SOIL SENSING FOR YIELD AND ENERGY-SMART FARMING – SOIL MANAGEMENT

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SOIL SCIENCE

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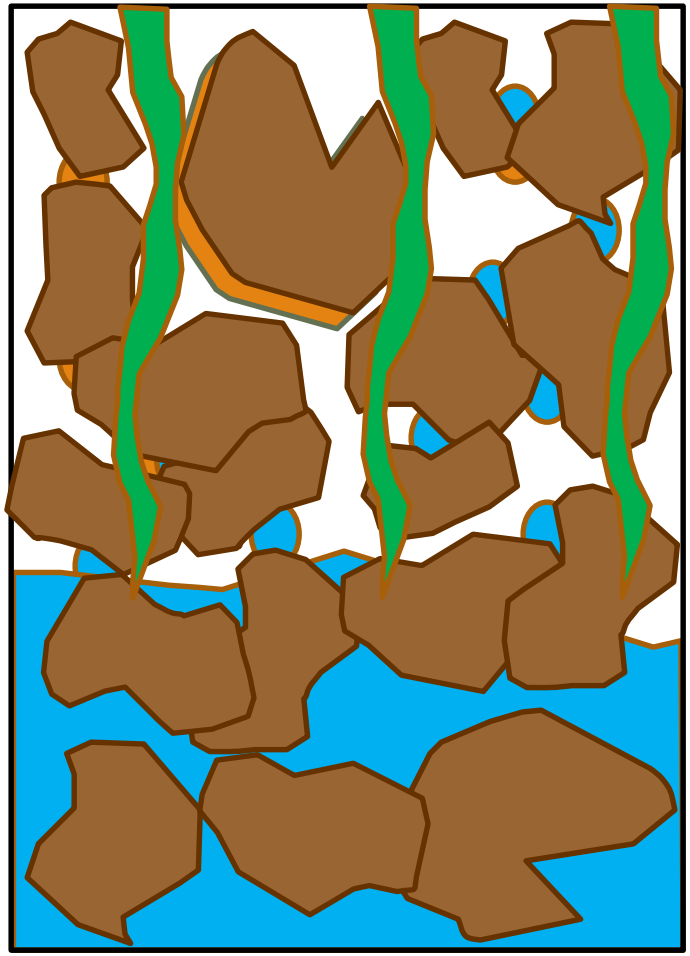
Outline

- Introduction to Soil Properties & Fertility
- Energy-Smart Farming: Soil Perspective

Soil as a 3 + 1 phase system



Sensing for Soil Nutrients requires discrimination between the soil phases

Solids

Liquids

Gas

+ Roots

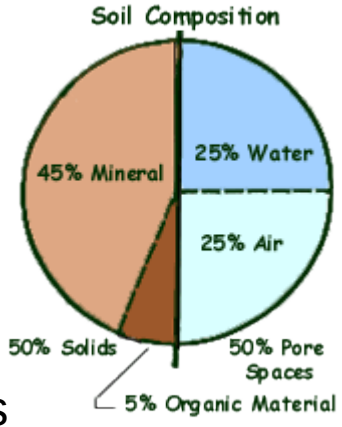
Soil Composition

<u>Solids</u>
Bulk Density/Porosity

Soil Minerals (Physical)
- •Particle Size Distribution
- •Mineralogy of silicate clays
- •Mineralogy of size-fractions

Soil Minerals (Chemical)
- •Cation Exchange Capacity
- •Exchangeable Cations and Ions
- •pH

Organic Carbon



<u>Liquids</u>
Water-filled pore space

Water-filled pore space as a function of matric potential

Extractable water chemistry

<u>Gasses</u>

Air-filled pore space as a function of water content or potential

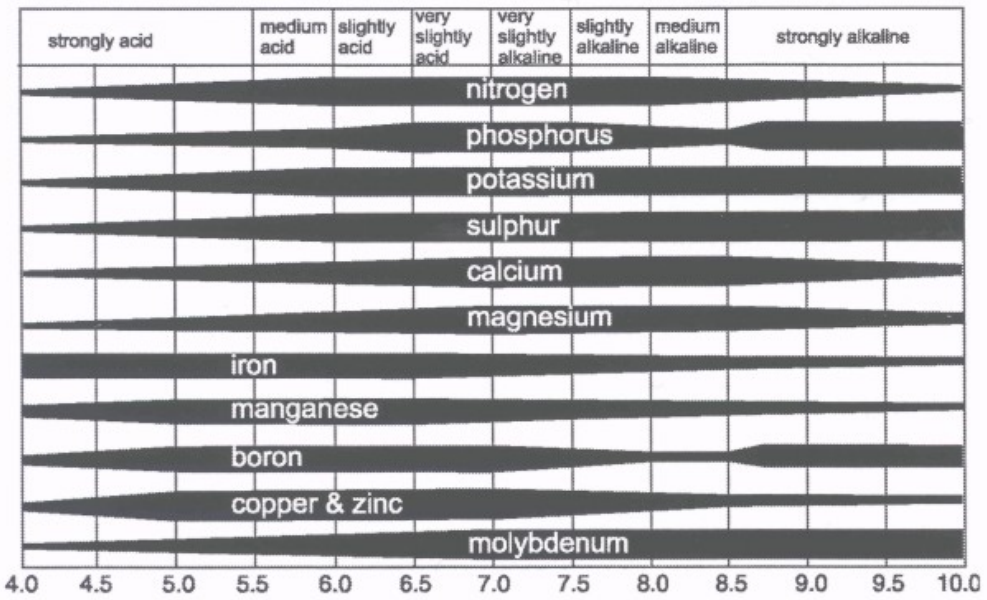
Gas Composition

Soil Nutrient Availability

Soil Minerals (Chemical)

- Cation Exchange Capacity
  - Sandy Soil 3 to 5 meq $100g^{-1}$
  - Clayey Soil 30 to 40 meq $100\ g^{-1}$
- pH

  5.5 to 8.5 (Temperate Agricultural Soil)



Energy Inputs in Soil Management

Optimize On-Farm Soil Ecosystem Services

1. Plant-Soil-Nutrient Interactions
    1. On-Time and Spatially Precise Applications

        Knowledge Gaps: sensing when, what, and where
    2. Manage Soil Organic Matter for on-time delivery of nutrients

        Knowledge Gaps: Soil; Cropping System, Manager specific

2. Plant-Soil-Water Interactions
    1. Reduce Tillage and controlled traffic systems: **available**
    2. Manage for optimal Soil Structure

        Knowledge Gaps (quantify soil structure; identify optimal; identify management)
    3. Manage Compaction

        Knowledge Gaps (mapping; thresholds; pan-busting cover crop)

Energy Inputs in Soil Management

Optimize Off-Farm Soil Ecosystem Services

1. Non-Point Erosion

   Fills reservoirs; contributes to poor water quality; harms ecosystems

   Knowledge Gaps:

   1. **Quantifying Off Farm Impacts linked to Soil Management**
   2. **Needs Hydrology Models that respond to Soil Health (Soil Structure)**

2. Non-Point Nutrient loss

   Impact water recreation (human health, fishing, aquatic ecosystems

   1. **Knowledge Gaps: Same as above**

3. Soil-Water Interaction

   Loss of water capture create flashiness in flooding

   Knowledge Gaps: Same as above

Summary

Soil Management for Farming Energy Smart?

1. Soil-Plant-Nutrient Management Timing
   - (-) Minimal yield improvement
   - (+) can reduce energy use requirements
   - (+) can improve off-farm energy needs (Engineering solutions to pollution)

Technologies: sensors that see soil water nutrients; good soil maps

2. Soil-Water-Plant Interactions
   - (+) Yes yield improvements
   - (+) Yes on-farm energy savings
   - (+) Yes off-farm energy savings (probably 10 to 100xs) on farm

Technologies: sensors that quantify soil structure; hydrology models that biophysically respond to soil health; compaction mapping strategies; compaction thresholds for yield

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Thank You

Observe it, Measure it, Model it