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

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

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

Healthy soil is the foundation of healthy plant growth

ROOTS!

Root health and plant growth is directly reliant on soil conditions

+ Healthy soil is the foundation of healthy plant growth +
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

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
Mottled Soil

Mottled grey and orange or yellow results from seasonally high water table. 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!

Coastal Plain Soils

Smearing/Glazing
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 Cawville 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’)

Common problems:

- **Compaction**
- **Rock**
- **High water table**
- **Low pH, low air content**
**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

**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!

**Perched Water Table**
- Water saturated top layer before moving into lower layer of different texture

**Adding gravel to containers does not increase drainage!**
- No Gravel
- With a Gravel Layer

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

**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

**Raised Beds**

- Trex – recycled plastic $$
- Treated or untreated boards
- Concrete blocks

**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
**Organic Matter & Compost**

- **Available to buy**
  - In bulk from mulch dealers
  - In bags from garden centers
- **No need to seek out special types** (e.g., 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
- **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/scrap, 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?
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

Hydrangeas

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

Acid Lovers:

Prefer 5.0-5.5
• Azaleas
• Dogwood
• Magnolia
• Gardenia
• American Holly
• Blueberries
• Loropetalum
• Virginia Sweetspire
• Centipedegrass

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

Changing Soil pH

Must soil test to know how much too add

Lime
Ideal Range 6.0 – 6.5
Lime lifts!

Sulfur
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

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!

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

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

• 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

- **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

What the numbers mean:

- **Number on the bag represent % of:**
  - **N** Nitrogen
    - New growth
  - **P** Phosphorus
    - Roots, Flowers and Fruits
  - **K** 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

- 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
**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

**Phosphorous 10-5-15**

- 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

**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

**Potassium 10-5-15**

- 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

**Potassium 18-18-21**

**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

**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:

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  - Franklin Horticulture Extension Agent
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Next Week:
Growing Veggies & Herbs

- Tuesday, March 13, 2018

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