Soil and Water Conservation CCA Study Session

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Overview of CCA materials for Soil and Water Conservation

- **Soil Management:**
  - Soil Properties
  - Erosion
  - Residue Management
  - Restrictive Soil Layers
  - Air Quality
  - Site Evaluation

- **Water Management:**
  - Water and Solute Movement
  - Soil-Plant/water relations
  - Irrigation and Drainage
  - Water Quality
Basic Soil Properties

- Chapter 1 of Soil Fertility Handbook
  - Formation
  - Soil Components
  - Soil profiles
  - Texture
  - Structure
- Cation Exchange Capacity
Soil Forming Factors

- Parent material,
- Climate,
- Living organisms,
- Topography,
- Time.
Soil Components

- Mineral (Sand, Silt, and Clay)
- Air
- Water
- Organic Matter
Soil Profile Horizons

- **O** = organic layer
- **A** = Topsoil
  - Elevated organic matter
  - Granular structure
- **B** = Subsoil
  - Elevated clay
  - Blocky structure
- **C** = unconsolidated parent material
- **R** = Rock
Soil Texture

- **Sand**
  - 2.0-0.05 mm
- **Silt**
  - 0.05-0.002 mm
- **Clay**
  - <0.002 mm
Soil Characteristic Influenced by Texture

- Reactive surface area:
  - Nutrient holding capacity
  - Water holding capacity
  - Organic matter content

- Pore size
  - Water infiltration
  - Air movement
  - Ease of root growth

Increase with clay content
Increase with sand content
The arrangement of soil particles into aggregates

Aggregates are clusters of sand, silt, clay, and organic material.
**Granular:** Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.

**Blocky:** Irregular blocks that are usually 1.5 - 5.0 cm in diameter.

**Prismatic:** Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.

**Columnar:** Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.

**Platy:** Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.  
Soil Science Society of America

**Single Grained:** Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.
Cation and anion exchange capacity

- Describes soils ability to adsorb nutrients
- Cations are positive: $\text{Ca}^{2+}$, $\text{Mg}^{2+}$, $\text{K}^+$, etc.
- Anions are negative: $\text{NO}_3^-$, $\text{SO}_4^{2-}$

Soils are dominated by cation exchange capacity

Clay and organic matter contain Cation Exchange sites
Site Characterization

- Soil depth
  - Surface and total Depth
- Drainage
  - Excessive
  - Poor
- Slope
Soil Depth Influences

- Water holding capacity
- Potential root growth volume
- Nutrient supply
Slope Influences

- Water runoff
  - Water availability for crop growth
  - Erosion
- Field operations
- Expressed as % changes in elevation along a slope
  \[100 \times \frac{1\text{ ft}}{100\text{ ft}}\]
Internal Drainage

- Poorly drained soils:
  - High clay content, shallow bedrock, shallow water table
  - Restricts root growth and respiration
  - Delay planting and spring warm up

- Rapidly drained soils:
  - Sandy soils
  - Excessive leaching of nutrients
  - Droughty
NRCS County Soil Survey

- Soil profile analysis and landscape position are used to map soils
- County Survey provides these maps and soil descriptions
- Can be used to determine
  - Crop production potential
  - Limitations of land
    - Wetness, droughty, low fertility erosivity, etc.
  - Now available on-line
Web soil survey

http://websoilsurvey.nrcs.usda.gov
Erosion
Impacts of Erosion on Crop Production

- Removes top soil
  - Reduces fertility
  - Degrades soil structure
    - Air and water movement, and root growth
  - Removes organic matter
  - Reduces water holding capacity

- Direct damage to crops
  - Burial and removal of crops
Off-site impacts of Erosion by Water

- Sediment is the #1 contaminate in surface water bodies.
- Sedimentation of waterways and reservoirs.
- Air quality degradation and burial of fences, ditches and roads.
Factors that Influence Erosion by Water

- Texture
- Climate
- Slope (steepness and length)
- Residue/crop cover
Texture’s influence on Erosion by Water

- Clayey soils are adhesive and therefore resist erosion
  - Clay Loam
- Large sands are difficult to move, and rapid infiltration minimizes runoff
  - Loamy Sand
- Silty soils are highly erosive because they are not adhesive and are very light weight.
  - Silt Loam
Climate’s influence on Erosion by Water

- Potential for erosion increases with increasing intensity and magnitude of rainfall
- Rainfall Erosion Index

Image from: Troeh, et al. (1991)
Slope’s influence on Erosion by water

- **Steepness** of slope influence velocity of runoff.
- **Length** of slope influences volume of water traveling down slope.
- Terraces dissect the slope length to reduce erosion and provide a shallow slope in the terrace channel for water diversion.
Residue and Crop Cover Impacts on Erosion by Water

- Residue protects the soil from raindrop impact.
- Raindrop impacts initiate erosions.
- Also causes surface crusting which reduces infiltration.

Types of Erosion by Water

- **Sheet:**
  - The removal of thin layers of soil over the whole surface

- **Rill:**
  - Occurs when runoff water concentrates in streamlets
  - Rills can be removed with normal tillage

- **Classic Gully:**
  - Channelized erosion that can not be erased by normal tillage.
Universal Soil Loss Equation (USLE)

- Provides estimate of sheet and rill erosion.
- \( A = R \times K \times LS \times C \times P \)
- \( R \) rainfall erosion index (Map of rainfall erosivity)
- \( K \) = soil erodibility (Soil Survey)
- \( LS \) = Slope and Length of slope
- \( C \) = Crop Management factor (tillage and crop)
- \( P \) = Conservation Practice (contour farming)
Factors Controlling Erosion by Wind

- Residue and crop cover
  - Most cost effective method to reduce wind erosion
- Wind velocity
  - 13 mph at 1 ft above soil can cause erosion
- Unsheltered distance
- Soil surface roughness
- Soil texture
  - Loamy sands are highly susceptible.
Types of Wind Erosion

- **Suspension:**
  - Small particles (<0.05 mm) are suspended in turbulent air until rainfall washes them back to surface or wind velocity is dramatically reduced.

- **Saltation:**
  - Intermediate particles (0.05-0.5 mm) move in a series of leaps.
  - Continued impacts dislodge other particles.

- **Surface creep:**
  - Large grains (>0.5 mm) are bumped along surface by saltation.
Residue and Tillage Management

- Temperature
  - Residue buffers against rapid changes

- Moisture
  - Residue buffers rapid changes

- Erosion
  - Maintenance of residue is the cheapest way to control erosion

- Tillage causes rapid decomposition of organic matter
Increasing organic matter improves:

- Water holding capacity
- Soil structure
- Fertility
- Reduces crusting
Restrictive Layers

- Naturally occurring Layers
  - Clay pans
  - Rock
- Crusts
- Tillage induced compaction
- Traffic Compaction
  - Deep vs shallow
Soil Crusting

- Reduces water infiltration
- Reduces crop emergence
- A soil’s susceptibility to crusting is influenced by texture, sodium content, and organic matter
Tillage Induced Compaction

- Caused by repeated tillage at a constant depth
- Horizontal soil structure is a visible symptom
Traffic induced compaction

- Surface compaction can be reduced by increasing footprint.
- Subsurface compaction is dictated by Axle load.
Air Quality

- Manure application methods
  - Odor and NH3

- Tillage and wind erosion
  - Can produce Paticulate matter

- Tillage can influence CO2 in the atmosphere

- N fertilizer applications produce N2O and NH3
Evapotranspiration
Water Cycle

- Precipitation
- Irrigation
- Runoff
- Drainage
- Evaporation
- Transpiration
Factors effecting Infiltration and Runoff

- Texture
- Structure
- Organic Matter
- Surface Residues
- Landscape Position
- Surface roughness
Factors influencing Leaching Potential

- Texture
  - Sands > clays
- Cation Exchange Capacity
- Concentrations
- Nutrient and/or solute chemistry
  - Cations (positively charged) generally don’t leach as readily as anions
Factors that impact Runoff losses of Nutrients

- Application Timing
- Rate of application
- Erosion
- Runoff amounts
- Drainage
- Cropping system
- Tillage.
Soil water terms

- Saturation
- Field Capacity (-33 kPa, water held against the force of gravity)
- Permanent wilting point (-1500 kPa, water that can’t be extracted by plants)
- Gravitation water (removed by gravity)
- Plant available water
Irrigation Systems

- Furrow
- Flood
- Sprinkler
- Drip/trickle
- Subsurface
Sprinkler Irrigation (Low Pressure Applicators)

- Listed from lowest to highest efficiency
  - Impact Sprinklers
  - Mid-elevation spray application (MESA)
    - 18-36 inches above the ground
  - Low-elevation spray application (LESA)
    - 12-18 inches above ground
  - Low energy precision application (LEPA)
    - Drag lines and bubblers
Flood Irrigation

- Listed from lowest to highest efficiency
- Wild flooding
- Basin flooding
- Boarder flooding
- Furrow
Water Balance Equation

- $D_c = D_p + E_{tc} - P - I_{rr} + R_O + D_R$

Where

- $D_c =$ current soil water deficient
- $D_p =$ soil water deficient of previous day
- $E_{tc} =$ Evapotranspiration
- $P =$ Precipitation
- $I_{rr} =$ irrigation
- $R_O =$ runoff
- $D_R =$ Drainage
15 year average Daily Evapotranspiration

- Peak ET for Corn

Date

- 3/11
- 4/30
- 6/19
- 8/8
- 9/27
- 11/16
- 1/5
- 2/24

Daily ET (inches)

- Corn
- Cotton
- Sorghum
- Soybeans
Irrigation capacity will impact ability to catch up

Vegetative growth

Critical period

Allowable Deficient

Permanent Wilting point in root zone

Soil water deficient
Irrigation Water Quality

- **Salts and Sodium**
  - Salt decreases water availability
  - Sodium caused dispersion and reduced permeability
  - Both can catastrophically impact productivity

- **Excess Alkalinity (Ca and/or Mg Carbonates)**
  - Cause scale build up in system

- **Boron**
  - Toxic to crop growth
Interaction between Sodium and Salinity (EC) of irrigation water
Sodium Adsorption Ratio (SAR)

SAR is the ratio of Na/Ca+Mg in a saturated soil extract

- High levels of sodium cause soil particles to disperse
- Soil becomes structureless because of loss of aggregate stability and structure
Sodium has a large hydrated radius
Prevents adhesion of clay particles
Causes disintegration of aggregates
Soil Salinity

- Measured using Electrical Conductivity (micromhos/cm)
- EC is can be converted to Salt concentration
  - EC (micromhos/cm) * 0.66 = Salt Conc. (ppm)
  - 1000 micromhos/cm = 660 ppm
Classification of Saline and Sodic Soils

- Thresholds at which adverse soil conditions will occur
- Remediation Strategies are also different
URL for Study guide

- [http://okcca.okstate.edu/exam-study-resource](http://okcca.okstate.edu/exam-study-resource)
- [http://soilwater.okstate.edu/](http://soilwater.okstate.edu/)
  - Go to CCA
  - Click on Study Guide
- This slide set will also be on [soilwater.okstate.edu](http://soilwater.okstate.edu)