A Healthy Soil-
The Basis of Gardening

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Something to think about…

- The quality of our lives depends on
  - the food we eat
  - the water we drink
  - and the air we breath.
- All of those things depend on the quality of the SOIL.

Charles Kome

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Outline

- Introduction
- Definition of a healthy soil
  - Soil physical properties
  - Soil biological properties
  - Soil chemical properties
- Managing soil the organic way
- Composting
- Soil Amendments
- Hands-On activities
  - Understanding the soil test report
  - Evaluation of soil texture
  - Evaluation of soil chemical attributes
  - Demonstration of soil amendments

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Introduction

- Importance of soils
  - Physical support
  - Air for root growth
  - Water
  - Temperature moderation
  - Protection from toxins
  - Nutrients

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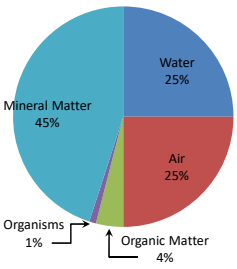
Soil Physical Properties

- Soil Composition
  - Mineral Matter
    - Sand, silt, and clay
    - Nutrients
  - Water
  - Air
  - Organic Matter
    - Residue from plants and animals
  - Soil Organisms



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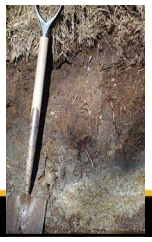
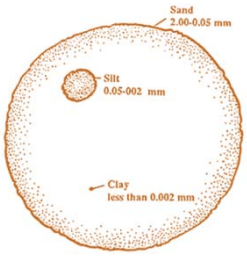
Soil Physical Properties

- Black: Rich in organic matter
- Gray: Poor drainage and aeration
- Red/Yellow: Weathered and well-drained



Soil Physical Properties



- Soil Texture
  - Refers to the percentages of sand, silt, and clay that comprise a soil
  - Determined mechanically or by hand
- Size Classes:
  - Clay: < 0.002 mm
  - Silt: 0.002 to 0.05 mm
  - Sand: 0.05 to 2.0 mm

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Soil Physical Properties

- Soil Texture affects:
  - Water drainage
  - Soil fertility
  - Nutrient leaching
  - Nutrient availability
  - Soil pH

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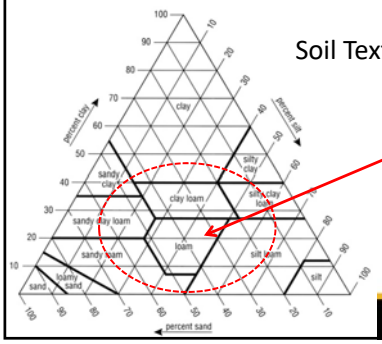
Soil Physical Properties



Soil Texture Triangle

Best type of garden soil

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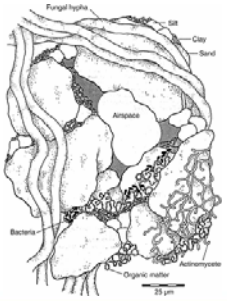
Soil Physical Properties

- Soil Structure
  - The way sand, silt, and clay particles are arranged together into aggregates or **peds**
  - Relationship between peds and pores
  - Importance of good soil structure:
    - Aeration
    - Water infiltration and availability
    - Water-holding capacity
    - Root penetration
    - Reduces erosion
    - Temperature buffer



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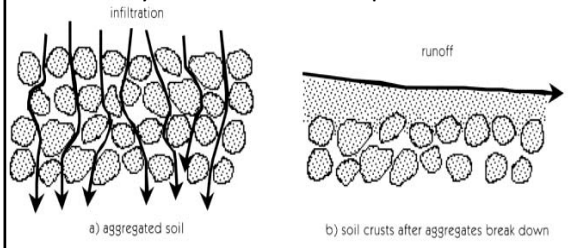
Soil Physical Properties

Why is soil structure important?



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Soil Physical Properties

- Pore Spaces
  - Vital for plants and soil microbes
  - Provides water and air
  - 50% pore space is goal

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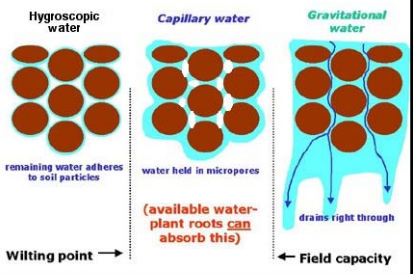
Soil Physical Properties

- **Soil Water terminology:**
  - ***Field Capacity***- Pores are saturated with water
  - ***Wilting Point***- Water in pore spaces is not available to plants



Soil Physical Properties

- It is easy to destroy soil structure
  - Rain drop impact
  - Excessive tillage
  - Excessive rainfall or heat
  - Compaction

Soil Physical Properties

- Can we improve soil structure?
  - Adding organic matter
  - Limit excessive tilling and "working" of soil
  - Using cover crops

Soil Physical Properties

- Organic Matter
  - Soil physical condition
  - Moisture holding capacity
  - Internal drainage
  - Aeration
  - Nutrient storehouse capability
  - Microorganism activity
  - Increases CEC
  - 2-5% OM good target (historical levels were 7-8% under prairie)

Soil Physical Properties

- Building soil organic matter
  - Direct additions of organic matter
  - Green manure crops
    - Crops that are grown and incorporated into the soil to improve soil fertility
    - Protection
    - Used for winter growth or in rotation
    - Nutrient (nitrogen) scavengers
    - Plow early in spring so it won't steal moisture or nutrients
    - Cover completely for decomposition

Soil Physical Properties

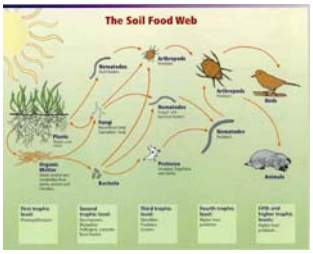
- Soil horizons and layers
  - O Horizons
    - Humus/Organic layer
  - A Horizon
    - Topmost mineral layer (topsoil)
    - Usually dark in color
    - Usually more coarse in texture
  - B Horizon
    - Below A horizon
    - Maximum accumulations of iron and aluminum oxides and silicate clays
  - C horizon
    - Unconsolidated material
    - More breakdown compared to bedrock
    - Bedrock
  - Claypans – dense clay layer
  - Fragipans – dense silt layer

Soil Physical Properties

- An ideal garden soil:
  - Medium texture and adequate organic matter for air and water movement
  - Sufficient clay to hold soil moisture reserves and nutrients
  - Deep, permeable subsoil with adequate fertility levels
  - Environment for roots to go deep for moisture and nutrients

Soil Biological Properties

The soil is alive!



- Decomposition requires a balance of:
  - Moisture
  - Oxygen (aeration)
  - Temperature (80-90°F)
  - pH (5.5 or more)
  - Nutrients
  - Carbon:Nitrogen Ratio (30:1)

Soil Biological Properties

In 1 teaspoon of a healthy garden soil there are…

❖ Bacteria	100 million to 1 billion
❖ Fungi	6-9 ft fungal strands put end to end
❖ Protozoa	Several thousand flagellates & amoeba One to several hundred ciliates
❖ Nematodes	10 to 20 bacterial feeders and a few fungal feeders
❖ Arthropods	Up to 100
❖ Earthworms	Several

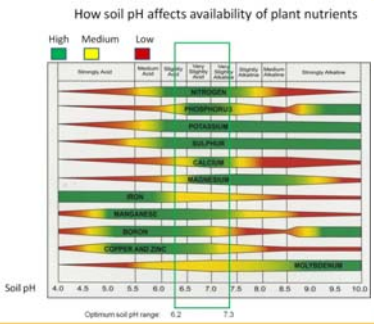
Travis and Cuming, PSU

Soil Chemical Properties

- Soil pH
- Addressing acidic soils
- Addressing basic soils
- Soil nutrients

Soil Chemical Properties

- Soil pH
  - pH scale = 0 to 14
    0=Strong Acid
    7= Neutral
    14= Strong Base
  - For best plant growth and nutrient availability:
    pH= 6.2 to 6.5



Soil Chemical Properties

- Causes of soil acidity
  - Hydrogen (H^+) is released as organic matter breaks down
  - Crop/Plant removal of basic cations (Ca and Mg)
  - Nitrogen fertilizer applications can form acids in soil
  - Rainfall
  - Parent material

Soil Chemical Properties

Liming for Efficient Fertilizer Use

Percent Nutrient Availability			
pH (salt)	Nitrogen %	Phosphorus %	Potassium %
4.0	30	23	33
4.5	53	34	52
5.0	77	48	77
5.5	89	52	100
6.5	100	100	100

Soil Chemical Properties

- Correcting acidity with lime
  - Limestone (Calcium Carbonate)
  - Effective Neutralizable Material (ENM) rates a liming substance's effectiveness
  - Smaller the particle size, the faster the action (higher ENM)
  - Till it into the soil in the fall or when convenient
  - No more than 50 lbs/1000 sq. ft at a time
  - Sources:
    - Calcium Carbonate (Ag Lime ~400 ENM)
    - Hydrated Lime (~600 to 800 ENM)
    - Dolomitic Lime (magnesium source)

Soil Chemical Properties

- Correcting alkalinity with sulfur
  - Blueberry, holly, azalea, rhododendron
  - Addition of acidifying material
  - Sources:
    - Elemental Sulfur- takes about 3 to 6 months to work (biological reaction)
    - Iron Sulfate- quick results (chemical reaction)
  - Acidifying materials need to be incorporated into soil
  - Beware of buffering capacity!

Soil Chemical Properties

16 Essential Elements for Plant Growth

- 3 Most Abundant
  - Carbon (C)
  - Hydrogen (H)
  - Oxygen (O)
- 6 Macronutrients
  - Nitrogen (N)
  - Phosphorus (P)
  - Potassium (K)
  - Calcium (Ca)
  - Magnesium (Mg)
  - Sulfur (S)
- 7 Micronutrients
  - Boron (B)
  - Chlorine (Cl)
  - Copper (Cu)
  - Iron (Fe)
  - Manganese (Mn)
  - Molybdenum (Mo)
  - Zinc (Zn)

Maintaining Soil Health

- A healthy soil:
  - has a stable soil surface
  - is increasing in SOC or is at the maximum level for the location
  - has a microbial population that efficiently decomposes organic residues
  - does not contain P, N, or other materials in sufficient quantities to cause water quality problems in the event of an unexpected erosional episode
  - is regenerative under its intended land use or management system

Maintaining Soil Health

- Manage more by disturbing less
- Diversity is Critical
- Feed your soil livestock all year long
- Keep the soil covered

Manage More by Disturbing Less

- Results of tillage:
  - Disturbance stimulates the first responders-increased weed population
  - Destroys soil pores by shearing and smashing - impacts infiltration and encourages erosion
  - Diminishes the soil's ability to respire
  - Disrupts the habitat of most microorganisms
  - Simplifies the soil fauna over time
    -fungi don't like disturbance
    -Mycorrhizal fungi – uptake of P, Zn, Cu, Fe

Manage More by Disturbing Less

- Results of chemical disturbances
  - If we want our natural mineral cycle to be healthy and functioning we have to understand how everything affects it, including the use of chemical fertilizers
  - Chemical fertilizers can nourish plants but certain fertilizers have a detrimental effect on certain soil microorganisms.
  - Some chemical fertilizers are actually acidifying the soil.

Managing More by Disturbing Less

"Every chemical-based pesticide, fumigant, herbicide and fertilizer tested, harms or outright kills some part of the beneficial life that exists in the soil, (or on the leaf surfaces) even when applied at rates recommended by their manufacturers... Less than half of the existing active ingredients used as pesticides have been tested for their effects on soil organisms."

Dr. E. Ingham, 2002, Soil Food Web, Oregon State University

Diversity is Critical

- What can you do in the garden?
  - Use cover crops
  - Rotate your garden crops
  - Interplant warm and cool season crops
  - Companion planting

Diversity is Critical

- Use mulches
  - Starts the biogeochemical mineral cycle
  - Feeds the microorganisms
  - Keeps the soil cool so plant roots remain alive and growing
  - Helps improve infiltration of water

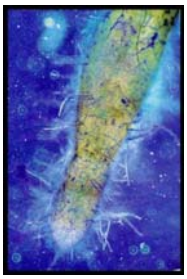
Feed Your Soil Livestock all Year Long

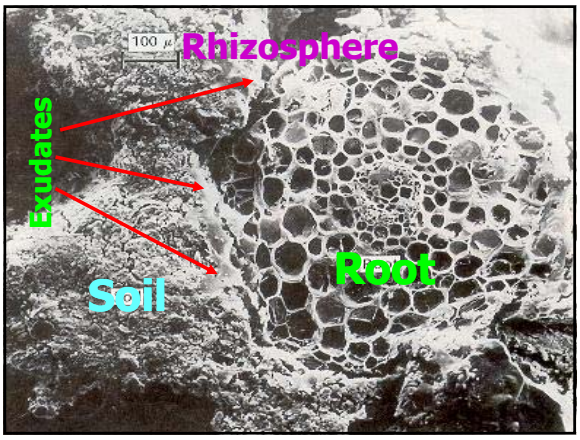
Type of Organism	number/acre	pounds/acre
Bacteria	800,000,000,000,000,000,000	2,600
Actinobacteria	20,000,000,000,000,000	1,300
Fungi	200,000,000,000,000	2,600
Algae	4,000,000,000	90
Protozoa	2,000,000,000,000	90
Nematodes	80,000,000	45
Earthworms	40,000	445
Insects/arthropods	8,160,000	830

Soil Food Web

Feed Your Soil Livestock all Year Long

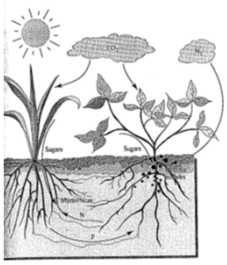
- Rhizosphere
  - Number one food source of most soil organisms is a living root.
  - Living roots release many types of organic materials into the rhizosphere around the surface of the root
  - The number of organisms in the rhizosphere is up to 2000 times higher than in the rest of the soil.





Feed Your Soil Livestock all Year Long

- Plants interacting with mycorrhizal fungi
  - Assists with P uptake from the soil
  - Moves P from the non-legume plant to the legume plant
  - Moves N from the legume plant to the non-legume plant



The Nature and Property of Soils, Brady and Weil

Feed Your Soil Livestock all Year Long

- How do you feed your soil organisms?
  - Avoid extended periods of time when the soil is bare of plants
  - Maintain a diversity of soil organisms

Keep the Soil Covered

- Bare soil is an unnatural and temporary situation in nature
- Benefits of covering the soil
  - Reduce soil erosion
  - Reduce soil compaction
  - Reduce soil temperature
  - Reduce weed growth
  - Reduce water loss
  - Provides organic matter and nutrients

When soil temp reaches. . .

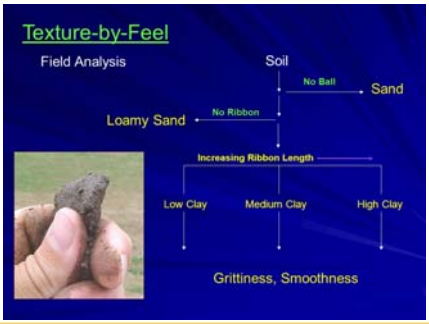
140° F	Soil bacteria die
130° F	100% moisture lost through evaporation & transpiration
100° F	15% moisture is used for growth 85% moisture lost through evaporation & transpiration
70° F	100% moisture is used for growth

J.J. Mc Entre, USDA SCS, Kerrville, TX, 1956

Soils In Summary:

- Soil test every 2-3 years to monitor progress
- Build soil organic matter with regular additions of organic amendments
- Reduce or eliminate tillage
- Keep the soil covered
- Plant cover crops between crop cycles

Soil Texturing Exercise



Any Questions?

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