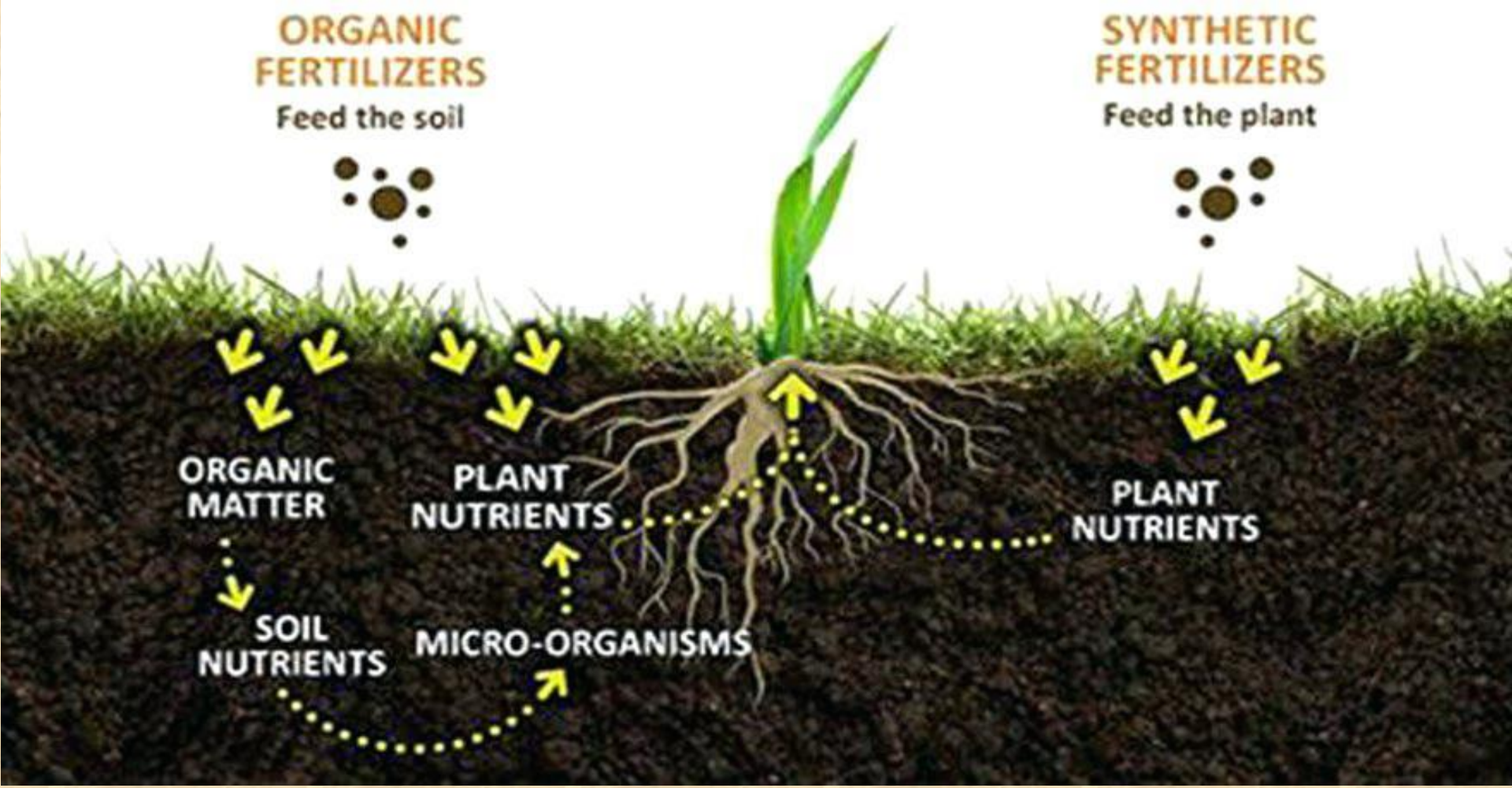


Soil and Fertilization:

Gary Fredricks: Extension Director/MG Coordinator

garyf@wsu.edu (360) 577- 3014 ext 3

WASHINGTON STATE UNIVERSITY
COWLITZ COUNTY EXTENSION

Words of Wisdom!

For a gardener, soil is where it all begins. Starting a garden without paying proper attention to soil permeability, texture, structure and nutrient content is a blueprint for failure. Not even the best plants, finest garden tools and most skilled gardening techniques can overcome the negative environment of poor soil.

“The success of your garden depends on your SOIL, so don't treat it like DIRT!”

Important Key Points to Keep in Mind!

- Do It Yourself (DIY) tests should have been conducted in the fall:

Soil Texture - https://extension.oregonstate.edu/sites/default/files/documents/1/jartest.pdf

Perc Tests - measures soil drainage.
https://extension.tennessee.edu/Williamson/Horticulture/Consumer%20Horticulture/DIY%20Soil%20Drainage%20Perk%20Test%20for%20Your%20Yard%20(2016).pdf

- Soil testing should be completed (either by yourself (Rapitest) or sent into a laboratory).
- Lime should have been added in the fall if needed.
- Composting (approximately 2 - 4 inches) added in the fall or prior to tilling/working into soil.
- Garden planning completed prior to any planting.
- The following **Cool Season Crops** can be planted in early spring (check soil temperature requirements either online or on seed package):

Hardy Vegetables - asparagus, broccoli, brussels sprouts, cabbage, collards, onions, rutabaga (can be started indoors and transplanted) while kale, kohlrabi, leek, peas, radishes, spinach, turnips (can be direct sown).

Semi-Hardy Vegetables - artichoke, cauliflower, celery (can be started indoors and transplanted) while arugula, Asian greens, beets, carrots, endive, lettuce, potatoes, salsify, swiss chard (can be direct sown).

Topics Covered:

- Soil Foundation.
- Soil Structure.
- Soil Testing.
- Soil Nutrients.
- Nitrogen Cycle.
- Soil pH.
- Fertilizing.
- Composting.
- Rototilling.
- Mulches.
- Manures.

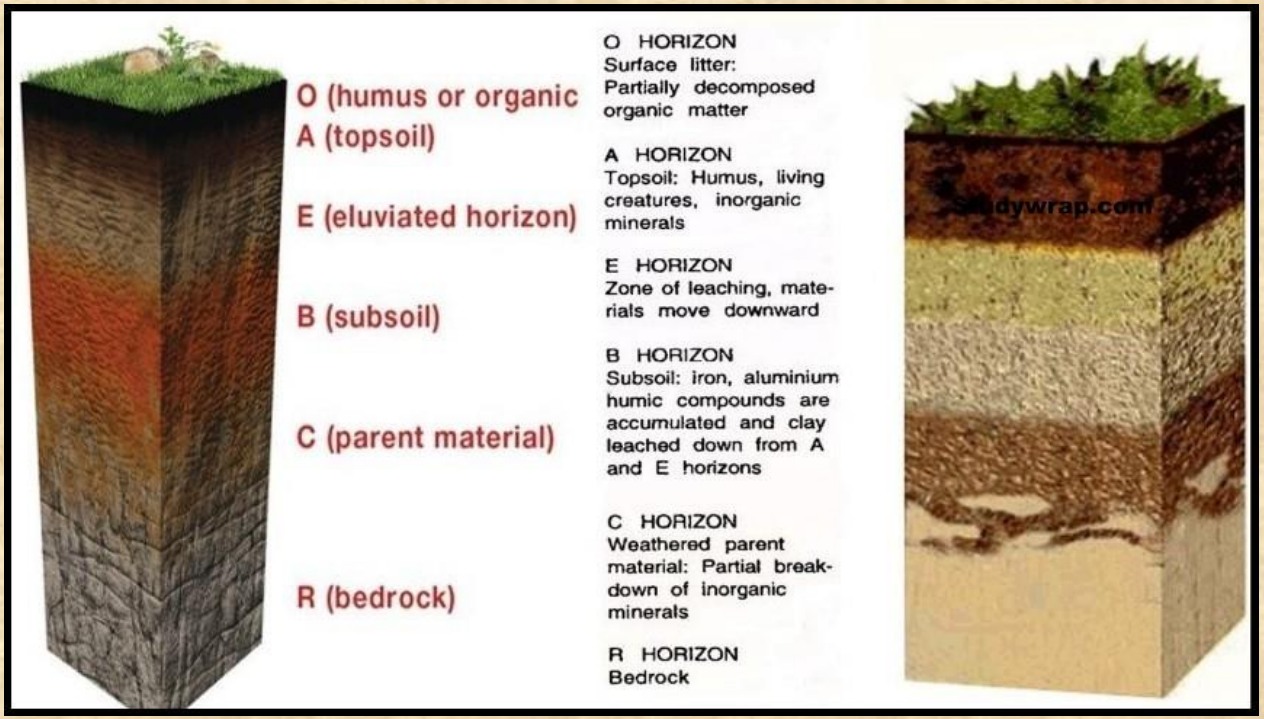
It takes more than 500 years to form one inch of topsoil.

Soil Foundation:

What is soil?

Soil is a mixture of weathered rock fragments and organic matter at the earth's surface.

- It is biologically active a home for countless microorganisms, invertebrates and plant roots.
- Porous.
- It provides:
  - Nutrients.
  - Energy.
  - Carbon Dioxide.
  - Water.

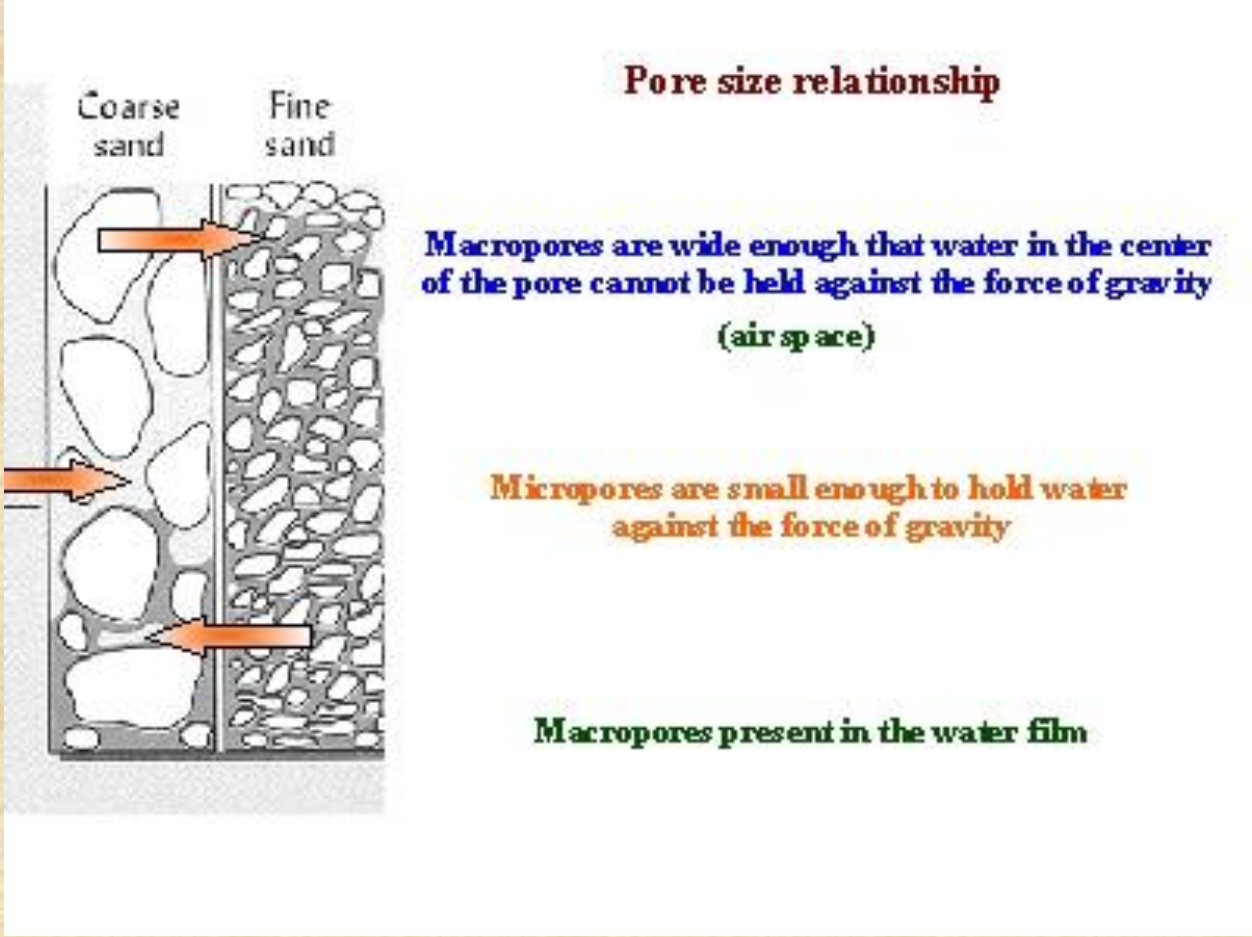


Soil Foundation:

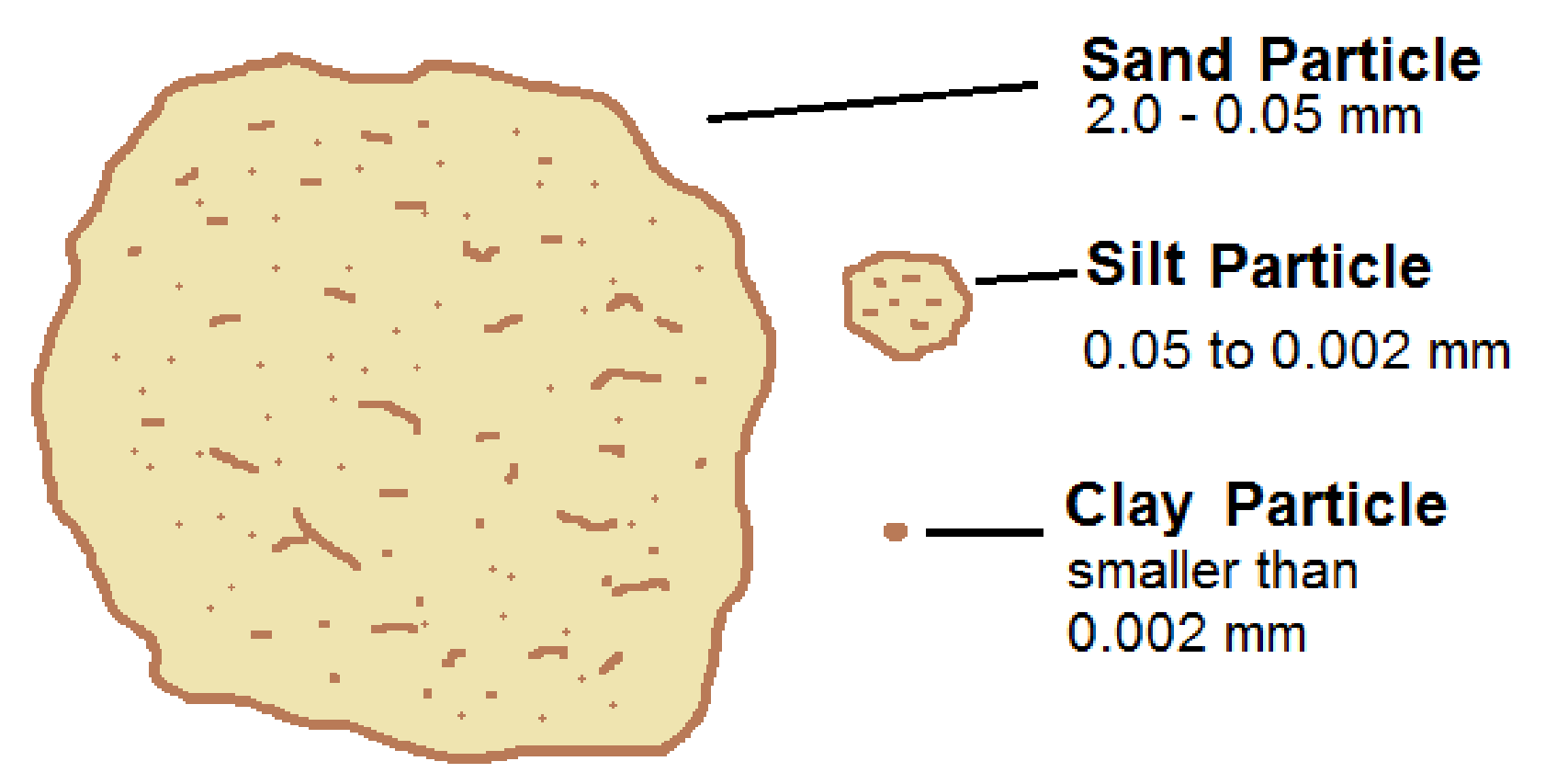
A productive soil is permeable to water and can supply water to plants.

Soils permeability depends on its porosity (network of pores):

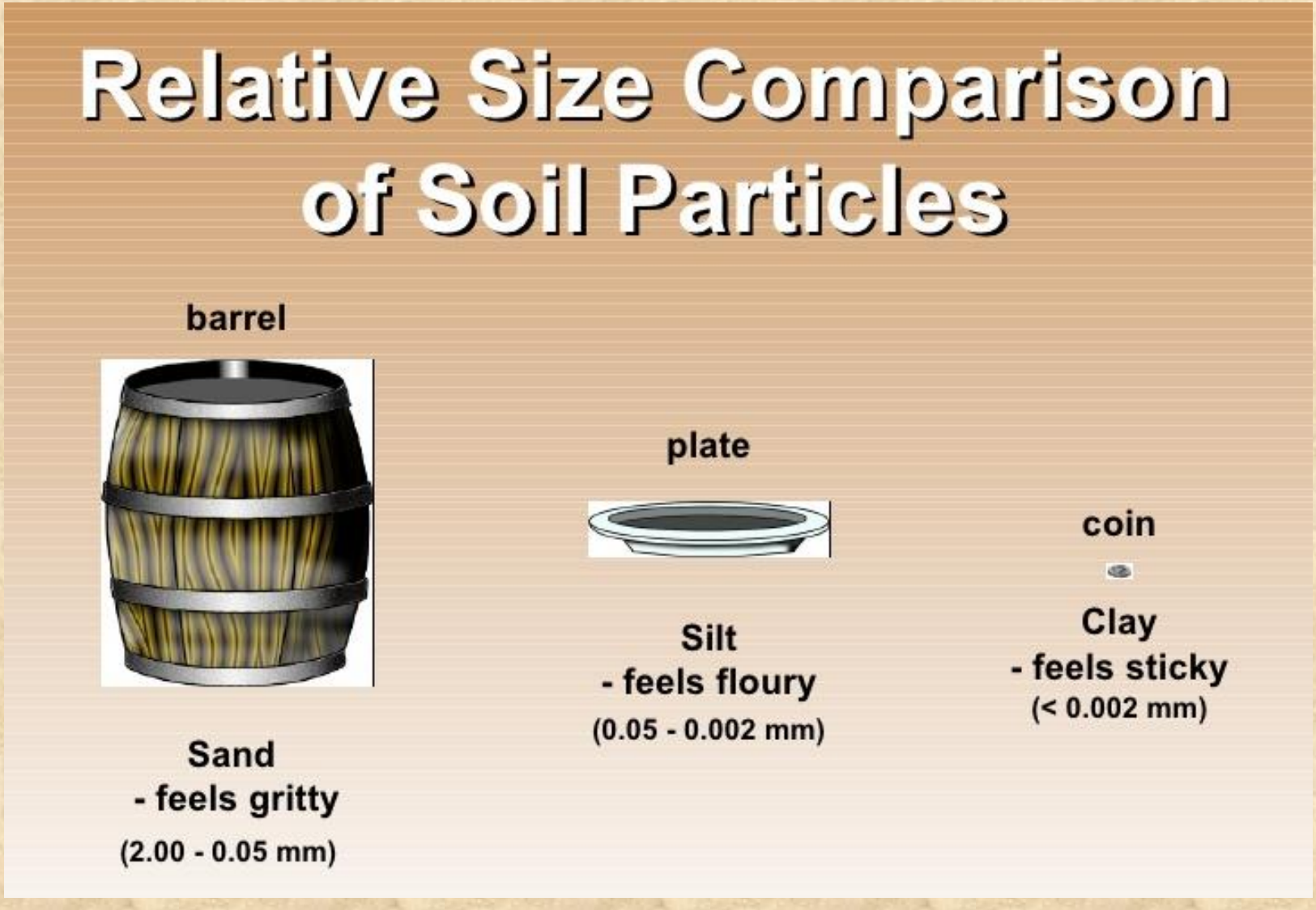
- Macropores large pores that control permeability and aeration.
- Micropores small pores responsible for water retention.



Size Comparison:



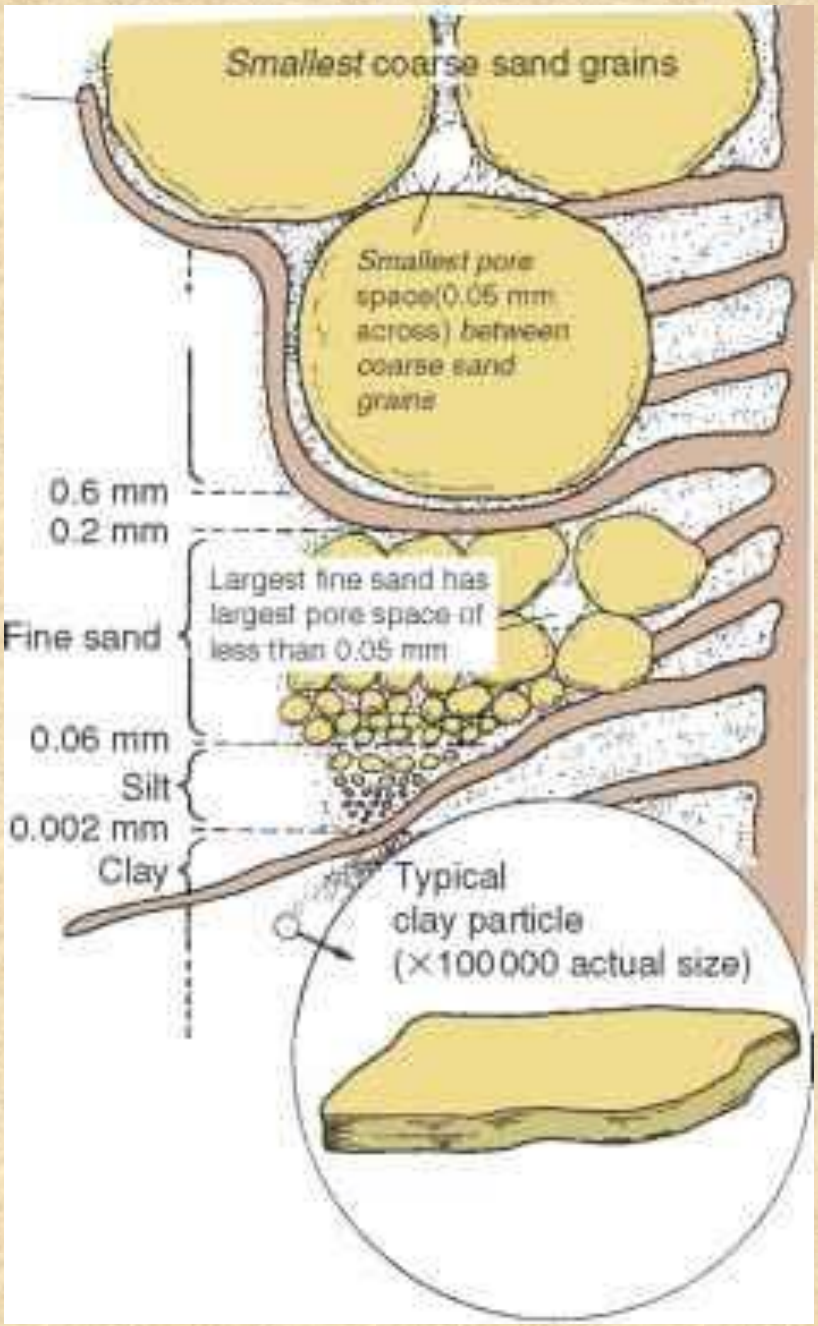
Size Comparison:



Shape Comparison:

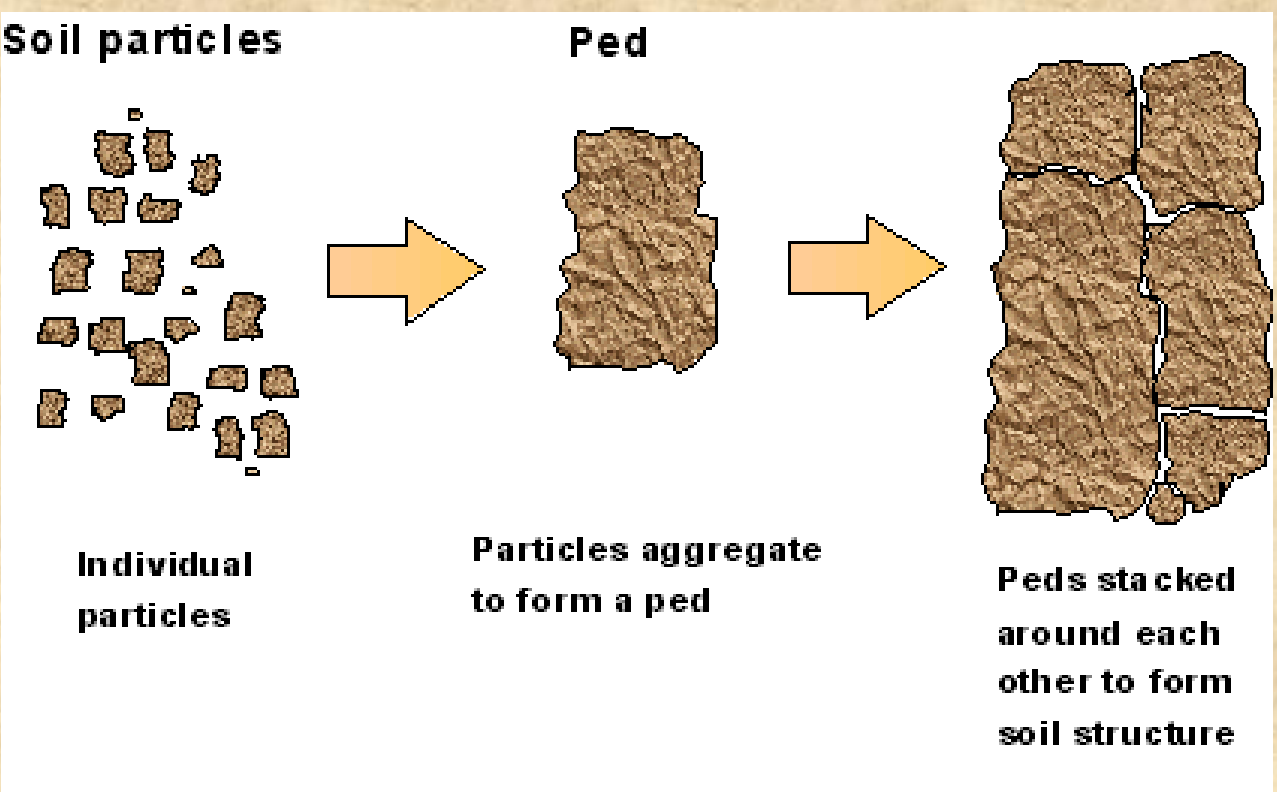
What do you see different between the shapes of sand and silt versus clay?

This is why clay retains water.



Soil Structure:

Peds are individual particles of sand, silt and clay that cluster or bind together and are separated by macropores and micropores.

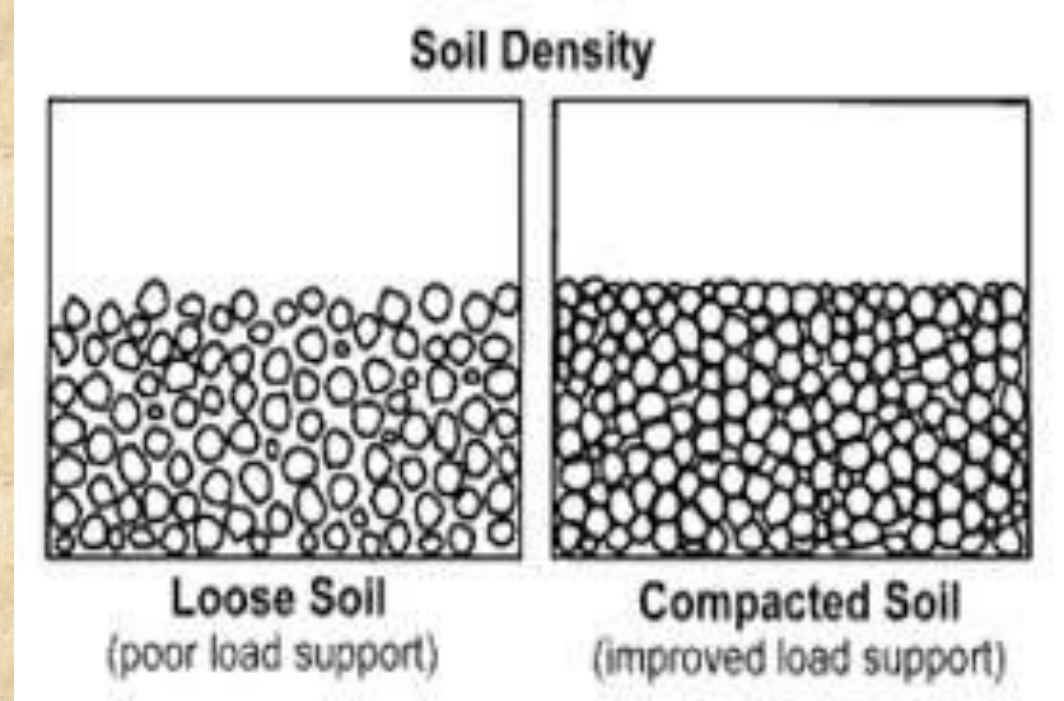


Soil Structure:

Damage to soil structure can be caused by:

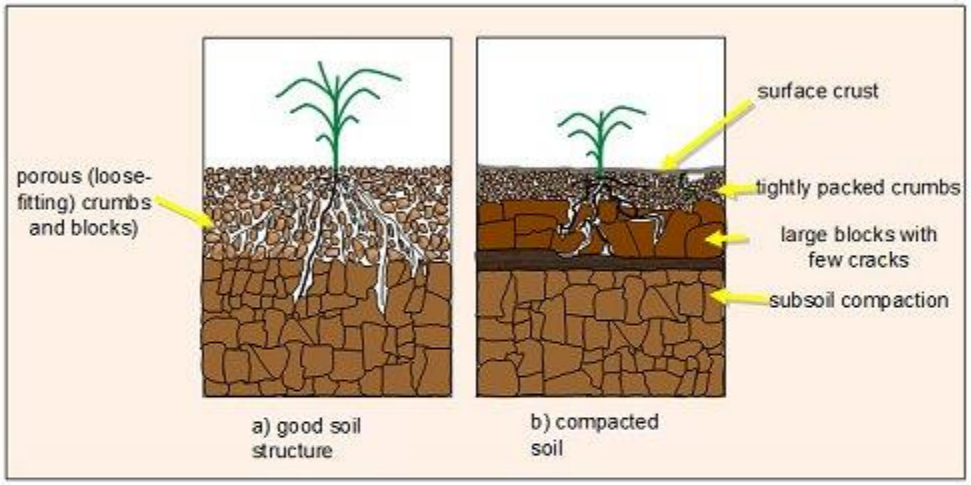
- Compaction - squeezes macropores and micropores closer decreasing root penetration, aeration and water movement.
- Tillage - excessive tilling interrupts delicate cycles.
- Loss of organic matter.

Adding organic matter is the best way to improve the environment for plants in most soils



Soil Structure:

Soil Compaction



Some Quick DIY Home Soil Tests:

- Soil Texture Test.
- Percolation Test.
- Both these tests go hand in hand with each other.

Identify Soil Texture:

- Collect sample from below the root zone.
- Sample should be representative of the gardening area.
- Sift to remove rocks and roots.

Soil Texture:

- ✓ Fill a one quart wide mouthed jar ½ way with your soil.
- ✓ Add 1 tablespoon powdered dishwashing detergent as a surfactant. This keeps the soil particles separate for a more accurate test.

Soil Texture:

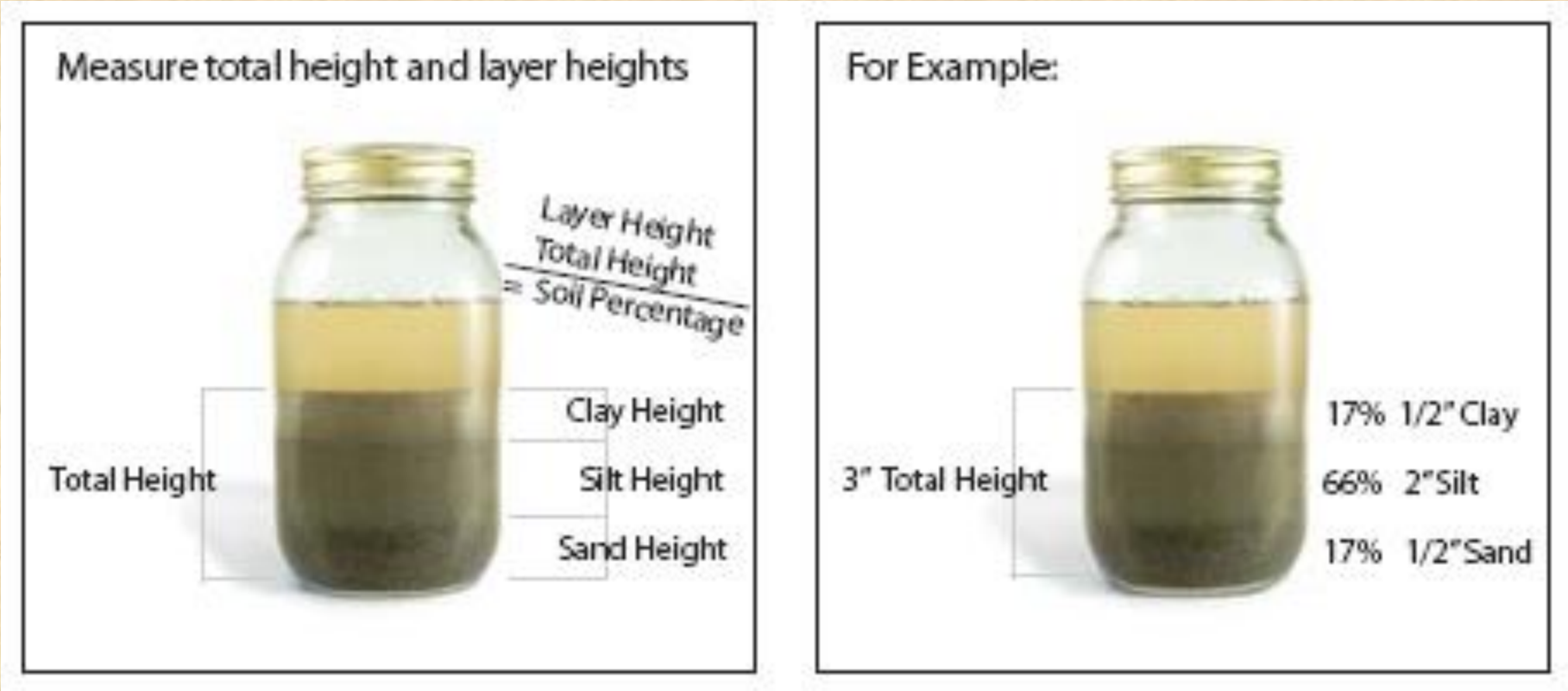
- Fill the jar to the top, leaving approximately one inch of head room.
- Tighten lid so it won’t leak.
- Shake the jar for approximately three minutes to thoroughly combine the soap, soil and water.

Soil Texture:

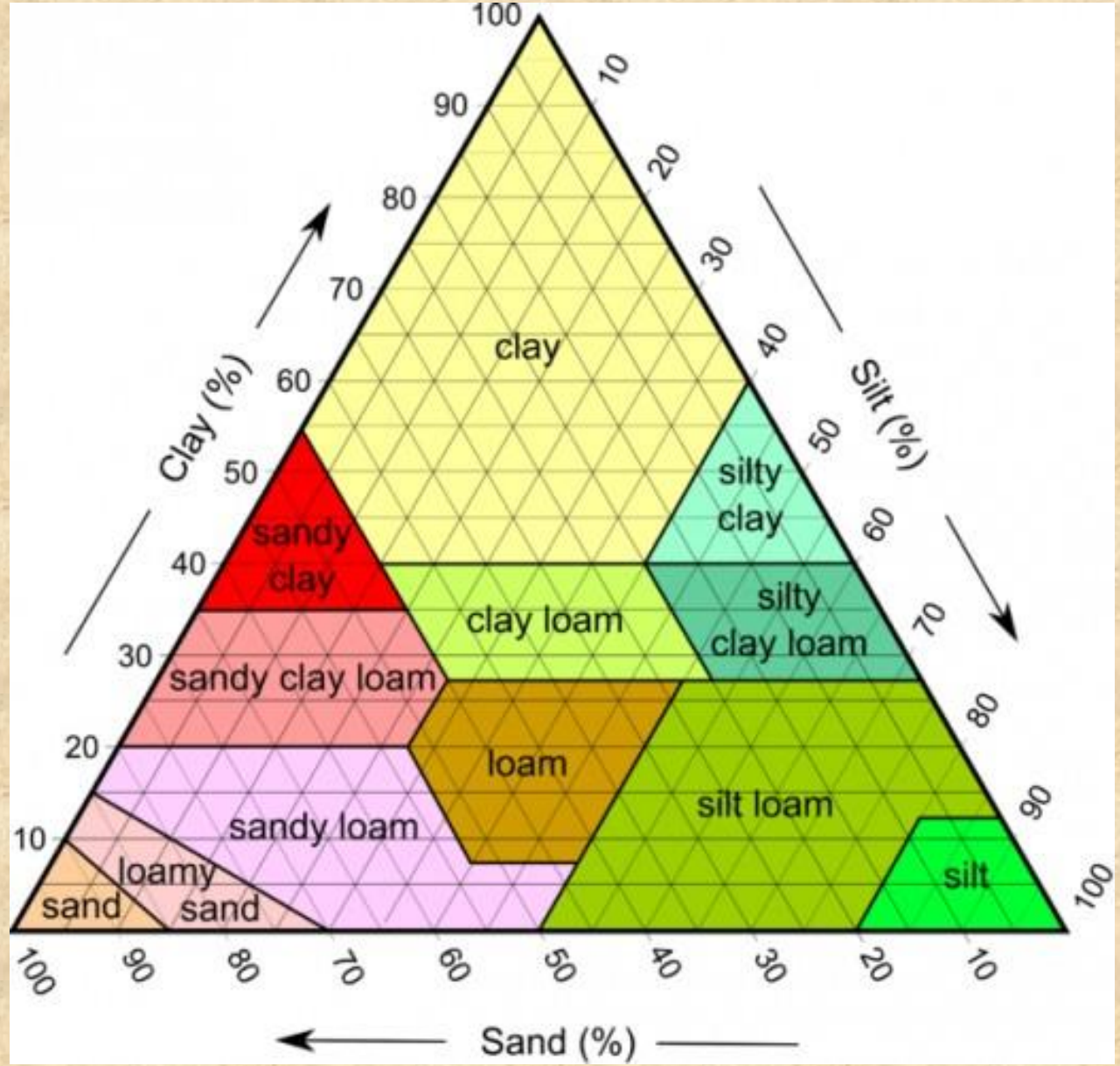
- Set the jar on a flat surface and allow it to settle for 24 hours.

- Mark and measure the levels of sand, silt and clay. Sand will be bottom layer, silt middle layer and clay top layer.

Soil Texture:



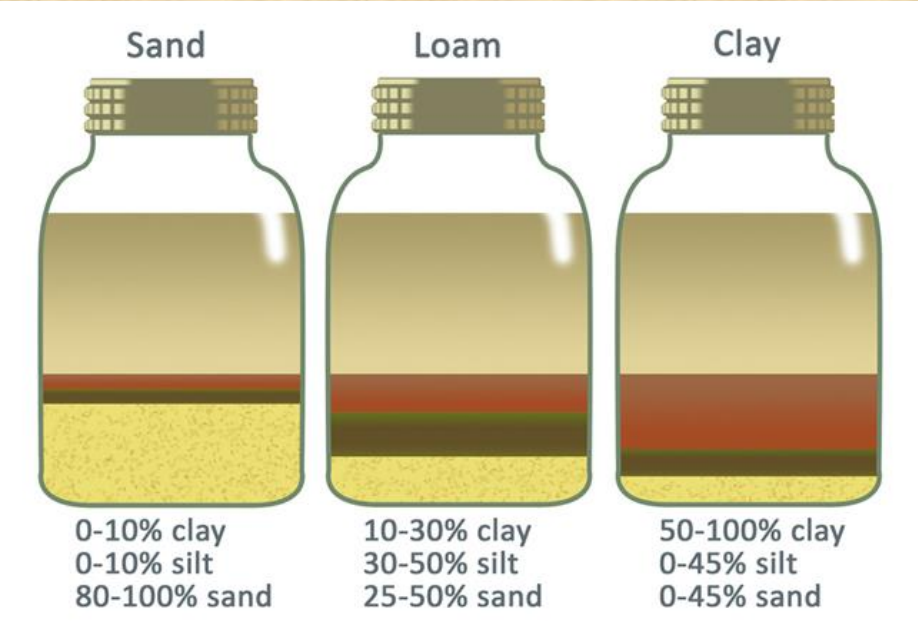
Soil Triangle:

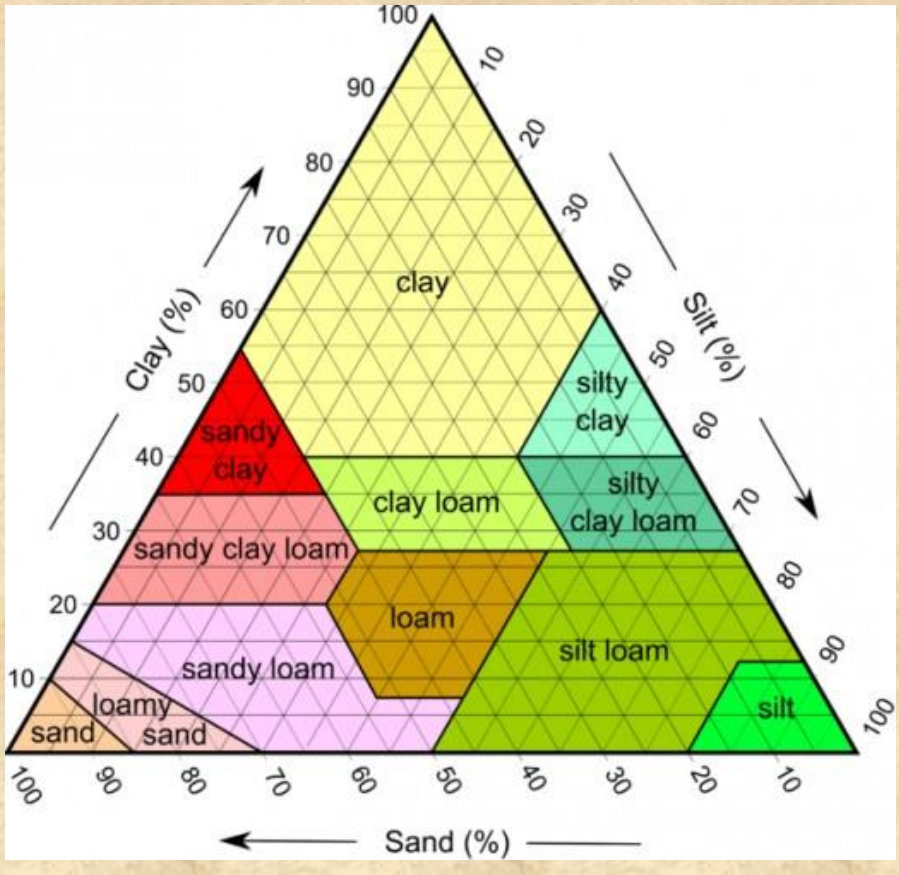


17% Clay
66% Silt
17% Sand

Silt loam type soil.

Using the Soil Triangle to Calculate Soil Texture:





Using the Soil Triangle:

Clay	Silt	Sand
35%	30%	35%

Clay Loam

10%	60%	30%

Silt Loam

20%	35%	45%

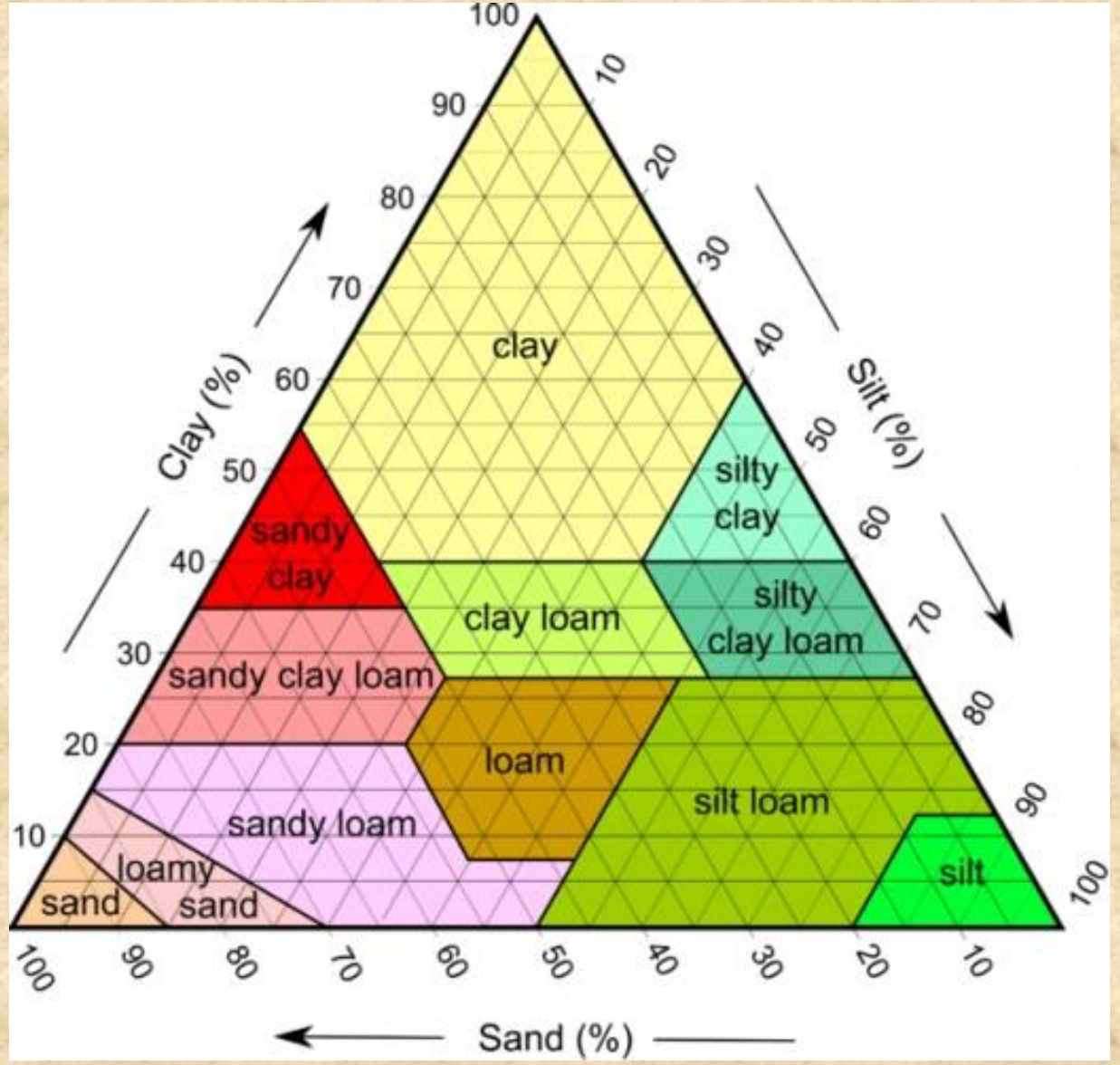
Loam

60%	20%	20%

Clay

5%	85%	10%

Silt



Next Easy DIY Test:

So once the texture is figured out another easy test to conduct is a Percolation (Perc) Test.

What Is and What Is the Purpose of a Percolation Test?

- A test that is conducted to give you an idea the drainage rate of your soil.
- This test gives the gardener an idea how often they need to water their garden or if you need to amend your soil.

Steps to Conduct a Percolation Test:

- Dig a hole approximately 1 foot diameter and 1 foot deep.

- Set the soil aside on a tarp or in a bucket.

Steps to Conduct a Percolation Test:

- Fill the hole with water, and allow to drain.

- Once drained, immediately refill the hole with water and measure the depth of the water with a ruler.

Steps to Conduct a Percolation Test:

- 15 minutes later, measure the drop in water in inches.

- Multiply the number by 4 to calculate how much water drains in an hour.

What do the Results Mean?

- The ideal soil drainage is around 2” per hour, with readings between 1”-3” generally OK for garden plants that have average drainage needs.
- If the rate is less than 1” per hour, your drainage is too slow, and you’ll need to improve drainage or choose plants tolerant of wet soil.
- If drainage is more than 4” per hour, it’s too fast, and you should consider choosing plants that tolerate dry conditions and "droughty" soils.

A Picture is Worth a Thousand Words!

Addressing the Issues:

- 1. COMPOST, COMPOST, COMPOST! Incorporate compost and organic matter into the soil. Organic matter helps heavy clay soil to drain and helps coarse sandy soil to hold moisture, so it’s a win-win no matter what your soil type!
- 2. Choose plants suited to your soil drainage.
- 3. Build raised beds for better control over the soil texture.

Soil Testing:

- Soil testing should be done every 2 - 3 years.
- The best way to determine where your soil nutrient and pH levels are at is to obtain a soil sample prior to planting and send it to a laboratory for testing.

simplysoiltesting.com

- The important thing to remember is to be able to understand the results of the analysis.
- There are test kits that can be purchased such as Rapitest but, it will just give you an approximation where your soil primary nutrient and pH levels are at.

Soil Testing:

<u>Soil Tests and Prices through Simply Soil Testing</u>: Feb 2022

- Basic Soil Test - $16 per sample
  - Includes pH, lime requirement, potassium, phosphorus, calcium, magnesium, soluble salts and fertilizer recommendations.
- Basic Test + Organic Matter - $20.
- Basic Test + Fe, Mn, Zn & Cu - $20 (iron, manganese, zinc and copper).
- Basic Test + S and B - $24 (sulfur and boron).
- Complete Test - $32 All of the tests listed above.
- Soil Texture - $16 Percentage of clay, silt, sand and gravel in the soil, and classification of the soil type.
- Toxic Metal Testing - $24.
  - Levels of lead, cadmium and arsenic in the soil, and interpretation of the results.

Rapitest Soil Test Kit:

The best part of this test kit is the table provided in the kit for pH levels for over 450 plants.

As for accuracy it does not give a precise reading.
It basically tells you if your primary nutrients and pH levels are high or low.

A lab test will give you precise pH, primary, secondary and micronutrient levels.

Soil Nutrients:

Macronutrients

- Macronutrients can be broken into two more groups:

Primary Nutrients

- The primary nutrients are nitrogen (N), phosphorus (P), and potassium (K). These major nutrients usually are lacking from the soil first because plants use large amounts for their growth and survival.

Secondary nutrients.

- The secondary nutrients are calcium (Ca), magnesium (Mg), and sulphur (S). There are usually enough of these nutrients in the soil so fertilization is not always needed.
- Also, large amounts of Calcium and Magnesium are added when lime is applied to acidic soils. Sulphur is usually found in sufficient amounts from the slow decomposition of soil organic matter, an important reason for not throwing out grass clippings and leaves.

Soil Nutrients:

14 essential nutrients:

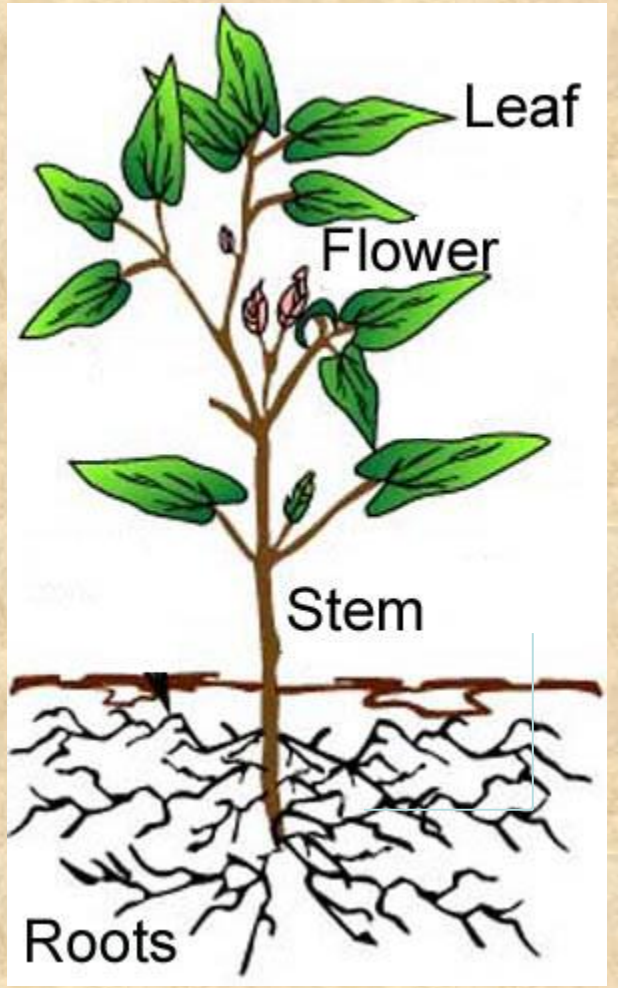
The three primary nutrients:

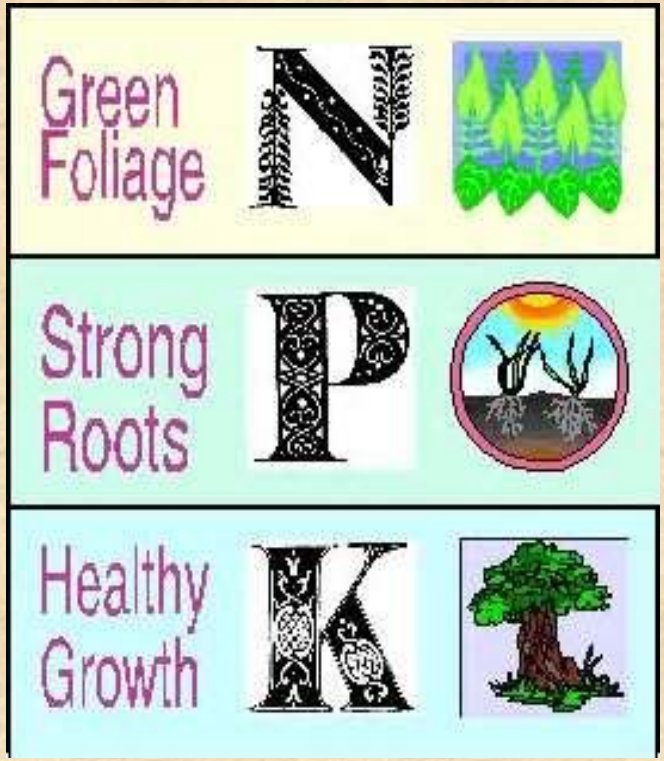
NPK

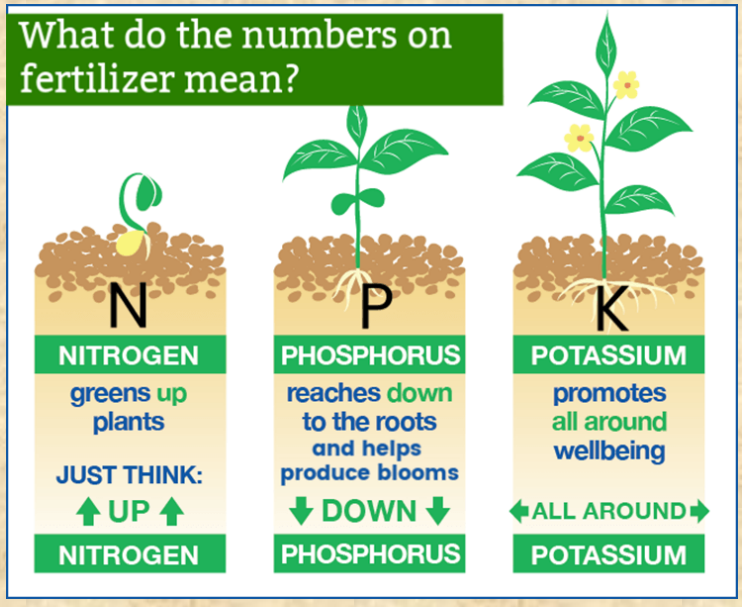
NPK in the stores/nurseries.

Name/per plant req.	Symbol
Primary Nutrients:	
Nitrogen 1 - 4%	N
Phosphorus 0.1 - 0.3%	P
Potassium 0.5 - 4%	K
Secondary Nutrients:	
Sulfur 0.15 - 0.3%	S
Calcium 0.1 - 0.2%	Ca
Magnesium 0.05 - 0.15%	Mg
Micronutrients:	
Zinc 10 - 30 ppm	Zn
Iron 10 - 75 ppm	Fe
Copper 2 - 10 ppm	Cu
Manganese 10 - 20 ppm	Mn
Boron 1 - 10 ppm	B
Molybdenum 0.1 - 0.7 ppm	Mo
Chlorine 25 - 1,000 ppm	Cl
Nickel trace amounts	Ni

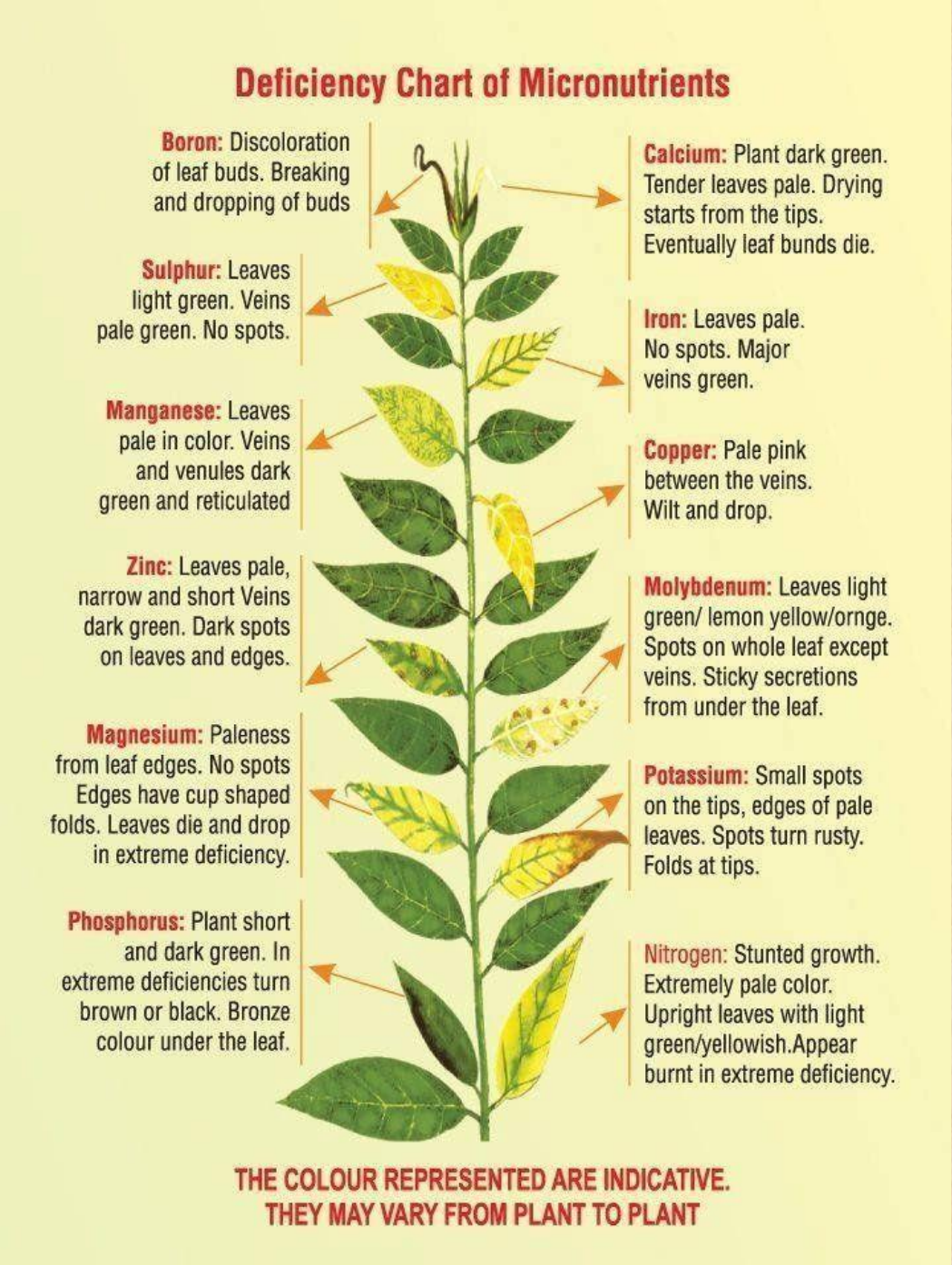
Importance of NPK:



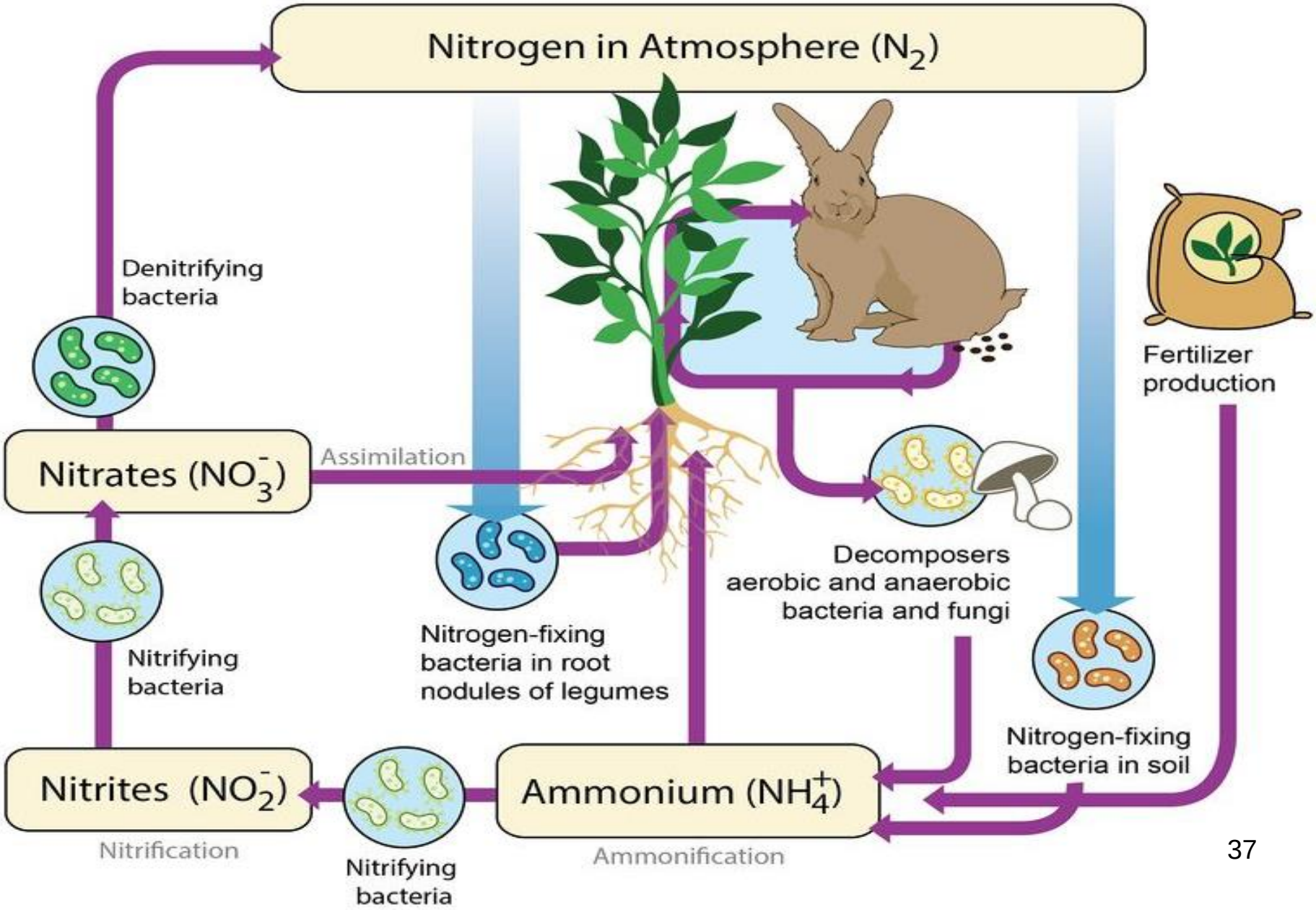




Importance of Secondary Nutrients and Micronutrients:



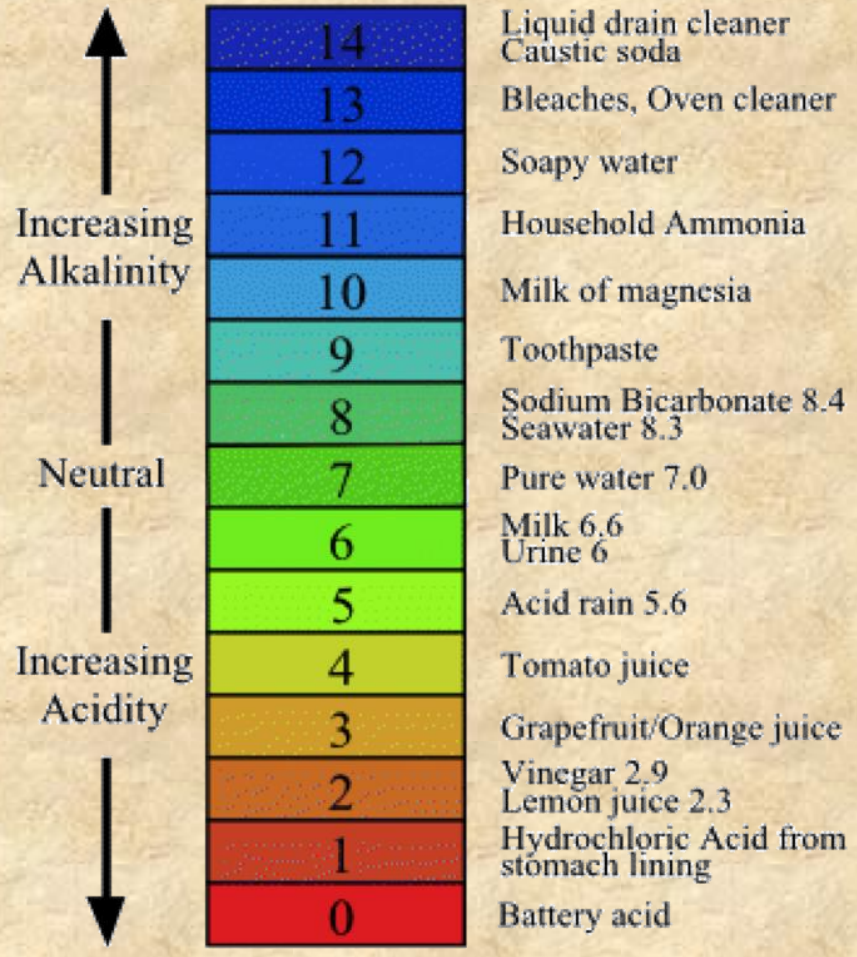
Nitrogen Cycle:



Soil pH:

Soil pH:

- The measure of acidity or alkalinity of the soil.
- At 7 on the pH scale alkalinity and acidity are balanced.
- When moving in either direction away from 7 alkalinity increases by a factor of 10 while acidity decreases by a factor of 10.
  - EXAMPLE: 5.5 is 10 times more acidic than 6.5.
- Some plants require different pH levels than others.
- pH levels also effects nutrient levels in soil.

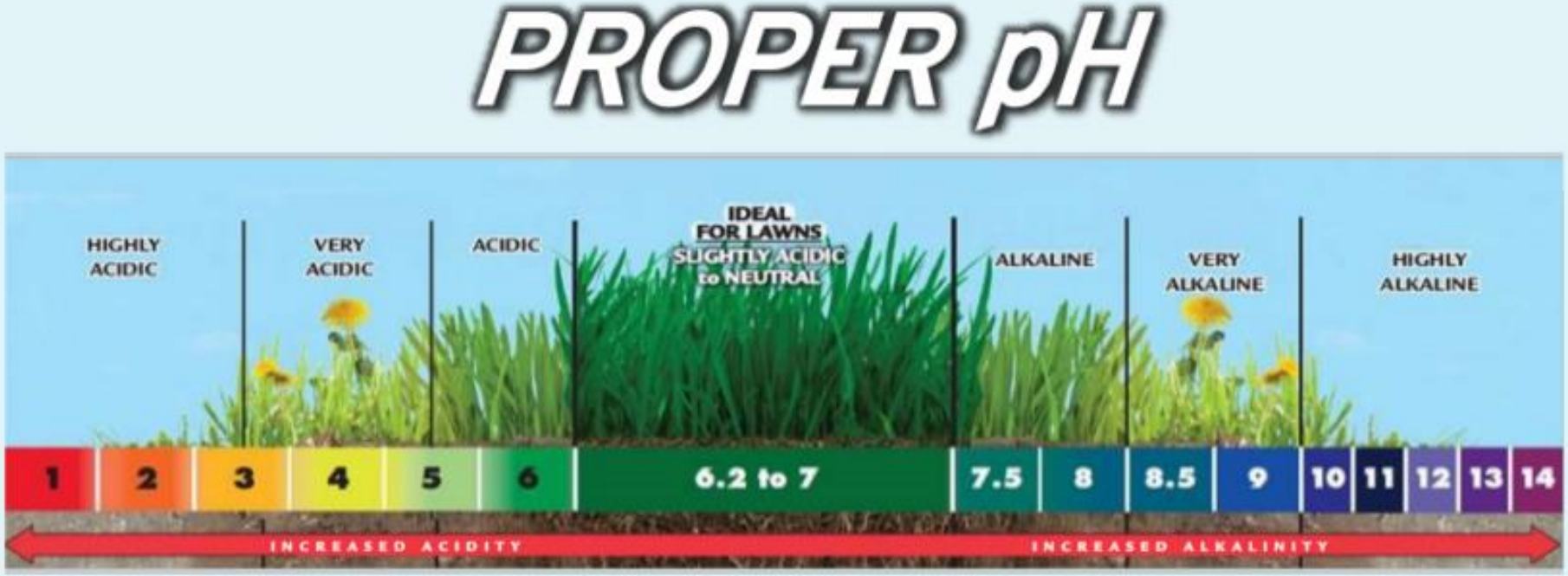


pH Scale

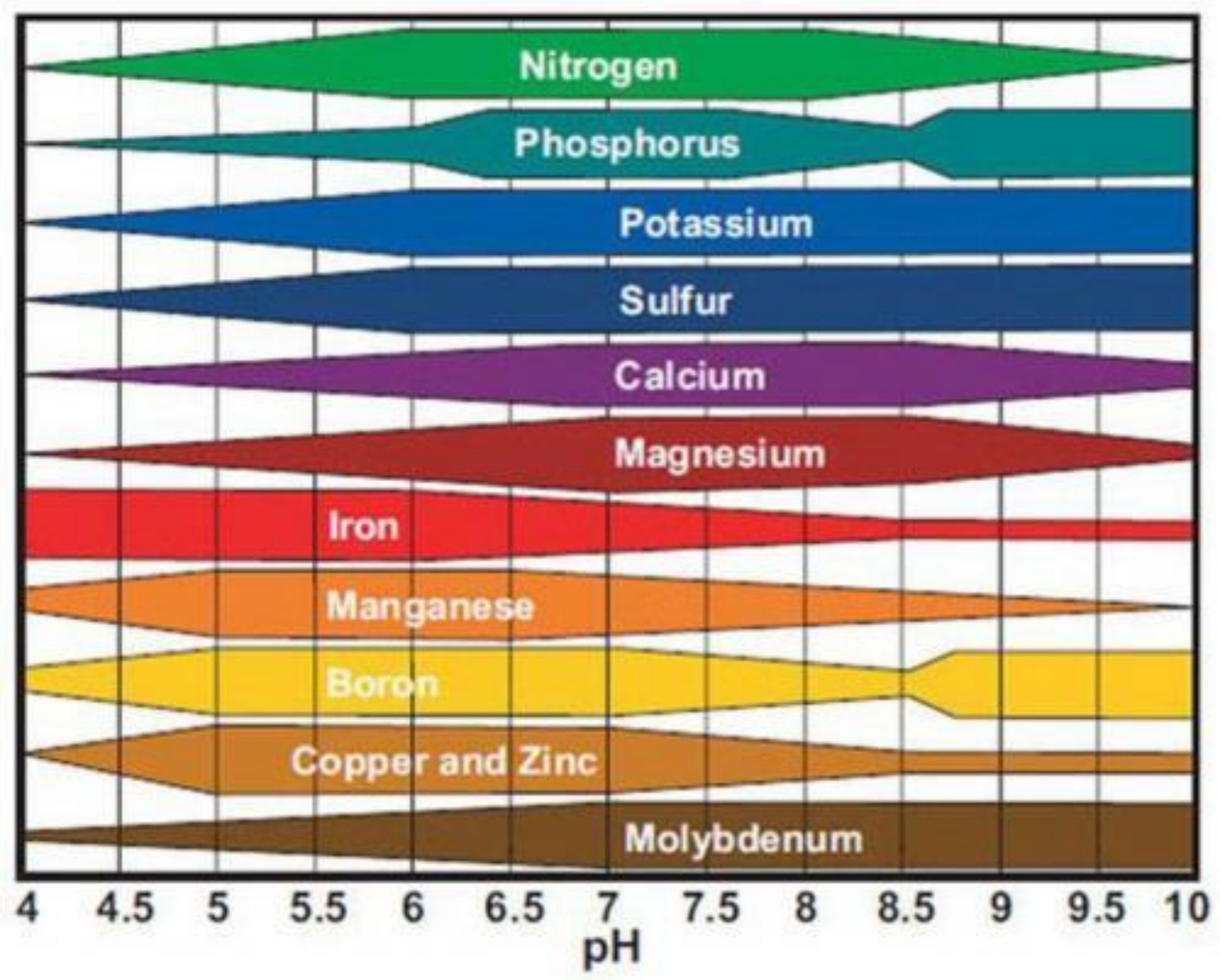
Soil pH:

Soil pH influences plant growth:

- Affects availability of plant nutrients.
- Affects availability of toxic metals.
- Affects the activity of soil microorganisms, which in turn affects nutrient cycling and disease risk.



pH Effect on Soil Nutrients:



Soil pH for Growing:

Neutral-alkaline
(7.0 to 8.0)

Asparagus	Beets
Cabbage	Cauliflower
Celery	Carrot
Lettuce	Parsley
Spinach	

Neutral-acidic
(6.0 to 7.0)

Potato	Strawberry
Raspberry	Grape

Acidic
(4.5 to 5.5)

Blueberry	Cranberry
Azalea	Rhododendron

Near neutral
(6.5 to 7.5)

Beans	Beets
Broccoli	Chives
Corn	Cucumber
Melons	Grape
Pepper	Peach
Pumpkin	Radish
Squash	Tomato
Peas	

Increasing & Decreasing pH:

- The most common way to increase soil pH is to add lime. Lime is ground limestone, a rock containing calcium carbonate. It is an organic (natural) amendment, suitable for use by organic gardeners. Lime raises the pH of acid soils and supplies calcium, an essential nutrient.
- Dolomitic lime contains magnesium as well as calcium. It is a good choice for gardeners in western Washington and Oregon, where soils often are deficient in magnesium.
- Elemental sulfur lowers soil pH. Soil testing is the best way to determine whether sulfur is needed and, if so, how much.
- Ammonium sulfate fertilizer also lowers pH, but it takes longer than sulfur to have an effect.
- Urea also reduces pH slowly, as do some organic fertilizers.

Fertilizers:

Easiest way to explain the difference between organic and inorganic fertilizers are:

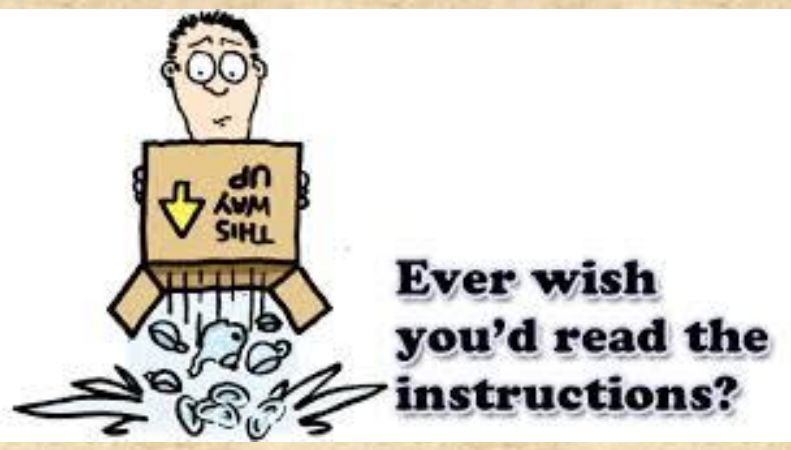
- Organic fertilizers are natural and breakdown to feed the micro-organisms in the soil and finally feed the plants.

  Examples of organic fertilizers include manure (poultry, cow or horse), bone meal, cottonseed, or other naturally occurring materials.

- Inorganic fertilizers are man made products and feed the plant directly. They usually have a higher nutrient content.

Excessive Nutrients:

- When used properly and at the right time fertilizers are safe for the environment.
- Excessive use of fertilizer can migrate nutrients to water tables through run off.
- Excessive N use on a plant results in vigorous vegetative growth and less fruit production.
- Over fertilization of vegetables can result in larger diameter of stalks and less production.
- **ALWAYS FOLLOW THE INSTRUCTIONS!**



Common Fertilizers Available in Landscape, Garden and Farm Stores:

Type:

- Single nutrient fertilizers.
- Multi-nutrient fertilizers/ Complete fertilizers.
- Balanced fertilizers
- Special purpose fertilizers.
- Common name.
- Fertilizer and %.

Calculating Amounts of Nutrients:

10 lbs. 25 - 3 - 5

Element	%		Weight		lbs.
N	25 = .25	x	10		2.5 lbs.
P	3 = .03	x	10		0.3 lbs.
K	5 = .05	x	10		0.5 lbs.
				Totals	3.3 lbs.

What are the remaining 6.7 lbs?

Inert ingredients such as sawdust, clean or sterile dirt, peat moss, sphagnum (moss), ground corn cobs and other products also serve as fillers.

Fertilizing:

Most gardeners should use a complete fertilizer with twice as much phosphorus as nitrogen or potassium. An example would be 10-20-10 or 12-24-12. These fertilizers usually are easy to find.

If the garden soil has not been tested, use 2 to 3 pounds of fertilizer such as 10-20-10 for every 100 square feet of garden area. A plot 10 x 10 feet (5 x 20 feet or 4 x 25 feet) would be 100 square feet. If a garden is 30 feet long and the rows are 3 feet apart, each row is almost 100 square feet. Use 2 pounds of fertilizer if the garden is sandy and 3 pounds if the soil is mostly clay.

The below hyperlink lets you know about fertilizing vegetable gardens, fruit trees, flowers, and lawns.

https://today.oregonstate.edu/news/know-what-your-plants-need-fertilizing

Fertilizing:

Heavy feeders: Beets, cabbage family crops (broccoli, Brussels sprout, cabbage, cauliflower, kale, kohlrabi, radish), celery, corn, cucumber, endive, lettuce, parsley, pumpkin, rhubarb, spinach, squashes, sunflower, tomatoes.

Light feeders: Bulbs, chard, herbs, mustard, pepper, root crops (carrot, garlic, leeks, onion, parsnip, potato, rutabaga, shallot, turnip).

Soil builders: alfalfa, beans, clover, peas.

Fertilizing:

Regular fertilizer applications keep plants vigorous and productive. When plants grow reluctantly or start turning yellow, fertilizer may help. If plants are vigorous and green, you can wait a little bit before applying more fertilizer. Too much fertilizer can burn plants. Tomatoes and beans given too much fertilizer grow lots of foliage but little fruit.

Vegetables growing in porous, well-drained soil should be fed a balanced fertilizer every **three to four weeks** throughout the growing season. Don't stop applications when fruit appears - continue to apply fertilizer as needed to ensure continued production.

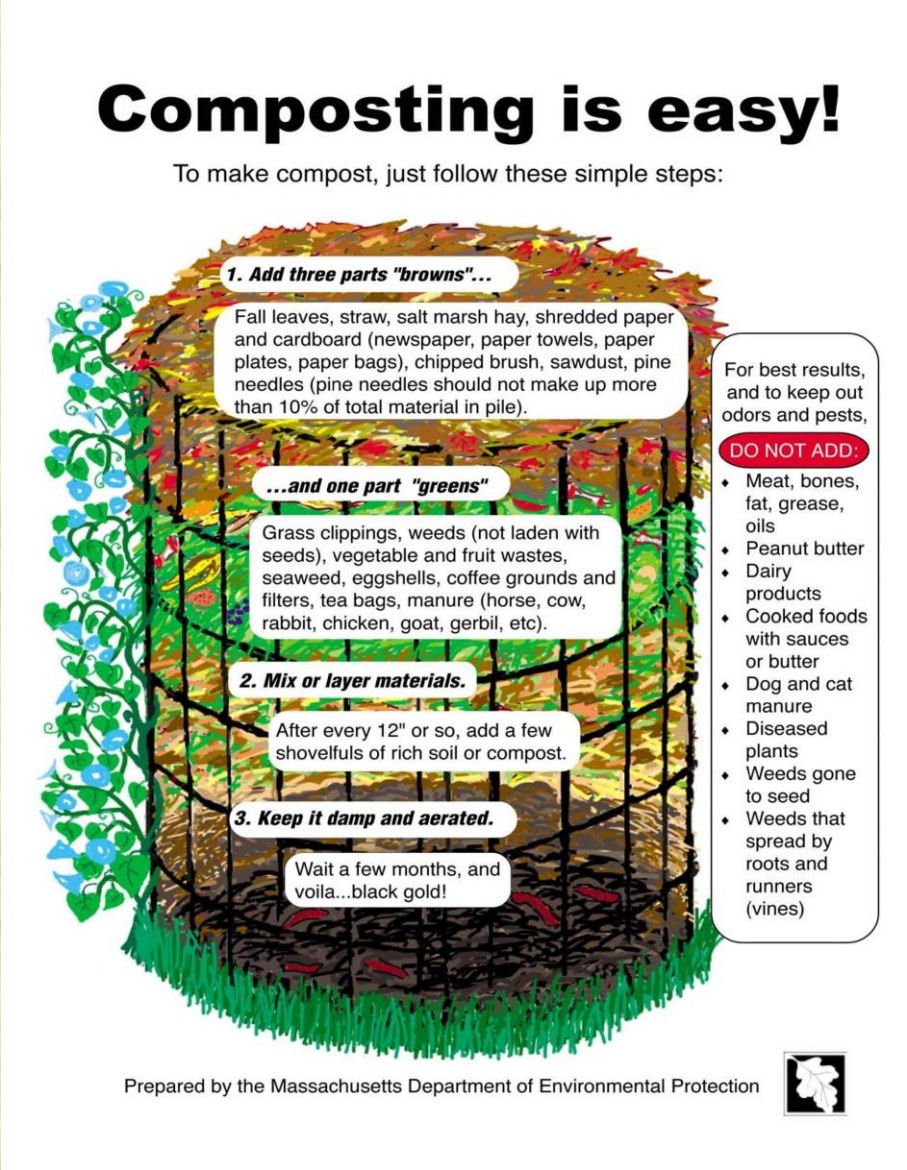
Vegetables growing in clay soils will need less fertilizer than those in sandy soils usually every **four to six** weeks after planting is typically enough. Crops growing in organic soils may need little additional fertilizer – again pay attention to foliage color and plant vigor as guides. In gardens where the soil is sand enriched with organic matter, one or two additional applications at intervals or three to four weeks is usually enough.

Composting:

Some people recommend late fall as a good time to spread compost over a garden bed, and cover it with a winter mulch, such as chopped leaves. By spring, soil organisms will have worked the compost into the soil.

Others recommend spreading compost two weeks before planting time in the spring.

There is really no wrong time to spread it. The benefits remain the same.



Composting:

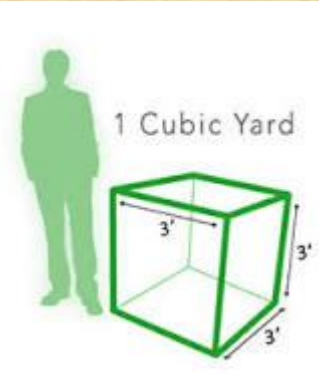
Amending garden soil:

To make a significant change in your garden soil, an amendment must equal at least one-third of the volume of the soil you are amending. For example, to amend a garden to a depth of 1 foot, you need to add one-third of a foot (4 inches) of material. Here is how to figure out the volume of material needed (using a 25-feet x 4-feet garden as an example):

1. Multiply width x length to get area: 25 feet x 4 feet = 100 square feet.

2. Multiply area x 0.333 (one-third of a foot) to get cubic feet: 100 square feet x 0.333 = 33.3 cubic feet.

3. Divide cubic feet by 27 to get cubic yards: 33.3 cubic feet ÷ 27 = 1.23 (1 ¼) cubic yards.



When can clay soil be worked?

- ✓ Too wet:

  Soil forms firm ball that will not break apart when dropped from shovel or tines of spading fork.

  (When your tiller blades become a roller.)

- ✓ Too dry:

  Tines of fork go into soil but bend instead of lifting soil.

Just right!

To Till or not to Till is your Decision:

You can find just as much information that recommends to till as you can not to till.

https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9027.pdf

- Tilling the garden performs a number of necessary functions. It mixes organic matter and fertilizer into garden soil and temporarily loosens the soil and helps control weeds that compete with crops for moisture and nutrients.
- Frequent tilling, however, may do more harm than good. Too much tilling tends to destroy the structural qualities of soil and eventually may leave you with soil that is better suited to making bricks than garden produce.
- **Till garden soil only when it will accomplish some useful purpose, such as turning under organic matter, controlling weeds, breaking crusted soil for water penetration, or loosening a small amount of soil for planting seeds.**

Garden Covered: 5 February 2022 (has been covered since mid November 2021.

Rototilled Garden: 17 May 2021

Rototilled Garden: 17 May 2021

Planted tomatoes 19 May 2021 and planted corn 12 June 2021.

Mulch:

Any material such as bark, chips, grass clippings, leaves, straw or pine/fir needles applied to the soil surface to:

- Reduce evaporation.
- Protect the soil surface.
- Reduce compaction.
- Smother weeds (use 3 - 4” blocks sunlight)
- Modify the soil temperature.

Mulch:

Pros and Cons of The Different Types

Type of Mulch	Pros	Cons
Bark Mulch	Sustainable (by product of the forestry industry). Breaks down to compost	Decomposing wood steals nitrogen from soil
Hay and Straw	Sustainable and cheap. Breaks down to compost	May contain seeds that will end up germinating in the garden
Stones	Can be used year after year. Decorative	Costly (buy and transport). Does not breakdown to feed soil
Plastic Coverings	Not sustainable but easy to apply	Does not add nutrients to soil or hold water
Landscaping Cloth	Reusable.	Expensive .Does not hold water or build soil
Grass Clippings	Sustainable and often free. Breaks down to compost which feeds soil	If put in too thick it will go moldy
Pine needles	Sustainable and free in some areas	decreases the pH

Manures:

Manures: **All manures release 5% N per year to the soil after 1st year until depleted!**

Type	Nutrient Lvl	Digestive System	Advantages	Disadvantage	N P K
Cow	Lower than horses 10-15) 5 gal buckets/100 sq ft.	1 stomach with 4 compartments.	High avail. Releases 33% N 1st yr.	Must age	Steer .7 - .3 - .4 Dairy .25 - .15 - .25
Alpaca/Llama	High and low in organic matter	1 stomach with 3 compartments.	Can use hot. Small pellets & breaks down quick. No weed seeds. Releases 33% N 1st yr.	Low avail	1.7 - .69 - 1.2
Horse	High 10) 5 gal buckets/100 sq ft.	One simple stomach	High avail. Releases 33% N 1st yr.	Can produce a lot of weeds. Must age prior to use.	.7 - .3 - .6
Pig	Lower than horses 10) 5 gal buckets/100 sq ft.	1 simple stomach	Releases 33% N 1st yr.	Low avail	.8 - .7 - .5
Goat/Sheep	10-20) 5 gal buckets/100 sq ft.	1 stomach with 4 compartments.	High avail. Releases 33% N 1st yr.		.7 - .3 - .9
Chicken	Highest 5-10) 5 gal buckets/100 sq ft.	Stomach (proventriculus or gizzard)	High avail	Must age prior to use in garden. Releases 75% N 1st yr.	1.1 - .8 - .5
Rabbit	High 5) 5 gal buckets/100 sq ft.	1 simple stomach	Can use hot. Releases 33% N 1st yr.	Low avail.	2.4 - 1.4 - .6
Worm Castings	High 10-15 lbs/100 sq ft	Stomach (gizzard)	High avail. Releases 33% N 1st yr.		3.2 - 1.1 - 1.5

Manures from carnivorous animals should not be used due to the chance of passing on pathogens and parasites into the compost pile.

Average nutrient concentrations and rates of availability for various organic materials:

Material	% N	% P	% K	Availability	Notes
Alfalfa hay	2 – 3	0.5 – 1	1 – 2	Moderate	
Bone meal	1 - 6	11 – 30	0	Moderate	alkaline
Blood meal	12	1 – 2	0 – 1	Rapid	acidic
Canola meal	6	2	1		
Cottonseed meal	6	3	1	Slow	acidic
Composts	1 – 3	1 – 2	1 – 2	Moderate	alkaline
Crab shell meal	4	1.5	0		
Feather meal	12	0	0	Moderate	
Fish emulsion	3 – 5	1	1		
Fish meal	6 – 12	3 – 7	2 – 5	Rapid	acidic
Grass clippings	1 - 2	0 – 0.5	1 – 2	Moderate	
Green sand	0	0	3.7		
Hoof/horn meal	12 – 14	1.5 – 2	0	Moderate	alkaline
Kelp	1 – 1.5	0.5 – 1	5 – 10	Moderate	zinc, iron
Leaves	1	0 – 0.5	0 – 0.5	Slow	
Legumes	2 – 4	0 – 0.5	2 - 3	Moderate	
Manures: cattle	2 – 3	0.5 – 1	1 – 2	Moderate	weedy
horse	1 – 3	0.5 – 1	1 – 2	Slow	weedy
swine	2 – 3	0.5 – 1	1 – 2	Rapid	
poultry	3 – 4	1 – 2	1 – 2	Rapid	high in salts
sheep	3 – 4	0.5 – 1	2 – 3	Moderate	weedy
Pine needles	0.5	0	1	Slow	acidic
Rock phosphate	0	25 – 30	0	Very slow	use only in acidic soils
Sawdust	0 – 1	0 – 0.5	0 – 1	Very slow	Ties up N
Sewer sludge	2 – 6	1 – 4	0 – 1	Moderate	zinc, iron
Seaweed extract	1	2	5	Rapid	zinc, iron
Straw/corn stalks	0 – 0.5	0 – 0.5	1	Very slow	ties up N
Wood ashes	0	1 – 2	3 – 7	Rapid	high in salts

Summary:

- Soil Foundation.
- Soil Structure.
- Soil Testing.
- Soil Nutrients.
- Nitrogen Cycle.
- Soil pH.
- Fertilizing.
- Composting.
- Rototilling.
- Mulches.
- Manures.

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Soils and Fertilizing:

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