The vetch will supply nitrogen, the mustard has a deep tap root and also releases some disease suppressive compounds. The grower also wants to try a strip trial of Rudbeckia and/or switch grass, which he learned in his cover crop class have good soil organics properties for strawberries. He will flail mow and then deep rip, leaving all of the residues on the field to add organic matter. He may consider drilling a new cover crop if one of these doesn't pan out. Then he will evaluate for next year whether he will continue this cover cropping or go to a cash crop like sweet corn.

Another example: Dairy farmers in Vermont were concerned about soil health on their corn lands. The colder continental climate of the state limits the time window for cover crop establishment before winter dormancy sets in. Working together with University of Vermont specialists, the farmers experimented with shorter-season corn varieties that mature seven to ten days earlier and increase the time window for cover crop establishment equivalently. They found their corn yields were generally unaffected by the shorter growing season, but their ability to establish a rye cover crop is greatly enhanced. In fields where high value market crops are grown, the years of the rotation with fallow crops have become ideal targets for the application of intensive remedial soil management. Larger equipment can be used to quickly manipulate the soil and seed rotation crops. Conventional wisdom suggests to start with strips and trial various strategies to arrive at cover crop and rotation crop combinations that fit best into a particular system.

## Field Management Sheet

### Step 1. Identify constraints

- Surface and subsurface compaction
- Low available energy for soil bio.
- Low conversion rate to NH<sub>4</sub>

### Step 2. List management options

- Find hard layer- plow, rip or use appropriate cover crop
- Feed soil with heavy debris, rich root residual, disease suppressive crop

### Step 3. Determine site history/ farm background

Grower has access to grain drill  
Local dairy will deep rip for \$100/A  
Grower attends CC workshop

### Step 4. Management Strategy

Spring plow, seed rye/vetch/mustard  
Strip trial of rudbeckia, switchgrass  
Flail mow, deep rip, drill new CC?  
Evaluate for cover or cash crop

CORNELL SOIL HEALTH TEST REPORT				
RyeVetch/ STW/STW				
Sandy loam				
Grower willing to experiment with cover crops				
Grower considering transitioning to organic				
Dairy farm nearby				
Indicators		Value	Rating	Constraint
PHYSICAL	Aggregate Stability (%)	66.1	95	
	Available Water Capacity (m/m)	0.13	51	
	Surface Hardness (psi)	273	12	rooting, water transmission
	Subsurface Hardness (psi)	375	27	Subsurface Pan/Deep Compaction
BIOLOGICAL	Organic Matter (%)	2.8	42	
	Active Carbon (ppm) [Permanganate Oxidizable]	365	21	Soil Biological Activity
	Potentially Mineralizable Nitrogen (µgN/ gdwsoil/week)	8.0	25	N Supply Capacity
	Root Health Rating (1-9)	3.3	75	
CHEMICAL	pH (see Nutrient Analysis Report)	6.0	67	
	Extractable Phosphorus (see Nutrient Analysis Report)	4.5	100	
	Extractable Potassium (see Nutrient Analysis Report)	112.5	100	
	Minor Elements (see Nutrient Analysis Report)		100	
OVERALL QUALITY SCORE (OUT OF 100):			59.6	Medium
Soil Textural Class:==> sandy loam				
SAND (%): 53.0 SILT (%): 42.0 CLAY (%): 5.0				

## Summary

A sound soil improvement and management plan should:

- ✓ Assess your soil's health to identify constraints
- ✓ Facilitate changes in management strategies that could work for your farm, and that address specific constraints
- ✓ Suggest creative experimenting on your farm to see what works in your situation... (start small)
- ✓ Adapt many resources of information to your farm
- ✓ Build healthy soils to increase resiliency to extremes

## Additional Resources

1. Mohler, C.L., and Johnson, S.E. 2009 Crop Rotation on Organic Farms: A Planning Manual. PALS publication 117, Ithaca, NY. 154 pp. <http://www.sare.org/Learning-Center/Books/Crop-Rotation-on-Organic-Farms>
2. Building Soils for Better Crops.
3. Managing Cover Crops Profitably, 3<sup>rd</sup> edition.
4. Cornell Cover Crop Decision Tool for Vegetable Growers. <http://covercrops.cals.cornell.edu/decision-tool.php>