

*Rockbridge Extension Master Gardeners*

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# Soils and Nutrient Management



This module was developed by Scott Baker, Virginia Cooperative Extension Agent

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# Welcome to 'Soils and Nutrient Management'

In this module you will learn about soil composition (physical and chemical; including pH). You will learn about soil tests, how to improve soil and using compost.

- Read Chapter 2 in your Master Gardener Handbook before viewing these slides
- Browse the Suggested Readings at the end of these slides. They contain online sources that will be helpful for your learning
- The Test Your Knowledge section is for fun and review



# What I Will Learn in This Module

- Desirable composition of surface soil
- Three types of soil particles that affect soil texture and their descriptions
- Definition and effect of pH in the soil, average pH range for most plants, and how to change pH for best plant production
- Definition of N-P-K and how it relates to the numbers on a bag of fertilizer
- How to calculate the amount of N, P, and K, in a bag of fertilizer and how to calculate the amount of fertilizer to buy for a given area
- Definition of complete and incomplete fertilizer
- Why plants need Nitrogen, Phosphorus, and Potassium
- Soil test: recommended procedures; purpose; how often taken; what information is provided
- How to improve soil structure
- The difference between soil texture and soil structure
- Pros and cons of the most common mulches

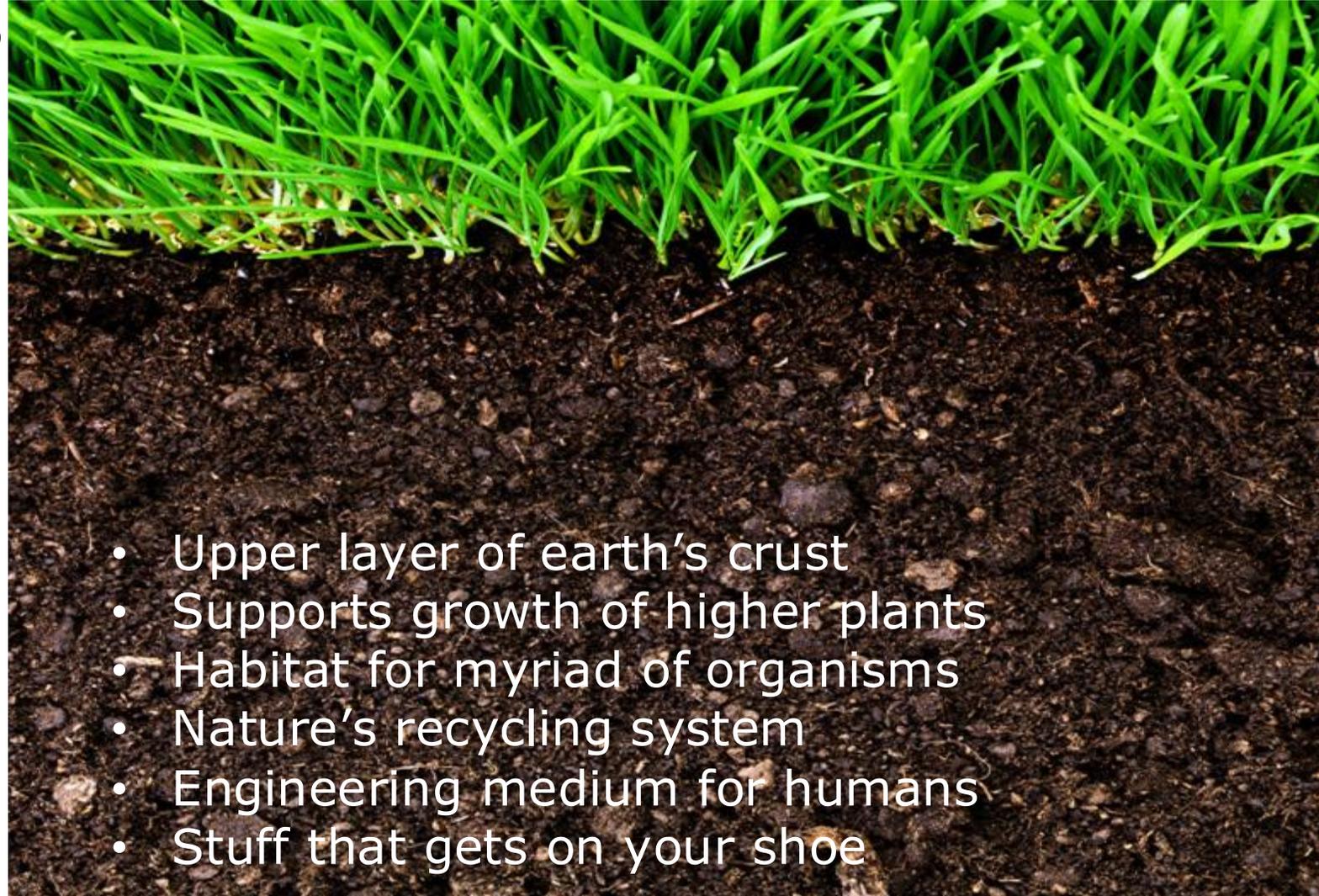


# What I Will Become Familiar With

- How soil is formed
- General characteristics of and differences between the surface, subsurface, subsoil and parent material
- What factors determine soil color
- Principal surface soil classes found in Virginia and their descriptions
- Soil structure, drainage, depth, and erosion
- Seventeen elements needed by plants
- Effect of pH on plant nutrient availability
- Slow release fertilizers
- Organic fertilizers
- Fertilizers that are combined with pesticides
- When, what kind, and how to apply a fertilizer
- Composting



# What is Soil?



- Upper layer of earth's crust
- Supports growth of higher plants
- Habitat for myriad of organisms
- Nature's recycling system
- Engineering medium for humans
- Stuff that gets on your shoe

[Photo credit](#)



# Soil Composition

- Weathered rock
- Mineral fragments
- Decaying plant and animal material
- Water and air

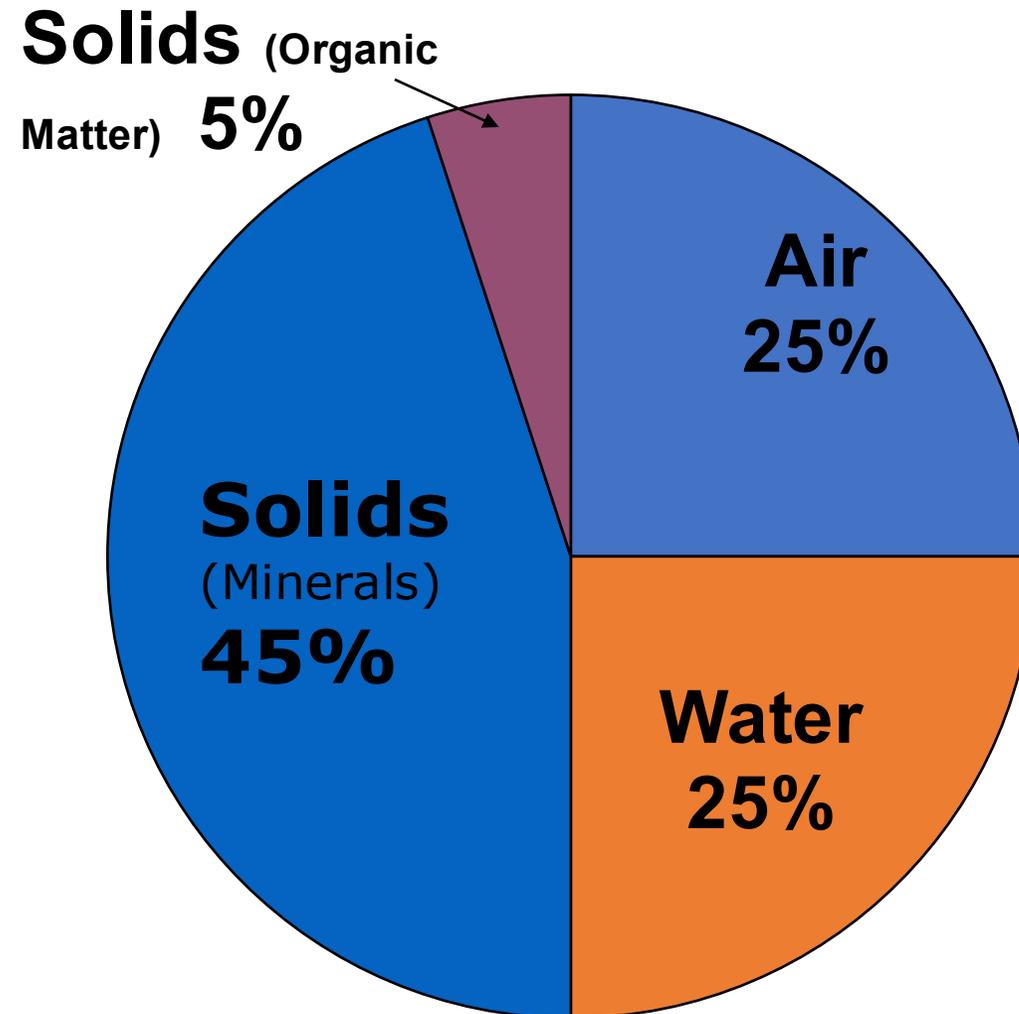


[Photo credit](#)

One inch of topsoil can take several hundred years or more to develop. [Credit:](#)



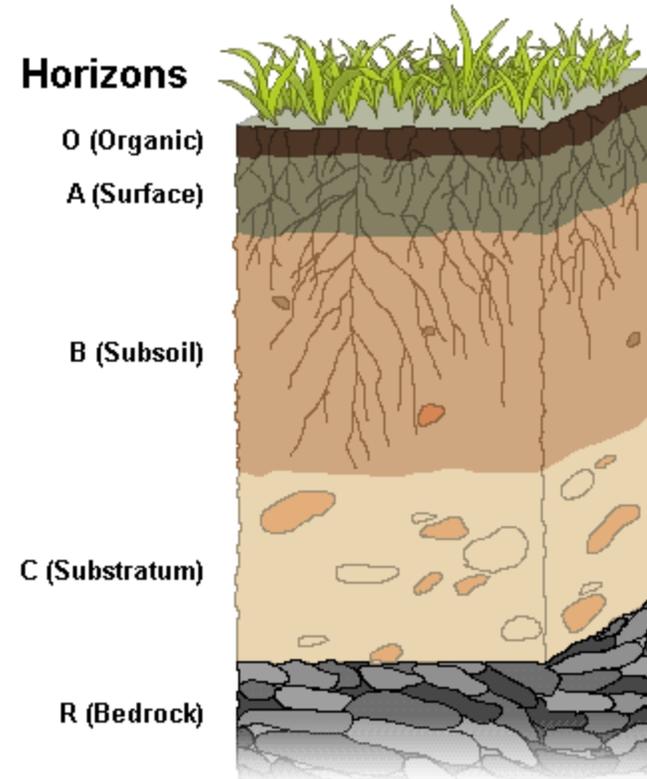
# Desirable Soil Composition



# Soil Profile / Slice

Divided into 3 horizons or layers

- Topsoil or surface soil
- Subsoil
- Parent material or substratum

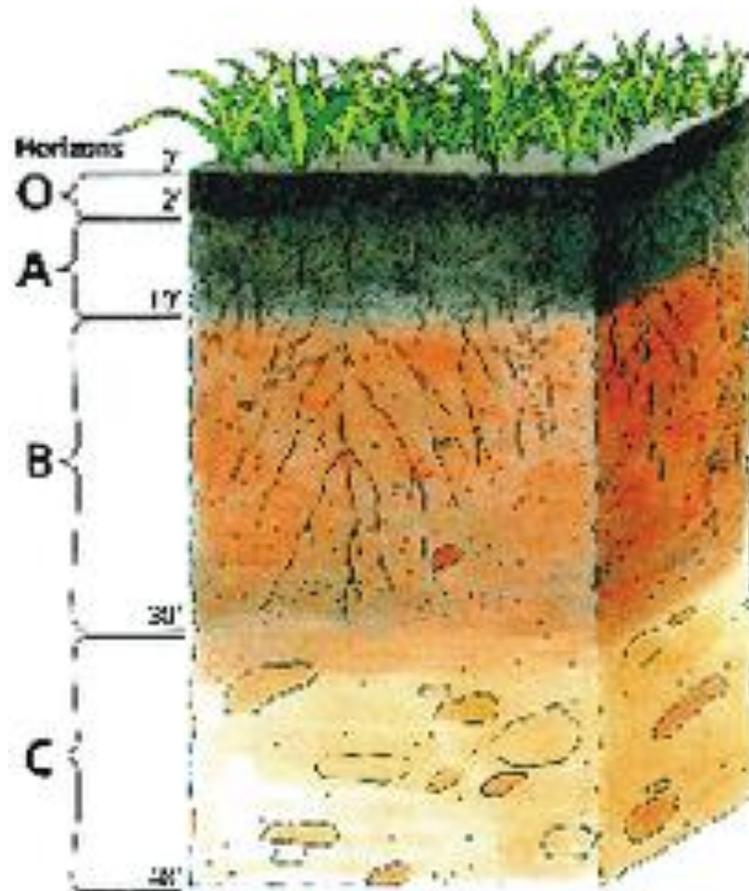


[Photo credit](#)



# Soil Profile

Photo credit



These horizons are also known as:

- the surface horizon (A)
- the subsoil (B)
- the substratum (C)

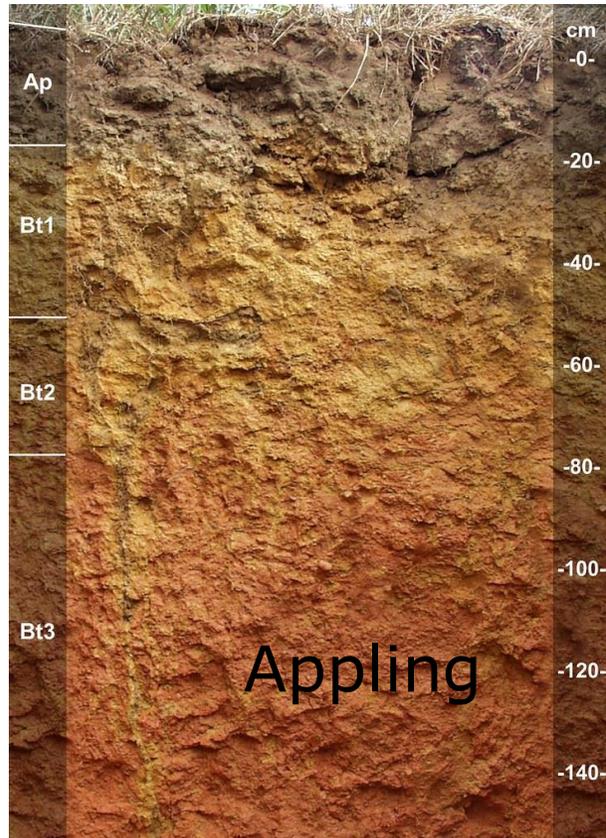
Some soils have an organic horizon (O) on the surface, but this horizon can also be buried

The master horizon E is used for horizons that have a significant loss of minerals (eluviation) Hard bedrock, which is not soil, uses the letter R

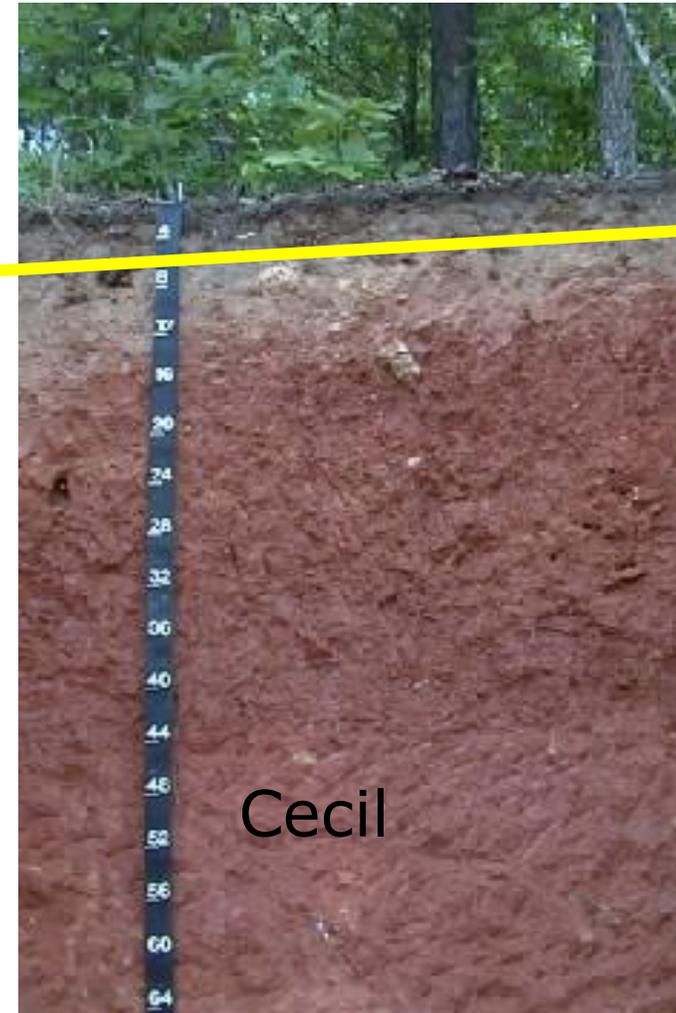
“The development of these horizons depend on time, climate, the type of rock and surface features”



Illustrating the differences that can be seen in soils (Appling and Cecil are 2 common soil types in the Piedmont region). The Cecil series developed over igneous rock such as granite, and metamorphic rock. The Appling consists of very deep well drained, moderately permeable soils on ridges and side slopes. They formed in residuum weathered from felsic igneous and metamorphic rocks



[Photo credit](#)



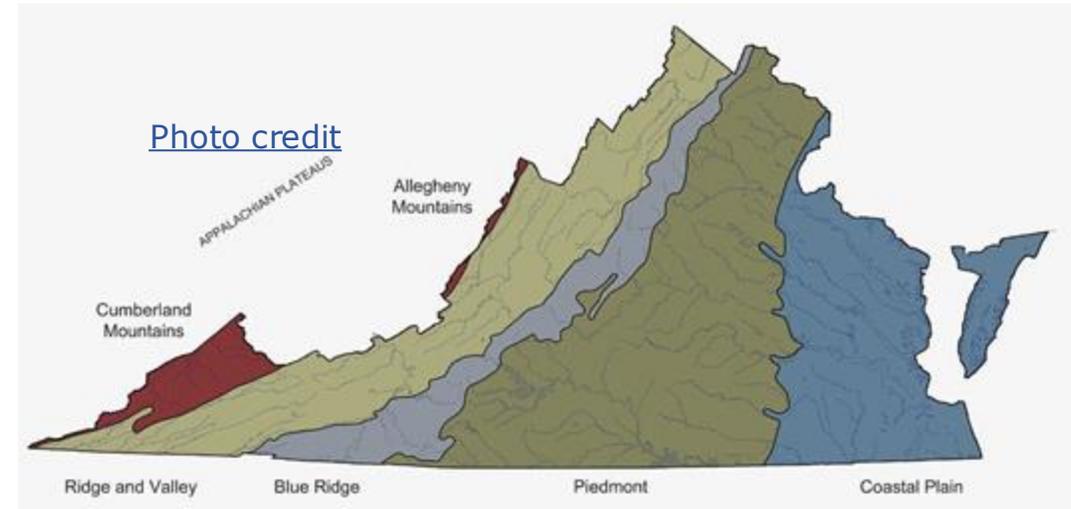
[Photo credit](#)



# Soil Differences in Virginia

Soils in Virginia show great ranges in properties and thus in their suitability for different uses. Much of the difference in soils relates to the geologic parent materials from which they have formed as well as the local topography. There are four major soil divisions in the state:

- Appalachian division
  - Includes Plateau;
  - Mountains and Uplands; and
  - Limestone Valleys
- Blue Ridge division
- Piedmont division
  - Includes Crystalline Rocks,
  - Triassic areas and Slate Belt
- Coastal Plains division
  - Includes Chesapeake Bay region, Middle Coastal Plain and Flat Woods



# Soil Characteristics

- Color
- Texture
- Structure
- Fertility
- pH
- Depth
- Drainage
- Organic Matter

[Physical Properties of Soil](#)



# Soil Color

- Parent material
- Varies by region and climate
- Little influence on the soil itself
- Indicates certain soil conditions
  - Organic matter content
  - Drainage conditions
  - Degree of oxidation



# Brown to Black Colors

- Result of organic matter in topsoil
- In subsoil may be waterlogged

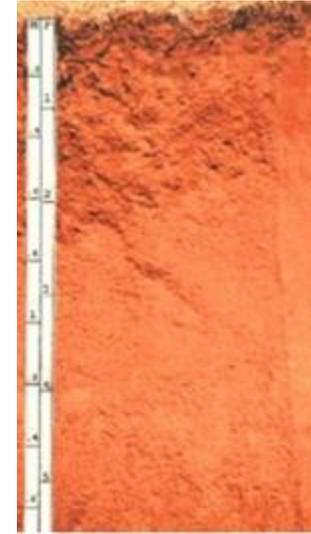


[Photo credit](#)



# Yellow to Red Colors

- Presence of iron oxides
- Reds are well drained
- Yellows slightly less well drained



[Photo credit](#)

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# White to Light Gray Colors

- Soil has been leached
- Lack of organic matter



## Bluish-gray Color

- Lack of oxygen
- Water logging



[Photo credit](#)

## Mottled or Mixed Colors

- Streaks of yellow and blue-gray
- Waterlogged for part of year



# Soil Texture

- How it feels
- Amount of different sized soil particles (Sand, Silt, Clay)
- All soils have all three particles but differ in relative amounts



# Soil Particles

## Sand

- Coarse particles
- Gritty or rough

## Silt

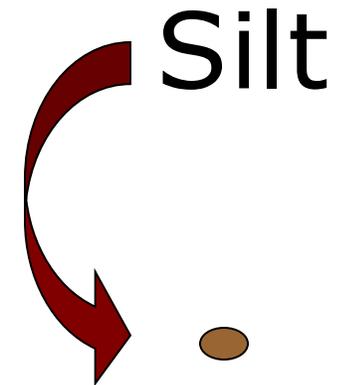
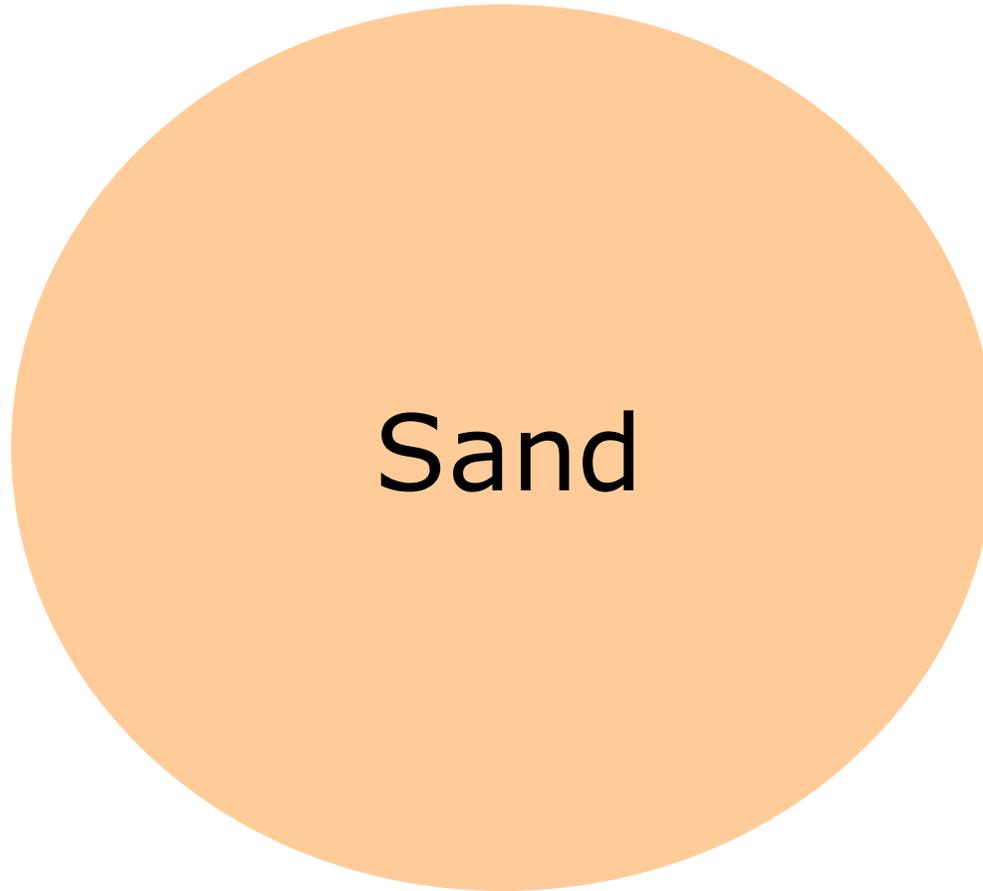
- Slightly smaller particles
- Feels floury when dry
- Silky like talcum powder when damp

## Clay

- Finest particle
- Feels very smooth when dry
- Slippery or sticky when wet



# Soil Texture Particle Size Comparison



# General Soil Types

- Sandy
  - Loose and drains rapidly
  - Less fertile - less surface area to hold nutrients
- Clayey
  - Fine particles stick together when wet and crust
  - Easily compacted that causes poor drainage
  - Moderate to high nutrient holding capacity
- Loamy
  - Crumbly, well drained
  - High organic matter and high nutrient capacity



# Principal Surface Soil Classes

- Sandy loam (more sand, less silt and clay)
- Clay loam (higher percentage clay, equal amounts sand/silt)
- Loam (relatively equal portions of sand and silt, less clay)
- Silt loam (more silt, less sand and clay)
- Silty clay loam (mostly silt, more clay than sand)



# Soil Class Determination

[Photo credit](#)



**Sandy Soil – soil rolled in palm falls apart and has no shape**

[Estimating soil texture](#)



[Photo credit](#)

**Clay Soil – soil maintains firm shape when rolled in palm**



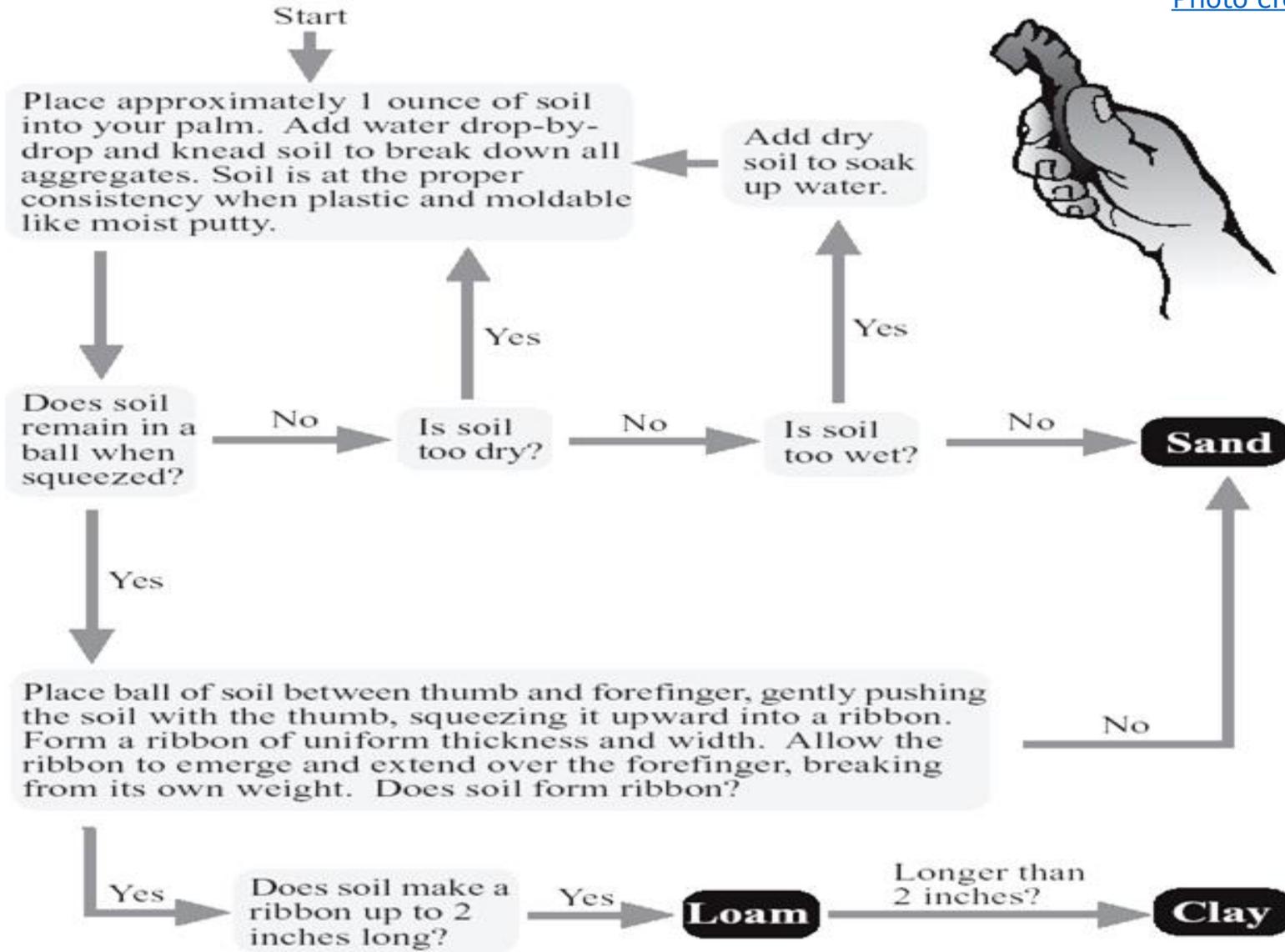
[Photo credit](#)

**Loamy Soil – soil rolled in palm maintains a loose ball shape**



# Determining soil texture by feel

[Photo credit](#)



# Soil Type Matters!

Example: Lime Recommendations. Clay based soils are more resistant to change so it takes more lime to change pH of a clay soil vs. other soil types.

Image credit: S. Baker, Extension

pH of un-limed soil	pH Desired: 6.5		
	Soil Type		
	Sandy	Loamy	Clayey
	Lime (lbs./1000 sq. ft.)		
5.0	120	145	170
5.5	80	85	110
6.0	45	60	70



# Soil Structure

## Arrangement of Soil Particles

### Granular

- Particle clusters about bread crumb size
- Large pore space for water/air/roots
- Well drained / good organic matter

### Blocky

- Larger soil aggregates
- Subsoil / allows for good drainage

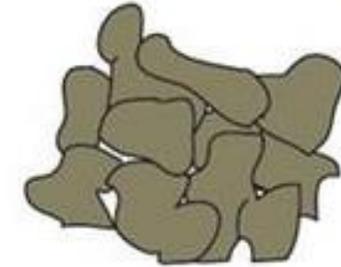
### Platy

- Plate-like sheets horizontal in soil

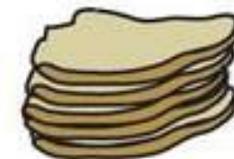
[Photo credit](#)



Granular (high permeability)



Blocky (moderate permeability)



Platy (low permeability)

## [Soil Structure](#)



# Soil Structure

High clay or sand content = poor structure

Structure can be damaged

- Excessive tilling
- Working when too wet / too dry
- Movement over with heavy equipment

Repairing damaged structure long process

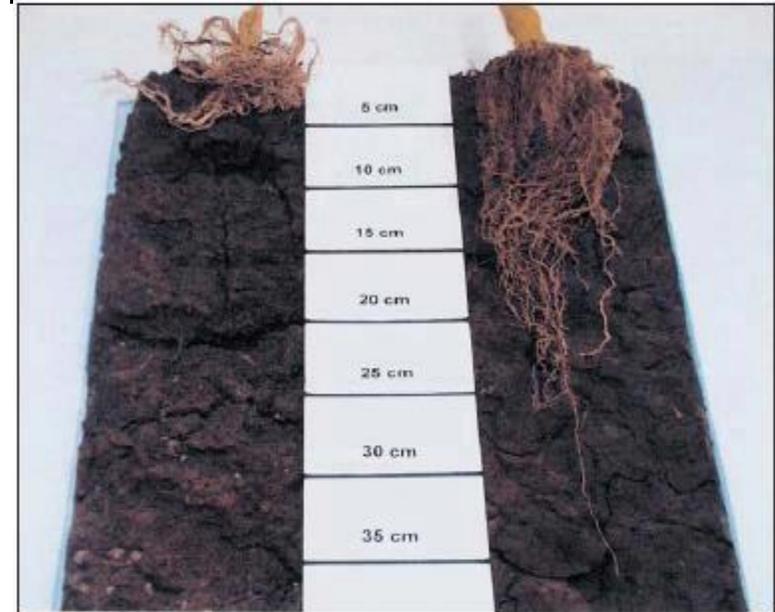
Incorporating organic matter improves structure



# Soil Drainage

## Rate and Extent of Water Movement In and Across Soil

- Dependent on soil texture, structure, & slope
- Poorly drained soils suffocate plant roots
- Rapidly drained soils lose nutrients and plants wilt sooner
- Impervious layers impede drainage and root growth
- Incorporate organic matter to improve



Corn roots in compacted (left) and non-compacted (right) heavy clay soil. [Photo credit](#)



# Soil Drainage Test

- Dig a hole 12 inch wide / 12 inch deep
- Fill with water
- Drainage good if empties within hour
- If takes several hours, choose another location to plant



# Soil Depth

Vertical Distance from Surface to Layer that Retards Root Penetration

Moderately deep soils - 20 to 36 inches

Shallow soils - 10 to 20 inches

- Limited water holding capacity
- Limited anchorage for plant roots



# Soil Erosion

## Reduction of Surface Soil Depth

### Reasons

- Insufficient vegetative cover
- Improper tillage

### Minimize

- Adequate fertilization and liming
- Use proper tillage methods
- Mulching to increase organic matter

Increasing organic matter by 1-3% reduces erosion by 20-30%



# Soil Organic Matter

Plant and Animal Remains in Various States of Decomposition and the Microorganisms

Serves many purposes

- Source of plant nutrients
- Retains nutrients from erosion
- Improves soil structure by binding soil particles
- Holds moisture in sandy soils and reduces leaching of nutrients

Good sources

- Compost, manures, leaf mold, peat, straw



# Organic Matter Precautions

Materials with high C:N ratio (carbon:nitrogen) can deplete available nitrogen

- Grass clippings 19:1, leaves 40-80:1
- Straw 80:1, sawdust 500:1

Microorganisms need nitrogen to break down organic matter

Composting avoids tying up nitrogen



# Composting

“Compost improves your soil. When added to soil, compost breaks up heavy clay soils, helps sandy soils retain water and nutrients, and releases essential nutrients. Compost also contains beneficial microscopic organisms that build up the soil and make nutrients available to plants. Improving your soil is the first step towards growing healthy plants.”

[Composting](#)



# Composting Recipe

- Start with a coarse layer on the bottom (3 inches of branches, twigs)
- Add layer of leaves, straw, weeds, kitchen scraps, coffee, ground egg shells (brown material)
- Add nitrogen rich layer like grass clippings or manure (green layer)
- Or add 1/2 cup 10-10-10 per 6" layer of material
- Also add pint of limestone per square yard of surface
- Sprinkling soil on each layer will add microorganisms
- Water as needed to keep the pile moist but not wet



# Composting Procedure

- Sprinkle with water to keep moist
- Pile should heat-up to 160° F  
Destroys disease organisms, insects, seeds
- Turn over about once a month
- Should be ready in 4 to 5 months depending on:
  - Number of turnings
  - Particle fineness
  - Air temperature



# Steps To Improve Soil

- Soil test
- Adjust soil pH
- Fertilize according to soil test / proper time
- Add organic matter to improve soil structure and drainage
- Grow cover crops to reduce erosion
- Add organic matter, control weeds, loosen compacted soils
- Aerate compacted soils to improve air and water penetration



# Cover Crops

Another way to improve the soil is to plant a cover crop, referred to as green manures.

- Ryegrass is an example of a cover crop
- Sow seeds before the first killing frost
- This may reduce the need for synthetic fertilizers

Chapter 2, MG Handbook has a Table of Common Cover Crops



# Plant Nutrients



# Mineral Nutrients Essential to Plant Growth

## Macro Nutrients (3%)

- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)

## Secondary Nutrients (1%)

- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

## Micronutrients (1%)

- Boron (B)
- Chloride (Cl)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Molybdenum (Mo)
- Zinc (Zn)

95 % Carbon (C),  
Hydrogen (H), Oxygen  
(O)

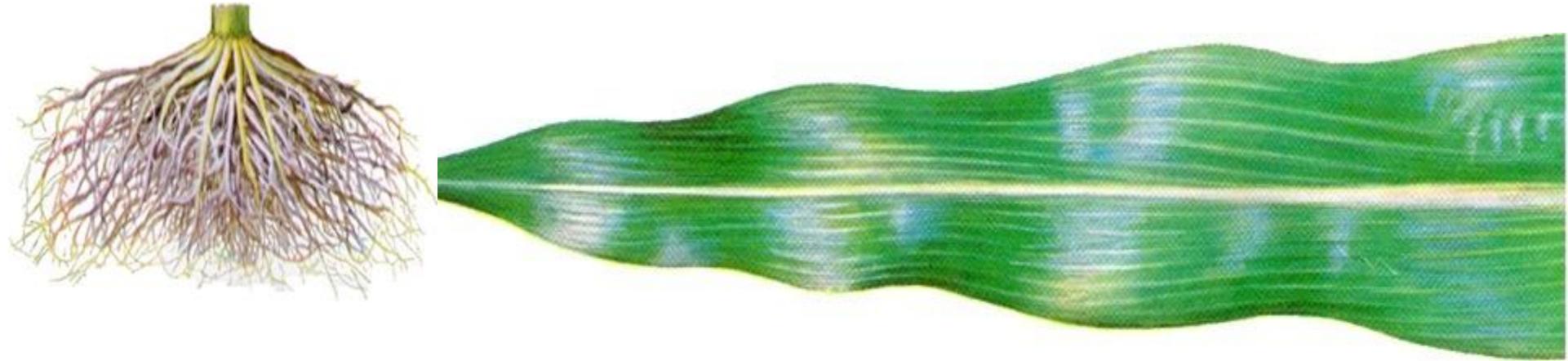


# Nitrogen

- Promotes growth of leaves and stems
- Critical to chlorophyll production
- Apply only when plants actively growing
- Very mobile in soil / easily leached
- Too vigorous growth can reduce flower and fruit production
- Deficiencies - lower leaves turn yellow, reduced growth in tops and roots



# Healthy Corn Plant



**Nitrogen Deficiency:** lower leaves turn yellow, reduced growth in tops and rows

[Photo credit](#)



# Soluble Nitrogen Sources

Ammonium  
nitrate

34-0-0

Monoammonium  
phosphate

13-52-0

46-0-0

Urea

Diammonium  
phosphate

18-46-0

Ammonium  
sulfate

21-0-0



# Soluble Nitrogen Sources

Calcium  
nitrate

15-0-0

Potassium  
nitrate

13-0-44

Sodium  
nitrate

16-0-0



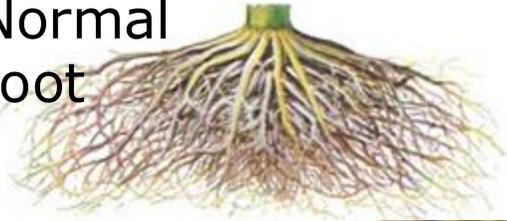
# Phosphorus

- Aids in blooming and fruiting / seed
- Encourages early and rapid root growth
- Critical for photosynthesis
- Helps plants resist cold temperatures and disease
- Does not move readily through soil
- Deficiencies - spindly growth, purplish color in older leaves



# Phosphate Deficiency

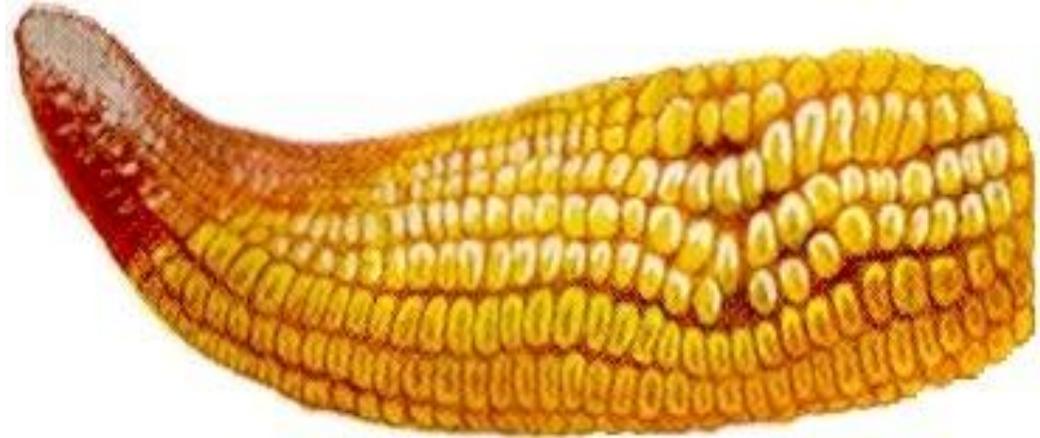
Normal  
root



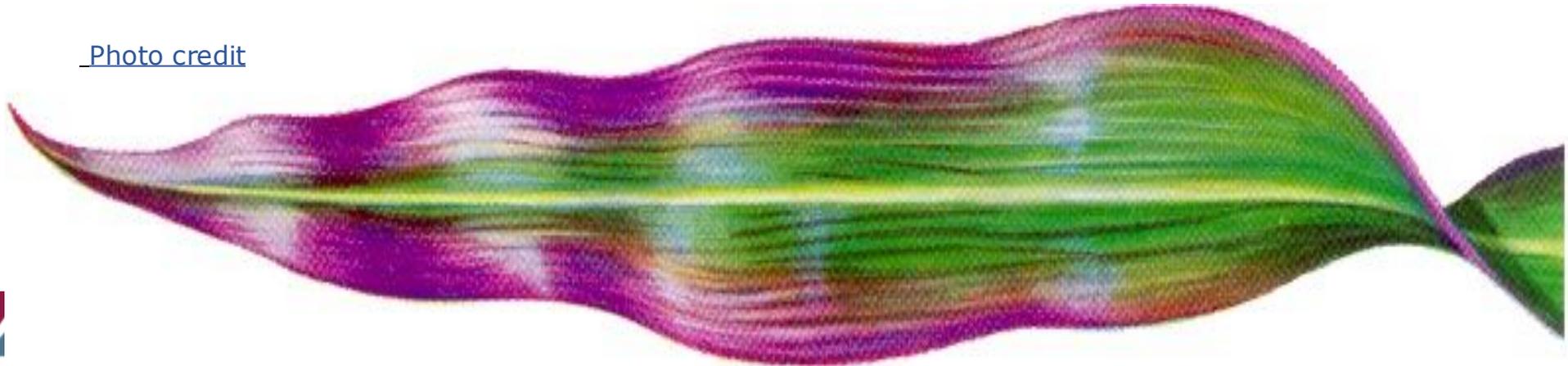
[Photo credit](#)



PHOSPHATE Shortage



[Photo credit](#)



# Sources of Phosphorus

- ➔ **Single superphosphate** 0-20-0
- ➔ **Triple superphosphate** 0-46-0
- ➔ **Monoammonium phos.** 13-52-0
- ➔ **Diammonium phosphate** 18-46-0
- ➔ **Monopotassium phos.** 0-50-40



# Potassium (Potash)

- Necessary for many vital processes such as opening and closing of leaf pores
- Promotes strong stems, disease resistance and winter hardiness
- Susceptible to leaching in sandy soils
- Deficiencies - browning of leaf tips, marginal scorching in lower foliage
- Especially important in legume crops

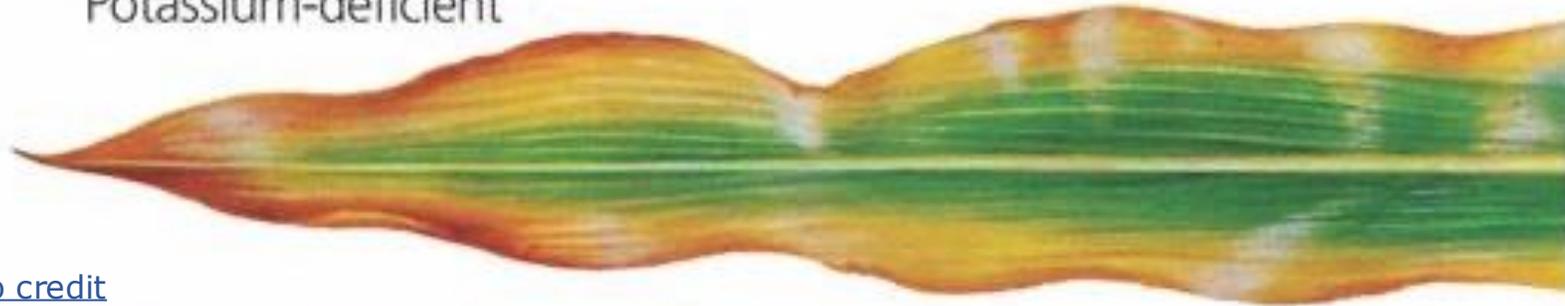


# Potash Deficiency

[Photo credit](#)



Potassium-deficient



[Photo credit](#)



# Sources of Potassium

Potassium  
nitrate

13-0-44

Potassium  
chloride

0-0-60

Potassium  
sulfate

0-0-50



# Calcium

- Used primarily to build cell walls
- Needed in growing root and shoot tips
- Plays role in protein formation and carbohydrate movement in plants
- Deficiencies - distorted young leaves, turning yellow, then brown / blossom-end rot in tomatoes



# Sources of Calcium

Irrigation water



Dolomitic limestone

21%

Ca

Calcitic limestone

31%

Ca

Triple superphosphate

13%

Ca

Calcium sulfate (gypsum)

22%

Ca

Calcium nitrate

19%

Ca



# Magnesium

- Essential ingredient in chlorophyll and aids in uptake of nutrients
- Deficiencies - thin leaves that curve upward, loses color between veins
- High soil potassium levels cause magnesium deficiencies in plants



# Sources of Magnesium

**Dolomitic  
limestone  
11% Mg**

**Magnesium  
sulfate  
16% Mg**

**Magnesium  
oxide  
45% Mg**



# Sulfur

- Component of plant proteins
- Essential for many reactions in living cells
- Deficiencies - lower leaves turn yellow, stems are hard and brittle
- Cabbage, turnips, and onions have high requirements



# Sources of Sulfur

	%S
<b>Ammonium sulfate</b>	<b>23%</b>
<b>Calcium sulfate (gypsum)</b>	<b>15%</b>
<b>Magnesium sulfate</b>	<b>14%</b>
<b>Potassium sulfate</b>	<b>17%</b>
<b>Single superphosphate</b>	<b>14%</b>
<b>Elemental sulfur</b>	<b>30-99%</b>



# Micronutrients / Trace Elements

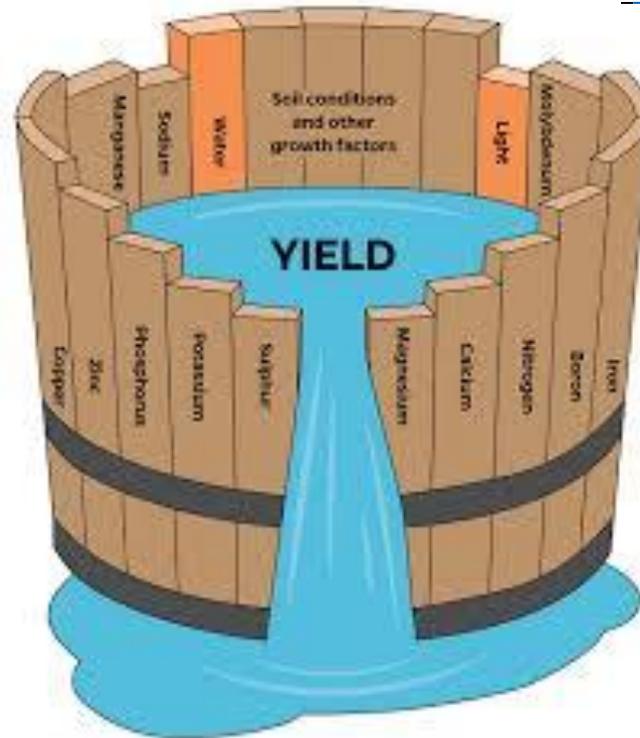
- Required in very small quantities
- Essential for proper plant growth
- Usually present in most soils
- Availability dependent on soil pH
- Addition of organic matter will supply any trace elements lacking in soil



# Liebig's Law of the Minimum

[Photo credit](#)

Illustration of a water barrel. The water can only rise to the lowest stave before leaking out.



With respect to fertility - the most limiting nutrient will limit maximum production of the soil and plant.



# Soil Testing



# Functions of Soil Test

- Determine nutrient status (fertilizer need) of soil
- Determine soil pH
- Determine proper type and amount of fertilizer
  - Less chance of nutrient runoff
  - Lower expenses
- Monitoring tool

Photo credit: P. Turner,  
EMG



Starting point for developing a fertilizer and lime program

# Soil Test

[Photo credit](#)

- Do every 3 years
- Sample in fall
- Same time each time



# Sampling Equipment

## Soil probes

- \$50 to \$150+
- Stainless steel / chrome-plated
- Do not use brass / bronze / galvanized



[Photo credit](#)

[Photo credit](#)



Shovels and other devices used for collecting soil samples. (A) Classic point-shovel. (B) hand shovel. (C) From left to right: Viehmeyer tube, trowel, Oakfield tubes, soil corers.

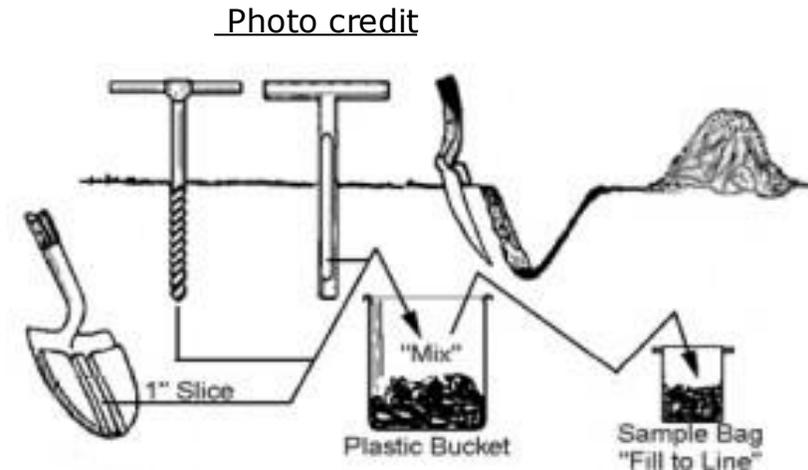
- Clean plastic bucket
  - No galvanized container
- Information sheet
- Sample box

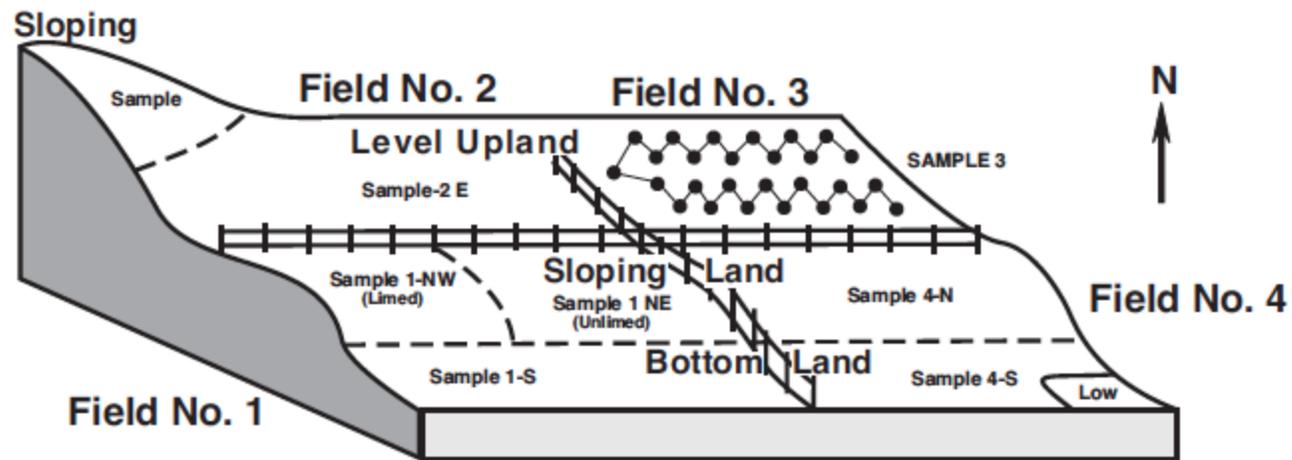


# Pulling Samples

- Soil probe works best
- Shovel / spade / trowel
- Sample to depth
  - Lawns 2"-3"
  - Gardens 6"
- Mix sub-samples together
  - Discard roots / rocks / litter
- Fill sample box and complete form

*The reliability of the soil test can only be as good as the sample submitted.*





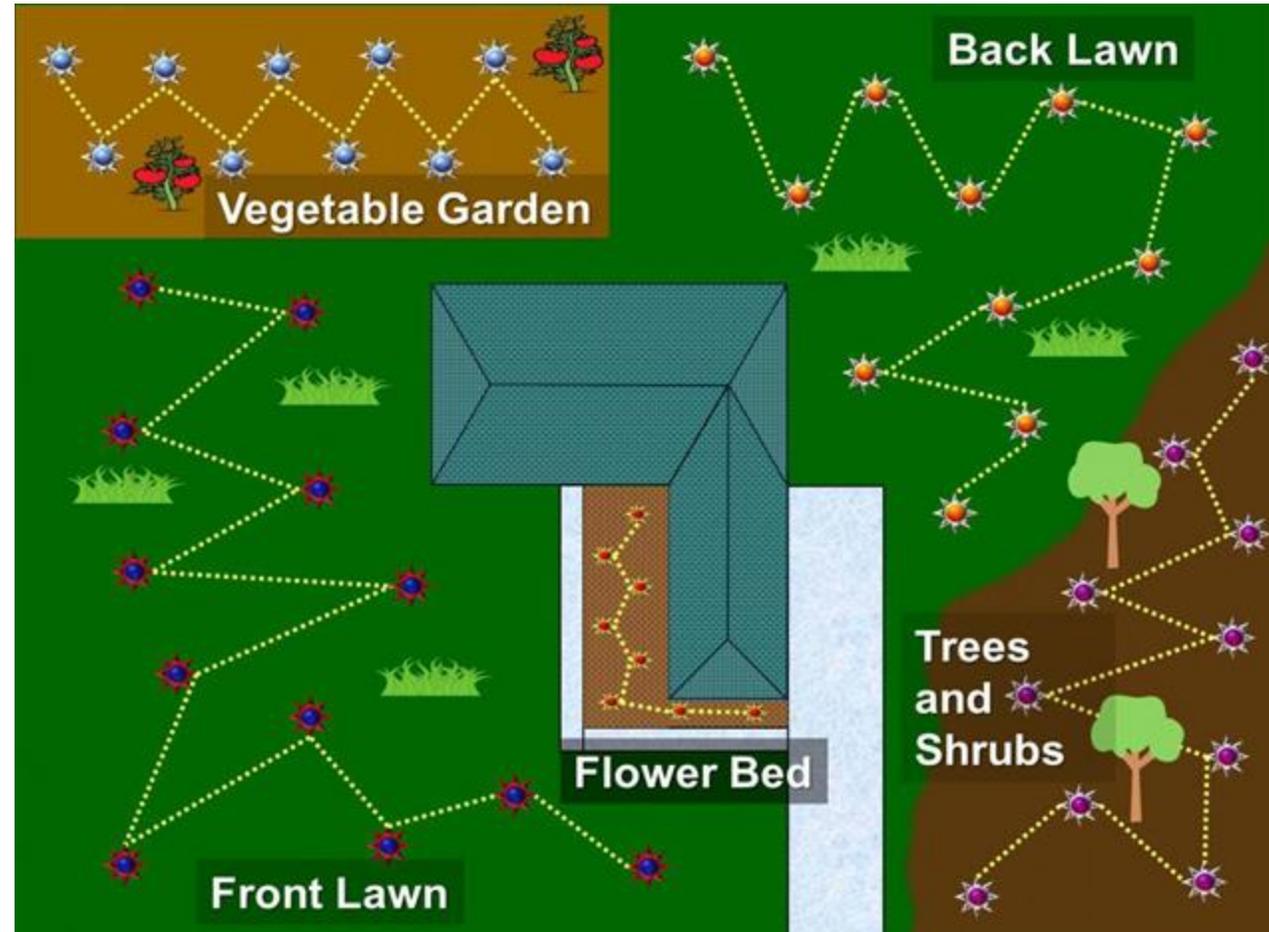
[Photo credit](#)

You can expect differences in soils due to different landscape positions (i.e. hilltops, steep slopes, poorly dried bottom areas)



How many sample areas? This graphic shows five zones to be tested. The stars show where the samples should be taken. The sub-samples should be taken in a zig-zag pattern

[Photo credit](#)



## Soil test request form

It is important to fill out the request form completely

# Virginia Cooperative Extension

PUBLICATION 452-125

Virginia Tech Soil Testing Laboratory

## Soil Sample Information Sheet for Home Lawns, Gardens, Fruits, and Ornamentals

**Please Print**

INSTRUCTIONS: See other side for sampling instructions. For a recommendation, be sure to fill in the plant code number. Place check marks (✓) where appropriate. Use another form for commercial crop production. Send samples, forms, and payment to Virginia Tech Soil Testing Lab, 145 Smyth Hall (0465), Blacksburg, VA 24061, in a sturdy shipping carton. Processing will be delayed if soil is not received in an official sample box. See [www.soiltest.vt.edu](http://www.soiltest.vt.edu) for more information.

Your Name _____ Street, Route _____	Date sampled: _____
City _____ ZIP (required) _____	Office Use only
Telephone No. _____ County _____	Extension Unit Code: _____
Extra Copy For (Dealer, etc.): _____	019
Street, Route _____	
City _____ ZIP (required) _____	

SAMPLE IDENTIFICATION	PLANT TO BE GROWN	PLANT CODE LIST																																										
Your Sample Box Number or Name (Up to 5 digits) <input type="text"/>	Insert Plant Code # from list at right <input type="text"/>	<table border="0"> <tr> <td><b>Lawn: Kentucky Bluegrass, Fescue, or Ryegrass</b></td> <td><b>Non-Acid-Loving Shrubs and Trees</b></td> </tr> <tr> <td>201 Establishing New Lawn</td> <td>245 Shrubs - Lilac, Forsythia, Boxwood, etc.</td> </tr> <tr> <td>202 Maintaining Lawn, Repair of Bare Spots</td> <td>246 Trees - Pine, Maple, Oak, etc.</td> </tr> <tr> <td><b>Lawn: Bermudagrass, Zoysia grass, or St. Augustine</b></td> <td><b>Fruits</b></td> </tr> <tr> <td>203 Establishing New Lawn</td> <td>220 Apples</td> </tr> <tr> <td>204 Maintaining Lawn, Repair of Bare Spots</td> <td>221 Blackberries</td> </tr> <tr> <td></td> <td>222 Blueberries</td> </tr> <tr> <td></td> <td>223 Cucarats</td> </tr> <tr> <td></td> <td>224 Gooseberries</td> </tr> <tr> <td></td> <td>225 Grapes</td> </tr> <tr> <td></td> <td>226 Nectarines</td> </tr> <tr> <td></td> <td>227 Peaches</td> </tr> <tr> <td></td> <td>228 Pears</td> </tr> <tr> <td></td> <td>229 Plums</td> </tr> <tr> <td></td> <td>230 Quince</td> </tr> <tr> <td></td> <td>231 Raspberries</td> </tr> <tr> <td></td> <td>232 Sour Cherry</td> </tr> <tr> <td></td> <td>233 Strawberries</td> </tr> <tr> <td></td> <td>234 Sweet Cherries</td> </tr> <tr> <td></td> <td><b>House Plants</b></td> </tr> <tr> <td></td> <td>250 Potted House Plants</td> </tr> </table>	<b>Lawn: Kentucky Bluegrass, Fescue, or Ryegrass</b>	<b>Non-Acid-Loving Shrubs and Trees</b>	201 Establishing New Lawn	245 Shrubs - Lilac, Forsythia, Boxwood, etc.	202 Maintaining Lawn, Repair of Bare Spots	246 Trees - Pine, Maple, Oak, etc.	<b>Lawn: Bermudagrass, Zoysia grass, or St. Augustine</b>	<b>Fruits</b>	203 Establishing New Lawn	220 Apples	204 Maintaining Lawn, Repair of Bare Spots	221 Blackberries		222 Blueberries		223 Cucarats		224 Gooseberries		225 Grapes		226 Nectarines		227 Peaches		228 Pears		229 Plums		230 Quince		231 Raspberries		232 Sour Cherry		233 Strawberries		234 Sweet Cherries		<b>House Plants</b>		250 Potted House Plants
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SOIL TESTS DESIRED AND FEES	COST PER SAMPLE	
	IN-STATE	OUT-OF-STATE
<input type="checkbox"/> Routine (soil pH, N, P, K, Ca, Mg, Zn, S, Cu, Fe, B, and estimated CEC)	\$ 10.00	\$16.00
<input type="checkbox"/> Organic Matter - Determines percentage in soil - no recommendation given	\$ 4.00	\$ 6.00
<input type="checkbox"/> Soluble Salts - Determines if fertilizer salts are too high	\$ 2.00	\$ 3.00
<input type="checkbox"/> Fax Results: FAX # (_____)	\$ 1.00	\$ 2.00

Send in payment along with soil sample and form; make check or money order payable to "Treasurer, Virginia Tech."



The report that comes back lists the levels of various nutrients and the pH of the soil. These values are then used to provide the lime and fertilizer recommendation. See for more detail:

[Explanation of Soil Tests](#)

Lab ID: 06-10371 17-FEB-06 BEDFORD / 019

### Virginia Cooperative Extension Soil Test Report

**Bedford County Office**  
122 East Main Street  
Suite 102  
Bedford, VA 24523-2035  
540-586-7675

**Virginia Tech Soil Testing Laboratory**  
145 Smyth Hall (0465)  
Blacksburg, VA 24061  
www.soiltest.vt.edu

SEE ENCLOSED NOTES:  
**1 17**

OWNER  
BEDFORD COUNTY OFFICE  
122 EAST MAIN STREET  
SUITE 102  
BEDFORD, VA 24523

C  
O  
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Y

Photo credit:  
S. Baker,  
Extension

#### SAMPLE HISTORY

Sample ID	Field ID	LAST CROP		LAST LIME APPLICATION		SOIL INFORMATION				
		Name	Yield	Months Prev.	Tons/Acre	SMU-1 %	SMU-2 %	SMU-3 %	Yield Estimate	Productivity Group
4AUTO										

#### LAB TEST RESULTS (see Note 1)

Analysis	P (lb/A)	K (lb/A)	Ca (lb/A)	Mg (lb/A)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)	B (ppm)	Salts (ppm)
Result	5	90	886	167	0.6	3.7	0.2	12.0	0.2	
Rating	L	M-	M-	H-	SUFF	SUFF	SUFF	SUFF	SUFF	

Analysis	Soil pH	Buffer pH	Est.-CEC (meq/100g)	Acidity (%)	Base Sat. (%)	Ca Sat. (%)	Mg Sat. (%)	K Sat. (%)	Organic Matter (%)
Result	5.4	6.11	4.7	36.3	63.7	46.7	14.5	2.4	

#### FERTILIZER AND LIMESTONE RECOMMENDATIONS

Crop: LAWN MAINTENANCE - BLUEGRASS, FESCUE (202)

**612. LIME RECOMMENDATIONS:** Apply 80 pounds of agricultural limestone (ground or pulverized) per 1000 square feet in several small applications of up to 50 lbs each, at intervals of 1 to 6 months, until the full amount is applied.

**206. FERTILIZER RECOMMENDATIONS:** Apply a 1-2-1 or 2-1-1 ratio fertilizer (examples of grades to use are 5-10-5, 15-30-15, 16-8-8, etc.) according to the instructions in the enclosed note on lawn fertilization.



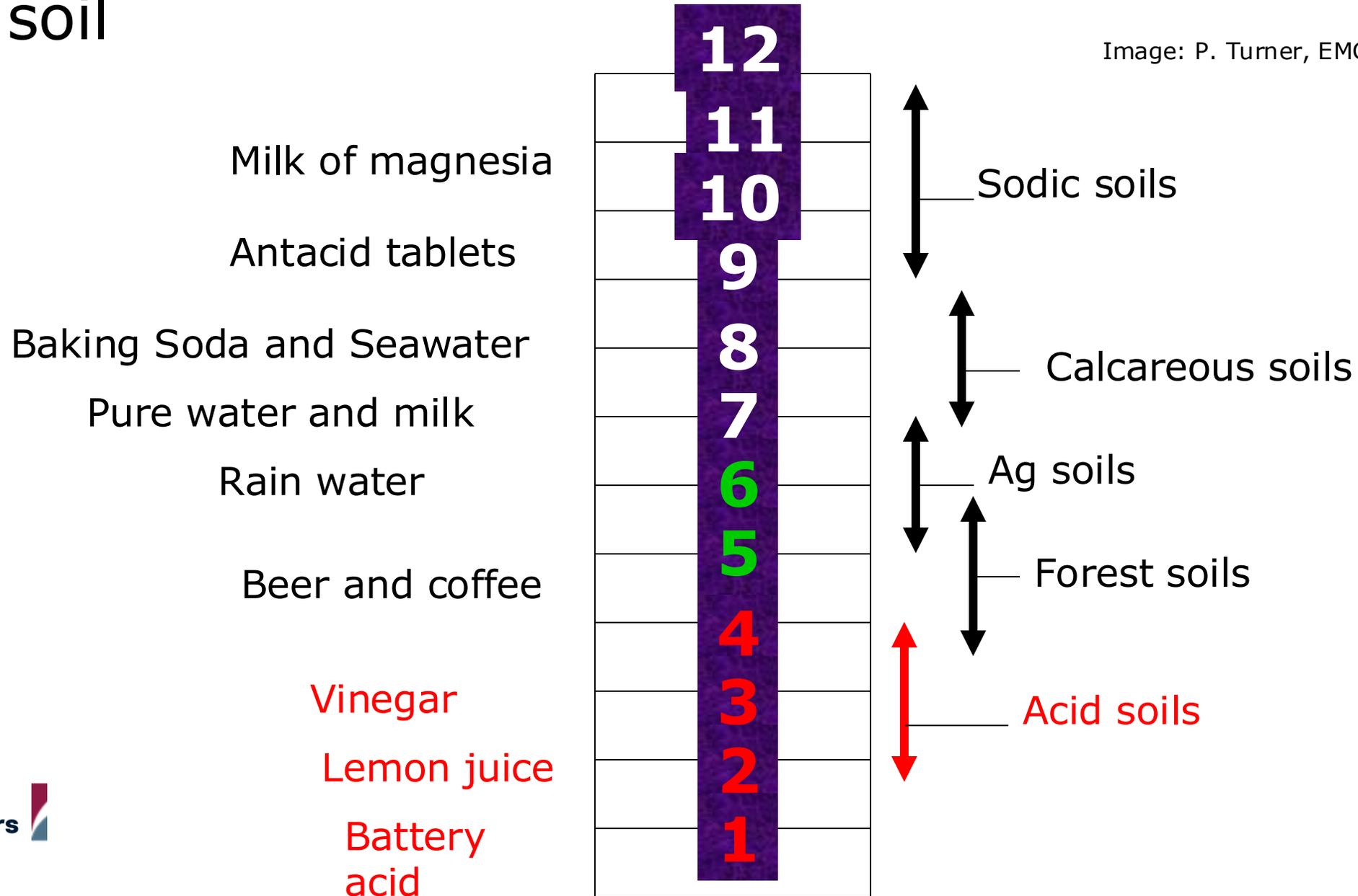
Don't Guess

Soil Test!



# Soil pH: Measures acid-forming (hydrogen) activity of soil

Image: P. Turner, EMG



# pH

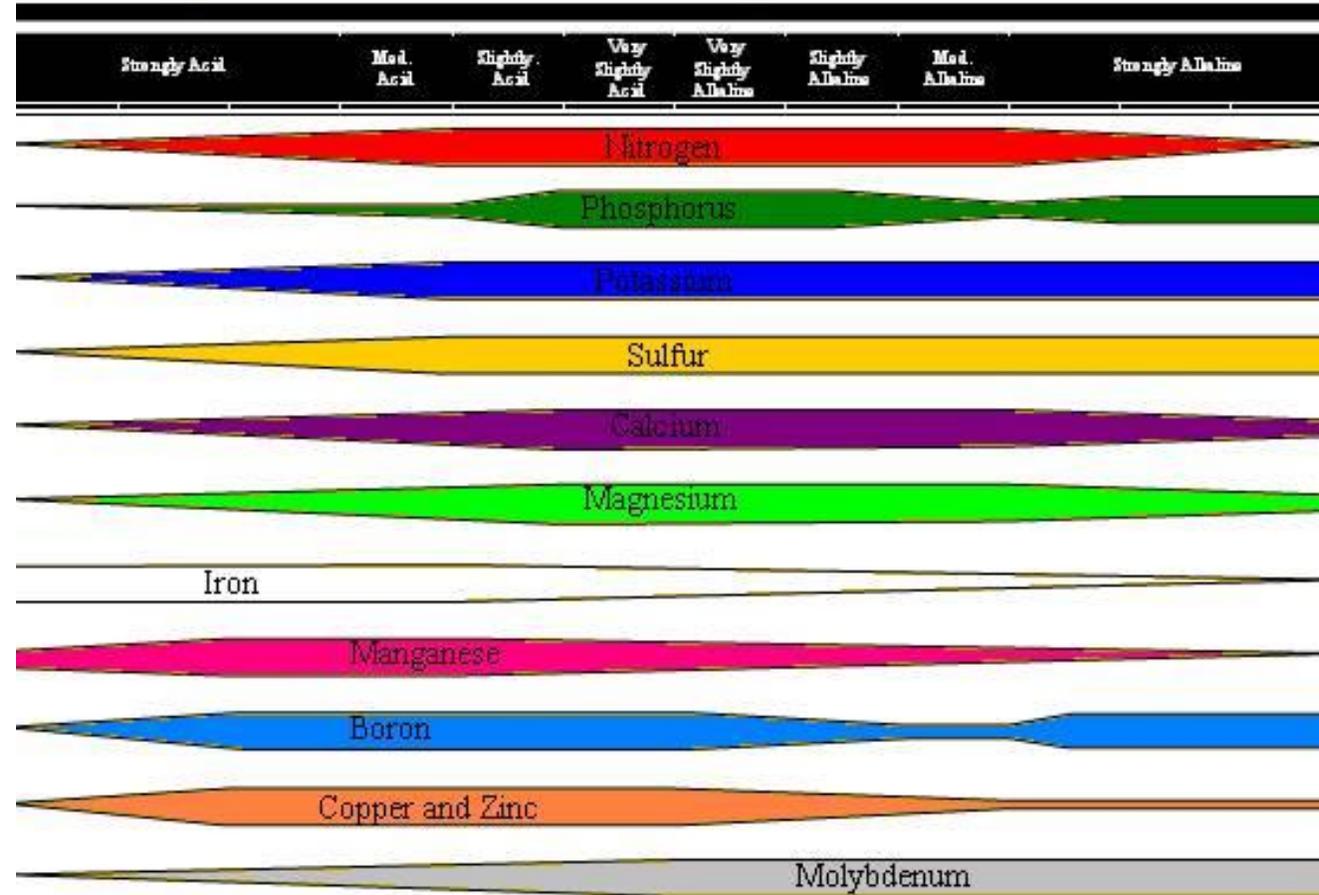
- Affects nutrient availability and use efficiency
- Imbalance can cause
  - toxicity and stunt root growth (Al, Mn)
  - mineral deficiencies (Fe, Mo, Mn)
  - reduced N fixation in legumes
- Affects microorganisms that break down organic matter and affects nutrients



# pH

- Effect of pH on the availability of plant nutrients
- Wider the bar, the more available a nutrient is to the plant

## pH vs Availability of Nutrients



# Desirable pH level

Best pH for

- Bedding plants = 5.5-6.5
- Vegetables = 6.2-6.8
- Lawns = 6.2
- Strawberries = 5.7-6.5
- Brambles = 5.8-6.5
- Blueberries = 4.2-5.5



# Soil Testing in Bedford – samples submitted to VT Soil Testing Lab 2020-2023

- 78 samples for new lawn establishment
  - 47% had a pH less than 6.0
  - 45% had low phosphorus level
- 278 samples for lawn maintenance
  - 27% had a pH less than 6.0
  - 25% had low phosphorus level

The low fertility in these soils would have negatively impacted lawn establishment and/or maintenance. The only way you know your soil's fertility is to test it!! Soils in Central Virginia are typically acidic and low in Phosphorus.



# Functions of Lime

Corrects soil acidity

- reduces solubility of toxic elements
- promotes nutrient availability
- increases bacterial activity

Furnishes Ca and Mg



# Lime

**Ground limestone** - rock is ground

- Ninety percent (90%) of rock passes a 20 mesh screen (400 holes/in<sup>2</sup>)
- Thirty percent (30%) of rock passes a 100 mesh (10,000 holes/in<sup>2</sup>)

**Pulverized limestone** - more finely ground than ground limestone therefore somewhat more quickly active (95% passes a 20 mesh and 70% passes a 100 mesh)

**Pelleted limestone** - ground limestone that has a bonding agent added to make pellets to control dust and increase handling ease



# Lime

## **Calcium Carbonate Equivalent = CCE**

is the neutralizing value of lime

- the higher the %; the less lime needed

Virginia Lime Law – for a product to be sold as lime it must have at least 85% CCE

### MINIMUM GUARANTEED DRY WEIGHT ANALYSIS

Calcium (Ca)	18.0%
Calcium Oxide (CaO)	25.0%
Calcium Carbonate (CaCO <sub>3</sub> )	46.0%
Magnesium (Mg)	11.5%
Magnesium Oxide (MgO)	19.0%
Magnesium Carbonate (MgCO <sub>3</sub> )	40.0%
Total (CO <sub>3</sub> )	86.0%
Calcium Carbonate Equivalent	93.6%
ENV	62.7%
Maximum Moisture Content	1.0%

Typical Lime Product Label

Photo credit: S. Baker, Extension

### MINIMUM SCREEN ANALYSIS\*

Screen (Mesh)	% Passing
8	100
10	100
20	90
50	70
60	60
100	35
200	10

\* ANALYSIS OF GROUND DOLOMITIC LIMESTONE BEFORE PELLETIZING



Photo credit: S. Baker, Extension



# Lime

Agricultural Lime, Ground limestone, etc.

- Calcitic Limestone
- Dolomitic Limestone
- Burnt Lime
- Hydrated Lime
- Marl
- Byproducts (wood ash and slags)



# Calcitic lime

- High calcium lime
- 85% Calcium carbonate ( $\text{CaCO}_3$ )
- CCE = 85-100%
- Very popular bagged lime



# Dolomitic Lime

- Calcium ( $\text{CaCO}_3$ ) and 15% Magnesium ( $\text{MgCO}_3$ ) Carbonates
- CCE = 85-108%
- Most popular bulk lime in area (due to type of rock)
- Used when Mg is needed in soil



# Burnt and Hydrated Lime

- Calcium Oxide (CaO) and Calcium Hydroxide Ca(OH)<sub>2</sub>
- CCE = 150-175% and 110-135%
- Both are very caustic
- Not recommended on turf due to potential burn
- Main application in gardens where quick pH adjustment is needed



Photo credit: S. Baker,  
Extension

# Hydrated Lime

High Calcium

**HAZARD WARNING!**  
CONTAINS HYDRATED LIME (CALCIUM HYDROXIDE). AVOID CONTACT WITH EYES OR SKIN. AVOID BREATHING LIME DUST. ALWAYS WEAR NIOSH-APPROVED EYE GOGGLES WHEN HANDLING LIME. WEAR PROTECTIVE CLOTHING TO PREVENT SKIN CONTACT. VENTILATE OR USE A DUST COLLECTOR TO PREVENT AIRBORNE LIME DUST. USE A NIOSH-APPROVED DUST RESPIRATOR. DO NOT USE THIS MATERIAL ON PLAYING FIELDS OR CHILDREN'S PLAY AREAS. Do not take internally. **FIRST AID:** In case of eye contact, flush eyes thoroughly, including under eyelids, with water for 15 minutes. **CALL PHYSICIAN IMMEDIATELY.** Wear protective clothing to prevent skin contact. If skin contact occurs, wash with water. Should skin irritation continue, see **PHYSICIAN.** If swallowed, **CALL PHYSICIAN IMMEDIATELY.** Product safety information.  
**KEEP OUT OF REACH OF CHILDREN.**

SEE MSDS FOR MORE INFORMATION ABOUT SAFETY AND DISPOSAL  
24 Hour Emergency Number: Chemtrec, 1-800-242-9300



# Recommendations

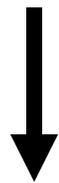
- Based on soil test
- No more than 50 lbs/ 1000 ft<sup>2</sup> per application
- Apply urea at least 3 weeks prior to lime application
  - Lime can interfere with urea and cause urea to be lost to atmosphere
- Lime anytime, but Fall is favored; lime reacts slowly with soil. Fall applications allow time for reaction before next growing season



# Fertilizers



# The Fertilizer Bag



% nitrogen



% phosphorus



% potassium



# Types of Fertilizers

- Simple - only supplies one macro fertilizer nutrient. Example - Urea 46-0-0. Nitrogen only
- Compound – supplies two macro fertilizer nutrients. Example - Diammonium Phosphate (DAP) 18-46-0. Supplies nitrogen and phosphorus
- Complete – supplies all three macro fertilizer nutrients. Example 10-10-10. Supplies nitrogen, phosphorus and potassium



# Fertilizer Grade

Percentage by Weight

**10 - 10 - 10**  
**N - P - K**

*50 Pound Bag of Fertilizer*

- *5 pounds nitrogen*
- *5 pounds phosphate*
- *5 pounds potash*
- *35 pounds filler*



# Examples of Fertilizer Ratios

- 10-10-10 = 1-1-1  
This fertilizer has equal parts of all nutrients
- 5-10-10 = 1-2-2  
This fertilizer has 2x the P and K than N
- 27-4-9 = 4-0-2 (Turf Type)  
High N, low P and moderate K



## Amounts of various types of fertilizers to apply certain rates of nitrogen (N) per 1,000 square feet

Fertilizer Analysis	Approximate Ratio	lbs. of N desired / 1000 sf		
		0.5	1.0	1.5
		---lbs. Fertilizer per 1000 sf---		
5-10-5	1-2-1	10.0	20	NA
5-10-1-	1-2-2	10.0	20	NA
6-2-0	3-1-0	8-3	16.6	24.9
10-10-10	1-1-1	5.0	10.0	NA
12-4-8	3-1-2	4.2	8.3	NA
16-8-8-	2-1-1	3.1	6.2	NA
16-4-8	4-1-2	3.1	6.2	NA
20-0-16	4-0-3	2.5	5.0	NA
23-3-7	8-1-2	2.2	4.3	NA
28-0-12	7-0-3	1.8	3.6	NA
31-0-0	1-0-0	1.6	3.2	4.8
33.5-0-0	1-0-0	1.5	3.0	NA
38-0-0	1-0-0	1.3	2.6	3.9
46-0-0	1-0-0	1.1	2.2	NA

Nitrogen levels from predominantly water-soluble sources should never exceed 1 pound N/1,000 square feet in a single application

$$1.0 \text{ (rate)} / .05 \text{ (\%N)} = 20 \text{ pounds per 1000 sq. ft.}$$



# Slow- Release Fertilizers

- Fewer applications
- Low burn potential
- Higher cost
- Release rate varies with ingredients
- Release rate governed by factors other than plant needs

[Photo credit](#)



# Conventional Fertilizers

- Fast acting
- Some are acid forming
- Lower cost
- Greater burn potential
- Solidify in bag when wet
- Nitrogen leaches readily



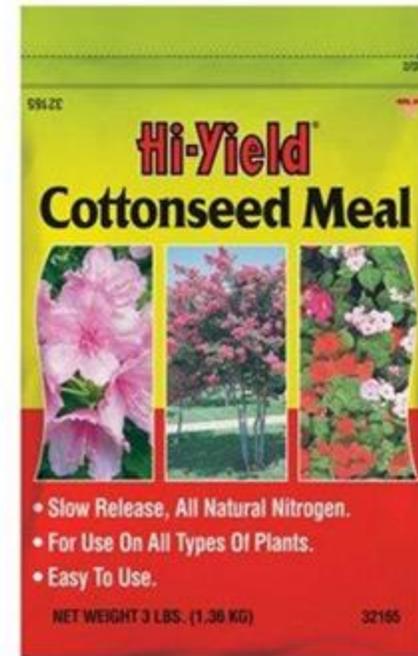
Photo credit: S. Baker, Extension



# Organic Fertilizers

- Nutrients derived from remains or by-product of a once-living organism
- Low burn potential
- Relatively slow release
- Contains micronutrients
- Conditions the soil
- Bulky to handle
- Odor
- Expensive per pound of actual ingredient
- Weed seeds can be problem

[Photo credit](#)



# Organic N Sources

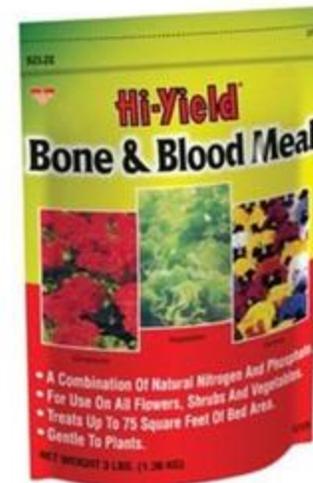
- Fish Emulsion
- Bone Meal
- Blood meal
- Manure
- Compost

Variable composition



[Photo credit](#)

[Photo credit](#)



# Fertilizer Pesticide / Herbicide Combinations

- Convenient but expensive
- Timing not always appropriate
  - Applying fertilizer with crabgrass control in fall  
Crabgrass control is needed in spring
  - Applying fertilizer with weed control in spring  
Generally lawns don't need fertilizer in spring
  - Applying fertilizer with grub control mid-summer  
Generally lawns don't need fertilizer in summer
- Fall fertilizer with weed control is effective



# Fertilizer Timing

- Apply when plants can most benefit – think roots!
- Depends on type – fast, slow release, organic
- Annuals – at planting and side dress
- Trees/Shrubs – early spring or mid – late fall
  - Note: healthy looking ornamentals don't need it
- Lawns
  - primarily fall (for fescue, bluegrass)
  - Late spring (zoysia, bermudagrass)



# Applying the right amount

Most recommendations for fertilizer treatments in a residential setting are given as an amount per set area (e.g. per 1000 square feet). Therefore, it is important to know the square footage of the area you wish to treat and then make sure your equipment is calibrated to provide the desired amount.

Most areas are not a perfect square, rectangle, triangle, etc.

As a general rule, use the length x width formula (60 feet long x 30 feet wide = 1800 square feet) and use your best judgment on odd-shaped areas. For details on equipment calibration: [Sprayer Calibration](#)



# Calculating Fertilizer Rate

Apply 1 lb N/1000 sq ft using 25-07 fertilizer.

$$\begin{array}{l} \text{(1\# N)} \\ \hline 25 \end{array} \times 100 = 4 \text{ lbs of 25-0-7 per } 1000 \text{ ft}^2$$

(25-3-1 fertilizer is 25% N)

[Video: Calculating Fertilizer Rate](#)



# Application Calculation Example

Lawn Area: 11,200 square feet

Fertilizer: Turf Grow (25-0-7)

Application Rate: 1.0 pounds of nitrogen per 1000 square feet

---

Total pounds N needed for area = **11.0 pounds** (11,200 / 1000 x 1.0 pound rate)

Total pounds of fertilizer needed = **44 pounds**  
(11.0 pounds N/ .25 N)



# Soil Amendments



# Soil Amendments

Any material added to a soil to improve its physical properties –Goal:  
To provide a better environment for the roots.

The best soil amendments increase water- and nutrient holding capacity and improve aeration and water infiltration.

DO NOT add sand to clay soils –Creates structure similar to concrete.



# Why Apply Soil Amendments

- Nutrients removed by plants
- Surface runoff
- Leaching
- Soil erosion
- Provide nutrient balance
- Proper plant growth



# Soil Amendments

## Organic Amendments

- Sphagnum peat
- Wood chips
- Grass clippings
- Straw
- Compost
- Manure
- Biosolids
- Sawdust
- Wood ash

## Inorganic Amendments

- Vermiculite
- Perlite
- Tire chunks
- Pea gravel
- Sand



# Organic Amendments

- Increase soil organic matter content
- Contain plant nutrients and act as organic fertilizers
- Important energy source for bacteria, fungi, and earthworms
- Improves:
  - Soil aeration
  - Water infiltration
  - Nutrient- and water-holding capacity



# Biosolids

- Byproduct of municipal waste water treatment
- May be found alone or composted with leaves or other organic matter
- Only Class A biosolids (e.g. Milorganite™ or properly composted biosolids) are approved for residential use
- Acceptable for food gardens
- As with all fertilizers, always follow directions for proper use



# Manure

- Use only aged manure (at least 6 months)
  - Fresh manure can harm plants
  - Pathogens are a potential problem, especially on vegetable gardens
- Home-composted products best used in non-food gardens
- Compost manure for at least 2 heating cycles (130° to 140°)



# Decomposition Rate of Various Amendments

- |                                    |                              |
|------------------------------------|------------------------------|
| 1. Grass clippings, manures        | 1. Rapid (days to weeks)     |
| 2. Composts                        | 2. Moderate (about 6 months) |
| 3. Wood chips, hardwood bark, peat | 3. Slow (possibly years)     |



# Permeability & water retention of various amendments

Amendment	Permeability	Water Retention
Fibrous		
Peat	Low medium	Very High
Wood Chips	High	Low medium
Hard bark	High	Low medium
Humus		
Compost	Low medium	Medium high
Aged Manure	Low medium	Medium
Inorganic		
Vermiculite	High	High
Perlite	High	Low



# Improving Soil Nutrients

- Greensand
- Granite Meal
- Cottonseed meal
- Kelp meal
- Leather meal
- Worm castings
- Synthetic fertilizers



# Mulches as Amendments

## Leaves

- 2"-3" after compaction = good annual weed control
  - Decompose fairly quickly
  - Easy to obtain
  - Attractive
- Improves soil once decomposed
- To prevent blowing, allow to partially decompose

## Grass Clippings

- 2" = good weed control
- Build up layer gradually, using dry grass
- Thick layer gives off heat and foul odors rather than decomposing



# Mulches as Amendments

## Sawdust

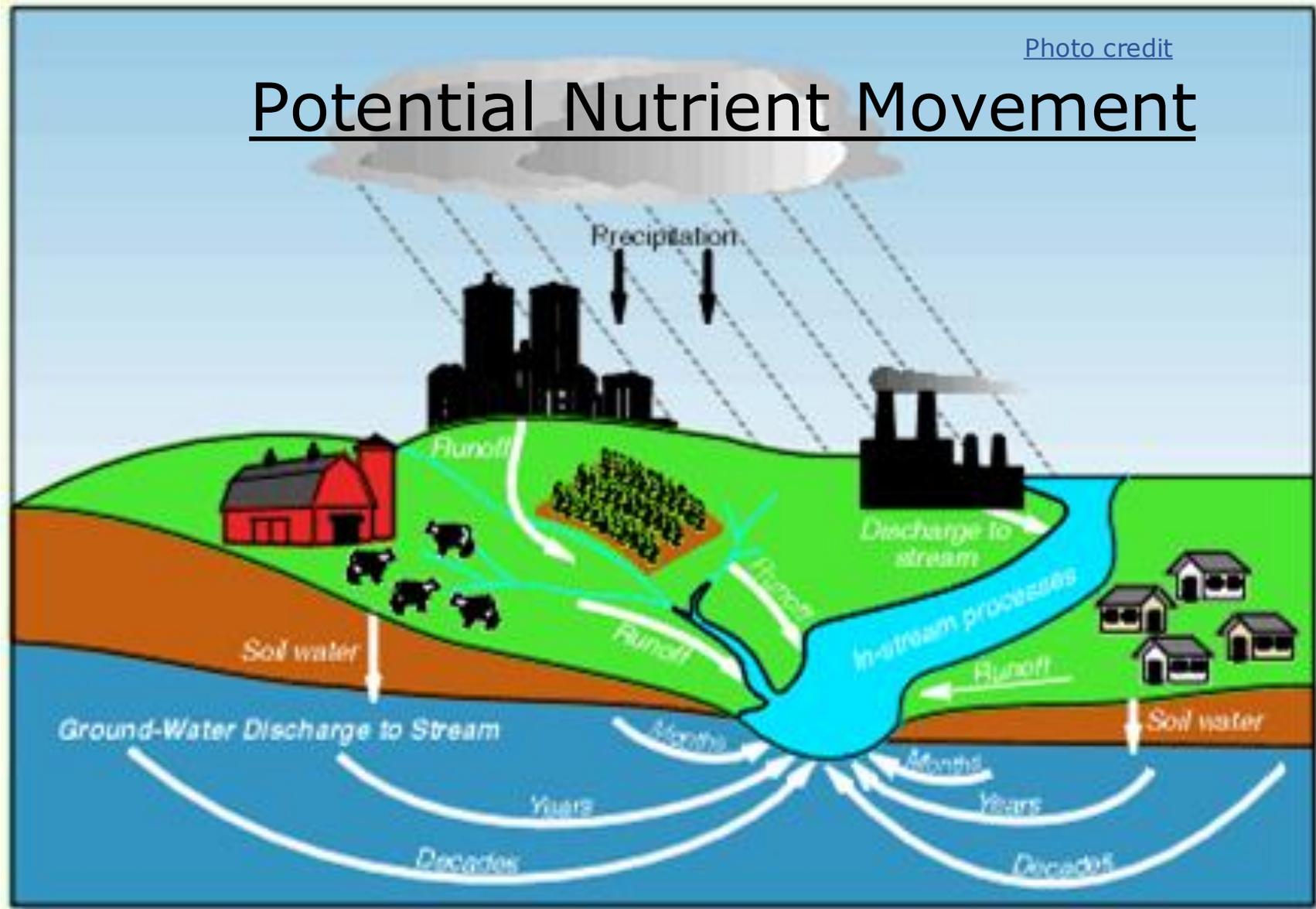
- 2" layer = good weed control
- If applied around growing plants, add ½ lb. nitrogen/10 ft<sup>3</sup>
- Fresh contains a great deal of carbon and very little nitrogen
- Breakdown requires microorganisms to take nitrogen from the soil
- Crusts resulting in impermeability of rainfall

## Hay and Straw

- 6"-8" = good annual weed control
- Decompose quickly
- Stay in place
- Improves soil as they decay
- Avoid hay w/weed seed or brambles
- Also avoid hay treated with weed killers
- Fresh legume hay supplies nitrogen as it breaks down
- Great for vegetables & fruit



# Potential Nutrient Movement



# Fertilizer Use: Precautions to Reduce Nutrient Movement

- Apply no more than is needed by the crop
- Apply when it can be best utilized
- Apply in proper manner
- Maintain good organic matter content
  - Compost, cover crops





# Balance of Soil Elements

- Need enough of each plant nutrient for adequate growth
- No more than required
- Excess potassium reduces availability of calcium and magnesium
- High phosphorus levels tie up zinc, iron, and other elements

***SOIL TEST SOIL TEST SOIL TEST***



# End of Slide Set

You can continue to next slide: 'Suggested Readings'

OR

Click on the house below to return to the Navigation Page



# Suggested Readings

- [Welcome to Web Soil Survey](#) (2 pages)
- [A Homeowners Guide to Soil Fertilization and Testing](#)
- [Fertilizing Landscape Trees and Shrubs](#) (3 pages)

## *Mulching and Composting:*

[Grass Clippings, Compost and Mulch: Frequently Asked Questions](#) (7 pages)



# Test Your Knowledge

pH makes a  
difference

Apply What You  
Have Learned

Improve the  
Soil

Unscramble

Fertilizer  
Calculation

Help Desk Quiz

Test your Soil  
Knowledge



# Apply What You Have Learned

Identify the following characteristics of soil in your yard/garden:

- Color, texture, structure, depth
- Do a soil drainage test
- Have a soil test done
- Build a compost pile
- Calculate the amount of fertilizer to use, and the rate of application for an area of your yard / garden

Click to  
return to the  
test of  
knowledge  
page



# What do you know about pH?

Answers on next slide

1. Which type of soil would need the MOST lime to raise the pH from 5.5 to 6.5?                      Sand                      Silt                      Clay
2. A pH of 5.5 (acidic) or 8 (alkaline) will have what impact on nitrogen availability for plants?
3. In what pH range are most macronutrients most available to the plant?
4. Vegetables grow best at what pH range?
5. What do I use to make the soil more acidic?

Click to  
return to the  
test of  
knowledge  
page



# What do you know about pH?

1. Which type of soil would need the MOST lime to raise the pH from 5.5 to 6.5?                      Sand                      Silt                      Clay

Answer: Clay

2. A pH of 5.5 (acidic) or 8 (alkaline) will have what impact on nitrogen availability for plants?

Answer: Reduces nitrogen availability

3. In what pH range are most macronutrients most available to the plant?

Answer: 6 – 7

4. Vegetables grow best at what pH range?

Answer: 6.2 – 6.8

5. What do I use to make the soil more acidic?

Answer: Sulfur

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# What 5 things are most important to do to improve the soil?

Answer on next slide

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# What 5 things are most important to do to improve the soil?

- Adjust soil pH
- Fertilize according to soil test / proper time
- Add organic matter to improve soil structure and drainage
- Grow cover crops to reduce erosion
- Aerate compacted soils to improve air and water penetration

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# Fertilizer Calculation

You want to apply 16-0-8 fertilizer to your lawn at a rate of 1 lb. of nitrogen per 1000 sq. ft. How many pounds of this fertilizer do you need for every 1000 sq. feet of lawn area? Answer on next slide.

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# Fertilizer Calculation

You want to apply 16-0-8 fertilizer to your lawn at a rate of 1 lb. of nitrogen per 1000 sq. ft. How many pounds of this fertilizer do you need for every 1000 sq. feet of lawn area?

$$1 / .16 = 6.25 \text{ pounds}$$

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# FERTILIZERS AND SOIL AMENDMENTS

Unscramble the following names for the nutrients and soil amendments that you have learned for fertilizers and soil amendments. (4 Answers are two words)

Answers on next slide

- TIUEVRMCIEL
- ETAAPGSMNHUP
- ODBOSLIIS
- CMEITILDMOOLI
- TROENIGN
- HSPOUHPSRO
- AMPSUOTSI
- UNAMGEIMS
- OMCSPOT
- UFLSRU
- IEINHSOFUSLM
- OHWOASD

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# FERTILIZERS AND SOIL AMENDMENTS

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- UFLSRU
- IEINHSOFUSLM
- OHWOASD
- SPHAGNUM PEAT
- VERMICULITE
- BIOSOLIDS
- DOLOMITIC LIME
- NITROGEN
- PHOSPHORUS
- POTASSIUM
- MAGNESIUM
- COMPOST
- SULFUR
- FISH EMULSION
- WOOD ASH

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# Matching

Match the items on the right with the appropriate descriptions on the left (Answers on next slide)

1. Builds cell walls
  2. Critical for photosynthesis
  3. Distance from surface to layer that retards root penetration.
  4. Makes up 25% of desirable soil composition.
  5. Presence of iron oxides, well drained
  6. Macro Nutrients
  7. Critical for chlorophyll production
  8. Promotes strong stems & disease resistance
  9. Secondary Nutrients
  10. Lacks oxygen; water logged
  11. Makes up 25% of desirable soil composition.
- a. Air
  - b. Gray colored soils
  - c. Potassium
  - d. Nitrogen
  - e. Ca, Mg, S
  - f. Water
  - g. Soil Depth
  - h. Phosphorus
  - i. N, P, K
  - j. Red colored soils
  - k. Calcium

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# Match the items on the right with the appropriate descriptions on the left

1. Builds cell walls
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1. C
2. H
3. G
4. A
5. J
6. I
7. D
8. C
9. E
10. B
11. F

- a. Air
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# Help Desk Quiz Answers on next slide

1. I read that cardboard and newspaper make good mulch for a perennial border. Is this true?
2. I just moved to this area from out of state and have been told I have red clay soil. What do I need to know before I prepare flower beds and a vegetable garden?
3. Toadstools come up twice a year encircling my maple tree. Are they dangerous? Did somebody plant them there? How do I get rid of them?
4. Thatch in lawn; poor soil. What do I do?

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# Help Desk Quiz

1. I read that cardboard and newspaper make good mulch for a perennial border. Is this true?

**Answer:** No. While newspapers and cardboard are suitable mulch for beds that you will till periodically, they are not good for more permanent locations that won't be worked often. They are pest havens; rodents often nest under them. They can become compacted and create an impermeable barrier to water and gas exchange. When they become dried out in summer months, they repel water.

2. I just moved to this area from out of state and have been told I have red clay soil. What do I need to know before I prepare flower beds and a vegetable garden?

**Answer:** The soil in our area is predominantly red clay and compact. Therefore, most clay soils need amendment. Before adding any amendments, get a soil test to know what amendments are best. Adding organic amendments to the soil lightens soil texture, discourages compaction, adds nutrients, improves drainage and aeration, moderates soil temperature, and provides pore space, which is essential to plant growth. Do not work in clay soil when it is wet as this compacts the soil and spreads fungal diseases.

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# Help Desk Quiz

3. Toadstools come up twice a year encircling my maple tree. Are they dangerous? Did somebody plant them there? How do I get rid of them?

**Answer:** Toadstools are the fruiting structure of fungi 'basidiomycota'. The circle is commonly known as 'fairy ring.' Toadstools can be poisonous; however, they are not harmful to trees. Remove toadstool by either mowing or picking by hand. Have soil test done to find out what nutrients soil needs under trees - then fertilize per VT's recommendation. Best time for lawn renovation is late summer / early fall. No chemical control of fungi warranted.

4. Thatch in lawn; poor soil. What do I do?

**Answer:** Advised to have a soil sample test done by Virginia Tech and follow recommendations given to improve soil. Also advised to de-thatch lawn and re-seed.

