Introduction to soil science

Master Gardener Training 2022

Oregon State University
Extension Service
Douglas County

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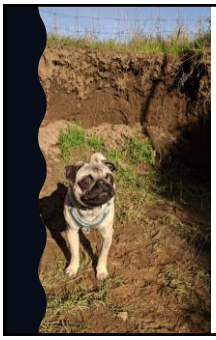

What we'll cover today

- **Soil Physical Properties**
  - How soils are formed and classified
  - Soil texture and structure
  - Protecting soils
- **Soil Biological Properties**
  - Soil organisms
  - Soil organic matter
- **Chemical Properties of soils and amendments**
  - pH and plant nutrients
  - Collecting a soil sample and interpreting a soil test
  - Understanding fertilizers
  - Soil amendments
- **Compost**

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What is Soil?

- A living, breathing, ecological system consisting of inorganic minerals, organic matter, living organisms, plant roots, water & air
- Essential for healthy plants, healthy planet

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Essential functions of soil

- Sustains plant and animal life
- Biological setting for water, nutrient, air, and heat exchange for living organisms.
- Controls distribution of rainfall/irrigation water. Runoff, infiltration, storage, and deep drainage.
- Nutrient cycling and plant growth.
- Acts as a filter to protect and clean water, air, and other resources.
- Engineering medium
- Historical archive

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Soil Classification and taxonomy

- Soil is grouped based on their physical, chemical, and geographic properties.
- 12 Orders of soil
- Soils are named and classified based on the physical and chemical properties in their horizons (layers).
- Over 20,000 different kinds of soil have been identified and mapped in the US.

- https://soilseries.sc.egov.usda.gov/osdname.aspx

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LOGAN SERIES

The Logan series consists of very deep, poorly drained, slowly permeable soils. These soils formed in alluvium and lake sediments from many kinds of rocks, but dominantly from quartzite, sandstone, and limestone gneiss on flood plains, low smooth undulating lake terraces, and stream terraces. Slopes range from 0 to 3 percent. The average annual precipitation is about 15 inches, and mean annual temperature is about 48 degrees F.

TAXONOMIC CLASS: Fine-silty, mixed, superactive, mesic Typic Calciaquolls

TYPICAL PEDON: Logan silty clay loam, 0 to 1 percent slope-rangeland. (Colors are for air-dry soil unless otherwise stated.)

Oe--0 to 2 inches; matted roots and plant remains. (0 to 12 inches thick)

A--2 to 15 inches; very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) moist; moderate medium granular structure; slightly hard, friable, moderately sticky and moderately plastic; many fine and medium roots; common fine pores; strongly effervescent, 12 percent calcium carbonate equivalent; moderately alkaline (pH 8.2); gradual smooth boundary. (10 to 16 inches thick)

Bkg--15 to 28 inches; gray (2.5Y 6/1) silty clay loam, dark gray (2.5Y 4/1) moist; massive; hard, firm, moderately sticky and moderately plastic; many fine and few medium roots; many fine and medium pores; violently effervescent, 45 percent calcium carbonate equivalent; moderately alkaline (pH 8.4); clear smooth boundary. (5 to 45 inches thick)

Cg1--28 to 47 inches; light gray (5Y 7/1) silty clay loam, gray (5Y 6/1) moist; massive; extremely hard, very firm, very sticky and very plastic; few fine and medium roots; common fine pores; violently effervescent, 34 percent calcium carbonate equivalent; strongly alkaline (pH 8.8); gradual wavy boundary. (0 to 37 inches thick)

Cg2--47 to 62 inches; light gray (5Y 7/1) silty clay loam, gray (5Y 6/1) moist; common medium distinct, grayish brown (10YR 5/2) redoximorphic depletions; massive; extremely hard, very firm, very sticky and very plastic; few fine and medium roots; common fine pores; violently , 24 percent calcium carbonate equivalent; strongly alkaline (pH 8.8); gradual wavy boundary.

TYPE LOCATION: Cache County, Utah; one mile south and 1 mile east of Mendon Post Office, 1,100 feet south and 500 feet east of the northwest corner of the northeast 1/4, sec. 12, T. 11 N., R. 1 W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature ranges from 47 to 52 degrees F.

The particle-size control section ranges from 25 to 35 percent clay with textures of silt loam or silty clay loam. The Logan soils are generally free from salts and alkali, but are moderately affected in some areas. Depth to a seasonal high water table is from the soil surface to 20 inches. The calcium carbonate equivalent averages from 15 to 40 percent in the particle-size control section. Electrical conductivity of the saturation extract is 0 to 4 throughout. Thickness of the mollic epipedon and depth to calcic horizon is 10 to 25 inches. Reaction is moderately alkaline or strongly alkaline.

The Oe horizon where present is peaty in places and ranges to 12 inches thick.

The A horizon has hue of 10YR or 2.5Y, values of 3 to 5 dry, 2 or 3 moist and chroma of 1 or 2. Texture is silt loam or silty clay loam. Clay content is 18 to 35 percent. Organic matter content is most commonly 6 to 10 percent but ranges from 4 to 20 percent. The calcium carbonate equivalent ranges from 3 to 25 percent.

The Bkg horizon has hues of 2.5Y, 5Y, 5GY or neutral, value of 5 to 8 dry, 4 to 7 moist and chroma of 1 or less. Structure is lacking to weak subangular blocky or is weak to moderate prismatic parting to angular blocky. It is weakly cemented in places. The consistence is friable or firm moist and slightly hard or hard dry. The calcium carbonate equivalent is 15 to 60 percent. Textures are silt loam and silty clay loam. Reaction is moderately or strongly alkaline. Some pedons have organic stains on faces of peds and lining pores. Carbonates are in nodules, soft masses or are disseminated.

The Cg horizon has hues of 2.5Y, 5Y or neutral, value of 5 to 8 dry, 4 to 7 moist and chroma of less than 2 where the soil is not mottled. The lower C horizon consists of stratified coarse to fine textured mixed lacustrine sediments and alluvium. Textures are silt loam, silty clay loam, silty clay and fine sandy loam. Structure is massive or prismatic parting to angular blocky. Consistence is hard to extremely hard dry and firm to very firm moist. Some pedons have carbonates as fine filaments.

COMPETING SERIES: These are the Chipman(UT), Harpster(IL), Prophetstown(IL) and Provo Bay(UT) series. The Chipman soils have a dominant hue of 10YR above 30 inches. Harpster soils have a mean annual soil temperature of 53 to 57 degrees F. and receive more than 32 inches of precipitation. Prophetstown soils have 18 to 27 percent clay in the control section and receive more than 32 inches of precipitation. The Provo Bay soils have more than 40 percent carbonates in the particle-size control section.

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Mollisol- Farmin' soil

- Dark "Mollic" surface horizons
- High in Organic matter
- Most fertile soils in the world
- Typically, very loamy (Equal parts sand, silt, clay)
- Found in grassy systems like prairies, require seasonal differences to form
- Found mostly in Europe, Asia, and North/South America
- Make up ~7% of the worlds ice-free surface

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Alfisol- Farmin' soil

- Less fertile than Mollisols
- Clay leaches into B layers, creating a place to hold moisture for crops
- Formed primarily in forested or mix cover stands
- Relatively high fertility
- Very good soil for crops
- ~10% of the earths ice-free surface

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Vertisol- Shrink Swell clays

- Shrink-swell clay soils, think of the big cracks in the ground!
- Mud in the winter, bricks in the summer
- High fertility and CEC- Inaccessible
- Transmit water very slowly (poor drainage)
- ~2% of the worlds ice-free surface

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Ultisol- Ultimate weathering (sort of)

- Very weathered soil
- Second only to Oxisols
- High concentration of iron
- Found on hills/hillsides
- Often in humid areas
- Clay, and typically acid
- ~8% of the worlds ice-free surface

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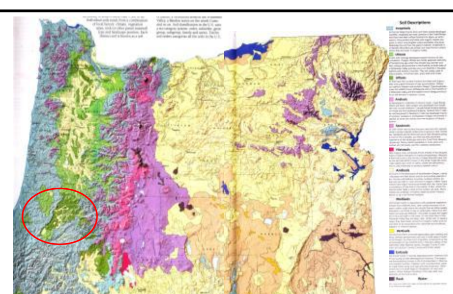

No Oxisols or Gelisols

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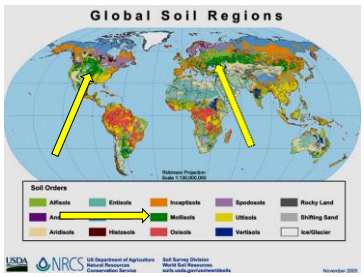
A brief introduction to soil taxonomy

That's the good stuff!



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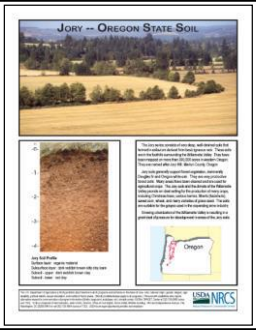

Oregon State Soil (Ultisol!)

- The Jory series consists of very deep, well-drained soils
- Found in the foothills surrounding the Willamette Valley
- Named after Jory Hill, Marion County, Oregon
- Jory soils and the climate of the Willamette Valley provide an ideal setting for the production of many crops, including Christmas trees, filberts (hazelnuts) and many varieties of grass seed.

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Soil Horizons

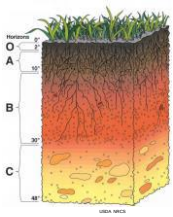
O – Litter layer

A – Mineral surface horizon, dark colored, granular structure

B – Subsoil horizon of maximum development, "brown," blocky structure

C - Weathered "parent material"

R – Hard Bedrock



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Restrictive features

- Cemented pan
- Erodes easily
- Flooding
- Permeability
- Low strength
- Restrictive layer
- Shrink-swell potential


UNCE, Reno, NV

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How can you find out what soil you have?

- There's an App for that! (Actually, a couple!)
- https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- https://casoilresource.lawr.ucdavis.edu/gmap/
- Websoil Survey (Desktop)
- SoilWeb (Mobile and Desktop)

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Web soil survey

- Can be used to look up soils at a geographically accurate scale
- Informs land managers of soil type, arability, and other important factors
- Can be used when planning the garden or farm!

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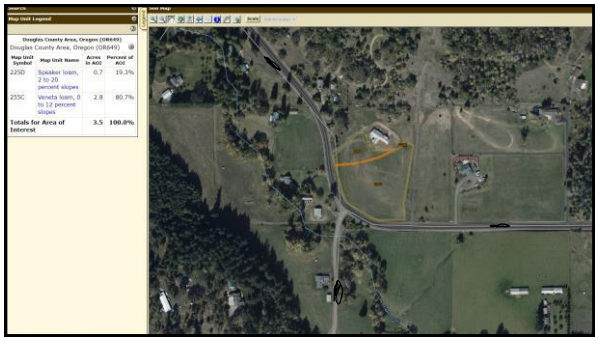

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Douglas County Area, Oregon (OR649)

Douglas County Area, Oregon (OR649)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
225D	Speaker loam, 2 to 20 percent slopes	0.7	19.3%
255C	Veneta loam, 0 to 12 percent slopes	2.8	80.7%
Totals for Area of Interest		3.5	100.0%

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Class 4

Class 3

Summary by Map Unit — Douglas County Area, Oregon (OR649)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
225D	Speaker loam, 2 to 20 percent slopes	4	0.7	19.3%
255C	Veneta loam, 0 to 12 percent slopes	3	2.8	80.7%
Totals for Area of Interest			3.5	100.0%

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Capability classes

Class 1 soils have few limitations that restrict their use.

Class 2 soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class 3 soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class 4 soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class 5 soils are subject to little or no erosion but have other limitations, impractical to remove, that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 6 soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat.

Class 8 soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or esthetic purposes.

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Capability Subclasses

- Soil groups within one class;
  - e (erosion)
  - w (water)
  - s (shallow, droughty or stony)
  - c (climate, too cold or too dry)

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Capability Subclasses

Example:

- Bashaw Clay (Vertisol) (4w): severe to very severe limitations for growing crops, water

Malabon silty clay loam (2w): Moderate limitations for growing crops, water

Chehalis silt loam (1): good farmland with few to moderate limitations

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Which one should you farm?

- Based on the data…?
- Get your boots on the ground!
- We can certainly learn a lot from online analysis, but looking at the soil in person is ALWAYS better
- Speaker Silt loam is a red clay soil- Less nutrients, clayier, harder to amend: still farmable, but less so.
- Veneta Silt loam is good farming soil

The best way to learn about your soil is by digging fence post holes

-Leo Grass, Douglas County Master Gardener

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What is soil made of?

Soil, Compost and Fertilizer Part 2

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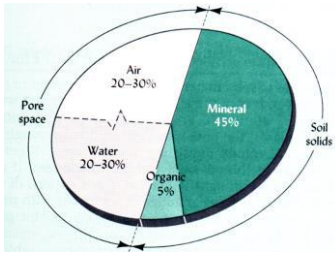
The four components of soil



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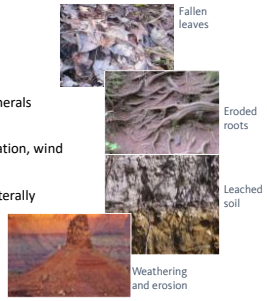
Soil Formation

- Additions
  - Accumulation of plant debris and minerals
- Losses
  - Plant use, erosion, evaporation, oxidation, wind
- Translocation
  - Movement downward, upward, or laterally
- Transformation
  - Weathering, one component changes into another



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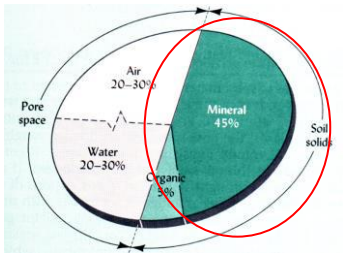
The four components of soil



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Rock, a primary mineral

- Rocks break down over time through a process called weathering
- Two main forms of weathering:
- Chemical weathering
- Physical or mechanical weathering

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Chemical weathering of rocks

- Chemical reactions change the formation of rocks, causing dissolution of minerals into the ecosystem
- Hydration/Hydrolysis: weathering by water
- Carbonation: Weak carbonic acid dissolves rock over time. Created by H^20
- Acidification: Acids seep into rock formations to dissolve them. Created by things like volcanic eruptions, lichen, acid rain
- Oxidation: Think rust!

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Physical/Mechanical weathering of rocks

- Rocks break down through physical manipulation
- Freeze-thaw: water seeps into cracks, expands as its frozen, eventually breaking down rock
- Abrasion: forces like wind, water, glacial movement
- Thermal expansion: subjected to heating and cooling temperatures
- Exfoliation: pressure changes from uplift

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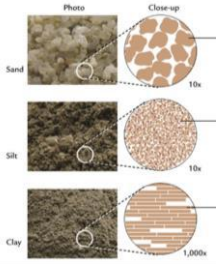
The Mineral Part of Soil



Sand (see with naked eye)
Between 0.05 and 2.0 mm in diameter
Feels rough

Silt (size of flour)
Between 0.002 and 0.05 mm in diameter
Feels 'floury' when dry, smooth when wet

Size classes

Clay (Electron microscope)
Less than 0.002 mm in diameter
Feels smooth when dry, slick & sticky when wet

Secondary mineral

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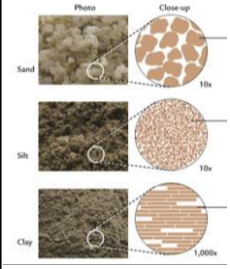
When rocks break down



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What about clay?

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Clay is a secondary mineral

- Clay is formed through a process called isomorphic substitution
- Iso (Same) Morphic (Changing)
- Rocks dissolved or broken into microscopic material
- Changes mineralogically
- "Remaking of minerals"
- Minerals break down and reform

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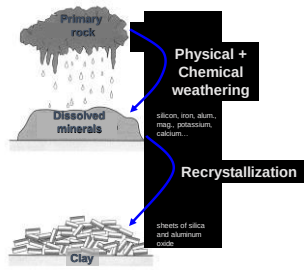
Rocks dissolve and recrystallize



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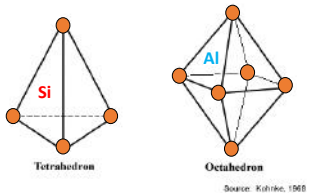
Isomorphous substitution of clay

Within the **silica** tetrahedron and **aluminum** octahedron



What ions are present in the soil water solution is determined by the PM and the weathering environment.

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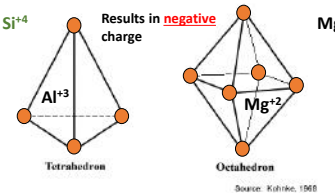
Isomorphous substitution of clay

Aluminum replaces **Silica** in tetrahedron

Magnesium replaces **Aluminum** in Octahedron

Al^{+3} for Si^{+4} Results in negative charge Mg^{+2} for Al^{+3}



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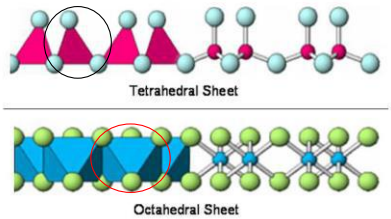

Darrell Schulze, Purdue Agronomy

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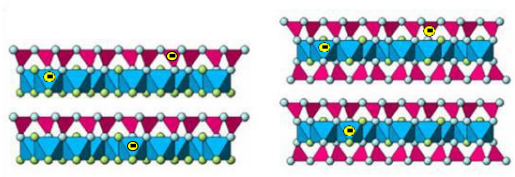
Interspersed substitutions create net negative charges in clay



Darrell Schulze, Purdue Agronomy

= Negative substitution

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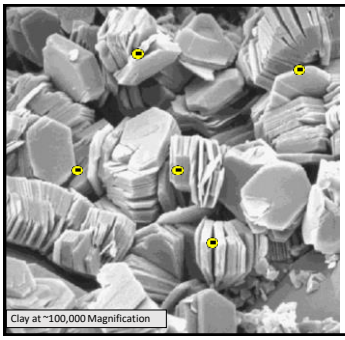

Clay minerals

- Forms in plate-like sheets
- TREMENDOUS surface area
- Negatively charged
- Room to hold cations

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Clay is negatively charged

- Negative charges allow for soil to hold positive ions (cations)
- Cations (fertilizer) are beneficial to plant life, (P,K)
- Allows for cations to be held in soil solution to be taken up later

Soils negative charge, or ability to hold onto cations is called

Cation Exchange Capacity (CEC)

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Plant Nutrients: Available Forms

- Soil nutrients are in form of positive cations and negative anions
- Clay & OM particles are negatively charged
  - Cations are adsorbed to these particles
  - Anions move through soil
- Cation Exchange Capacity (CEC) =
  - A soil's capacity to hold cations

Cation	Nutrient
Ca^{++}	Calcium
Mg^{++}	Magnesium
K^{+}	Potassium
NH^{4+}	Ammonium
H^{+}	Hydrogen
Na^{+}	Sodium
Anion	**Nutrient**
Cl^{-}	Chlorine
NO^{3-}	Nitrate
SO^{4-}	Sulfate
PO_4^{3-}	Phosphate

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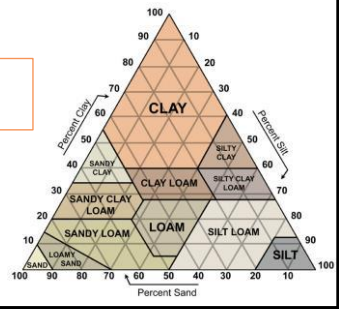
Soil Texture

Soil texture gives us a hint to the lands:
- Drainage
- CEC
- Arability
- Capacity for non-ag (Buildings, wetlands)



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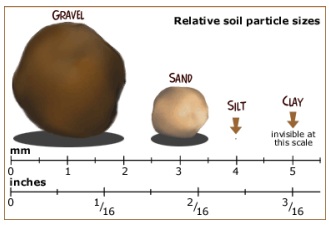
Soil Texture



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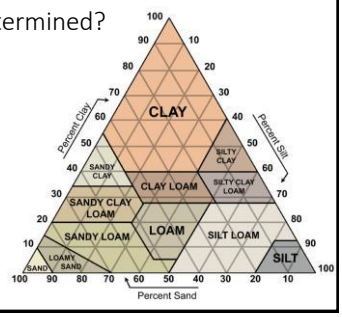
How is soil texture determined?

Lab method: Hydrometer method

At home: Quart Jar method

In field: hand texturing



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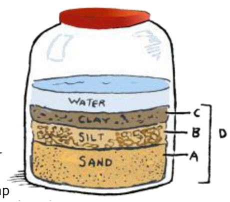
Estimating your soil textural components at home - soil fractional analysis

A= 20 min.
B= 2 hrs.
C= 24 hrs.
D= total

Quart jar
2/3 full water
1 cup dry soil
2 tsp dish soap



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How do you hand texture soil?

https://puyallup.wsu.edu/soils/video_soiltexture/

Photo from Government of Western Australia

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Break time!

- Take 10-15 minutes

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Why care about soil texture?

- Soil texture influences:
  - Water intake rates (infiltration)
  - Water storage capacity
  - Permeability
  - Ease of tillage
  - Amount of aeration
  - Soil fertility

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It's not all Loam!

Image: Wilson Bros Gardens
https://theconstructor.org/geotechnical/soil-formation-types-weathering/1227/

- Topsoil is another name for the A horizon, where the bulk of biological activity in the soil occurs.
- Loam is a near-equal mixture of sand, silt and clay.

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Soil structure and formation

Soil, Compost and Fertilizer Part 3

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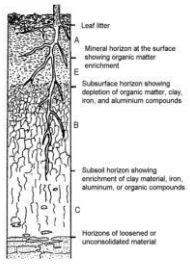
Soil Horizons



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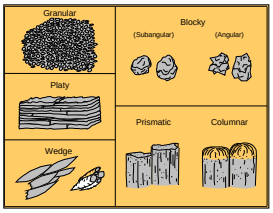
Soil Structure



- Soil structure refers to the way individual particles of sand, silt and clay are bound together into larger units called **peds**.

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Soil Peds: A sign of good tilth

Soil peds (one = pedon) are individual small crumbs

A ped ranges in size from about 1 mm to 10 cm.

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Soil structure

Influenced by biological activity, organic matter content and texture

Image from: Soil Aggregate Microbial Communities: Towards Understanding Microbiome Interactions at Biologically Relevant Scales
Regina L. Wilpiszeski, Jayde A. Aufrecht, Scott T. Retterer, Matthew B. Sullivan, David E. Graham, Eric M. Pierce, Ottowin D. Zablocki, Anthony V. Palumbo, Dwayne A. Elias
Applied and Environmental Microbiology Jul 2019, 85 (14) e00324-19; DOI: 10.1128/AEM.00324-19

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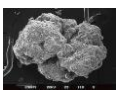
Soil Aggregate Stability

Influenced by:

- Soil Organic Matter
- Biological Activity

Influences:

- Water Holding Capacity
- Erosion potential
- Permeability



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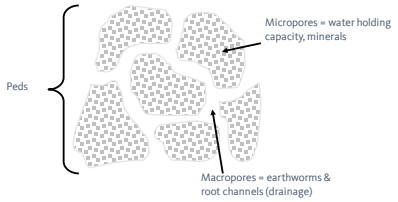
Macro- and Micropores



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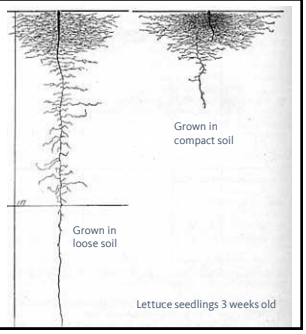
Soil Structure

- Arrangement of soil particles into peds
- Allows movement of air, water, roots
- Compaction squeezes pores
  - Less water movement
  - Less root penetration



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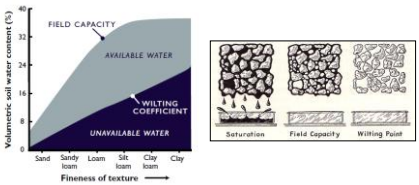
Water in the Soil



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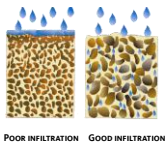
Soil and Water

- A productive soil in permeable to water and is able to supply water to plants.



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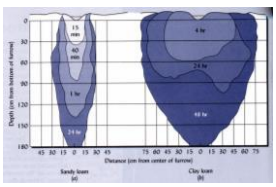
Effect of texture on water movement



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Good Porosity & Permeability Resolve Many Garden Problems

- **Porosity:** amount of space (pore space) between particles in a soil.
- **Permeability:** ability of water to move through that pore space.
- Good structure is associated with large pores (**macropores**).
- OM is essential to the formation and maintenance of good soil structure (tilth).

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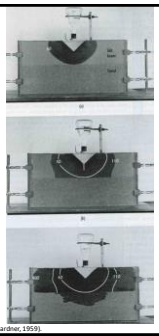
Myths of Soil Amendments

If you have a clay soil, add sand to improve drainage and texture.

NO!

Incorporating these materials leads to vertical and horizontal textural barriers to surrounding unamended soil. In containers, a perched water table can occur.



Perched water table development caused by soil texture interface (photo from Hsieh and Gardner, 1959).

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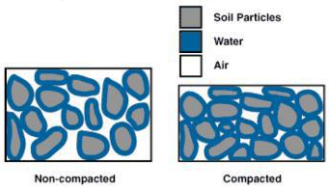
Soil Compaction

- Excessive tilling destroys soil structure
- Gravity and rainfall compress soil
- Excess weight physically compacts soil
  - Walking on loose soil will compact it
  - Heavy equipment REALLY compacts soil

Compaction destroys structure



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Leaving soil exposed can cause compaction

- Reduces pore space and destroys soil structure.
- Rototilling or plowing wet soil can lead to long term compaction problems
- What happens to soil when you make a mud pie?

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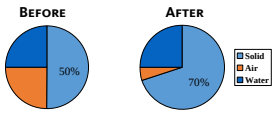
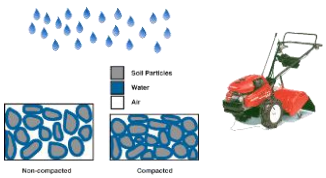
Composition of a compacted soil



Note the reduced air space in a compacted soil.

72

Compaction leads to loss of structure



- Tilling when soil is too wet damages soil structure.

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Soil pH

Soil, Compost and Fertilizer Part 3

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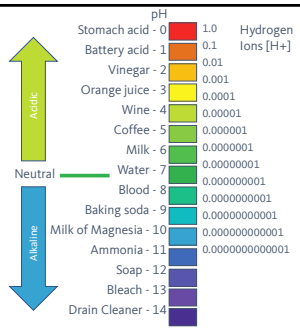
Soil pH

- Measure of hydrogen ion activity
- pH range of 0-14
  - Less than 7 = acidic
  - 7 = neutral
  - Greater than 7 = alkaline
- Optimal plant growth between 5.5-7.5



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Plant Nutrients: Available Forms

- Soil nutrients are in form of positive cations and negative anions
- Clay & OM particles are negatively charged
  - Cations are adsorbed to these particles
  - Anions move through soil
- Cation Exchange Capacity (CEC) =
  - A soil's capacity to hold cations

Cation	Nutrient
Ca^{++}	Calcium
Mg^{++}	Magnesium
K^{+}	Potassium
NH^{4+}	Ammonium
H^{+}	Hydrogen
Na^{+}	Sodium
Anion	**Nutrient**
Cl^{-}	Chlorine
NO^{3-}	Nitrate
SO^{4-}	Sulfate
PO_4^{3-}	Phosphate

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Cation Exchange Capacity

- Varies with soil texture & OM content
- Measured in milliequivalents per 100 grams
- Higher CEC holds more nutrients

Soil Texture	CEC (meq/100g)
Sands	1 – 5
Fine sandy loams	5 – 10
Silt loams	5 – 15
Clay loams	15 – 30
Clays	30+

Leaching

Nutrient Storage

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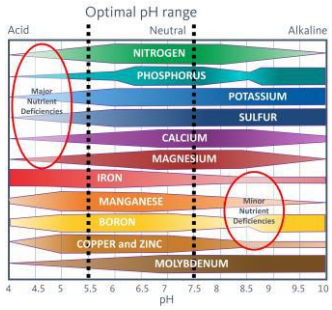
Nutrient Availability

- Optimal plant growth between 5.5-7.5
  - Maximum availability of nutrients
- Low or high pH reduces availability of some nutrients



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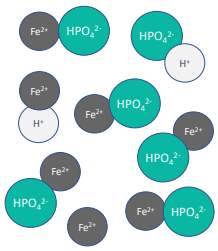
Example: Iron Chlorosis



Rhododendron with iron-deficiency chlorosis

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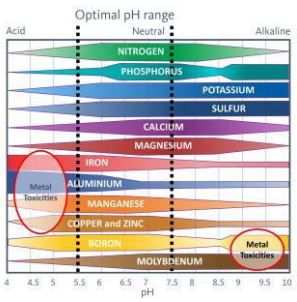
Soil pH

- Affects microorganism populations
- At a high pH, calcium ties up phosphorus, making it unavailable to plants
- Aluminum, manganese, copper, zinc, iron can be toxic in very acid soils
- Molybdenum and boron can be toxic in very alkaline soils



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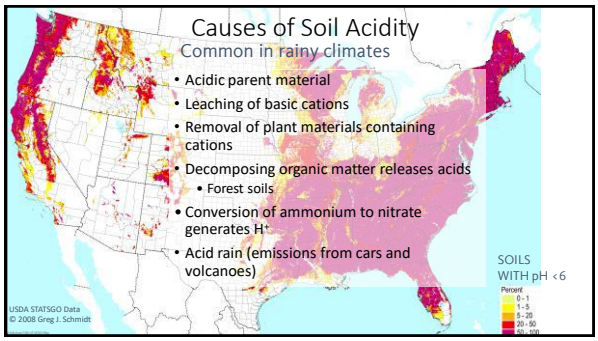

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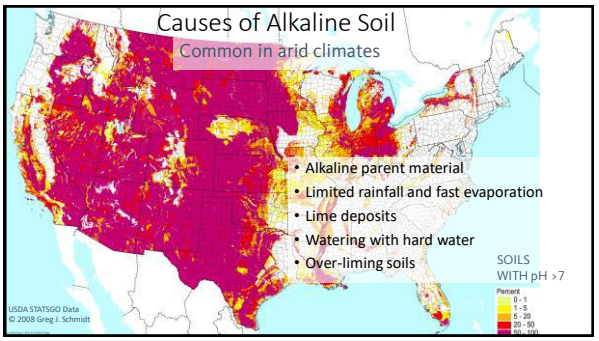


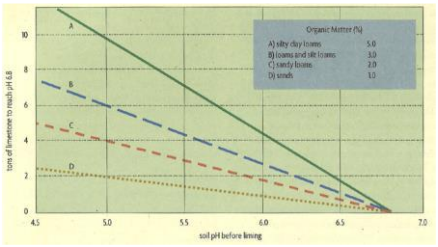
82

What makes soils acidic?

- Acidic soils: pH is below 7
- Soils become acidic because of heavy rainfall that weathers soils quickly
- Basic elements such as calcium, magnesium, sodium and potassium are used or leached from the soil
- This natural weathering process makes soils acidic
- The addition of some fertilizers can also cause soil acidification (ammonium and sulfur).

83

Soils have different liming requirements to raise pH



Soil pH test indicates if lime is needed.
Lime requirement test (SMP) determines how much lime is needed.

84

Adjusting Soil pH

- pH Buffering
  - High CEC
  - Clay and Organic Matter (OM)
- Adjust low soil pH (acid soils)
  - Lime – calcium carbonate
  - Dolomitic lime – lime w/magnesium
  - *Quicklime and hydrated lime not recommended*
  - Wood ash
    - Increases pH and provides trace elements
    - Use with caution
- Adjust high soil pH (alkaline soils)
  - Elemental sulfur

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Calcium Carbonate Equivalents

Material	Calcium Carbonate Equivalent	Amount to Apply	Notes
Calcium carbonate ($CaCO_3$)	100%	50 lb per 1000 square feet of garden	Most commonly used for gardens
Dolomitic lime ($CaMg(CO_3)_2$)	109%	46 lb per 1000 square feet of garden	Use is soil needs Magnesium
Quicklime (CaO)	170-180%	28-29 lb per 1000 square feet of garden	Caustic, use with care.
Hydrated lime $Ca(OH)_2$	135%	37 lb per 1000 square feet of garden	Caustic, use with care. Used primarily for pickling and construction.
Wood ash	50%	100 lb per 1000 square feet of garden	Don't inhale, don't over-apply

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A real-life application:

How lime raises pH (lowers acidity) --

$CaCO_3 + 2H^+ \rightarrow H_2O + CO_2 + Ca_2^+$

Table 11.—SMP lime requirement—gardens.

If the SMP lime requirement test is	Apply this amount of lime (lb/1,000 ft²)
5.4 or below	250
5.5–6.0	150–250
6.0–6.5	100–150
above 6.5	0

Table is from OSUEC EC1478: Soil Test Interpretation Guide

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Timing

If needed, add lime <u>before</u> fertilizing

pH	N availability	P availability	K availability
5.0	53%	34%	52%
6.0	89%	52%	100%
7.0	**100%**	**100%**	**100%**

Nutrients are less available at lower pH levels, compared to pH 7.0

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Soil Biology

Soil, Compost and Fertilizer Part 4

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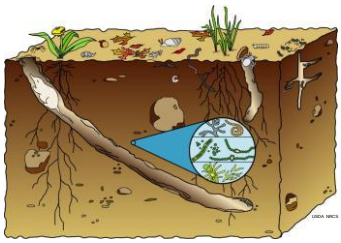
Soil Biology: The Living Soil



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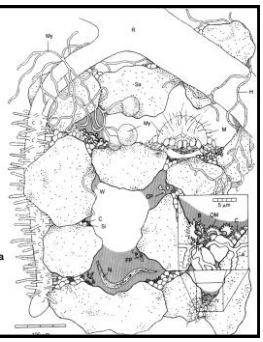
Soil is HABITAT!

- Animals – Earthworms, arthropods, vertebrates
- Soil microorganisms (bacteria, fungi)
- Plants (roots)



B – Bacteria
A – Actinomycetes
My – Mycorrhizae
H – Saprophitic fungus
N – Nematode
CP – Ciliate protozoa
FP – Flagellate protozoa
M – Mite

< 1mm

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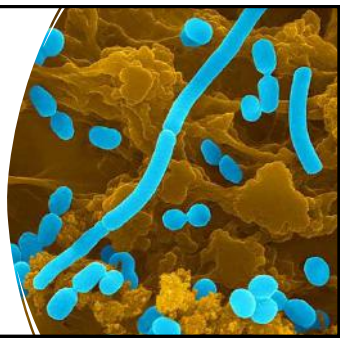
Micropores

Bacteria



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Nematode


Nematode


Protozoa

Small pores

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Microfauna

Protozoa

- One-celled
- Feed on bacteria (live and move in water films)
- Up to 30% of all mineralized N from protozoa

95

Live in medium pores

Mesofauna

96

Mesofauna

- Heterotrophs (detritivores, predators)
- Feed on fungi, protozoa, nematodes, mites
- Important in regulating populations of everything smaller

Collembola (springtails)

Fungus feeding mite

Nematode feeding mite

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Macrofauna


University of New Hampshire

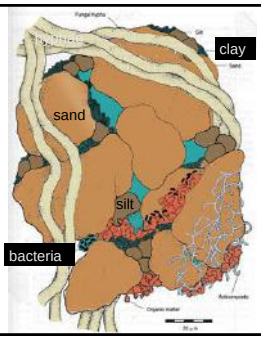

DamianKuzdak—E+/Getty Images

98

Fungi

- **The major agent of decay Network of hyphae improves soil structure**
- **<u>Decomposition of cellulose</u>**
- **Can compete with higher plants for N**

99



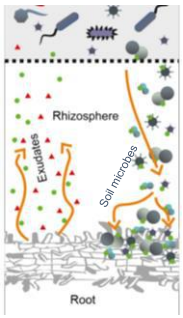
Aggregates held together by:

1. **Fungal hyphae**
2. **Bacterial "glues"**
3. **Organic matter**

100

Plant/Microbe Partnership

- Plant root exudates feed microbes
- Microbes break down OM
  - Plant nutrients = "active" OM
  - Humus = "storage" nutrients
- Good temp for microbes 70-100ºF



Root exudates attract soil microbes in mutually beneficial relationship

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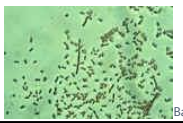
Bacteria & Fungi

In ¼ tsp of soil

Ectomycorrhizal Fungi on Plant Roots

- Bacteria
  - 100 million -1 billion
- Fungi/Mycorrhizae
  - 100,000 -1 million
- Abundant on **rhizosphere** (area around the roots)



Bacteria

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Nematodes

Up to 100 million
In ¼ tsp of soil

Plant-parasitic and non-parasitic nematodes recovered from soil by sieving

Black vine weevil pupae infected with beneficial nematodes (left, dark) and uninfected (right, white)

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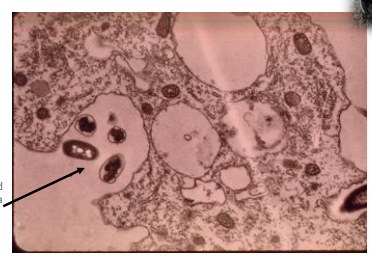
Protozoa

10,000 to 100,000
In ¼ tsp of soil



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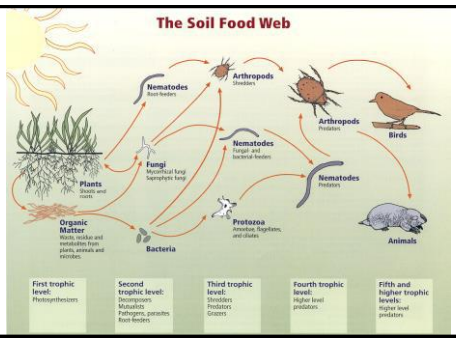

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Soil organisms need three things to thrive

The activity of soil organisms depends on:

- Soil moisture
- Soil temperature
  - 70°f- 100°f for microorganisms
  - 50°f for earthworms
- Organic matter (food)

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Critical functions of soil organisms:

- translocation and mixing of OM and mineral soil
- shred plant litter (speeds up decomposition)
- increased aeration and improved water infiltration
- population control of smaller organisms

gee whiz fact: dung beetles can bury up to 78% of the cattle feces in a pasture within weeks

Photo: Whitney Cranshaw, Colorado State University, Bugwood.org

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Earthworms

Approximately 2,700 different kinds of earthworms

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Earthworms – (have gizzards!)

- Eat organic matter and pass as much as 24,281 lbs/acre of soil through their bodies (mixing horizons) each year
- Can eat their weight each day
- One of the most important component of soil fauna (not in acid soils, not in very dry soils)
- Eat OM & pass as much as 30 tons/ha of soil through their bodies (mixing horizons) each year
- Excreted casts higher in N, P, K, Ca, Mg, pH, and CEC
- Promote good soil structure and aeration

"It may be doubted whether there are many other animals which have played so important a part in the history of the world, as have these lowly organized creatures." Charles Darwin 1881

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Good quality soil has:

- Good aeration
- Good drainage
- Good tilth (easy to work)
- Lots of organic matter
- Lots of organisms

OSU Extension Service

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Soil Organic Matter (OM)

- Cells of soil microorganisms
- Living organisms are also part of S.O.M
- Plant and animal residues in different stages of decomposition
- Substances that are so well-decomposed it's impossible to tell what they were to begin with

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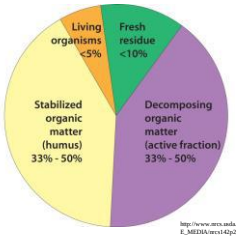
Soil organic matter is the base for the Soil Food Web



http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_049823.jpg

112

Organic Matter (OM)

- Leaf litter
- Recently deceased microorganisms, plants, or animals
- Fresh manures

Leaf litter and fungi

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Benefits of Soil Organic Matter

- Soil aggregation
- Aeration and water penetration
- Moisture holding capacity
- Cation exchange capacity
- pH buffer
- Micronutrient chelation
- Plant nutrient source

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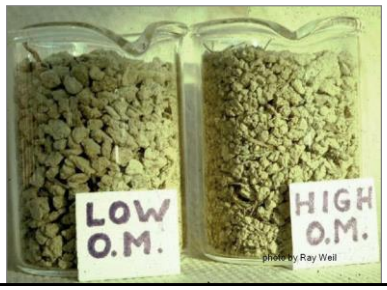
SOM enhances water-holding capacity

25 years of conventional corn



20 years of bluegrass, then 5 years conventional corn

Gruver, 2005

115

After adding water…

Soils after drying

Gruver, 2005

116

How to add organic matter

Cover Crops

Crop residue

Compost

- Compost is an excellent source of organic matter for garden soils.
- Composting also closes the recycling loop by turning waste materials into a soil amendment.
- You can make compost at home or buy commercially prepared compost.

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How much S.O.M is there?

Recommended minimum 3% - 5% for agricultural soils

- Primarily due to natural factors like:
  - Temperature
  - Soil texture
  - Drainage
- Management may reduce S.O.M:
  - Frequent tillage
  - Periods of bare ground
  - Removal of crop residues

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Organic Matter

Helps sandy soils retain water and nutrients

In clay soils

Helps with infiltration and permeability of water

Provides better aeration for plant roots

Too much of a good thing?

- Maybe
- Fresh organic material stimulates increase of microbial activity
- Ties up available nitrogen until equilibrium is reached
- Can result in excess salts
- More nutrients than plants can use, especially phosphorus

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Encouraging High SOM

- Avoid tilling; use no-till methods
- Reduce or eliminate chemical pesticides
- Leave grass clippings and leaves
- Add compost if needed

120

Protecting your soil from erosion

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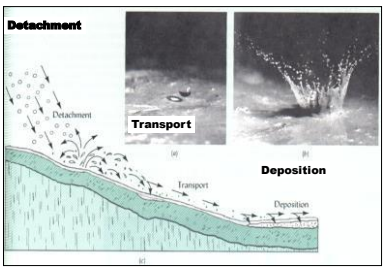
Process of Erosion



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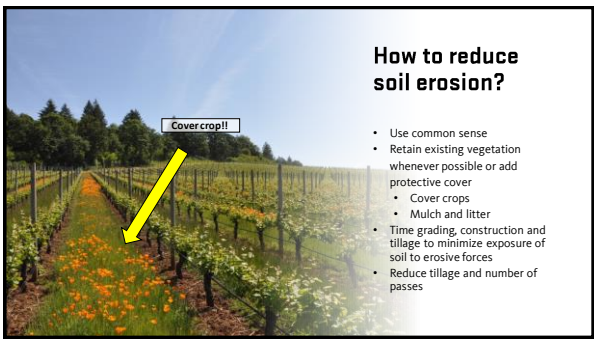

How to reduce soil erosion?

- Use common sense
- Retain existing vegetation whenever possible or add protective cover
  - Cover crops
  - Mulch and litter
- Time grading, construction and tillage to minimize exposure of soil to erosive forces
- Reduce tillage and number of passes

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Mulching and seeding reduces erosion

124

125

Gardening with challenging soils

- High clay
- Rocky

126

High clay

- Slow to dry out in Spring
- Compacts easily

- Increase organic matter
- Don't work when wet
- Don't try to change texture by adding sand
- Avoid compaction

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How can I manage my soils to improve them?

- Avoid compaction by
  - Reducing tillage of wet soils
  - Reducing traffic on wet soils
- Increase the organic matter content by
  - Mulch soil surface
  - Adding compost and manure
  - Growing and tilling in cover crops (green manure)
- Maintain cover with vegetation

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Fertilizers and Soil Amendments

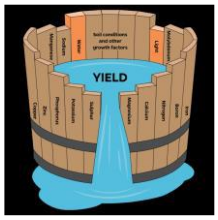
129

Why do we care about soil fertility?

130

Nutrient deficiencies can limit yield

Liebig's Law
Yield is proportional to the amount of the most limiting nutrient, whichever nutrient it may be.



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Do you need to fertilize your garden?

- Which nutrients (elements) do you need?
- What type of fertilizer material should you use?
- How much should you apply?
- How should you apply?
- When should you apply it?
- Will you get a return on your investment?

132

Test your soil!

Soil testing provides an estimate of the quantity of nutrients which should become 'available' during the growing season.

Not the total amount of nutrients in the soil.

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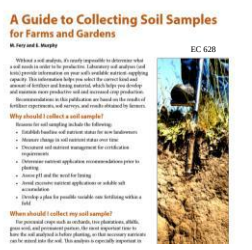

A Guide to Collecting Soil Samples for Farms and Gardens

EC 628

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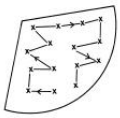
Soil sampling gives you information about the chemical composition of your soil



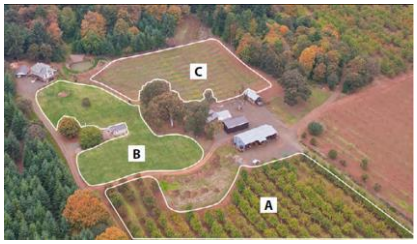
Collect 15 – 20 subsamples randomly around the management unit.
Combine into one composite sample to submit to certified lab.

135

Management Units

Use field characteristics (soil type, size, history)

***WEBSOILSURVEY**.NRCS.USDA.GOV*



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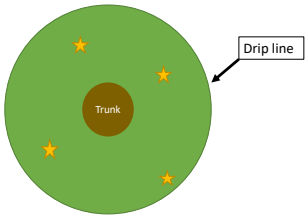
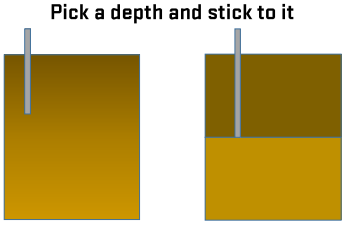
If sampling a small area (one tree) combine at least four cores



137

Sampling depth is very important
Pick a depth and stick to it



Uncultivated

4 – 6 inches

Cultivated

6-8 inches
"plow layer"

138

How often should I take a soil sample?

- Prior to a new landscape or garden
- New property
- Every 2 – 5 years in home gardens/lawns/landscapes, use the same lab or testing methods
- Frequently enough to make good decisions on fertilization
- Having a problem

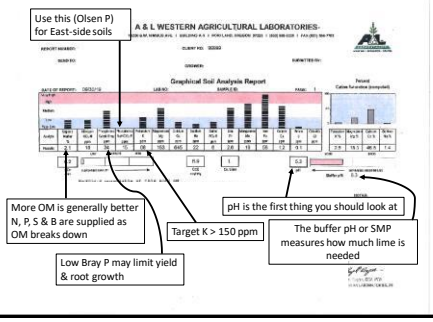
Time of year generally does not matter for routine chemical analysis but be consistent.

139

What do you do with your soil samples?

- Send them to a lab for chemical analysis
- Soil test methodologies are calibrated

140



141

Plants need nutrients to grow

Macronutrients
- Primary - Nitrogen (N), Phosphorus (P), Potassium (K)
- Secondary – Calcium (Ca), Magnesium (Mg), Sulfur (S)

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

Table 1. Plant-available nutrient forms.

Nutrient	Form used by plant
Cations (+):	
Nitrogen	NH_4^+
Potassium	K^+
Calcium	Ca^{2+}
Magnesium	Mg^{2+}
Manganese	Mn^{2+}
Copper	Cu^{2+}
Zinc	Zn^{2+}
Anions (–):	
Nitrogen	NO_3^-
Phosphorus	$H_2PO_4^-$ and HPO_4^{2-}
Sulfur	SO_4^{2-}
Boron	$H_2BO_3^-$ and $H_2BO_3^-$
Molybdenum	$HMoO_4^-$ and MoO_4^{2-}
Chloride	Cl^-

Table from OSU Publication EC 1478, Soil Test Interpretation Guide

142

NPK- What do they do?

N (ammonium – NH_4^+ or nitrate – NO_3^-)
- important for healthy plant growth, protein formation, root growth, chlorophyll, carbohydrate use.

P (phosphate – HPO_4^{2-})
- essential for vigorous growth of seedlings, especially in cool, wet, spring weather. Key role in photosynthesis, energy storage and transfer, and cell division. Vital to flowering, seed formation, and maturation.

K (Potassium – K^+)
- important for disease resistance and starch formation. Helps plants adapt to environmental stress. Essential for photosynthesis, protein synthesis, starch formation, and translocation of sugars.

143

Nutrient deficiencies can cause visual symptoms

144

- Yellowing of older leaf material – N is mobile in plants
- Stunted growth, reduced plant vigor
- General chlorosis of entire plant

NITROGEN (N) Deficiency

145

Table 1. Nitrogen requirement for vegetable crops (lb/1000 ft²).

Based on seasonal nitrogen uptake (adapted from Gaskell et al. 2007). From PNW 646, pg. 4

Low: 3 lb/1000ft2	Med: 4lb/1000ft2	High: 5 lb/1000ft2
Baby greens	Carrot	Broccoli
Bean	Corn, sweet	Cabbage
Cucumber	Garlic	Cauliflower
Radish	Lettuce	Celery
Spinach	Melon	Potato
Squash	Onion	
	Pepper	
	Tomato	

Multiply values by 44 to approximate the conversion of lb/1000 ft to lb/acre.

146

Table 2. Phosphorus (P) soil test categories and suggested fertilizer rate recommendations.

	West of Cascades Bray P1 test P (ppm)	East of Cascades Olsen test P (ppm)	Recommendation (lb P_2O_5/acre)
Low	<20	<10	0–300
Medium	20–40	10–25	0–200
High	40–100	25–50	0–30
Excessive	>100	>50	0

Table from OSU Publication EC 1478, Soil Test Interpretation Guide

- Purpling of leaves, especially in leaf veins. Mobile in plants so symptoms show in older leaves first.
- May result because of cold soil temperatures
- Sparse flowering, poor fruit and seed development
- **PHOSPHORUS (P) Deficiency**

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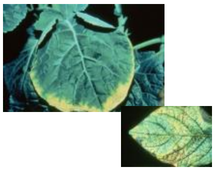

Photos: http://landresources.montana.edu/soilfertility/kdeficiency.html

Table 3. Extractable potassium (K) soil test categories and suggested fertilizer rate recommendations.

	Extractable or soil test K	Recommendation (lb K_2O/acre)
Low	<150 ppm*	100–300
	<0.4 meq/100 g soil	
Medium	150–250 ppm	60–250
	0.4–0.6 meq/100 g soil	
High	250–800 ppm	0
	0.6–2.0 meq/100 g soil	
Excessive	>800 ppm	0†
	>2.0 meq/100 g soil	

* For ammonium acetate or sodium bicarbonate extraction method.
† When extractable K is excessive, determine soil and irrigation water electrical conductivity.

Table from OSU Publication EC 1478, Soil Test Interpretation Guide

- Leaf margins turn chlorotic and then necrotic.
- Tip and marginal burn starting on mature leaves
- Lower leaves turn yellow
- Weak stalks and plants lodge easily
- Mobile in plant so symptoms appear on older leaves first

- **Potassium (K) deficiency**

148

- Light green color or uneven chlorosis of young leaves, tip burn on mature or new leaves, distorted new growth.
- Blossom-end rot on tomatoes, peppers and eggplants?

- **Ca Deficiency caused by uptake issue**

Calcium uptake is inhibited by watering- too much or too little!

Ohio State University Extension

149

http://www.omafra.gov.on.ca/IPM/images/grapes/plant-nutrition/magnesium/magnesium7_zoom.jpg?rand=481915241

Table 4. Extractable magnesium (Mg) soil test categories and suggested fertilizer rate recommendations.

	Extractable or soil test Mg	Recommendation (lb Mg/acre)
Low	<60 ppm	10–100
	<0.5 meq/100 g soil	
Medium	60–300 ppm	0–60
	0.5–2.5 meq/100 g soil	
High	>300 ppm	0
	>2.5 meq/100 g soil	

Table from OSU Publication EC 1478, Soil Test Interpretation Guide

- Interveinal chlorosis on older leaves, proceeds to younger leaves with more severity
- Curling of leaves upward along margins
- **Magnesium (Mg) deficiency**

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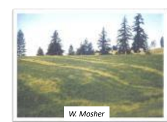
Soil Test Report: Other items

- Nitrogen (N) and Sulfur (S)
  - Very mobile in soil so regular soil tests not reliable
  - Tissue analysis for S and N better than soil test for S and N



151

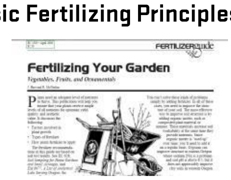
Boron (B)

- Not routinely provided in soil tests
- Check with lab, you may have to request it
- Crops susceptible to B deficiency: cabbage, broccoli, cauliflower, cane berries, strawberries, beets, carrots)
- Many soils in western OR are deficient
- If test results indicate less than 1ppm, add Boron. See pg. 4 of Fertilizing your garden for recommendation
- Be careful – don't over apply, too much can be toxic to plants!

Photo: WSU, http://mtvernon.wsu.edu/wp-content/uploads/2016/02/broccoli-boron-deficiency-2L.jpg

152

Basic Fertilizing Principles



- Nitrogen, Phosphorus, Potassium most limiting nutrients
- pH often most limiting factor

154

Fertilizer and Soil Amendments

A natural or synthetic material that provides useful quantities of nutrients in forms soluble in soil

- Most soluble nutrients become immobilized in soil (adsorbed, incorporated into humus):
- This is GOOD. It increases soil reserves
- Increased soil reserves → increased concentration in soil → greater availability to plants

155

Types of fertilizers

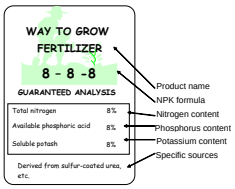
Synthetic fertilizers (urea, diammonium phosphate, potassium chloride, etc.)

Organic fertilizers (bone meal, compost, crab or fish meal, manure, etc.)

156

Fertilizer Mixes

- Listed as N - P - K
- Numbers are %
- Example:
  - Fifty pound bag of contains how much nitrogen, phosphorus and potassium?



157

Comparing organic and synthetic fertilizers

	Organic Fertilizers	Synthetic Fertilizers
Source	Natural materials; little to no processing	Manufactured or extracted from natural materials; often undergo extensive processing
Examples	Manure, cottonseed meal, rock phosphate, fish by-products, ground limestone	Ammonium sulfate, processed urea, potassium chloride
Nutrient Availability	Usually slow-release; nutrients are released by biological and chemical processes in soil	Nutrients usually are immediately available to plants
Nutrient Content	Usually low	Usually high

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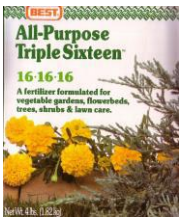

159

Commercial Organic Fertilizers

160

Fertilizing with manures

- Watch out for weeds and pathogens
- Consider application method and timing
- Rule of thumb: 5 gallon bucket of cow manure per 50 square feet.
- Why would composted manure a better source?

161

Nutrient value of manures

Animal	N lbs/ton	P_2O_5 lbs/ton	K_2O lbs/ton
Beef	11.3	8.4	9.5
Chicken	27.3	23.5	13.2
Goat	22.0	5.4	15.1
Horse	12.1	4.6	9.0
Sheep	22.5	7.6	19.5

162

Using manure

- Nutrient content can be variable
- Should be tested for best results
- Often over supplies P & K to get amount of N needed for crop needs
- Do not over apply
- Nitrogen availability not guaranteed

163

Elements of Compost

Soil, Compost and Fertilizer Part 7

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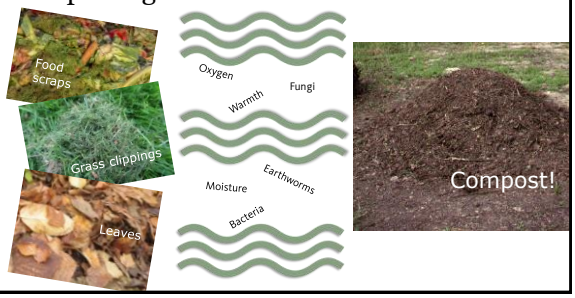
Composting



165

Compost Promotes Soil Health

Compost provides many benefits to soil, including:

- Increases soil organic matter
- Supports earthworms and beneficial soil microbes
- Increases soil water holding capacity
- Increases soil nutrient retention
- Can improve drainage
- Helps roots spread freely

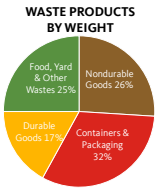
Soil is easier to work and better for plant growth

166

Compost Reduces Waste

- The average U.S. household generates over 650 lbs of compostable materials each year.
- Limited landfill space should be reserved for materials that cannot be recycled or composted

Roseburg, OR Landfill
August, 2004



167

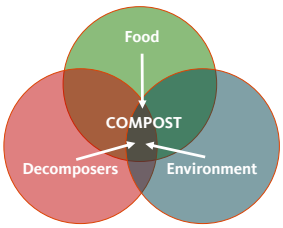
Other Benefits of Compost

- Can reduce the need for fertilization
- Increases growth of some woody plants
- Can suppress plant disease

168

Ingredients of Good Compost

- Decomposers
  - Microbes, earthworms and arthropods that do the work
- Food for decomposers
  - Organic materials – Carbon & Nitrogen
- Suitable environmental conditions
  - Oxygen
  - Moisture – 40-60%
  - Warmth – 90-140 deg. F.



169

Where to Find Decomposers?

If you build it, they will come... (video)

170

Commercial Starters

- Can be beneficial
- Not usually needed
- Add some finished compost

171

Browns and Greens

- Carbon-rich organic wastes are known as **"BROWNS"**
  - Carbon to Nitrogen Ratio > 30:1
  - Bulk materials
- Nitrogen-rich organic wastes are known as **"GREENS"**
  - Carbon to Nitrogen Ratio < 25:1
  - Energy materials
- Ideal C:N ratio for compost piles ≈ 30:1
  - 1 part green, 2 parts brown

172

Browns Relatively high carbon content (>30C:1N)

- Leaves (30-80:1)
- Straw (40-100:1)
- Manure (horse) with bedding (60:1)
- Sawdust (100-500:1)
- Wood chips (600:1)
- Paper (150-200:1)
- Shredded Newspaper: 170:1

173

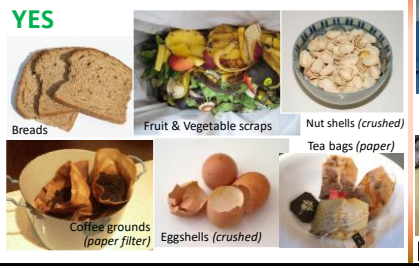
Greens Relatively high nitrogen content (<25C:1N)

- Fruit & Vegetable scraps (15-20:1)
- Coffee grounds (20:1)
- Grass, green plant clippings (15-25:1)
- Fresh Manure
  - Cow (20:1)
  - Horse (25:1)
  - Poultry (10:1)
  - Sheep (17:1)

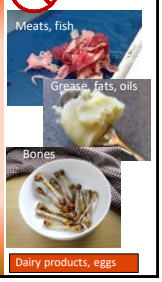
174

What to Compost: Food Scraps

YES



NO

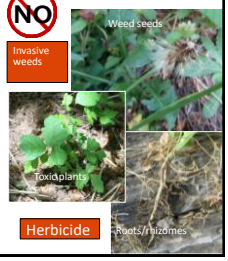


175

What to Compost: Garden and Yard Waste

YES

NO



176

What to Compost: Manures

YES Herbivore manure

NO

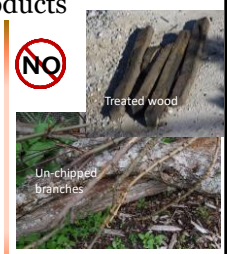
Carnivore manure, herbicides

177

What to Compost: Wood Products

YES

NO



Glossy, colored inks

178

Other Materials

- Natural fabrics (cotton, linen, wool) shredded
- Dryer lint (cotton, linen, wool)
- Fur and hair
- Soil amendments: Rock powder, greensand, bone meal etc


Dryer Lint (natural fibers)


Dog fur


Hair trimmings

179

Compost with Care

Diseased plants
Pest-infested plants
- Safest if hot composted at >140 degrees F (60 C)

Potato early blight

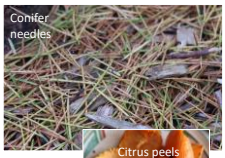
Cabbage aphids


Rose black spot

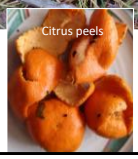
180

Compost with Care

"Compostable" containers


Conifer needles


Wood ashes (small amount)


Citrus peels

BPI COMPOSTABLE

HOME OK compost TÜV AUSTRIA HOME

181

Herbicide Residues in Compost

- Avoid materials sprayed with Clopyralid (and similar herbicides)
  - Sold under the names: Redeem, Stinger, Transline, Confront, Lontrel, Curtail, and Millennium Ultra
  - Straw
  - Manure from animals fed sprayed hay
- Use compost as soil amendment
  - Planting medium or mulch more risky if contaminated


Clopyralid damage damage on potatoes

182

Building A Compost Pile

Soil, Compost and Fertilizer Part 8

183

Building a HOT Compost Pile

- Collect materials for a minimum size of 1 cubic yard = 3x3 ft
- 2 parts browns to 1 part greens, + desired amendments
- Chop coarse materials
- Mix and moisten materials as pile is assembled. Cover.
- Should heat to 120-150deg
- Turn when temp drops and volume down by 1/2
- Finished when it cools, about 8 weeks

Should be free of viable seeds, rhizomes and disease organisms

184

Building a COLD Compost Pile

Compost Happens!

- 2 parts browns to 1 part greens
- Add materials as acquired
- Dig new materials into center
- Keep moist
- Harvest when center appears done
- Re-compost unfinished parts
- *Seeds, rhizomes and disease organisms may still be viable*

185

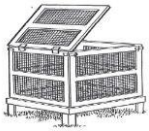
Types of Compost Systems

- Container is not essential
- Min. size 1 cubic yard – 3x3 ft
- Hot or Cold composting

186

Open Compost Containers

- Min. size 1 cubic yard – 3x3 ft
- Walls determine size
- Can hold in moisture



187

Closed Compost Containers

- Fixed
- Rotating

Simple plastic compost bin from local waste collection company

Double rotating bins allow for compost in 2 stages

Convenient location in vegetable garden

188

Three-Chambered Bin

Three batches of compost in varying stages of decomposition

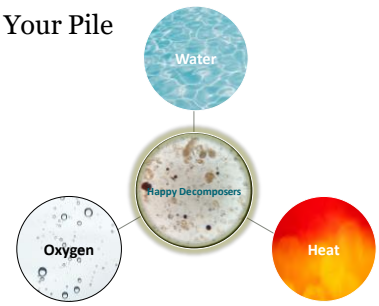
- Bin #1 for 3-6 weeks
- Turn into bin #2 for 4-8 weeks
- Turn into bin #3 to cure
- Meanwhile start another pile in bin #1
- Sift finished compost if desired

System with built-in sifter

Removable slats in the front for easy access

189

Caring for Your Pile



190

Oxygen

55-65% free air space

FREE AIR SPACE TEST from UMN

Supplies needed: 5-gallon bucket, 1-gallon plastic milk jug, compost

1. **Use 1 gallon jug to put 5 gallons of water in bucket. Mark this level as the 'full line'.**
2. **Empty water out and fill bucket 1/3 full with compost.**
3. **Drop bucket 10 times from a height of 6 inches onto hard surface, to settle everything.**
4. **Add more compost to 2/3 full and drop 10 times. Fill pail to full line and drop 10 times.**
5. **Use the 1-gallon jug to add water to full line.**
   a) **2.75 -3.25 gallons means adequate air space.**
   b) **Less than 2.75 gallons means inadequate air space. Add bulking materials like straw or coarse wood chips.**
   c) **More than 3.25 gallons means too much air space. Reduce particle size of compost (grind, shred or add finer materials).**

191

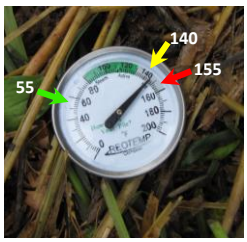
Turning Your Compost

Aeration = Oxygen

192

Temperature

- Active composting occurs between 55°F to 155°F
- < 55°F = too cold for most microbes
- >140°F = too hot for most microbes, but good for curing
- 120-150°F for 15+ days = most pathogens killed
- A soil or compost thermometer is useful



193

Water

40% to 60% moisture is best

- As wet as a squeezed-out sponge
- If too dry, bacterial activity will slow or cease
  - Add water as you turn the pile
- If too wet anaerobic conditions occur
  - Add browns and/or turn the pile

194

When is Compost Finished?

- No longer heats up when turned
- Dark brown color
- Crumbly and loose
- Smells earthy
- Original materials are mostly not recognizable
  - Sift out twigs, woody material
- Pile has shrunk to about 1/3 original volume

195

Be Patient – Let Compost Cure

Uncured compost

- Can burn plants through phytotoxicity
- Can foster root rot and damping off in young seedlings
- Can rob the soil of nitrogen
- Could still have herbicide residues if those were present

Allow to cure at least 4 weeks

Nasturtiums and tomatoes growing in unfinished compost

196

Tests for Finished Compost

Important for compost used in potting mix or for seedlings

Bag test: sealing compost in a plastic bag for several days should produce no foul odor

Germination test: compare seed germination in compost vs. standard potting mix

Finished compost Potting mix

197

Harvesting Compost

- Sift if desired
- Recognizable plant material? Outer parts of pile may not be finished.
- Turn unfinished material into center of new pile

Sifting compost with hardware cloth in a frame

Uncomposted material around outside edge of pile

198

Using Finished Compost

- Soil amendment
  - Work well into soil. Add to planting holes.
- Mulch (if seed-free)
  - Won't deter weeds.
- Lawn topdressing (if seed-free)
  - Core lawn, rake in fine compost. Seed-free only.
- Potting mix
  - <1/3 by volume. Fine, well-cured compost.
- Don't over-apply

Weed and other seeds sprouting in a sample of cold compost

199

Commercial Compost

- Inspect for trash
- Earthy smell
- Questions to ask vendor:
  - Ingredients?
  - Temperature
  - Tested for contaminants, herbicide residues?
  - Length of time composted
- Evaluate effect on seedlings before using

201

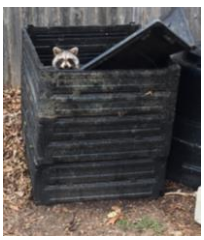
Compost Troubleshooting

Problem	Cause	Remedy
Foul smell	Meats	Remove meat
Foul smell	Anaerobic (low oxygen) conditions. Excess moisture, compaction	It needs more air and less water. Turn pile, add browns
Ammonia odor	Too much N or pH too high	Add high carbon material (browns), turn pile
Pile is too dry		Add more moisture
Pile is too wet	Needs more air and less water	Turn pile, add browns. Cover in rainy weather.
Pile won't heat up	It is too small, or weather is too cold	Build a larger pile and cover it.

202

Animals and Compost Piles

- Rodents and raccoons
  - Remove meaty, fatty foods
  - Turn pile to raise temperature
  - Use rodent-proof bin
- Flies and gnats
  - Don't leave kitchen waste exposed.
  - Mix or cover with brown materials, finished compost, or soil
- Snakes
  - Not pests – garden helpers
  - Say thanks and move on!
- Dogs
  - Cover the pile



203

Manure vs. Compost

- Compost is the active management of manure and bedding
- Composts are lower in plant-available N
- Composting kills weeds seeds & pathogens
- More uniform material, can be easier to handle

204

Herbicides in manure and compost

- Clopyralid and aminopyralid herbicides can persist in manure and compost
- Active at very low concentrations
- Do not use manure or compost from animals fed forages treated with these herbicides in vegetable or home gardens (kills broadleaf plants)

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Food safety considerations with fertilizers

- Raw manure
- Composted manure*
- Compost made with no manure
- Commercial organic or chemical fertilizers

High risk

Low risk

* Compost needs to be properly heat-treated.

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How to minimize risk from fertilizers

- Do not use non-composted manure in your edible garden.

- If you do use manure:
  - Incorporate it into the top 8" of soil.
  - Apply at least 90 or 120 days before harvest.
  - Be aware of potential from cross contamination
  - Be very careful when using manure or compost teas for foliar feeding.

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Other Soil Amendments

- Leaves, plant materials, food wastes and other composted materials
- Sawdust, wood shavings
- What about using stall waste from a horse farm on your garden?

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What About Wood Ashes?

- Readily available K, Ca, and Mg
- Increase soil pH
- Salt injury could be a problem if too much is applied
- Avoid direct contact with plant roots

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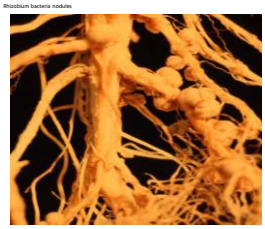
Benefits of Cover Crops to Soil Fertility

- Nutrient cycling
- Nitrogen additions by Rhizobium associated with legumes
- Enhanced phosphorus availability
- pH buffering
- Energy and food source for soil biota



http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs142p2_050219.jpg

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Applying fertilizers

- Nitrogen in chemical fertilizers is highly soluble, do not need to mix into soil but do need to irrigate.
- Organic sources of N should be mixed into top 2-3 inches
- Phosphorous moves slowly in the soil. Mix in or band below seeds.
- Potassium fertilizers should be worked into the soil. Do not allow K fertilizers to contact plant roots.

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Nutrient mobility & placement

- Broadcast (incorporate or topdress)
- Band
- Side dress

Nutrient	Mobility in soil
Nitrogen	Mobile as nitrate; Immobile as ammonium
Phosphorous	Immobile
Potassium	Somewhat mobile
Calcium	Somewhat mobile
Magnesium	Immobile
Sulfur	Mobile

See page 3 of "Fertilizing your Garden"

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Best Practices: 4Rs of Nutrient Management

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Best Management of Nutrients

- Apply fertilizer in small doses
- Keep fertilizer application rates in balance with crop utilization rates
- Use soil tests to evaluate trends
- Protect water sources
- Prevent erosion & runoff
- Use conservation tillage

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Take home message

- Soil is alive and complex
- Soil is more than "dirt"
- Add organic matter!
- Keep the soil covered
- Apply lime and fertilizer based on soil test results
- Correct pH is essential for nutrient availability

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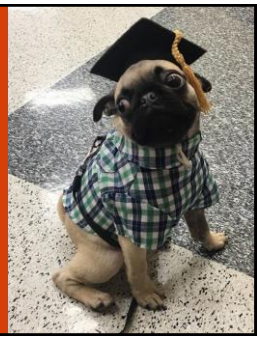
Congratulations!

Welcome to the world of soil science class of 2022!



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Credits

OSU Faculty who contributed to this presentation:

Logan Bennett
Singe Danler
Melissa Fery
Gordon Jones
James Cassidy
Steve Renquist (Retired)
Sara Runkel (Former)

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NRCS Soil health lessons in a minute: how healthy soil should look

- https://www.youtube.com/watch?v=2JZJB4zM3Y4&list=PL4J8PxoprpGbRi3gZ-fWN0dGD8bnnq3wM

Understanding the Basics: Buz's 'Fab-Five Facts of Healthy Soil'

- https://www.youtube.com/watch?v=4BTW28oeKJw&list=PL4J8PxoprpGa3wFYSXFu-BW_mMatIeIt0&index=30

The Science of Soil Health: Changing The Way We Think About Soil Microbes

- https://www.youtube.com/watch?v=EyKfpOso8q8

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