Growing Healthy Soil

2018
Extension Gardener
Short Course
Class 2

Today's Class

Growing Healthy Soil:

1. Soil physical properties: texture and structure
2. Improving physical & biological properties with organic matter
3. Soil chemistry: pH and nutrients
4. Soil testing

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Healthy soil is the foundation of healthy plant growth

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What do healthy soils provide plants?

- **Water & Nutrients**
- Want right amount and constant supply of both
- **How do plants get water and nutrients from soils?**

Soil controls **fate** of water and nutrients

ROOTS!

What do healthy soils provide plants?

- **Water and Nutrients**
- **Air!** Roots have to have it!
  - Soils that are easy to dig have plenty of air
- **Microbes**
  - Beneficial microbes help roots absorb nutrients and suppress soil diseases
  - Microbes need water, nutrients and air

What do healthy soils provide plants?

Space/Depth

- Roots need space to grow both deep and wide
- Roots grow where there is air, water and nutrients
- Want these to extend deep into the soil profile – ideally:
  - At least 8" for turf, annuals and vegetables
  - At least 2' for shrubs and small trees
  - 3' or more for large trees

Top growth directly proportional to root growth!

Soil Physical Properties

Improve before you plant!

- Particles
- Color
- Texture
- Structure
- Pores
- Compaction
- Depth

You can't fix it with fertilizer!!!

Soil Particles

Sand

- Feels gritty, largest particle size
- Cannot hold nutrients

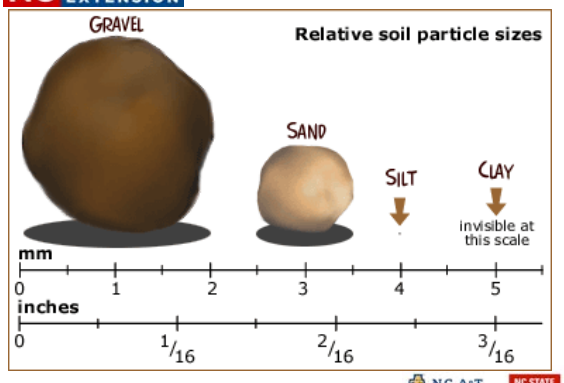
Silt

- Feels floury, medium particle size
- Pure silt rare

Clay

- Feels smooth, can mold, "ribbons"
- Smallest particle size, holds nutrients well

Clay soils "ribbon" when mashed



Soil Color

Red-orange

- Due to Iron oxidation
- Indicates good internal drainage

Pale yellow, light gray

- Poorly drained

Darker colors, brown/gray hues

- Organic matter darkens soils
- **Humus** – what's left when O.M. completely decomposed

Top = rust
Bottom = humus

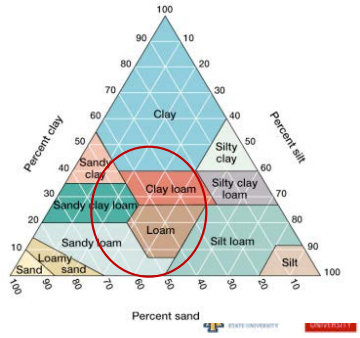
Mottled Soil

Mottled grey and orange or yellow results from <u>seasonally high water table</u>

Orange due to oxidized iron (rust) – Iron cannot oxidize if low oxygen

Soil Texture

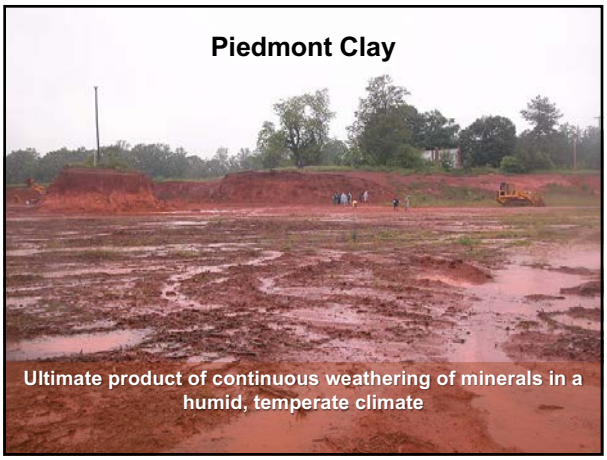
- **Relative amounts** of sand, silt and clay in soil
- Mixture of 2 or more = **loam**
- **Unrealistic** to change soil texture



Implications of Texture

- Water infiltration
- Water holding capacity
- Drainage
- Aeration
- Workability

Piedmont Clay



Ultimate product of continuous weathering of minerals in a humid, temperate climate

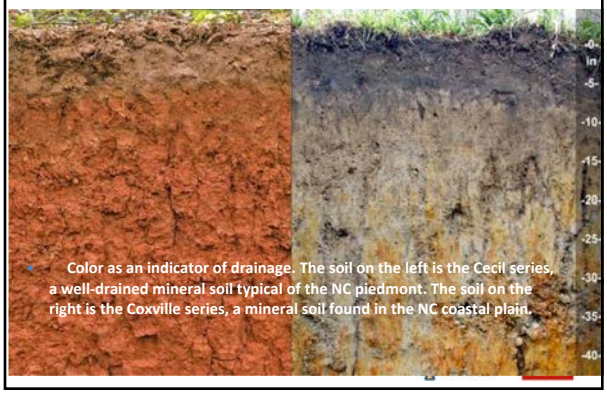
Never work/dig wet clay!

TOO WET!

Smearing/Glazing

Coastal Plain Soils

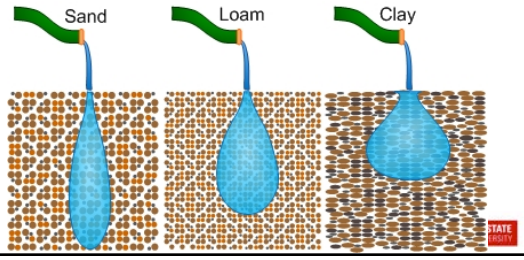
Coastal Plain Soils



- Color as an indicator of drainage. The soil on the left is the Cecil series, a well-drained mineral soil typical of the NC piedmont. The soil on the right is the Coxville series, a mineral soil found in the NC coastal plain.

Drainage

- **Infiltration** = surface drainage into the soil
- **Percolation** = internal drainage through the soil profile



Where is water coming from?
If excess, can it be re-directed?

Measuring Drainage

- Dig 12" hole
- Fill with water
- Measure how long takes water to drain away
  - Less than an hour = **excessive drainage**
  - Less than 12 hours = **good drainage**
  - Over 24 hours = **poor drainage**

Soil Depth

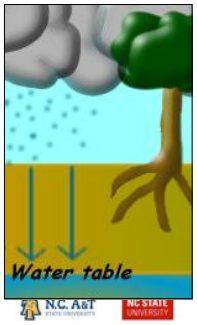
- Want good rooting environment to extend deep into soil profile
- Enables drainage and deep root growth
- **Healthy soils = 12"+ deep**
- **Common problems:**
  - Compaction
  - Rock
  - High water table
  - Low pH, low air content

Shallow Soils

- **Poor growth**
  - Due to shallow root systems – growth of plant above ground directly proportionate to size of root system
- **Uprooting in wind**
  - Trees with shallow root systems are much more likely to uproot in high winds
  - If soils less than 3' deep do not plant large maturing trees (over 30')

High Water Table

- Water table found within 12” of soil surface in some areas
  - Highest in late winter/spring
- **Roots cannot grow into saturated soil** (no air)
- If **seasonal high water table** (spring only), roots grow deeper in summer and fall and are killed back each winter/spring



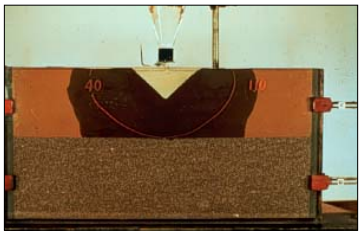
Assessing Soil Depth

Dig a hole!

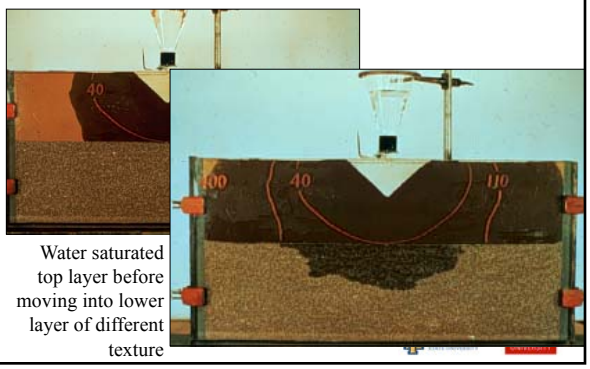
- Dig until you reach water, rock, compacted layer, or get tired!

Perched Water Table

- Occurs when soil layers of two different textures meet
- Water will not freely move from one texture to another until first layer becomes saturated



Perched Water Table



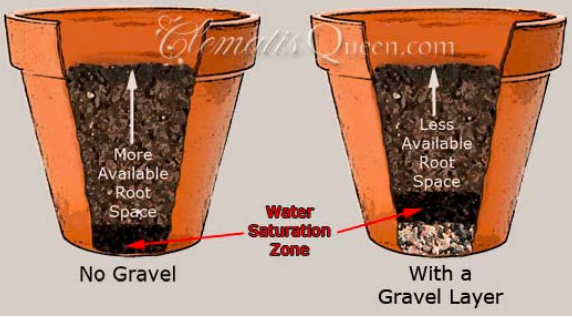
Water saturated top layer before moving into lower layer of different texture

Make Your Bed!

- When amending soils, amend at least 10 sq. ft. area rather than planting hole
- NEVER layer soils!

Amend whole bed, not just planting hole!

Adding gravel to containers does not increase drainage!



Source: https://secure.clematisqueen.com/content/do-not-add-gravel-your-containers

Depth

- **Cultivate deep**
  - Into clay
  - Mix in aged organic matter/compost
- **Build up**
  - Above existing soil level
  - Ideally at least 12", deeper for trees
  - Raised beds or berms
  - Fill with soil/compost mix
  - Don't plant large maturing trees (over 30') in shallow soils

Raised Beds

Trex – recycled plastic $$

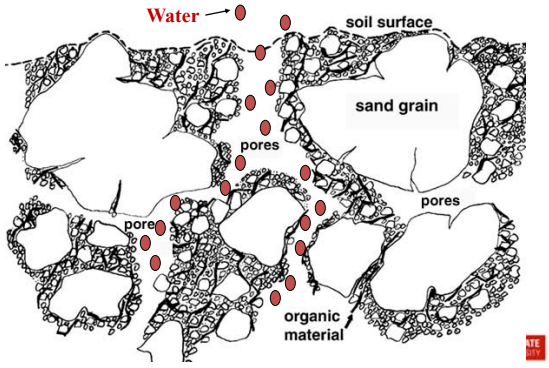
Treated or untreated boards

Concrete blocks

Soil Structure

- Grouping of individual particles into clumps, aka **aggregates**
- Creates **pores**
- Allows **water** to move through soil and provides space for **air**

Soil Pores

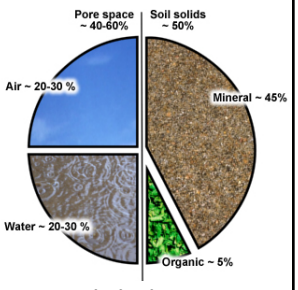


Large Pores

- Hold air
- Let water into soil, allow drainage

Small Pores

- Hold water
- Water available to plants



Ideal Volume:
20-30% large pores
20-30% small pores

Compare

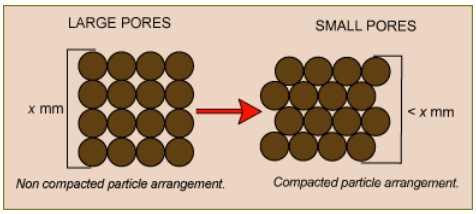
- Heavy
- Dense – less air
- Slowly absorbs water
- Holds water

- Light
- More air space
- Readily absorbs water
- Drains water

Compare

Which is your soil more like?

The Problem with Clay: Compaction



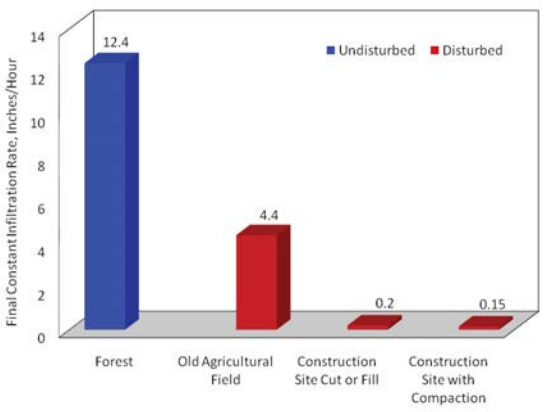
- Tiny particles – easily compacted
- All small particles – hold water
- Lack of large particles – low infiltration, drainage impeded

Compaction

- If it is difficult for you to dig, it is difficult for roots to grow!
- **Causes:** heavy equipment, constant foot traffic
- Compaction causes **poor surface drainage** – encourages growth of **moss**, as do shade and acid soil

Moss is a symptom of compaction

Every yard was a construction site at some point in the past!



Compaction Symptoms: Lichen

Surface Rooting

Roots grow where there is air, water and nutrients!

Root Rot, Poor Growth

Turf fails to establish, low vigor

Leyland cypress that died from drowning

Turning a Brick into a Sponge

- Unrealistic to change texture = **never add sand!!!**
- Want to **improve structure**
- **Organic matter** binds soil particles into aggregates = improves structure

A pickaxe is NOT a planting tool!

Factors Affecting Structure

- Wetting and drying
- Freezing and thawing
- Physical activity of roots
- Animals
- Soil tillage
- **Decaying organic matter**

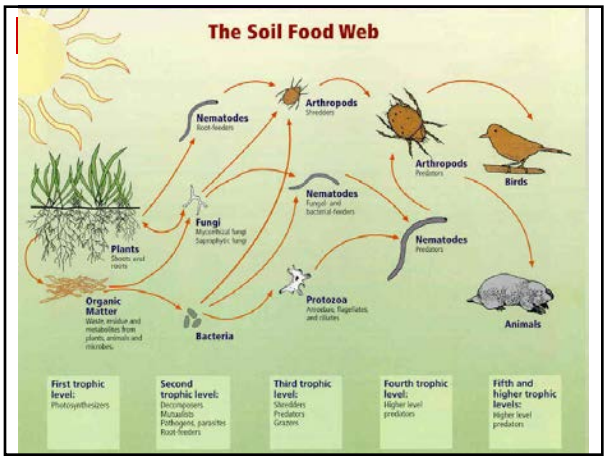
Earthworms improve soil structure over time

Organic Matter

- Improves number and distribution of large and small pores
  - Increases infiltration
  - Improves drainage
  - Increases water holding capacity = one of best defenses against drought!
- Also increases nutrient holding capacity, adds nutrients and supports beneficial microbes!

Increase Good Microbes

- **Microscopic organisms**
  - bacteria, fungi, nematodes
  - Help plants grow better
  - Suppress diseases
- **Thrive where plants thrive, in soils that are**
  - Consistently moist, not too wet
  - Rich in nutrients with moderate pH
  - Have lots of **organic matter**



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Organic Matter & Compost

- **Available to buy**
  - In bulk from mulch dealers In bags from garden centers
- No need to seek out special types (eg. Mushroom compost)

Compost is available from most places that sell mulch.

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Organic Matter

- ✓**Ground pine bark** – sold as pine or pine bark soil conditioner
- ✓ **Rotted leaves** (leaf mold) – pile them up and let them rot 2-3 years
- ✓ **Aged manure** – at least 6 months
- **X Peat moss** – only holds water, no nutrients, only recommended for extremely sandy soils

Don't waste your money! Will not fix your problems

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Compost: Make Your Own

- A great way to recycle yard debris and vegetable scraps!
- **Two methods:**
  - **Active** = turn regularly (at least 1/week), ready in 2-3 months
  - **Passive** = pile up and let nature do the work, ready in 2-3 years

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Composting

- **YES:** Vegetable scraps, fruit peels, eggshells, lawn clippings, yard debris, leaves, straw, manure
- **NO:** meat/scraps, pet waste, perennial weeds/weed seed, diseased plants
- **Finished product is typically 1/3 original volume!**

Some wood ashes okay but too much raises pH – sprinkle thin layers

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Composting

Bins are helpful but not required!

Incorporate!

- Organic matter breaks down quickly in warm, humid climates
- **Till into soil each year**
  - 2”-3” layer, mix in 6”-8” deep
  - **NOT** sand, peat moss, vermiculite or potting soil!
  - **Gypsum/Landplaster**, aka “Clay Buster” does not help!

What about Topsoil?

- **The soil on top -** No standards
- Often contains weed seed and roots – screening can remove some of these
- May contain disease spores, insects, chemical residues
- A couple of inches of topsoil does not provide adequate rooting depth!
- Creates perched water table
- **Not the answer to soil problems!**

Grow Your Own Compost!

Cover Crops
- Are mown or sprayed when mature and left on soil surface

Green Manures
- Are turned into the soil

Both are seeded directly into open garden spaces

Seeding Cover Crops

- Till soil and rake level
- Scatter seed thickly over soil surface
- Rake in lightly
- Water

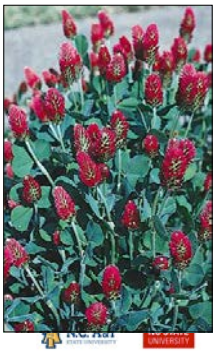
Cover Crops

- **Warm season cover crops:**
  - Sow mid-April – early Aug.
  - Cowpeas, soybeans, crowder peas = legume - add nitrogen
  - **Buckwheat** = very quick, turn under in 30-45 days
- **Cool season cover crops:**
  - Sow Sept – Oct or Feb-March
  - **Hairy vetch, crimson clover** = legumes - add nitrogen
  - Rye, wheat often mixed in

Crimson clover (top)
Buckwheat (bottom):

Cover Crops and Green Manures

- Till in, mow, or spray a week or two after flowering begins
- If leave too long, will set seed
- When mowing – resprouting can be a problem
- Can spray with glyphosate to kill and plant directly into to crop debris 1 week later (no till)



Another Option

- Spread 2-10" layer of organic matter over top
- Wait 6 months to 1 year
- Till under
- ALSO: Maintain 3" mulch layer around plantings

Mulch improves soil over time (years)

Amendments vs. Mulch

- **Soil amendments-** composted, suitable for incorporation
  - May also be surface applied (top-dress)
- **Mulch-** not decomposed; suitable for surface application only
  - If you can tell what it was, it's not ready to till in

Too course to incorporate!

Vertical Mulching

- Only way to alleviate compaction around established trees and shrubs
- Very labor intensive but effective
- Drill 3"-4" wide holes, 18"-2' deep throughout the root zone (ideally at least every 2')
- Fill with 50/50 mix of pea gravel and compost – can also add slow release fertilizer

Soil Auger

Plant Selection

- Some soils will always stay moist, plant moisture tolerant plants:
  - River Birch
  - Bald Cypress
  - Willow Oak
  - Clethra
  - Hardy hibiscus
  - Joe Pye Weed

Siberian Iris, Virginia Sweetspire and Seashore Mallow all thrive in heavy to wet soils

Soil Chemical Properties

- Soil pH
- Soil nutrient levels
- Fertilizers
- Soil testing

Address these issues AFTER soil physical properties are improved!

Why do the forests thrive without fertilization?

Forests

- Adapted species
- Density matches the carrying capacity of the land
- Nutrients are recycled – leaves fall and rot
- Soils are not compacted – amazing microbe activity!

For every live plant, how many plants didn't make it?

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Soil pH

- Measure of how acidic or alkaline (basic) soil is
- Most NC soils typically acidic, > 5.3
- **5.5 – 6.5** ideal for most plants (and microbes!)
- Logarithmic scale

Hydrangeas flower pink in basic soils

And blue in acidic soils

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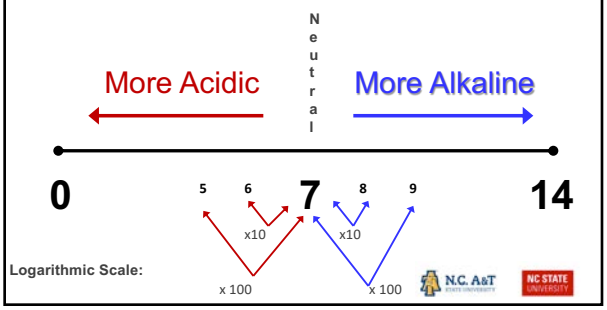
pH



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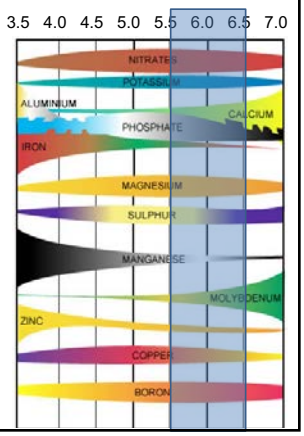
How pH affects nutrient availability

- Width of horizontal bars represent how available nutrient is at different pH levels
- 5.5 to 6.5 ideal for most plants
- Piedmont soils typically 5.0 or lower



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Acid Lovers:

Prefer 5.0-5.5

- Azaleas
- Dogwood
- Magnolia
- Gardenia
- American Holly
- Blueberries
- Loropetalum
- Virginia Sweetspire
- Centipedegrass

Yellowing between the veins on new growth is a common symptom of high pH (iron deficiency)

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Low Soil pH

- pH below 5.0 too low for most plants, except blueberries!
- **Submitting samples to soil test lab most accurate way to determine pH**
- **Raise pH with lime** – based on soil test recommendation
- Wood ashes – have 1/3 liming potential

Blueberries thrive in very acidic soils, pH 4.0-5.5

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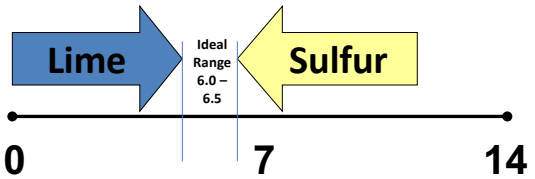
Changing Soil pH

Must soil test to know how much too add



Lime increases pH
Lime Lifts!

Sulfur lowers pH
Sulfur Suppresses!

Raising pH

- **Raise with lime based on soil test results**
  - Dolomitic lime also supplies magnesium
  - Target range 5.5 – 6.5 for most plants, especially vegetables
- Must mix into the soil, **takes 6 months** to completely react
- If must surface apply (lawns), do not apply more than 50 lbs. per 1000 sq. ft. at a time – fall/winter best time to apply

Only apply fast acting lime in areas where plant are not growing

Nutrients and Fertilizers

Is Fertilizer Plant Food?

– **No!** – plants make their own food by photosynthesis

What is fertilizer?

– Concentrated source of the nutrients plants need to produce their own food

Carnivorous plants have found an alternate nutrient source: Insects!

How do plants take up the nutrients they need?

ROOTS!

How Do Roots Absorb the Nutrients in Fertilizers?

- Can roots ingest fertilizer pellets?
- **No** – nutrients must be dissolved in water
- Fertilizers need water to work
  - This is why liquid fertilizers work so fast!
- During drought plants cannot take up nutrients

Must have healthy root system to take up nutrients

Low Nutrients

- NC soils typically lack required nutrient levels
- **Compost** adds some nutrients but not enough
- **Supplement with fertilizers** based on soil test recommendations
- Organic and time release fertilizers provide nutrients over extended time

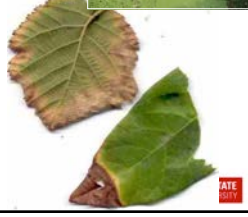
Yellowing and dropping of **lower leaves** is a common sign of nitrogen deficiency

Low Nutrients

- **Adjust pH first!!!**
- Soil test to determine which nutrients and how much is needed
- **When to apply:**
  - Lawns – after mid April
  - Vegetables – when growing
  - Ornamentals – spring
  - Containers – spring and mid-summer

Over Fertilization

- Burn plant roots and tissues
- Pollute ground and surface waters
- Increase insect and disease problems
- Overly lush plants require more water; more frequent pruning/mowing



Fertilizers: Nutrient Sources

Synthetic

- Manmade
- More predictable, higher analysis
- More likely to leach, burn

Natural

- Often low analysis, slow to release
- Condition the soil – feed microbes
- Expensive if only source of nutrients
- Do not release well in cold weather

Fertilizers

- **Time release fertilizers** (e.g. Osmocote) = slowly release nutrients over 2-6 months
- **Organic fertilizers** naturally slow release – nutrients not readily available in cold weather; feed microbes
- **Liquid fertilizers** (Miracle Grow, Compost tea) **= fast food**, quick boost but no sustained feeding

Fertilizers

- **10-10-10 and other granular fertilizers**
- Dissolve in water – excess leaches
- Apply only small amounts at a time, reapply as needed – easy to over do it!
- **Specialty fertilizers**
- **Fertilizer spikes** – not good! Need to spread fertilizer across root zone, not concentrate
- **Rose, Tomato, ect. Fertilizer** – just a marketing ploy

18-18-21

What the numbers mean:

Number on the bag represent % of:

N P K

Nitrogen – **New growth**

Phosphorus – **Roots, Flowers and Fruits**

Potassium/Potash – **Flavor and Hardiness**

For a 100 pound bag of fertilizer:

10 – 5 – 15

= 10 lbs. N + 5 lbs. P + 15 lbs. K + 70 lbs. filler

Nitrogen 10-5-15 N

- Promotes green, leafy growth
- **Most limiting nutrient**
  - Most common deficiency
- **Most forms easily leach from soil** - Pollute surface and groundwater
  - **Not enough?** Stunted growth, yellow leaves – older leaves first

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Nitrogen

- **Too much burns plants**
- **Too much increases pest problems**
  - Especially aphids, scale, and mealybug
- **Too much reduces vegetable yields**
  - Especially in beans, tomatoes, cucumbers, squash, peppers

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Phosphorous 10-5-15 P

- Promotes root growth, flower, fruit and seed production
- **Held tightly by soil – leaching rare**
- **Causes pollution when soil erodes,** P attached to soil particles
- **Needs to be incorporated**
- **Frequently fertilized** soils probably have too much

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Phosphorous

Not Enough?
- Reduced growth
- Plants dark green
- Purple or reddish color to older leaves

Not taken up as well in cold or wet soils
- Deficiency symptoms in winter usually due to cold weather rather than lack of nutrient in soil

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Potassium 10-5-15 K

- **Plant health tonic!**
  - Increases drought tolerance, disease resistance and improves winter hardiness
- **Improves flavor in melons and tomatoes**
- **Can leach**
- Sometimes called potash
- **Visible deficiency symptoms rarely seen** though levels often low

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Other Nutrients

- **Calcium, magnesium, sulfur** – occasionally need to supplement
  - » **Epsom Salts:** Magnesium sulfate
- **Micronutrients:** iron, manganese, copper, zinc, molybdenum, boron, chlorine, sodium – very rarely supplement

If pH is correct, these are rarely an issue

Blossom End Rot is caused by calcium deficiency due to low pH, or more commonly, uneven watering

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Miracle Grow All Purpose Plant Food

24-8-16
- Lots of N! Plenty of K!
- Quick release, **high analysis**
- Quick boost of growth
- No sustained feeding
- Easy to over feed

Natural alternatives: fish emulsion, compost tea

Espoma Plant-tone

5-3-3

- Low analysis, some of everything, general feeding
- Slow release – organic
- Sustained feeding, good for microbes
- Not a 'quick fix'
- 20 lbs./1000 sq. ft. = 1 lb. of nitrogen (60 cups)
- More expensive but worth it!

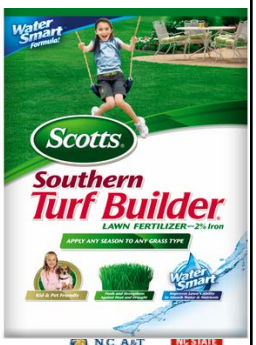
Osmocote Indoor/Outdoor 3-4 month release

14-14-14

- Balanced, time release
- Will release faster under warm moist conditions (summer!)
- Takes 2-3 weeks for nutrients to begin releasing
- More expensive but worth it

Scott's Southern Turf Builder

- **32-0-10**
- Lots of N – new growth, no P, some K
- Some of N in slow release form
- Sustained feeding but too much N!
- 3 lb. per 1000 sq.ft. = 6 cups



Soil Sampling

Why Soil Sample?

- **ONLY** accurate way of knowing what nutrients your soil needs
- Find out **pH** (how acidic or basic your soil is) and if changes need to be made
- **Do it yourself kits are extremely inaccurate!**

What Soil Sampling Can and Can Not Tell You

Can

- **Nutrients** your soil needs to support healthy growth
- **Soil pH**, if lime is needed or not
- If nutrient levels are **too high** (heavy metals)

Can Not

- **Why your plant died**, unless nutrient or salt related
- If **diseases** are present in the soil
- Does not directly tell you **how to amend** your soil

Soil Sampling in NC

- Send samples to NC Dept. of Agriculture Soil Testing Lab in Raleigh
- **No direct charge April – November**; peak season fee $4/box December-March
- Funded through fertilizer tax
- **Results posted online** – turnaround time depends on time of year

Soil Sampling

- Results are only as good as the sample!
- **Can be done anytime of the year**
  - Plan ahead: want to send samples off and get results BEFORE beginning project
  - Wait 6-8 weeks after applying fertilizer or lime
- Sample established areas every 2-4 years

How to Soil Sample

Start with clean equipment

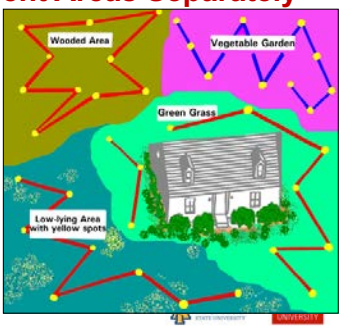
- Stainless steel soil probe, hand shovel, shovel
- Not brass, bronze or galvanized
- Clean plastic bucket

Decide where to sample

- Divide landscape into areas of unique use

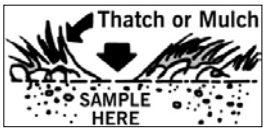
Areas of Unique Use:
Sample Different Areas Separately

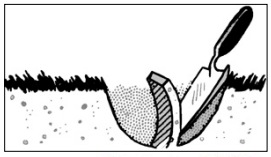
- Different plants/crops
- Changes in plant health
- Obvious changes in soil type (color, texture, topography)
- 5-10 random samples from each area



How to Take Soil Samples

- Avoid thatch or mulch
- Take a 'slice' of soil
- **Turf:** 4" deep
- **Landscape beds, vegetables**: 6" deep
- Mix subsamples together to make one composite sample for each unique area





Packaging Soil Samples

- Boxes and forms available from any Extension office
- **Fill box to 'fill' level**
- Soil can be moist but not so wet it dissolves the box!
- Do NOT put soil in plastic bag!
- Do NOT tape box shut

Soil Sample Forms

- Fill in contact information (ink)
- Make up sample ID #
  - Letters or numbers
  - Something you will remember (veg, flower, shrub, etc)
- Crop codes listed on back of sheet
  - Lawn and garden codes will give recommendations in lbs. per 1000 sq. ft.
- Access results online:
  - http://www.ncagr.gov/agronomi/pals/

Questions?

Contact Information:

- **Colby Griffin**
  - Franklin Horticulture Extension Agent
    - 919-496-3344
    - colby_griffin@ncsu.edu

Next Week: Growing Veggies & Herbs

- **Tuesday, March 13, 2018**

Learn the basics of of year-round vegetable gardening and appropriate planting times.