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Bedford Extension Master Gardeners

Soils and Nutrient Management

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

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 Chapters 3 and 4 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
- When you are ready, take the quiz, you can print out a copy by clicking on “Printable Copy of Quiz” on the first slide to get a copy to work on
- Take the “Soils Quiz” online

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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

Continued.....

What I Will Learn in This Module

- 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

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Continued…..

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

Continued....

What I Will Become Familiar With

- 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

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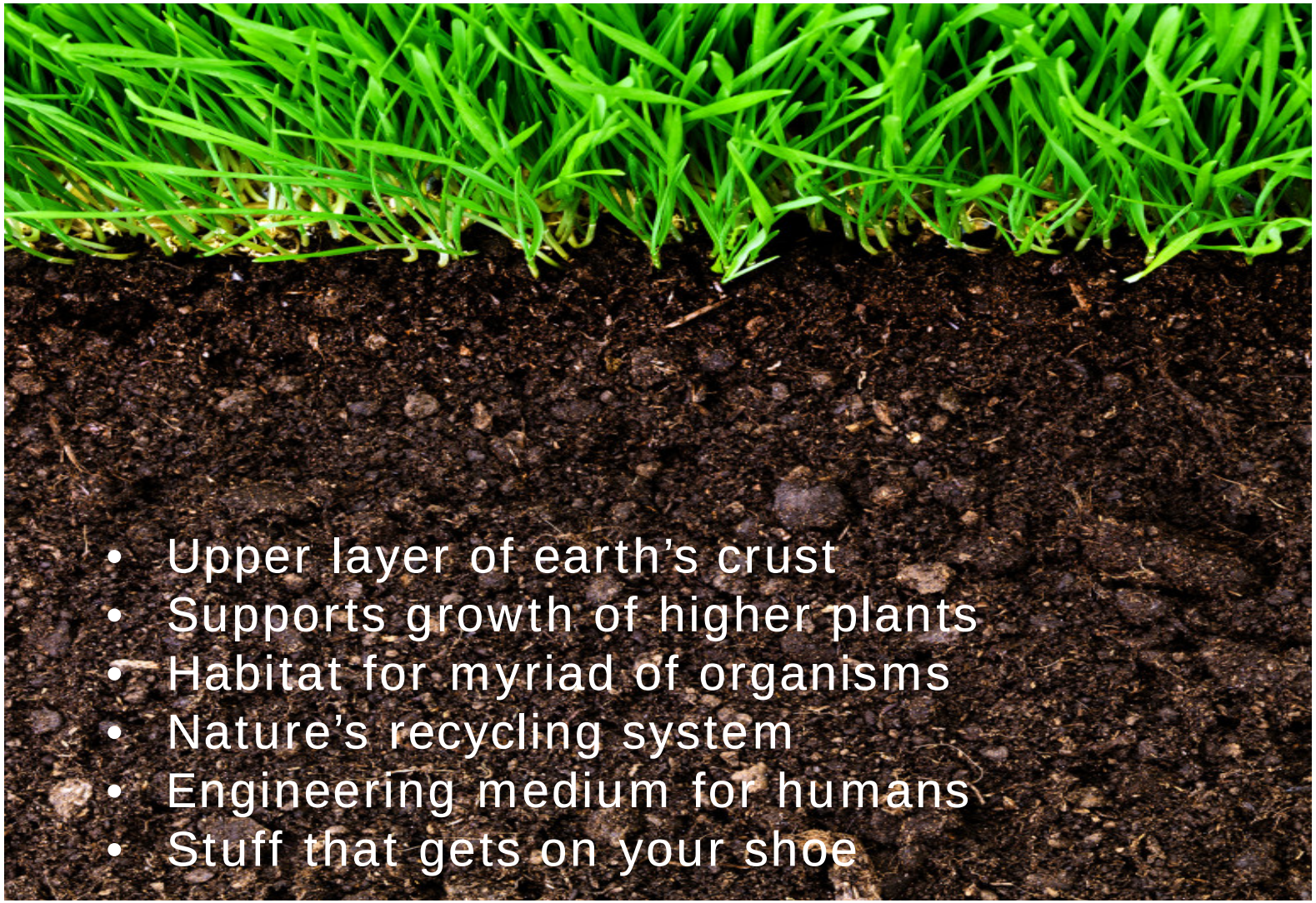
What is Soil?



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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." Soils.org

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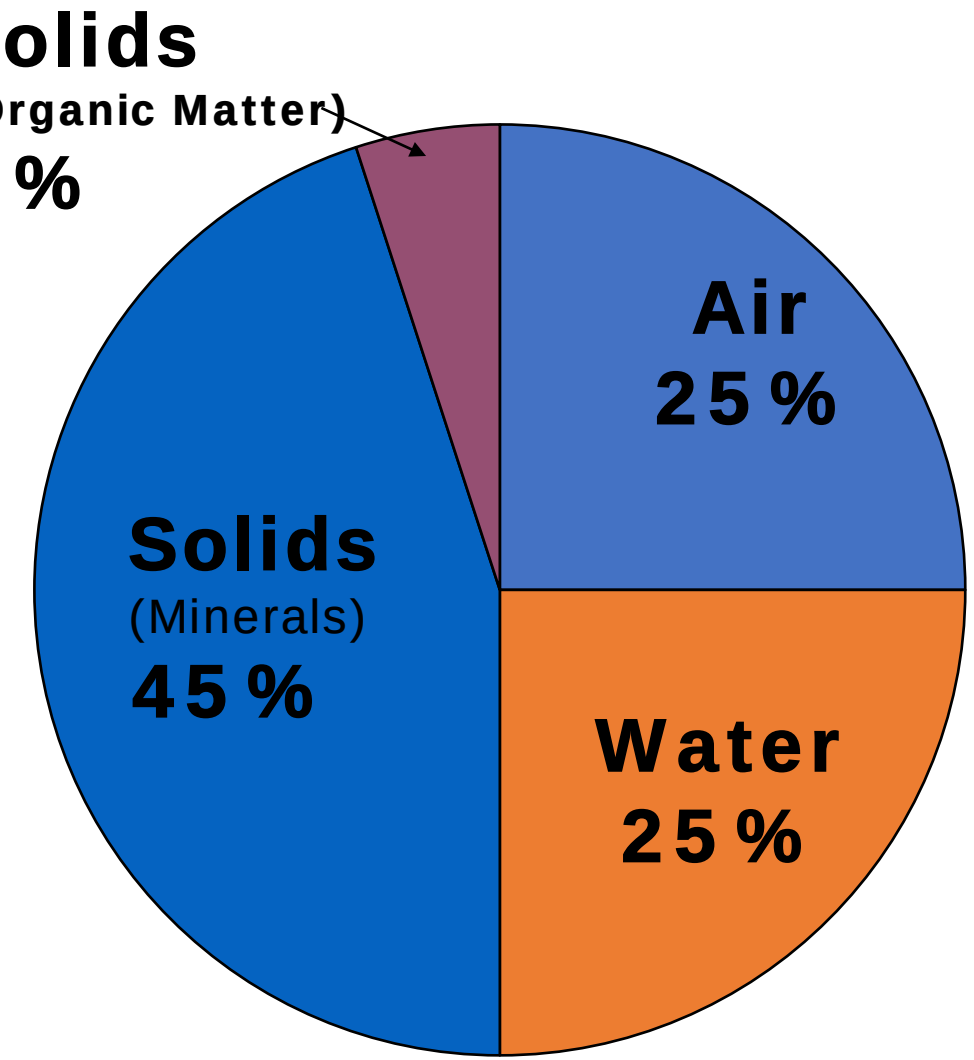
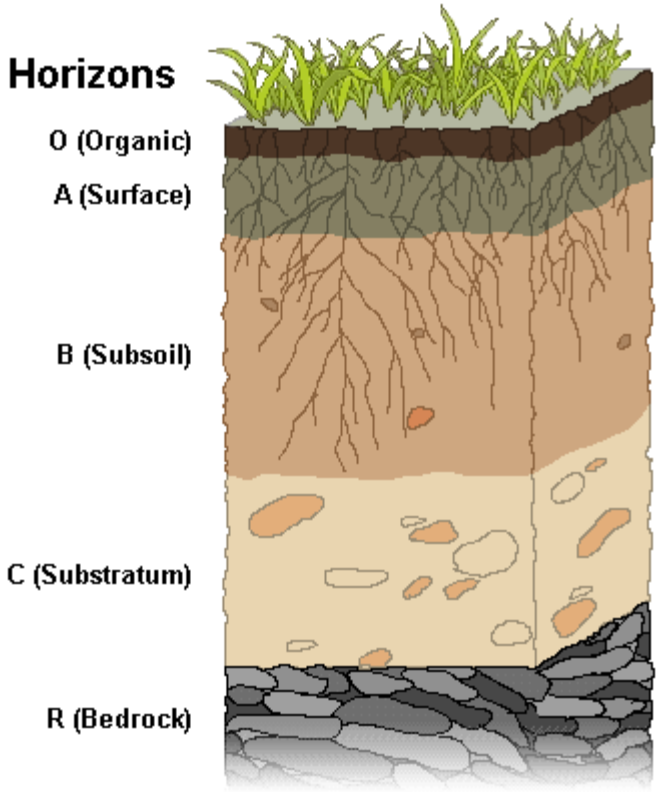
Desirable Soil Composition



Soil Profile / Slice

Divided into 3 horizons or layers

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



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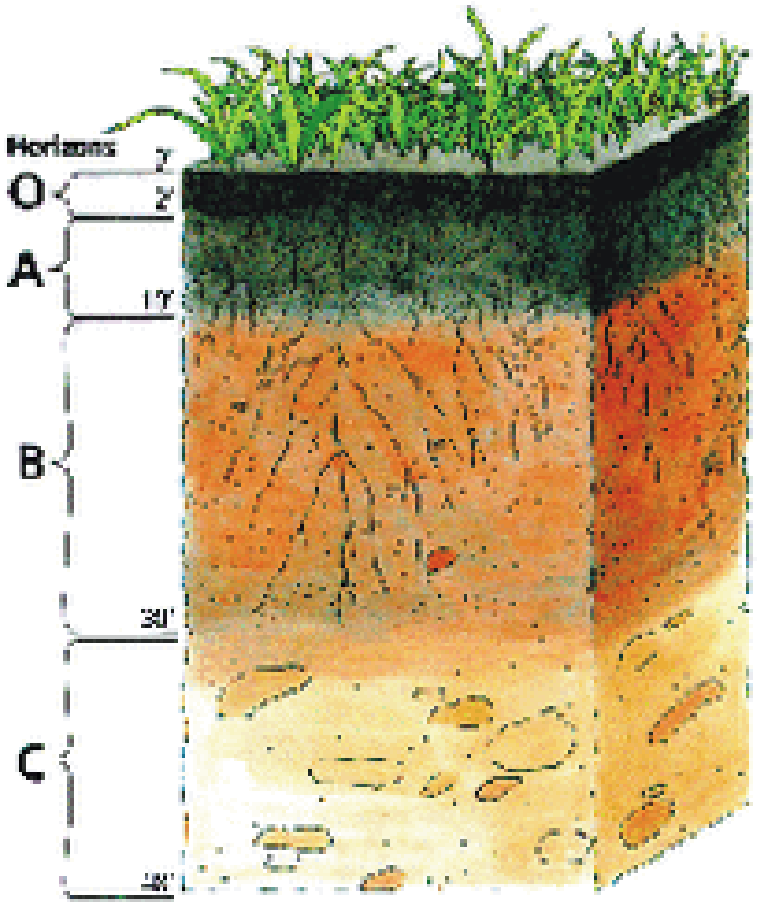
Soil Profile

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”

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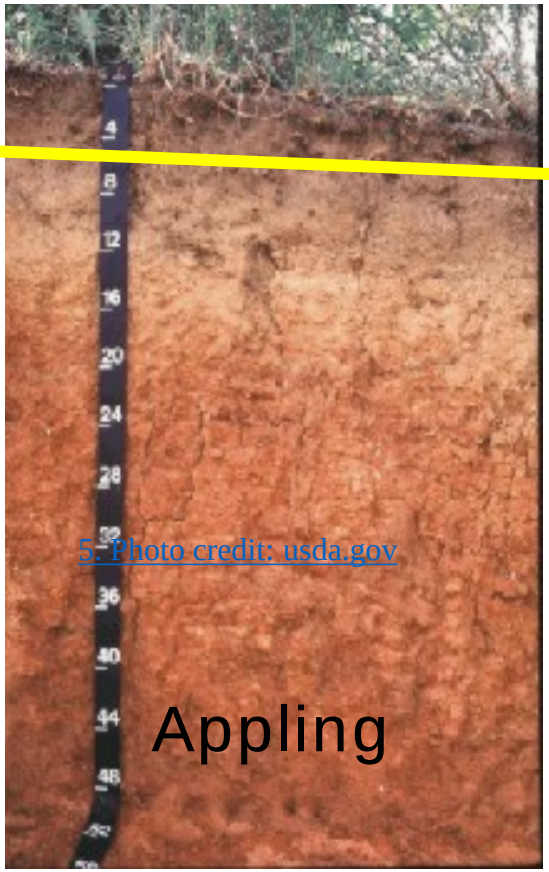
Soil

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



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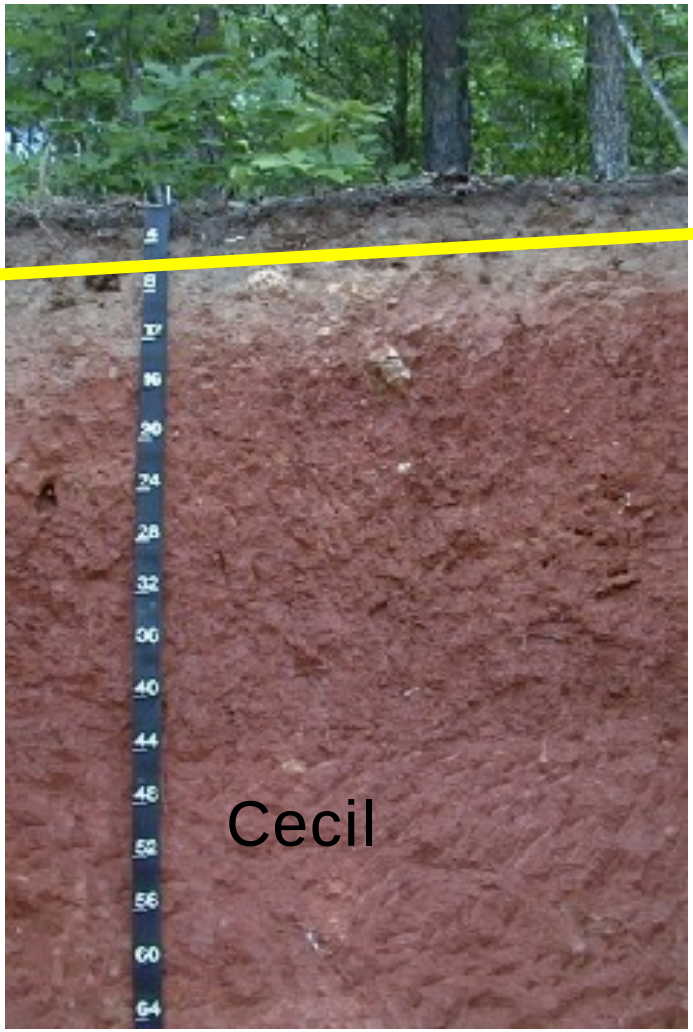
5. Photo credit: usda.gov



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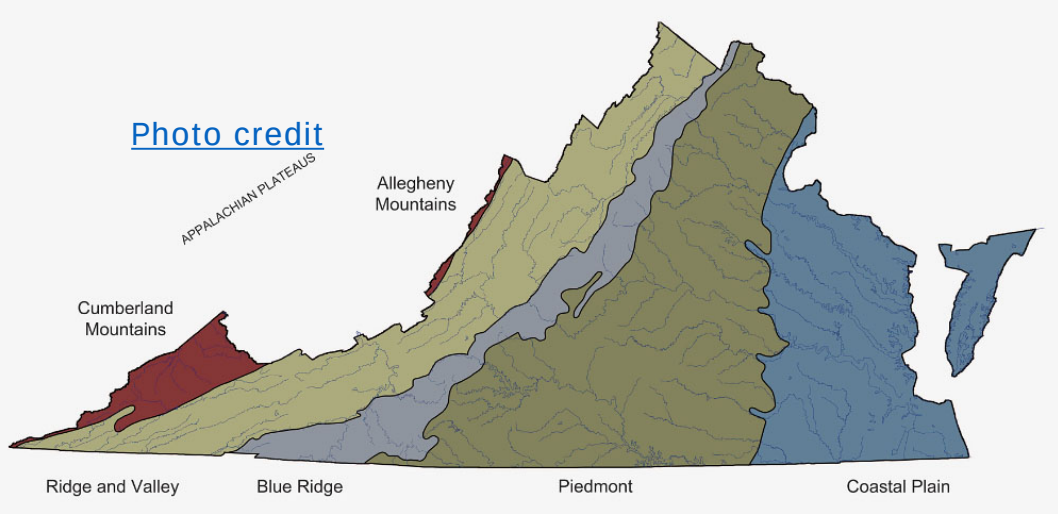
Soil Differences in Virginia

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



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Soil Characteristics

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

Physical Properties of Soil

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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

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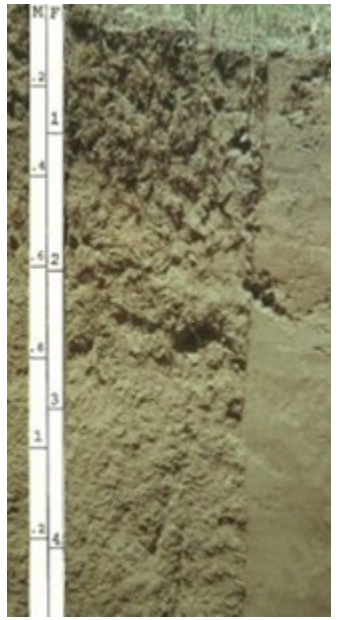
Yellow to Red Colors

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

Photo credit

White to Light Gray Colors

- Soil has been leached
- Lack of organic matter



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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

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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- sand, silt, and clay

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

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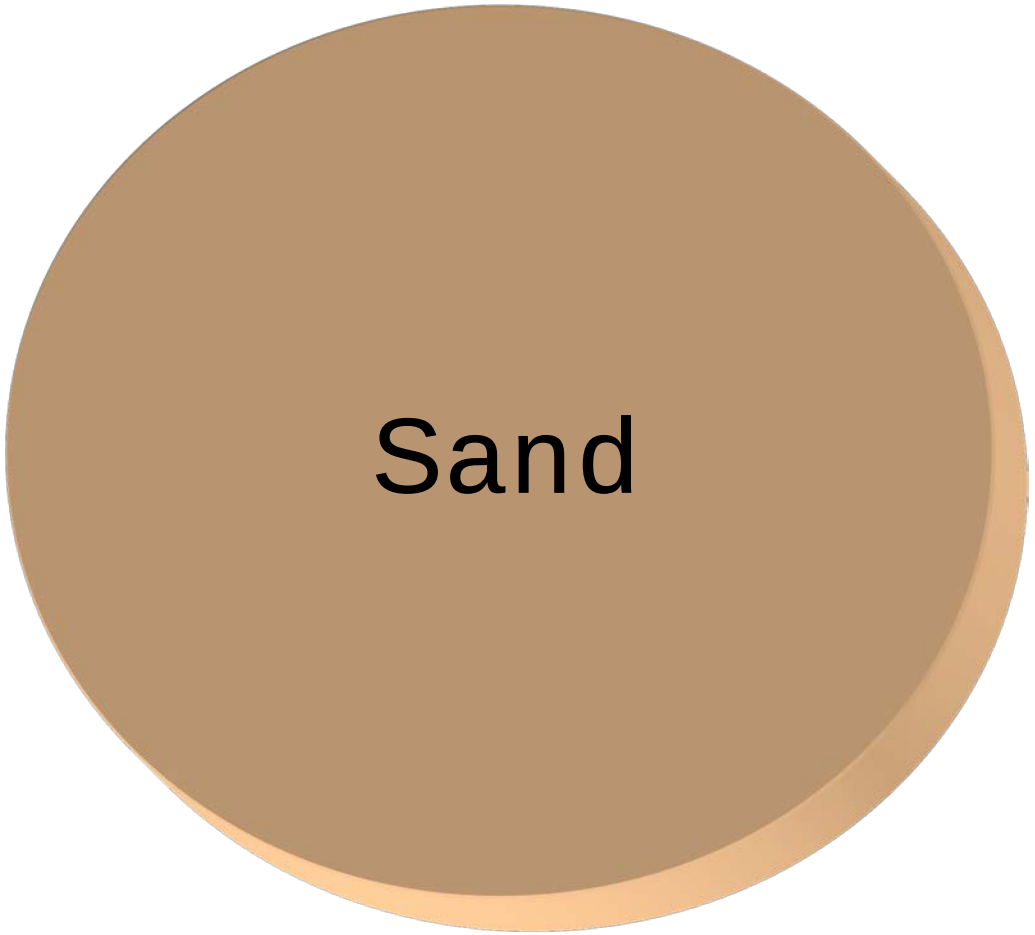
Soil Texture
Particle Size Comparison



Clay

Silt

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Photo credit

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)

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Soil Class Determination

Photo credit

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

Photo credit

Clay Soil – soil maintains firm shape when rolled in palm

Estimating soil texture

Photo credit

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

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Determining soil texture by feel

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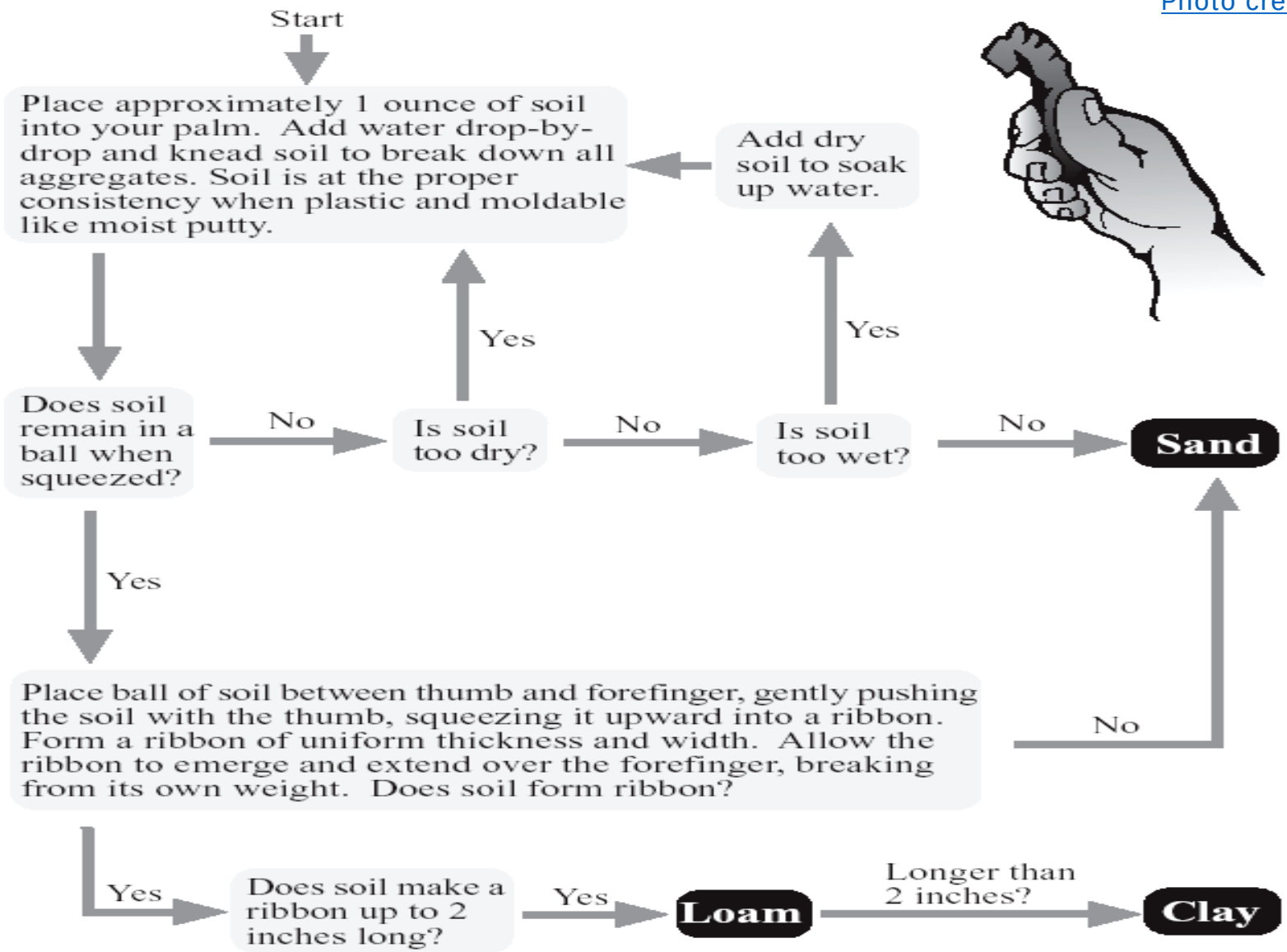

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Soil Type Matters!

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

Attribution of Photos 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

Blocky

Platy

Soil Structure

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Soil Structure

High clay or sand content = poor structure

Structure can be damaged

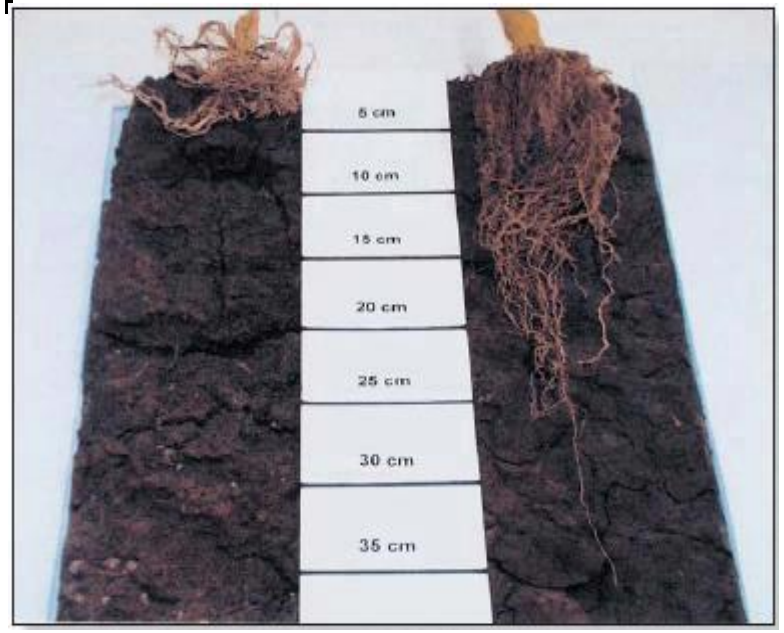
- Excessive tilling
- Working when too wet / too dry
- Movement over with heavy equipment

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

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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

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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

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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

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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 160º 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

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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 4, p. 101, MG Handbook has a Table of Common Cover Crops

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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)

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Plant Nutrients

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

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Healthy Corn Plant

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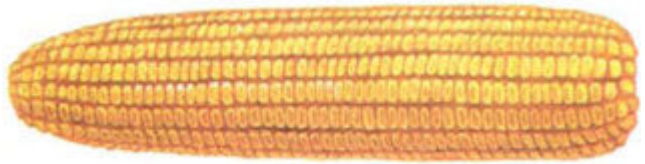

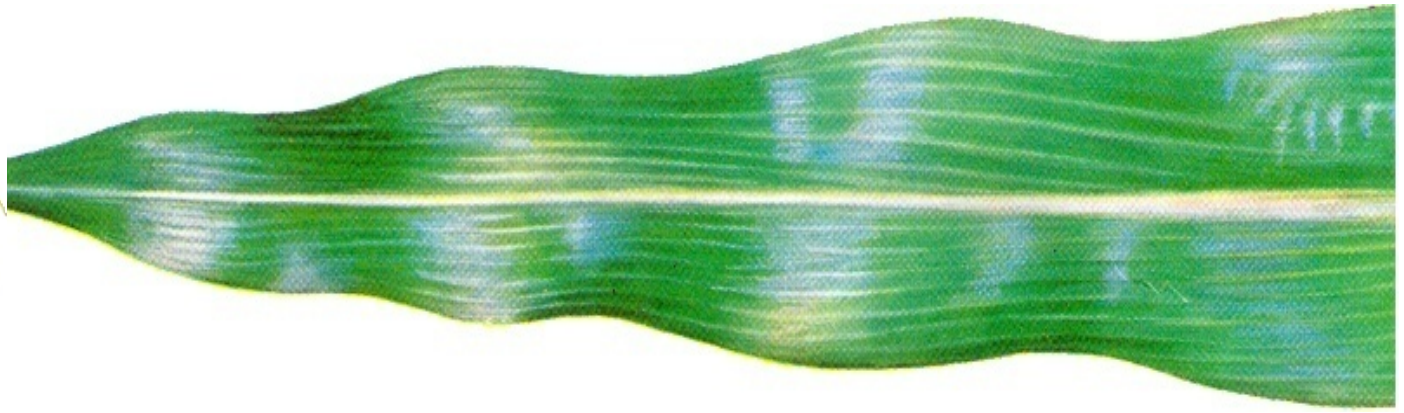

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Nitrogen Deficiency: lower leaves turn yellow, reduced growth in tops and rows

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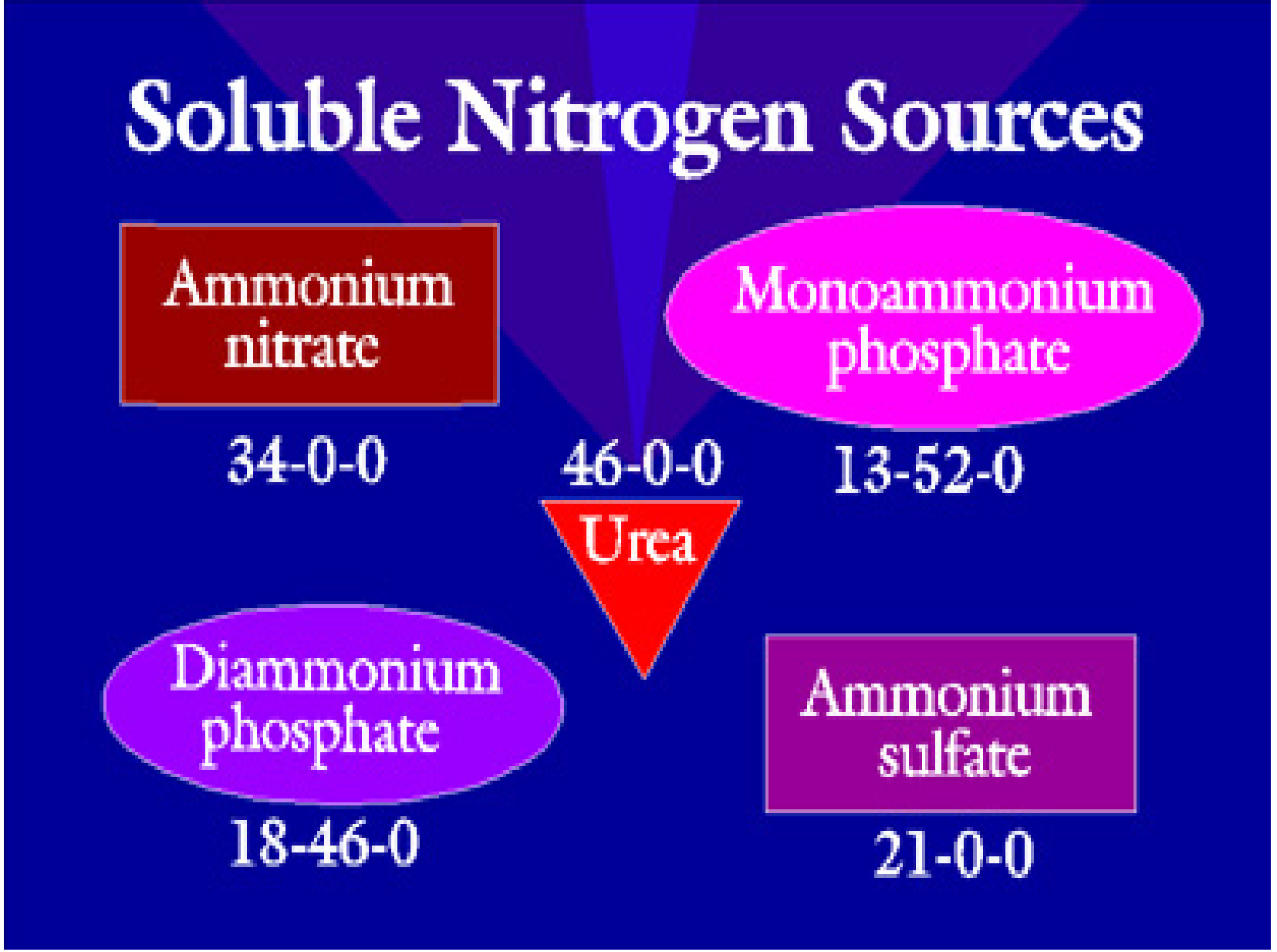

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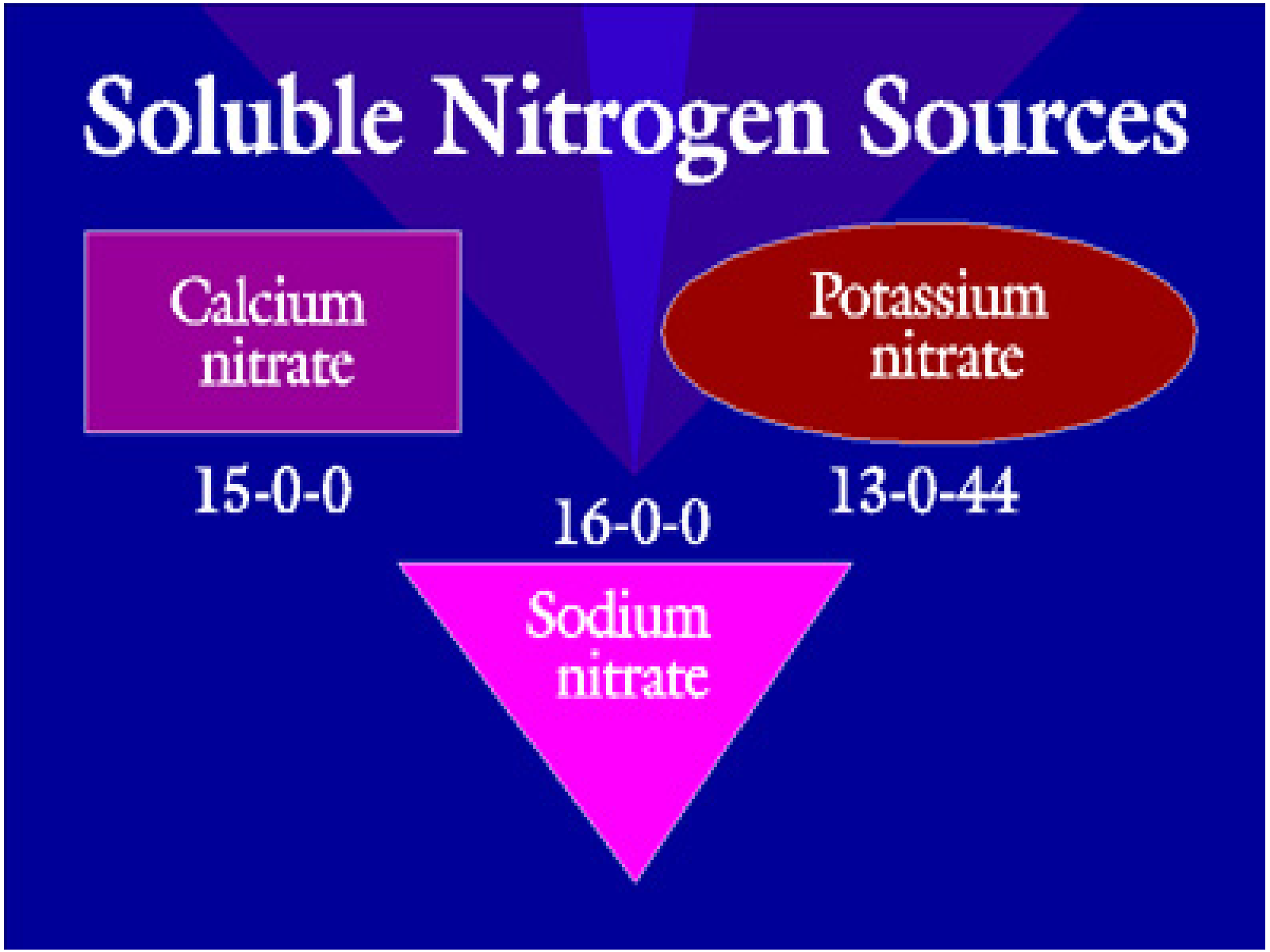

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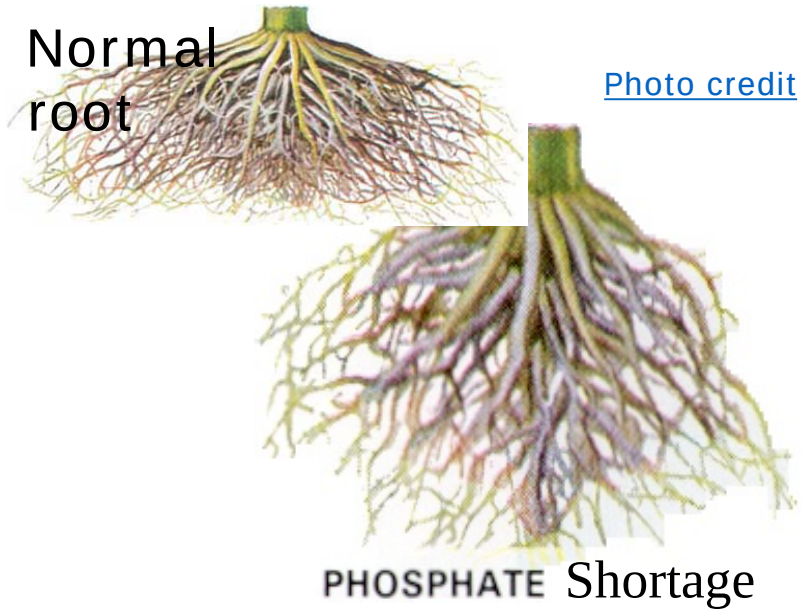
Phosphorus

- 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



Shortage

Photo credit

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

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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

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Potash Deficiency

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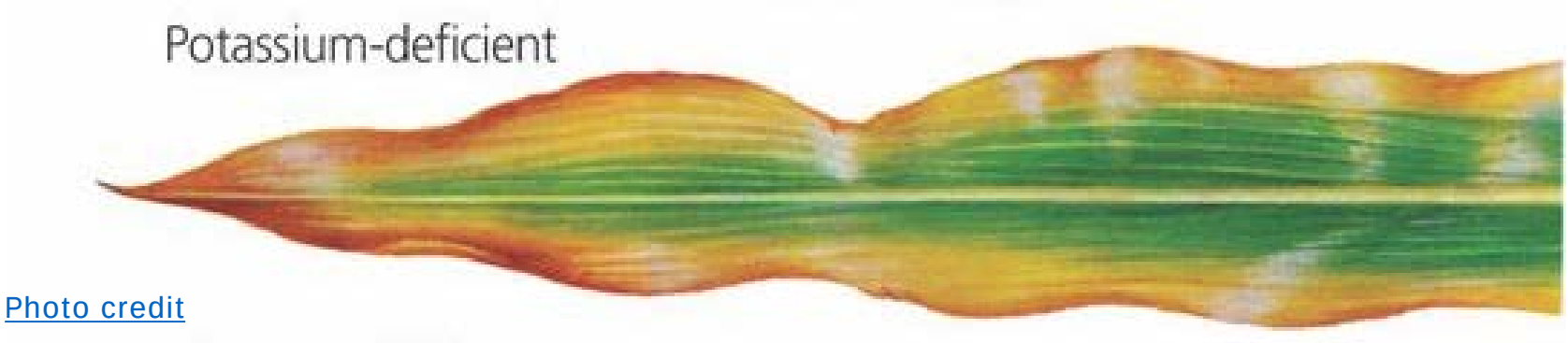

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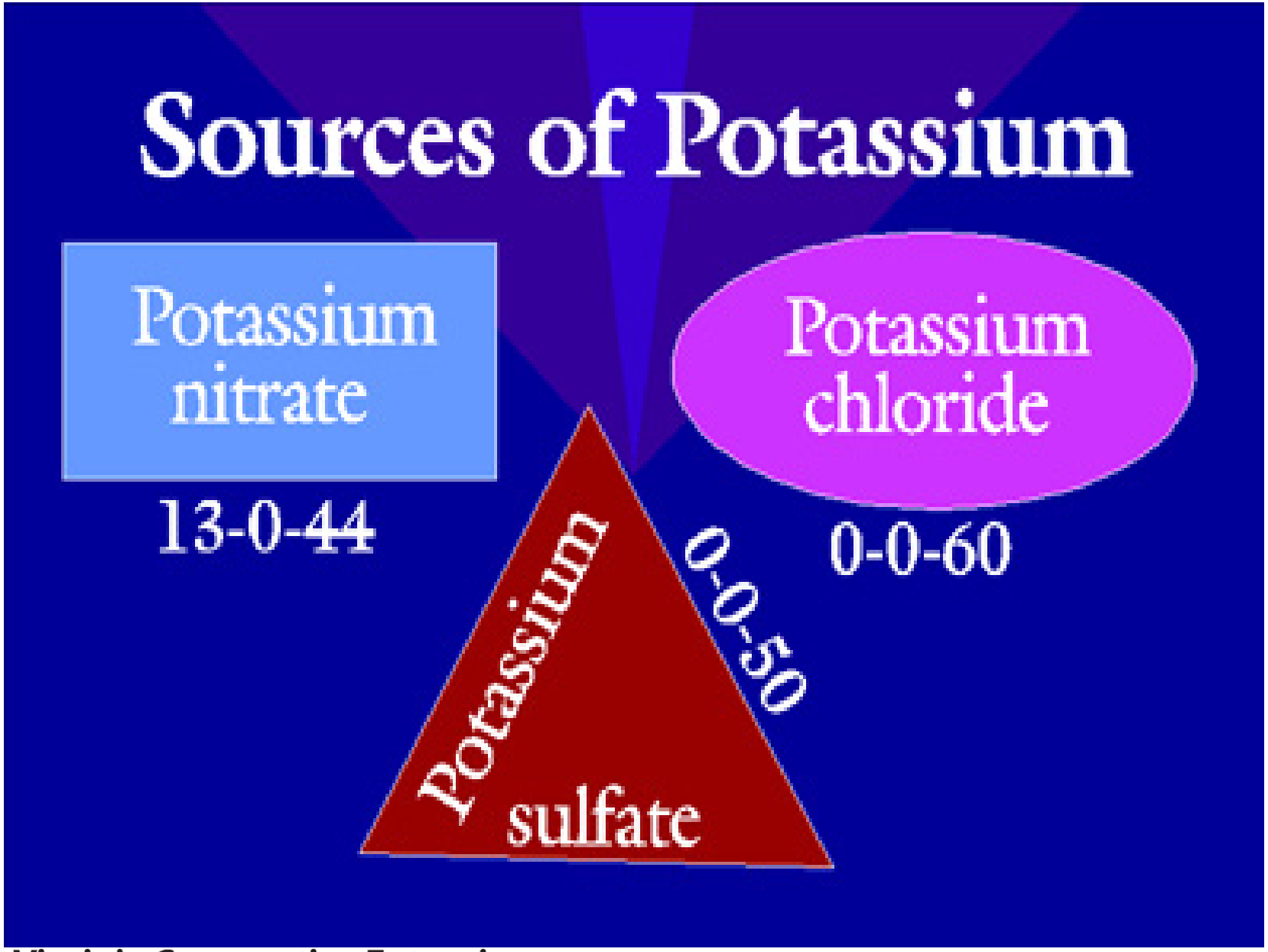

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Calcium

- 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

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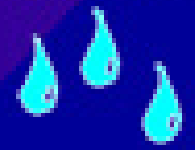
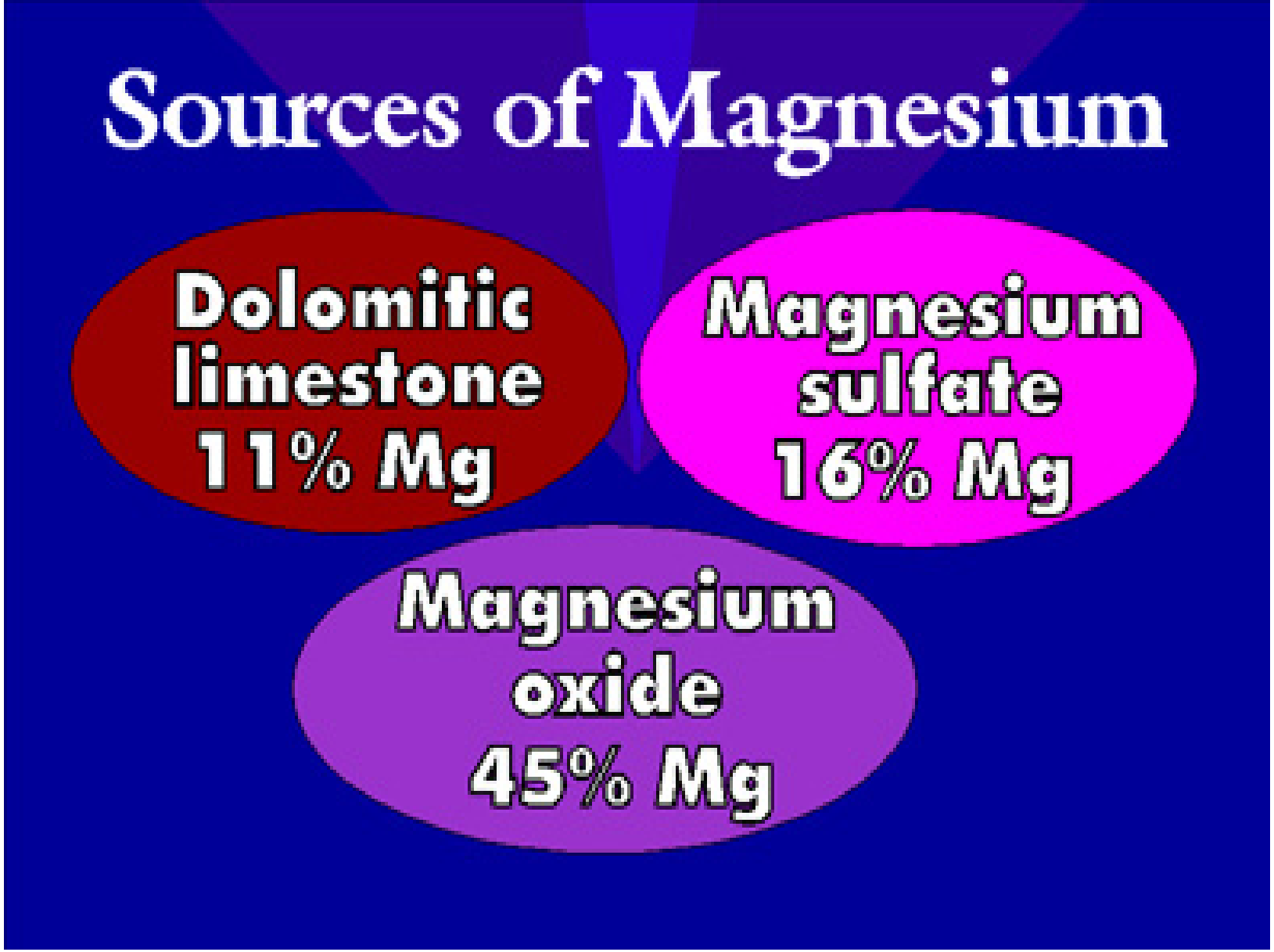
Sources of Calcium



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



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

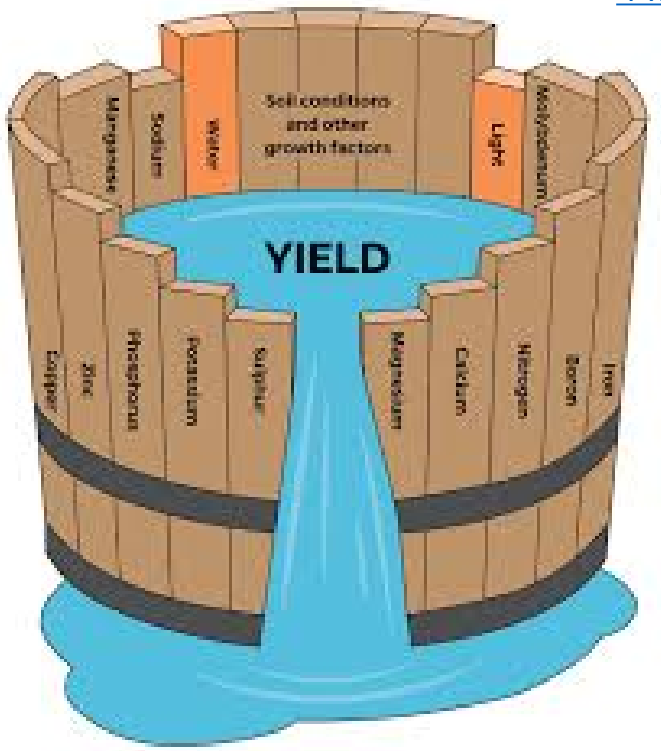
Micronutrients / Trace Elements

- 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

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

Photo credit



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

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Soil Testing

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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

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

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Sampling Equipment

Soil probes

- $48 to $93
- 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.

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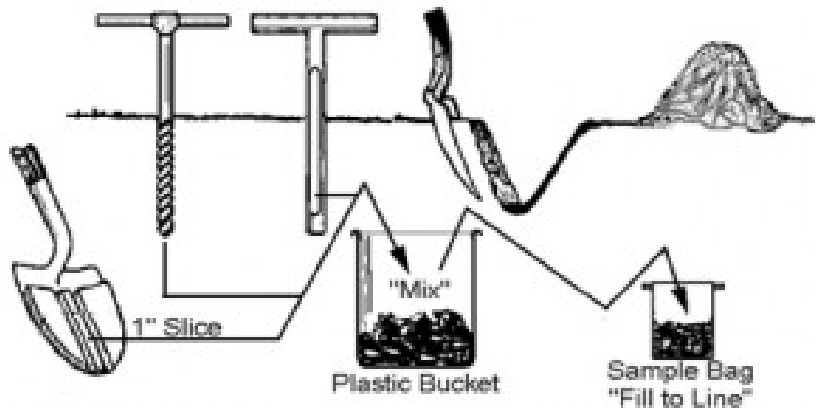

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Video: Taking Soil sample for testing

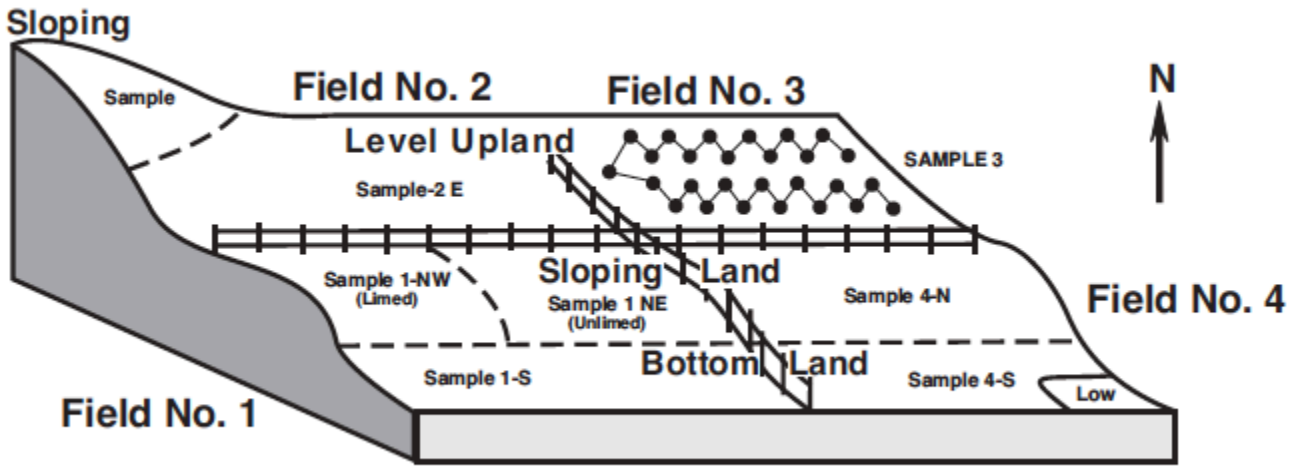

Photo credit

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

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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

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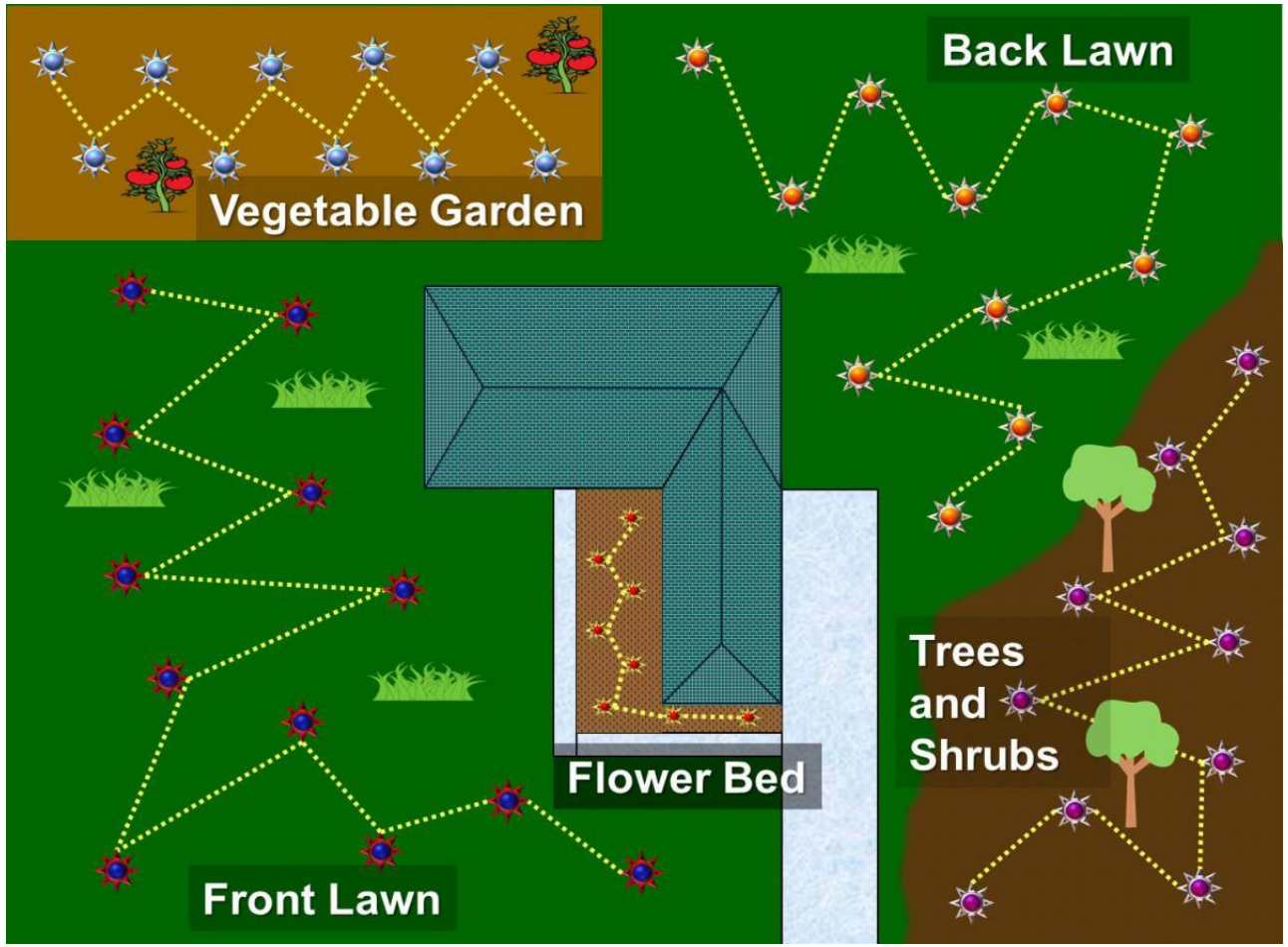

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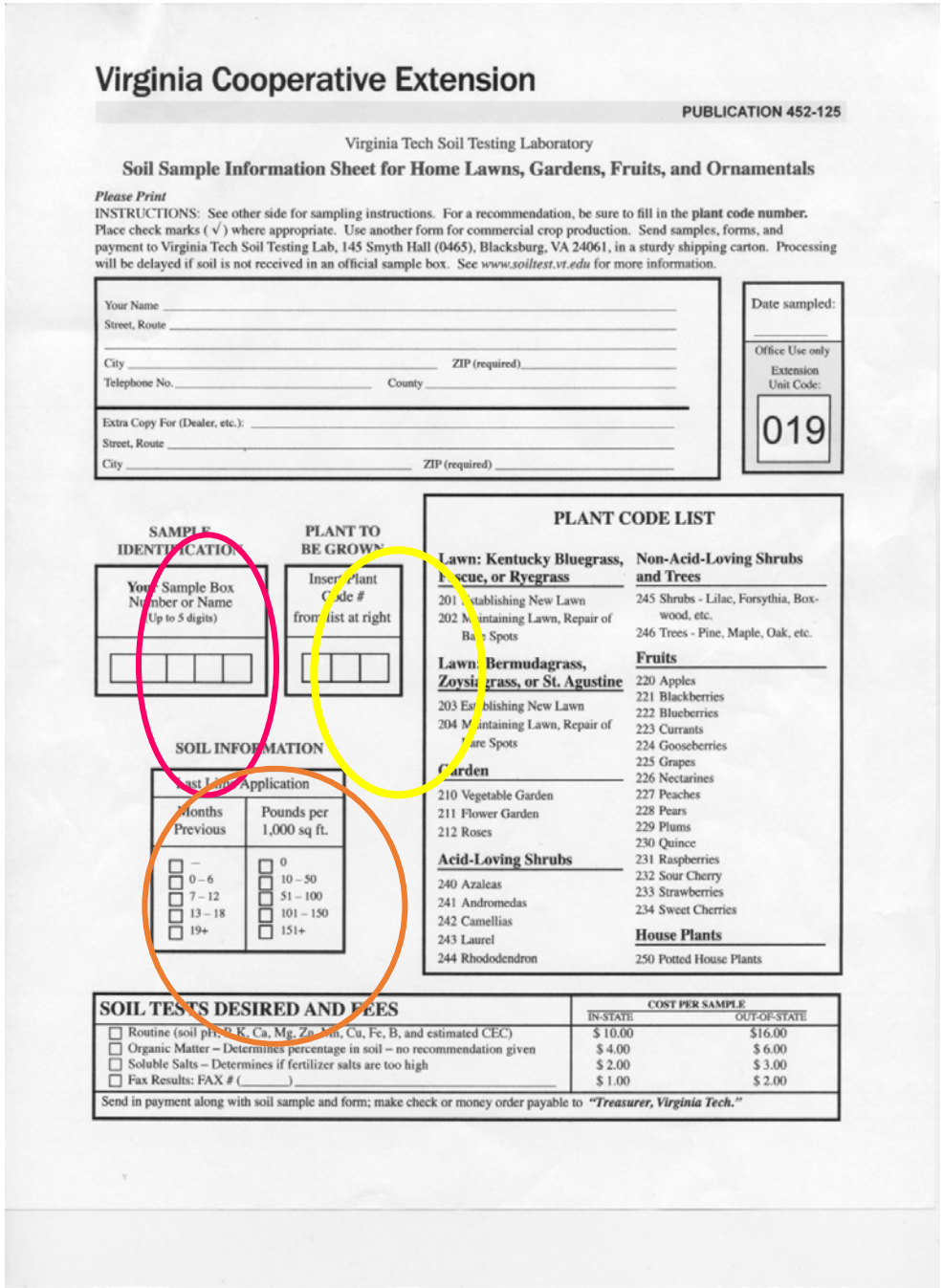
Soil Sampling for the Home Gardener

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* for more information.

Your Name _____

Street, Route _____

City _____ ZIP (required) _____

Telephone No. _____ County _____

Extra Copy For (Dealer, etc.): _____

Street, Route _____

City _____ ZIP (required) _____

Date sampled: _____

Office Use only

Extension Unit Code: 019

SAMPLE IDENTIFICATION

Your Sample Box Number or Name (Up to 5 digits)

PLANT TO BE GROWN

Insert Plant Code # from list at right

SOIL INFORMATION

Last Lime Application

Months Previous	Pounds per 1,000 sq ft.
☐ –	☐ 0
☐ 0 – 6	☐ 10 – 50
☐ 7 – 12	☐ 51 – 100
☐ 13 – 18	☐ 101 – 150
☐ 19+	☐ 151+

PLANT CODE LIST

Lawn: Kentucky Bluegrass, Fescue, or Ryegrass
201 Establishing New Lawn
202 Maintaining Lawn, Repair of Bare Spots

Lawn: Bermudagrass, Zoysiagrass, or St. Agustine
203 Establishing New Lawn
204 Maintaining Lawn, Repair of Bare Spots

Garden
210 Vegetable Garden
211 Flower Garden
212 Roses

Acid-Loving Shrubs
240 Azaleas
241 Andromedas
242 Camellias
243 Laurel
244 Rhododendron

Non-Acid-Loving Shrubs and Trees
245 Shrubs - Lilac, Forsythia, Boxwood, etc.
246 Trees - Pine, Maple, Oak, etc.

Fruits
220 Apples
221 Blackberries
222 Blueberries
223 Currants
224 Gooseberries
225 Grapes
226 Nectarines
227 Peaches
228 Pears
229 Plums
230 Quince
231 Raspberries
232 Sour Cherry
233 Strawberries
234 Sweet Cherries

House Plants
250 Potted House Plants

SOIL TESTS DESIRED AND FEES	COST PER SAMPLE IN-STATE	COST PER SAMPLE OUT-OF-STATE
☐ Routine (soil pH, P, K, Ca, Mg, Zn, Mn, Cu, Fe, B, and estimated CEC)	$ 10.00	$16.00
☐ Organic Matter – Determines percentage in soil – no recommendation given	$ 4.00	$ 6.00
☐ Soluble Salts – Determines if fertilizer salts are too high	$ 2.00	$ 3.00
☐ 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."***

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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

COPY FOR

Photo credit:
S. Baker,
Extension

SAMPLE HISTORY

Sample ID	Field ID	LAST CROP Name	LAST CROP Yield	LAST LIME APPLICATION Months Prev.	LAST LIME APPLICATION Tons/Acre	SOIL INFORMATION 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)	S.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.

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Photo credit

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

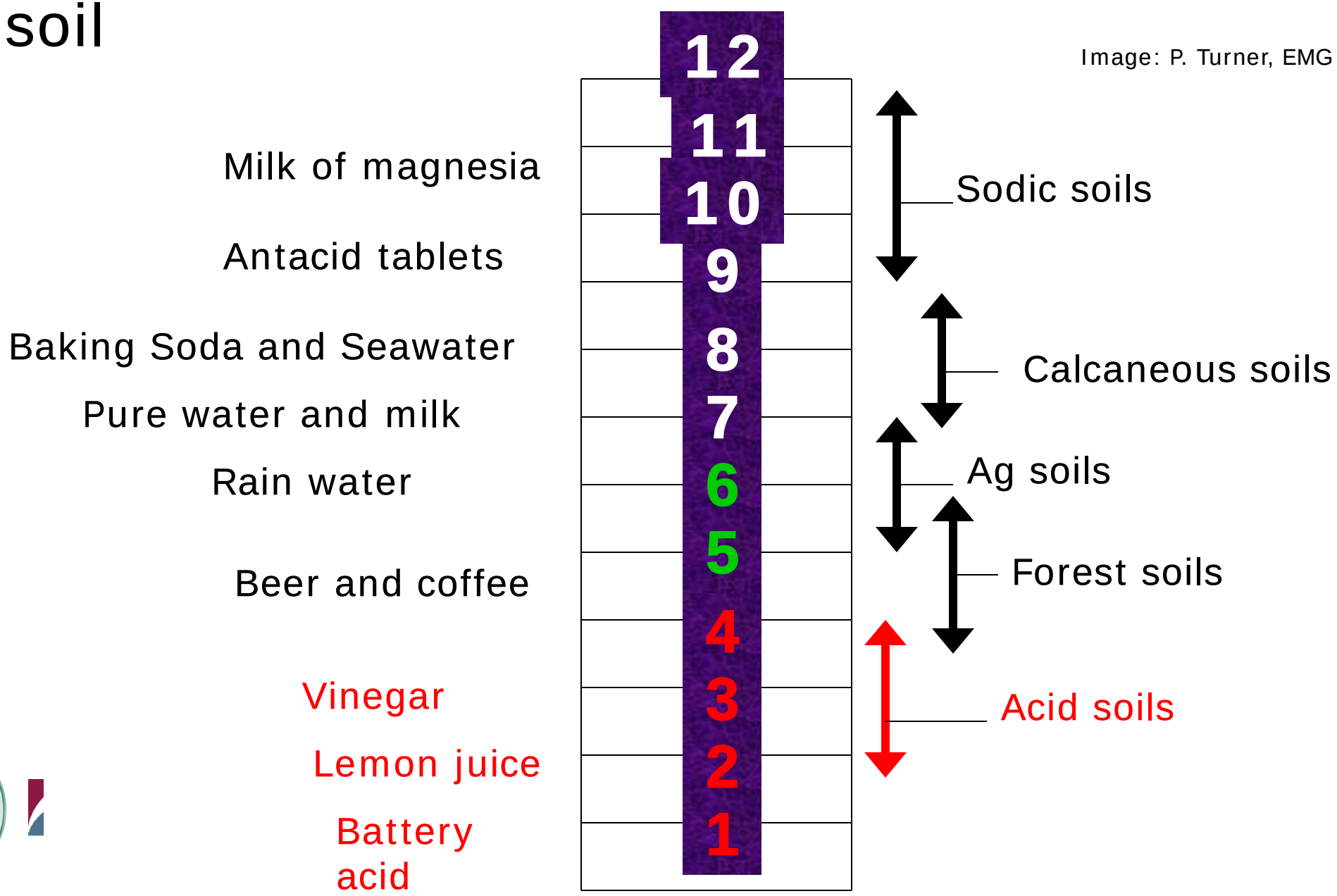


Image: P. Turner, EMG

pH

- Affects nutrient availability and use efficiency

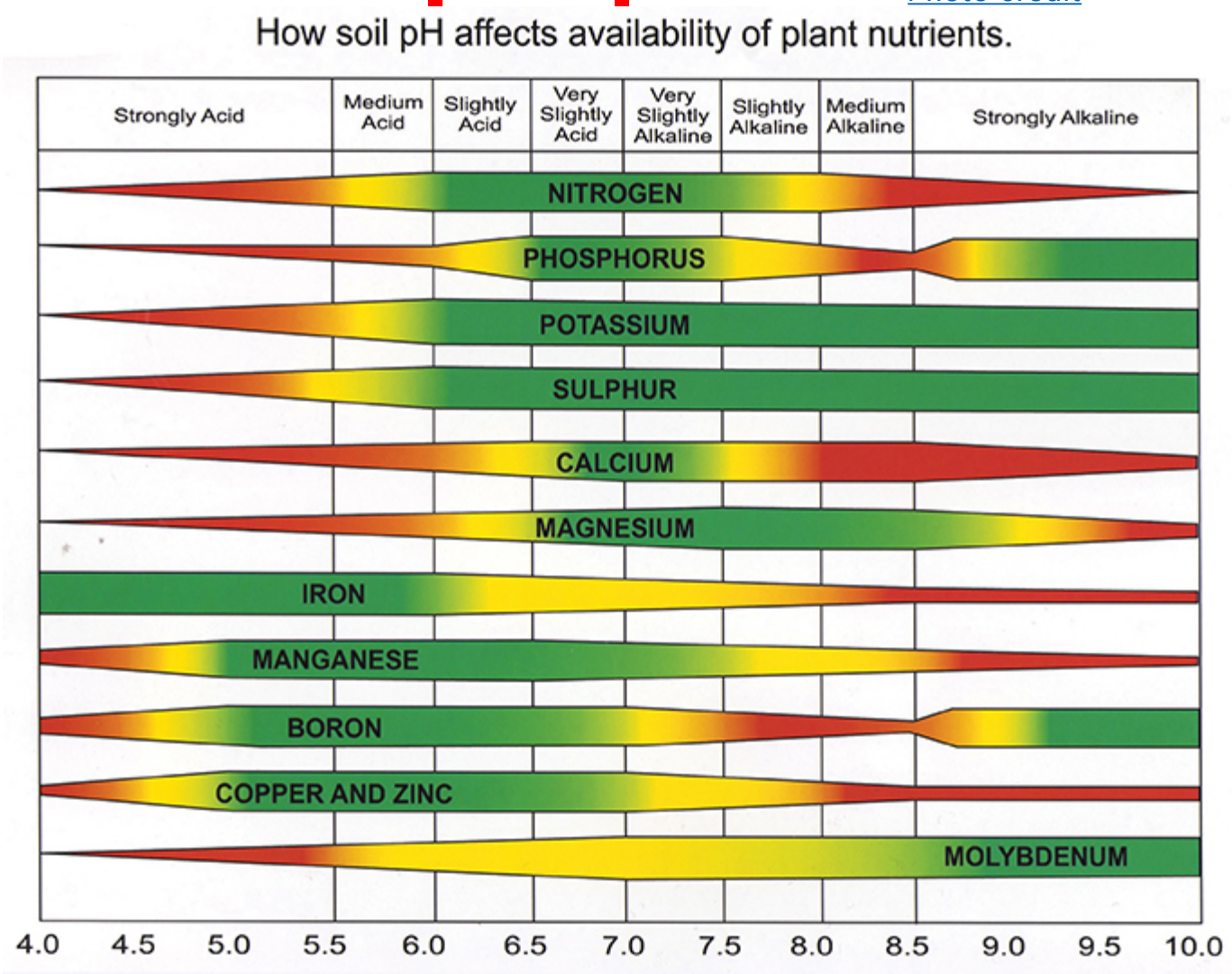
- Imbalance can cause
  - toxicity and stunt root growth (Al, Mn)
  - mineral deficiencies (Fe, Mo, Mn)
  - reduced N fixation in legumes

- 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

Photo credit



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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

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Soil Testing in Bedford – samples submitted to VT Soil Testing Lab 2019

- 100 samples for new lawn establishment
  - 43% had a pH less than 6.0
  - 43% had low phosphorus level

- 101 samples for lawn maintenance
  - 23% had a pH less than 6.0
  - 32% 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.

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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^2)
- Thirty percent (30%) of rock passes a 100 mesh (10,000 holes/in^2)

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

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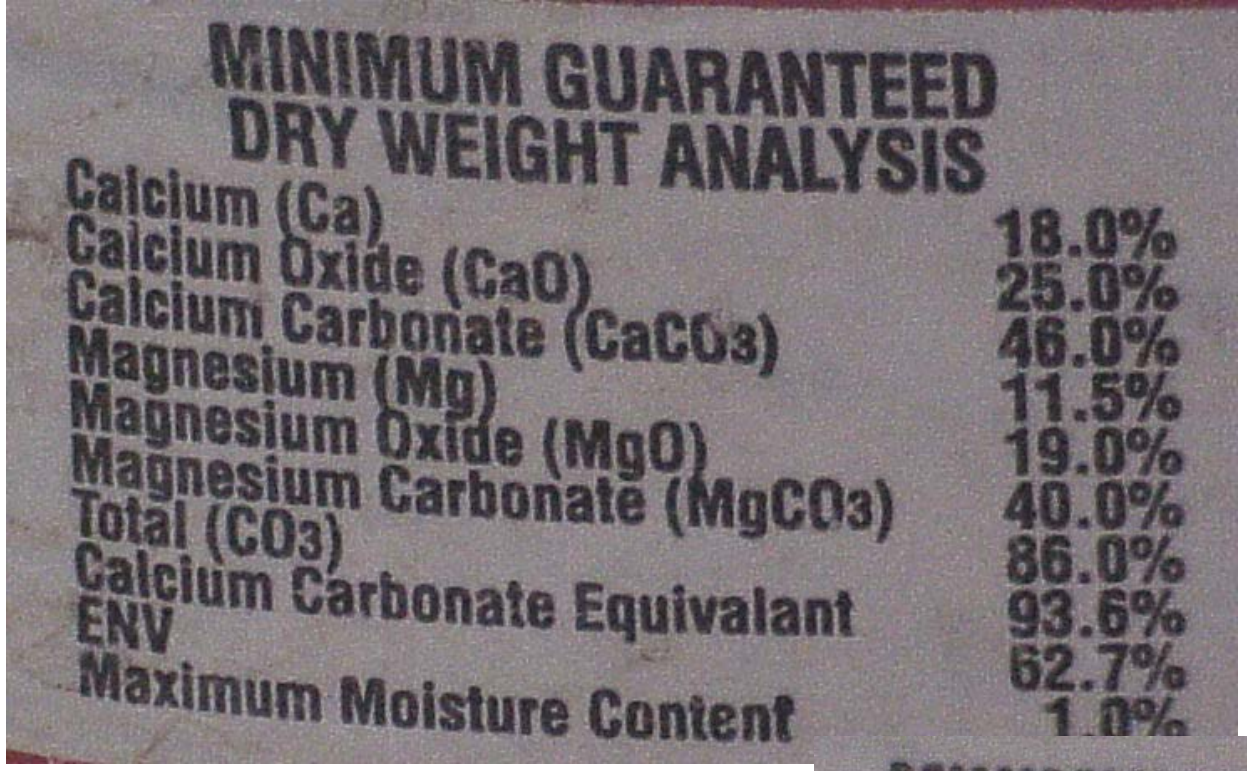
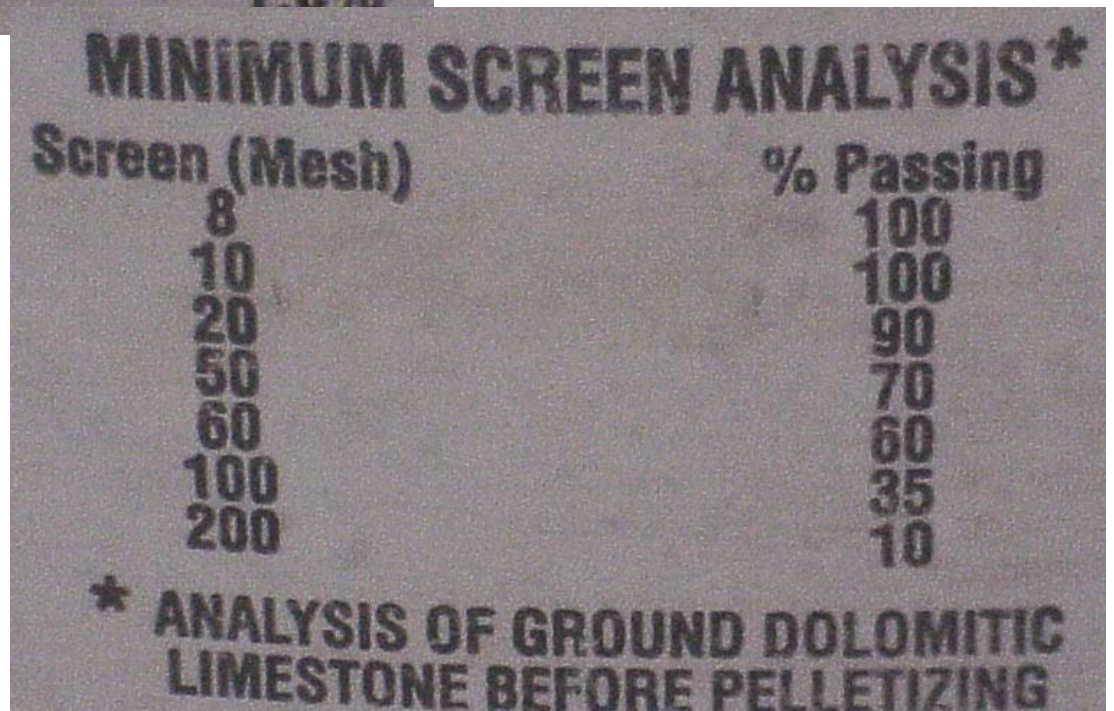
Typical Lime Product Label



MINIMUM GUARANTEED DRY WEIGHT ANALYSIS

Calcium (Ca)	18.0%
Calcium Oxide (CaO)	25.0%
Calcium Carbonate ($CaCO_3$)	46.0%
Magnesium (Mg)	11.5%
Magnesium Oxide (MgO)	19.0%
Magnesium Carbonate ($MgCO_3$)	40.0%
Total (CO_3)	86.0%
Calcium Carbonate Equivalant	93.6%
ENV	62.7%
Maximum Moisture Content	1.0%

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 ($CaCO_3$)
- CCE = 85-100%
- Very popular bagged lime

Dolomitic Lime

- Calcium ($CaCO_3$) and 15% Magnesium ($MgCO_3$) 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)2
- 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

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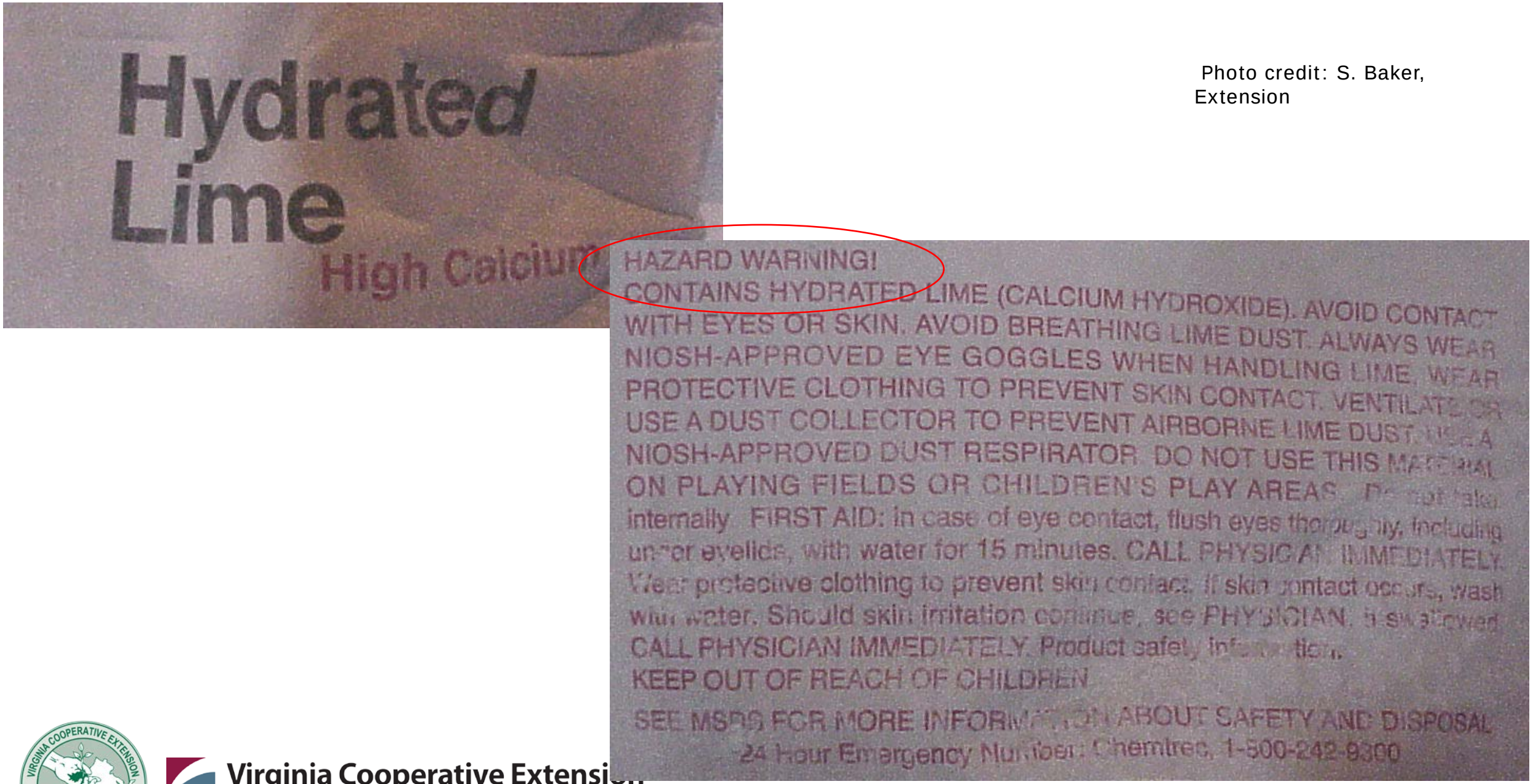

Photo credit: S. Baker, Extension

Recommendations

- Based on soil test
- No more than 50 lbs/ 1000 ft^2 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

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Fertilizers

The Fertilizer Bag

$$N - P_2O_5 - K_2O$$

% nitrogen % phosphorus % potassium

(by weight)

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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

<u>50 Pound Bag of Fertilizer</u>

- *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 (rate) / .05 (%N) = 20 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

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Conventional Fertilizers

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

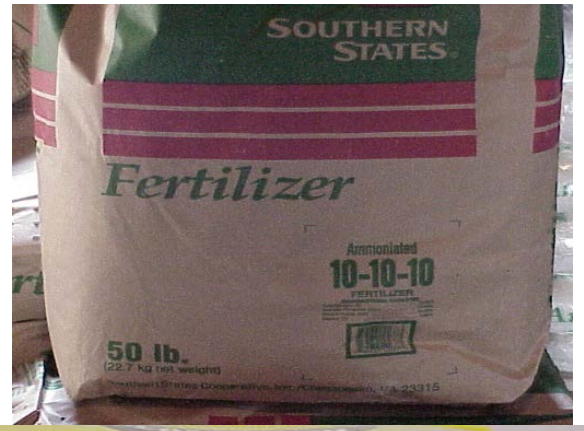

Photo credit: S. Baker, Extension

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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

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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, see:

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Calculating Fertilizer Rate

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

$$\frac{(1\#\ \text{N})}{(25\text{-}3\text{-}1\ \text{fertilizer is } 25\%\ \text{N})} = \frac{1}{25} \times 100 = 4\ \text{lbs of } 25\text{-}0\text{-}7 \text{ per } 1000\ \text{ft}^2$$

Video: Calculating Fertilizer Rate

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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)

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Soil Amendments

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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

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Organic Amendments

- Increase soil organic matter content
- Contain plant nutrients and act as organic fertilizers
- Important to the 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

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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 nonfood gardens
- Compost manure for at least 2 heating cycles (130° to 140°)

Decomposition Rate of Various Amendments

1. Grass clippings, manures
2. Composts
3. Wood chips, hardwood bark, peat

1. Rapid (days to weeks)
2. Moderate (about 6 months
3. Slow (possibly years)

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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^3
- 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
- Improve 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

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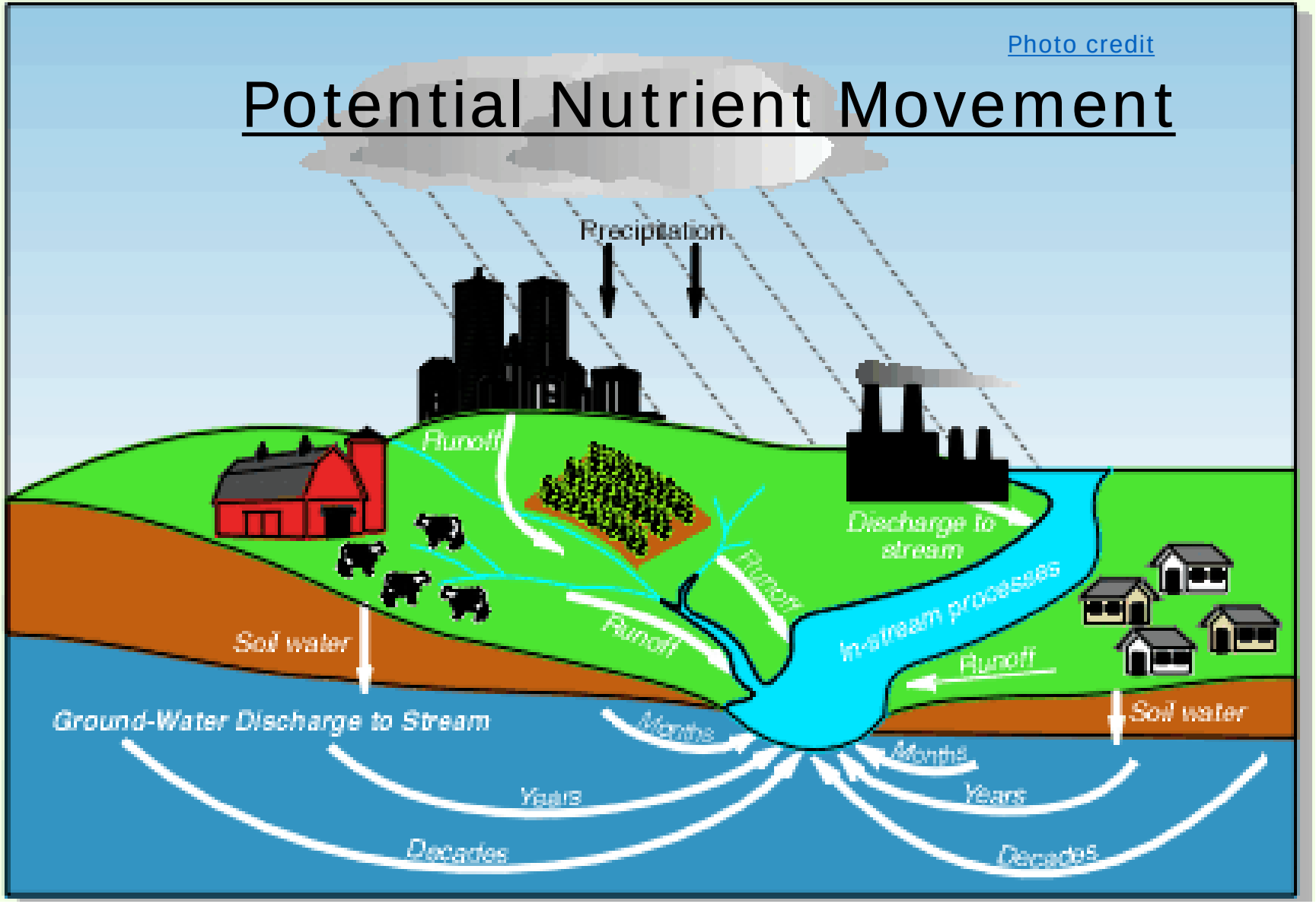
Photo credit

Potential Nutrient Movement



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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

Photo credit

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

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End of Slide Set

You can continue to next slide: ‘Suggested Readings’

OR

Click on the house below to return to the Navigation Page

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Suggested Readings

- Welcome to Web Soil Survey (2 pages)
- A Homeowners Guide to Fertilizer (2 pages)
- Fertilizing Landscape Trees and Shrubs (3 pages)

Mulching and Composting:

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

Test Your Knowledge

Improve the Soil

pH makes a difference

Apply What You Have Learned

Unscramble

Fertilizer Calculation

Test your Soil Knowledge

Help Desk Quiz

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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

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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

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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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Click to return to the test of knowledge page

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

Answer on next slide

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Click to return to the test of knowledge page

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.

Click to return to the test of knowledge page

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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 pounds

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Click to return to the test of knowledge page

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

Click to return to the test of knowledge page

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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)

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- AMPSUOTSI
- UNAMGEIMS
- OMCSPOT
- 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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1. C
2. H
3. G
4. A
5. J
6. I
7. D
8. C
9. E
10. B
11. F

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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 dry 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 this 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.

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SOILS QUIZ

1. Soil texture refers to: a. How it feels as a result of different sized particles b. How wet it is c. How soft it is
   d. How deep the top soil is
2. Clay soils have moderate to high nutrient holding capacity. a. True b. False
3. Sandy soils are the most fertile. a. True b. False
4. Rapidly drained soils lose nutrients and plants wilt sooner. a. True b. False
5. Depth of soil means;
   a. Distance from topsoil to bedrock b. Distance from topsoil to where it gets dry
   c. Distance from surface to layer that retards root penetration d. Distance from surface to parent materials
6. What is organic matter in the soil?
   a. Weathered rocks b. Plant and animal remains in various states of decomposition and the microorganisms
   c. Anything besides rocks d. All the nutrients
7. Increasing organic matter by 1-3% reduces erosion by:
   a. 1-3% b. 10% c. 15-20% d. 20-30%
8. Which material has a higher carbon to nitrogen ratio and can therefore deplete available nitrogen?
   a. Grass clippings b. Leaves c. Straw d. Sawdust
9. pH of soil measures the:
   a. Possible hydration level b. acid-forming activity of soil c. Amount of fertilizer d. Amount of minerals in soil
10. What is a complete fertilizer?
    a. One that contains all three of the macronutrients b. One that contains all the nutrients a plant needs
    c. One that contains carbon, nitrogen and urea d. One that contains macro and micro nutrients
11. Which number in a 5-10-15 fertilizer represents the proportion of nitrogen?

    a. 5 b. 10 c. 15