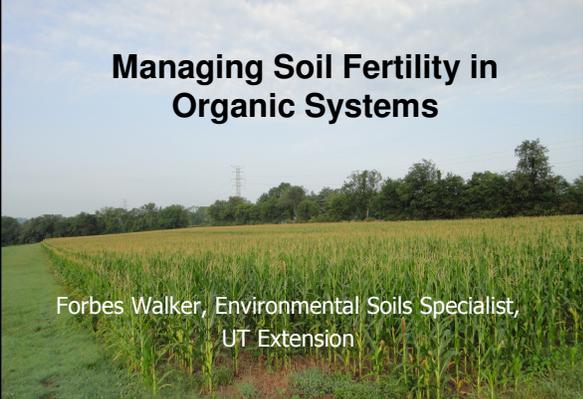


Managing Soil Fertility in Organic Systems



Forbes Walker, Environmental Soils Specialist,
UT Extension

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Overview

- Soil Fertility
- Soil Quality
- Reducing tillage
- Organic amendment
- Tools
 - Soil testing
 - Manure, compost, organic fertilizer analysis

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Soil Fertility or Soil Quality?

- Soil Fertility = "Capacity of soil to produce the desired crops"
- Essential Nutrients
 - C, H, O
 - Primary: N, P, K
 - Secondary: Ca, Mg, S
 - Micro-nutrients: Cu, B, Zn, Fe, Cl, Mo, Mn
- Soil pH

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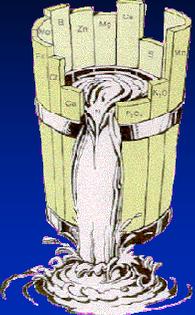
Soil pH

- 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

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Liebig's Law of Minimum

- Justus von Liebig (1803-1873)
- German chemist
- Nutrient that is deficient or lacking will limit plant growth
- Also moisture, temperature, insect control, light, plant population and genetic capacities of plant varieties



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Soil Quality

- Not just fertility, include other functions of soil
 - Air and water quality
 - Water flow
 - Degradation of wastes
- Physical, chemical and biological properties
 - Medium for plant growth
 - Regulate water flow
 - Environmental buffer
- Soil structure is critical!

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USDA Soil Quality: D, W, F, N, S

- Soil functions include:
 - sustaining biological **Diversity**, activity, and productivity
 - regulating **Water** and solute flow
 - **Filtering**, buffering, degrading organic and inorganic materials
 - storing and cycling **Nutrients** and carbon
 - providing physical **Stability** and support

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USDA Soil Quality Test Kit

- Soil respiration
- Infiltration
- Bulk density
- Electrical conductivity (EC)
- Soil pH
- Soil nitrate
- Aggregate stability
- Soil slaking
- Earthworms
- Soil physical observations and estimations
- Water quality



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Improving Soil Quality

- Build Soils
 - Bare fallow
 - Crop rotation
 - Cover crops
 - Diversification
- Reduce or improve tillage
- Organic amendments



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Bare Fallow

- Fallow periods between harvested crops
- Typically during winter or dry season
- Accumulate water / control weeds
- Erosion must be prevented!
- Not recommended for TN



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Crop rotation

- Varies plant species in time and space
- Keep the soil surface covered with a growing crop for most of the year
- Break disease and pest cycles
- Include "soil building" cover crops or cropped fallow periods
 - Maintain or increase soil organic matter content and nutrient availability when cash crops are not grown
- For most organic farmers, fertility is based on the rotation and not the amendment.

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Cover crops

- Annual, biennial, or perennials grown in pure or mixed stands
- Provide soil cover = less erosion
- Enhance soil physical condition and improved water filtration.
- Can provide nitrogen (legumes) and increase nutrient availability to subsequent crops
- Weed suppression or control

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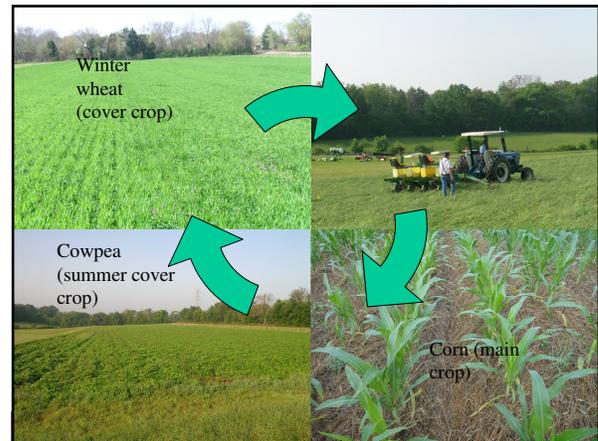


Cover Crops for Tennessee

- Grasses / cereals
 - Rye, oats, wheat, millet, sorghum
- Legumes
 - Vetches, clovers, cowpea, lupin
- Others
 - Buckwheat, brassicas



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Weed Control with Cover Crops

- Competition for nutrient and water
- Shading
- Allelopathy



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Diversification

- Rotation and use of cover (or lay) crops
- Reduce crop insect pests and diseases
- Maintain or increase soil organic matter if they are allowed to grow long enough to produce sufficient biomass
- Prevent soil erosion caused by both water and wind
- Suppress weeds

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Reduce Tillage

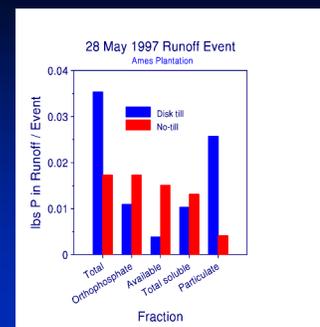
- Tillage destroys the organic matter
 - Nutrient cycling
 - Nutrient holding capacity of soil, "pool" of nutrients
 - Water dynamics
 - Water infiltration, less evaporation, better water holding capacity
 - Structure
 - Reduces crusting, more root development, better aggregation, prevents erosion
- Tillage should only be performed when soil moisture is low enough to prevent compaction
- Try no-till!

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Runoff and tillage

Tillage = more erosion, more nutrient loss



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Lessons Learned: 2008 to 2010

- Correct fertility
 - Many organic fertilizers are expensive!
 - Broiler litter
- Winter cover crops vital
 - Oats and crimson clover
 - Wheat and crimson clover
- Rolling
 - One pass is enough
- Planting into cover crop
 - Plant populations
 - Seed depth
 - Plant soon after rolling



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On-going Studies

- Crop roller – speed x pressure
- Tennessee brown rock phosphate
- Cover crops (wheat, barley, rye, oats, buckwheat, crimson clover)
- Nitrogen fertility study – soybean meal



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Organic Amendments



- Is it on USDA's National Organic Program (NOP) list?
 - Crop nutrient or soil amendment included on the National List of synthetic substances allowed for use in organic crop production
 - A mined substance of low solubility
 - A mined substance of high solubility NOT on the National List of non-synthetic materials prohibited for crop production
 - Ash obtained from the burning of a plant or animal material that has NOT been treated or combined with a prohibited substance
 - A material that has been chemically altered by a manufacturing process

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What Soil Amendments Can Be Used?*

- Aquatic plant extracts
 - Elemental sulfur
 - Humic acids
 - Magnesium sulfate (Gypsum) – mined only
 - Micronutrients - nitrates or chlorides are not allowed
 - Soluble boron products
 - Sulfates, carbonates, oxides, or silicates of zinc, copper, iron, manganese, molybdenum, selenium, and cobalt
- ** USDA National Organic Program

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What Soil Amendments Can Be Used?*

- Liquid fish products — can be pH adjusted with sulfuric, citric or phosphoric acid
 - Potassium chloride — derived from a mined source
 - Sodium nitrate (Chilean Nitrate) — no more than 20% of the crop's total nitrogen requirement
- ** USDA National Organic Program

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Sources of Nitrogen

- Manure
- Cover Crops
- Plant Products
- Animal Byproducts
- Seaweeds
- Mined nitrate (Chilean Nitrate)



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Sources of Phosphorus

- Manures and compost
- Rock phosphate
- Phosphatic clays
- Bone meal
- Guano



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Sources of Potassium

- Manures and compost
- Greensand
- Langbeinite (Potassium-magnesium sulfate)
- Potassium Sulfate
- Rock Powders
- Sylvinite (Potassium Chloride)
- Wood ash

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Economics of Soil Amendment Selection

- Commercial fertilizer
 - N ~ \$1.00 per lb
 - P₂O₅ ~ \$0.80 per lb
 - K₂O ~ \$0.80 per lb
- How much do organic nutrients cost?
 - What is the NPK analysis?
 - Bulk or bagged??
 - What is the carbon footprint?

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Fertilizer Analyses?

- What is the analysis?



=

3 % N
3% P₂O₅ = 1.3% P
3% K₂O = 2.5% K

- Convert to lbs per 50 lb bag or per ton

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Fertilizer Analyses?

- 3% N = 3% / 100 x 50 lb
= 1.5 lb / 50 lb bag
= 60 lb per ton
- 3% P₂O₅ = 1.5 lb / 50 lb bag
– or 60 lb per ton
- 3% K₂O = 1.5 lb / 50 lb bag
– or 60 lb per ton

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2009 Prices**

- Blood meal (12-0-0) \$6.25 per lb N
- Feather meal (13-0-0) \$4.92 per lb N
- Chilean nitrate (13-0-0) \$4.91 per lb N
- Bone meal (1-13-0) \$4.91 per lb P₂O₅
- ID Rock P (0-3-0) \$9.83 per lb P₂O₅
- Greensand (0-0-7.5) \$3.33 per lb K₂O

** From Seven Springs Farm, VA
<http://www.7springsfarm.com/catalog.html>

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Broiler Litter in Tennessee

- Excretion by broilers*
 - 12,000 tons nitrogen
 - 8,000 tons phosphorus (as P_2O_5)
 - 8,000 tons potassium (as K_2O)
- How many tons litter?
 - Estimated 150 to 200,000 tons
- “Typical” nutrient content
 - 60 lbs N : 50 lbs P_2O_5 : 50 lbs K_2O
 - Approximately a 3 : 2.5 : 2.5 fertilizer
- \$40 per ton = \$0.25 per lb NPK
- \$100 per ton = \$0.64 per lb NPK



*Based on ASAE Manure Production Characteristics; *ASAE D384.2 March 2005

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How Much Do I Add?

- More is not always better!
 - Decrease yield
 - Environmental concerns
 - Economics
- Do not guess!

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Soil Testing

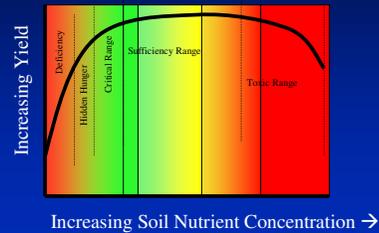
- “Don’t guess, soil test!”
- Sampling
 - 0 – 6”; Random
- UT Lab analyses
 - **Basic:** P, K, pH, Ca, Mg (\$7)
 - **Basic Plus:** Zn, Mn, Fe, Cu, Na, and B (\$15)
 - **Container Media** -Saturated Paste Extract: pH, P, K, Ca, Mg, NH_4 , NO_3 , Sol. Salts (\$20)
 - <http://soilplantandpest.utk.edu/>
- Interpretation of results
- Sufficiency vs. Maintenance



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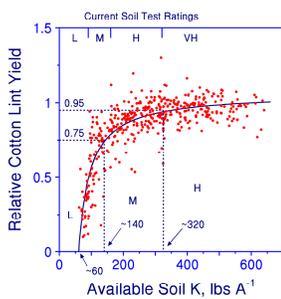
Yield and Nutrient Concentration



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No-till Cotton Yield Response to Available Soil K



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Which Lab Should I Use?

- University or private lab?
- In-state or out of state?
- How and where are the recommendations generated?
- Sufficiency or maintenance approach?

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Don't Be Fooled by Marketing!

The image shows a complex soil test report with multiple columns and rows of data. Two red circles are drawn around specific sections: one around the 'NATURAL METHOD MEAN' header and another around the 'MICROBIOLOGY' section. The report includes various chemical and biological parameters.

- What soil extractant is being used? What is CO₂ Natural Method mean?
- How are the nutrient recommendations generated?
- What do the numbers mean?

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Other Tests: Soil FoodWeb

- Based on the concept of that bio-diversity in the soil is good for a healthy soil or compost
- Soil, compost, and compost tea analysis
- Measure the "correct" density of bacteria and fungi and amount of bacterial / fungal activity. Also nematodes, protozoa etc.
- Labs in Europe, USA, Africa etc.
- What do the numbers mean?



- <http://www.soilfoodweb.com/>

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Other Tests: Woods End Lab

- Compost tests – required by some states if you are marketing compost
- Compost analysis
 - Composition: density, solids, organic matter, pH
 - Nutrients: N (total, organic, NH₄ and NO₃) P, K, Ca, Mg etc.
 - Metals; Cu, Zn, Fe, Pb, Hg etc.
 - Bacteria: Coliform, E. coli
- Home test kits for soil, compost and manure: ammonia and carbon dioxide
- Recognized by Organic Materials Review Institute (OMRI for OMRI-Listing™, Mulch and Soil Council (MSC) and is a Manure Analysis Proficiency (2005-2009) certified laboratory and CAP Compost Analysis Proficiency (2010-2011) lab
- <http://www.woodsend.org/>

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Summary

- Don't guess soil test!
- Don't guess have your organic amendments analyzed!
- Match soil amendments with UT soil test recommendations – if you are using private or out-of-state labs what do the numbers mean?
- Do not over-apply nutrients

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