



## Building Productive Soils for Vegetable Crops

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**“We know more about the movement of celestial bodies than about the soil underfoot.” ---  
Leonardo DaVinci, circa 1500s.**

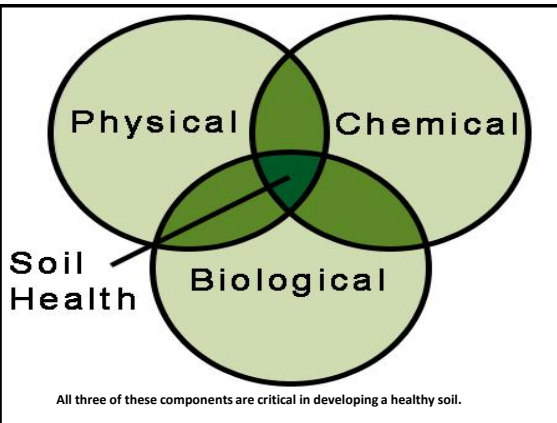


### Healthy Soil

**Chemical:** adequate nutrients for plant growth

**Physical:** good soil structure/ proper aeration and drainage

**Biological:** abundance of beneficial microorganisms

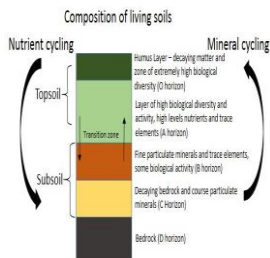


## The Soil is a Living System

- There are billions and billions of soil microorganisms in a mere handful of a typical, garden soil.
  - Bacteria
  - Fungi
  - Protozoa
  - Nematodes
  - Mites and other micro-arthropods
- Almost all of these countless soil organisms are not only beneficial, but essential to the life giving properties of soil.
- These soil microorganisms keep your soil healthy, decompose organic matter, replenish soil nutrients, form humus, promote root and plant growth, increase nutrient uptake, and breakdown herbicides and pesticides.

## Importance of Soil Building

- Addition of nutrients is not enough to optimize plant growth
- Nitrogen, phosphorus, carbon and sulfur are dependent on microbial transformations to become plant available
- Proper aeration and drainage are necessary for beneficial microbial and plant growth
- Root exudates feed soil microbes which in turn help make nutrients plant available



## To build soils:

1. Keep vegetation on the soil as much as possible
2. Disturb the soil as little as possible
3. Keep plants growing throughout the year to feed the soil
4. Diversify as much as possible using crop rotation and cover crops
- \*5. Add Organic Matter



### Reduced tillage and cover crops protect and build soils

No-till helps prevent soil compaction from rain beating on bare soil, soil is more spongy so water is soaked up instead of eroding and running off

Strip tillage in rye stubble

#### Tillage:

No-till  
Strip till  
Conservation till  
Shallow tillage

#### Killing cover crop:

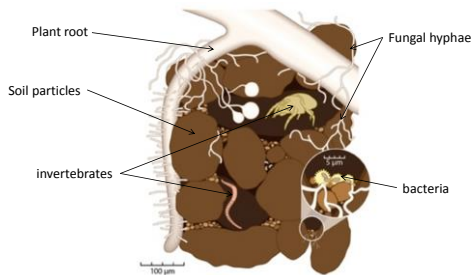
Herbicide  
Crimping and rolling  
Frost kill  
Cutting  
Tilling



## Addition of organic matter

- Organic matter is ~ 58% carbon
- Carbon is needed as a food source for microbes to drive nutrient transformations
- Incorporating residues high in carbon (straw, wood chips, mature plants) may bind up nitrogen at first but will eventually release nitrogen back
- Be aware of those materials with high C:N ratios
- Organic matter contains humic and fulvic acids which have a biological benefit for plant growth
- Improves water holding capacity, CEC, aeration and porosity of soil

Polysaccharides from roots, fungal hyphae, bacterial digestion and coatings, and shredding of organic matter by invertebrates help form soil aggregates which produce the crumb like structure of good soil



## So—how do we build soil through organic matter additions?

- Compost or Vermicompost
- Cover Crops (green manures or mulches)
- Animal manures
- Organic mulches

### Sources of organic matter

Vermicompost



Compost



Animal manure



Cover crops



## Composting

- Composting easy process
  - Kitchen scraps, leaves, vegetable wastes from farm
  - Add moisture
  - Aerate (turn frequently)
  - Maybe some additional N
  - Compost or soil to provide microbes
- Thermophilic process caused by activity of microbes
- In a few weeks to months can have useable product



## Vermicomposting

- The biological processing of organic wastes through digestion using earthworms such as *Eisenia fetida* (also known as red wigglers or red manure worms)
- The casts or vermicompost which is formed is rich in plant available nutrients, growth regulators such as hormones, humic acids and a diverse microflora.

## Comparison of Compost and Vermicompost samples taken from SIUC

Vermicompost analysis							
Year	pH	C/N	OM	N	P205	K2O	C
2009	5.2	11.8	52.9 <sup>a</sup>	2.5	1.4	.6	29
2010	5.6	11.5	46.9	2.5	1.4	.5	29
2011	6.4	8.8	49.1	2.8	.8	1.0	25
Fresh Vermi-compost 2012 coffee	7	12.1	91.3	4.2	.6	1.0	50

Compost analysis							
Year	pH	C/N	OM	N	P205	K2O	C
2009	8.1	20.6	23.4 <sup>a</sup>	1.0	.45	.6	21
2010	7	11	28.8	1.8	1.0	1.2	19.4
2011	7.9	17	23.3	1.2	1.1	.6	20.1

- Vermicompost more expensive than compost
- Use it to inoculate soil with beneficial microbes or use in transplant production or place a little in root zone at planting
- Effect is primarily biological.
- For heavy feeders other fertility needed



Spinach plants grown with 0, 25, 50 and 75% vermicompost at SIUC



## Using vermicompost in vegetable/fruit production

### Transplants

- 25-50% of vermicompost to potting media
- 25% for salt sensitive crops (lettuce) and with 10-20% with other fertility sources

### In field

- Placed in transplant hole (1/3-1/2 cup) or use tea (soil inoculant)

## Cover crops

- Hot topic right now in agricultural production systems and for good reason
  - Easy way to prevent erosion with vegetative cover
  - Hold nutrients and prevent leaching
  - Add organic matter to system (green manures or mulches)



Crimson clover nitrogen fixing



Red clover nitrogen fixing



Buckwheat summer Weed suppression in July/Aug.



Tillage radish soil compaction



Hairy Vetch (50 lbs N/A available for next crop)

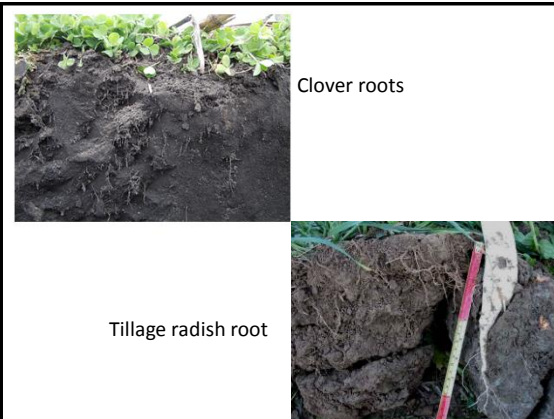
### Benefits

- Versatility: There is a cover crop for many soil and cropping situations
- You can reduce compaction without deep tillage by letting roots do the work
- Increase soil fertility, organic matter and biological diversity (plant and microbial)
- Reduce erosion
- Cover crop use in vegetable and specialty crops are ~ less than 15% but increasing

### 2012-2013 North Central SARE (Sustainable Agriculture Resource Center) farmers Survey

- Top 4 reasons farmers used cover crops
  - reduced soil compaction, soil erosion, nitrogen scavenging and weed control
- Top 3 challenges faced by farmers
  - establishment, increased labor and cover crop selection
- Top 4 cover crops used
  - 72% winter grains, 62% brassicas, 58% legumes, 56% annual grasses

### SIUC Student Organic Farm



### Animal Manures

- Great source of organic matter and nutrients
  - Becoming more difficult to find
  - Most recommend composting before use
  - Fresh manure can have pathogens
- Great soil builders and soil fertility providers
- Many nutrients in organic form (esp. N) and slowly released through microbial action as season progresses

Table 1. Approximate nutrient composition of various organic fertilizers and soil amendments.

	N	P2O5	K2O
	-----% (dry weight basis)-----		
Dairy manure	2.1	3.2	3.0
Beef manure	1.2	2.0	2.1
Poultry manure	2.0	5.0	2.0
Composted yard waste	1.3	0.4	0.4
Animal tankage (dry)	7.0	10.2	1.5
Alfalfa hay	2.5	0.5	2.5
Blood meal	<b>13.0</b>	2.0	1.0
Fish meal	<b>10.0</b>	6.0	0
Kelp/seaweed	1.5	1.0	4.9
Soybean meal	7.0	1.2	2.0
Bone meal (raw)	3.0	<b>22.0</b>	0
Bone meal (steamed)	1.0	<b>15.0</b>	0
Cottonseed meal	6.0	3.0	1.5
Wood ashes	0	2.0	<b>6.0</b>
Rock phosphate (total P2O5)	0	20-32	0
Colloidal phosphate (total P2O5)	0	25	0
Greensand (total P2O5 and K2O)	0	1.3	4-9.5
Granite dust (total P2O5 and K2O)	0	0	22
Potassium sulfate	0	0	50

## Mulches

- Mulch - describes anything that can be placed on top of the soil to reduce evaporation, prevent weed growth, and insulate plants.
- Organic mulches include:
  - leaves and leaf mold, aged pine needles, grass clippings, aged bark and wood chips, straw, well-rotted manure, seaweed, "almost any compost", certain plant remnants, and paper.
- Mulches can also prevent the soil compaction caused by heavy rains
- Can also add organic matter and improve microbiology of soils

## Soil benefits from mulching

- Moisture/temp regulation
  - water percolates in and is retained better
- Increased organic matter
  - feeds soil microbes and invertebrates which then produce humus

## Common Mulching materials

- Leaves
- Straw
- Hay
- Cardboard
- Killed cover crop

## Living Mulches

- Timing important (need to reduce competition with cash crop)
- Need to reduce competition for nutrients/water/sunlight
- Legumes like clovers fix nitrogen for themselves. They do not share with cash crop. Nitrogen is released when cover crop is killed
- Benefits are that soil is covered and fresh nitrogenous plant matter added to soil

## Keeping soil covered with living and dead mulches



Clover planted along side cabbage

Leaves make a great winter cover and mulch during the season



## Conclusion

- Soil Building
  - Important task that should be implemented onto every farm
  - Improve soils over the long term
    - More drought tolerance
    - Higher fertility
    - Greater soil diversity
  - Described a few simple ways to improve soils through organic matter additions

