

Tips on Waking Up Your Soil After a Long Winters Slumber to Maximize Your Gardening Success

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Presentation to the Evergreen Garden Club

March 12, 2019

Objectives

- Provide a very brief overview of soil, soil function, soil types, and the physical, chemical and biological properties they may exhibit, and their impact on *“Soil Behavior”*
- Discuss the role of soil temperature and site conditions and what you can do to help *“Wake Up Your Soil”*
- Steps you can take to help answer the question *“Is my soil hungry and what should I feed it?”*
- Describe important basic soil-plant relationships and the processes of nutrient uptake and utilization

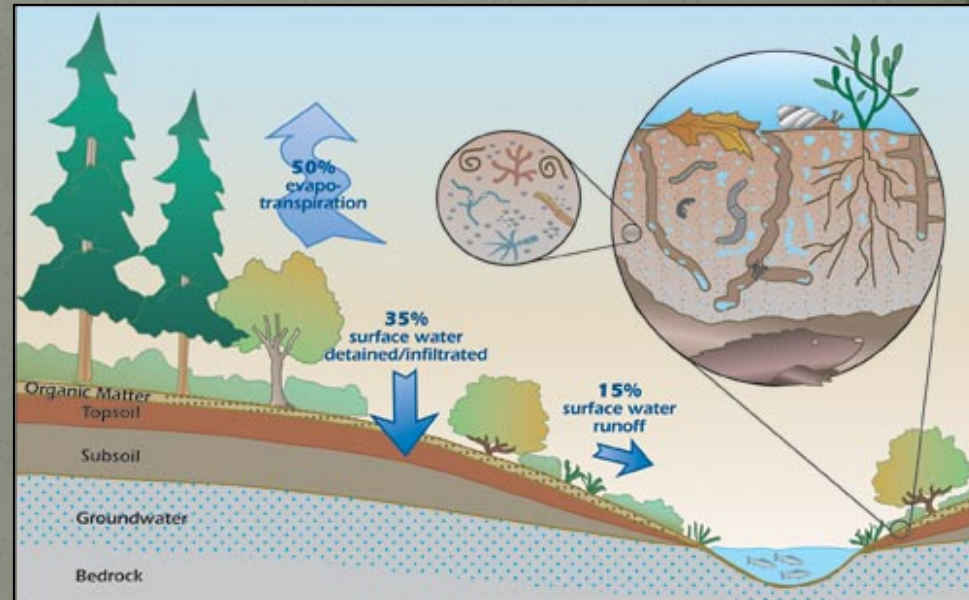
Soils are complex mixtures of minerals, water, air, and organic matter (both living and decaying).

Soil is the medium capable of supporting plant life and is vital to all life on earth.



Soils Perform Several Vital Functions in Our Gardens

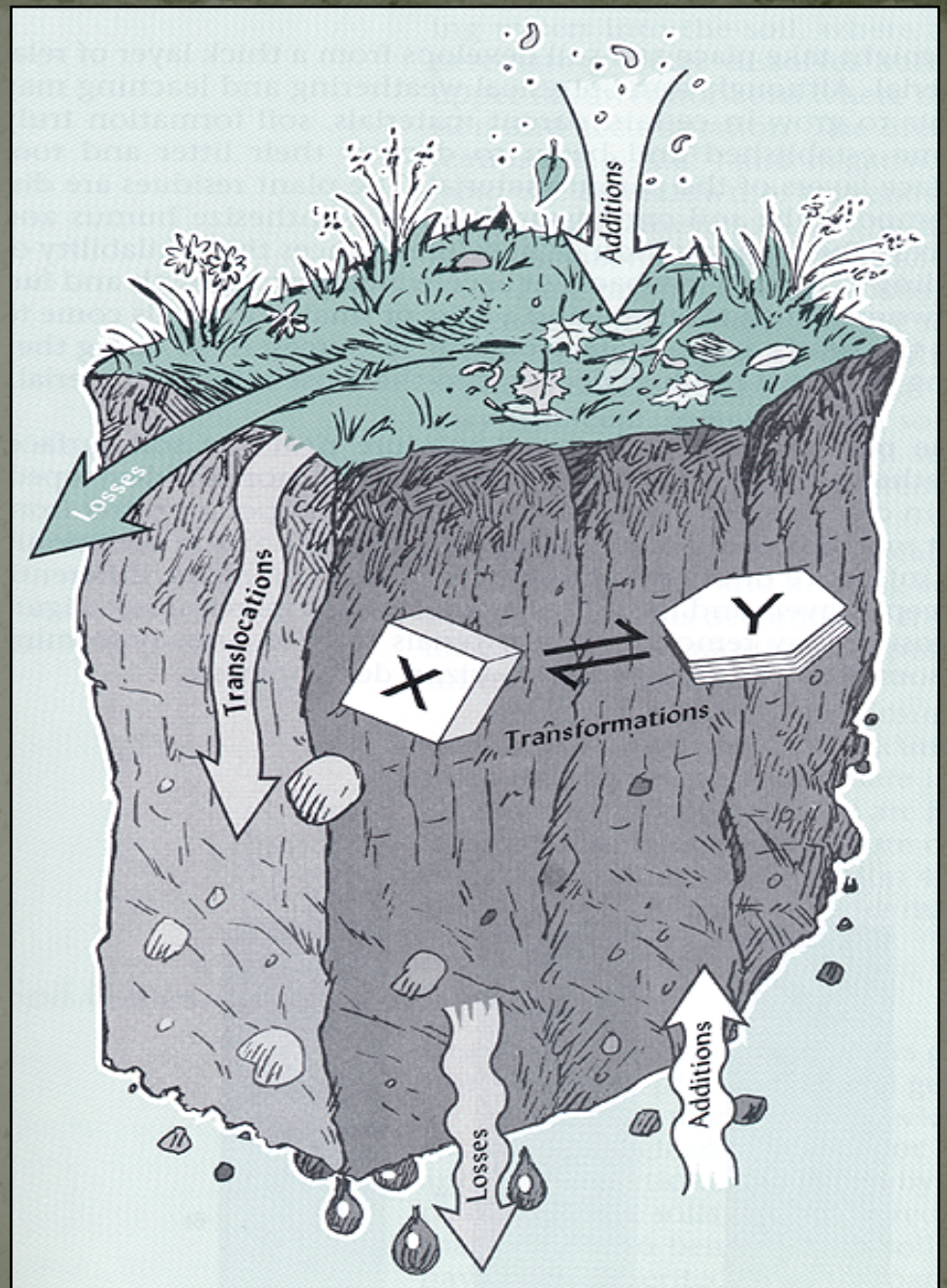
- ◆ Sustains plant and animal life above and below the surface
- ◆ Regulates water flow and retention for plant and animal use
- ◆ Stores and cycles valuable nutrients



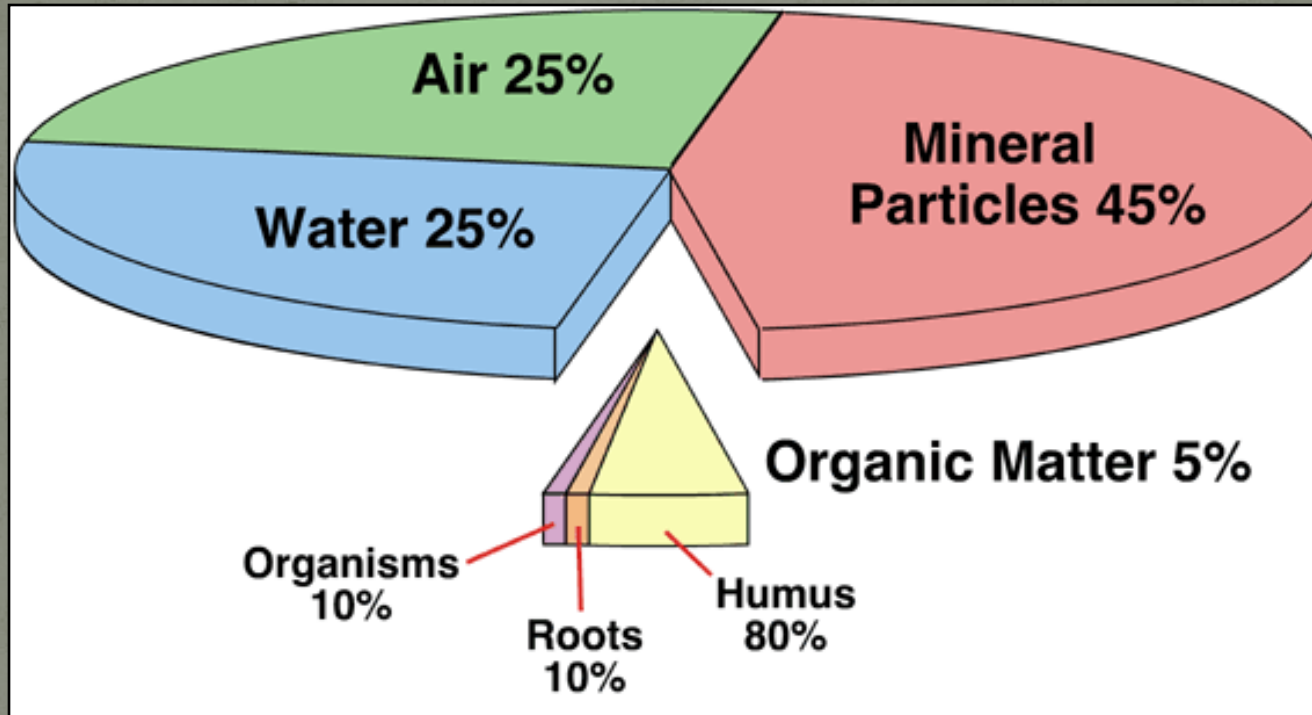
Example of a “Native Soil”



*Native Soils are a
“Dynamic System” and
are modified over time
based upon
environmental and
human interactions*



Native Soil Components

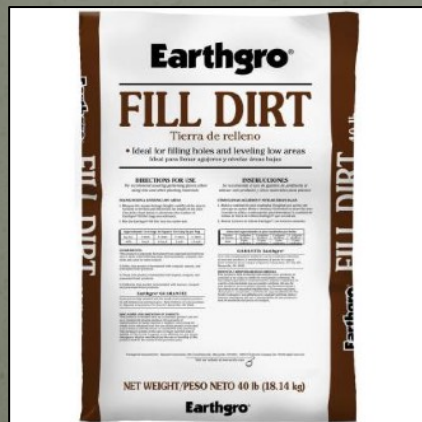


“Manufactured Soil”

- Mineral based soil mixtures
- Organic based soil (sometimes referred as “soil-less”) mixtures
- Versions for use in garden beds or containers (*use dependent*), etc.
- Usually lacking “essential nutrients, water and life”
- *Multi-million dollar business \$\$\$\$\$*



"Manufactured Soil Menu"



"Garden Soil or Potting Mix?"

Garden Soil - contains actual mineral soil particles (mainly sand) and is intended to supplement your existing soil.

Potting Mix - does not contain mineral soil and is intended to be used in portable containers.

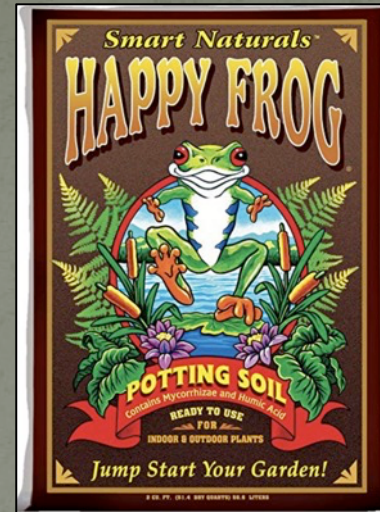
The marketing of these can be focused on intended use of specific plants (violets, roses, cactus, etc.,) So be sure to read the label for intended use but don't expect a breakdown of ingredients !!!!



“Designer Soils”

Contain high quality “ingredients” designed by soil scientists and horticulturalists to “take the guess work” out of gardening

Premium products at a premium price \$\$\$\$ with potential premium performance



So Then What is Dirt?



Soil and Dirt Cycle – “Dirty Soil”

Organic Matter Accumulation
High Biological Activity
Soil Function is Stable

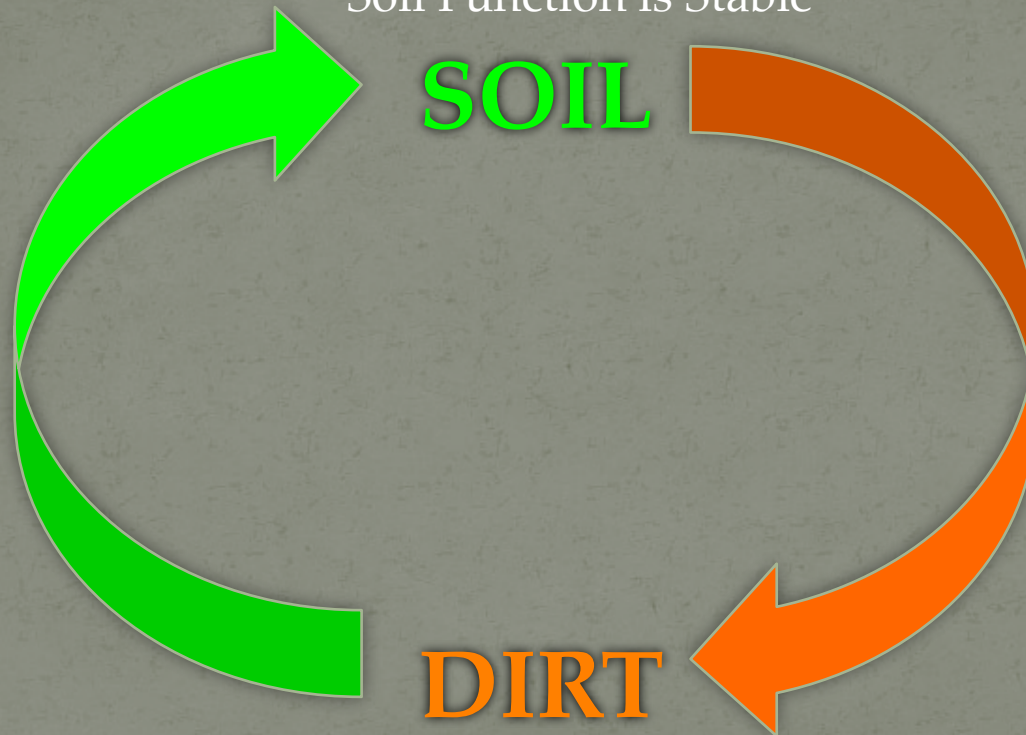
SOIL

TIME &
INPUTS

DISTURBANCE

DIRT

Low Biological Activity
Low Organic Matter
Soil Function is Unstable



Soil Properties

Physical

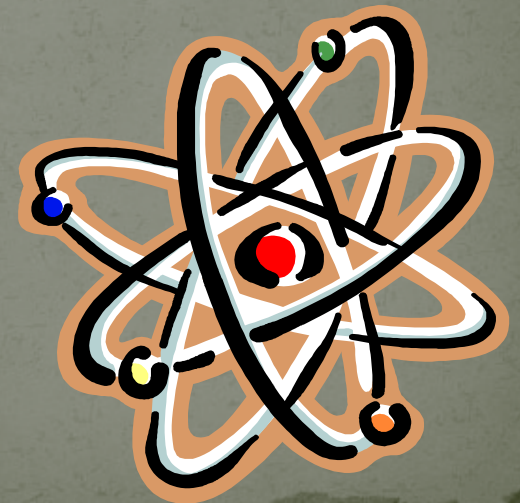


Chemical

Biological

Physical Properties of Soil

- ◆ Soil texture
- ◆ Soil-water relationships



Soil Textural Groupings

Loamy Soils

loam, silt loam, silty clay loam, clay loam, sandy loam, sandy clay loam

Clayey Soils

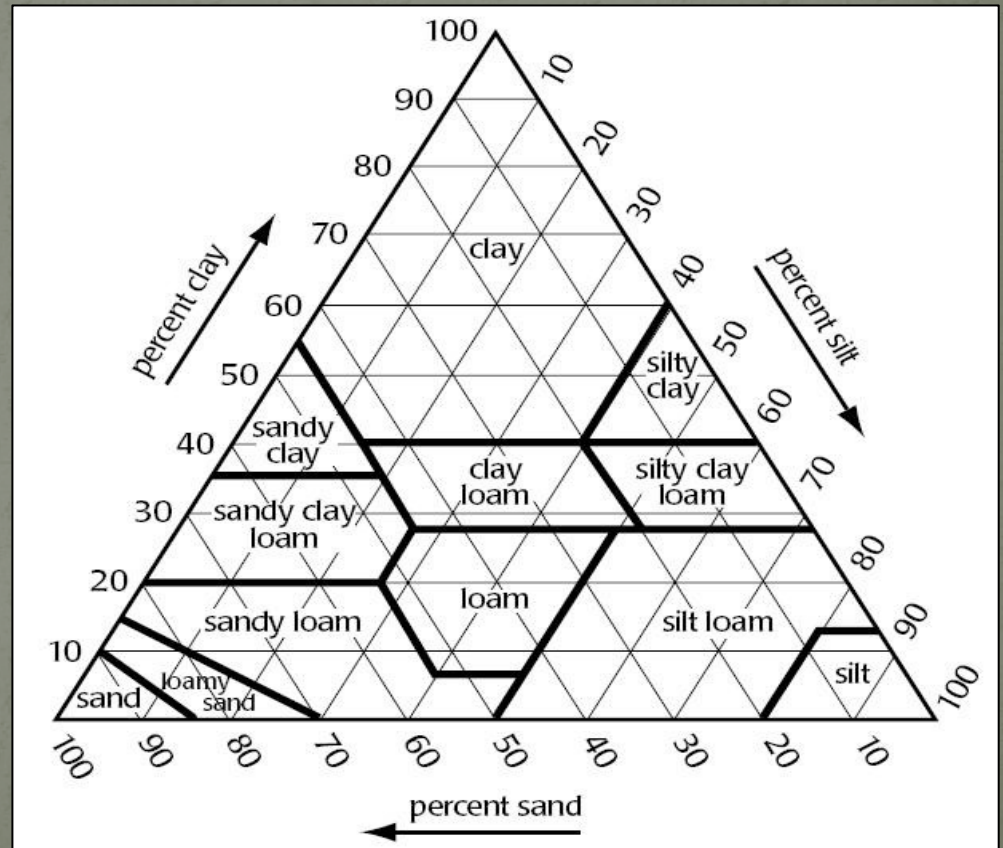
clay, sandy clay, silty clay

Sandy Soils

sand, loamy sand

Silty Soils

silt

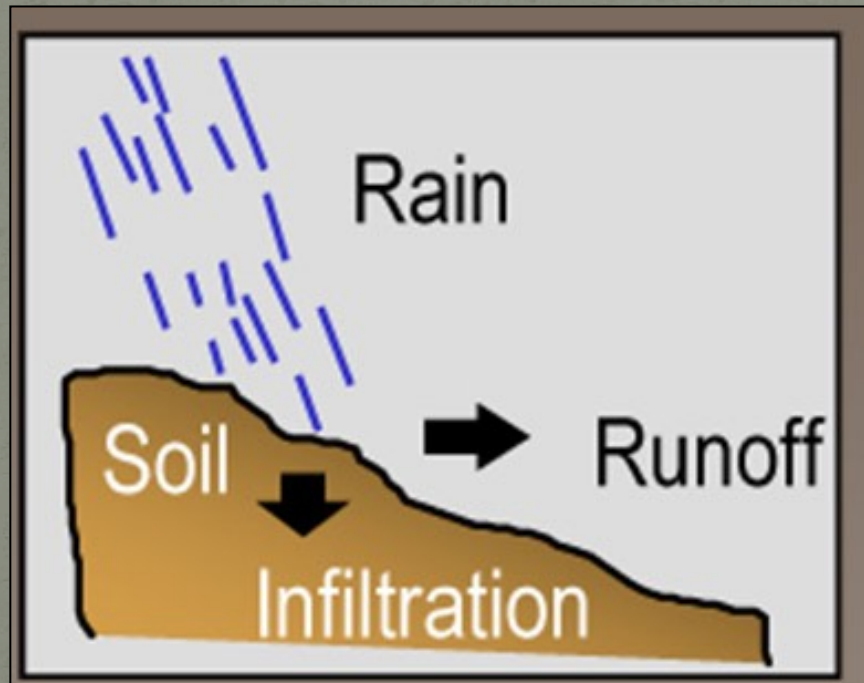


Two Fractions of Soil Texture for Organic Soils

- **Peat** - you can still distinguish the plant material after rubbing (partially decomposed organic matter, "*immature compost*")
- **Muck** – you cannot distinguish the plant material after rubbing (decomposed organic matter, "*mature compost*")

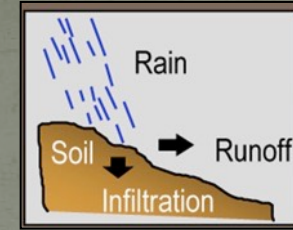


Soil-Water Relationships

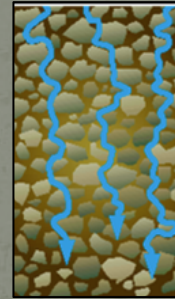


Soil-Water Relationships

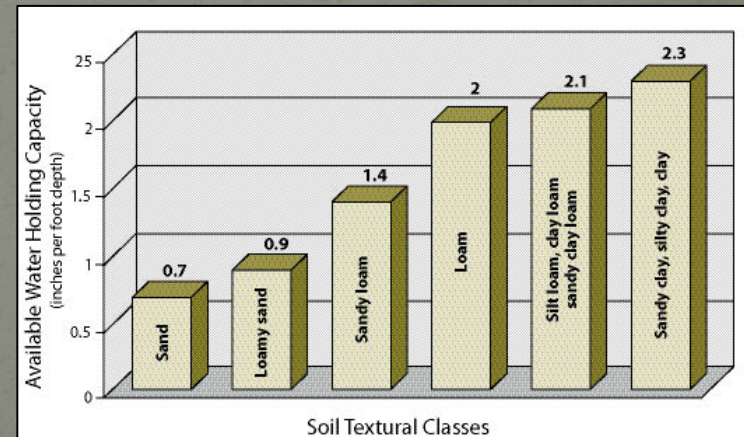
Infiltration is the downward entry of water *into the soil* (inches/hour)



Permeability is the movement of water *through the soil* (inches/hour)



Available Water Capacity (AWC) is the ability of the entire soil to *retain water for plant use* (inches/inch)



Soil texture, structure, and soil depth will affect these relationships, as will cultivation

Soil-Water Relationships by Soil Texture

	SANDY	LOAMY	CLAYEY	PEATY	MUCKY
Infiltration Rate	High	Moderate	Low	Moderate	Low to Moderate
Permeability	High	Moderate	Low	Moderate	Low to Moderate
Available Water Capacity (AWC)	Low	Moderate	High	Low	Moderate

Understanding Soil Behavior

- ◆ **Loamy soils** are the “best behaved” garden soils. Water infiltration, permeability, and AWC is good
- ◆ **Sandy soils** have rapid infiltration, high permeability, but have very low AWC resulting in droughty soils, but can be modified with organic matter and properly managed thru crop selection and proper irrigation practices



Understanding Soil Behavior

- ◆ **Clayey soils** have very low water infiltration rates, very low permeability, and high AWC, which can greatly affect crop growth, and will require management to improve soil function
- ◆ May require low impact cultivation methods in conjunction with addition of organic matter and soil amendments over time
- ◆ Tend to *“Behave Badly”*



Understanding Soil Behavior

- ◆ **Manufactured soils** with a dominance of peaty material will have lower AWC, and if used in shallow containers or garden beds may exhibit droughty conditions much sooner than loamy soils



- ◆ *Choose your soil mix and containers wisely – “the bigger the better”!!*
- ◆ *Consider container type, depth and drainage factors*



WHICH SOIL IS BEST
FOR PLANT GROWTH



Understanding Soil Behavior – Be a Dirt Whisperer!!!!



“Dirt Whisperers” Graduating Class of 2018

OK Soil, Time to Rise and Shine !!!



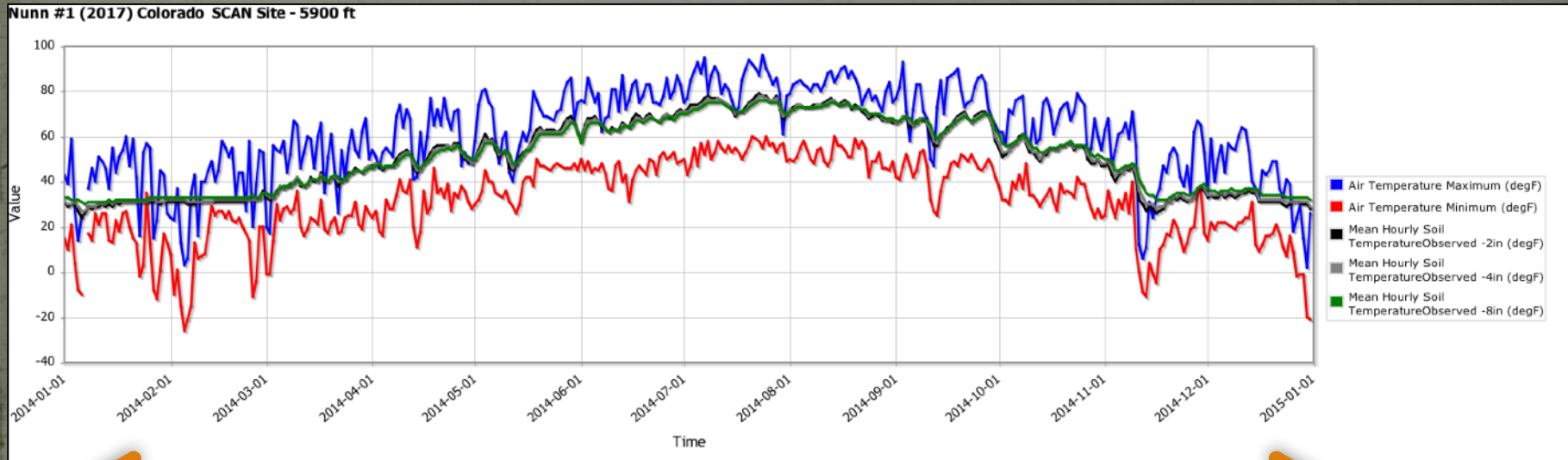
how to
Prepare Your Soil
for spring planting

Soil Temperature – Why Should We Care?

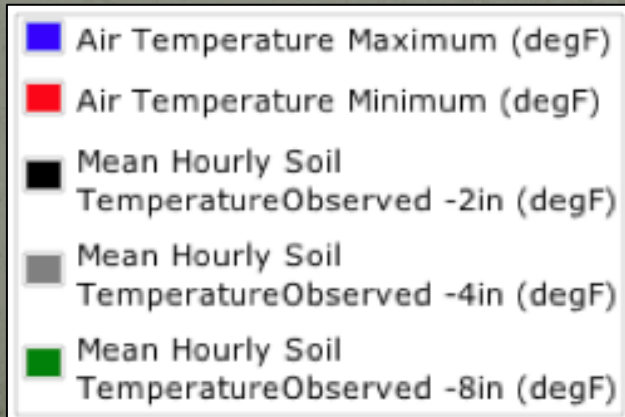
- ◆ Seed germination
- ◆ Soil biological activity
- ◆ Root stimulation and growth
- ◆ Soil-water relationships (frozen soils, evapotranspiration)
- ◆ Nutrient availability and uptake by plants



Soil Temperature



← January



December →

Soil Temperature

- Soil texture, surface cover, soil moisture content, aspect, and elevation have the greatest influence on soil temperature
- The greatest variation in soil temperature occurs at the soil surface and becomes more stable at lower depths (*warmer in the winter, cooler in the summer*)
- *Bare, uncovered soil has the largest fluctuation !!!*



*The best way to know
it's time to plant*

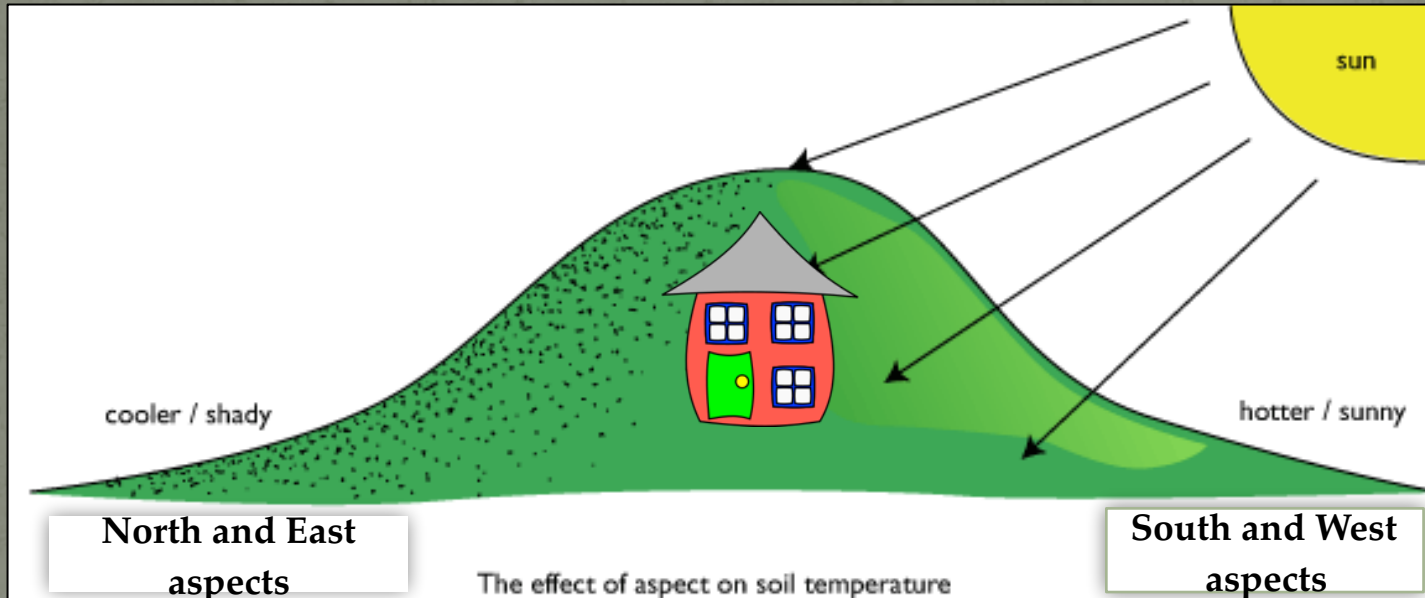
**Soil
Temperature**

Soil Temperature and Soil Texture

- All things being the same, *clayey soils* will tend to be colder than sandy or loamy soils due to a higher *available water holding capacity* - AWC
- *Manufactured soils* with lots of organic matter also have a high AWC and tend to be colder than sandy or loamy soils
- *Sandy soils* with little or no organic matter will be your warmest soils in the garden environment
- *This is due to the fact that air in the soil pores is a much better insulator than water, so soils with pores filled up with water will be cooler*



Aspect and Soil Temperature



** These aspect differences commonly occur along fences and buildings in our garden environments and are sometimes called "micro-climates"*

Soil Temperature and Seed Germination

- Soil temperature is one of the best methods to determine spring planting time.
- Plant seeds for your desired crop when soils reach identified minimum temperature measured at a *depth of 4 inches (10 cm), at 8:00 AM*

Source: *CMG GardenNotes #720 Vegetable Planting Guide*

Seed Starter Chart by Temperature

min 35°F			
	Best °F	Max °F	#Days
Parsnip	65	85	14
Spinach	70	86	5
Lettuce	75	85	3
Onion	75	95	6

min 50°F			
	Best °F	Max °F	#Days
Asparagus	75	95	10
Tomato	80	95	6
Sweetcorn	95	105	3

min 60°F			
	Best °F	Max °F	#Days
Bean, Snap	80	95	7
Eggplant	85	95	6
Bean, Lima	85	85	6
Pepper	85	95	8
Muskmelon	90	100	4
Cucumber	95	105	3
Okra	95	105	6
Pumpkin	95	100	4
Squash	95	100	4
Watermelon	95	105	4
Chicory	80	-	6

min 40°F			
	Best °F	Max °F	#Days
Celery	70	85	7
Leek	70	90	7
Parsley	75	90	13
Pea	75	85	6
Cabbage	80	100	4
Carrot	80	95	6
Cauliflower	80	100	5
Kohlrabi	80	90	4
Beets	85	95	4
Radish	85	95	4
Swiss Chard	85	95	4
Turnip	85	105	3

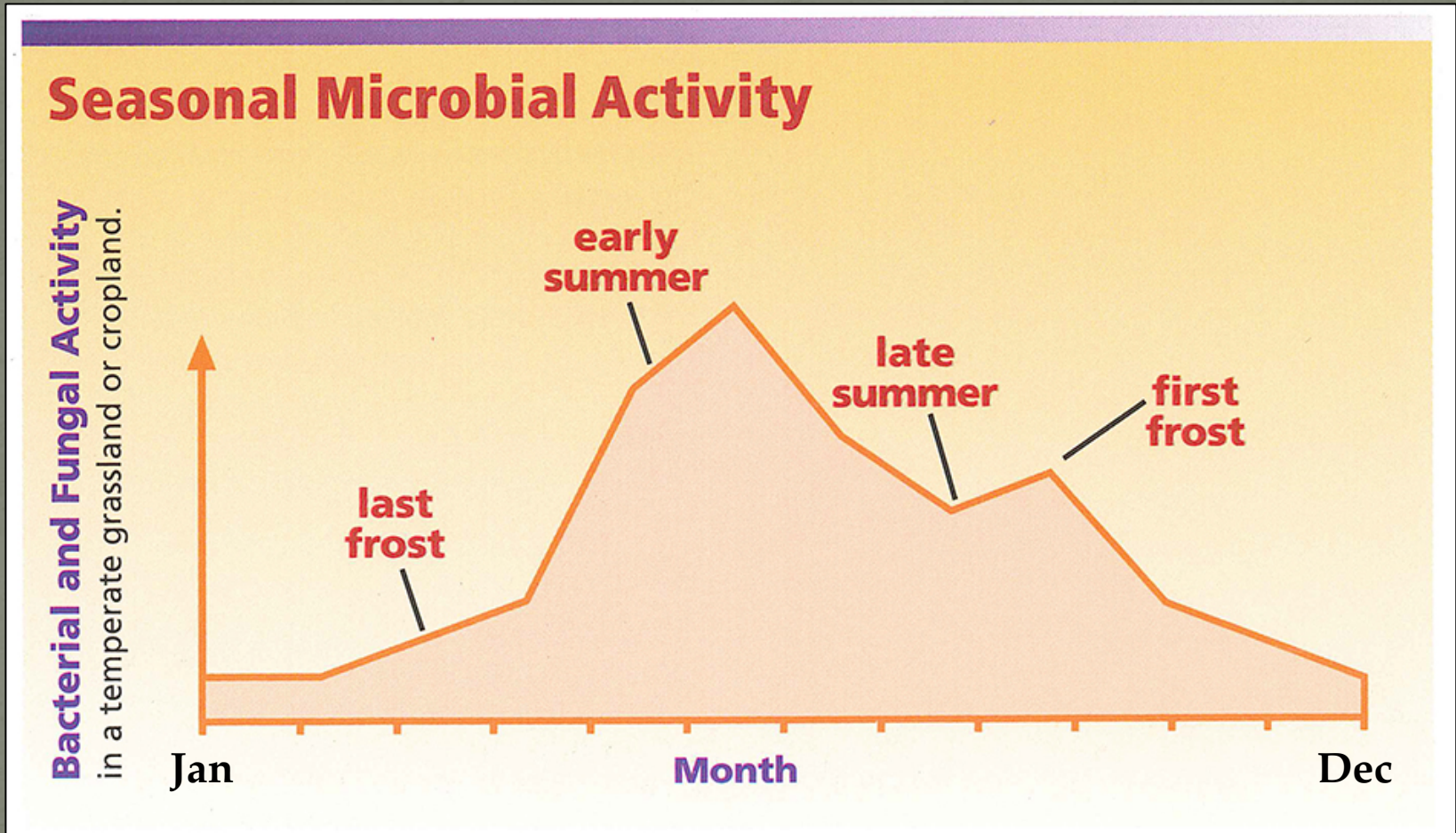
min 70°F			
	Best °F	Max °F	#Days
Brussel Sprouts	80	-	4
Endive	80	-	6

min 75°F			
	Best °F	Max °F	#Days
Chinese Cabbage	80	-	4
Kale	80	-	4
Rutabaga	80	-	4
Broccoli	85	90	4

Soil Thermometers



Soil Temperature and Soil Biological Activity



Optimal soil biological activity occurs between 32 and 140 degrees F

Garden Management Options To Manipulate Soil Temperature

- Add or remove mulches on the soil surface to warm or cool the soil (*light, dark mulches*)
- Use of plastic film to absorb solar radiation and warm the soil (*Clear, Black, White, etc.,*)
- Install raised garden beds with an appropriate soil mixture to help raise soil temperature as well as provide greater rooting depth
- Be aware of your aspect differences in your garden and use them to your advantage (*shady areas and cool season crops*)
- ***Consider taking and documenting soil temperature in your various garden plots based upon different management actions***



Garden Management Options To Extend the Growing Season

- Start seeds indoors
- Use a Cold Frame, Greenhouse
- Fabric frost barriers
- Mini-greenhouse or “cloche”

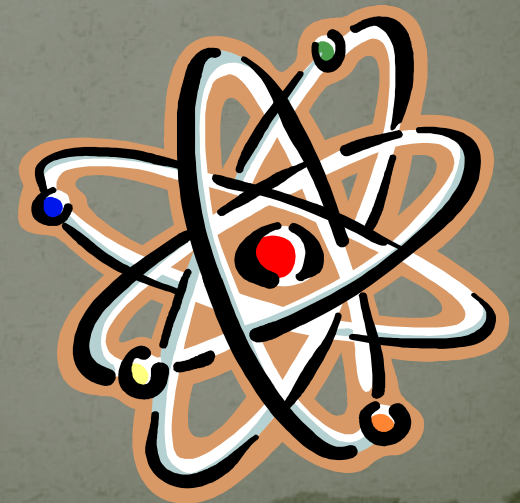


What About Cultivation or Tillage?



Chemical Properties of Soil

- ♦ Macronutrients and micronutrients
- ♦ Soil pH



Soil Nutrients

- Most of these are present in our “*native*” and “*dirty soils*” but may be absent or limiting in many of the “*manufactured soils*”
- These can also be found in compost or other more decomposed organic materials
- It's always wise to have your soils as well as any compost/ amendment tested to see what you have and what you may be adding*

Hierarchy of Elemental Nutritional Requirements for Plant Life

These basic nutrients are generally available to plants in sufficient quantities simply through air, soil, & water

BASIC NUTRIENTS



Primary macronutrients (NPK's) are the primary foci of most traditional fertilizer application programs.

PRIMARY MACRONUTRIENTS



Secondary macronutrients and micronutrients are often grouped together for classification and identification. While they are not generally the foci of fertilization programs, they are absolutely essential for successful and healthy plant growth.

SECONDARY MACRONUTRIENTS



While not widely considered to be essential components of plant nutrition, these elements are known to be required by certain plant types in certain environmental circumstances.

MICRONUTRIENTS



OTHERS



Color-Coding Key:
Elemental
Classifications

NONMETALS

ALKALI METALS

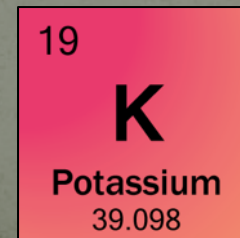
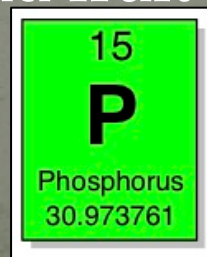
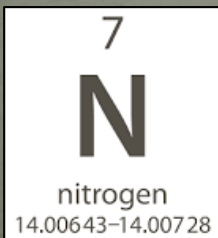
ALKALINE
EARTH METALS

POOR METALS

TRANSITION
METALS

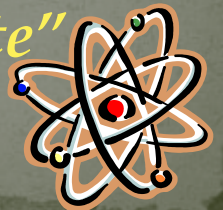
Role of Primary Macronutrients

- **Nitrogen** – Is a component of chlorophyll, vital to photosynthesis and plant growth. As organic matter in soil increases, nitrogen levels increase thru digestive process of soil microbes *“Growth”*
- **Phosphorus** – Development and transport of sugars and starches. *“Energy”*
- **Potassium** – Root development and nutrient uptake and distribution, flower and fruit development *“Circulation”*

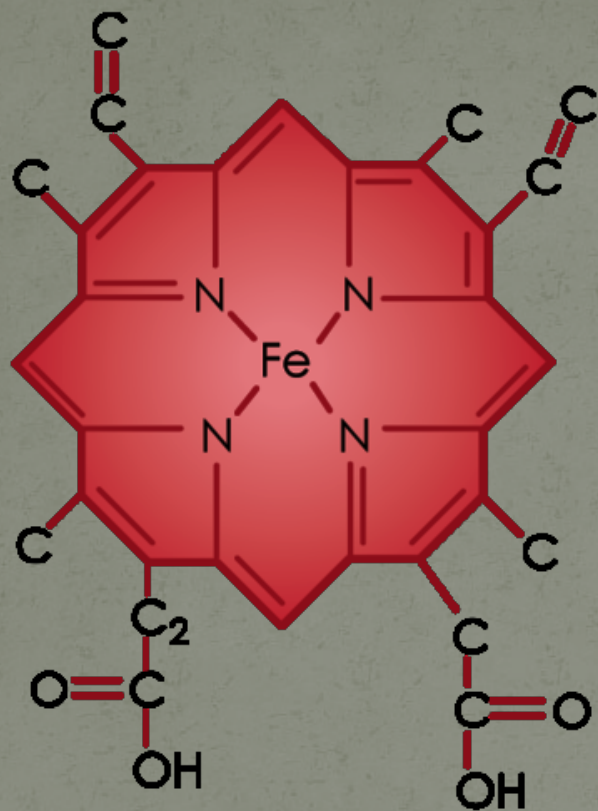


Role of Secondary Macronutrients

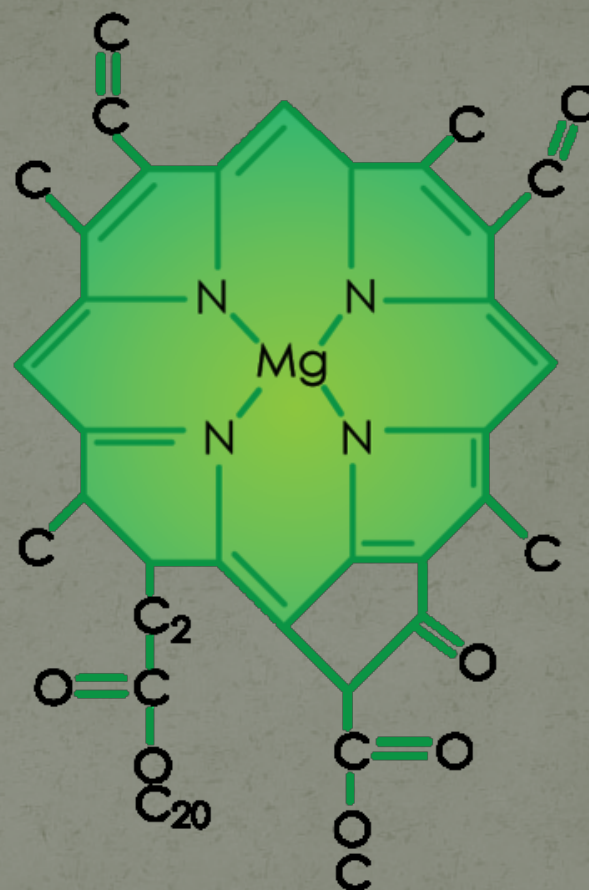
- **Calcium** – Cell wall development and provides physical barrier to plant diseases, and also affects fruit quality. *“Armor”*
- **Magnesium** – Chlorophyll development and formation of sugars, oils, and fats. *“Central Atom” in chlorophyll*
- **Sulfur** – Seed development and provides color and taste to many cruciferous crops, onions, garlic, mustards. As organic matter in soil increases, sulfur levels increase thru digestive process of soil microbes. *“Essence and Taste”*



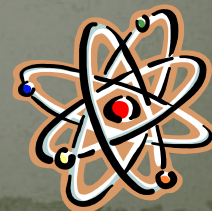
A Little Trivia For You!!!



Human Blood
Hemoglobin



Plant Chlorophyll



Boron (B)

- Helps in the use of nutrients and regulates other nutrients.
- Aids production of sugar and carbohydrates.
- Essential for seed and fruit development.
- Sources of boron are organic matter and borax

Copper (Cu)

- Important for reproductive growth.
- Aids in root metabolism and helps in the utilization of proteins.

Chloride (Cl)

- Aids plant metabolism.
- Chloride is found in the soil.

Iron (Fe)

- Essential for formation of chlorophyll.
- Sources of iron are the soil, iron sulfate, iron chelate.

Manganese (Mn)

- Functions with enzyme systems involved in breakdown of carbohydrates, and nitrogen metabolism.
- Soil is a source of manganese.

Molybdenum (Mo)

- Helps in the use of nitrogen
- Soil is a source of molybdenum.

Zinc (Zn)

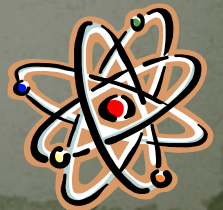
- Essential for the transformation of carbohydrates.
- Regulates consumption of sugars.
- Part of the enzyme systems which regulate plant growth.
- Sources of zinc are soil, zinc oxide, zinc sulfate, zinc chelate.

Micronutrients

Most of these essential micronutrients work in conjunction with each other as well as the macronutrients.

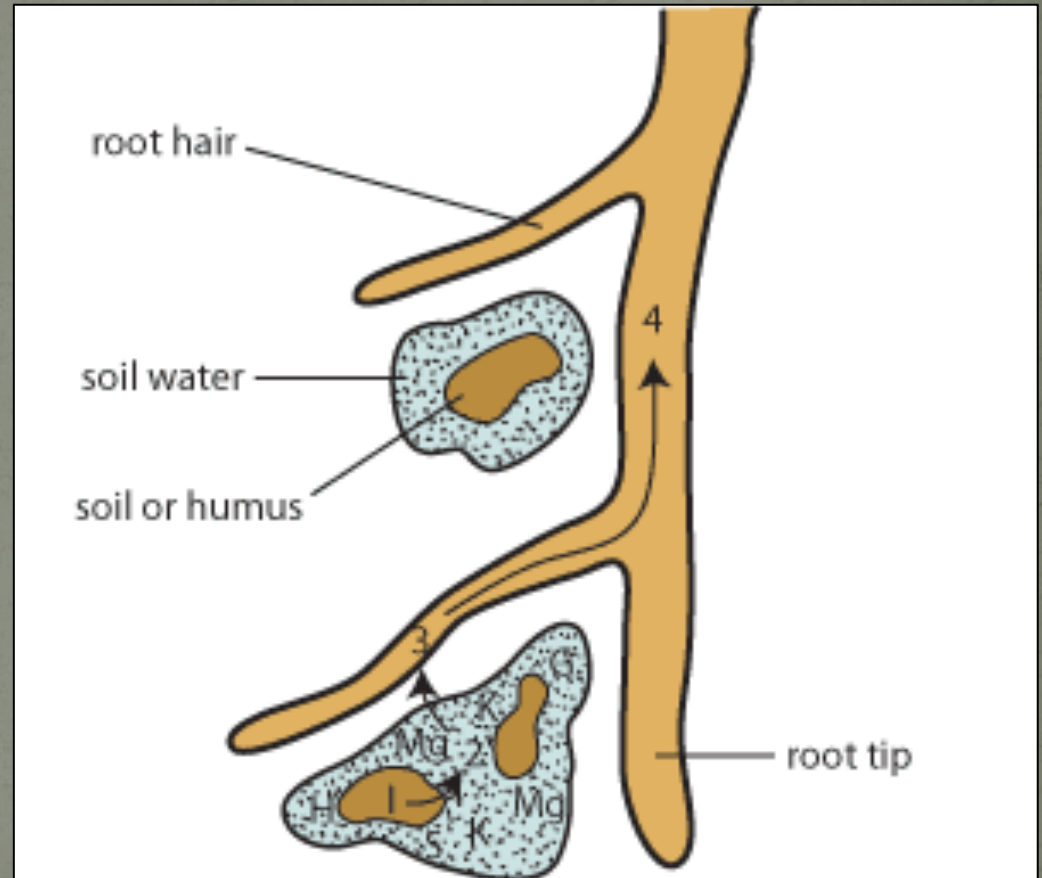
These can be “limiting factor” in some Native soils, and will not be “ingredients” found in your typical planting mix.

These are usually measured in most soil tests.



“Soil Solution”

- The water and dissolved (*soluble*) nutrients held between soil particles are known as the *Soil Solution*
- Nutrients must be in the soil solution for uptake by root hairs



Soil pH

Figure 1. Soil pH and Plant Growth

<u>Soil Reaction</u>	<u>pH</u>	<u>Plant Growth</u>
	>8.3	Too alkaline for most plants
	7.5	Iron availability becomes a problem on alkaline soils.
Alkaline soil	7.2	6.8 to 7.2 – “near neutral” 6.0 to 7.5 – acceptable for most plants
Neutral soil	7.0	
Acid soil	6.8	
	6.0	
	5.5	Reduced soil microbial activity
	<4.6	Too acid for most plants

- Soil pH is a measurement of the acidity or alkalinity of the *soil solution*.
- On the pH scale, 7.0 is neutral.
- Below 6.8 is acidic, and above 7.2 is alkaline.
- A pH range of 6.8 to 7.2 is termed *near neutral*.

Source: **CMG**
GardenNotes #222
Soil pH

Soil pH and Nutrient Availability

- Soil pH is an important chemical property because it affects the availability of nutrients to plants and the activity of soil microorganisms



The screenshot shows a webpage from Colorado State University Extension. The header features a close-up image of pink roses and the text 'Colorado State University Extension' and 'CMG GardenNotes'. Below the header, it says 'Colorado Master Gardener Program | Yard and Garden Publications | CMG GardenNotes #222'. The main title is 'Soil pH' with a 'Print this CMG GardenNotes' button. An 'Outline' section lists: 'pH', 'pH and nutrient availability', 'Managing alkaline soils' (with a sub-item 'Lowering the pH'), 'Raising the pH on acid soils', and 'Home pH test kits'. The main text explains that pH is a measurement of soil acidity or alkalinity, with 7.0 being neutral. It notes that areas with limited rainfall have alkaline soils, while areas with higher rainfall have acid soils. It also states that in Colorado, most soils are alkaline (pH 7.0-7.8) and have high calcium carbonate content, known as 'free lime'. Finally, it mentions that many gardening books list preferred pH for plants (6.0-7.2), but most garden and landscape plants tolerate a pH up to 7.5-7.8 with little problem.

✓ Information on how to raise or lower your soil pH can be found in our CMG GardenNotes

Source: *CMG GardenNotes*
#222 Soil pH

The Influence of Soil pH on Nutrient Availability

4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0

RANGE OF ACIDITY

RANGE OF ALKALINITY

NITROGEN

PHOSPHORUS

POTASSIUM

SULFUR

CALCIUM

MAGNESIUM

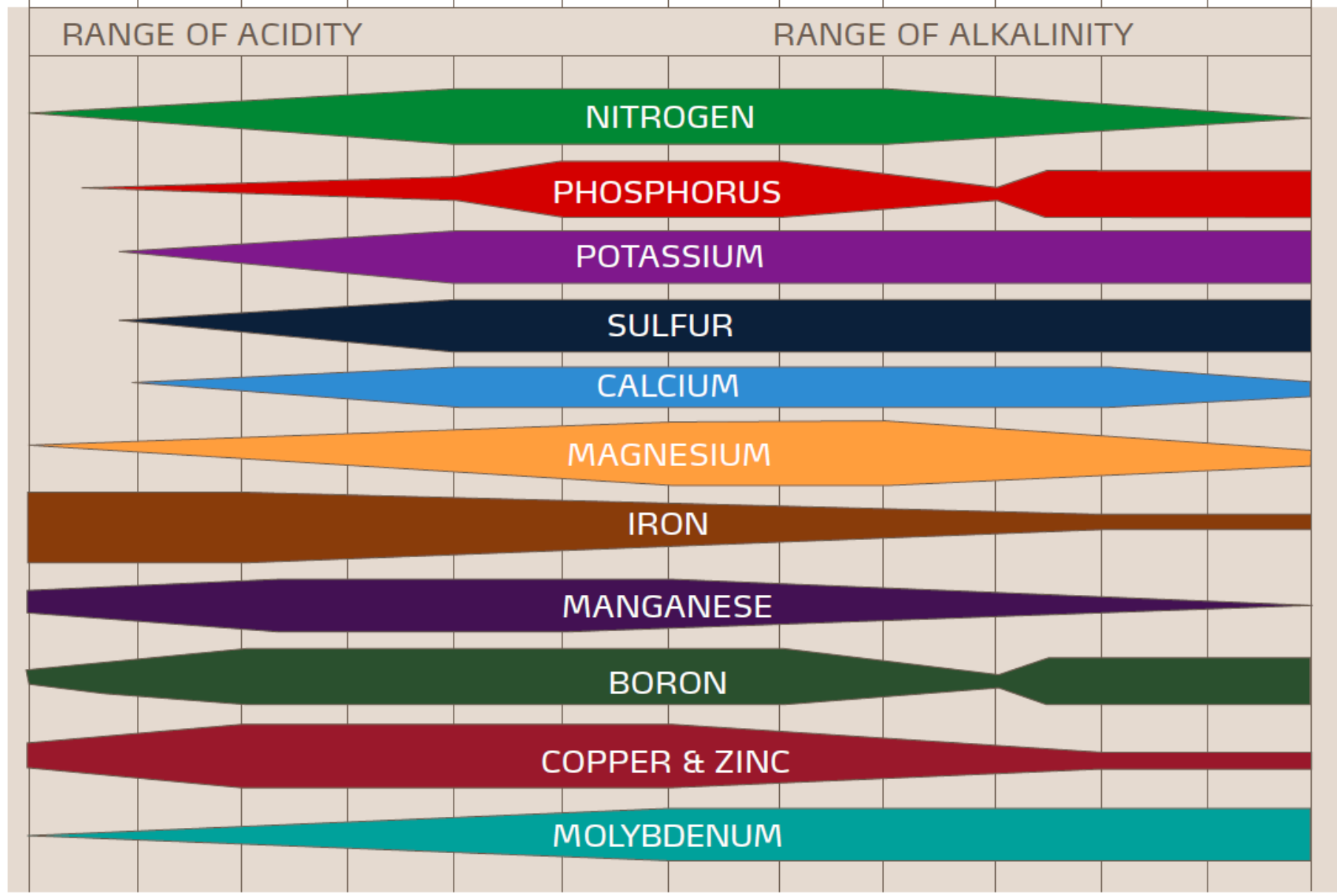
IRON

MANGANESE

BORON

COPPER & ZINC

MOLYBDENUM



Soil pH Kits



Color Test Kits



Meters and Probes - \$\$\$\$

Quick and Easy Soil pH Test



Use general purpose pH strips (litmus paper)

Mix soil and distilled water (pH 7.0) as an equal portion **1:1 paste** in a plastic container – *not metal!!!*

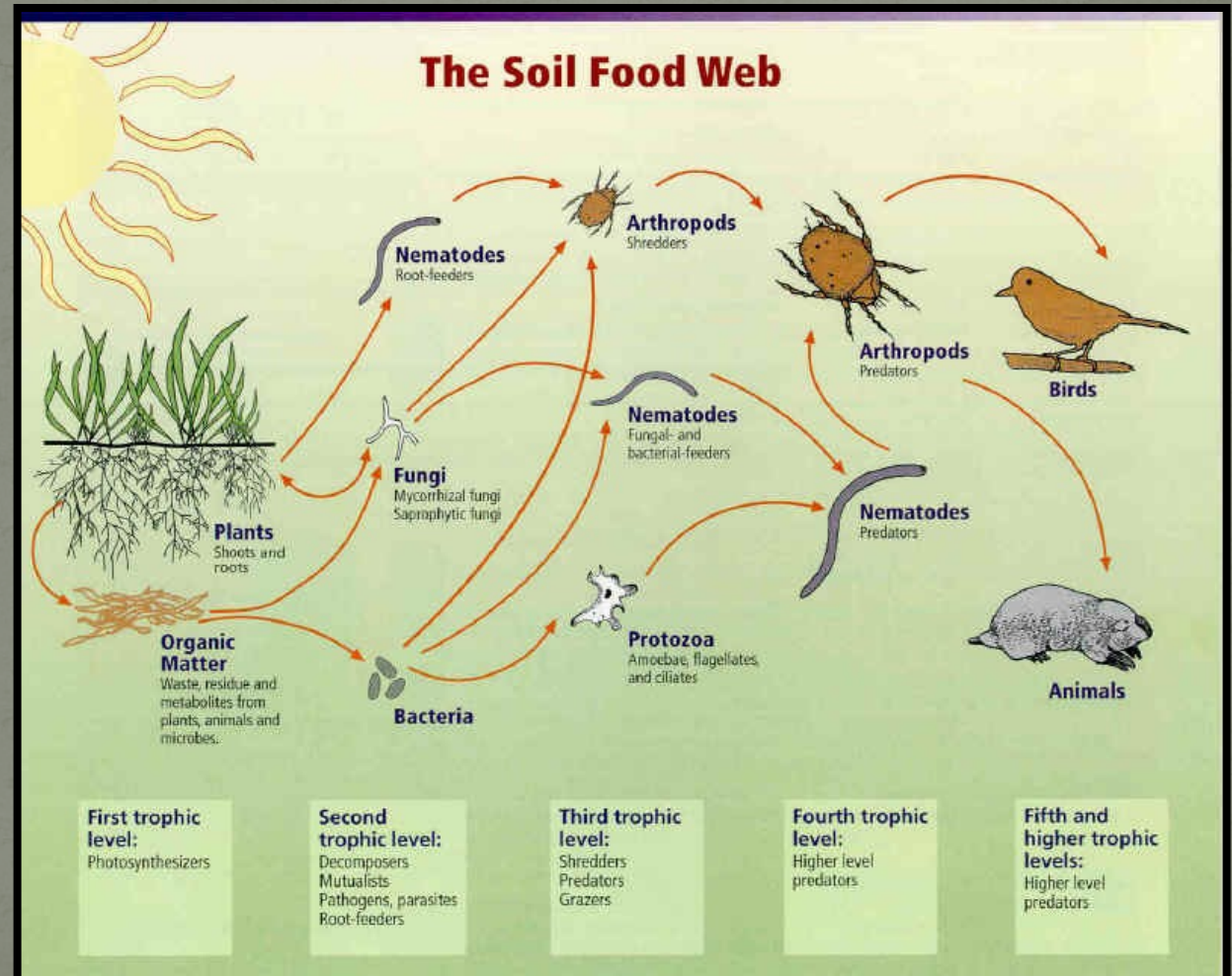


Match color to the provided chart

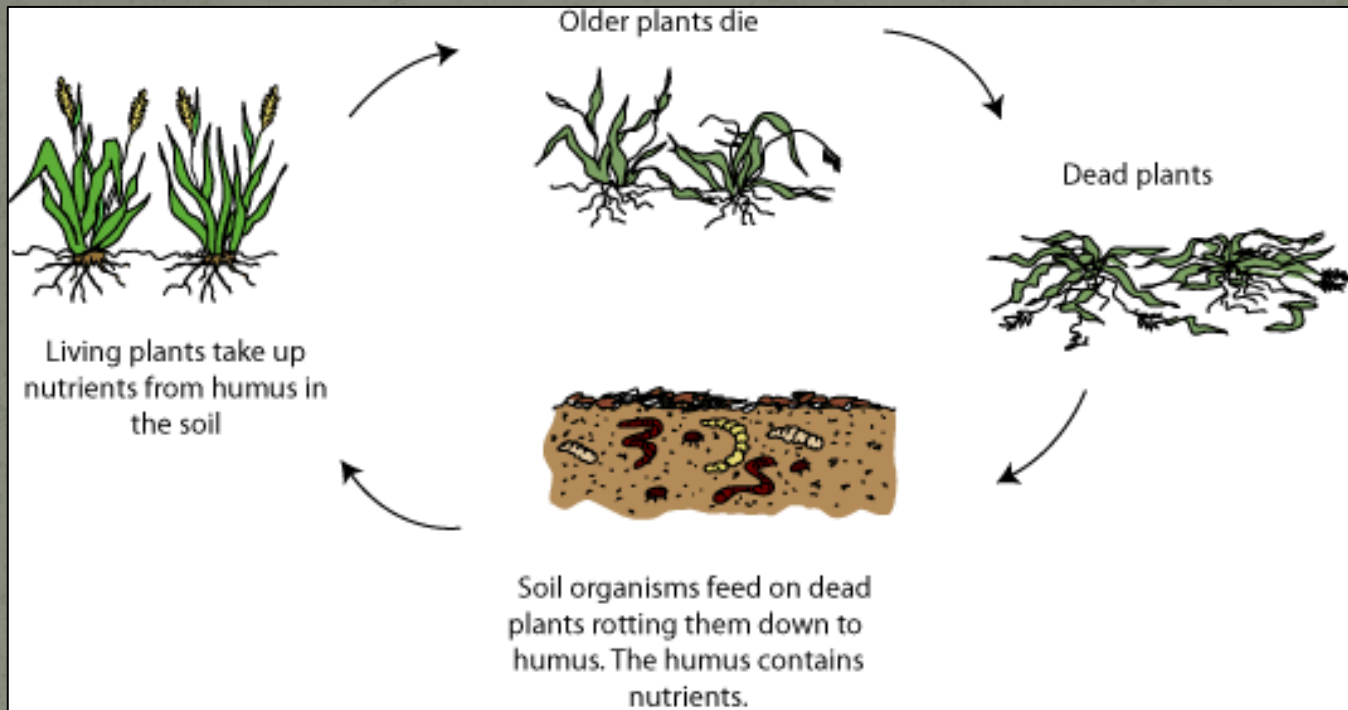
Calibrate with lemon juice or vinegar (pH 2.0 – 3.0)

Biological Properties of Soil

Soil Biota

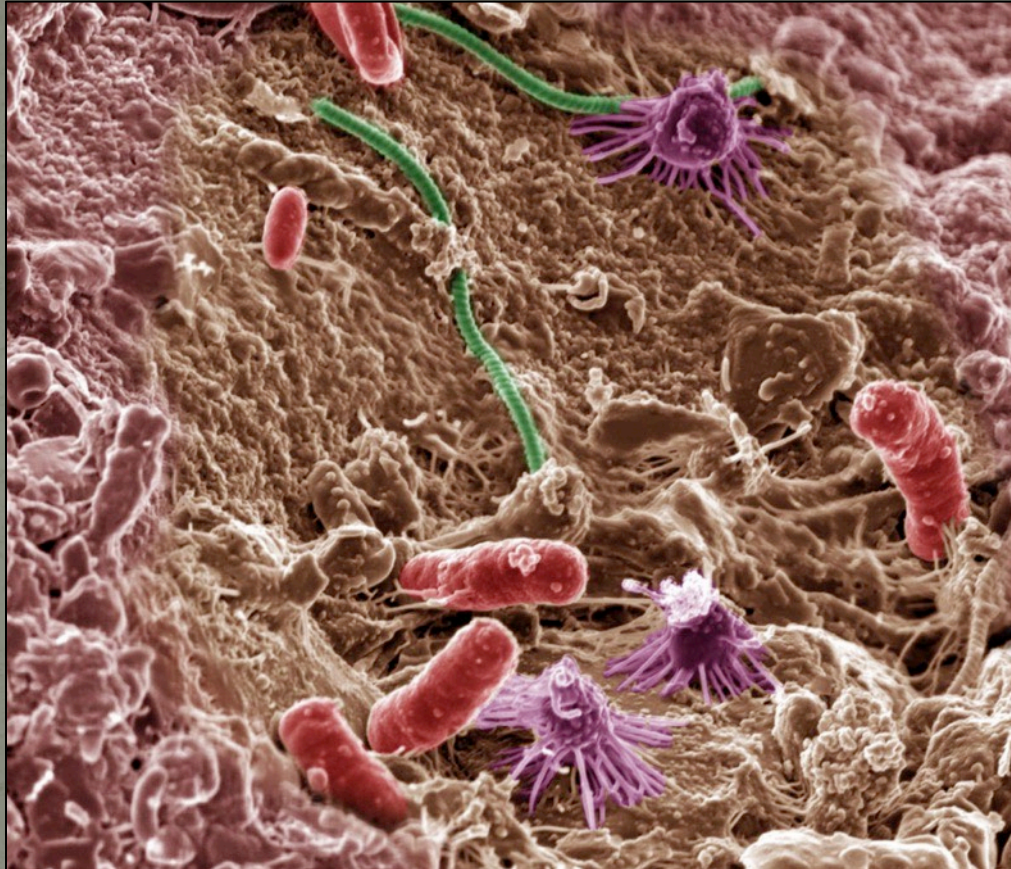


Organic Matter Decomposition → Humus



Feed Your Soil

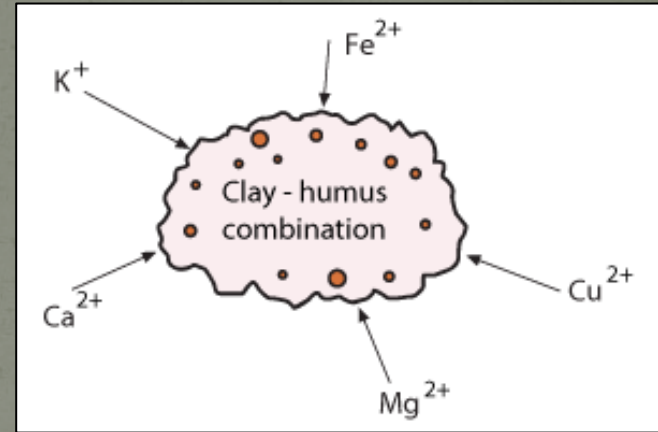
Organic Matter Decomposition → Humus



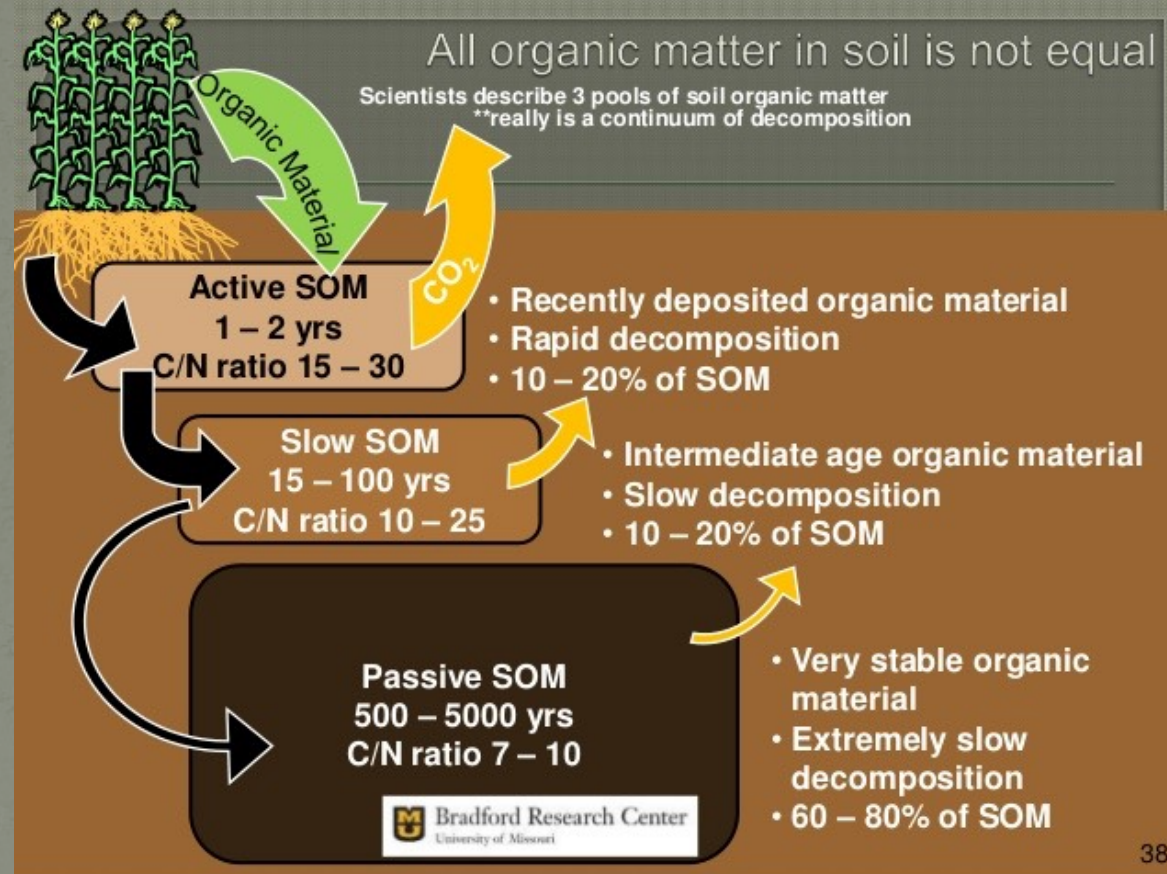
Feed Your Soil To Feed Your Plants!!!

Build Your Humus – *Improve Your Soil!*

- Binds soil particles to improve soil structure
- Has high water holding capacity
- Helps store nutrients
- Improves plant growth
- Serves as a food source for other soil micro-organisms
- *“Black Gold for the Gardener”*

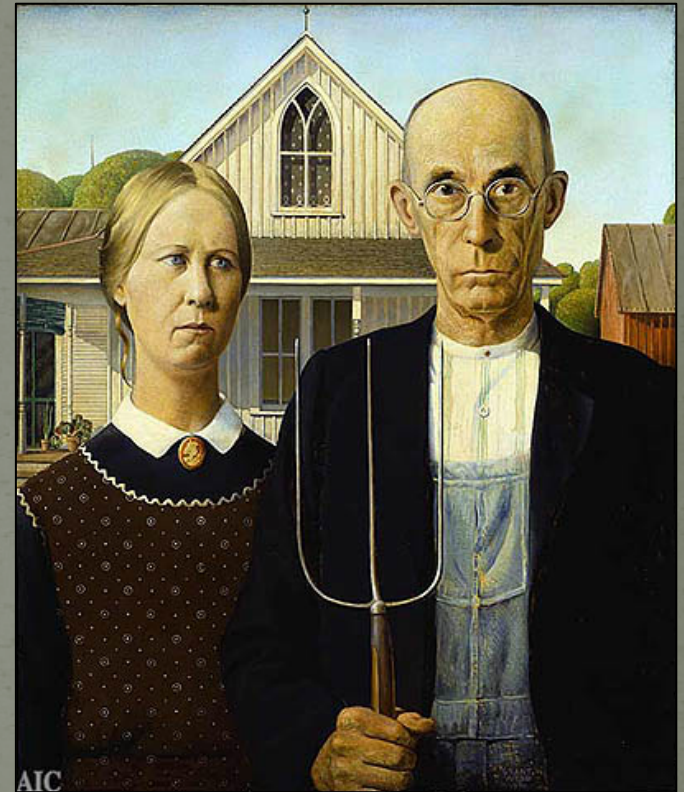


Organic Matter Decomposition Timeline



Traditions and Soil Management

- Fertilization
- Soil Amendments

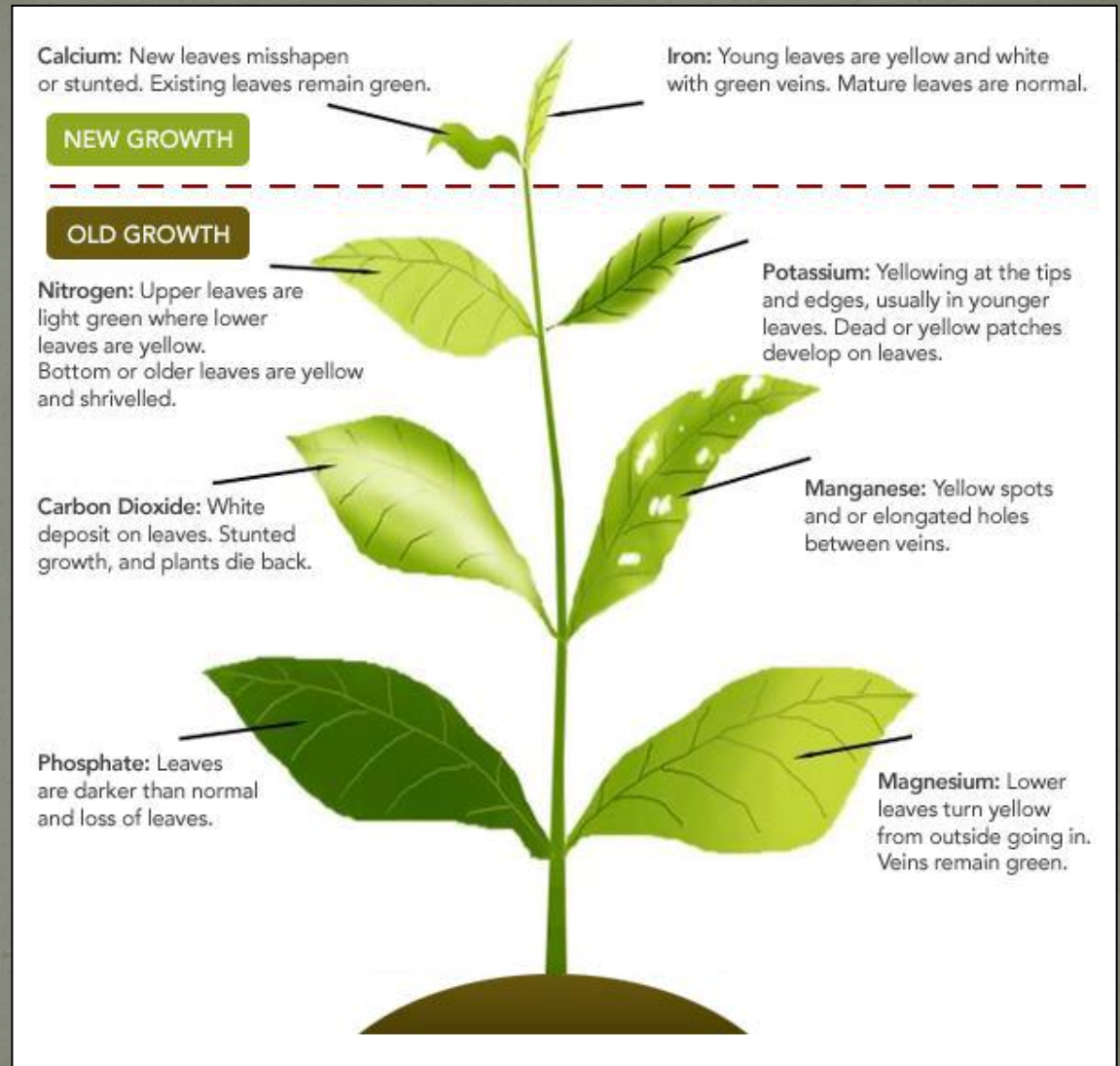


How Do I Know If I Even Need to Fertilize or Amend My Soil?

- Observed poor plant vigor and quality from previous growing season (stunted growth, yellowing of leaves, poor bloom or fruit development, blossom end-rot, etc.)
- Ask yourself – *“When was the last time I fertilized or amended my soil and what did I apply, and why did I do it, and did it work ???”*
- Soil Laboratory Analysis – Strongly Advised !!!!!!!!!!!!!

How Do I Know If I Even Need to Fertilize or Amend My Soil?

■ Visual Indicators (very subjective)



Have your Soil and Compost Tested to See What You Have

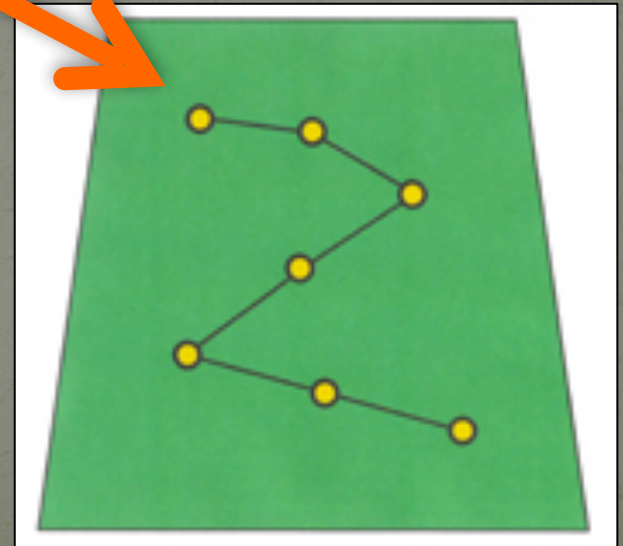
- Soil should be tested every 4-8 yrs.
- Test individual garden beds separately
- Compost should be tested if you change your “recipe” or source

<u>PLEASE CHECK ANALYSES REQUESTED</u>	Price per Sample
<u>Routine Garden and Landscape soil test</u> (pH, EC, organic matter, nitrate, phosphorus, potassium, zinc, iron, copper manganese, boron and lime & texture estimates) <i>(This is a basic evaluation for characterizing the soil fertility status for growing lawns, gardens and topsoil. Normally this test is sufficient unless a special problem is suspected.)</i>	\$35.00
<u>Manure, Compost and Potting Soil analyses (For soil amendments only)</u> (pH, EC, organic matter, ammonium, nitrate, phosphorus, potassium, zinc, iron, copper, manganese, % lime, dry matter, C:N ratio, Total N)	\$48.00
<u>Routine + Texture analysis by hydrometer</u> <i>(This analysis accurately measures the percent sand, silt, and clay of the soil to help manage plant growing conditions.)</i>	add \$13.00
<u>Routine + Sodium Evaluation (SAR)</u> <i>(Sodium Adsorption Ratio is the ratio of sodium to calcium + magnesium. Some Colorado soils contain excess sodium. This test determines whether or not chemical amendments such as gypsum or sulfur will be effective to reclaim the site and determines the amounts of these materials needed.)</i>	add \$7.00
<u>Routine + Chromium, Molybdenum, Cadmium, Lead</u> <i>(In some situations, such as near mining sites or with applications of biosolids such as sewage sludge, these metals may be found at toxic levels in the soil.)</i>	add \$10.00
<u>Routine + C/N ratio</u> <i>(The C/N ratio helps determine the fertilizer N recommendation for a soil that has had high rates of compost or manure applied to it.)</i>	add \$28.00
MINIMUM CHARGE	\$15.00
<i>NOTE: A 25% discount coupon for rerun analyses will be included with your test results. For special issues and problems, a soil specialist is available for an individual phone or email consultation (approx. 1 hr) at the cost of \$50.00.</i>	
<i>Soil, Water & Plant Testing Lab, Campus Delivery 1120 Room A-320 NESB, Fort Collins CO 80523-1120 Revised 2-20-2018</i>	

Source: **CMG**
GardenNotes #221,
Soil Tests

Identify Your Garden Soil Management Units

- Treat your individual garden beds as separate *“Soil Management Units”* and sample and test them accordingly, and document lab results over time



Source: *CMG*
GardenNotes #221,
Soil Tests

What Is A Soil Amendment?

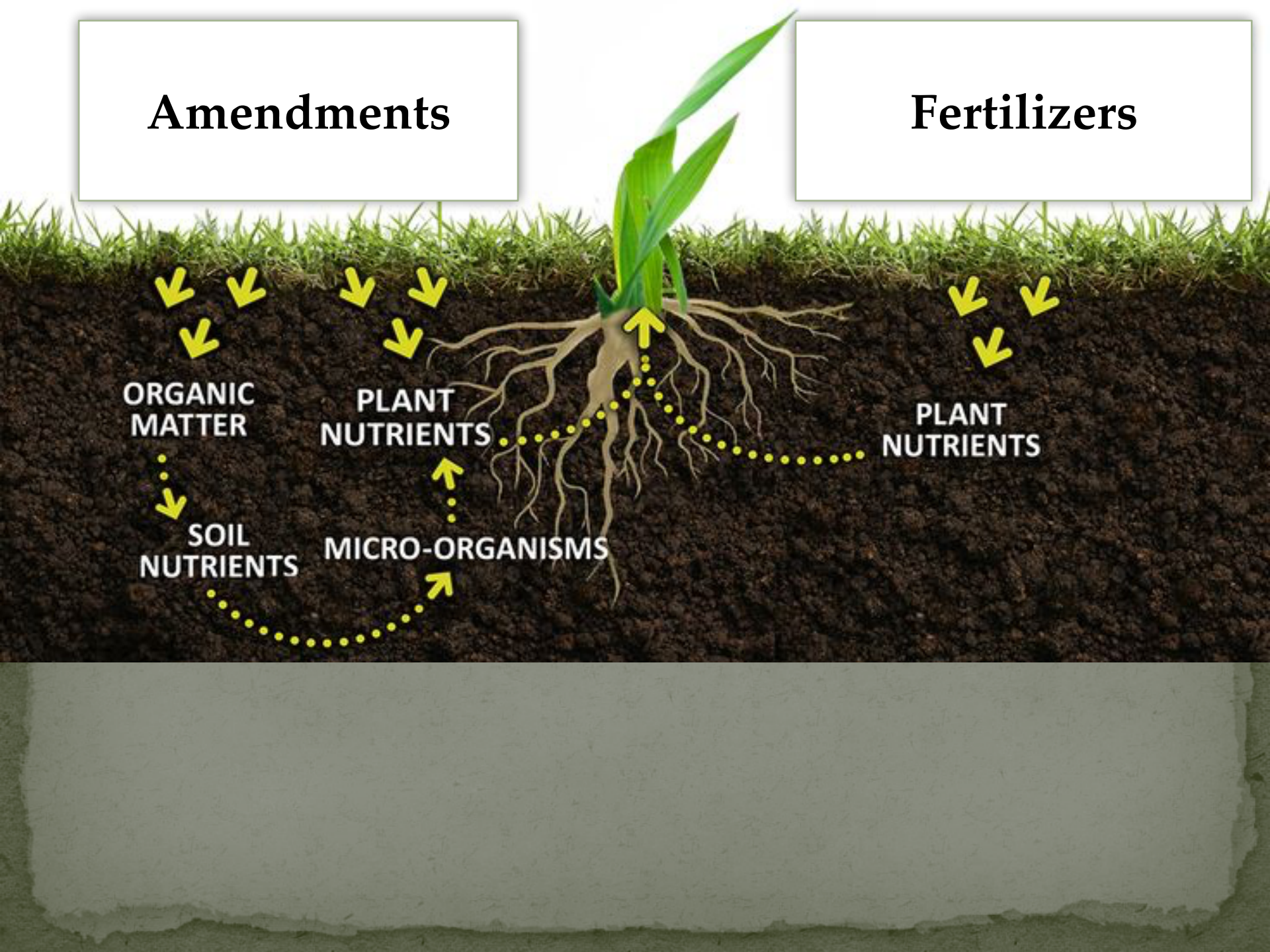
Any material mixed into a soil to improve its “ability to function”, such as regulating water flow and retention, storing and cycling valuable nutrients, and sustaining plant and animal life above and below the soil surface.

What's the Difference Between an Amendment and a Fertilizer?

- **Amendments** *“feed the soil”* (worm castings, compost, humus, perlite, etc.) to improve soil function and the physical, chemical, and biological properties, and are usually unregulated.
- **Fertilizers** *“feed the plant”* and by law, need to document their elemental analysis and source following approved labeling requirements. These also tend to be “plant specific”

Amendments

Fertilizers



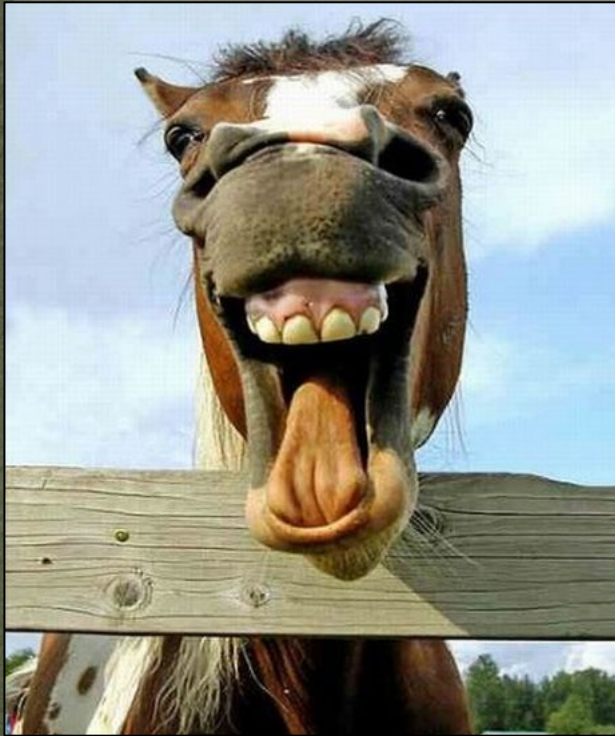
Soil Amendments

- **Organic Amendments** – The source of these were previously “alive”, or in some cases, “still alive”
- **Inorganic Amendments** – The source of these were either mined from the earth, or man-made

Organic Soil Amendments

- Animal Manure (horse, cow, chicken, sheep, goat, bat, etc.)
- Green Manure
- Compost and/or Compost Tea
- Worm Castings and/or Worm Casting Tea
- Peat Moss
- Coir (coconut husk by-product)
- Lawn Clippings
- Leaf Mold
- Bone Meal
- Blood Meal
- Alfalfa Meal
- Cottonseed Meal
- Kelp Meal
- *Wood Ash/Wood Chips*

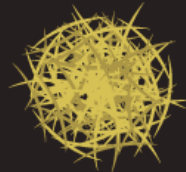
Manure and Compost



Carbon & Nitrogen

Sources for Compost

Carbon Materials

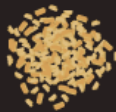


Aged Hay

Oat Hay



Cardboard



Dry, Shredded Leaves

Sawdust



Chipped Wood



Newspaper

Cardboard Egg Cartons

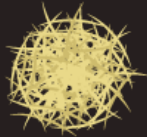


Wrapping Paper

Paper Towels



Straw



Toilet Paper Rolls

Wood Ash (not coal)

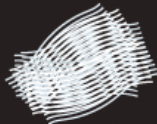


Dried Grass

Shredded Paper



100% Cotton Fabrics
(small pieces)



Nitrogen Materials

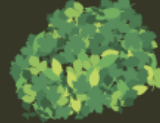


Vegetable Trimmings

Algae



Green Leaves



Grass Clippings

Kelp or Seaweed



Green Shrub Prunings

Tea Bags



Alfalfa Meal/Hay



Coffee Grounds/Filter

Animal Manure (herbivores only)



Houseplants

Weeds
(without seed heads)

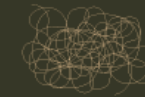


Old Flower Bouquets



Human/Animal Hair

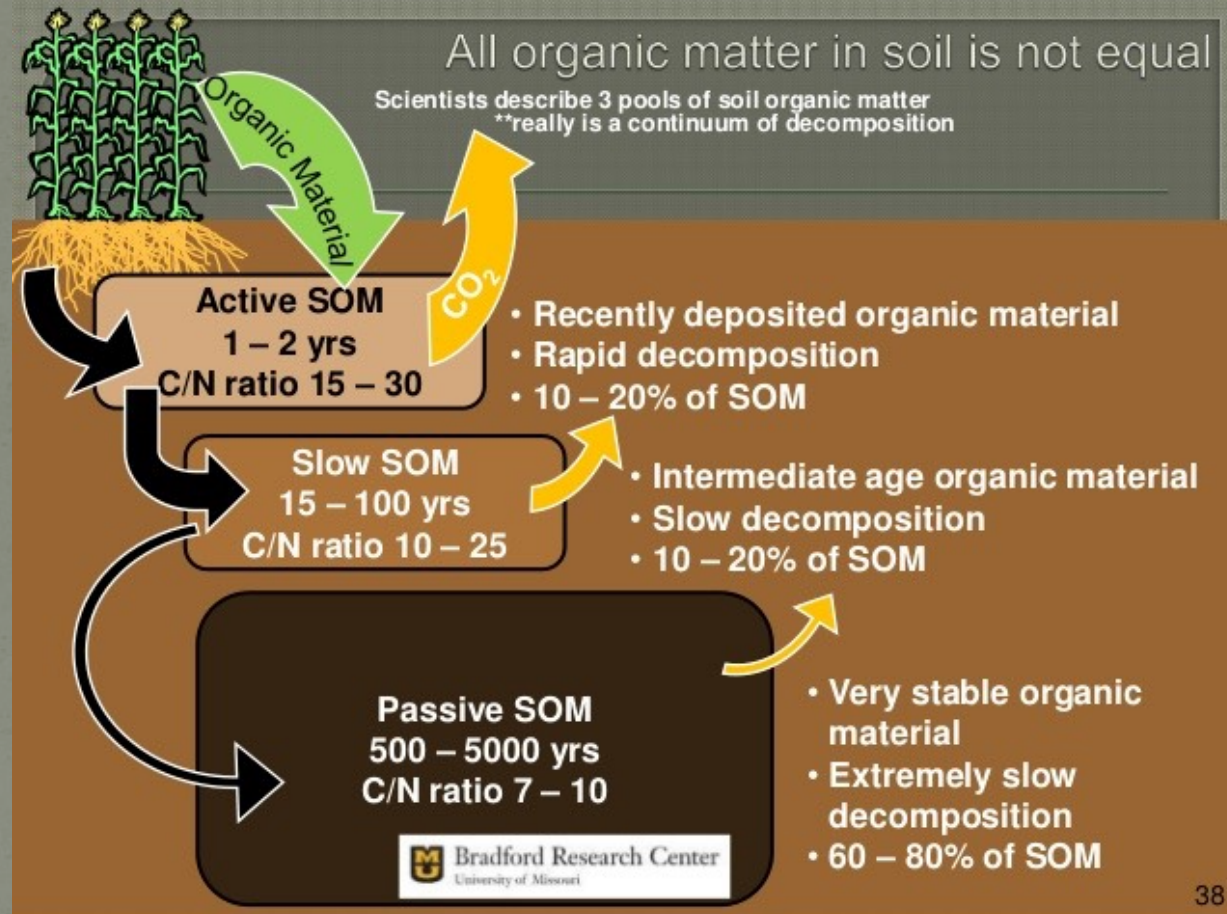
Aquarium Water
(freshwater only)



Carbon/Nitrogen Ratio

- Soil organisms need carbon for building essential organic compounds and to obtain energy
- They need nitrogen to synthesize nitrogen-containing cellular components such as amino acids, enzymes and DNA.
- Microbes need 1 g of N for every 24 g of C in their food
- Higher than 25:1 – not enough nitrogen so 1) microbes take from plant supply, 2) decay delayed because microbes can't survive

Organic Matter Decomposition Timeline



Other Organic Soil Amendments

Humates

“Dinosaur Compost”

Passive Soil Organic Matter

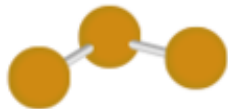
Occur as a coal –like organic deposit (*Leonardite, Humalite*) and is mined and then processed into a granular or liquid form

Also contains other beneficial macro and micronutrients such as Sulfur, Iron, Magnesium, *etc.*



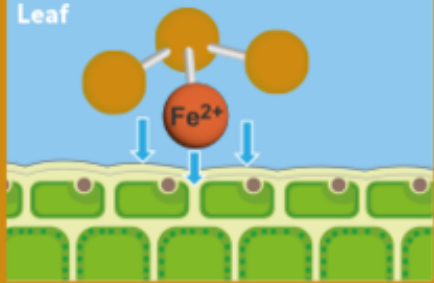
Humates

Fulvic Acid - Soluble

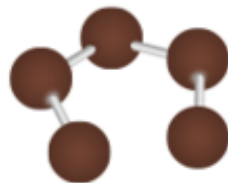


Chelator

Leaf

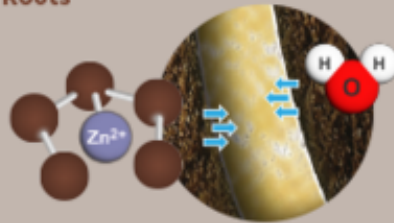


Humic Acid - Soluble



Nutrient Carrier

Roots

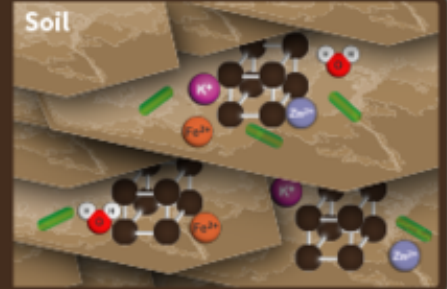


Humins - Insoluble



Flocculator, Bacteria Habitat
and Cation Exchange Sites

Soil



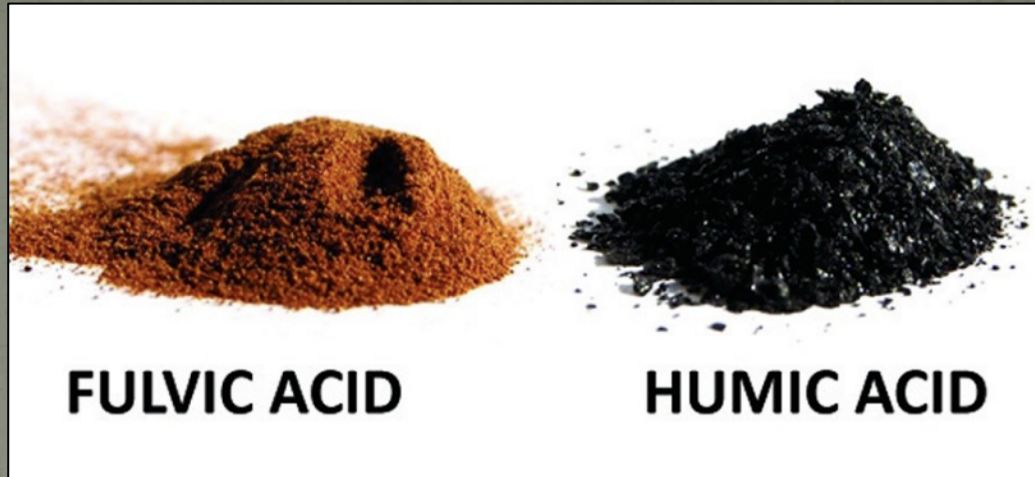
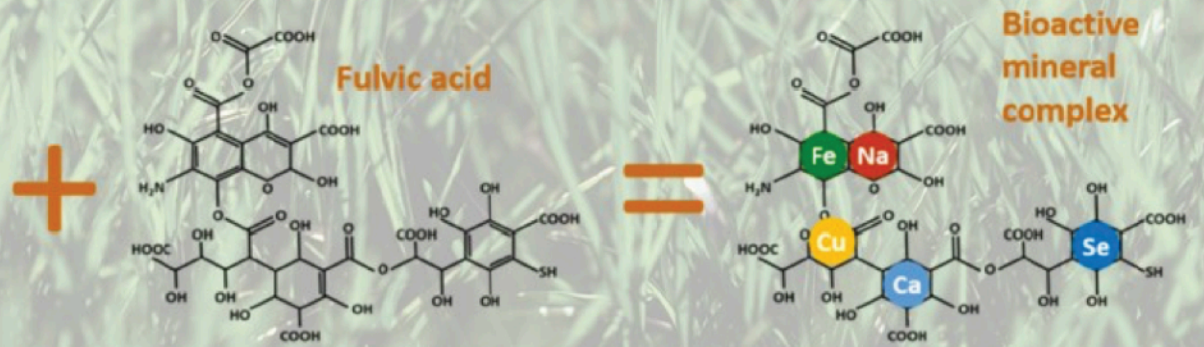


Figure 4



Chelation – “Grabbing and Holding of Soil Nutrients In a Chemical Compound To Facilitate Their Adsorption By Roots and Leaf Surface”-

Other Organic Soil Amendments

Humates



Humate
Organic Granular Soil Conditioner

TRI-C

CONTAINS NON PLANT FOOD INGREDIENT:
40% Humic Acids derived from leonardite

Application Rates

SOIL PREPARATION: 4 – 6 inch depth 50 lbs per 1,000 sq ft = 2220 lbs per Acre 2 – 4 inch depth 40 lbs per 1,000 sq ft = 1760 lbs per Acre	MAINTENANCE: 60 Day Post Construction: 5 lbs per 1,000 sq ft or 220 lbs per Acre								
BULK MIXES (e.g. backfill, horticultural mix, etc.): 3 lbs per cubic yard mix with a mix of HIGH % organic material 4-5 lbs per cubic yard mix with a mix of LOW % organic material <small>*note: such as sand or backfill mix of 70-80% heavy native soil</small>	TURF: 2-3 times per year 10 lbs per 1,000 sq ft								
HYDROSEEDING/AGRICULTURE: 400-500 lbs per Acre in hydroseeding slurry 500-600 lbs per Acre for crop application	CONTAINERS/POTS <table border="0"><tr><td>Rates: 4" POT</td><td>1/4 TSP.</td></tr><tr><td>8" 1 GAL CAN</td><td>1 TSP.</td></tr><tr><td>5 GAL CAN</td><td>1 TBL.</td></tr><tr><td>15 GAL CAN</td><td>3 TBL.</td></tr></table>	Rates: 4" POT	1/4 TSP.	8" 1 GAL CAN	1 TSP.	5 GAL CAN	1 TBL.	15 GAL CAN	3 TBL.
Rates: 4" POT	1/4 TSP.								
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15 GAL CAN	3 TBL.								

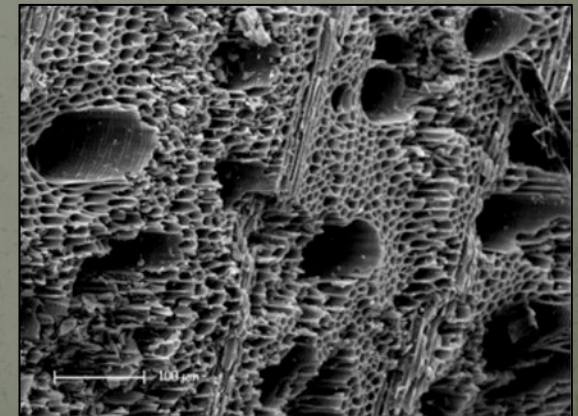
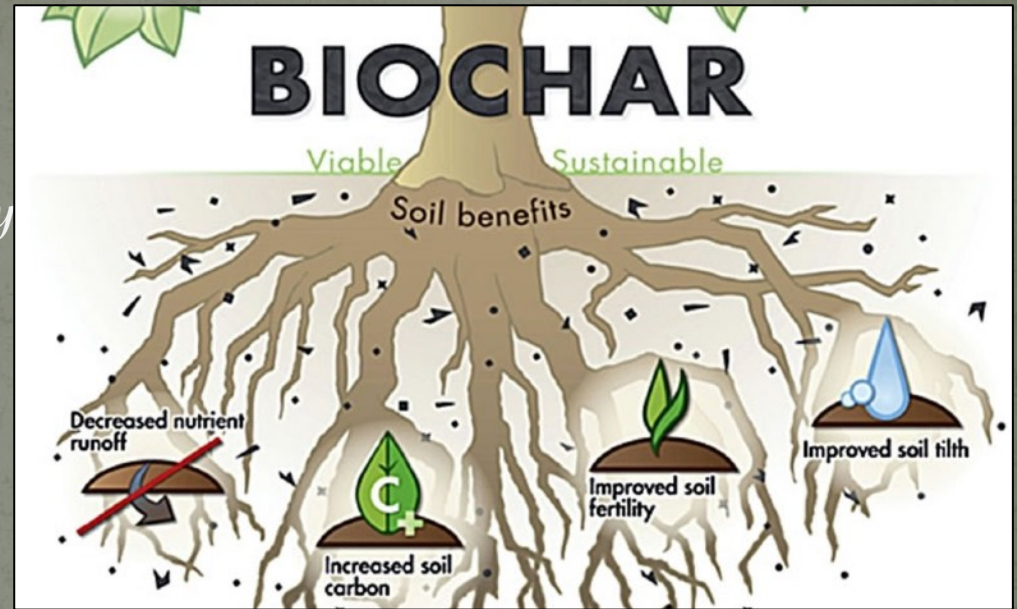
****DIRECTIONS:**

1. Aeration prior to application will enhance response of organic based soil conditioner.
2. Slightly increase irrigation 1-2 days after application, then resume normal schedule.

Other Organic Soil Amendments

BioChar

- *Organic matter that is burned very slowly under low oxygen conditions to yield that yields a product with “sponge-like” qualities – “Activated Charcoal”*
- *Stimulates growth and development of beneficial soil fungi*
- *Greatly improves nutrient and water storage capacity and soil tilth*
- *Works best when used in conjunction with composted manures and other amendments*



Other Organic Soil Amendments

BioChar – Terra Preta (Dark Earth)

- *A practice used by indigenous people of the Amazonian Basin prior to European arrival to improve the productivity of their inherently poor quality tropical soils, allowing them to grow specialty crops such as melon, squash, corn, etc.*
- *“Biochar” was mixed with animal manures, broken clay pots, and human urine, and added to the soil as an amendment that improved the soil biological community, nutrient cycling, and water retention*
- *Early “Dirt Whisperers” !!!!!*



Other Organic Soil Amendments

- *Soil MicroBiotics*
- *Similar in function to the probiotics human take, these help the “soil digestive process” and improve nutrient cycling, availability and uptake by plant roots.*
- *Great for use with planting mix in container gardens !!!*



TRULY ADVANCING BIOTICS

1990
ProBiotic®
*Beneficial soil microbes
plus Mycorrhizae*

16 >>>>>>>>

2016
TruBiotic®
*Beneficial soil microbes
plus Mycorrhizae*

NON-PLANT FOOD INGREDIENTS:	Propagules / cc		
Bacillus subtilis.....	1430	<p>Greater Microbial Adaptability</p> <p>Greater Biological Biodiversity</p> <p>Greater Genetic Variation</p> <p>Greater Population Dynamics</p> <p>Greater Biotic Potential</p> <p style="color: yellow; font-weight: bold; font-size: 1.2em;">Greater Results!</p>	
Bacillus cereus.....	1430		
Bacillus megaterium.....	1430		
Azotobacter vinelandi.....	.75		
Lactobacillus acidophilus.....	1430		
Rhizobium japonicum.....	750		
Aspergillus oryzae.....	.75		
MYCORRHIZAE:			
<i>Ectomycorrhizae</i>			
Pisolithus tinctorius.....	211,864		
Rhizopogon villosuli.....	5,296		
Rhizopogon luteolus.....	5,296		
Rhizopogon amylopogon.....	5,296		
Rhizopogon fulvigleba.....	5,296		
<i>Endomycorrhizae (VAM)</i>			
Glomus intraradices.....	.42		
Glomus mosseae.....	.42		
Glomus aggregatum.....	.42		

NON-PLANT FOOD INGREDIENTS:	Colony Forming Units (CFU) / gram		
Bacillus amyloliquefaciens.....	3,500,000	<p>Greater Microbial Adaptability</p> <p>Greater Biological Biodiversity</p> <p>Greater Genetic Variation</p> <p>Greater Population Dynamics</p> <p>Greater Biotic Potential</p> <p style="color: yellow; font-weight: bold; font-size: 1.2em;">Greater Results!</p>	
Bacillus licheniformis.....	3,500,000		
Bacillus megaterium.....	1,250,000		
Bacillus pumilus.....	1,250,000		
Bacillus subtilis.....	1,250,000		
MYCORRHIZAE:			
<i>Endomycorrhizae (VAM):</i>			
Glomus aggregatum.....	.16		
Glomus clarum.....	.16		
Glomus deserticola.....	.16		
Glomus etunicatum.....	.16		
Glomus intraradices.....	.16		
Glomus mosseae.....	.16		
Glomus monosporum.....	.16		
Paraglomus brasilianum.....	.16		
Gigaspora margarita.....	.16		
<i>Ectomycorrhizae:</i>			
Laccaria laccata.....	37.12		
Laccaria bicolor.....	37.12		
Pisolithus tinctorius.....	1,485		
Rhizopogon villosulus.....	37.12		
Rhizopogon luteolus.....	37.12		
Rhizopogon amylopogon.....	37.12		
Rhizopogon fulvigleba.....	37.12		
Sclerotium cepa.....	74.25		
Sclerotium citrinum.....	74.25		

Soil Trivia - *Earthworms*



- Are a major contributor to soil health by aerating and cultivating the soil and adding decomposed organic matter and nutrients back into the soil thru their digestive system
- *On average, earthworms occurring in an acre can digest 15 tons of soil in a year providing valuable humus that in turn feeds other organisms!*
- *“Earth’s Intestines” – Leonardo DaVinci*

WORM CASTINGS

ARE A "MIRACLE" SOIL CONDITIONER

SAFE FOR KIDS AND PETS

Unlike Chemical Fertilizers, Worm Castings are completely non-toxic and won't hurt animals or people.

INCREASES SOIL FERTILITY

Better seed germination. More flower and fruit production.

INCREASES YIELD

Plants, Fruit and Flowers grow bigger with worm castings.

NO ODOR

castings smells like dirt.

NON TOXIC

Unlike Chemical Fertilizers which are made from Natural Gas, Worm castings are 100% natural and non-toxic.

WILL NOT BURN PLANTS

Unlike Chemical Fertilizers, Worm Castings will not burn plants or harm soil at ANY level.

SAFE FOR THE ENVIRONMENT

Unlike Chemical Fertilizers, worm castings do not destroy the water table or environment.

INCREASES AERATION

Castings add organic matter in to the soil improving air flow in the soil.

SAVES WATER

Worm Castings help the soil retain water meaning you can water them less saving water.

BENEFICIAL MICROBES

Worm castings add beneficial microbes to the soil that destroy bad microbes helping keep the plants and soil healthy.

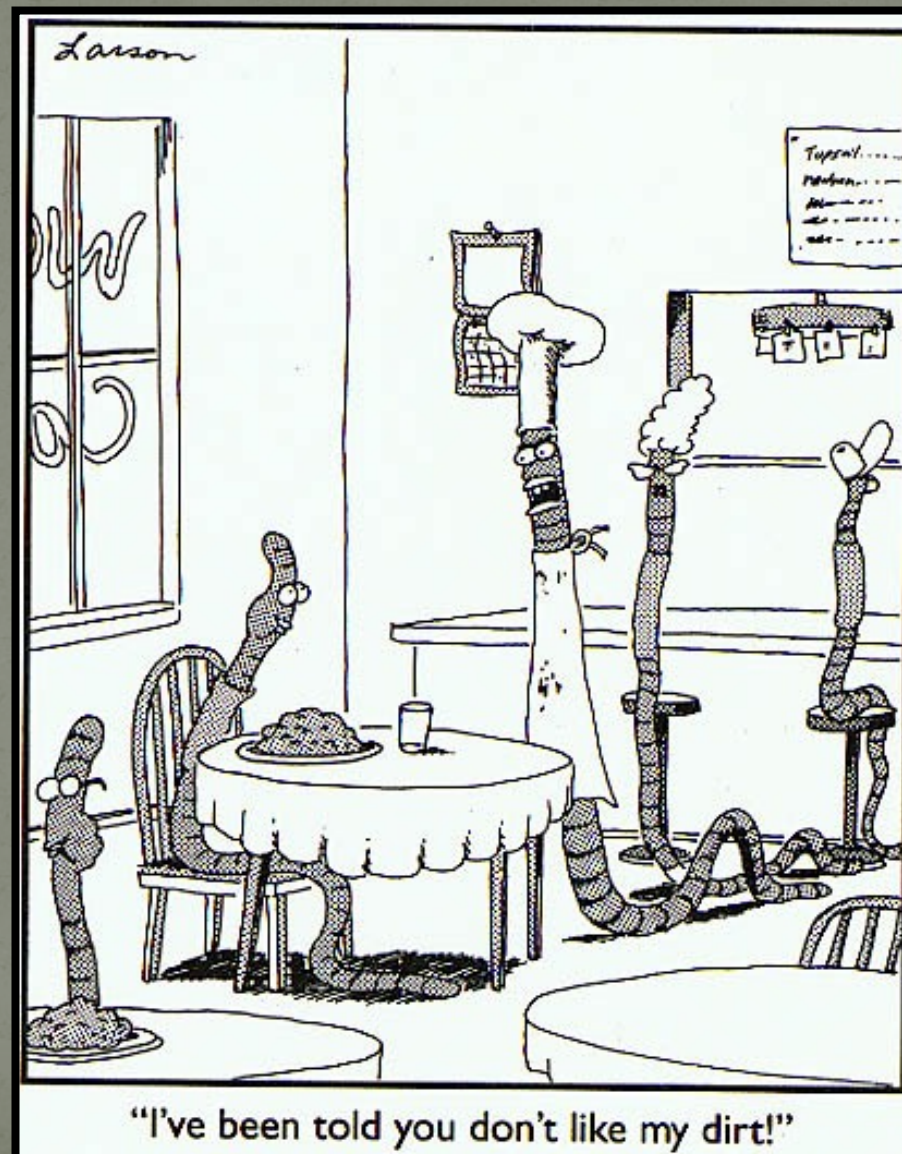
Infographic Produced by BioSoil Farm (www.BioSoil.farm)
2016 Copyright Chad Currin & BioSoil Farm

BioSoil Farm



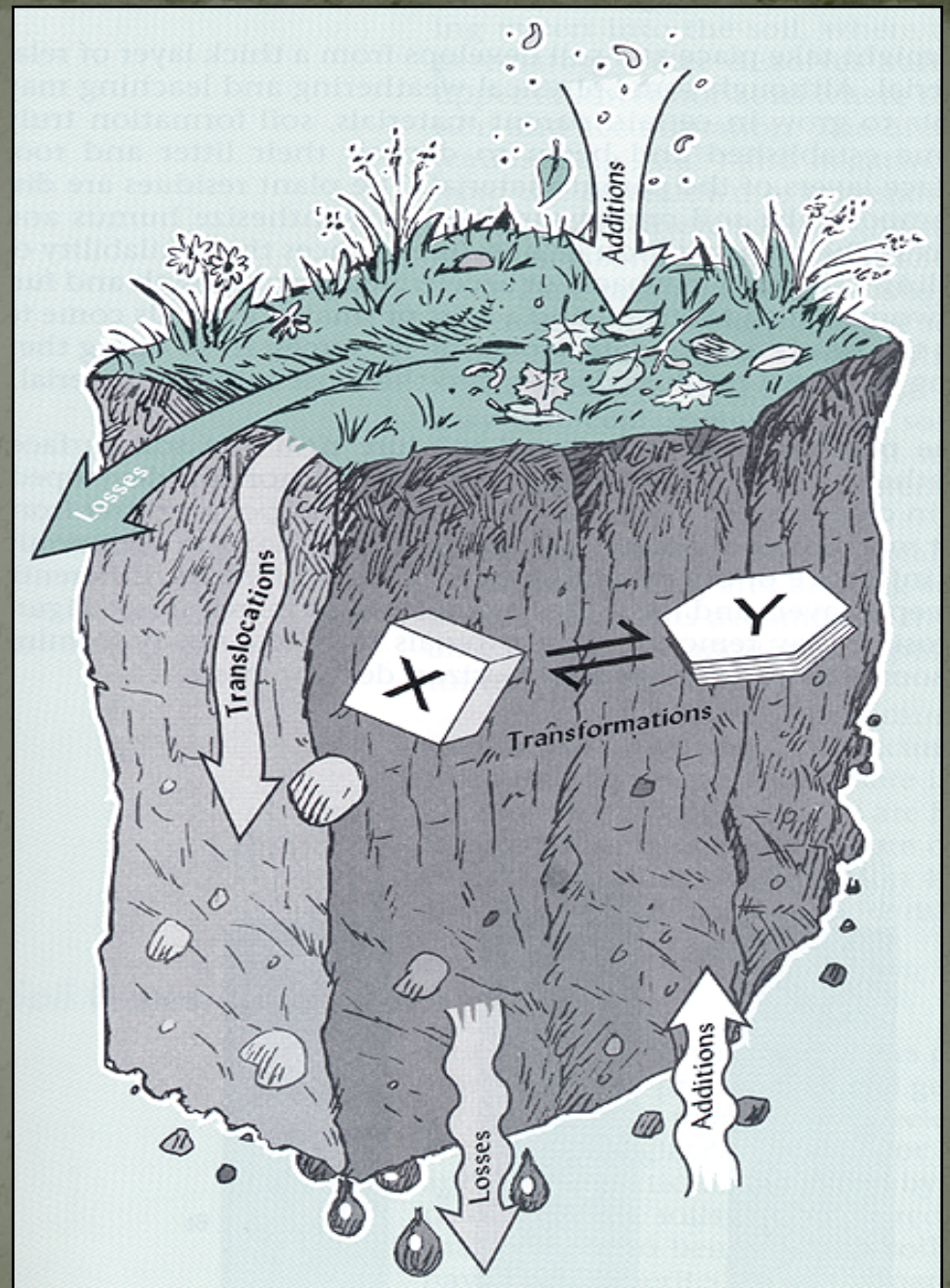
- Extremely rich in beneficial microbial life and essential organic nutrients and humus and works with clay minerals to store macro and micronutrients in the soil and make these available to plants
- Can be directly added to garden bed soils and container mixes without fear of "nutrient burn"
- Works great as an ingredient in compost teas and cocktails

Soil Health Indicators

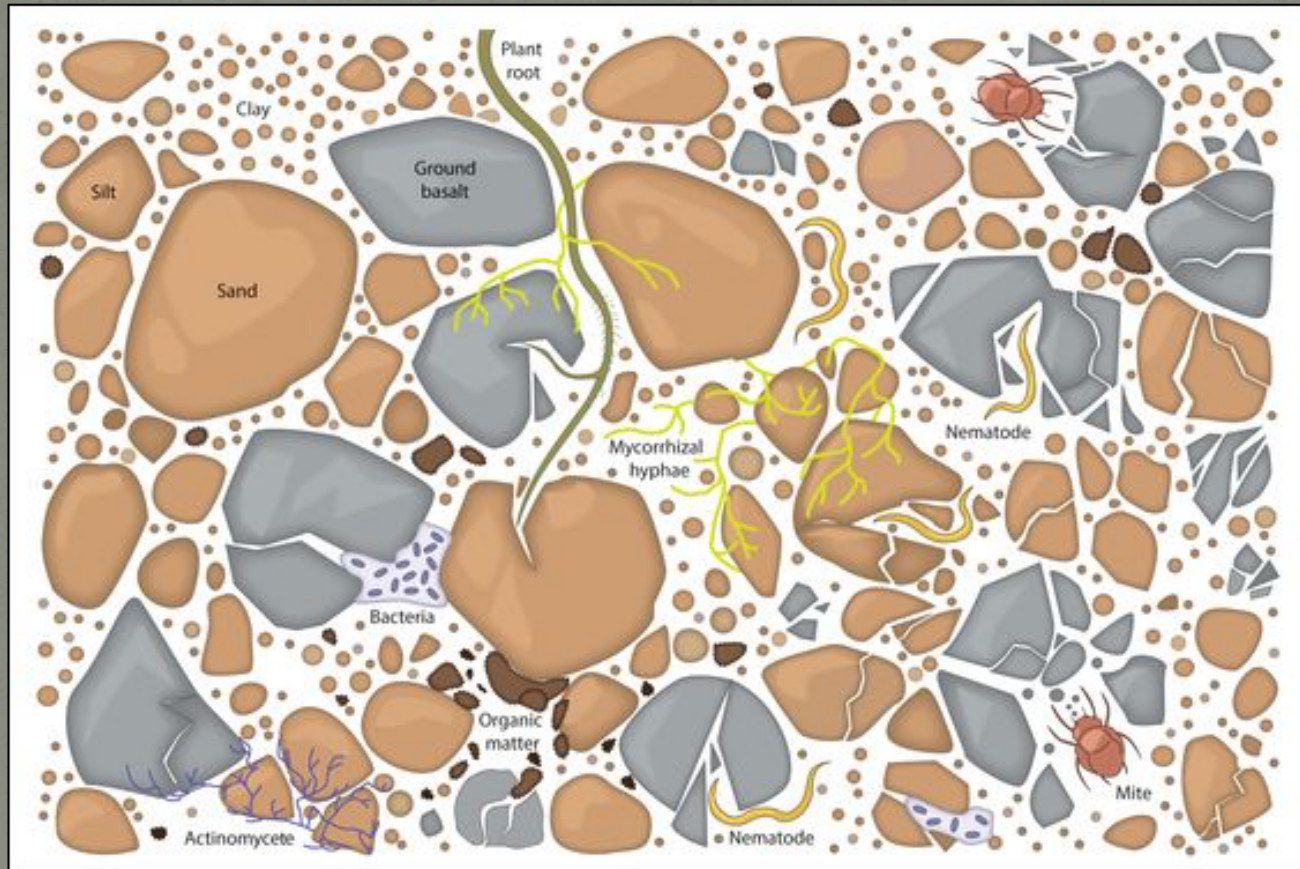


Native soils rely on annual airborne deposition of minerals (dust) and rainwater to supply the needed macronutrients and micronutrients, in conjunction with the addition of organic matter and its decomposition

It takes about 1,000 yrs to form 1 inch of soil!



Soil Remineralization



Rock Dust – Soil Remineralization

- Mineral deposits that contain valuable soil micronutrients that are mined and then pulverized to an appropriate “grit size” based upon its intended application (trees and shrubs, lawns, flower and vegetables)

Includes a free copy with each purchase

Exploring new IDEAS in gardening

An introduction to
Remineralization

Improving the flavor and quality of home grown food
Achieving a balanced soil, healthier plants, healthier people

Ever wish you could...

- depend on your garden to be productive regardless of the condition, hot or cold, wet or dry
- consistently produce nutrient dense fruits and vegetables
- learn how to manage soils without an advanced degree in horticulture

From Rocks to Life.....pg 3
The Organic Method.....pg 4
A Perfect Soil.....pg 5
How to Apply Minerals. .pg 8
The Next Step.....pg 9

Garden writers ahead of the curve
Read portions from their books (pg14-18)

Natural Soil Amendments

Glacial Rock Dust.....	pg 14
Basalt Rock Dust.....	pg 15
Limestone Rock Dust.....	pg 16
Olivine Rock Dust.....	pg 17
Azomite Rock Dust.....	pg 18
Phosphate Rock Dust.....	pg 19

Expand your horizons

Resource Material.....	pg 6
------------------------	------

TEAMING WITH NUTRIENTS
the intelligent gardener
The Organic Gardener's Guide to Optimizing Plant Nutrition
FF. LOWENFELD

nature's footprint
nature'sfootprint.com

32 Pages

SoilKey® Glacial Rock Dust

ABOUT GLACIAL ROCK DUST

Glacial Rock Dust is made from a wide variety of rocks which contain a broad spectrum of trace minerals that are collected and pulverized by the expansion and contraction of glaciers. As the glacier recedes, it leaves behind deposits of glacial moraine. Nature has already done the work of mixing and much of the grinding.

Glacial Rock Dust is an excellent source of calcium, iron, magnesium and potassium plus trace elements and micro-nutrients. It also increases phosphorus availability to plants.

ADVANTAGES

- Corrects mineral balance in the soil
- Provides an excellent source of macro and micro nutrients
- Improves the cation exchange capacity
- Improves soil structure and drainage

MINERAL CONTENT

Phosphorus (P).....	0.06%
Potassium (K).....	0.18%
Calcium (Ca).....	0.65%
Magnesium (Mg).....	0.85%
Sulfur (S).....	0.01%
Boron (B).....	0.00%
Chlorine (Cl).....	0.00%
Manganese (Mn).....	0.05%
Iron (Fe).....	3.28%
Nickel (Ni).....	0.00%
Copper (Cu).....	0.00%
Zinc (Zn).....	0.01%
Molybdenum (Mo).....	0.00%
Silica (Si).....	0.34%



Application

Rock dust/minerals are a great product to add directly to raised beds, container gardens or other areas that are using “manufactured soils” that are typically very low in soil micronutrients

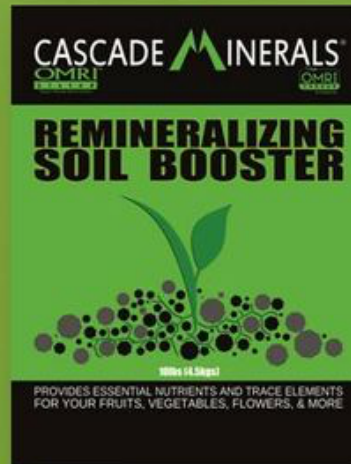
One application may last for several years dependent upon the plant type and soil texture

Can also add to compost and worm bins to provide a mineral component to help balance soil biological community

ROCK MINERALS... THE MISSING LINK

Cascade Minerals Remineralizing Soil Booster

- Improves plant structure, flavor profile, weight & yield
- Delivers essential nutrients and trace elements
- 100% natural, nutrient-dense volcanic basalt
- Silica-based minerals benefit **ALL** plants
- Naturally fast-acting and long-lasting



GUARANTEED ANALYSIS

Calcium (Ca) 1.0%
Magnesium (Mg) 0.5%
Iron (Fe) 4.0%
Manganese (Mn) 0.05%

Derived from: Basalt
No synthetic chemicals or man-made additives

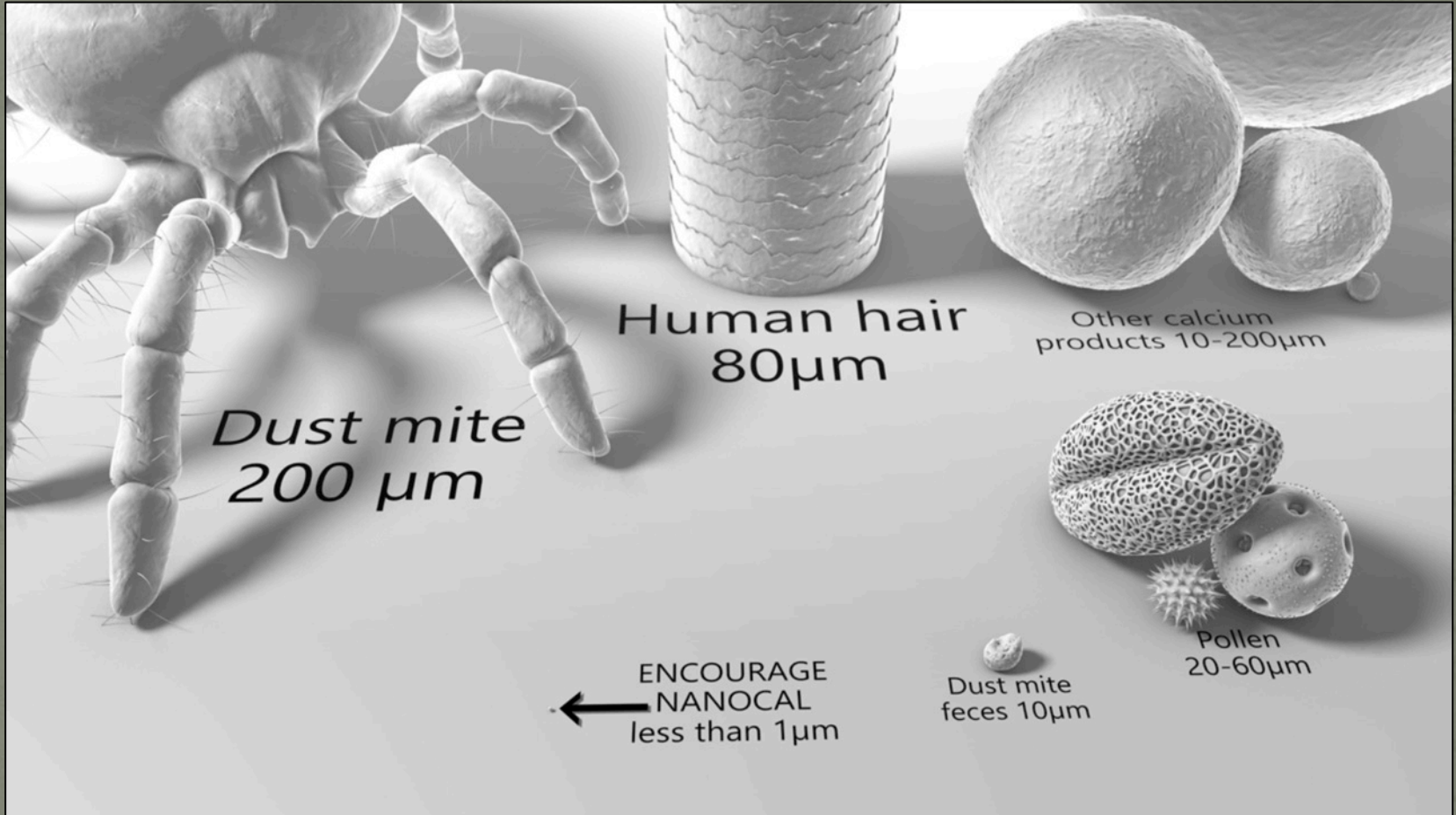
NON-PLANT FOOD INGREDIENTS
35% Silicon Dioxide (SiO₂) derived from basalt



Sunlight Supply, Inc.
National Garden Wholesale.

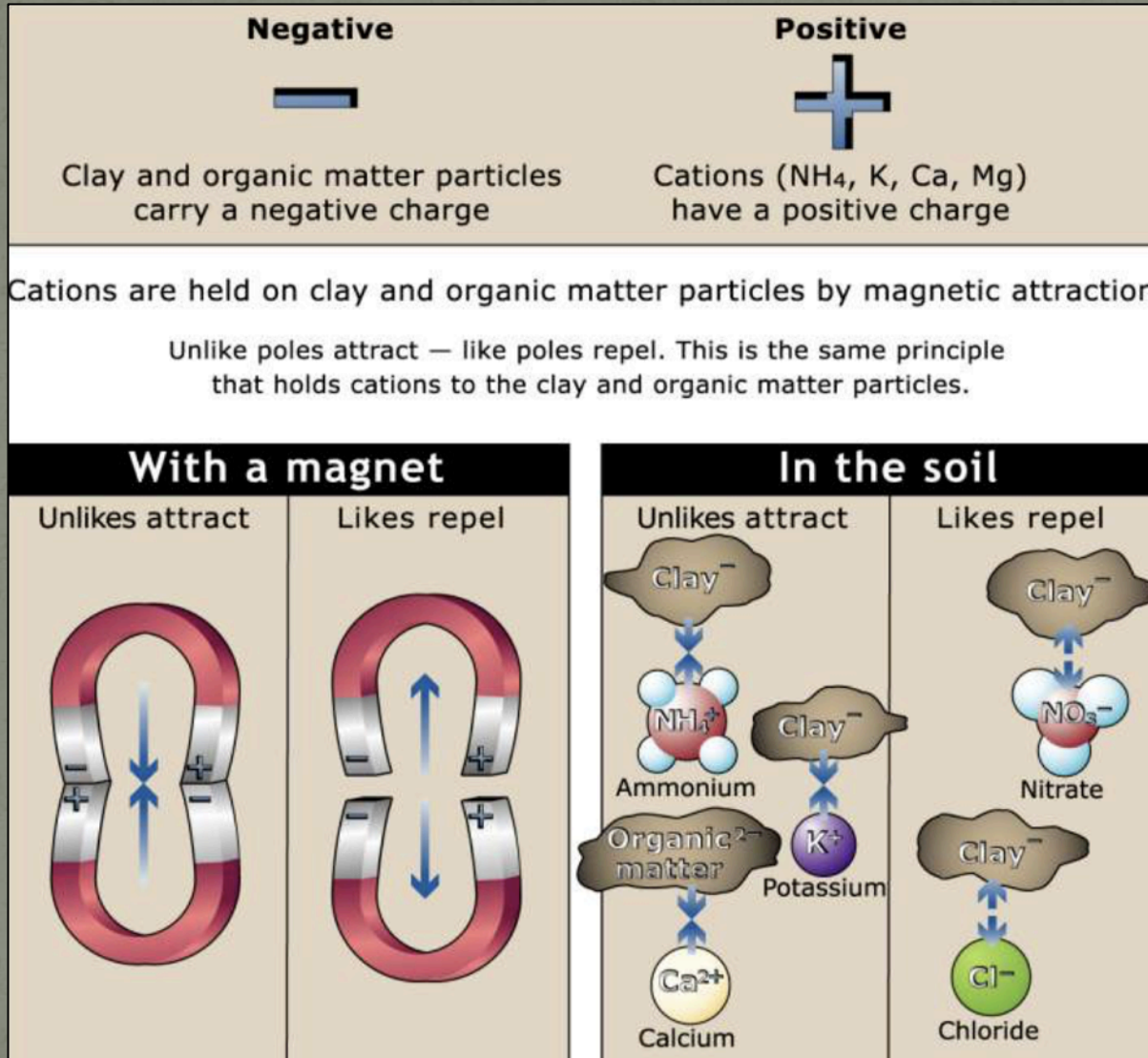
www.CascadeMineralsNW.com – Tel. (541) 475-3044

Diameter Size is Key

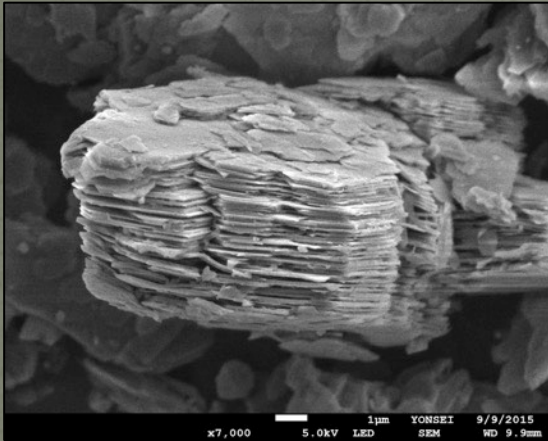


Annual or Perennial Potting Soil?

Soil-Plant-Nutrient Uptake Interactions



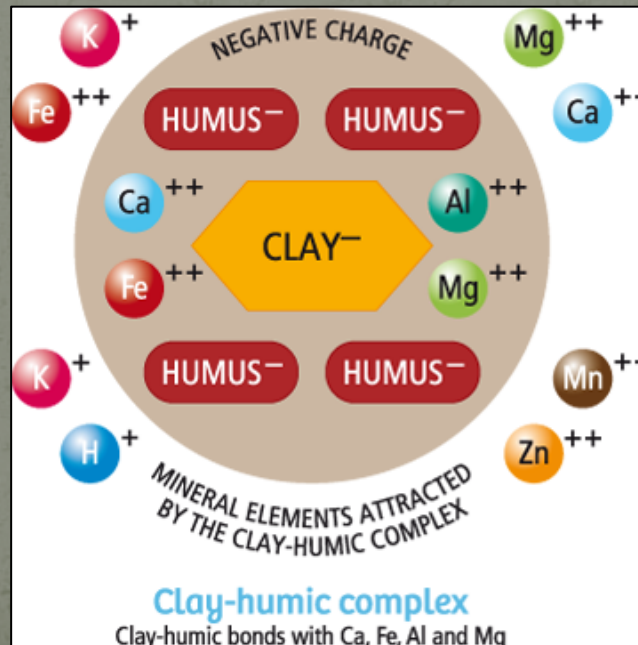
Clay-Humic Complex



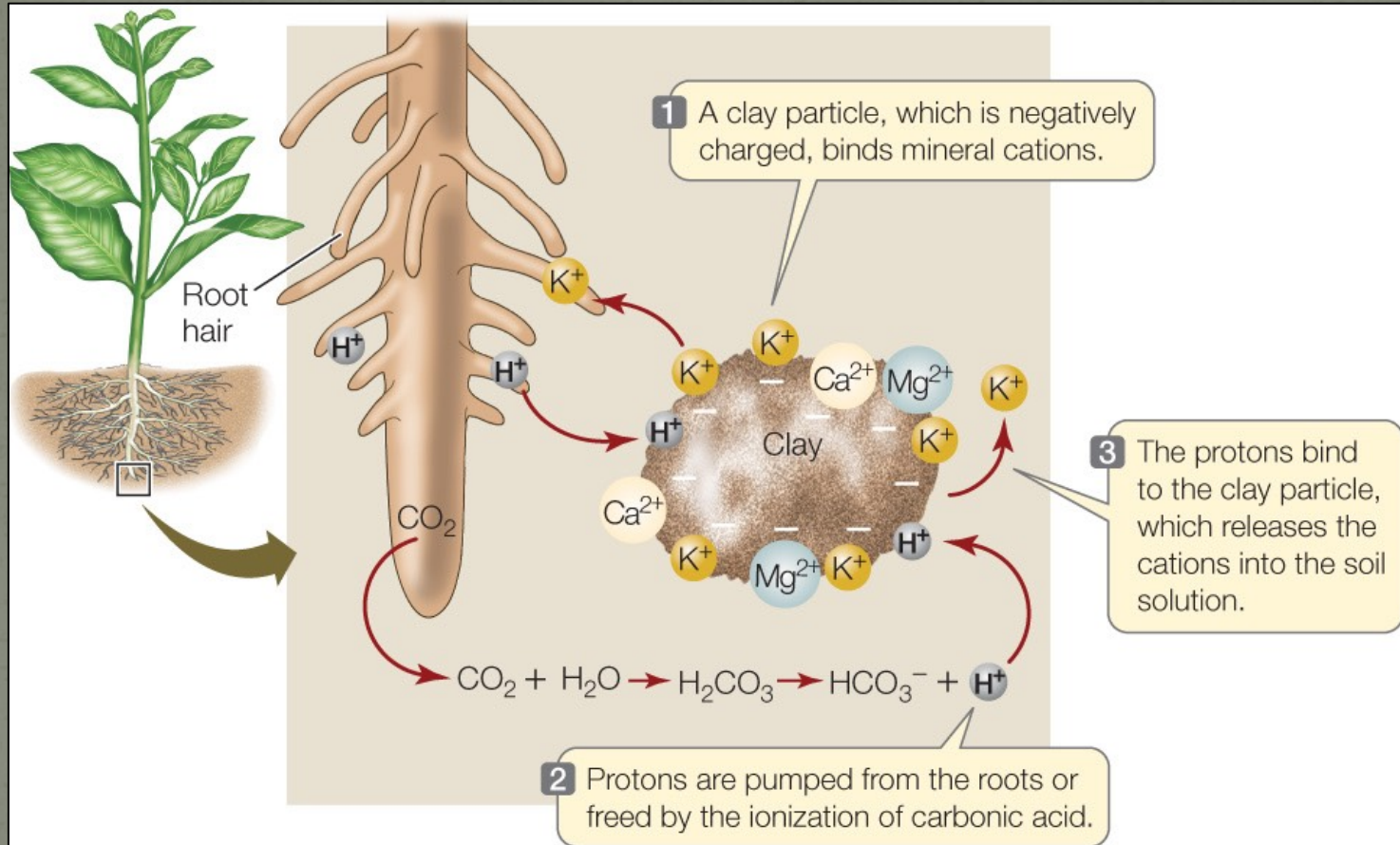
Clay



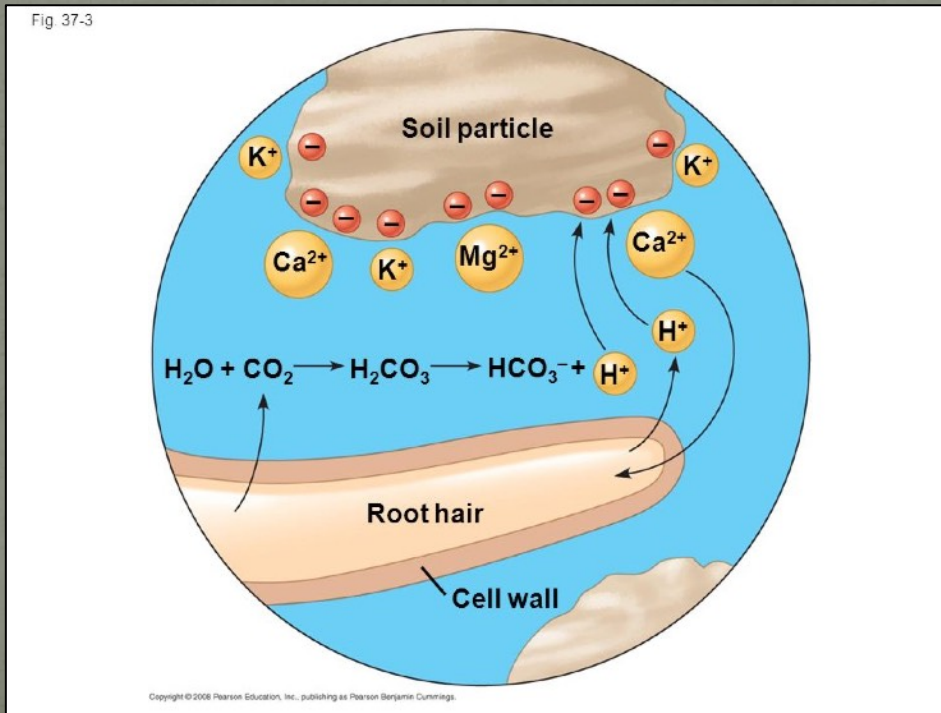
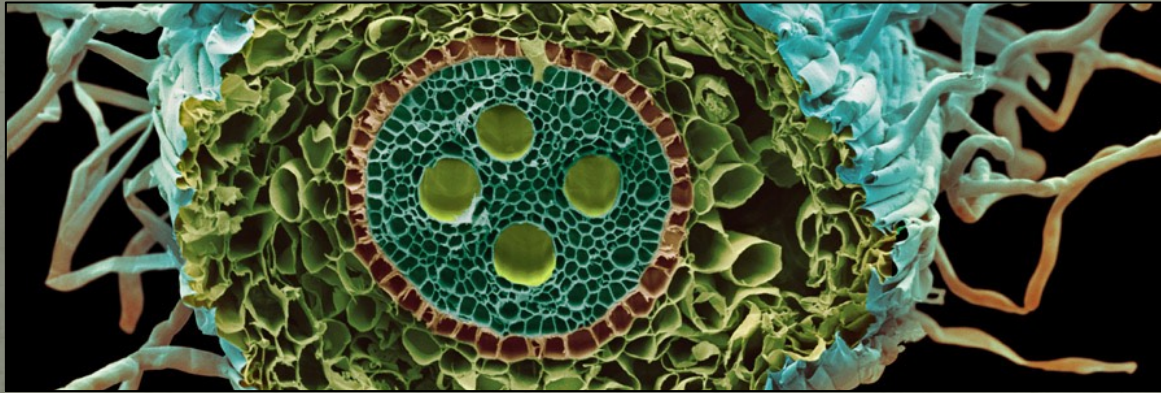
Humic Material



Soil-Plant-Nutrient Uptake Interactions



Cation Exchange in the Soil To The Plant

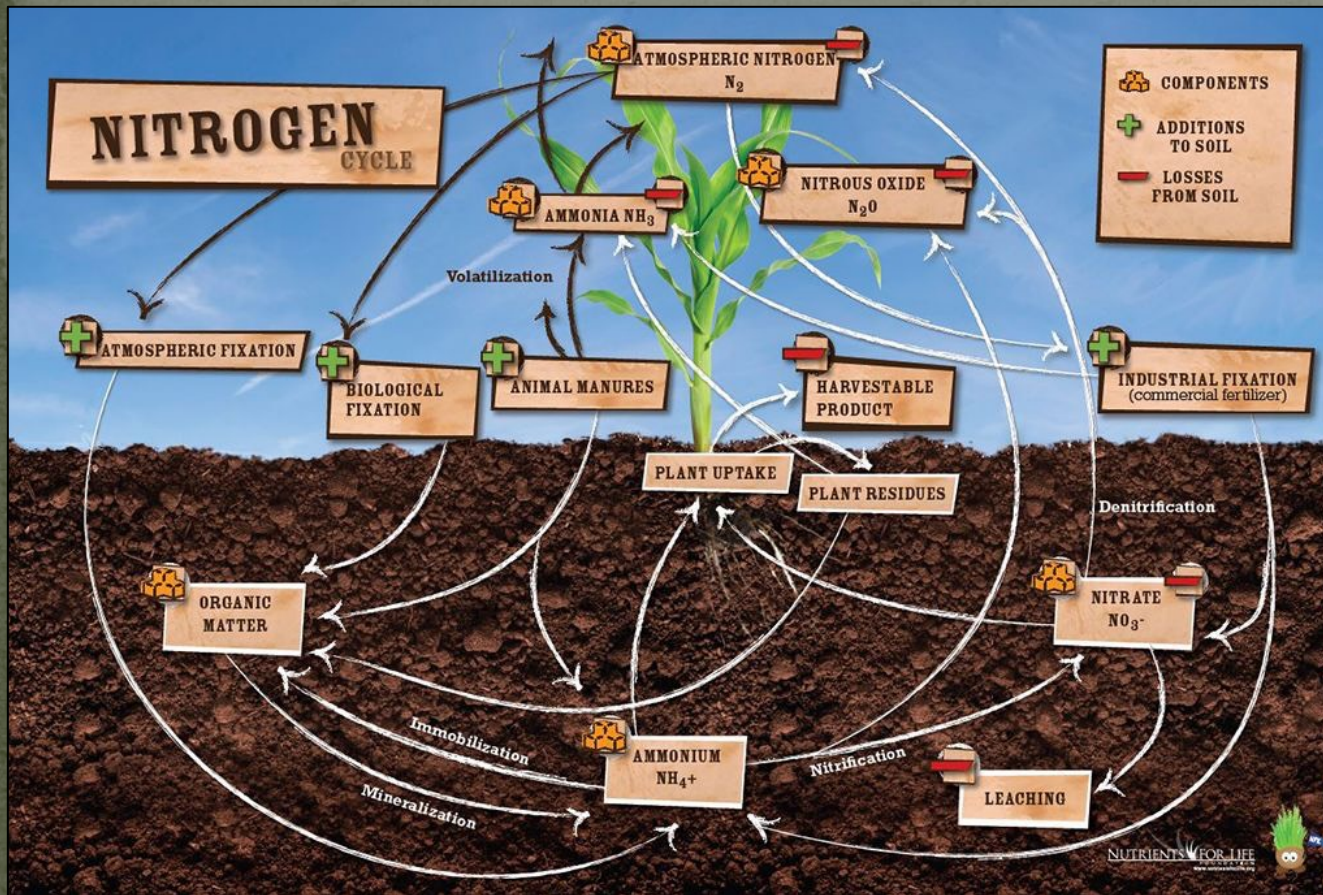


Soil Cation Exchange Capacity (CEC)

Affected by Clay Minerals and Humic substances

Low to High

Nitrogen – The “Wild Card”



Nitrogen is neither a positive nor a negatively charged element

Plants can only uptake N in 2 forms – *Nitrate* NO_3^- or *Ammonium* NH_4^+ in the soil solution

Ammonium NH_4^+ can attach itself to clay or OM due to positive charge and be saved for a rainy day when the plant needs it, or be converted to Nitrate

Nitrate NO_3^- carries a negative charge and will remain in the soil solution but risks being converted to *Nitrite* NO_2^- and leached out of the soil affecting the groundwater

CSU Extension – Colorado Master Gardener Program Garden Notes

Colorado State University Extension
CMG GardenNotes
 Colorado Master Gardener Program | Yard and Garden Publications | **CMG GardenNotes #211**

Introduction To Soils

Print this CMG GardenNotes

Outline

- Soil attributes
- Soil-forming factors
- Soil variation
- Landscape soils

Soil Attributes

What is soil? Gardeners know that soil is more than simply broken up rocks. Rather than being an inert unchanging material, soil is a dynamic living substance in which complex chemical and biological reactions are constantly occurring.

According to the Soil Science Society of America, soil is defined as, "...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." **Unconsolidated** materials are loose materials composed of multiple units (e.g. sand, gravel, etc.) unlike hard, massive materials like rock. Effective gardeners manage soils to produce healthy and resilient plants.

Soil contains a variety of substances. In a well-managed western soil, usually around 50% percent of the soil's volume is composed of soil particles, while the other 50% is empty space. Soil scientists refer to these empty spaces as "pores." [Figure 1]

Colorado State University Extension
CMG GardenNotes
 Colorado Master Gardener Program | Yard and Garden Publications | **CMG GardenNotes #232**

Understanding Fertilizers

Print this CMG GardenNotes

Outline

- Fertilizer or soil amendment?
- What's in a fertilizer?
 - Analysis or grade
 - Ratio
 - Formulation
- Nitrogen applications
- Phosphate and potash applications
- Specialty fertilizers

Fertility is only part of the soil management process. Colorado soils are naturally low in organic matter. To maximize productivity, our soils also need routine applications of organic matter to improve soil tilth. For flower and vegetable gardens, it is desirable to raise the soil organic content, over time, to 4-5%.

Manufactured fertilizers are popular with gardeners because they are readily available, inexpensive, easy to apply, and generally provide a quick release of nutrients for plant growth. Application rates depend on the nutrient need of the soil and the percent of nutrients in the specific fertilizer. **In products containing multiple nutrients, the application rate is always based on the nitrogen content.**

Fertilizer or Soil Amendment?

Colorado State University
Colorado State University

Home

Useful Articles

Contact Us

Additional Resources

- Locations to pick up soil kits

Welcome to the Soil, Water and Plant Testing Laboratory at Colorado State University!

The Soil-Water-Plant Laboratory analyzes soil, water, plant, sludge, manure and miscellaneous types of samples from farmers, homeowners, consultants, government agencies and CSU personnel, and provides fertilizer suggestions for improving crop growth.

THE LAB IS OPEN YEAR-ROUND
 Our hours are 8-5 Monday-Friday
 Except major holidays.

****The Soil-Water-Plant Testing Lab does not test for pesticides or herbicides.****

Information and Forms: (Forms are in PDF format.)

- **Analytical Services Provided:** list of services provided by the lab
- **Commercial Customer Information sheet:** Customer Submittal Form with Chain of Custody
- **Soil Sampling Instructions (Farmers):** Farmer Soil Sample Instructions
- **Lab Submission forms: (Please submit with sample)**
 - Horticultural Applications for Gardeners (PDF Format)
 - Horticultural Applications for Gardeners (Word Format)
 - Agricultural Applications for Farmers
 - Water Analysis
 - Forage Analysis/price list

Further analysis is available please contact the lab for more information and prices.

The lab is certified with **Manure Analysis Proficiency at Minnesota Dept. of Agriculture (MAP), National Forage Testing Association (NETA)**, and participates in the **National Association for Proficiency Testing (NAPT)**.

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Soil pH

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Outline

- Soil pH
- pH and nutrient availability
- Managing alkaline soils
 - Lowering the pH
 - Raising the pH on acid soils
- Home pH test kits

Soil pH

Soil pH is a measurement of the acidity or alkalinity of a soil. On the pH scale, 7.0 is neutral. Below 7.0 is acidic, and above 7.0 is basic or alkaline. A pH range of 6.8 to 7.2 is termed **near neutral**. A soil's pH is a product of the factors which formed it. Primarily, it is a result of the parent material of the soil and climate. The quality of irrigation water used can also have an effect on soil pH. Areas of the world with limited rainfall typically have alkaline soils while areas with higher rainfall typically have acid soils.

Soil pH is important to gardeners because it can affect the availability of plant nutrients as well as the soil ecology. In very acid or alkaline soils some plant nutrients convert to forms that are more difficult for plants to absorb. This can result in nutrient deficiencies. Plants which have evolved under such soil conditions often have developed mechanisms to deal with this issue.

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Soil Amendments

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Outline

- Terms
- Managing soil texture and structure
- Selecting soil amendments
 - Over-amending
 - Evaluating the quality of soil amendments
 - Examples of soil amendments
 - Peat
 - Biosolids
 - Compost, manure, cover crops and green manure crops
 - Worm castings
 - Perlite and vermiculite
 - Summary: Considerations in selecting soil amendments

Terms

The term **soil amendment** refers to any material mixed into a soil. **Mulch** refers to a material placed on the soil surface. By legal definition, soil amendments make no legal claims about nutrient content or other helpful (or harmful) effects that it will have on the soil and plant growth. In Colorado, the term **compost** is also unregulated, and could refer to any soil amendment regardless of microorganism activity.

By legal definition, the term **fertilizer** refers to soil amendments that guarantee the minimum

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Plant Nutrition

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Outline

- Fertility and fertilizers
- Plant nutrients
- Colorado soils and plant nutritional needs
 - Nitrogen
 - Iron
 - Phosphorus
 - Potassium
 - Zinc

Fertility and Fertilization

Many people confuse plant nutrition with plant fertilization. **Plant nutrition** refers to the need for basic chemical elements for plant growth.

The term **fertilization** refers to the application of plant nutrients to supplement the nutrients naturally occurring in the soil. Nutrients may be applied as commercial manufactured fertilizers, organic fertilizers and/or other soil amendments. Organic fertilizers and soil amendments are typically low in plant-available nutrient content. For additional information about fertilizers and soil amendments, refer to the **CMG GardenNotes #232, Understanding Fertilizers and #241, Soil Amendments.**

Questions?

