Soils, Soil Characteristics and Factors Affecting Management
What is Soil?

Mineral
- Sand, Silt, Clay

Organic Matter
- Decomposed Plants
- Decomposed Microorganisms
- Decomposed Animal Material
Soil Profiles

- Note difference in top soil depth, organic matter, color, and clay content.
Harney soil
Harney silt loam
Factors Involved In Soil Formation

- Climate
- Parent Material
- Ecology (plant and animal life)
- Slope
- Time
Average Annual Precipitation
Soil Microorganisms

- N fixation in legume crops (Rhizobium)
- Decompose organic materials
  - Crop residues
  - Organic chemicals
- Diseases
- Mineralize and immobilize nutrients
# Soil Microorganisms

## Amount of organisms in top foot of soil

<table>
<thead>
<tr>
<th>Organism</th>
<th>Number/gram soil</th>
<th>Typical Pounds/acre-foot soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria</td>
<td>1 Billion</td>
<td>750</td>
</tr>
<tr>
<td>Actinomycetes</td>
<td>15 Million</td>
<td>1,100</td>
</tr>
<tr>
<td>Fungi</td>
<td>1 Million</td>
<td>1,700</td>
</tr>
<tr>
<td>Protozoa</td>
<td>1 Million</td>
<td>300</td>
</tr>
<tr>
<td>Algae</td>
<td>100,000</td>
<td>250</td>
</tr>
<tr>
<td>Yeasts</td>
<td>1,000</td>
<td>---</td>
</tr>
<tr>
<td>Worms and Insects</td>
<td>---</td>
<td>900</td>
</tr>
</tbody>
</table>

Soil Microbes Mineralize and Immobilize Plant Nutrients.

Organic nutrients

- Plant Unavailable Form

Inorganic nutrients

- Plant Available Form

Mineralization

Immobilization
FACTORS AFFECTING SOIL MICROBIAL ACTIVITY

Soil Temperature
  80 to 90° optimum
Soil Moisture
  Near field capacity
Soil Aeration
  Related to soil moisture
Soil pH
  6 to 7 optimum
Organic matter/residue
  Food source
'Biological Activators'

- With few exception, they do not work
- Soil microbe population resistant to change
- Best way to stimulate soil microbes is to provide high levels of organic residues
- Fertilizers generally beneficial to soil microbes
Why Soils Vary in Productivity

- Soils tend to be vary greatly in chemical and physical properties even within fields that appear uniform.
- This variability is the source of the interest in intensive soil sampling and variable rate technology.
- Let’s look at soil properties that affect crop production.
Soil Physical Properties Affecting Soil Productivity

- Drainage
- Color
- Depth of Rooting Zone
- Structure
- Slope
- Texture
- Porosity
- Permeability

Soil Productivity
## Depth of Rooting Zone

<table>
<thead>
<tr>
<th>Crop</th>
<th>Rooting Depth</th>
<th>Major Feeding Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>4 - 6 ft.</td>
<td>80% in top 3 ft.</td>
</tr>
<tr>
<td>Corn</td>
<td>4 - 7.5 ft.</td>
<td>75% in top 2 ft.</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>4.5 - 6 ft.</td>
<td>75% in top 3.5 ft.</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>20 ft. +</td>
<td>50% in top 3.5 ft.</td>
</tr>
<tr>
<td>Bromegrass</td>
<td>5.5 - 6.5 ft.</td>
<td>75% in top 3.5 ft.</td>
</tr>
</tbody>
</table>

Weaver, Root development of field crops
Soil Structure

• The arrangement of soil particles into larger units

• Structure affects soil permeability, porosity and root growth

• Affects resistance to surface crusting

Structure is destroyed by ?

Structure is improved by ?
Kinds of Soil Structure

Crumb ← Desirable → Granular

Platy (less desirable)

Angular Blocky

Prismatic

Subangular Blocky

Columnar
Bulk Density

• The weight of a unit volume of soil, including any air space and organic materials.

• Average soil bulk density for a cultivated loam is 68 to 87 lb/cu ft or 1.1 to 1.4 g/cu cm

• Soils compacted will have higher bulk densities

• Good growth below 87 lb/cu ft for clays and 98 lb/cu ft for sands
1. TRAFFIC OR TILLAGE WHEN SOIL IS WET.

SOIL BULK DENSITY

WATER CONTENT
Soil Porosity and Permeability

• Porosity is the total amount of pore space in the soil (30 to 60%)
  – Affects the storage of air and water
  – Affects the rate of movement of air and water

• Permeability is the ease in which water, air, and plant roots move through the soil
  – Ease of air, water and root movement
  – Affects rate of water intake and drainage

• Porosity and permeability are affected by soil texture, structure, organic matter and compaction
Soil Textural Triangle
# Soil Texture as Defined by Soil Textural Class and Estimated by a Hand-Feel Method

<table>
<thead>
<tr>
<th>Soil Textural Group</th>
<th>Soil Textural Class</th>
<th>Feel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse Sand</td>
<td>Feels gritty does not leave a very coarse ribbon or smear on hand.</td>
<td></td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>Sandy loam</td>
<td>Feels gritty does not leave coarse ribbon, breaks into small pieces.</td>
</tr>
<tr>
<td>Medium Loam</td>
<td>Feels smooth and flour-like, does not ribbon, breaks into pieces about 1/2 inch long or less</td>
<td></td>
</tr>
<tr>
<td>Silt Loam</td>
<td>Silt</td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td>Clay loam</td>
<td>Forms ribbon that breaks into pieces about 3/4” long</td>
<td></td>
</tr>
<tr>
<td>Sandy clay</td>
<td>Forms long pliable clay ribbons</td>
<td></td>
</tr>
<tr>
<td>Silty clay</td>
<td>2” or longer</td>
<td></td>
</tr>
<tr>
<td>Clay</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparative Size of Sand, Silt and Clay

- **Sand**: 2.00-0.05 mm
- **Silt**: 0.05-0.002 mm
- **Clay**: Less than 0.0002 mm

Clay Surface Area

- 1,000X equal weight of Sand
- Acre plow depth equals the surface area of the U.S.A.
Types Of Soil Clay

- **Kaolinite**
  - Lower CEC and water holding capacity
  - Not a shrink/swell clay
  - Dakota Sandstone formation in central Kansas

- **Montmorilinite**
  - Predominant clay in Kansas
  - High shrink/swell - ‘gumbo’ if high clay content
  - High CEC and water holding capacity

- **Illite**
  - High potassium soils
  - Good tilth, water holding capacity
  - No shrink/swell
**Soil Water**

**EXCESS OR GRAVITATIONAL:** amount of water between saturation and field capacity.

**AVAILABLE SOIL WATER:** water held by capillary forces between field capacity and permanent wilting point.

- **Saturation**
  - Readily Drained Water

- **Field Capacity**
  - Water Managed by irrigation scheduling

- **Minimum Balance**
  - Water available to plant under stress

- **Permanent Wilting**
  - Water Unavailable to plants

- **Oven Dry**
Soil Moisture Holding Capacity

Water is attracted to soil particles and held as a film against the pull of gravity. Water closest to the soil particle is held the most tightly.

At field capacity gravity drainage has ceased.

Pore Space

Water Film

Soil Particle

Forces of Surface Tension
Soil Moisture Holding Capacity

Wilting Point

At permanent wilting point, soil clay particles have greater affinity for water than plants' ability to compete.

Plant Root

Forces of Surface Tension

Water Film

Soil Particle
Water holding Capacity as Affected by Soil Texture

- **Field Capacity**
- **Available Water**
- **Permanent Wilting Percentage**
<table>
<thead>
<tr>
<th>Crop</th>
<th>Maximum ET</th>
<th>Threshold ET</th>
<th>Yield vs. ET</th>
<th>Long-term Yield vs. ET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full-season Variety</td>
<td>inches water</td>
<td>inches water</td>
<td>bu/acre/inch</td>
</tr>
<tr>
<td>Corn</td>
<td>25</td>
<td>10.9</td>
<td>16.8</td>
<td>12.6</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>21</td>
<td>6.9</td>
<td>12.2</td>
<td>9.1</td>
</tr>
<tr>
<td>Sunflower</td>
<td>22</td>
<td>5.4</td>
<td>220 *</td>
<td>150 *</td>
</tr>
<tr>
<td>Winter Wheat</td>
<td>23</td>
<td>10.1</td>
<td>6.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Soybean</td>
<td>23</td>
<td>10.0</td>
<td>5.5</td>
<td>4.25</td>
</tr>
</tbody>
</table>

Source: L. Stone, Kansas State University, 15th Central Plains Irrigation Conference Proceedings, Feb. 4-5, 2003, Colby, KS
### Available Water For Several Kansas Soils

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Depth</th>
<th>Available Water</th>
<th>Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches</td>
<td>inches/foot of soil</td>
<td>Inches/hour</td>
</tr>
<tr>
<td><strong>Harney silt loam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-7</td>
<td>2.2</td>
<td></td>
<td>0.2-0.3.</td>
</tr>
<tr>
<td>7-18</td>
<td>2.2</td>
<td></td>
<td>0.2-0.3.</td>
</tr>
<tr>
<td>18-26</td>
<td>2.2</td>
<td></td>
<td>0.1-0.2</td>
</tr>
<tr>
<td>26-60</td>
<td>2.2</td>
<td></td>
<td>0.2-0.4</td>
</tr>
<tr>
<td><strong>Richfield silt loam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-6</td>
<td>2.2</td>
<td></td>
<td>0.2-0.4</td>
</tr>
<tr>
<td>6-34</td>
<td>2.2</td>
<td></td>
<td>0.2-0.4</td>
</tr>
<tr>
<td>34-60</td>
<td>2.2</td>
<td></td>
<td>0.2-0.4</td>
</tr>
<tr>
<td><strong>Pratt loamy fine sand</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-70</td>
<td>1.4</td>
<td></td>
<td>2.0-5.0</td>
</tr>
<tr>
<td><strong>Wymore silty clay loam</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-6</td>
<td>2.6</td>
<td></td>
<td>0.2-0.6</td>
</tr>
<tr>
<td>6-26</td>
<td>1.6</td>
<td></td>
<td>0.06-0.2</td>
</tr>
<tr>
<td>26-60</td>
<td>2.3</td>
<td></td>
<td>0.2-0.6</td>
</tr>
<tr>
<td><strong>Parsons</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-14</td>
<td>2.4</td>
<td></td>
<td>0.6-2.0</td>
</tr>
<tr>
<td>14-60</td>
<td>2.2</td>
<td></td>
<td>&lt; 0.06</td>
</tr>
</tbody>
</table>
Erosion

- Erosion moves detached soil particles by wind or flowing water
Detachment

- *Detachment* separates individual soil particles from the soil matrix, e.g. by impact from raindrops, other soil particles, hooves or wheels.
Soil Erosion by Water

- **Sheet erosion** - soil is eroded uniformly across a slope

- **Rill erosion** - numerous tiny gullies (rills) randomly occur

- **Gully erosion** - with increased rainfall duration and intensity, runoff volumes increase and concentrate in small ravines
Sheet/Rill Erosion
Rill Erosion
Gully Erosion
Universal Soil Loss Equation (RUSLE)

Erosion (ton/a) = R * K * LS * C * P

R.... Climate (rainfall index)
K.... Soil Erodibility Factor
LS .. Slope Steepness & Length
P..... Soil Surface Conditions / Practices
C.... Vegetative Cover
Wind Erosion
Westcentral-Northwest Kansas Memorial Weekend, 2004
Westcentral-Northwest Kansas Memorial Weekend, 2004
Wind Erosion

• Similar to water, except wind becomes transports

Three types of movement:

1. Suspension
2. Saltation
3. Surface Creep

• Once soil particles begin to move, they have abrasive action on the soil surface, and break down soil aggregates.
Wind Erosion

Sandy soils are most susceptible to wind erosion - because usually poorly aggregated (less O.M., clay to form aggregates)

Conditions conducive to Wind Erosion:
* Poorly Aggregated
* Bare Soils
* Loose Surface
* Dry

Prevention of Wind Erosion:
* Windbreaks
* No-till
* Crop Residues
* Stubble Mulch
Ground Cover Reduces Erosion

Note: 30% residue cover reduces soil loss >50%
% ORGANIC MATTER

TOPSOIL DEPTH (INCHES)

Y = 0.85 + 0.57 ln(X)

R^2 = 0.63 **
Soils, Soil Characteristics and Factors Affecting Management
Review Exercises

1. Which of the following is not a major factor affecting soil development and its eventual productivity:
   a. Climate.
   b. Parent material.
   c. Native wildlife.
   d. Native vegetation.

2. For optimum plant growth conditions, a desirable surface soil should have approximately _____% pore space for air and water.
   a. 15.
   b. 35.
   c. 50.
   d. 75.

3. The following is a parent material deposited by wind:
   a. Alluvium.
   b. Loess.
   c. Glacial till.
   d. Colluvium.
4. As a general rule, most potassium deficient soils and those requiring lime occur in humid regions receiving in excess of about 30" of annual precipitation.

   a. True.
   b. False.

5. Subsoil fertility does not contribute significantly to a crop's nutritional requirements.

   a. True.
   b. False.

6. A fertile soil is always a productive soil.

   a. True.
   b. False.
. Soil structure has considerable influence on soil:

a. Porosity.

b. Permeability.

c. Drainage.

d. All of the above.

e. None of the above.

. Of the three size classes of mineral particles comprising soil texture (sand, silt, and clay), only silt contributes significantly to soil fertility.

a. True.

b. False

. Sand particles are primarily composed of:
1. A silt loam soil can typically provide plants about _____" of available water per foot of soil.

   a. 1.
   b. 2.
   c. 4.
   d. 5.

2. Organic matter is an important contributor of all of the following nutrients: potassium, nitrogen, phosphorus, and sulfur for good plant nutrition.

   a. True.
   b. False.
4. Which of the following does not have a significant influence on organic matter content:
   a. Temperature and precipitation.
   b. Drainage.
   c. Slope and erosion.
   d. Bulk density.

5. Fertilizer generally has a positive effect on soil microorganisms by providing nutrients and increasing crop residues.
   a. True  b. False

6. An acre of soil to a tillage depth of 6" to 7" weighs approximately __________ lb (see Page 17).

7. Soil is most subject to compaction when the soil moisture