Don't treat your soil like dirt!

"Soil 101"

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UT Extension

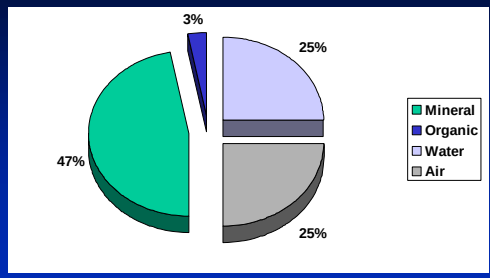
Overview

- What is soil?
- How is it formed?
- Importance of texture and structure
- What can your color soil tell you?
- Soil pH
- Soil organic matter
- Essential plant nutrients
- Soil testing
- Tillage

What is Soil?

- Unconsolidated **mineral** and **organic** material that serves as a natural medium for the growth of plants
  - Anchors plants
  - Pores: gaseous exchange ($CO_2 \leftrightarrows O_2$); water infiltration and storage
  - Moderates temperature
  - Supplies nutrients
- Recycling system for nutrients, wastes
- Habitat for numerous soil organisms
- System for water supply and purification

What is in Soil?

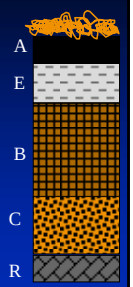


Soil Forming Factors

- Parent Material
  - Geology; wind-blown, glacial or river deposits
- Climate
  - Temperature; rainfall
- Topography / landscape position
  - Erosion
- Biota
  - Plants, animals, humans
- Time
  - Weathering; availability of nutrients

Soil Horizons

- Vertical section of soil exposing all layers of the soil
- Soils vary in number of layers and their thickness

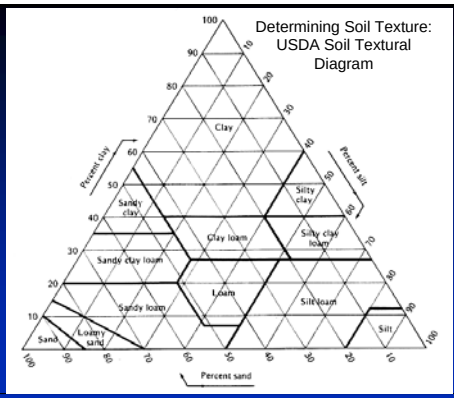


Soil Texture

- Percentage of sand, silt and clay particles
- Does not include material > 2 mm diameter (gravel, rocks etc.), or organic material
- Permanent characteristic of soil
- Important for many properties:
  - water holding capacity
  - water movement into and off soil
  - nutrient holding capacity
  - resistance to erosion
  - influences crop management
  - engineering applications

Soil Texture

- Sand: 0.05 - 2 mm diameter
  - single grained, gritty feel, SiO_2 (silicates)
- Silt: 0.002 - 0.05 mm diameter
  - smooth, floury feel, slightly cohesive,
  - quartz, feldspars
- Clay: < 0.002 mm diameter
  - stiff, sticky, very cohesive
  - secondary minerals (weathered)



Soil Structure

- Definition:
  - Aggregation of primary soil separates into compound particles that are separated from adjoining aggregates by planes of weakness
- Helps to determine drainage of soil; Influences erosion; Rooting medium; Aeration of subsoil
- Five structure types
  - Granular
  - Platy
  - Prismatic / columnar
  - Blocky: angular / sub-angular
  - "Structureless"

Soil Color

- Black - organic matter
- Grey - REDUCED IRON (Fe^{2+}), indicates poor drainage, saturated conditions, low oxygen
- Reds, browns, yellows, tans - OXIDIZED IRON (Fe^{3+}), good drainage, adequate oxygen
- White - high silica content or salts

Soil pH

- Concentration of hydrogen ions
- Measured on pH scale (1 to 14)
- Most crops need pH 5.7 to 6.5
- Micro-nutrient availability less at high pH
- Nutrient uptake; nitrification; acid rain
- Low pH (<5.5) = Al toxicity
  - Correct with calcitic or dolomitic lime
  - Determine with soil test

Soil Organic Matter

- Source of plant nutrients: N, P, S
- Soil aggregation
- CEC and buffering capacity
- Water holding capacity, air movement, etc.
- Chelation of metals (Zn, Cu)
- C supply for microorganisms
- Surface mulches regulate temperature, moisture

Humus

- Humic Substances
  - high molecular weight
  - highly aromatic ring structure
  - formed by decomposition and synthesis processes, microbial and chemical
  - Very high specific surface area
- Very high Cation Exchange Capacity
  - pH dependent
  - 200 to 300 $cmol_c/kg$
- High water holding capacity
  - 4 to 5 times its mass

18 Essential Plant Nutrients

Oxygen Hydrogen Carbon

Nitrogen Phosphorus Potassium

Calcium Magnesium Sulfur

Copper Zinc Manganese Molybdenum

Iron Chlorine Boron Nickel Cobalt

Role of Nitrogen

- Importance: proteins, chlorophyll, nucleic acids
- Low N = low yields
- Total soil N: < 400 to >8000 kg/ha
  - Available soil N = < 5% of total at any time
  - Available N = NH_4^+ and NO_3^-
    - only nutrient taken up as cation and anion
  - Remainder = organic forms and NH_4^+ "fixed" by clays

Role of Phosphorus

- The energy currency in the cell
  - ATP -- adenosine triphosphate
  - DNA--deoxyribonucleic acid
  - RNA--ribonucleic acid
- Enhances many aspects of plant physiology
  - photosynthesis, maturation
  - N-fixation, flowering, fruiting, seed production

Role of Potassium

- Enzyme activation
- Water relations – osmotic regulation
- Energy relations
  - Photosynthesis
  - Translocation
  - Protein synthesis
- Stress resistance

Nutrient Management

Supply essential nutrients

Effective & efficient use of nutrients

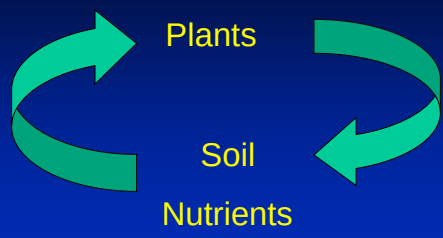
Minimize environmental degradation

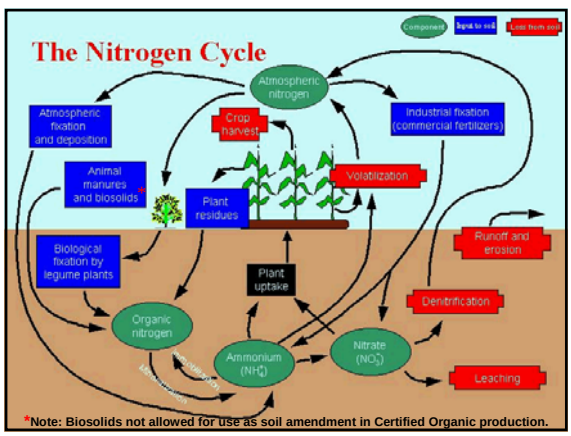
Maintain or improve soil quality

Major Nutrient Cycles

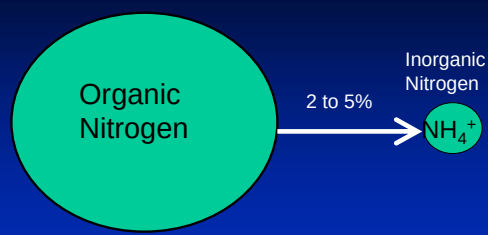
•Nitrogen: organic nitrogen, ammonium (NH_4^+), nitrate (NO_3^-), ammonia (NH_3)
•Phosphorus: phosphorus or phosphate (sold as "P_2O_5"); taken up as PO_4^{3-}, HPO_4^{2-}, $H_2PO_4^-$,
•Potassium: potash (sold as "K_2O"); taken up as K^+

Nutrient Cycling

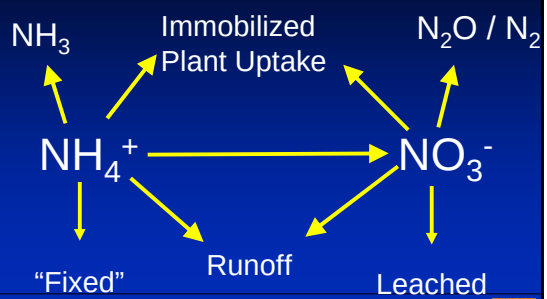




Nitrogen Mineralization



Fate of NH_4 and NO_3



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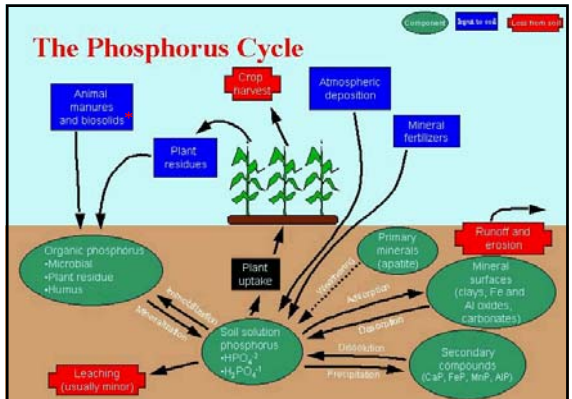
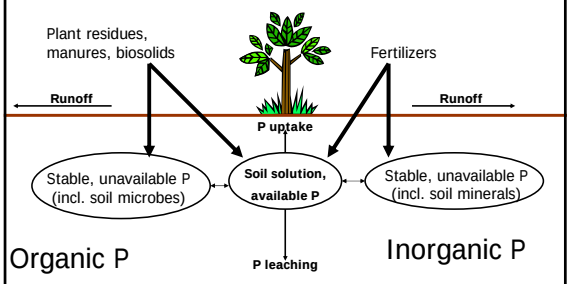
The Phosphorus Cycle



*Note: Biosolids not allowed for use as soil amendment in Certified Organic production.

Phosphorus Cycle



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Forms of Phosphorus

Minerals: Ca-P, Fe-P, Al-P, Mn-P

Soluble P (depends on pH)

PO_4^{3-} ➔ HPO_4^{2-} ➔ $H_2PO_4^-$ ➔ H_3PO_4

Fixed Inorganic P

Organic P: available & labile

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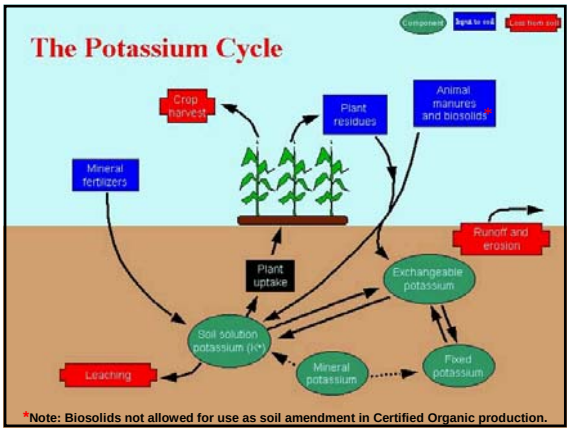
The Potassium Cycle



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Transport Mechanisms

Surface Water Runoff	N, P, K
Soil Erosion	N, P, K
Groundwater	N, K
Gas	N

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Environmental Concerns

Nitrogen: Air & Water quality
Phosphorus: Water quality
Potassium: Feed Quality

Best Management Practices

Reduce Surface Runoff & Erosion

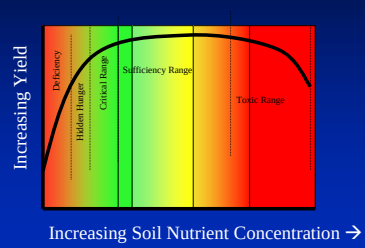
Avoid over application

Maintain soil pH

Soil Testing

- "Don't guess soil test!"
- Sampling
  - 0 – 6"
  - Random
- Lab analyses
  - Basic: P, K, pH
  - Cost: $7
  - http://soilplantandpest.utk.edu/
- Interpretation of results
- Sufficiency vs. Maintenance

Yield and Nutrient Concentration



To Till or Not to Till?

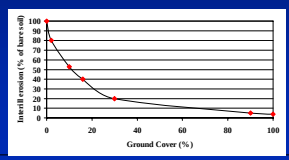
- Tillage – "a weakness in organic systems?"
- Minimize the negative consequences:
  - Timing of tillage
  - Equipment operation
  - Soil conditions
  - Crop rotation
- Primary (plows) & secondary (harrows) tillage
- No-till – 30% residue cover

Organic Certification and Tillage

- Must document tillage practices as part of Organic System Plans [NOP section §205.201(a)(1)]
- Hand weeding and mechanical cultivation are allowed weed control measures [NOP section §205.206(c)(4)]
- Records must document the frequency of tillage
- Organic inspector will consider whether tillage practices are being used in ways that maintains or improves the physical, chemical, and biological condition of the soil and that minimize soil erosion [NOP section §205.203(a)]

Tillage

- Weed management
- Destroys soil structure
- Reduces soil organic matter
- Energy intensive
- Increases erosion: 30 % cover = 80 % less erosion



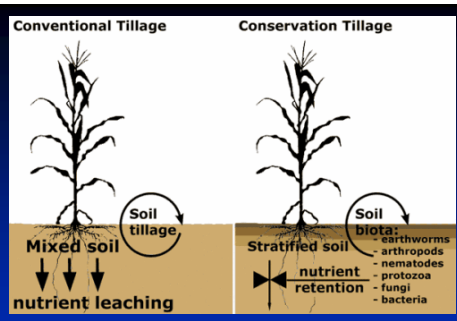
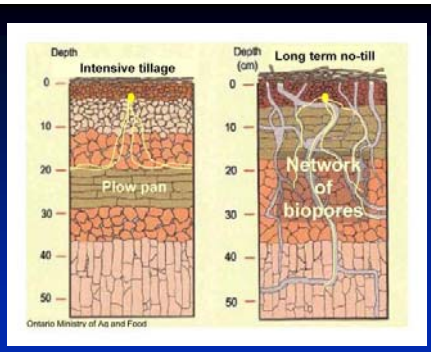


Figure credit: Ed Zaborski, University of Illinois. Adapted from House and Parmelee (1985).



Ontario Ministry of Agriculture, Food and Rural Affairs. 2008

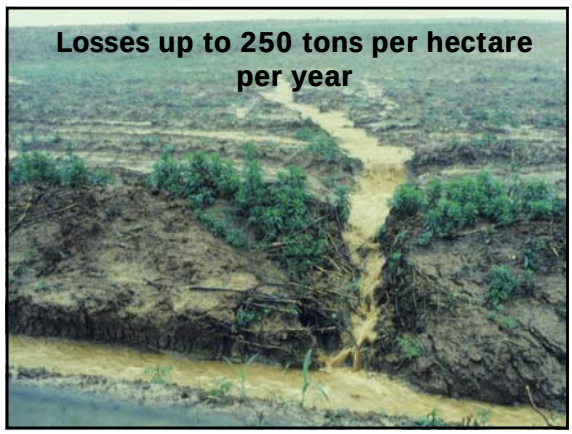
Tennessee Soils

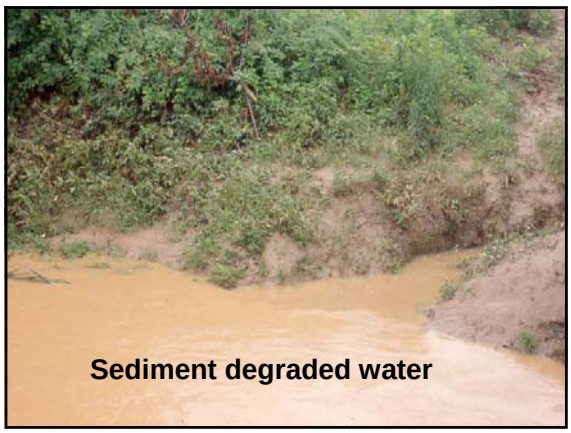
Topography very variable:

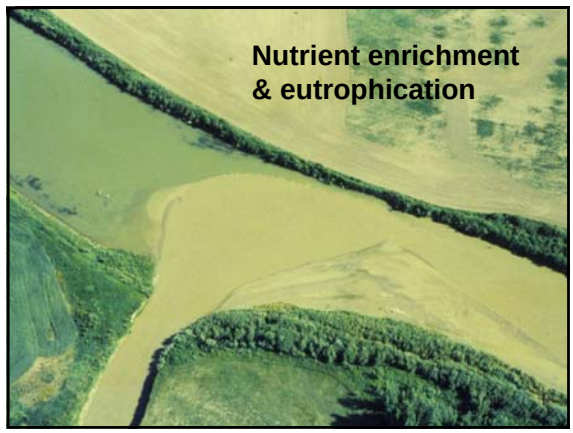
- Mountains (east)
- Flat alluvial plains (west)

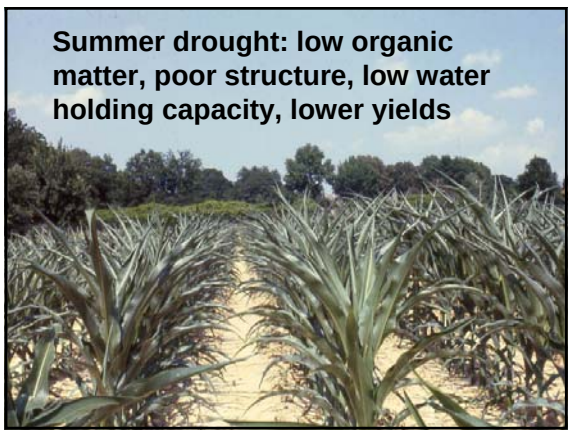
Parent materials: limestone to loess

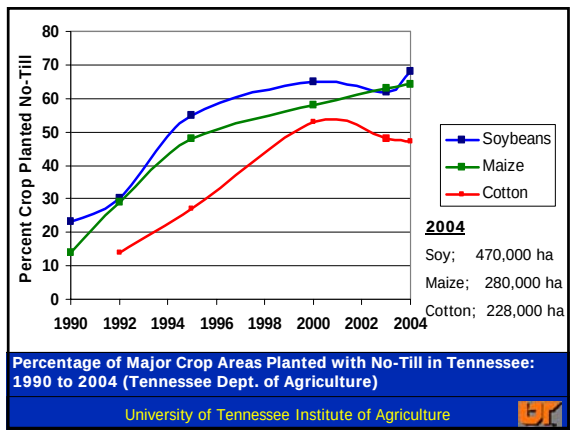
- Loess derived soils in west (very prone to erosion)



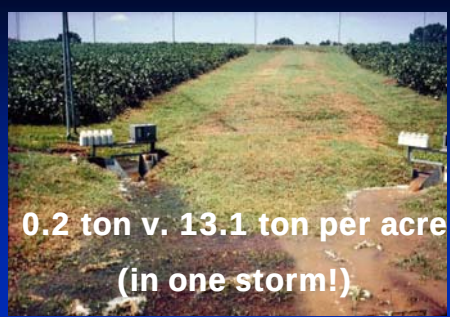








No-Till vs "Conventional"



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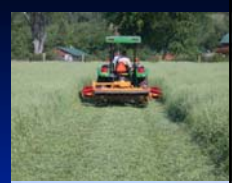
UT No-Till Organic Research

- Winter cover crop
  - Oats and crimson clover
- Crop roller
  - May 14, 2008
- Planted corn
  - May 23, 2008
- No weeding
- Harvested
  - Sept 24, 2008
- Weed suppression??



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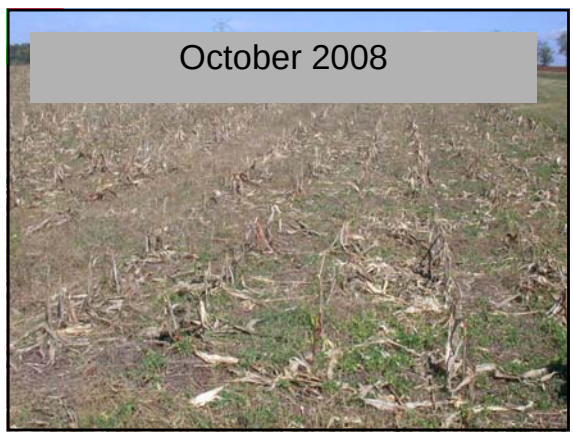
Harvesting

Oat Mulch Prior to Harvest

October 2008




January 2009


Questions?