Santa Fe County Master Gardener Training
Part 1: Soil Basics
Santa Fe, NM February 18^{th} & 19^{th}, 2019

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What is a Soil?

- Soil is many things to many people. It is the underlying foundation of our houses, factories, and motorways as well as a filter for human, industrial and animal wastes. (NZ Institute for Crop & Food Research)
- The unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants. (SSSA)
- Soil, often called the Skin of the Earth, is a mixture of decaying organic matter (humus), minerals, liquids, and many countless living organism **https://www.maximumyield.com**

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Ecosystem functions of Soil

1. Soils serve as medium for plant growth.
2. Soils modify the atmosphere by emitting and absorbing gases.
3. Soils serve as habitat for organisms that live in the soil.
4. Soils absorb, hold, release, alter, and purify most of the water in terrestrial systems
5. Soils recycle nutrients; waste and dead organic materials are decomposed and the nutrients released are made available in the soil
6. Soils serve as engineering media for construction of foundations, roadbeds, dams and buildings

http://www.soils4kids.org/about

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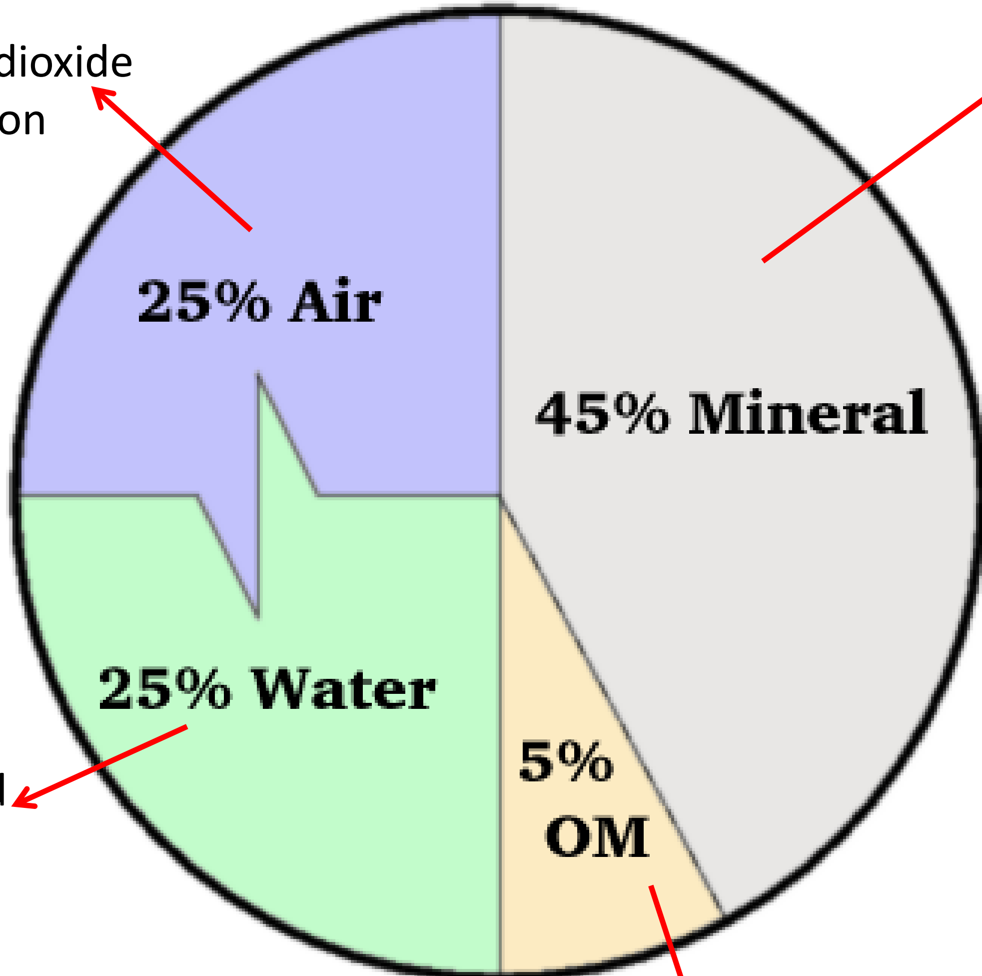
Components of a soil

Oxygen, Carbon dioxide
soil respiration

Sand: 0.05–2.0 mm
Silt: 0.002–0.05 mm
Clay: < 0.002 mm

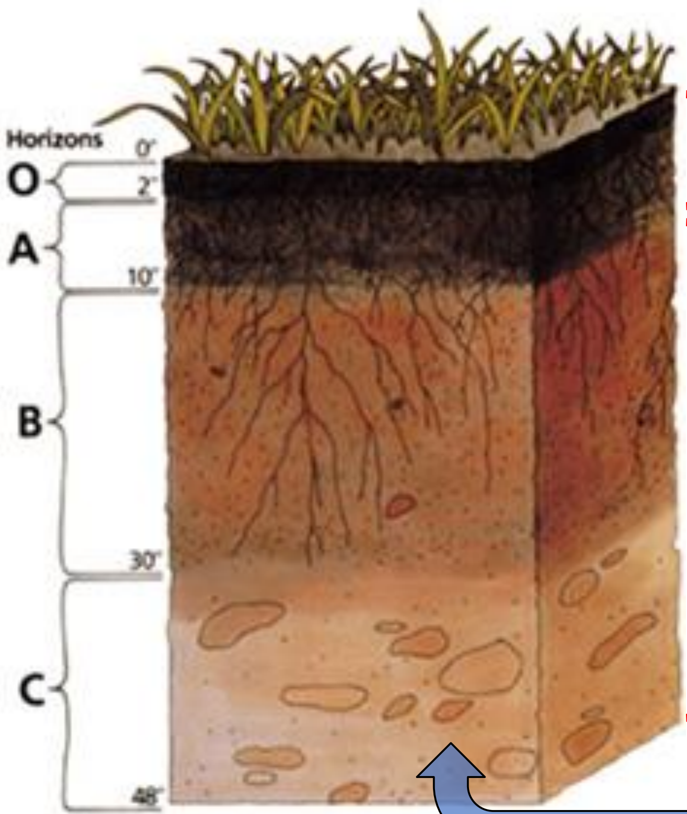
Sand, Silt, Clay,
soil texture



Water with dissolved
nutrients

Organic Component;
dead & living organisms

Formation of soil



Topsoil – Very Crucial!

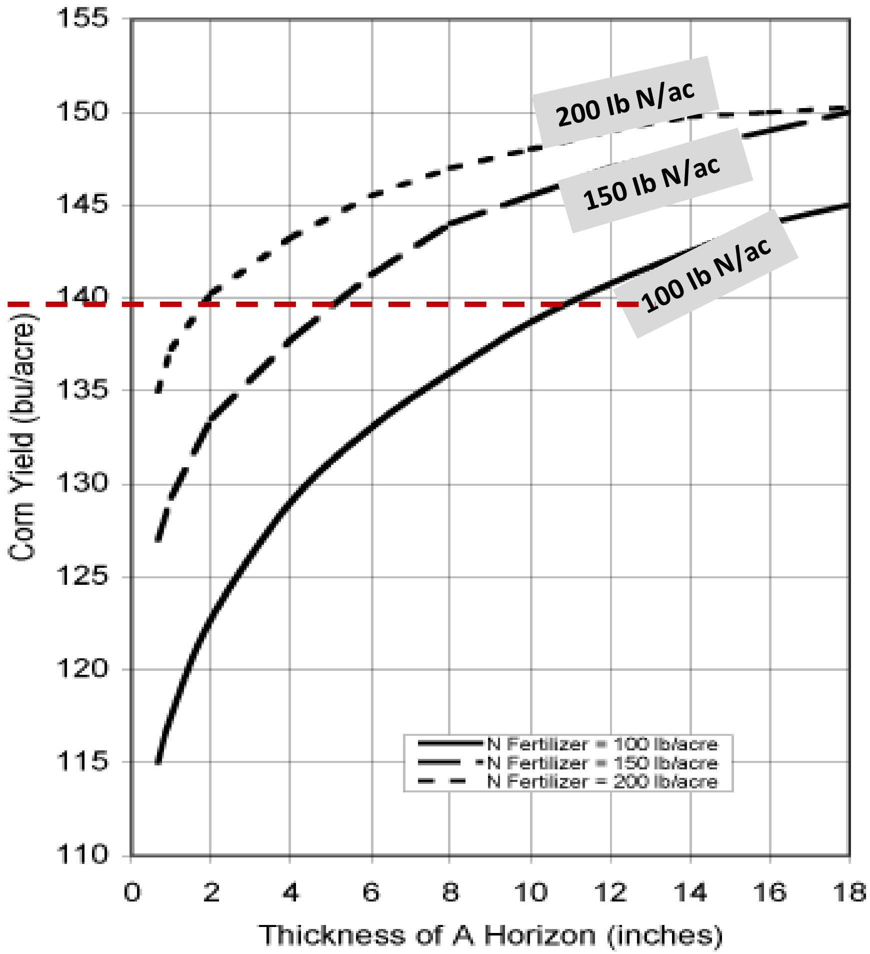
Subsoil

Soil Forming Factors

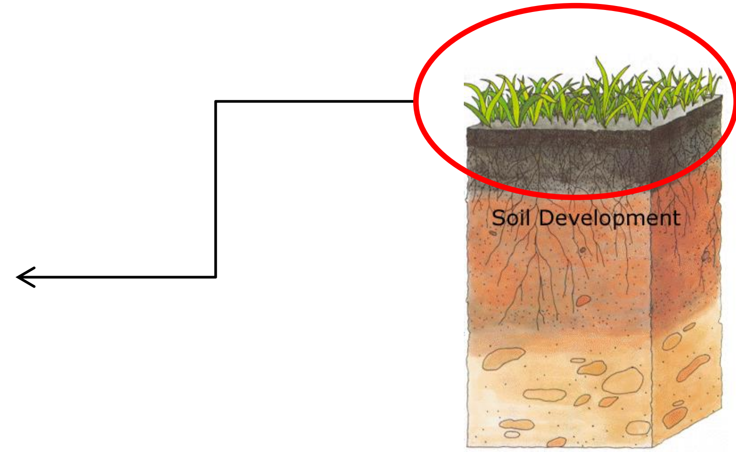
- Parent material
- Climate
- Topography
- Biological factors
- Time

Different soil types will form depending on soil forming factors operating at a given location

Yield and Topsoil Thickness



Impact of soil management practices on yield
Iowa State University Extension



Soil Map

Sandoval County (Sample)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
LtB	Latene sandy loam, 1 to 5 percent slopes	10.2	31.7%
MaB	Madurez loamy fine sand, 1 to 5 percent slopes	16.1	49.8%
MWA	Madurez-Wink associatin, gently sloping	5.9	18.4%
Totals for Area of Interest		32.3	100.0%

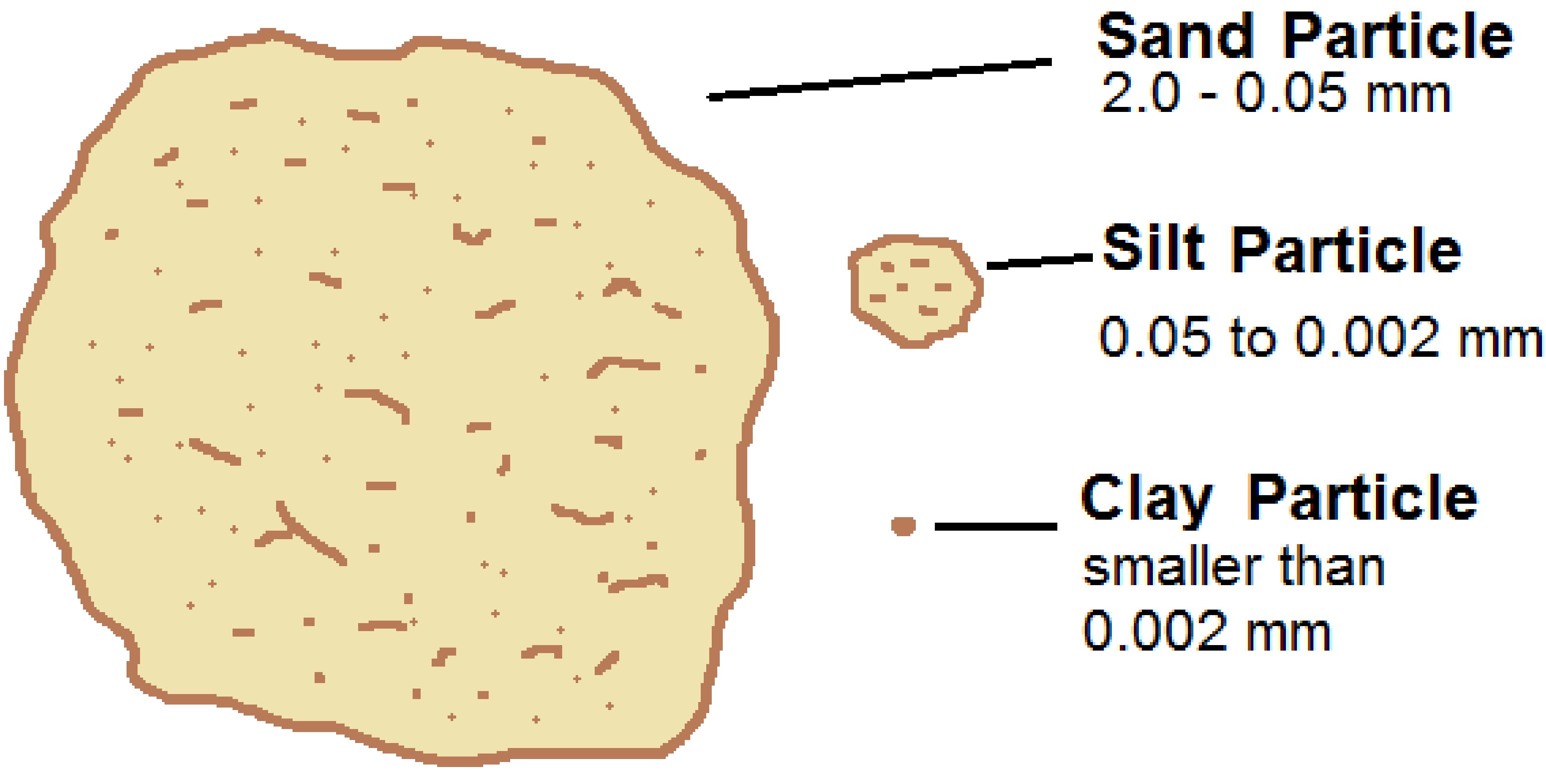
Google: NRCS Web Soil Survey

https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Soil topics to be covered

- Soil Texture
- Soil Water Holding Capacity
- Soil Density
- Soil Structure
- Soil Chemical Properties (nutrients, salinity, pH)
- Soil Biology

Soil Texture = %Sand, Silt & Clay in a soil



http://www.livingoffgridguide.com/gardening/how-to-create-amazing-garden-soil/

- Critical for understanding soil behavior and management
- Soil texture is not subject to change in the field

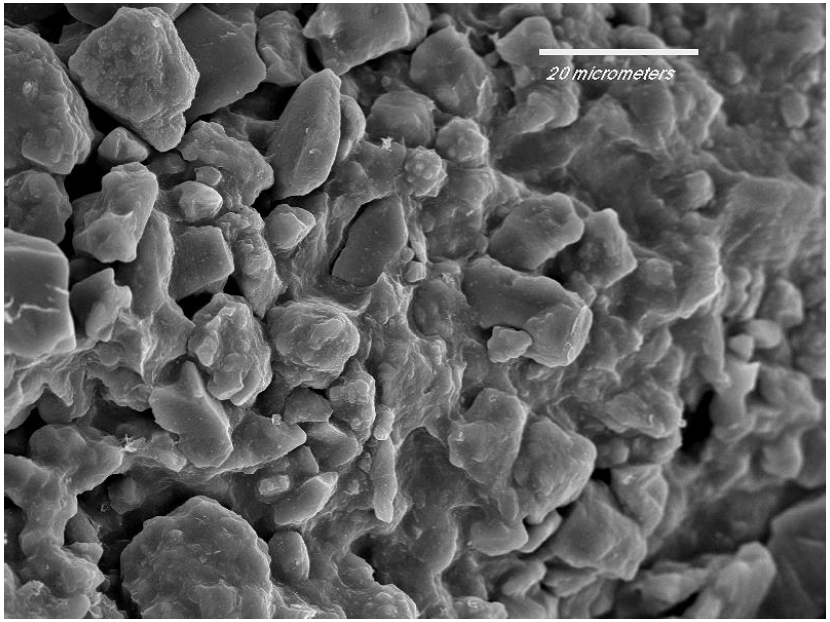
Sand

- Low specific surface area
- Sand has less nutrients for plants than smaller particles
- Voids between sand particles promote free drainage and entry of air
- Holds little water and prone to drought

http://www.microlabgallery.com/gallery-Sand.aspx

Silt

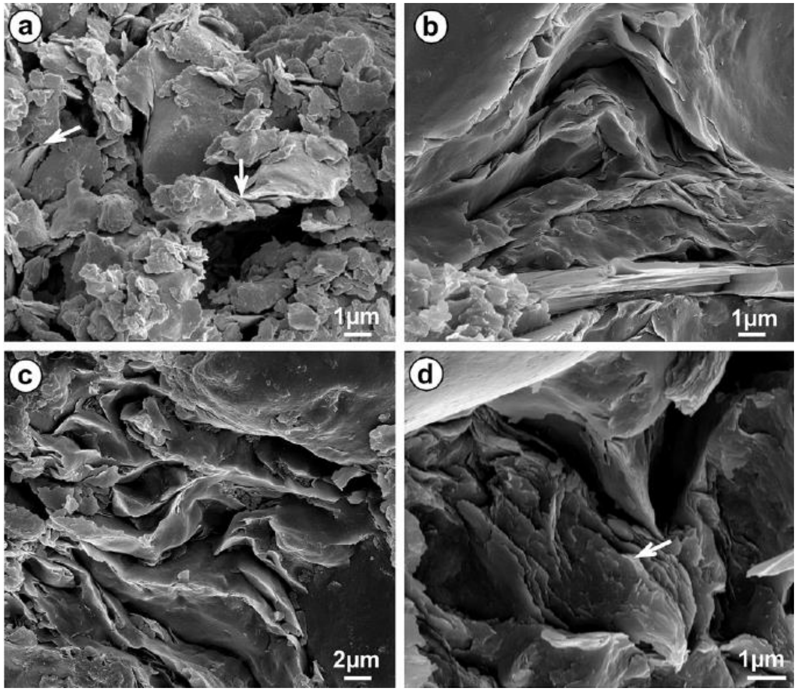
- < 0.05 mm to > 0.002 mm
- Not visible without microscope
- Quartz often dominant mineral in silt since other minerals have weathered away.



http://www.scientistcindy.com/soils-and-groundwater.html

Clay

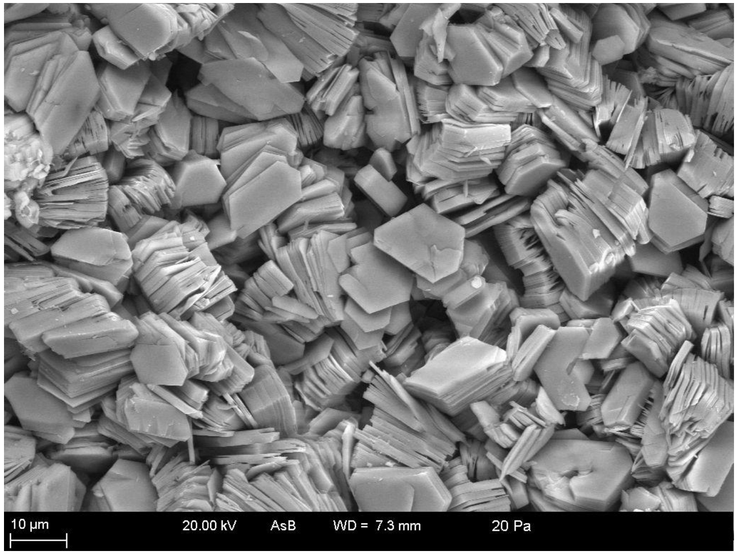
- < 0.002 mm
- Flat plates or tiny flakes
- Small clay particles are colloids
  - If suspended in water will not settle
- Large surface area
  - spoonful = football field



Janssen, C., et al. "Clay fabrics in SAFOD core samples." Journal of Structural Geology 43 (2012): 118-127.

Clay - Properties

- Pores spaces are very small and convoluted
  - Movement of water and air very slow
- Water holding capacity
  - Tremendous capacity to adsorb water- not all available for plants.
- Chemical adsorption is large



https://blogs.egu.eu/divisions/sss/files/2014/09/4f97b8eeed7f9.jpg

Clay Particles and Organic Matter

- **Clay Particles/Organic Matter are very reactive**
- **They have negative charges**

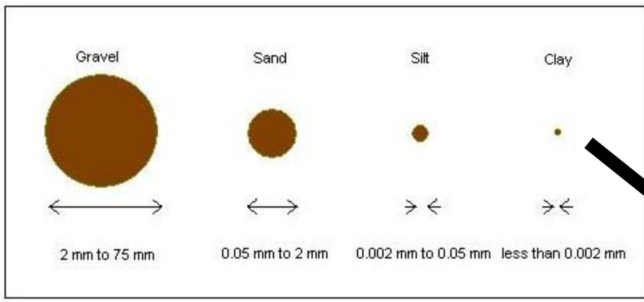
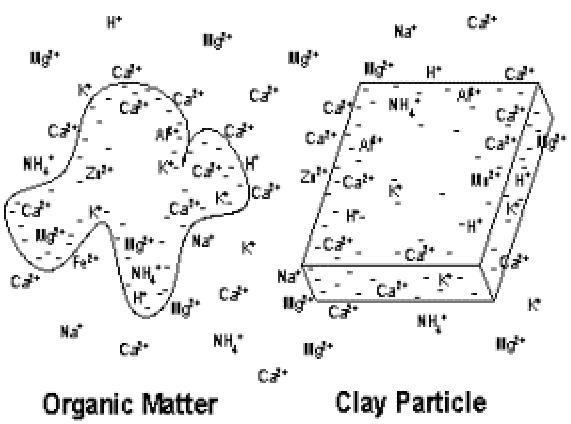
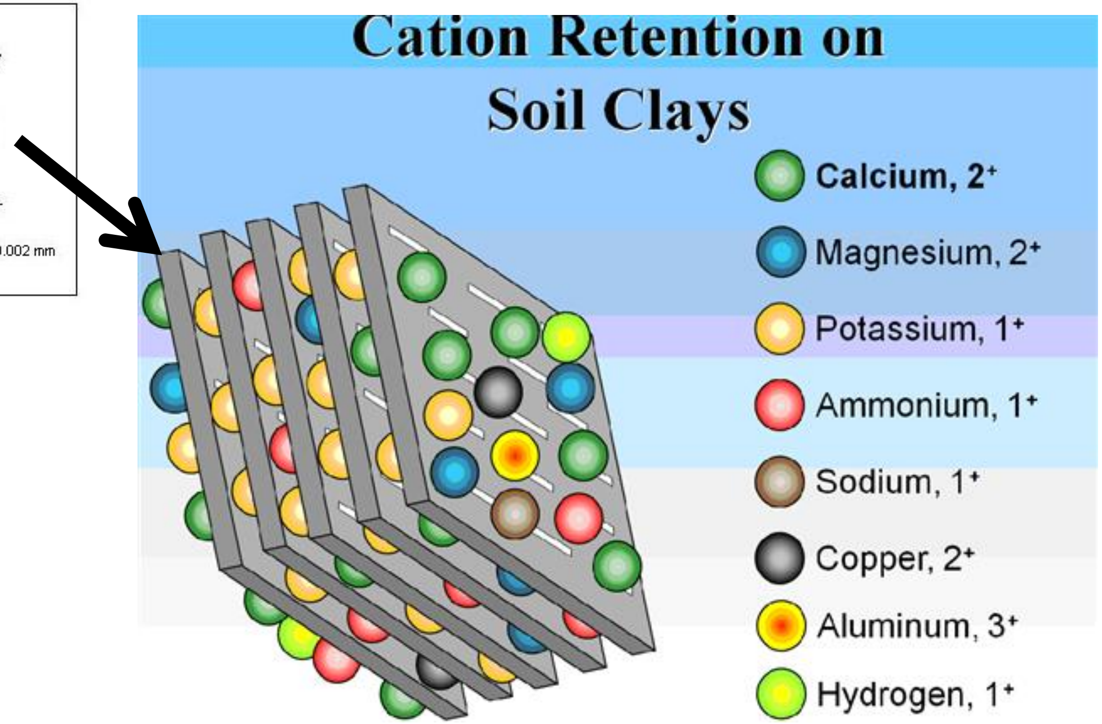


Fig. 2. Cation Exchange Capacity (CEC)





https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcSdg4lpzc4X7-tYoxKQKa53hA1c_Jnwwwyxkgy8978LwSa2EGN9Ew

Soil Texture

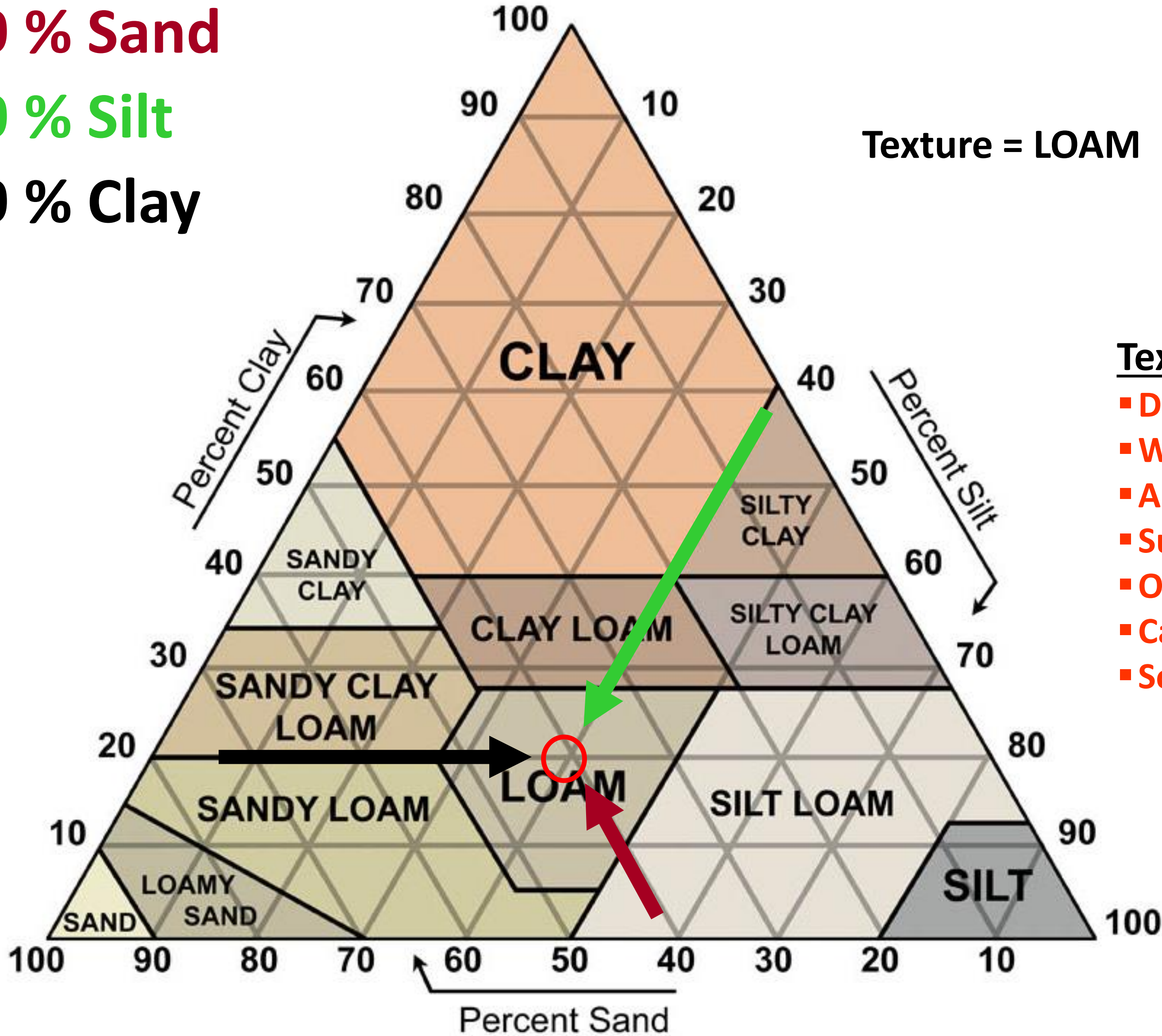
Textural Triangle

Sand + Silt + Clay = 100%

40 % Sand

40 % Silt

20 % Clay



Texture = LOAM

Texture Affects:

- Drainage
- Water holding capacity
- Aeration
- Susceptibility to erosion
- Organic matter content
- Cation exchange capacity
- Soil tilth

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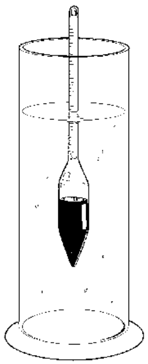
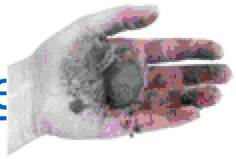
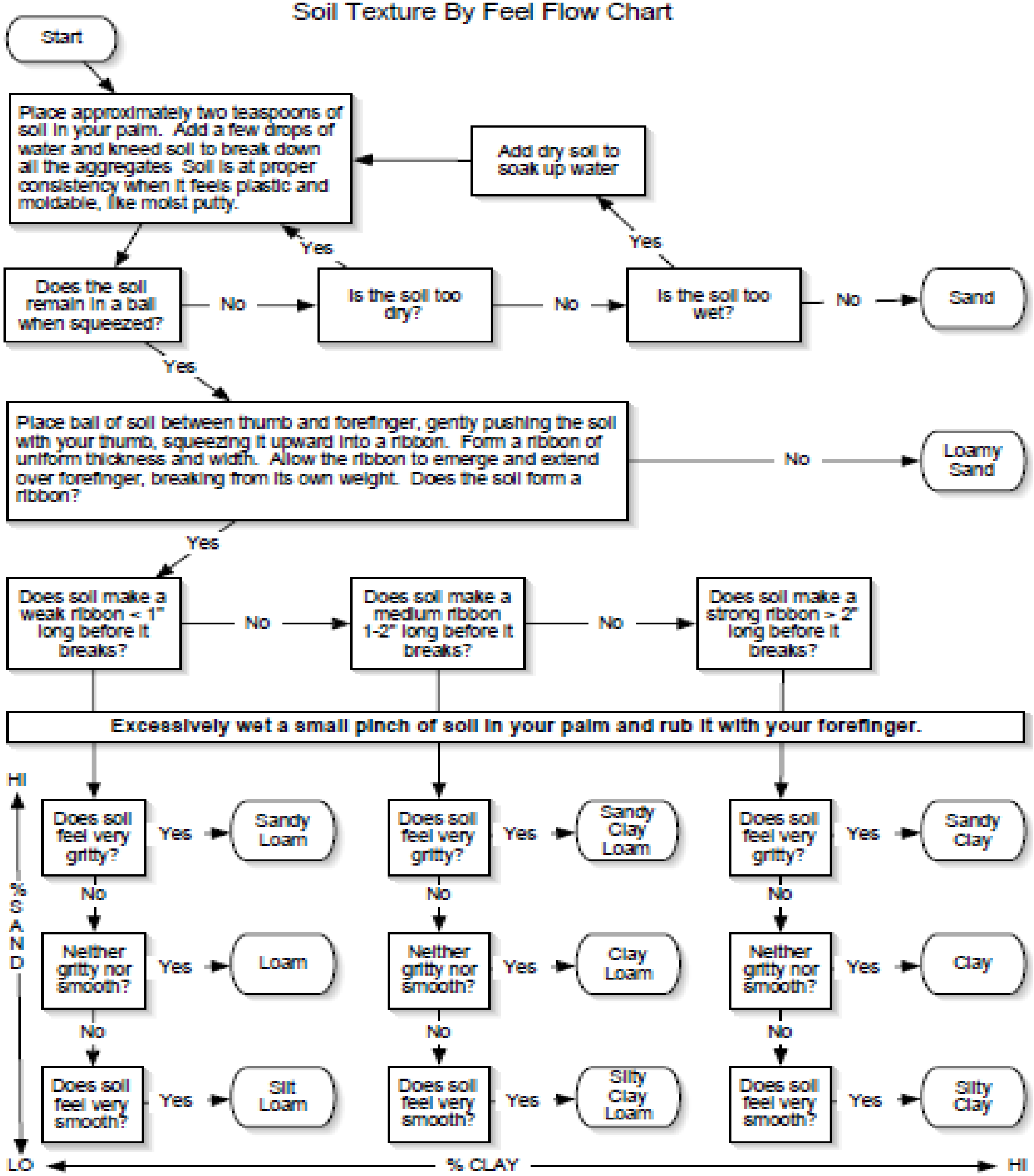
How to Measure the Soil Texture



- Standard Laboratory Analysis
  - Gives % sand, %silt and %clay
  - Gives precise textural class
- Texture by feel
  - You only know the approximate textural class
  - A flow chart available on http://soils.usda.gov/education/resources/lessons/te re/
  - Google “NRCS Soil Texture by feel”



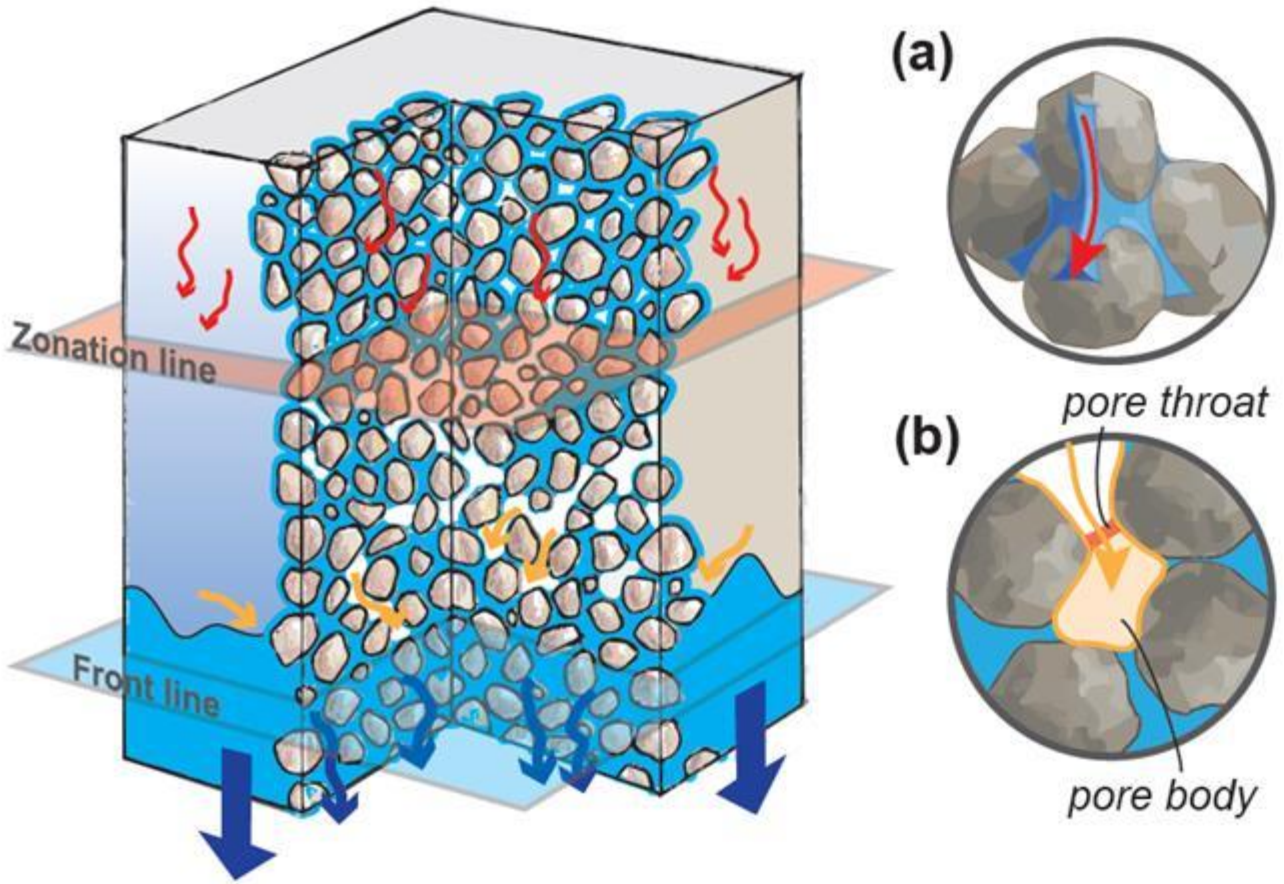
Soil Texture By Feel Flow Chart



Soil Water

Soil acts as a sponge to take up and retain water

- Pore space in soil is the conduit that allows water to infiltrate and percolate
- Pores also serves as the storage compartment for water



http://www.step6.ites.ethz.ch/researches/index/42

Soil Water Availability – Saturated Soil

- ***Saturation*** or saturated conditions – all soil pores are filled with water
  - Implication – there will be no air in the soil
  - Very easy to recognize in the field
  - This normally happens just after rainfall or irrigation event
  - The soil is weakest at the point of saturation

Saturated Soil

Soil Water Availability – Field Capacity

Field Capacity (FC) – measure of the greatest amount of water a soil can store under conditions of complete wetting followed by free drainage

- Full saturation minus water lost to drainage
- Sandy soils reach field capacity about two days after a major rainfall or irrigation event
- Heavier soils, you may need to wait up to four days before the soil reaches field capacity

Soil Water Availability – Wilting Point

Permanent Wilting Point (PWP) – water held at PWP held so tight that plants not able to extract it fast enough to meet their needs

- Water is bound tightly around soil particles especially the smaller particles
- In conditions of true PWP – a plant will wilt and won't recover, unless additional water is added

Soil Water Availability – Available Water Capacity

- ***Available Water Capacity (AWC)*** – the difference between the water held at field capacity and the permanent wilting point

AWC = FC – PWP

- **AWC is soil dependent – function of**
  (Texture, Structure, Organic Matter, Porosity)

WATER HOLDING CAPACITY DEMO

Availability of water in relation to soil texture

Available Water Capacity by Soil Texture	
Textural Class	**Available Water Capacity (Inches/Foot of Depth)**
Coarse sand	0.25-0.75
Fine sand	0.75-1.00
Loamy sand	1.10-1.20
Sandy loam	1.25-1.40
Fine sandy loam	1.50-2.00
Silt loam	2.00-2.50
Silty clay loam	1.80-2.00
Silty clay	1.50-1.70
Clay	1.20-1.50

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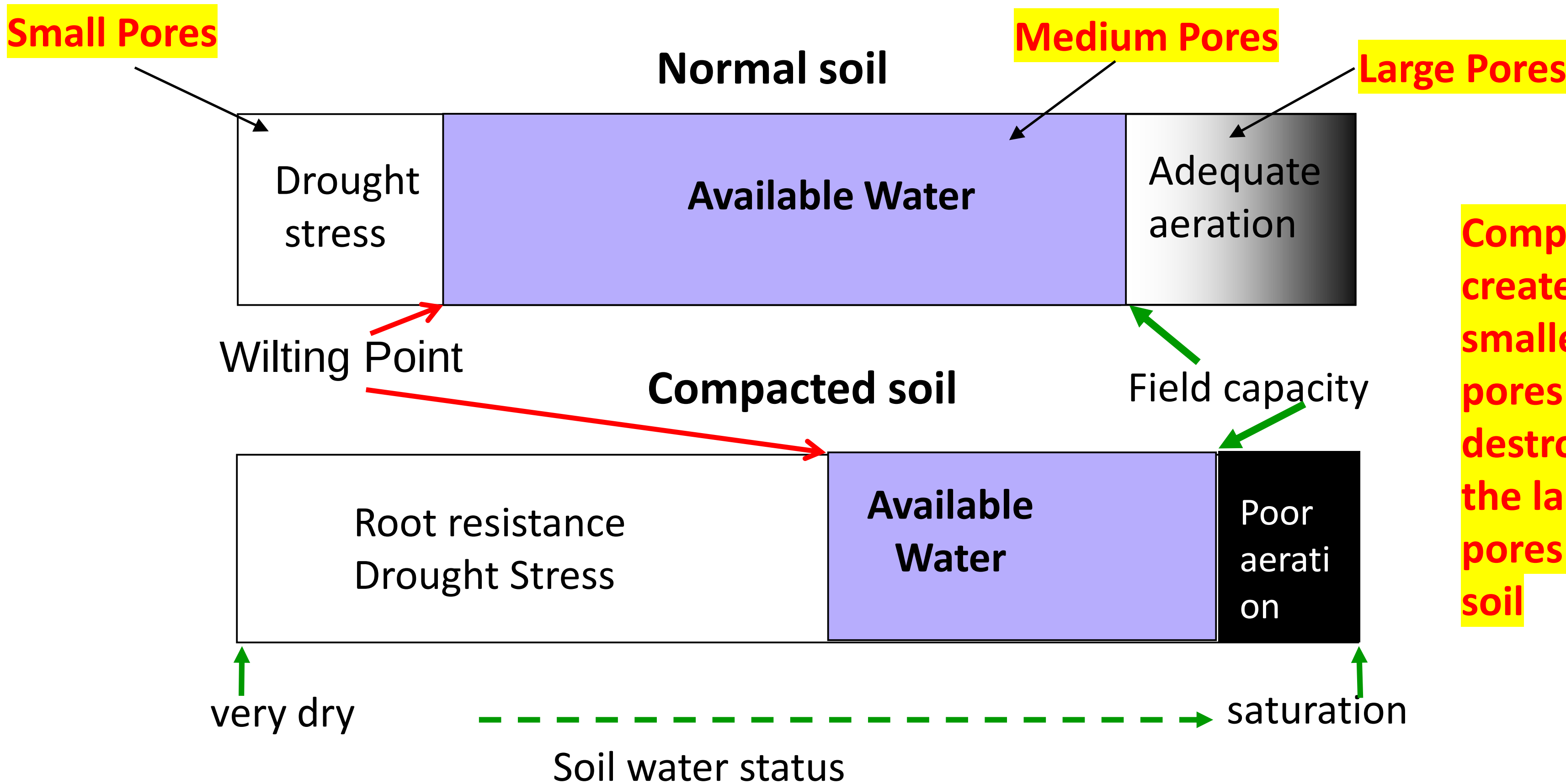
Soil Density

- When the soil is too dense we call it "compaction"
- Soil compaction can affect water availability for crops
- Water is held more tightly in the soil when compaction occurs
- Roots will not grow well into the soil
- Water will not move very well into the soil

Compaction Changes Porosity and Affects Water Availability



Compaction creates more smaller pores by destroying the large pores in the soil

The optimum water range for crop growth for two different soils.

Compaction Assessment

PENETROMETER

can be used to identify compaction layer in the soil

Quick and Cheap Assessment

DIG with a shovel

Solving Compaction Problem

Very difficult task

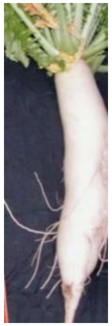
Method 1

Soil loosening with tillage equipment

- Require a lot of energy to achieve
- Does not bring the soil totally to pre-compacted state

Method 2

- Use deep rooted crops to loosen the compact layer, examples: alfalfa, forage radish,
- Takes more time to become effective



Best is to combine both methods

Tillage Radish: Bio-drilling

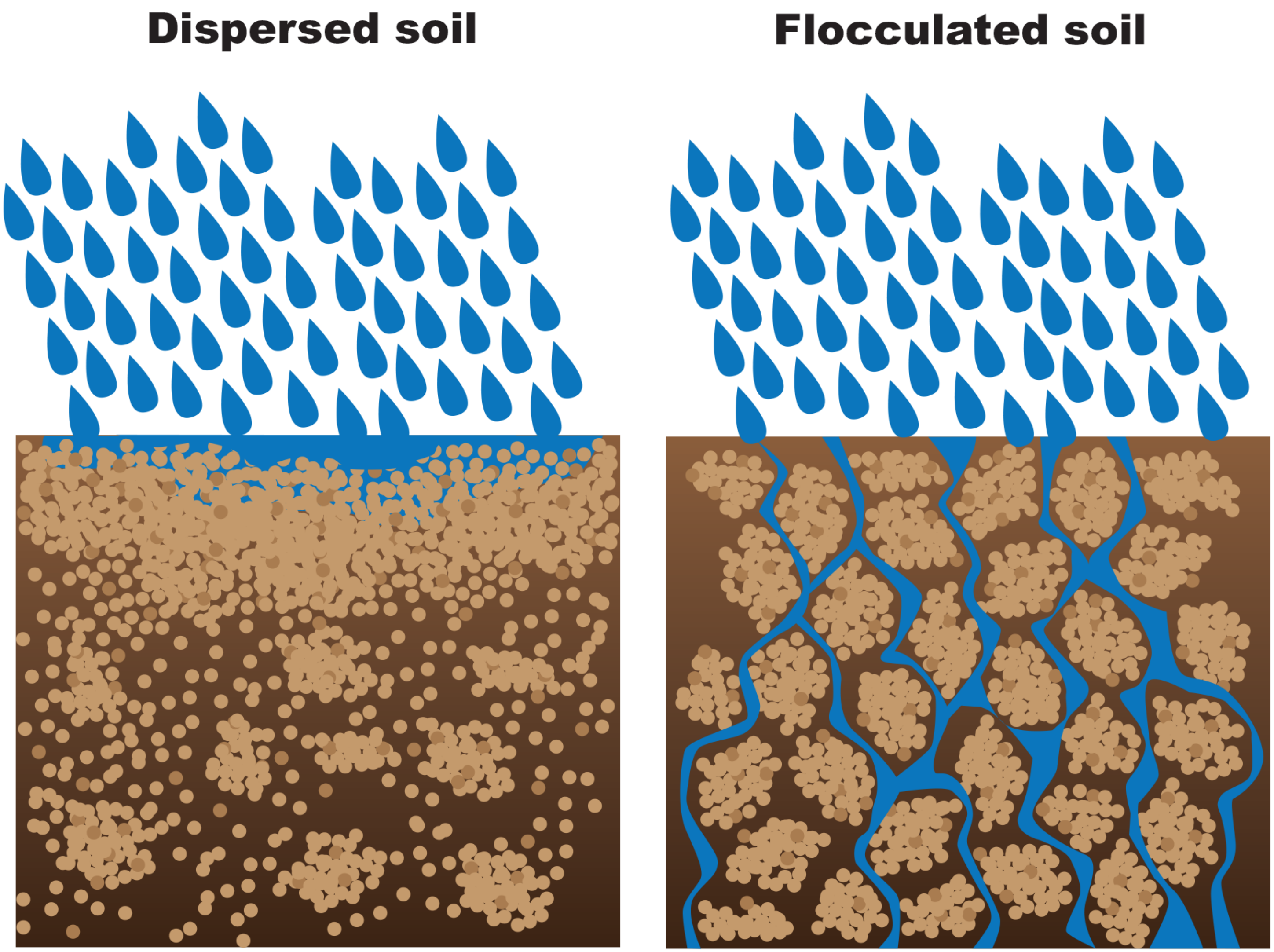
Soil Structure

- The arrangement of soil particles into aggregates of different shapes and size
  - How is the distribution of aggregates?
  - How stable are the aggregates?
  - How is the configuration of the pores?

Factors Affecting Aggregate Stability

- Kind of clay
- Chemical elements associated with the clay
- Nature of the products of decomposition or organic matter
- Nature of the microbial population

Stability of Surface Aggregates



http://www.eco-gem.com/gypsum-grow-better-alfalfa/

Surface compaction (surface crusting)

Due to the breakdown, rearrangement and drying out of surface aggregates

Prevention Strategies

- Use mulches to prevent the soil surface from drying out rapidly
- Add more Organic Matter to the soil

Soil Chemical Issues

- Nutrient Sufficiency
- **Soil Salinity Levels**
- **Sodium Problem**

Related to Irrigated Conditions

Essential Elements for Growth

Nutrients from air & water	Nutrients from soil, lime and commercial fertilizers		
	primary nutrients	secondary nutrients	micronutrients
carbon (C)	nitrogen (N)	calcium (Ca)	boron (B)
hydrogen (H)	phosphorus (P)	magnesium (Mg)	chlorine (Cl)
oxygen (O)	potassium (K)	sulfur (S)	copper (Cu)
			iron (Fe)
			manganese (Mn)
			molybdenum (Mo)
			zinc (Zn)

A Total of 16 Elements

Nutrient Sufficiency

- Very basic and important for crop growth & development
- Nutrient requirement is crop dependent
- Knowing the nutrient status of the soil before crop establishment will help in calculating how much to add
- Soil testing and manure testing will help determine how much to add

Soil salinity Levels

- Soil salinity can affect the growth and development of crops
- Water becomes limiting due to high osmotic forces in the soil (salts holding tightly to water)
- High salinity can lead to productivity decline and eventual death of crops
- To assess salinity, you need to do soil testing

Salinity Measurement

- Soil test result will report the **Electrical Conductivity** of the soil
- Salinity tolerance vary with crops

Solving Salinity Problem

- Leaching of salts with extra water may be needed to correct salt problems
- Some soil testing laboratory will give you the leaching requirement (amount of extra water needed to leach out the salts)
- Planting salt tolerant species is another option to overcome salinity

Vegetable Crops	Yield potential, ECe				Maximum ECe
	100%	90%	75%	50%	
Bean	1.0	1.5	2.3	3.6	7
Beet	4.0	5.1	6.8	9.6	15
Broccoli	2.8	3.9	5.5	8.2	14
Cabbage	1.8	2.8	4.4	7.0	12
Cantaloupe	2.2	3.6	5.7	9.1	16
Carrot	1.0	1.7	2.8	4.6	8
Cucumber	2.5	3.3	4.4	6.3	10
Lettuce	1.3	2.1	3.2	5.2	9
Onion	1.2	1.8	2.8	4.3	8
Pepper	1.5	2.2	3.3	5.1	9
Cotton	7.7	9.6	13.0	17.0	27
Barley	8.0	10.0	13.0	18.0	28
Sugar beet	7.0	8.7	11.0	15.0	24
Wheat	6.0	7.4	9.5	13.0	20
Sweet potato	1.5	2.4	3.8	6.0	11
Tomato	2.5	3.5	5.0	7.6	13

Sodium problem (Sodicity)

- Sodium problem leads to dispersion of soil resulting in loss of structure
- Water will not be able to enter or move through the soil adequately

Sodium Problem

- Laboratory measurements will clarify if you have sodium problem
- For sodium problem to be present, the Sodium adsorption ratio (SAR) must be greater than 13

$$SAR = \frac{[Na^{+}]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}}$$

Correcting Sodium Problem

- Addition of ions to displace Na from clays
- Calcium is the usual ion used to displace Na
  - Gypsum
  - Calcium chloride
  - Sulfur (if sufficient lime is in the soil)
- Leach out the sodium salts
- Adequate drainage is required

Resolving Chemical Issues

Soil Testing is Important !!!

- Helps to know what is in your soil
- Helps to plan how much of nutrients to apply
- Nutrient needs vary with soil and crop
- Helps to know if your soil is building up salts
- Will let you know if your management is improving, degrading or maintaining your soil

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Which Lab Do I Choose?

- Go to NMSU site (www.nmsu.edu)
- Type “Labs for New Mexico Soils” in the search
- Click on the link “Labs for New Mexico Soils”

- Go to the website of the lab you have chose
- Make sure you check their sampling protocol and costs
- Stick with the same lab to be able to compare results

Colorado State University Extension

SOIL, WATER & PLANT TESTING LABORATORY
FORT COLLINS, COLORADO 80523-1120
Phone 970-491-5061 Fax 970-491-2930

AGRICULTURAL TEST REPORT

IDENTIFICATION / ROUTINE SOIL TEST RESULTS

Lab No.	Sample ID	Sample Depth	pH	Salts mmhos/cm	Excess Lime (Estimate)	Texture Estimate	SAR	Gyp meq 100g	Organic Matter % (Modified Walkley Black)	Nitrate N ppm (AB-DTPA Extract)	Phosphorus P ppm ($NaHCO_3$ Extract)	Phosphorus P ppm (AB-DTPA)	Potassium K ppm (AB-DTPA)	Zinc Zn ppm (AB-DTPA)	Iron Fe ppm (AB-DTPA)	Manganese Mn ppm (AB-DTPA)	Copper Cu ppm (AB-DTPA)	Boron B ppm (Hot Water)
F245a	AF 1		8.2	0.7	Very High	Clay			3.2	13	92	60.0	770	4.3	4.4	2.1	3.3	0.10
F246b	AF HHd		8.2	0.9	Very High	Clay			3.4	30	85.0	50.0	684	3.5	4.1	2.6	3.4	0.07
F247c	LS V-4		8.6	1.3	Very High	Clay			2.2	15	89.0	55.0	1052	2.5	5.1	2.8	1.7	0.10
F248d	Herb garden		8.2	2.0	Very High	Clay			2.5	68	81.0	47.0	841	1.7	6.1	5.0	2.3	0.13
F249e	AYF HH		8.3	1.1	Very High	Sandy Clay			4.5	24	142.0	100.0	863	6.6	5.2	2.2	2.6	0.12
F250f	LS HH		8.4	0.9	Very High	Sandy Clay			3.4	13	106.0	64.0	723	2.9	4.1	3.3	1.7	0.16

FERTILIZER RECOMMENDATIONS:

POUNDS OF ACTUAL NUTRIENT PER ACRE

Lab No.	Sample ID	Acres	Irrigation	Proposed Crop	Yield Goal	Lime (T/A) to raise pH to: 6.0	6.5	7.0	N lbs/A	P_2O_5 lbs/A	K_2O lbs/A	Zn lbs/A	Fe lbs/A	Mn lbs/A	Cu lbs/A	Boron lbs/A	Sulfur lbs/A	Gypsum T/A
F245a	AF 1		unknown	vegetables	variable				85	0	0	0	0	0	0	0	0	N/A
F246b	AF HHd		unknown	vegetables	variable				0	0	0	0	0	0	0	0	0	N/A
F247c	LS V-4		unknown	vegetables	variable				85	0	0	0	0	0	0	0	0	N/A
F248d	Herb garden		unknown	vegetables	variable				0	0	0	0	0	0	0	0	0	N/A
F249e	AYF HH		unknown	vegetables	variable				40	0	0	0	0	0	0	0	0	N/A
F250f	LS HH		unknown	vegetables	variable				85	0	0	0	0	0	0	0	0	N/A

SPECIAL COMMENTS AND SUGGESTIONS:

Good Soil Management

- Good soil management goes beyond just knowing about Nutrients
- Many other soil properties and attributes not measured in conventional soil test can affect crop growth and yield
- Compaction for example, can physically restrict root growth and reduce soil aeration which can lead to reduced yields

Compaction effect on yields

(compaction not measured in lab soil test)

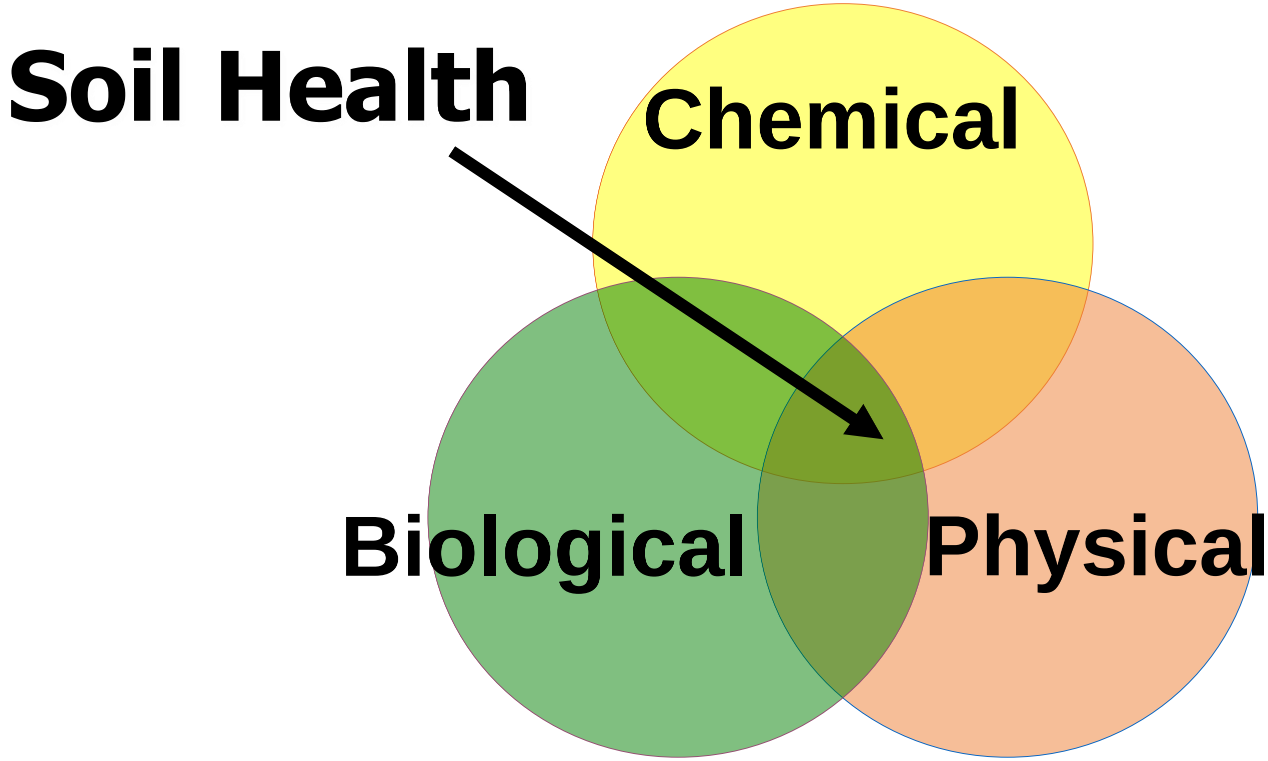
Vegetable Crops	% Yield Reductions due to compaction
Cabbage	73%
Snap Bean	49%
Cucumber	41%
Sweet Corn	34%

Wolfe, David W., et al. "Growth and yield sensitivity of four vegetable crops to soil compaction." Journal of the American Society for Horticultural Science 120.6 (1995): 956-963.

What is Soil Health (Quality)?

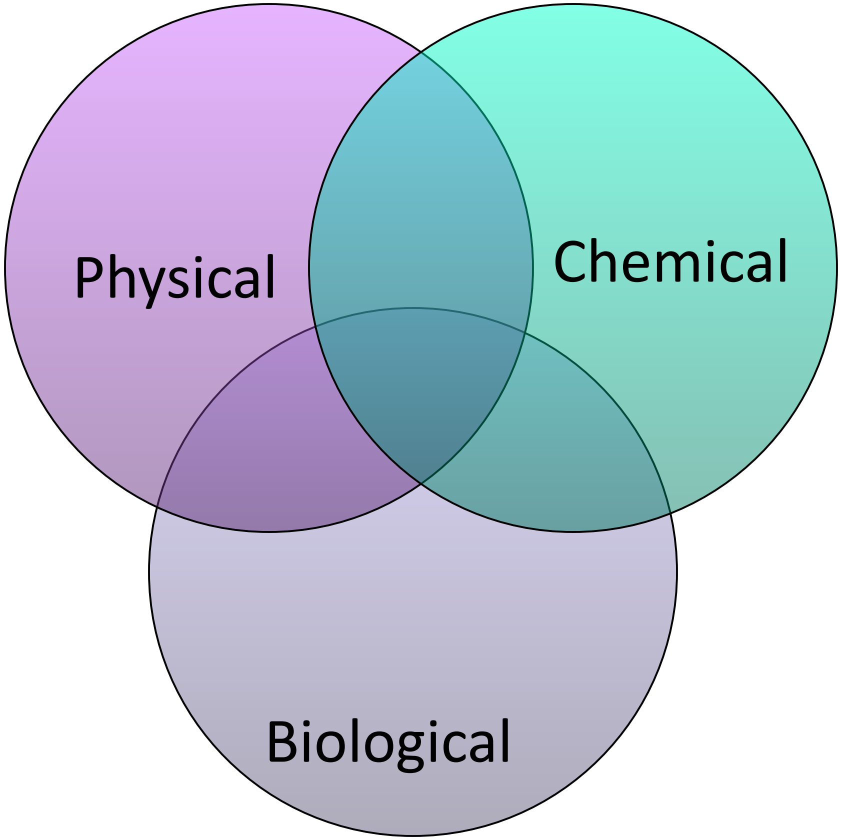
- Ability of the soil to support crop growth … (Power & Myers, 1989)
- Capacity of the soil to function in a productive and sustained manner … (NCR-59 Madison WI, 1991)
- The capability of the soil to produce safe and nutritious crop …. (Parr et al., 1992)
- Fitness for use (Pierce & Larson 1993)

Approach to Soil Health



Soil Health Indicators

- **Bulk density**
- **Penetration resistance**
- **Aggregate stability**
- **Water infiltration rate**
- **Water holding capacity**
- **Pore size distribution**



- **Cation exchange capacity**
- **N, P, K**
- **Salinity**
- **Micronutrients**
- **[Toxins, pollutants]**

- **Soil disease suppressive capacity**
- **Beneficial and pathogenic nematodes, [other pathogens]**
- **N mineralization rate (PMN)**

- **Decomposition rate**
- **Respiration rate**
- **Earthworm counts**
- ***% OM***
- ***“Active” C, N in OM***

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END OF SOILS PART ONE

Santa Fe County Master Gardener Training
Part 2: Soil Biology
Santa Fe, NM February 18th & 19th, 2019

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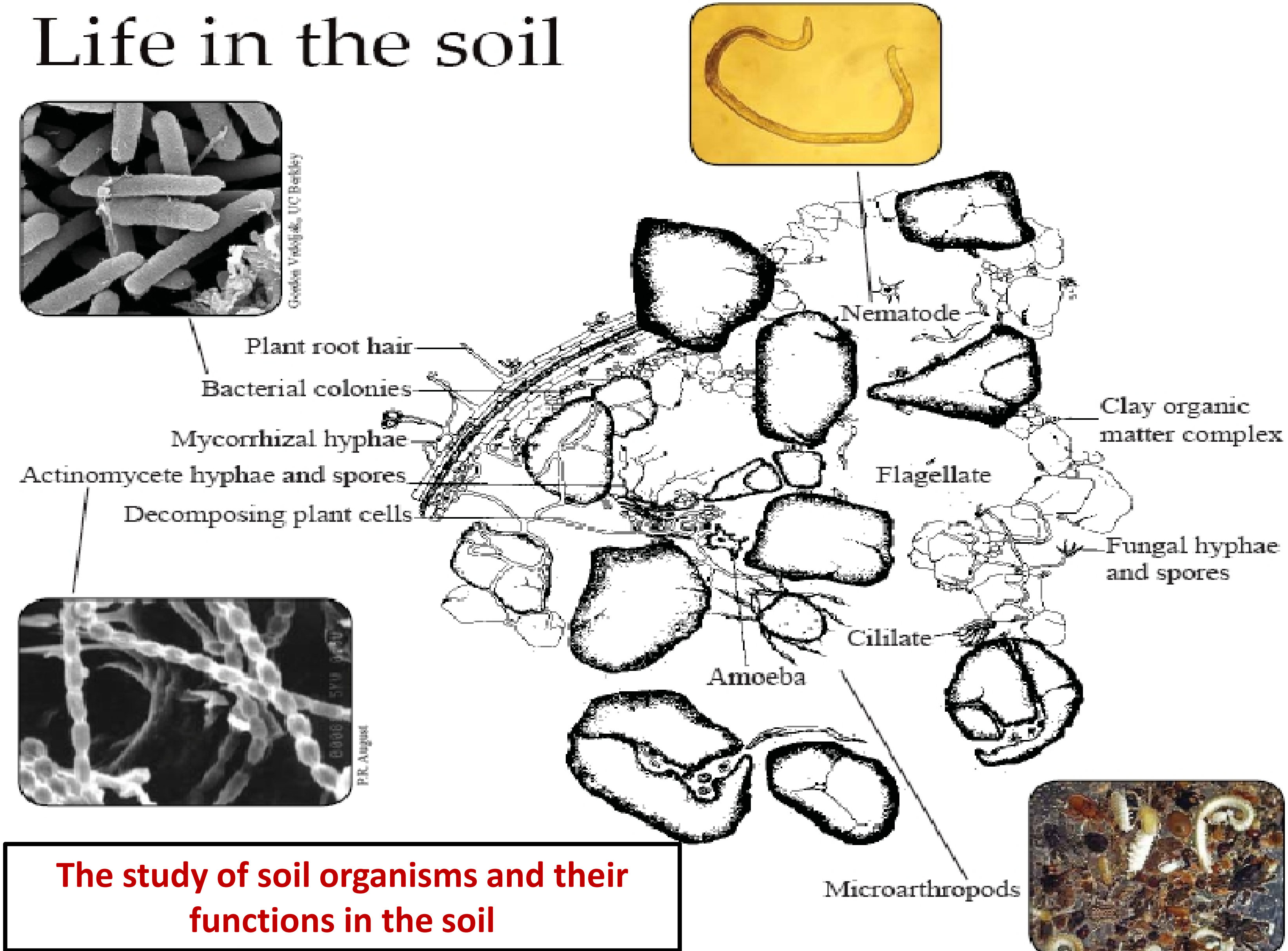
SOIL BIOLOGY

What is soil biology?



The study of soil organisms and their functions in the soil

Modified drawing by S. Rose and E.T. Elliott

Soil organisms

- Those we can see with our eyes
  - Earthworms
  - Insects
  - Burrowing animals

- Those we cannot see with our eyes
  - Bacteria
  - Fungi
  - Actinomycetes
  - Nematodes
  - Protozoa

Why is soil biology important?

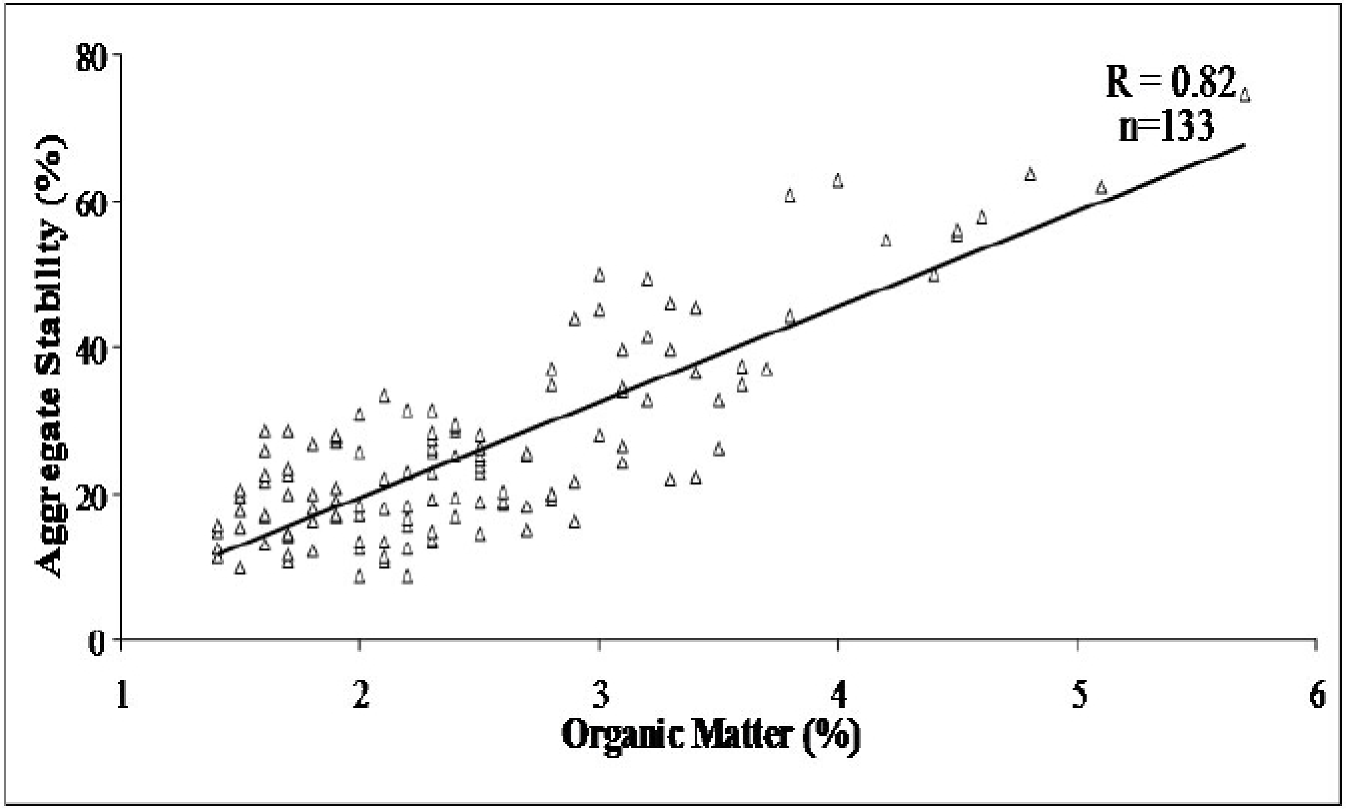
- Soil biological activity is related to soil fertility
- Soil organic matter is the driving force behind soil health
- Soil borne pathogens can constitute problem to production agriculture
- Soil biology is related to sustainable soil use

Factors affecting soil structure

- Amount of organic matter
- Root systems of plants
- Soil microorganisms
- Actions of burrowing organisms

Aggregation & soil organic matter

Well aggregated soil resists erosion and promote good water flow and retention



Aggregation is not just because OM is present but because soil organisms are acting on the organic matter in the soil

Soil organisms

In 1 teaspoon of healthy soil contains

- **Bacteria** — **100 million to 1 billion**
- **Fungi** — **6-9 ft fungal strands put end to end**
- **Protozoa** — **Several thousand flagellates & amoeba**
  One to several hundred ciliates
- **Nematodes** — **10 to 20 bacterial feeders and a few fungal feeders**
- **Arthropods** — **Up to 100**
- **Earthworms** — **5 or more**

Microbial populations and biomass

Organism	Number/m^{-2}	Pounds/Acre
BACTERIA	10^{13}-10^{14} (10 – 100 trillion)	350-4,500
ACTINOMYCETES	10^{12}-10^{13} (1 – 10 trillion)	350-4,500
FUNGI	10^{10}-10^{11} (10 – 100 billion)	900-13,000
ALGAE	10^{9}-10^{10} (1 – 10 billion)	9-450

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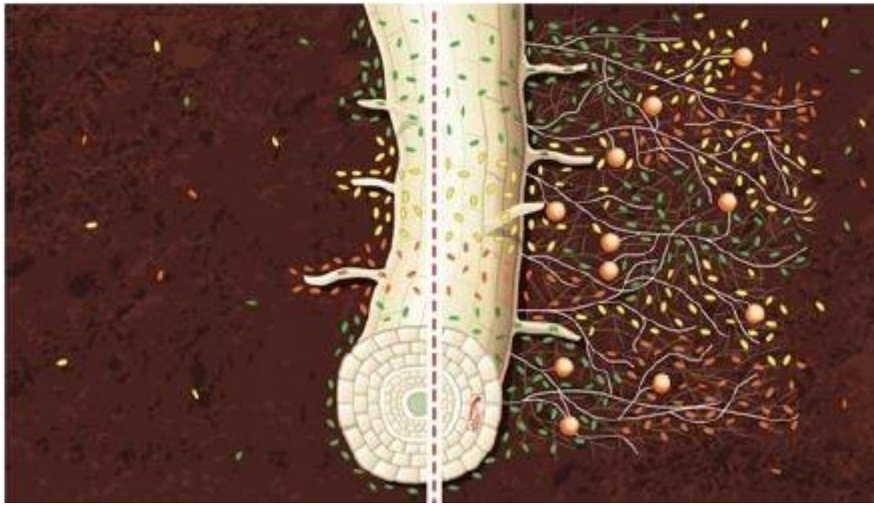
Location of microbes in the Soil

- Mostly in top inch
- Almost all in top 6 inches
- Rhizosphere
  - Zones close to the roots
  - Region of intense activity
  - Stimulus: Secretions from roots



1mm around the roots

Root exudates (including other losses) can account for 10 to 33% of the net plant photosynthetic product

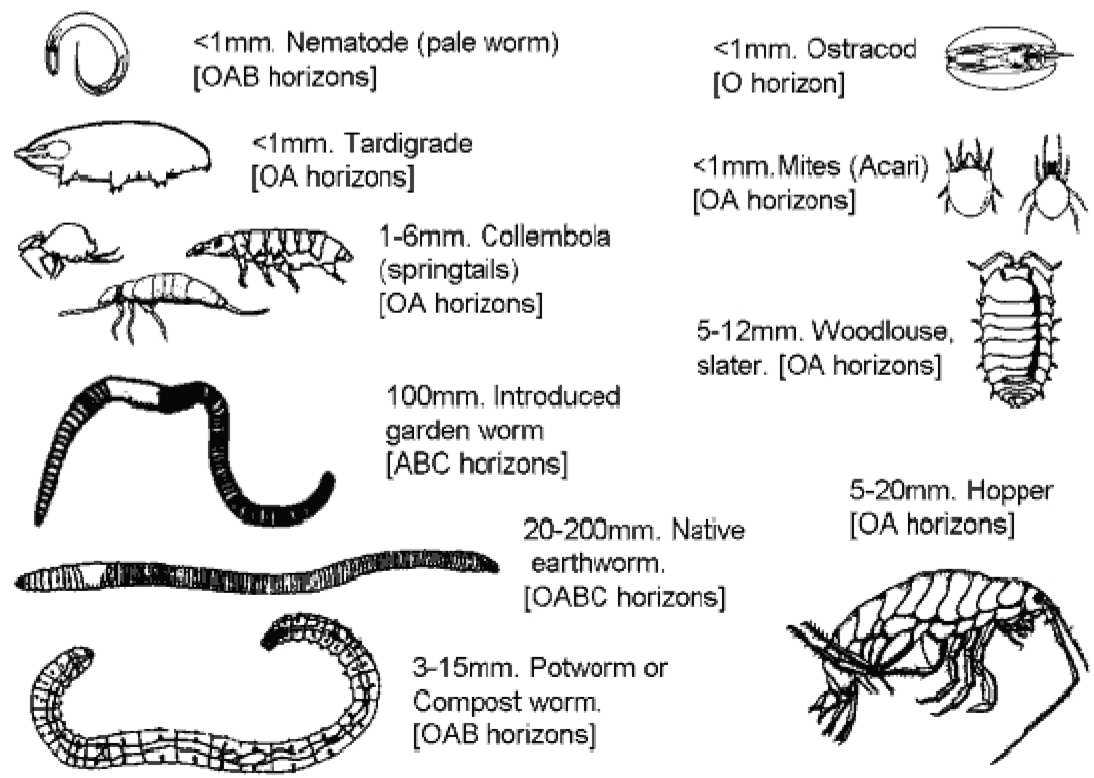
NM STATE

Soil microorganisms

- Bacteria (Often Single Cell)
- Fungi (Often Long Filaments or Hyphae)
- Actinomycetes (Properties of Both)

Soil animals

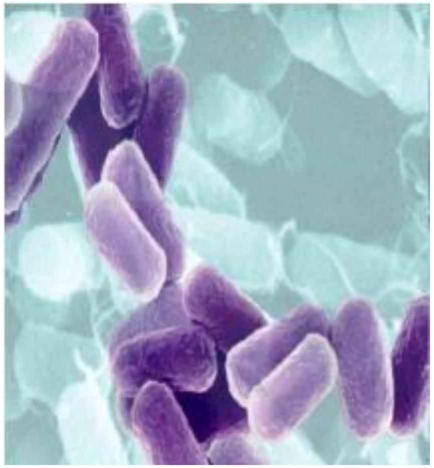
- Nematodes
- Springtails
- Mites
- Insects
- Earthworms

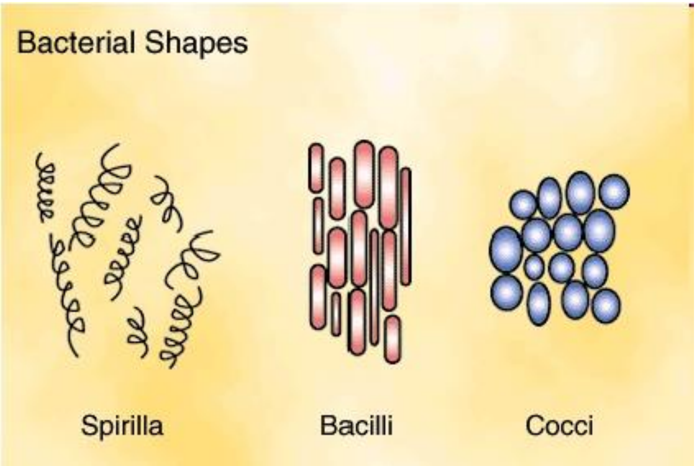


Bacteria

Bacteria are:

- very tiny, one-celled organisms
- They are NOT plants or animals
- They are much simpler than plants and animals
- They can be shaped like a grain of rice or have other shapes





Characteristics of Bacteria

- They are so small that you need a powerful microscope to see them
- There are so many of them in nature
- Many bacteria live freely in the soil
- Others grow on the roots of plants like clover and alfalfa to help make nitrogen
- Some bacteria feed on dead plants to help recycle nutrients (make nutrients available)

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Fungi

- Vary from single cell yeast to molds and mushrooms
- They are heterotrophs – depend on complex carbon molecules for nutrition
- Grow from spores by a thread-like structure call hypha (about 5 microns in diameter)
- Tolerant of acidity (e.g. acid forest soils)
- Important decomposer of lignin

Bacteria vs. Fungi

- Fungi tend to be selected for by plant residues with high C/N ratios.
- Bacteria tend to select for materials that have low C/N ratio (easily decomposable)
- Both bacteria and fungi can cause plant diseases but majority of soil-borne diseases have fungal origin (e.g. Phythium, Fusarium, Phytophtora, Rhizoctonia etc.)
- Bacteria are smaller than fungi and can occupy smaller pores and thus potentially have greater access to material contained within these pores.
- Bacteria are less disrupted than are fungi by tillage practices commonly used in agriculture.

Bottom-line

- **Bacterial and fungal population and diversity depends heavily on:**
  - **Type and abundance of food available**
    - **Food is always a limiting factor**
    - **This ultimately affects the rate of growth and reproduction**
  - **The soil environmental conditions**
    - **Soil management in modern agriculture has a great influence on soil bacterial and fungal community**

Soil Health and Microbial diversity

- Quantity and quality of the soil organic matter is central in determining SOIL HEALTH and MICROBIAL DIVERSITY
  - Bacteria respond most when starch and simple sugars are added as OM
  - Actinomycetes and Fungi respond more to cellulose and other resistant compounds
  - Fungi dominate microbial activity when residue are at the surface while bacteria are more active when incorporation takes place

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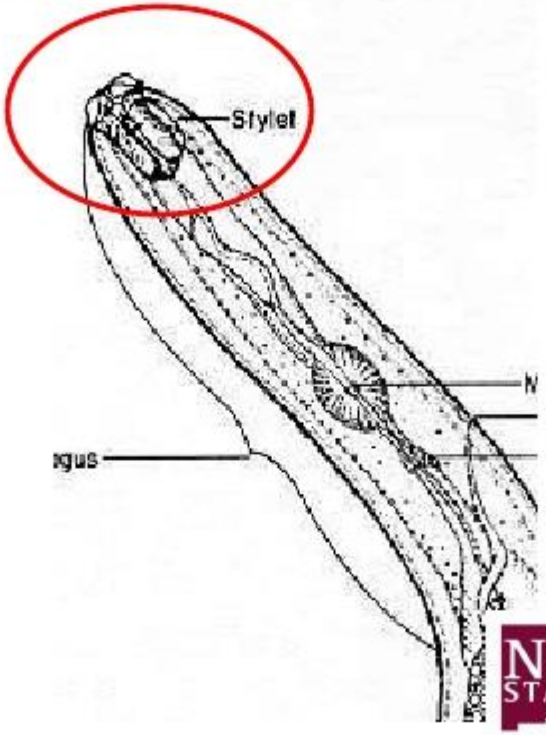
Another soil organism

- **Earthworms**
  - Best known among larger animals
  - Prefer moist environment, abundance of OM and plentiful supply of calcium
  - Found mostly in fine-textured soil with high OM and not strongly acidic
  - Ingest dead organic material and soil mixing them together to form cast (excrement)
  - Create channels within the soil
  - Help with nutrient cycling and water infiltration
  - Prefer untilled soils than tilled soils

Other important soil organisms

- **Nematodes**
  - Worms that are microscopic in size
  - Most abundant soil animal
  - Live in water films surrounding soil particles or in plant roots
  - Encyst in dry soil and repopulate when conditions are favorable
  - Parasitic nematodes have stylet and are more mobile than beneficials
  - Upon infection of host plants the react by forming galls, knots or deformed roots.



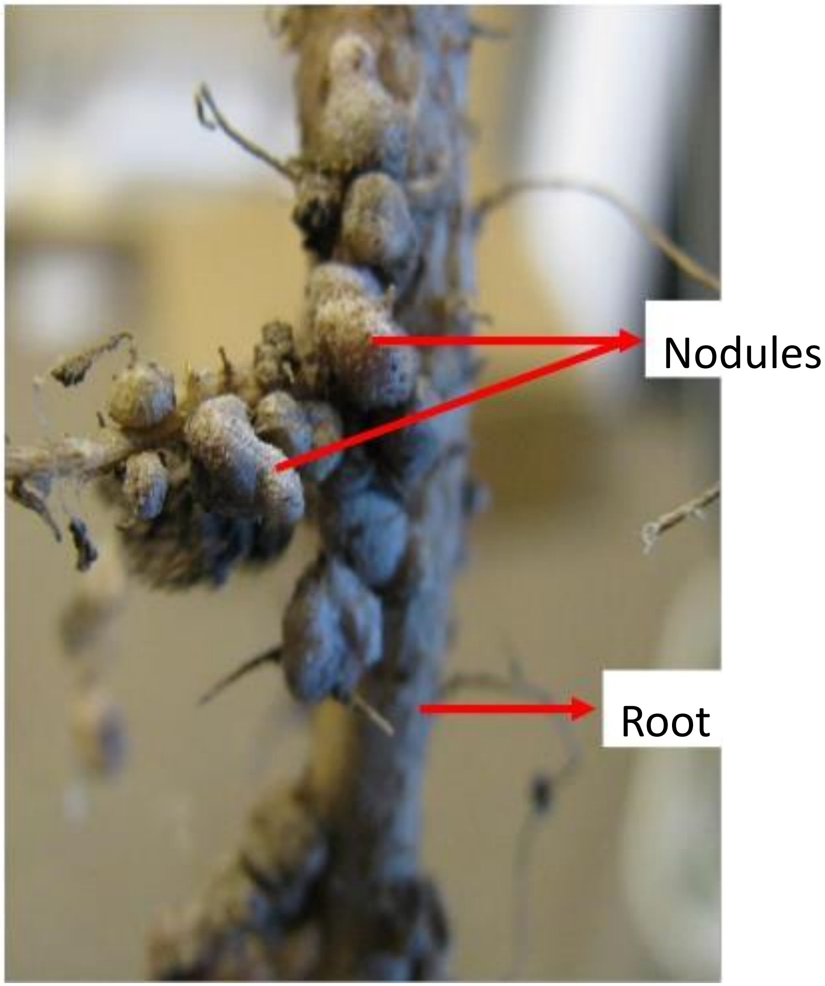
Other ecosystem engineers

- Millipedes
- Woodlice
- Mites
- Insects
- Springtails
- Termites
- Ants
- Beetles
- Fly Larvae
- Caterpillar






Nitrogen Fixation in Legumes
(making nitrate-N available to crops)



Sesbania Nodules (Grown as summer green manure in Las Cruces)

- Examples of legumes are alfalfa, clovers, beans
- Bacteria that make nitrate in plant roots with plants are called Rhizobium
- Nitrogen come from the soil air (79% N_2 in soil)
- It is a relationship of give and take
- Plants supply bacteria with food and bacteria gives back nitrate to plants
- Can fix up to 300 kg/ha N (270 lbs/ac N) in a year

Active Nodules

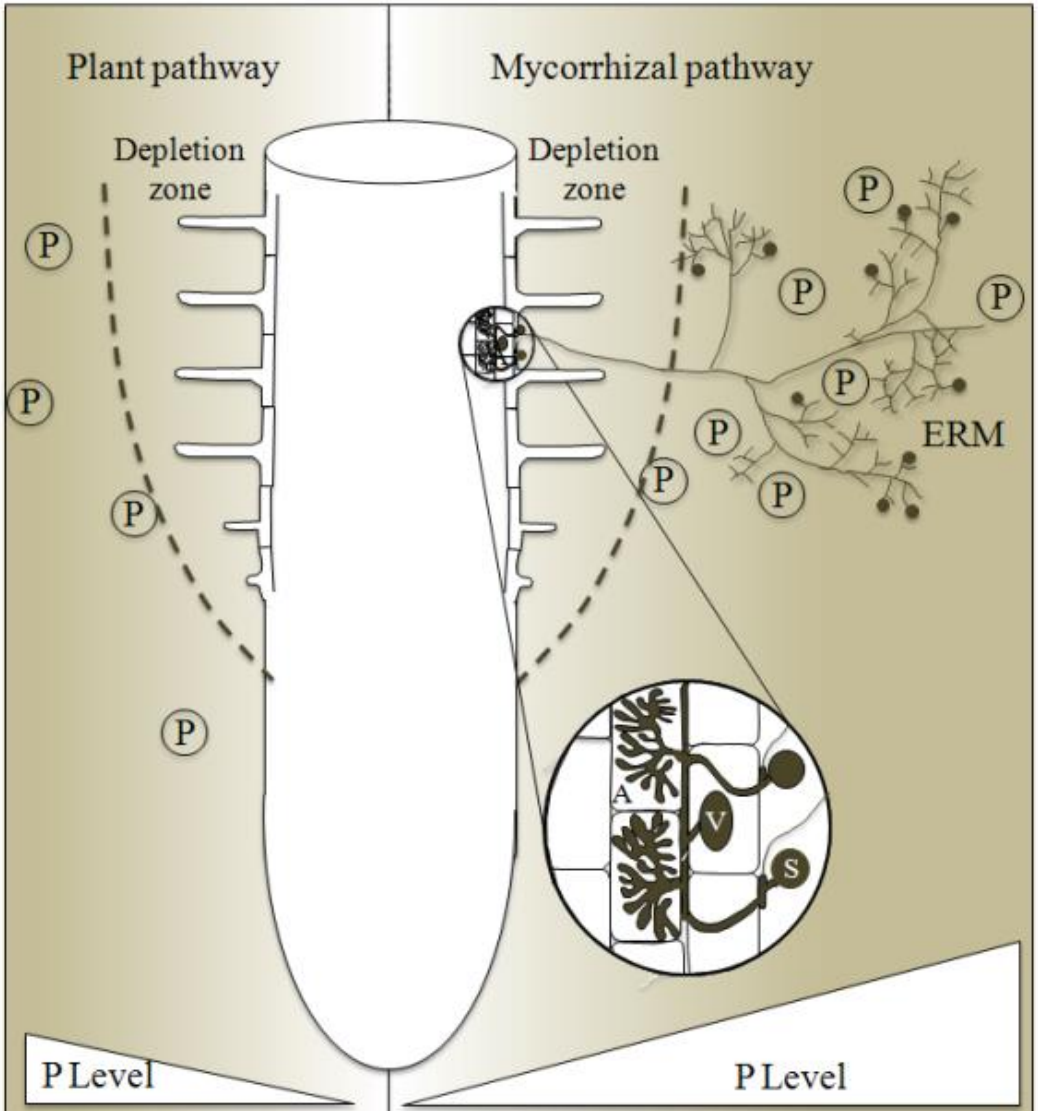
Mycorrhizae

- Some types of beneficial fungi that can grow on plant roots are called **Mycorrhizae**
- **Mycorrhizae** fungi have many filaments that are like thin hairs around the roots

Benefits of Mycorrhizae

- Mycorrhizae fungi helps the plant to obtain
  - Water
  - Nutrients (Phosphorus has been demonstrated)
- The plant makes carbohydrates and gives some to the mycorrhizae fungi for energy.
- The fungi help the plant and the plant helps the fungi

Mycorrhizae and roots



http://www.intechopen.com/books/plant-science/the-role-of-the-mycorrhizal-symbiosis-in-nutrient-uptake-of-plants-and-the-regulatory-mechanisms-und

Mineralization:
(Breakdown of Organic Matter)

- Organic materials are full of nutrients that can help crops grow in the field. Example of such nutrients include:
  - Nitrogen, phosphorus, sulfur
- Example of organic materials are:
  - Cow manure, dead leaves and plant residue, compost, chicken manure, etc.
- Mineralization is the release of these nutrients in forms that growing crops can use

How does soil mineralization happen?

As the microbes feed on soil organic matter, nutrients are released

Microorganisms
(bacteria, fungi and others)

Small and large animals
(earthworms, bugs, nematodes)

K NO_3 Mg

Ca P S

Fertile soil with nutrients will produce good crops

Decomposition of OM dependent on

- Temperature (Low in winter high in summer)
- Moisture (problems – too dry or too wet)
- Food Supply (Amount of Organic Matter)
- Oxygen (problem – low O_2)
- C:N Ratio (next slide)

Carbon to Nitrogen Ratio

slower

Relative Decomposition Rate

faster

Material	C:N Ratio
Wood chips	700:1
Sawdust or pellets	500:1
Paper	170:1
Straw, wheat	130:1
Bark	100:1
Straw, oat	80:1
Leaves	60:1
Cornstalks	60:1
Peanut hulls	50:1
IDEAL RATIO	**30:1**
Legume grass hay	25:1
Grass clippings	19:1
Poultry house litter, stockpiled	15:1
Yard waste	14:1
Fresh manure, cattle	8:1
Fresh manure, swine	6:1
Fresh manure, poultry	6:1

Less N available

700 units of Carbon to 1 unit of Nitrogen

30 units of Carbon to 1 unit of Nitrogen

More N available

Positive & Negative Roles of Microbes

- **Positive**
  - **Mineralization**
  - **Nitrogen fixation**
  - **Aggregate stabilization**
  - **Mycorrhizae association**
  - **Predation on pests and pathogens**

- **Negative**
  - **Immobilization**
  - **Denitrification**
  - **Pathogens (disease causing agents)**

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Soil Organic Matter

- **Percentage small (often <5%) but effects profound!**
  - **Influence physical, chemical and biological properties**
  - **Provide much of the soil's cation exchange capacity**
  - **Provides much of the water holding capacity**
  - **Help formation and stabilization of aggregates**
  - **Hold tremendous amounts of nutrients that are slowly released, especially N**
  - **Food for microbes in the soil**

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Organic Matter

The living

- Bacteria
- Fungi
- Viruses
- Protozoa
- Insects
- Plant roots
- Etc.

The dead

Recently deceased

- Micro-organisms
- Earthworms
- Crop residues
- Plant roots
- Etc.

Recent manure

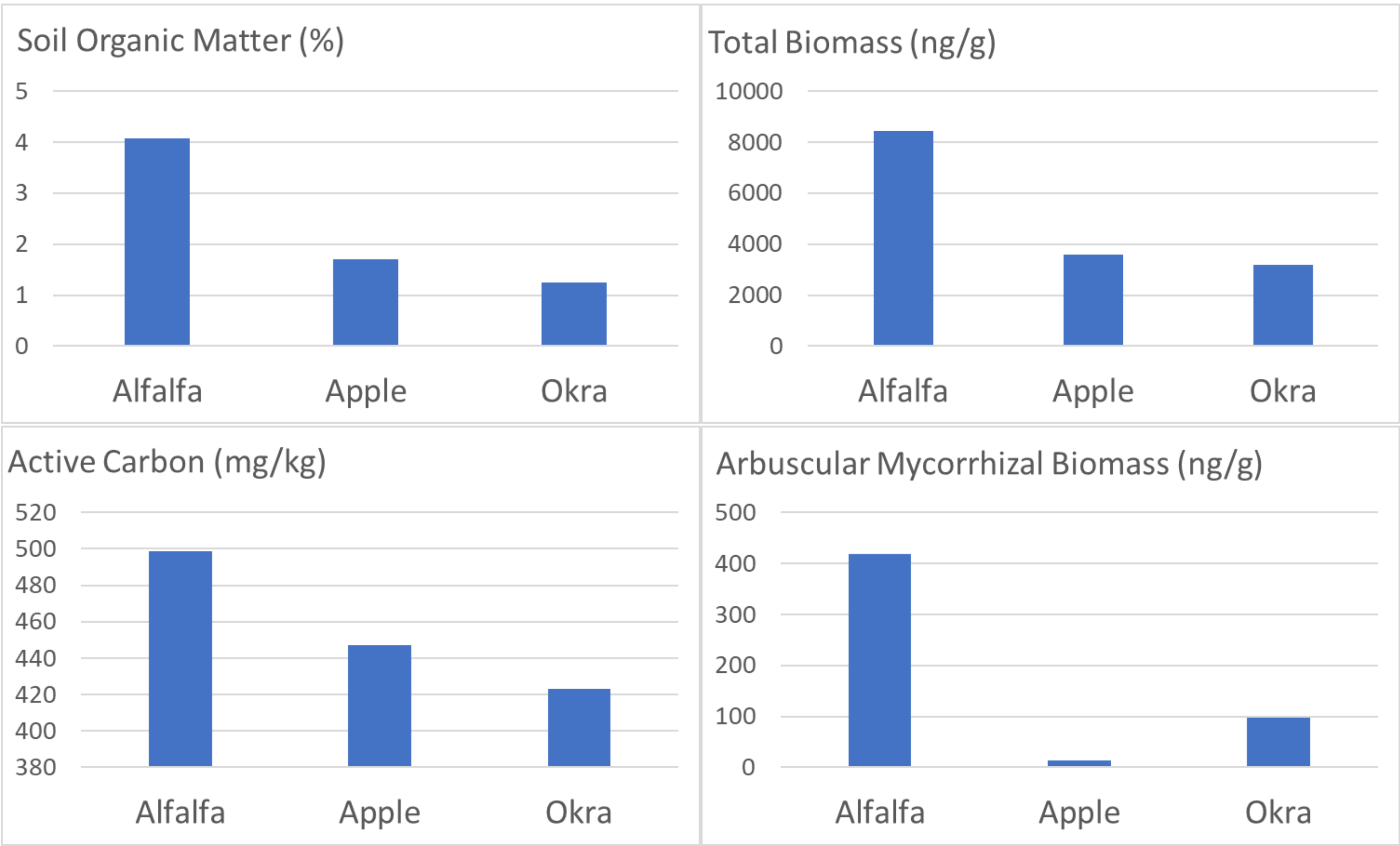
The very dead

Humus substances

- Colloidal in nature
- Resistant to decomposition
- Very useful for water and nutrient storage

after Magdoff and van Es

Soil Health Results



Building Soil Organic Matter

- Increasing organic carbon to improve soil structure, reduce erosion and build pest and disease suppressive soils
- Increasing SOM storage involves
  - increasing C inputs (addition)
  - decreasing rates of C decomposition (prevention)
- Best strategy is to combine both (addition + prevention)

What is Organic Fertilizer?

Derived from natural sources

- plant byproducts
- animal byproducts
- natural mineral deposits

Minimal processing

- no added chemicals
- no chemical alteration

in case of doubts: check **“Organic Materials Review Institute” (OMRI.org)**

Organic vs. Chemical Fertilizers

Chemical fertilizers are:

- **Purified simple salts – easily dissolve in water**
- **rapid availability => rapid uptake (or loss)**
- **high "salt effect" => desiccation/fertilizer burn**
- **no organic matter (food for beneficial microbes)**
- **Chemical nitrogen tends to lower soil pH**

Organic vs. Chemical Fertilizers

Characteristics of Organic Fertilizers

- Complex materials – more than one nutrient
- Slow to very slow release of nutrients
- Plant and animal byproducts
- Food for microbes and soil organisms
- Add organic matter to the soil
- Tend to moderate soil pH

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What is a Mulch?

- A mulch is any material placed on or spread over the soil surface
- First major concern is PROTECTION of the soil surface from:
  - **Erosion (water & wind)**
  - **Rapid evaporation of water**
  - **Weed infestation**

Examples of organic mulches

- Compost
- Grass clippings
- Wood chips or bark
- Wood shavings
- Nut shells
- Waste papers
- Sawdust
- Straw
- Cotton gin trash
- ………….. and many other materials

NM STATE

Composting =Turning Trash to Treasure

Processing organic waste into soil amendment

- ❑ Composting can be done anywhere.
- ❑ Composting where there is excess organic waste and a need for soil that is healthier for plants

Browns

High carbon materials such as

- Leaves (30-80:1)
- Straw (40-100:1)
- Paper (150-200:1)
- Sawdust (100-500:1)
- Animal bedding mixed with manure (30-80:1)

Greens

High nitrogen materials such as

- **Vegetable/food scraps (12-20:1)**
- **Tea/Coffee grounds (20:1)**
- **Grass clippings (12-25:1)**
- **Manure**
  - **Cow (20:1)**
  - **Horse (25:1)**
  - **Poultry (10:1), with litter (13-18:1)**
  - **Hog (5-7:1)**

Browns

- Decay very slowly
- Coarse browns can keep pile aerated
- Tend to accumulate in the fall
- Tie up nitrogen in soil if not fully composted
- May need to stockpile until can mix with greens

Greens

- Decay rapidly
- Poor aeration – may have foul odors if composted alone
- Tend to accumulate in spring and summer
- Supply nitrogen for composting
- Best composting if mixed with browns

Benefits of compost

Plant nutrients

- Compost is not a fertilizer, but does contain plant nutrients
- Nitrogen and phosphorus are mostly in organic forms
  - Released slowly to plants
  - Not readily leached from the topsoil
- Compost contains many trace nutrients that are essential for plant growth

Compost Analysis Report

	Analysis Dry Basis	Lbs / Ton Dry Basis	Lbs / Ton As Is Basis	Lbs / Ton Available First Year
Organic N, % N	0.78	15.6	9.6	1.9
Ammonium, % N	0.016	0.3	0.2	0.2
Nitrate, % N	< 0.001	0.0	0.0	0.0
Total N (TKN), % N	0.79	15.9	9.8	2.1
Phosphorus, % P_2O_5	0.52	10.4	6.4	4.5
Potassium, % K_2O	1.36	27.3	16.8	15.1
Sulfur, % S	0.25	5.0	3.1	1.2
Calcium, % Ca	2.77	55.4	34.0	23.8
Magnesium, % Mg	0.38	7.6	4.7	3.3
Sodium, % Na	0.15	2.9	1.8	1.8
Sodium Adsorption Ratio (SAR)	2.17			
Zinc, ppm Zn	62.9	0.1	0.1	0.1
Iron, ppm Fe	5449.0	10.9	6.7	4.7
Manganese, ppm Mn	196.3	0.4	0.2	0.2
Copper, ppm Cu	19.7	0.0	0.0	0.0
Soluble Salts, mmho / cm	14.11	18.1	11.1	11.1
pH	8.5			
Moisture, %	38.57			
Dry Matter (TS), %	61.43			
Ash, %	59.74			
Organic Matter, %	40.26			
Organic Carbon, %	23.35			
Organic C:N Ratio	29.6			

"<" - Not Detected / Below Detection Limit

Colorado State University Extension

SOIL, WATER & PLANT TESTING LABORATORY
FORT COLLINS, COLORADO 80523-1120
Phone 970-491-5061 Fax 970-491-2930

AGRICULTURAL TEST REPORT

IDENTIFICATION — ROUTINE SOIL TEST RESULTS

METHOD USED:					Estimate	Estimate			Modified Walkley Black	AB-DTPA Extract	$NaHCO_3$ Extract	AB-DTPA Extract						Hot Water
Lab No.	Sample ID	Sample Depth	pH	Salts mmhos/cm	Excess Lime	Texture Estimate	SAR	Gyp meq 100g	Organic Matter %	Nitrate N ppm	Phosphorus P ppm	Phosphorus P ppm	Potassium K ppm	Zinc Zn ppm	Iron Fe ppm	Manganese Mn ppm	Copper Cu ppm	Boron B ppm
F245a	AF 1		8.2	0.7	Very High	Clay			3.2	13	92	60.0	770	4.3	4.4	2.1	3.3	0.10
F246b	AF HHd		8.2	0.9	Very High	Clay			3.4	30	85.0	50.0	684	3.5	4.1	2.6	3.4	0.07
F247c	LS V-4		8.6	1.3	Very High	Clay			2.2	15	89.0	55.0	1052	2.5	5.1	2.8	1.7	0.10
F248d	Herb garden		8.2	2.0	Very High	Clay			2.5	68	81.0	47.0	841	1.7	6.1	5.0	2.3	0.13
F249e	AYF HH		8.3	1.1	Very High	Sandy Clay			4.5	24	142.0	100.0	863	6.6	5.2	2.2	2.6	0.12
F250f	LS HH		8.4	0.9	Very High	Sandy Clay			3.4	13	106.0	64.0	723	2.9	4.1	3.3	1.7	0.16

FERTILIZER RECOMMENDATIONS:

I. D.	FIELD INFORMATION								POUNDS OF ACTUAL NUTRIENT PER ACRE									
						Lime (T/A) to raise pH to:												
Lab No.	Sample ID	Acres	Irrigation	Proposed Crop	Yield Goal	6.0	6.5	7.0	N lbs/A	P_2O_5 lbs/A	K_2O lbs/A	Zn lbs/A	Fe lbs/A	Mn lbs/A	Cu lbs/A	Boron lbs/A	Sulfur lbs/A	Gypsum T/A
F245a	AF 1		unknown	vegetables	variable				85	0	0	0	0	0	0	0	0	N/A
F246b	AF HHd		unknown	vegetables	variable				0	0	0	0	0	0	0	0	0	N/A
F247c	LS V-4		unknown	vegetables	variable				85	0	0	0	0	0	0	0	0	N/A
F248d	Herb garden		unknown	vegetables	variable				0	0	0	0	0	0	0	0	0	N/A
F249e	AYF HH		unknown	vegetables	variable				40	0	0	0	0	0	0	0	0	N/A
F250f	LS HH		unknown	vegetables	variable				85	0	0	0	0	0	0	0	0	N/A

SPECIAL COMMENTS AND SUGGESTIONS:

(85 lb/A)/(2.1lb N/ton of compost) = 40.48 tons compost /ac – not realistic

Using finished compost

Soil amendment

- Be sure that compost is mature, has an earthy smell (no ammonia or rotten smell), looks dark and crumbly with no recognizable feedstock
- Compost improves soil health when mixed in the top 4 to 6 inches (work in no more than a 2” layer of compost)
- Compost improves water and nutrient retention of sandy soils
- Compost loosen compacted clay soils and make them more friable

Animal Manures

Cow manure

- good general nutrient source (especially K)
- OM benefit depends on amount of bedding
- can carry weed seed

Poultry manure

- potent source N, P, Zn, and lime
- organic matter addition is relatively low
- Best if composted

Horse manure

- heavily bedded with wood shavings
- nitrogen availability can be a problem the first year

Peat Moss

- Improves soil moisture retention
- Minor improvement to nutrient holding capacity
- Provides negligible nutrient benefit
- High proportions may make soil hydrophobic

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Nutrient content of organic fertilizers

	N	P_2O_5	K_2O
	--------------% (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	13.0	2.0	1.0
Fish meal	10.0	6.0	0
Kelp/seaweed	1.5	1.0	4.9
Soybean meal	7.0	1.2	2.0
Bone meal (raw)	3.0	22.0	0
Bone meal (steamed)	1.0	15.0	0
Cottonseed meal	6.0	3.0	1.5
Rock phosphate (total P_2O_5)	0	20-32	0
Granite dust (total P_2O_5 and K_2O)	0	0	22
Potassium sulfate (mined)	0	0	50

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Materials to Avoid

- Sawdust, wood shavings, wood chips
  - very high carbon/nitrogen ratio
  - will tie up all available N during breakdown
  - (immobilization)
- Worst when tilled in
  - minor detrimental effect if used as mulch
- Best used as mulching materials

To apply organic fertilizer correctly

- You need to test the soil
- You need to test the organic material

Thanks