THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
College of Agricultural and Environmental Sciences
College of Family and Consumer Sciences

Introduction to Soils

Paul Pugliese, MPPPM
Bartow County Extension Coordinator
The University of Georgia

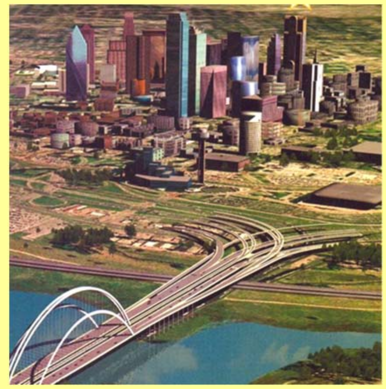
Adapted from:
C. Owen Plank
UGA Extension Agronomist

Webster Defines Soil As…..

- The upper layer of the earth that may be dug or plowed and in which plants grow
- However, to soil scientists the definition is more complex
- It may have different meanings to different people

Golf Course Superintendent

Engineer



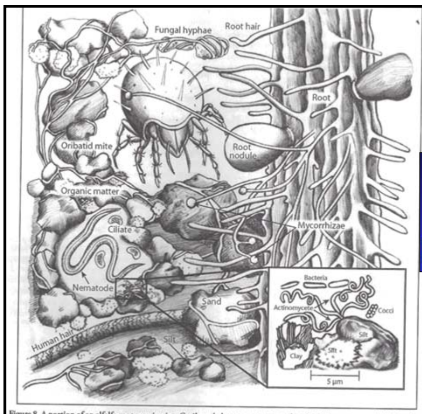
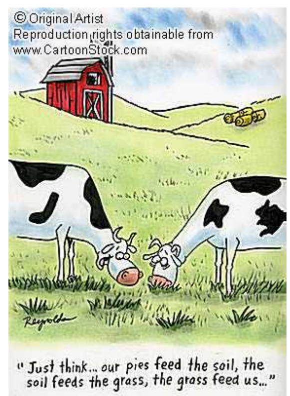


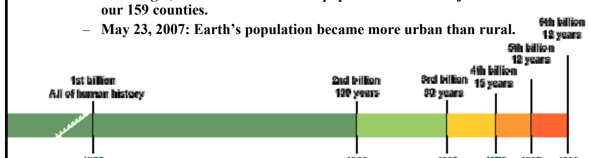
Figure 8. A portion of an alfalfa root growing in a Cecil sandy loam, a common soil in the Piedmont, containing less than 1% organic matter. The soil is well-aggregated and not compacted. A human hair (diameter, 100 micrometers) is included for comparison. (Original drawing by Wendy Giminski.)



How Much Topsoil is on Earth?

Globalization Facts…"The Big Picture"

- **World Population Today: 7.2 Billion People**
  - **Increasing at 2 Billion every 25 years**
  - **Predictions:**
    - **In the next 50 years, the world may reach a maximum sustainable population of 10-12 Billion people…**
    - **Fifty percent of the population will reside in mega cities of 12 to 15 million.**
  - **How will Agriculture feed and sustain that many people?**
  - **In the United States, over two-thirds of the population resides in metropolitan areas.**
  - **In Georgia, over half of our state's population resides in just 24 of our 159 counties.**
  - **May 23, 2007: Earth's population became more urban than rural.**

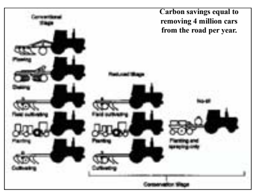


- All jobs rely on one of two industries – mining and agriculture. Every tangible thing our society needs is either pulled from the ground or grown from the ground. Without these fundamental industries there would be no jobs of any kind. There would be no economy. Civilization begins with miners and farmers, and polite society is only possible when skilled workers transform those raw materials into something useful or edible.

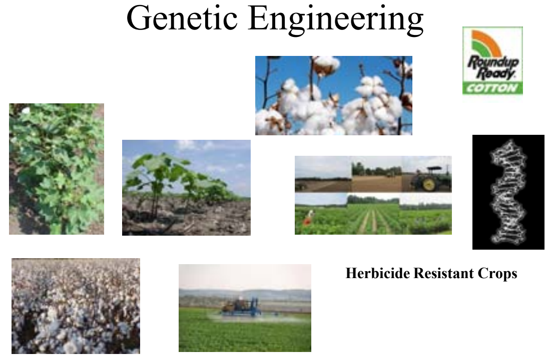
  -Mike Rowe, Dirty Jobs (Discovery Channel)

Soil Conservation & Carbon Savings

- **Chemical control of weeds and insects requires about 80% less energy than mechanical control by cultivation.**

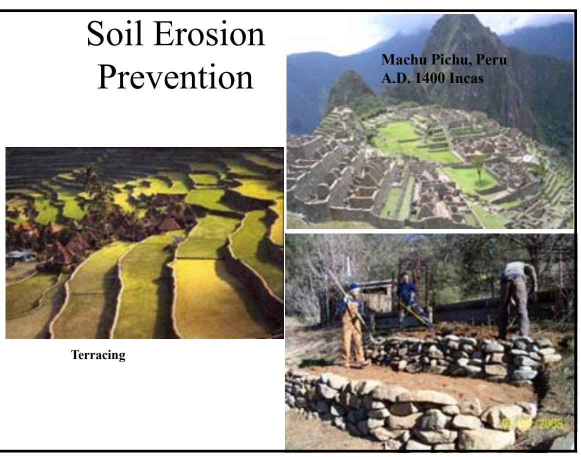


Biotechnology & Genetic Engineering



Herbicide Resistant Crops

Soil Erosion Prevention



Terracing

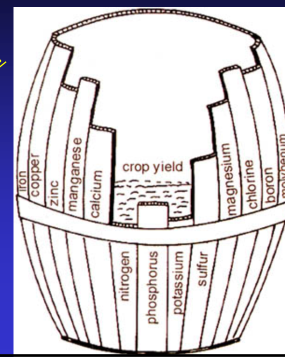
Six Abiotic Factors

- **Nutrients**
- **pH**
- **Water**
- **Oxygen**
- **Temperature**
- **Light**

Note: Six Biotic Factors will be covered in other parts of the book and are outside the scope of today's lecture.

16 Essential Plant Nutrients:

Fertilizer is not plant food!



Essential Macronutrients

- Carbon (C), Hydrogen (H), Oxygen (O)
  - Make up 94% of plant dry weight
- Primary Soil Nutrients:
  - Nitrogen (N), Phosphorus (P), Potassium (K)
  - Almost all soil N comes from atmosphere and must be combined with other elements for plants to use.
- Secondary Soil Nutrients:
  - Calcium (Ca), Magnesium (Mg), Sulfur (S)
  - Epsom Salts for Mg?

N-P-K

- Nitrogen (N) → UP!
- Phosphorus (P) → DOWN!
- Potassium (K) → All Around!
  - K from Latin word kalium

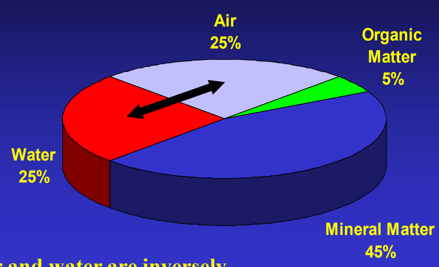
Staying Alive…

Soil Micronutrients

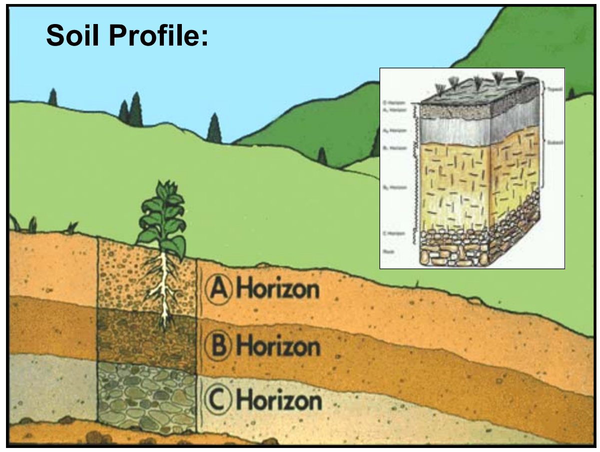
- Boron (B), Copper (Cu), Manganese (Mn), Zinc (Zn), Iron (Fe), Molybdenum (Mo), and Chloride (Cl^-)
- Just as important as macro-nutrients, but taken up in smaller amounts.
- Boron and Zinc are commonly of short supply in garden soils.
  - Usually due to high soil pH…
  - 1 tbsp. borax per 100 sq.ft.

Nutrient	Part of plant affected by nutrient deficiency	Symptoms	External circumstances leading to the nutrient deficiency
Nitrogen	**Older foliage, going to whole plant……………… Petioles (rare)…………**	**Pale green or yellow Red**	**Excessively leached or waterlogged soils, Soils with low organic matter**
Phosphorus	Older Leaves…………… Whole plant……………… Petioles……………………	Purpling, bronzing Stunting Red	Cold wet soils (early spring), acid or very alkaline soils, compacted soils
Potassium	Older Leaves…………… Leaf Margins……………	Yellow translucent spots Browning	Soils with excessive leaching, high pH soils
Calcium	Roots……………………… Whole plants……………… New shoots……………… Stem or petiole…………… Fruit……………………… Young or old leaves ……	Thickened Stunted Withered or dead Collapse Blossom End Rot Tip Burn	**Improper watering (most common cause)**, very acid soils, soils with excessive potassium, excessively dry or wet soils
Iron	**Young leaves……………**	**Tissue between veins becomes pale or white**	**High pH soils, soils with low organic matter, high phosphorus, excess zinc, manganese or copper**
Zinc	**Young leaves……………… Petioles……………………**	**Pale or grayish, yellowing between veins; rosetted Weak**	**High pH, low organic matter, excess phosphorus in soil, lack of nitrogen**
Manganese	**Young leaves……………**	**Yellow mottled areas**	**Soils with pH over 6.5, high iron soils, low nitrogen soils, dry weather compacted soils**
Magnesium	Interveinal space of older leaves; may begin around interior perimeter of leaf	Yellowing	Light acid soils, soils with excess potassium, calcium or phosphorus
Sulfur	Young leaves……………… Leaf Veins……………… Whole plant………………	Yellowing Paler than rest of leaf Stunted, pale	Sandy soils, soils with low organic matter
Boron	Growing points…………… Young leaves………………	Die back Yellowing, distorted, form unnatural rosettes	Soil pH under 5.5 or over 6.8, sandy soils with low organic matter lack of nitrogen
Copper	New shoots……………… Young leaves……………… Whole Plant………………	Do not open Yellowing, become thin Pale green	High pH soils, lack of nitrogen compacted soils
Molybdenum	Older leaves	Yellow, distorted, narrow	Soils with pH under 5.5

Soil Composition - Volume Basis



***Air and water are inversely proportionate to each other.**



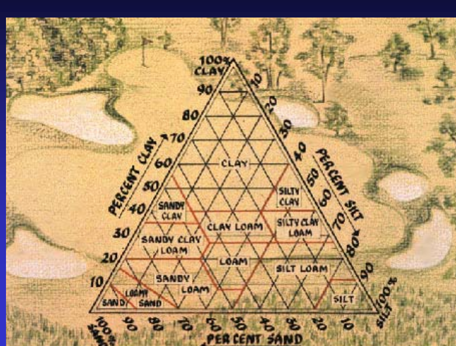
"Permanent" Soil Properties

- Texture
- Thickness of topsoil
- Thickness of subsoil
- Certain Chemical Properties

Changeable Soil Properties

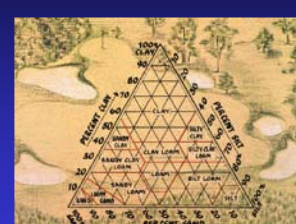
- Soil Structure
- Soil Organic Matter
- Soil Color
- Soil pH (Acidity)
- Soil Nutrient Levels

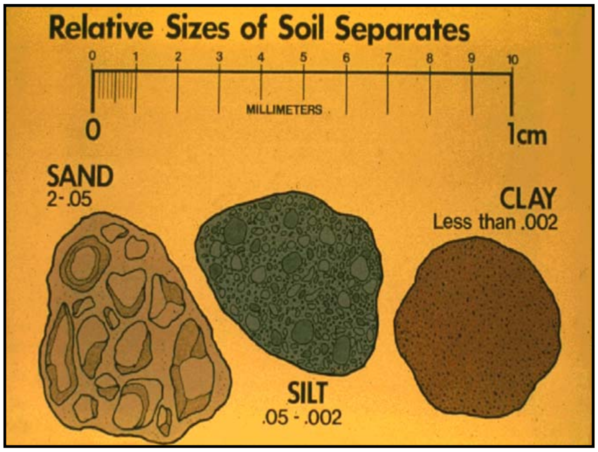
SOIL TEXTURE



Soil Texture

- Soil texture refers to the relative proportions of sand, silt, and clay in a soil
- 12 textural classes
- Loam is considered to be ideal texture for growth of plants
- Difficult to alter soil texture on large scale

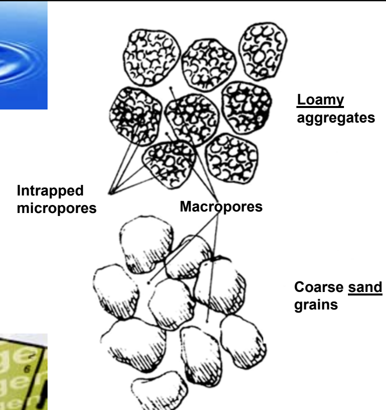


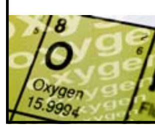


- In the field, texture is determined by "feel"

Importance of Soil Texture

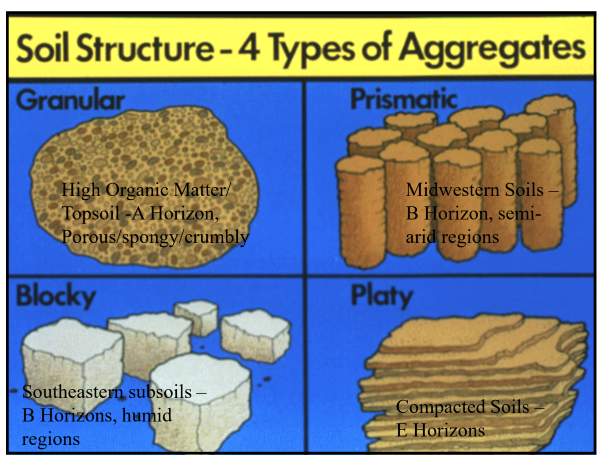
- Influences pore size and pore space
  - large pores - air
  - small pores - water
  - sandy soils have larger pores, less surface area, and water drains more freely compared to clay soils
- Influences a soils water holding capacity
  - fine textured soils have more and smaller pores
  - hold more water than sandy soils
  - also hold water more tightly





Soil Structure

- Manner in which soil particles are arranged together
- Particles in sandy soils may remain independent of each other
  - a.k.a. single grain texture
- Particles in fine textured soils are arranged in a definite manner to form stable aggregates—how soil particles clump or stick together.

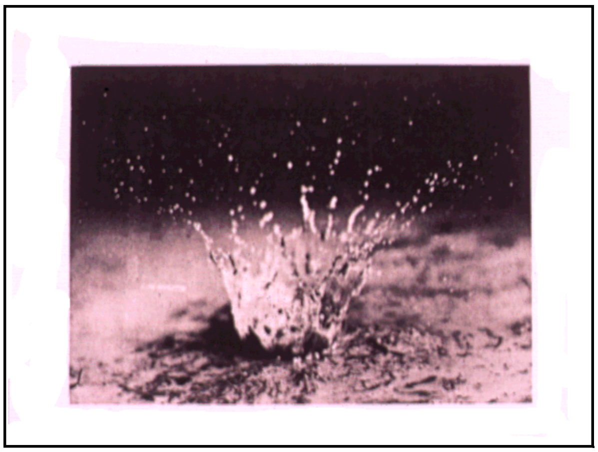


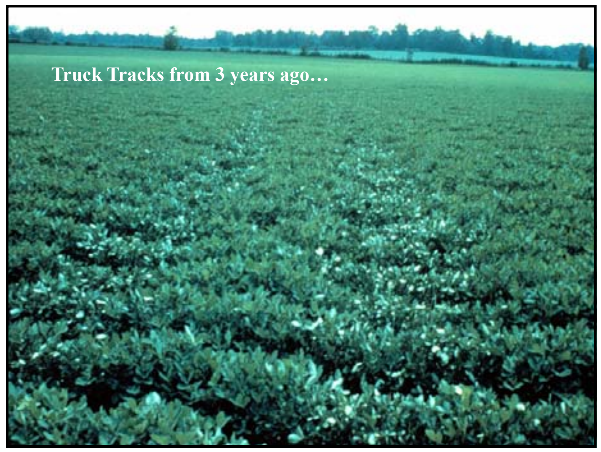
Importance of Soil Structure

- Improves air & water relationships
- Improves root penetration
- Improves water infiltration
- Reduces erosion
- Ease of tillage
- Reduces crusting
- Affects soil drainage

Maintaining Soil Structure:

- Add Organic Matter
- Till Soil When Moist
  - Not Too Wet; Not Too Dry
- Grow Grasses
- Grow Cover Crops
  - Keeps Soil Protected from Rain, etc.
- Restrict Traffic to avoid compaction





Soil Compaction

Relative Compacting Effects of Soils by Different Agents

Item	Pressure, Lb. Per Sq. Inch
Man (150 pounds)	6
Crawler Tractor	12
Farm Tractor	20
Cattle	24
Trucks	50 –100
Rototiller (garden)	107 – 750

Soil Color

- Many different soil colors: black, brown, gray, red, beige
- Give important clues about soils chemical and physical environment
- Sand, Clay, Humus

Soils Vary in Clay and Humus Content

Half-Way Point

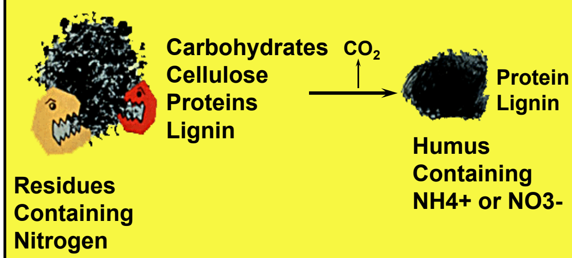
Organic Matter

- Improves soil physical condition
- Reduces erosion
- Improves water infiltration
- Improves water holding capacity
- Increases soil cation exchange capacity
- Source of nutrients

Organic Matter

- Contains varying amounts of all the essential nutrient elements
  - e.g. ~ 5% Nitrogen
- Serves as important storehouse of elements such as nitrogen and sulfur
- Nutrient elements contained in freshly added organic matter are not immediately available to plants
- Residues must be decomposed into humus, and nutrients released in ionic form (+ or - charge)

Humus Formation & Nitrogen Transformation



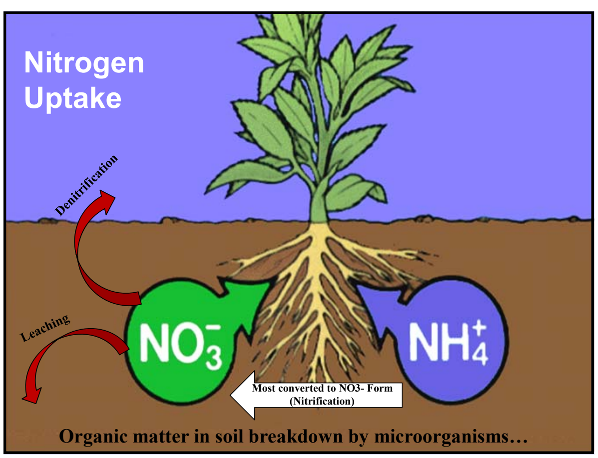
ORGANIC MATTER

TEMPERATURE

RAINFALL = % SOIL ORGANIC MATTER

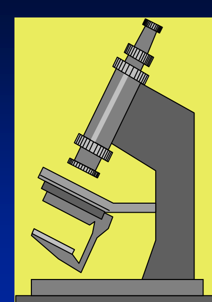
AMOUNT OF RESIDUE

Regular Additions of Organic Residues Must Be Made to Maintain Soil Organic Matter Levels



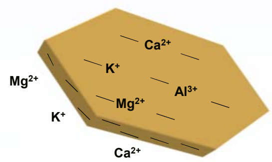
6 Soil Microorganisms

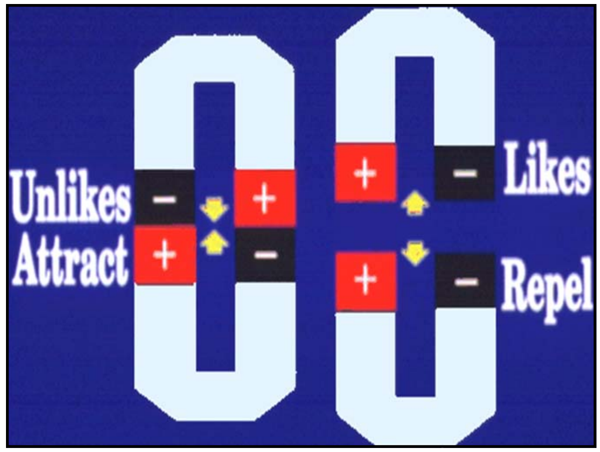
- Viruses
- Bacteria (fixation)
- Fungi/Algae
- Protozoa
- Nematodes
- Earthworms



Soil colloids may be envisioned as a huge anion (-)

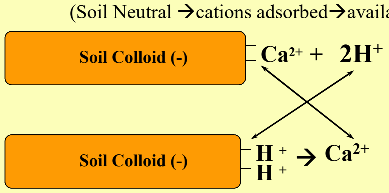
Kaolinite Particle (clay)





Cation Exchange

(Soil Neutral →cations adsorbed→available)



(Soil Acidifies →cations lost →unavailable)

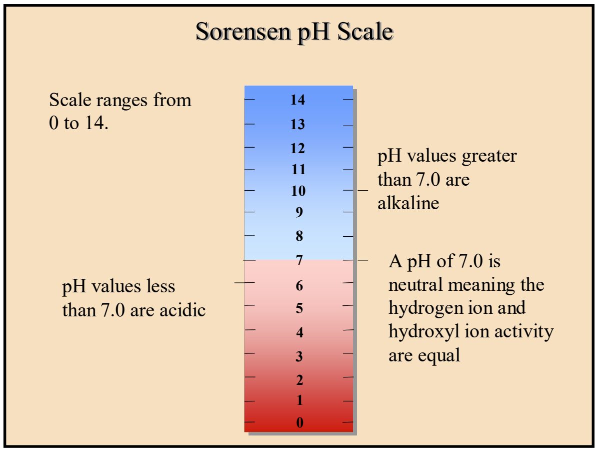
Cation Exchange Capacity of Clays & Organic Matter

	Clay Mineral	Exchange Capacity cmol(+)/kg
(S. GA)	Kaolinite & Sands	3-15
	Montmorillonite	100-120
	Vermiculite	100- 180
(IL)	Illite & Silty Clay Loams	20-40
	Organic Matter	200-400

- The higher the exchange capacity, the more positively charged nutrients a soil can hold…
- Each 1% organic matter present adds 2-4 cmol (+)/kg

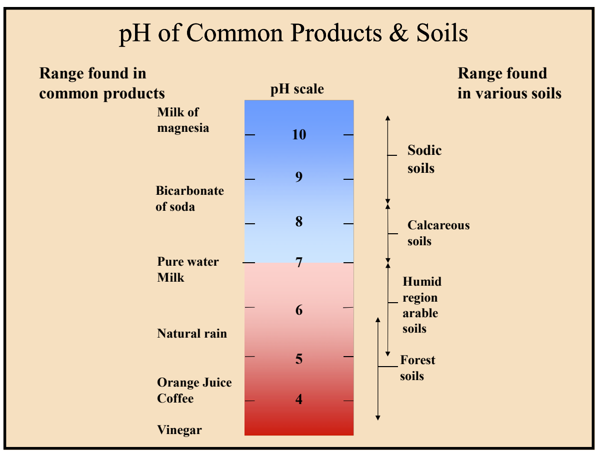
pH is a term used to describe the Hydrogen ion (H^{+}) activity and/or concentration in solution

$$pH = -\log (H^{+})$$



Soil pH Reflects Hydrogen Ion Activity

Soil pH	Acidity/Alkalinity Compared to pH 7.0
9 (Alkalinity)	100
8	10
7	Neutral
6	10
5 (Acidity)	100
4	1000

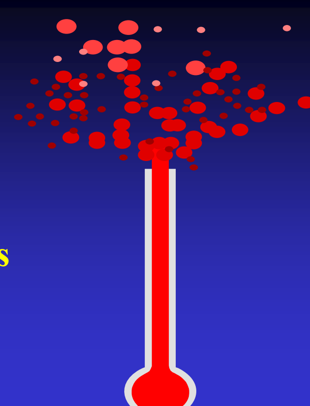


Soil pH is one of the most important chemical reactions that occurs in soils

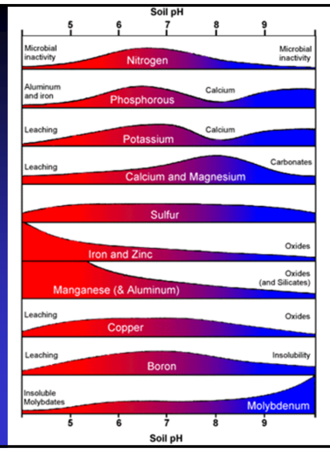
Why?

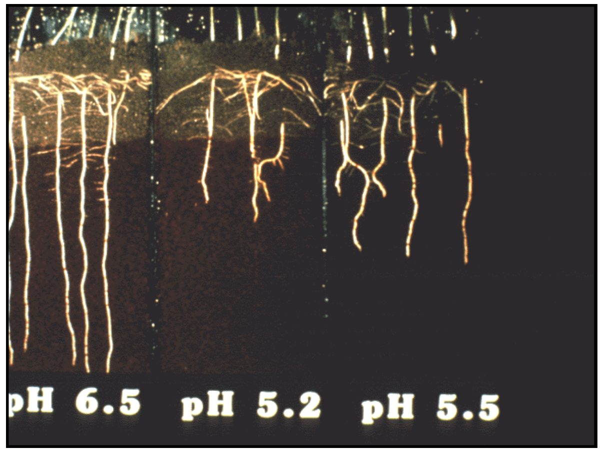
pH affects many reactions and activities that occur in soils

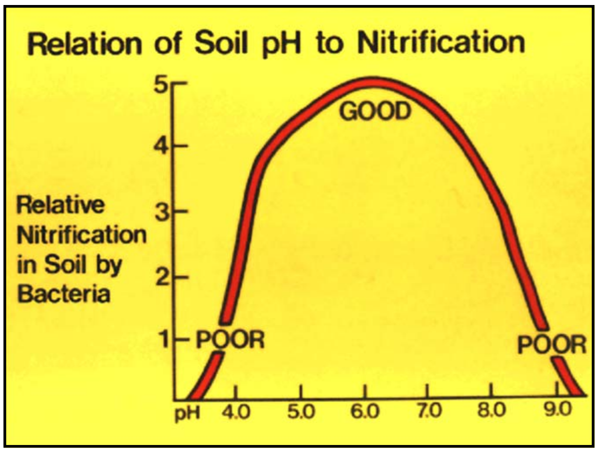
- **Chemical Reactions Occur Faster in Acidic Soils**

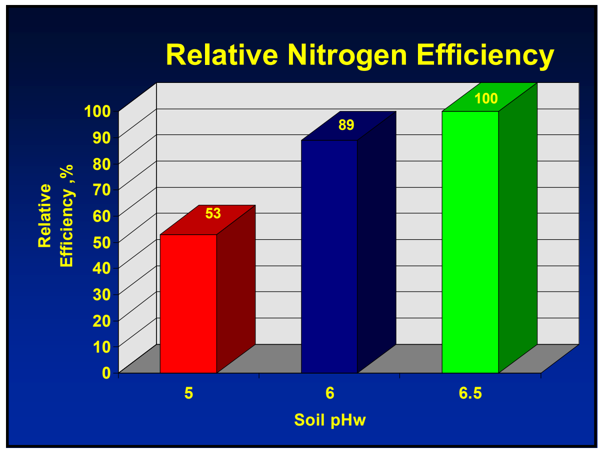


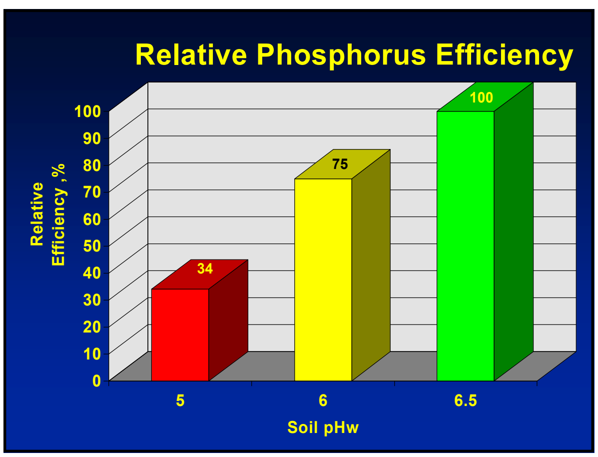
- pH affects Nutrient Availability whether from organic or synthetic sources…

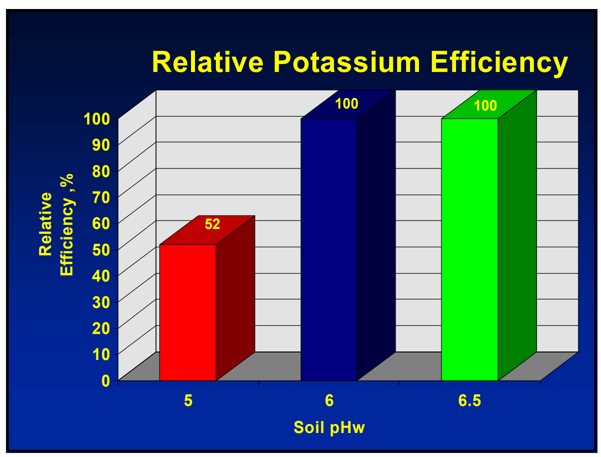












Soils Become Acid Because-

- Areas with high rainfall, result in:
  - a. leaching and plant uptake of base forming cations (Ca^{2+}, Mg^{2+}, and K^{+})
  - b. rapid reaction of water with Al & Fe, which produces H ions
- Application of acid forming fertilizers
  - mostly those containing ammonical (NH_4^{+}) nitrogen
- Decomposition of organic matter
- Microbial activity

Nitrogen Conversion in the Soil Produces Acidity

Organic Matter
Manure, etc.

$$2\ NH_4^{+} + 4O_2 \xrightarrow{\text{Bacteria}} 2NO_3^{-} + 2H_2O + 4H^{+}$$

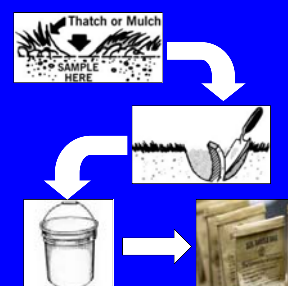
NH_4 - N Fertilizer Sources

Note: The H^{+} is the acidity component

Determining Soil Acidity

- pH Kits
- pH Meters

Soil Sampling: The soil test is only as good as the sample!



www.soiltest123.com

Determining Soil pH & Limestone Requirement at UGA Laboratory

- Automated soil pH analyzer (130 samples can be analyzed per hour)
- Two analyzers operational gives the Lab capacity to analyze 260 samples/hour for pH and lime requirement
- Soil pH is recorded on soil test report along with the lime buffer capacity.

THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION

Soil, Plant, and Water Laboratory
2400 College Station Road
Athens, Georgia 30602-9150
Web site: http://aesl.ces.uga.edu

Soil Test Report

(CEC/CEA Signature)

Sample ID

Client Information	Lab Information	County Information
Ackerman, Ken 201 Wellington Falls Way Canton, GA 30114 Sample: 1 Crop: Zoysia Lawn	Lab #63296 Completed: 05/29/2007 Printed: 01/12/2008	Cherokee County 130 E. Main Street, Suite 200 Canton, GA 30114 phone: 770-479-0421 e-mail: uge1057@uga.edu

Results — Mehlich I Extractant — UGA Lime Buffer Capacity Method*

	Phosphorus (P)	Potassium (K)	Calcium (Ca)	Magnesium (Mg)	Zinc (Zn)	Manganese (Mn)	pH *	Lime Buffer Capacity (LBC)	
Soil Test Index	16 lbs/Acre	124 lbs/Acre	396 lbs/Acre	62 lbs/Acre	4 lbs/Acre	10 lbs/Acre	5.1	303	Soil Test Index

Recommendations

Limestone: 30 pounds per 1000 square feet

Recommended pH: 6.0 to 6.5

*For information on how the Soil, Plant, and Water Laboratory measures and reports pH and makes lime recommendations, see http://aesl.ces.uga.edu/publications/soilcirc.

For establishment, incorporate 25 pounds of 5-10-15 per 1000 square feet into the top 4 to 6 inches of soil prior to seeding, sprigging, or sodding. Then apply 3 pounds of 34-0-0 or 2 pounds of 46-0-0 per 1000 square feet monthly during the growing season through August. To improve winter hardiness, apply 6 pounds of 16-4-8 or 8 pounds of 12-4-8 per 1000 square feet in September. Follow this fertilizer program for the first year only, then use the maintenance fertilizer program for the next 2 to 3 years. Retest 2 to 3 years after establishment.

For maintenance, apply 10 pounds of 10-10-10 per 1000 square feet when spring growth begins and in September. In June and July, apply 3 pounds of 34-0-0 or 2 pounds of 46-0-0 per 1000 square feet.

Clippings do not contribute to thatch under proper management and thus, do not need to be removed. If they are removed, increase the fertilizer application rate by 30%.

CAUTION: Water lawn thoroughly immediately after applying fertilizer. Do not apply fertilizer when grass is wet.

Desired pH 6.0 - 6.5

Desired pH for Some Crops

5.0 – 5.5*	5.5 – 6.0*	6.0 – 6.5*
Blueberries	Sweet Potatoes	Sweet Corn
Irish Potatoes	Lawn Grasses	Tomatoes
Azaleas	Annual Flowers	Onions
Rhododendrons	Perennial Flowers	Cabbage
	Spring Flowering Bulbs	Watermelon

*pH_w Values

How Can We Reduce Soil Acidity?

Apply Liming Materials!

Lime Sources and Their Relative Neutralizing Values

Liming Material	*Relative Neutralizing Value**
Calcitic Limestone	*85 – 100*
Dolomitic Limestone (Mg)	*95 - 108*
Burned Lime	*179*
Hydrated Lime	*120 - 135*
Gypsum	*None*

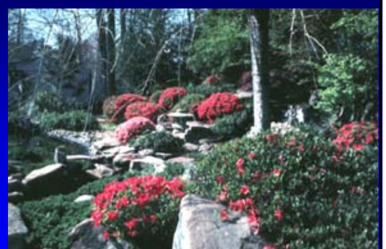
**Calcium Carbonate is used as a standard with a neutralizing value of 100*

FREQUENCY AND RATE OF LIMING DEPENDS ON:

- SOIL pH
- SOIL TEXTURE
- NITROGEN FERTILIZATION RATES
- REMOVAL OF Ca AND Mg BY PLANTS
- AMOUNT OF LIME PREVIOUSLY APPLIED
- SOIL pH RANGE DESIRED

Acidifying Soils

- Acidifying soils is frequently required in nursery and horticultural situations.



Materials Used for Acidifying Soils

- Elemental sulfur
- Aluminum sulfate (Alum)
- Iron sulfate

Reducing Soil pH with Sulfur or Aluminum Sulfate

	Desired pH 5.5			Desired pH 6.0		
Initial Soil pH_w	Textural Classification					
	Sandy	Loamy	Clayey	Sandy	Loamy	Clayey
	Sulfur Required, lbs per 1000 ft^{2}**					
5.5	0	0	0			
6.0	4	10	16	0	0	0
6.5	8	20	32	4	10	16
7.0	12	29	47	8	20	32
7.5	15	38	61	12	29	47

***Aluminum sulfate rate = lbs. Sulfur x 6*

Reducing Soil pH with Sulfur or Aluminum Sulfate

	Desired pH 4.5			Desired pH 5.0		
Initial Soil pH_w	Textural Classification					
	Sandy	Loamy	Clayey	Sandy	Loamy	Clayey
	Sulfur Required, lbs per 1000 ft^{2}**					
5.0	4	10	16	0	0	0
5.5	8	20	32	4	10	16
6.0	12	29	47	8	20	32
6.5	15	38	61	12	29	47
7.0	19	48	77	15	38	61
7.5	23	57	92	19	48	77

***Aluminum sulfate rate = lbs. Sulfur x 6*

- Elemental sulfur and sulfur compounds are the most popular acidifying materials.
- Bacteria are required for this process to occur through oxidation.
- Bacteria are most active in warm soil.
  - $2S + 3O_2 + 2H_2O \rightarrow 2H_2SO_4$ (Sulfate) (Thiobacillus)

- Aluminum and iron sulfates can also be used
- These materials are very effective but are sometimes difficult to find
- They react quicker and do not require microbial oxidation
- Acidity is result of hydrolysis reaction:
  - $Al_2(SO_4)_3 + 6H_2O \leftrightarrow 2Al(OH)_3 + 6H^+ + 3SO_4^=$
  - $Fe_2(SO_4)_3 + 6H_2O \leftrightarrow 2Fe(OH)_3 + 6H^+ + 3SO_4^=$

The Fertilizer Bag Example: 16-4-8

- Numbers refer to percent by weight of nitrogen, phosphorous, potassium in the bag
- Example: 16-4-8 has 16% N, 4% P, 8% K
- 50 lb. bag = 8 lbs. N, 2 lbs. P, 4 lbs. K
- Nutrient sources also listed

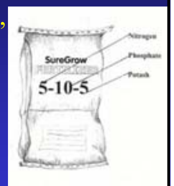


Table 1. The Most Commonly Recommended Fertilizer Ratios for Lawns, Example Fertilizer Grades and Application Rates

Fertilizer Ratio	Example Fertilizer Grade	Lbs. needed to apply 1 lb. N per 1000 sq.ft.	Lbs. applied with 1 lb. N P_2O_5	Lbs. applied with 1 lb. N K_2O
1-1-1	8-8-8	12	1.00	1.00
1-1-1	10-10-10	10	1.00	1.00
1-2-3	5-10-15	20	2.00	3.00
1-2-3	7-14-21	14	2.00	3.00
1-2-2	6-12-12	17	2.00	2.00
1-2-2	5-10-10	20	2.00	2.00
3-1-2	12-4-8	8	0.30	0.60
4-1-2	16-4-8	6	0.25	0.50
1-0-1	15-0-15	7	0	1.00
1-0-0	34-0-0	3	0	0

If substituting complete fertilizers of different rations, base the application rate on the amount of fertilizer needed to supply the recommended quantity of nitrogen. Therefore, from Table 1, 6 pounds of 16-4-8 can be substituted for eight pounds of 12-4-8 or vice versa. Proper substitutions of other materials can also be calculated as shown before. When substituting fertilizers, remember to select a fertilizer grade that most nearly matches the grade recommended.

Pros/Cons of Organic Fertilizers

- Bulky (low nutrient content)
- Availability, odor, potential salt and weed seed hazards, expense per pound of nutrient
- Release nutrients over long period
  - May need supplemental fertilizers in combination
- Beneficial effects on soil physical properties:
  - Improves structure, water infiltration, nutrient holding capacity, micronutrients

Table 8. Guide to the mineral nutrient value of organic materials

Materials	Percent[1] N	Percent[1] P_2O_5	Percent[1] K_2O	Availability
Bone meal (steamed)	.7 to 4	18 to 34	0	Slow medium
Castor pomace	5	1.8	1	Slow
Cocoa shell meal	2.5	1	2.5	Slow
Compost (not fortified)	1.5 to 3.5	.5 to 1	1 to 2	Slow
Cottonseed meal (dry)	6	2.5	1.7	Slow medium
Dried blood (dry)	12	1.5	.6	Medium rapid
Fertrell-Blue Label	1	1	1	Slow
Fertrell-Gold Label	2	2	2	Slow
Fertrell-Super	3	2	3	Slow
Fertrell-Super "N"	4	3	4	Slow
Fish meal (dry)	10	4	0	Slow
Fish scrap (dry)	3.5 to 12	1 to 12	.08 to 1.6	Slow
Garbage tankage(dry)	2.7	3	1	Very slow
Guano (bat)	5.7	8.6	2	Medium
Guano (Peru)	12.5	11.2	2.4	Medium
Kelp[2]	.9	.5	4 to 13	Slow
Manure[3] (fresh)				
Cattle	.25	.15	.25	Medium
Horse	.3	.15	.5	Medium
Sheep	.6	.33	.75	Medium
Swine	.3	.3	.3	Medium
Poultry (75% water)	1.5	1	.5	Medium rapid
Poultry (50% water)	2	2	1	Medium rapid
Poultry (30% water)	3	2.5	1.5	Medium rapid
Poultry (15% water)	6	4	3	Medium rapid
Marl	0	2	4.5	Very slow
Milorganite (dry)	5	2 to 5	2	Medium
Mushroom compost	.4 to .7	.57 to .62	.5 to 1.5	Slow
Peat and muck	1.5 to 3	.25 to .5	.5 to 1	Very slow
Sawdust	4	2	4	Very slow
Sewage sludge (active dry)	2 to 6	3 to 7	0 to 1	Medium
Sewage sludge (digested)	1 to 3	.5 to 4	0 to .5	Slow
Soybean meal (dry)	6.7	1.6	2.3	Slow medium
Tanbark[4]	0	1.5	2	Very slow
Tobacco stems(dry)	2	.7	6	Slow
Urea[5]	42 to 46	0	0	Rapid
Wood ashes[6]	0	1 to 2	3 to 7	Rapid

Nitrogen, Phosphorus and Potassium Needed for 5 lbs of 10-10-10			
5 lbs 10-10-10 (for even analysis fertilizers)	33.3 lbs of compost (1.5-1-1.5) 33.0 lbs of 30% poultry manure (3-2.5-1.5) 50.0 lbs of OMRI approved fertilizer 1-1-1		
	Nitrogen Needed for 5 lbs of 10-10-10	**Phosphorus Needed for 5 lbs of 10-10-10**	**Potassium Needed for 5 lbs of 10-10-10**
5 lbs 10-10-10 (using component fertilizers)	4.2 lbs blood meal 17.0 lbs alfalfa meal 8.3 lbs cotton seed meal 3.3 lbs feather meal 5.0 lbs fish meal 4.2 lbs hoof meal 16.7 lbs cricket manure 7.5 lbs soybean meal	4.5 lbs bone meal 2.8 lbs colloidal phosphate	2.3 lbs Sul-Po-Mag 10.0 lbs greensand 16.6 lbs kelp

[1]Use only one of these amounts of fertilizer materials to equal 5 lbs of nitrogen or use one-half of two different materials to make up the 5 lbs of nitrogen required. The same process can be used for any other nutrient in the chart.

The "Dirt" on Soils: Review

- Don't Guess! Soil Test!
  - Adjust soil pH per plant/soil needs
  - Fertilizer per plant needs
  - Apply fertilizer & lime accurately
  - Soil test every 2 years
- Add organic matter to improve soil structure
- Minimize soil compaction
- Minimize soil erosion! Soil is a limited natural resource…

Abiotic Factors: Future Problems

- **Temperature** – extreme fluctuations with La Nina and El Nino weather patterns
- **Water** – recurring droughts and floods
- **Nutrients** – synthetic fertilizers are petroleum based and therefore a limited resource

Fertility Under Drought Conditions

- Grass growth is reduced during drought
- You don't want to try and push growth on drought-stressed grass, so fertilizer needs should be reduced
- Best to postpone fertilization or reduce amount applied
- Slow-release N is better, as it will provide more regulated growth
- Irrigate after applying fertilizers

CAES/FACS Extension Publications

- Over 1,000 free publications and fact sheets:
  - Most can be accessed online: www.caes.uga.edu/publications/
  - Clients that do not have computer access can get printed copies upon request

Questions?

The End

Thank You!

Table C. Lime Requirement to raise pH of the surface 8 inches of soil to a pH of 6.0														
Soil pH	Lime Buffer Capacity [1]													
	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
	lbs Ag lime per acre 8" to raise pH to 6.0													
5.9	1000	1000	1000	1500	1500	2000	2000	2500	2500	3000	3000	3500	4000	4000
5.8	1000	1000	1000	1500	1500	2000	2500	2500	3000	3500	3500	4000	4500	4500
5.7	1000	1000	1000	1500	2000	2500	2500	3000	3500	3500	4000	4500	5000	5000
5.6	1000	1000	1500	1500	2000	2500	3000	3500	3500	4000	4500	5000	5500	5500
5.5	1000	1000	1500	2000	2500	3000	3000	3500	4000	4500	5000	5500	6000	6500
5.4	1000	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000
5.3	1000	1000	1500	2000	2500	3500	4000	4500	5000	5500	6000	6500	7000	7500
5.2	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6500	7000	7500	8000
5.1	1000	1500	2000	2500	3000	3500	4500	5000	5500	6000	6500	7500	8000	8500
5.0	1000	1500	2000	2500	3500	4000	4500	5500	6000	6500	7000	8000	8500	9000
4.9	1000	1500	2000	3000	3500	4000	5000	5500	6500	7000	7500	8500	9000	9500
4.8	1000	1500	2500	3000	3500	4500	5000	6000	6500	7500	8000	9000	9500	10000
4.7	1000	1500	2500	3000	4000	4500	5500	6000	7000	7500	8500	9500	10000	10000
4.6	1000	1500	2500	3500	4000	5000	5500	6500	7500	8000	9000	9500	10000	10000
4.5	1000	2000	2500	3500	4500	5000	6000	7000	7500	8500	9500	10000	10000	10000
4.4	1000	2000	3000	3500	4500	5500	6500	7000	8000	9000	10000	10000	10000	10000
4.3	1000	2000	3000	4000	4500	5500	6500	7500	8500	9500	10000	10000	10000	10000
4.2	1000	2000	3000	4000	5000	6000	7000	8000	9000	9500	10000	10000	10000	10000
4.1	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	10000	10000	10000	10000
4.0	1000	2000	3500	4500	5500	6500	7500	8500	9500	10000	10000	10000	10000	10000

[1] Pounds of pure calcium carbonate to raise soil pH one unit per 1,000,000 pounds of soil.