URBAN AGRICULTURE

A Participatory Primer Course
Part 4a: Equipment and Tools

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UF/IFAS Extension Sarasota County
Outline

• Short Review of Course Syllabus

• Production Equipment and Tools
  – Soil and water tools and tests
  – Field production tools
    • Preparation
    • Planting
    • Cultivation
    • Harvesting
  – Crop pest management tools
  – Hoophouses/Shadehouses

• Post Harvest Handling & Produce Quality
Urban Agriculture Certificate Course
Class Topics Sequence

• #1: Introduction and Production Systems
• #2: Business and Marketing Plans
• #3: Regulations and Direct Markets
• #4: Equipment and Tools; Post Harvest Handling
• #5: Financial Resources & Management
Urban Agriculture Certificate Course
Workshop Topics Sequence

• #1: Container and Hydroponic Growing
• #2: Frost Protection and IPM
• #3: Farmscaping w/ Cut Flowers
• #4: Farm Food Safety Plan
• #5 Composting and Renewable Energy Technologies
Introductory Activity (10 min.)

- **World Café Format**
  - Collaborative
  - Respectful

- **Answer the following:**
  - What is a tool?
  - What tools do you need for your Urban Ag plans?

- Form groups of 4 persons. Appoint 1 spokesperson to take notes and report out to the class on your group’s responses, using bulleted descriptors.
Urban Agriculture
Equipment/Tools Needs Factors

• High ‘value’ cash crops
• Done by both profit and/or non-profit groups
• Production attributes
  – Intensive production per unit area
  – High crop diversity (fruits, vegetables, flowers)
  – Field and/or protected production
  – Low volume per crop
  – More manual labor and horticultural techniques
Watch the video: “An Urban Farmers tools of the trade.” – see https://www.youtube.com/watch?v=8EcdunV2Ghg
Urban Ag Equipment/Tools Resource

Watch the videos:
http://www.themarketgardener.com/market-gardening-tools/
Urban Ag Equipment/Tools Resource

Watch the video:
https://www.youtube.com/watch?v=dsMz207FhCI&list=PLgVHK3pelUa5GsnOuP5lHhLUfURKsFEF&index=14
Urban Ag Equipment/Tools Resource

Watch the short video “NRCS: Urban Farming” – see [https://www.youtube.com/watch?v=l0OaU4RnIB4](https://www.youtube.com/watch?v=l0OaU4RnIB4)
“The right tool for the right job will save your time, money, and you . . .
Anonymous

One machine can do the work of fifty ordinary men. No machine can do the work of one extraordinary man . . .
Elbert Hubbard

Law of the workshop: Any tool, when dropped, will roll to the least accessible corner. . .
Anonymous
What is a Tool?

• Something (as an instrument or apparatus) used in performing an operation or necessary in the practice of a vocation or profession

http://www.merriam-webster.com/

• Holistic management has an expanded definition of tools!

http://agonist.org/jimbo92107/20080321/cow_tools_revisiting_a_comic_masterpiece
How do you achieve the holistic goal from your business plan of your selected production systems?

– Appropriate use & planning of tools
  • Financial
  • Land
  • Biological

– Monitoring of decisions and actions w/ tools

https://www.misa.umn.edu/publications/buildingasustainablebusiness
Work with ecological cycles as “tools”
- Water hydrology
- Nutrient recycling
- Biodiversity
- Energy flow

Use “biological tools” to replace technological tools
Agroecology provides concepts for the design of Urban Ag that achieves:

- Improved overall biological efficiency & production
- Biodiversity preservation
- Maintenance of productivity and self-regulating capacity/resiliency

Ecosystem concept from ecology science is the unifying concept of agroecology

- the idea that farms are “agroecosystems” with subsystems (e.g., soil) & should mimic the functioning of local ecosystems with tight nutrient cycling, complex structure, and enhanced biodiversity conservation.
Agroecosystem “Tools”

- Assess tools available with integration of all “subsystems” of the agroecosystem of your urban farm
- Identify tools to serve as indicators for monitoring all subsystems, as well
Assessment of Urban Soils

- Impacts of the urban environment on soils:
  - physical soil properties are strongly influenced by compaction that occurs during the transformation of native and agricultural lands into urban environments
  - urban heat island effect, modifications of local cloud cover and precipitation, & alterations to hydrologic regimes by urban infrastructure can strongly affect soil microclimates, the availability of water, & activity of soil organisms.

- The net effect of these urban effects on the physical, chemical, and biological properties of soils is an alteration of the fundamental nature of the belowground component of urban ecosystems.

- Urban soils with drastic changes and degradation require strong manipulations and interventions.

http://www.u.arizona.edu/~mzucker/Pavao-Zuckerman%202008%20Restoration%20Ecology.pdf
Soil Ecosystem Restoration for “Tools” of Crop Production

Watch the short video “Regenerate Life in Your Soil | healthy soil” – see https://www.youtube.com/watch?v=XOgnB0KoCaQ
‘Tools’ of the Soil Ecosystem

Nutrient Cycles

Soil Food Web

Organic Matter
Management Goal: Increase Soil Ecosystem ‘Emergent’ Properties

Examples

• Soil fertility and tilth
• Nutrient cycling
• Soil life
• Organic matter (OM)
• Soil ‘quality’ and ‘health’

Watch the short video “Emergent Properties – see https://www.youtube.com/watch?v=R-auQOP1sCM

Basic Strategies or “Tools” for Sustainable Soil Management

- Soil care (composting, cover crops, soil testing, etc.)
- Crop rotations
- Variety selection and cultural practices
- Encourage natural predators
- Managing water
- Prevent compaction

Soil and Water Tests “Tools”

- Soil and water tests were developed to assist in fertility management of vegetable, fruit and agronomic crops.

How to Sample Your Lawn or Garden

Obtain a small amount of soil from 10-15 different spots over the area you wish to test (a minimum of one-half pint). When you sample a lawn, take the soil from the upper 2-4 inches. When sampling a vegetable garden or landscape plants, take soil from the upper six inches. If soil is wet, spread soil on clean paper or other suitable material to air dry.

Figure 1a. Use a soil probe to speed soil sampling, or...

Figure 1b. Use a hand trowel, shovel or other garden tool. Trim out soil of uniform thickness to the recommended depth.

Figure 2. Place 10 to 15 soil cores into a plastic bucket; mix, dry, and transfer to a bag.

SAMPLES WILL NOT BE PROCESSED WITHOUT PAYMENT. Please enclose payment and this sheet in the same package as sample(s). Do not send cash through the mail.

http://soilslab.ifas.ufl.edu/ESTL%20Tests.asp
## Soil and Water Tests

- **UF/IFAS Extension Soil Testing Laboratory**
  - (including water, manure, soilless media & plant tissue)
  - see - [http://soilslab.ifas.ufl.edu/ESTL%20Tests.asp](http://soilslab.ifas.ufl.edu/ESTL%20Tests.asp)

<table>
<thead>
<tr>
<th>Analysis Code</th>
<th>Analysis Name</th>
<th>Determinations Made</th>
<th>Analysis Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Standard Soil Fertility Test</td>
<td>pH, lime requirement, P, K, Ca, and Mg</td>
<td>$7.00</td>
</tr>
<tr>
<td>2*</td>
<td>Soil pH and Lime Requirement</td>
<td>pH and lime requirement</td>
<td>$3.00</td>
</tr>
<tr>
<td>3</td>
<td>Soil Micronutrients</td>
<td>Cu, Mn, Zn, and pH</td>
<td>$5.00</td>
</tr>
<tr>
<td>4</td>
<td>Organic Matter</td>
<td>percent organic matter</td>
<td>$10.00</td>
</tr>
<tr>
<td>5</td>
<td>Electrical Conductivity (&quot;soluble salts&quot;)</td>
<td>conductivity in 1:2 soil:water</td>
<td>$2.00</td>
</tr>
<tr>
<td>13</td>
<td>Bahia Standard Soil Fertility Test</td>
<td>pH, lime requirement, K, Ca, Mg, and P Value</td>
<td>$7.00</td>
</tr>
<tr>
<td>B1</td>
<td>Bahia P Test</td>
<td>pH, lime requirement, P, K, Ca, and Mg (Soil) P test (Tissue)</td>
<td>$15.00</td>
</tr>
</tbody>
</table>

* Included in Standard Soil Fertility Test. Do not request both codes 1 and 2 for the same soil sample.
Water tests require precise procedures for sampling too.
Soil and Water Tests

- **UF/IFAS Extension Soil Testing Laboratory**
  - (including water, manure, soilless media & plant tissue)

![UF/IFAS Analytical Services Laboratories Extension Soil Testing Laboratory](image)

**WATER TEST FORM**

Note: This lab only tests samples from Florida.

Direct any questions about this test or the interpretation of the results to your county UF/IFAS Extension agent.

Note: These tests will not determine if the water is suitable for human consumption. Bacteriological tests may be available from the county health department or select commercial laboratories.

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<table>
<thead>
<tr>
<th>Lab Use Only</th>
<th>Sample ID</th>
<th>County</th>
<th>Crops to be grown</th>
<th>Water Source Information</th>
<th>Water Use Information</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

http://edis.ifas.ufl.edu/pdffiles/SS/SS18400.pdf
Soil and Water Tests

- Soil Contaminants and Soil Testing

- For resources on testing urban soils for contaminants see http://ucanr.edu/sites/UrbanAg/Production/Soils/Soil_Contaminants_and_Soil_Testing/
Soil pH Basics

• The measure of acidity or alkalinity of the soil
• Determines the concentration of available plant nutrients and toxicities in the soil solution
• Typically pH 6.5 is recommended
pH Range Examples

- battery acid
- lemon juice
- pure rain (H₂O in equilibrium with atmospheric CO₂)
- freshly distilled water
- seawater
- baking soda (NaHCO₃ solution)
- household ammonia (NH₃)
- household bleach (NaClO solution)
- household lye (NaOH solution)
- gastric fluid
- carbonated beverages
- vinegar
- orange juice
- beer
- coffee
- egg yolks
- milk
- blood
- milk of magnesia (Mg(OH)₂) solution

The pH scale and the acidity and alkalinity of reference materials. (Credit: Steven Lower)
Soil pH and Nutrients Basics

Horizontal bars with increasing width demonstrate pH range for greater nutrient availability.
## Soil pH & Food Crops Tolerance Examples

<table>
<thead>
<tr>
<th>Vegetables &amp; Herbs</th>
<th>Preferred pH Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artichoke</td>
<td>6.5 - 7.5</td>
</tr>
<tr>
<td><strong>Asparagus</strong></td>
<td>6.0 - 8.0</td>
</tr>
<tr>
<td>Basil</td>
<td>5.5 - 6.5</td>
</tr>
<tr>
<td>Bean</td>
<td>6.0 - 7.5</td>
</tr>
<tr>
<td>Beetroot</td>
<td>6.0 - 7.5</td>
</tr>
<tr>
<td><strong>Broccoli</strong></td>
<td>6.0 - 7.0</td>
</tr>
<tr>
<td>Brussels</td>
<td>6.0 - 7.5</td>
</tr>
<tr>
<td>Cabbage</td>
<td>6.0 - 7.5</td>
</tr>
<tr>
<td>Calabrese</td>
<td>6.5 - 7.5</td>
</tr>
<tr>
<td><strong>Carrot</strong></td>
<td>5.5 - 7.0</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>5.5 - 7.5</td>
</tr>
<tr>
<td><strong>Celery</strong></td>
<td>6.0 - 7.0</td>
</tr>
<tr>
<td>Chicory</td>
<td>5.0 - 6.5</td>
</tr>
<tr>
<td><strong>Chinese Cabbage</strong></td>
<td>6.0 - 7.5</td>
</tr>
<tr>
<td>Chives</td>
<td>6.0 - 7.0</td>
</tr>
</tbody>
</table>
Soil pH Management Basics

- To raise soil pH (make more alkaline): apply lime (calcium carbonate) or dolomite (magnesium carbonate) - carbonate compounds

- To lower soil pH (acidify): apply elemental sulfur compounds

- To add calcium or magnesium without changing soil pH: use sulfate compounds (ex.: gypsum = calcium sulfate)
Soil pH and Liming Basics

- There’s lots of misunderstanding about the use of agriculture lime
- We lime a soil to avoid Iron (Fe) and Aluminum (Al) toxicity at high soil levels!
- Low pH factors
  - Fe and Al are active at low pH ranges
  - Proper soil tests methods of ‘reserve pH’ levels are critically important for correct interpretation to correctly measure Fe and Al levels.
  - UF/IFAS Soil Lab uses the Adams/Evans Buffer and water pH with a calibration curve to recommend liming rates!

http://edis.ifas.ufl.edu/hs1207
## Soil Test Results Example

### UF/IFAS Analytical Services Laboratories
**Extension Soil Testing Laboratory**  
Wallace Building 631 PO Box 110740 Gainesville, FL 32611-0740  
Email: soilslab@mail.ifas.ufl.edu  
Web: soilslab.ifas.ufl.edu  
Phone #: 352-392-1950

### Soil Test Results and Their Interpretations

<table>
<thead>
<tr>
<th>Soil Test Parameter</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target pH:</td>
<td>6.0</td>
</tr>
<tr>
<td>pH (1:2 Sample:Water)</td>
<td>7.5</td>
</tr>
<tr>
<td>A-E Buffer Value:</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Mehllich-1 Extractable

<table>
<thead>
<tr>
<th>Extractable Element</th>
<th>Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (ppm P)</td>
<td>58</td>
<td>V HIGH</td>
</tr>
<tr>
<td>Potassium (ppm K)</td>
<td>59</td>
<td>HIGH</td>
</tr>
<tr>
<td>Magnesium (ppm Mg)</td>
<td>&gt; 218</td>
<td>MED</td>
</tr>
<tr>
<td>Calcium (ppm Ca)</td>
<td>&gt; 2648</td>
<td>LOW</td>
</tr>
</tbody>
</table>

### Lime and Fertilizer Recommendations

- **Crop:** Woody orn/trees in the landscape
- **Lime:** 0.0 lbs per 1000 sq. ft (1 Ton = 2000 Lbs)
- **Nitrogen:** 2.30 lbs per 1000 sq. ft.
- **Phosphorus:** $(P_2O_5)$ 0 lbs per 1000 sq. ft.
- **Potassium:** $(K_2O)$ 0.70 lbs per 1000 sq. ft.
- **Magnesium:** (Mg) 0 lbs per acre
Used to monitor salts in soil and water (i.e., composites of positive and negative ions) which can damage organisms at high levels.

Contributed to by soil mineral components, organic matter components, fertilizers, pollutants, and from salt water.

Salts are especially an issue in areas where salt water flooding occurs or where irrigation water is from a salt-intruded source (salty well; brackish canal; etc.).
Understanding Water Salts Tests

- Two most important measures for determining irrigation water quality are:
  - Total amount of dissolved salts (TDS)
  - Amount of sodium (Na) compared to calcium (Ca)
  - Or both

- Liming potential
  - Amounts of carbonates

- Salinity level comparisons
  - Fresh water $< 1500$ mg/L TDS
  - Brackish water $< 1500$ to $5000$ mg/L TDS
  - Saline water $> 5000$ mg/L TDS
Salinity and Plant Water Availability

- Nonsaline soil
  - Available water
  - Plant wilts
- Moderately saline soil
  - Available water
  - Plant wilts
- Highly saline soil
  - Unavailable water
  - Plant wilts
  - Available water
### Water Quality Ratings Basics

**• Water Hardness (Ca + Mg salts only)**

<table>
<thead>
<tr>
<th>ppm Range</th>
<th>Water Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-60</td>
<td>Soft</td>
</tr>
<tr>
<td>61-120</td>
<td>Moderately hard</td>
</tr>
<tr>
<td>121-180</td>
<td>Hard</td>
</tr>
<tr>
<td>&gt; 180</td>
<td>Very hard</td>
</tr>
</tbody>
</table>

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### Salinity Assessment

<table>
<thead>
<tr>
<th>Irrigation Water Quality</th>
<th>EC mmho/cm or dS/m</th>
<th>TDS ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>&lt; 0.25</td>
<td>&lt; 175</td>
</tr>
<tr>
<td>Good</td>
<td>0.25 – 0.75</td>
<td>175 – 525</td>
</tr>
<tr>
<td>Permissible</td>
<td>0.75 – 2.00</td>
<td>525 – 1400</td>
</tr>
<tr>
<td>Doubtful</td>
<td>2.00 – 3.00</td>
<td>1400 – 2100</td>
</tr>
<tr>
<td>Unsuitable</td>
<td>&gt; 3.00</td>
<td>&gt; 2100</td>
</tr>
</tbody>
</table>

*Don’t Confuse Different Water Quality Ratings!*
# Salinity & Crop Tolerance Examples

<table>
<thead>
<tr>
<th>ppm</th>
<th>Sensitive</th>
<th>Moderately sensitive</th>
<th>Moderately tolerant</th>
<th>Tolerant</th>
</tr>
</thead>
<tbody>
<tr>
<td>980</td>
<td>almond</td>
<td>alfalfa</td>
<td>red beet</td>
<td>sugarbeet</td>
</tr>
<tr>
<td>2100</td>
<td>apple</td>
<td>broccoli</td>
<td>safflower</td>
<td>cotton</td>
</tr>
<tr>
<td>4200</td>
<td>avocado</td>
<td>cabbage</td>
<td>olive</td>
<td>date palm</td>
</tr>
<tr>
<td>7000</td>
<td>bean</td>
<td>tomato</td>
<td>soybean</td>
<td>bermuda-grass</td>
</tr>
<tr>
<td></td>
<td>carrot</td>
<td>lettuce</td>
<td>wheat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>grapefruit</td>
<td>corn</td>
<td>ryegrass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>orange</td>
<td>cucumber</td>
<td>wheatgrass</td>
<td></td>
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<tr>
<td></td>
<td>lemon</td>
<td>grape</td>
<td>wildrye</td>
<td></td>
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<td></td>
<td>okra</td>
<td>peanut</td>
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<td></td>
<td>onion</td>
<td>potato</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>strawberry</td>
<td>radish</td>
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<tr>
<td></td>
<td>peach</td>
<td>rice</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>plum</td>
<td>sugarcane</td>
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</tbody>
</table>

(adopted from Jensen, 1980)
Water Tests by UF/IFAS Soil Test Lab for Irrigation Problems (including micro-irrigation)

(http://soilslab.ifas.ufl.edu/ESTL%20Pages/ESTLAnalysis.htm)

- Ca, Mg, & Total carbonates
- liming
- hardness
- Fe & Mn
- foliage stains
- staining, taste
- Na & Cl

- electrical conductivity
- plant damage from salt content
- pH
- corrosion potential/plugging
- corrosion
- suspended solids
- plugging problems
Well Water Quality: What’s In Your Water?

Hidden Sources of Pollution
Taking a Representative Water Sample

Tools

1. A clean plastic bottle holding about 1 pint in which to collect the water sample. Do not use shampoo or detergent bottles since it is difficult to remove all residues. **Glass Bottles Are Not Recommended.**

2. A corrugated shipping box. These boxes (also used to mail soil samples) are available free of charge at your local county Cooperative Extension Service office.

3. Some packing material with which to pack the sample to avoid damage or leakage during shipment to the Extension Soil Testing Laboratory.

4. This form. Use additional copies if you plan on sending more than 5 water samples.

Sampling

1. Allow the water source to run from the intended collection point for several minutes.

   For household samples, allow the water to flow for several minutes to ensure the water sample is directly from the well. Water that has been standing in the house plumbing for some time is not a representative sample.

   For irrigation and microirrigation samples, sampling as close to the water source as possible will ensure that the sample represents the water source. If you are filtering the water, you may wish to sample the water both before and after filtration to assess the effect of the filtering operation. Filtration will only affect the physical characteristics (suspended solids) of the water.

2. Rinse the sample container and its lid several times in the flowing water. Do not use soap or detergent during this rinsing step.

3. Fill the container completely with the flowing water. Leave as little air as possible in the container. Tightly seal the lid immediately after filling the container to ensure against leakage.

4. Label the container and pack it carefully in the prelabeled shipping box.

5. Include in the shipping box:
   - Your labeled water sample(s)
   - This Water Test Information Sheet with all the requested information on page 1 of the form completed
Alternative Soil Tests


- What additional information do they provide?
  - organic matter
  - soil life
  - tilth
  - soil health

- And why would you consider them?
  - assessment of soil restoration needs
  - monitoring of soil restoration strategies
Soils and Crop Nutrition Basics

**What is Soil?**

- A Proportional Mixture of Components
  - Pore Space 50% (v)
  - Solids 50% (v)
    - Minerals
    - Organic matter

- Air
- Water

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Soils and Crop Nutrition Basics

- **Triangle used to Determine Soil Texture Class**
- **Depends on % of sand, silt & clay**
- **For example,**
  - **Loamy soils:** mixture of all 3 components
  - **Sandy loam:** mostly silt w/ sand
  - **Loamy sand:** mostly sand w/ silt

*FL soils are typically in different sand texture classes!*
Soil Texture Property Basics

Water Holding Capacity (WHC)

- SAND
- CLAY
- LOAM
Soil Texture Property Basics

Soil Pore Sizes

Pore size by soil texture:
- Sand – macropore
- Loam – mesopore
- Clay - micropore

www.homepage.montana.edu/~ueswl/307%2008A.ppt
A high CEC value (>25) is a good indicator that a soil has a high clay and/or organic matter content and can hold a lot of nutrients.

Soil with a low CEC value (<5) is a good indication that a soil is sandy with little or no organic matter that cannot hold many nutrients. Typical of FL sandy soils
What Is Cation Exchange Capacity?

Cation Exchange Capacity

- Cation exchange capacity (CEC) is the total amount of cations that a soil can retain.
- The higher the soil CEC, the greater ability it has to store plant nutrients.
- Soil CEC increases as:
  - The amount of clay increases
  - The amount of organic matter increases
  - The soil pH increases
Management of Soil Texture, Pore Space, WHC, and CEC

- **Negative Impacts**
  - compaction
  - mixing of soil profile strata
  - excessive soil salt concentrations

- **Positive Impacts**
  - soil organic matter additions & conservation
  - plant root growth
Soil and Crop Nutrition Basics

Chemical Processes of Crop Nutrition:
Potassium (K) & Cation Exchange Capacity Example
Soil Biological Activity As a ‘Tool’ for Crop Nutrition

Watch these videos:
https://www.youtube.com/watch?v=Qas9tPQKd8w
https://www.youtube.com/watch?v=4wO5WwOaPKE
Soil and Crop Nutrition Basics

Biological Processes of Plant Nutrition: Rhizosphere

Watch short video “The Rhizosphere: an interaction between plant roots and soil biology” – see https://www.youtube.com/watch?v=tvA7CWSIbTc
Soil and Crop Nutrition Basics

Soil Food Web on Rhizosphere

- Root tip & OM contact →
- Rhizosphere OM decomposition
- Rhizosphere & protozoa →
- Protozoa N wastes (chelated)
- Root uptake of N wastes →

Root Tip

OM

Rhizosphere microbes

Food web
What Is Chelation?

- a natural process by chelates, i.e., organic substances in the soil either applied or produced by plants and/or microorganisms
- elements are held more strongly by chelates than by binding of positive and negative charges
- chelates are smaller than the particles that make up humus

M = metals & trace elements

Soil Life & Plant Nutrition Basics

Significance of Soil Chelation?

- Optimizes plant nutrition because
  - prevent mineral nutrients from forming unavailable chemical precipitates
  - root uptake of chelated nutrients is more efficient & requires less energy
  - consequently plants require lower soil nutrient levels
- Reduces toxicity of some metal ions to plants
- Prevents nutrient leaching losses because chelated nutrients are no longer water-soluble salts
- Suppresses the growth of plant pathogens.

Management of Soil Life: Rhizosphere

- **Negative Impacts**
  - Excessive use of chemical soil fertilizers and pesticides
  - Soil fumigation
  - Soil salt concentrations (EC) above 100-350 ppm) hinders microbial chelation

- **Positive Impacts**
  - Soil organic matter additions & conservation
  - Plant root growth
Soil ecosystems have functional properties & subsystems (e.g., nitrogen cycling) from soil life.
Soil Life ‘Tool” Example: Nitrogen-Fixing Bacteria Mutualism

- Nodules formed where *Rhizobium* bacteria infected roots of legume crops
- Converts atmospheric nitrogen for plant uptake & use in protein synthesis

\[
N_2 + 12 \text{ ATP} \xrightarrow{\text{nitrogenase}} 2 \text{NH}_3 + 12 \text{ADP} + 12 \text{P}_i
\]

It takes 12 ATPs to provide sufficient energy to break the strong triple bond between the two nitrogen atoms of \(N_2\) gas: \(\equiv N\)

Simplified Equation For Nitrogen Fixation
Legume Root Nodules Development

- Rhizobium bacteria
- Infection thread
- Bacteroid
- Vacuole
- Leghemoglobin pink color
Non-Legume N-Fixing Symbiont Plants: Florida Examples

**Actinomyces Frankia**
- Wax myrtle (*Morella cerifera*) - native species
- Australian Pine (*Casuarina equisetifolia*) - invasive species

**Blue-green algae**
- Coontie (*Zamia floridana*) - native species
- Mosquito fern (*Azolla pinnata*) - native species
Management Factors With Impacts on Rhizobium Mutualism

• Negative Impacts
  – excessive N fertilizer use (including compost additions)
  – very low pH (4.7 or lower)
  – high soil surface temperatures and dessication

• Positive Impacts
  – inoculation of specific Rhizobium group required for different legume crop species at first planting of a location

Watch this short video “Nitrogen Fixation - Seven Wonders of the Microbe World”
  – see https://www.youtube.com/watch?v=4NKGS4bj7cc
Soil Life ‘Tool’ Example: Mycorrhizae

- Myco (fungi) + rhizae (root)
- Serves as an expanded root system that provides water and nutrient benefits to plant host
- More than 90% of all plants are mycorrhizal
Mycorrhizae Mutualism Basics

Acquisition of Phosphate by Roots

Roots Without Mycorrhizae

Uptake area limit

Source: Harrison et al 1999
Mycorrhizae Mutualism Basics

Acquisition of Phosphate by Mycorrhizal Roots

- Soil particle
- Phosphate

Roots With Mycorrhizae

Expanded Uptake area limit
Management Factors With Impacts on Mycorrhizae Mutualism

• **Negative Impacts**
  – excessive P fertilizers *(including compost additions)*
  – soil disturbance and/or tillage
  – fallow soils

• **Positive Impacts**
  – Mycorrhizae maintenance in soil require annual replenishment of soil spores via infection of living roots
  – Use of mycorrhizae inoculant in transplants

Watch this short video “Mycorrhizae on the farm” – see [https://www.youtube.com/watch?v=LbQq4dQ3OfY](https://www.youtube.com/watch?v=LbQq4dQ3OfY)
Soil Life ‘Tool’ Example: Earthworms

- Earthworms dramatically alter soil properties for growing conditions favorable for crop plants.
Earthworm Basics

• Stimulate microbial activity
• Mix and aggregate soil
• Increase infiltration
• Improve water-holding capacity
• Provide channels for root growth
• Bury and shred plant residue
• Casts at the soil surface are evidence of earthworms shredding, mixing, and burying surface residue

Earthworm castings

Earthworm burrow
Earthworm Basics

Earthworms are classified in ecological groups

**ENDOGEIC**
- rich soil feeder
- topsoil (A) dweller
- no pigmentation
- horizontal burrows
- small size

**EPIGEIC**
- litter feeder
- litter dweller
- pigmented
- no burrows
- small size

**ANEIC**
- litter + soil feeder
- soil dweller
- dorsally pigmented
- extensive vertical burrows (permanent)
- large size

Use of multi-species of earthworm enhances potential benefits
Earthworm Management

- **Negative Impacts**
  - Excessive tillage
  - Chemical fertilizers and pesticides

- **Positive Impactts**
  - **Introduction**
    - Nightcrawler spp more than shallow-dwelling spp respond to additions
  - **Food supply**
    - Adding organic matter
  - **Mulch protection**
    - Leaving a surface mulch, by no-till or other conservation tillage systems with plenty of residue cover
  - **Chemical environment**
    - Soil pH should be maintained between 6.0 and 7.0 for optimum conditions, although lower pHs are tolerated by most species.

Source: Earthworms and Crop Management, Purdue Univ. Extension
http://www.ces.purdue.edu/extmedia/AY/AY-279.html
Composting as a ‘Tool’

- Art & science of producing stable organic matter soil amendment by:
  - mixing organic materials properly
  - monitoring resultant biological activity

- Types
  - aerobic
  - anaerobic
  - worm (vermicomposting)

- Adds biological inoculum, as well as nutrients and organic matter, to restore the soil life
Soil Organic Matter as a ‘Tool’

• Contributes the most to soil fertility & health.
• Range of values
  – Temperate soils have higher OM levels (5-10%)
  – Tropical soils generally have 0.5-1.0% (this is us)
• Incorporation of compost into soils provides beneficial soil life and a complete nutrient package. As OM decomposes the nutrients are released into the soil, becoming available to plants.
• High OM levels encourage greater biodiversity in the soil and discourages diseases and soil pests (like nematodes) via emergent property of population homeostasis.
Soil Organic Matter Basics

- Soil Organic matter encompasses all *organic components* of a soil:
  - Fresh residues
  - Decomposing organic matter
  - Stable organic matter
  - Living organisms
Soil Organic Matter Basics

Effects of OM additions

Add organic matter

Increase biological activity (& diversity?)

Decomposition

Pore structure improved

Aggregation increased

Humus formed

Nutrients released

May reduce soil-borne disease

Improved tilth

HEALTHY PLANTS

Watch these short videos:
“Soil Organic Carbon” – see https://www.youtube.com/watch?v=Ymy0IO7nizw
and
“Soil Organic Matter and Nutrition” – see https://www.youtube.com/watch?v=PpVGTfx0R6c
✓ Newly-formed humus =

- combination of resistant materials from the original plant tissue,
- compounds synthesized as part of the microorganisms' tissue which remain as the organisms die. (Fluvic and Humic Acid)
- humus is resistant to further microbial attack - N and P are protected from ready solubility.

Watch this short video “Humus” – see https://www.youtube.com/watch?v=gRpcVhUmfCs
Humus Basics

OM adds to soil nutrient holding capacity w/ Cation Exchange Capacity (CEC)

OM adds to soil nutrient holding capacity w/ chelation
Humus Basics

- Increases soil structure and aggregation
  - how components are held together not just composition
  - good “tilth” indicator for improved crop growth
  - improved by root growth, OM, & soil life
  - reduced by compaction and increased density

Gershuny & Smillie, 1995, 77 Soul of Soil.

Good, crumb-like structure
Poor, clod-like structure
Use is critical for many Florida soils, especially for sandy soils which typically have low inherent soil fertility, do not retain much water or nutrients, and are often prone to excessive nutrient leaching losses.

Benefits also include soil pests control and providing insectary plants.

[http://edis.ifas.ufl.edu/aa217](http://edis.ifas.ufl.edu/aa217)
### Managing cover crops profitably, 3rd edition

#### Chart 3A CULTURAL TRAITS

<table>
<thead>
<tr>
<th>Species</th>
<th>Aliases</th>
<th>Type</th>
<th>Hard through Zone</th>
<th>Tolerances</th>
<th>pH (Pref.)</th>
<th>Best Established</th>
<th>Min. Germin. Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual ryegrass p. 74</td>
<td>Italian ryegrass</td>
<td>WA</td>
<td>U</td>
<td>ESp, LSu, EE, F</td>
<td>6.0-7.0</td>
<td>40F</td>
<td></td>
</tr>
<tr>
<td>Barley p. 77</td>
<td></td>
<td></td>
<td></td>
<td>E, W, Sp</td>
<td>6.0-8.5</td>
<td>38F</td>
<td></td>
</tr>
<tr>
<td>Oats p. 93</td>
<td></td>
<td></td>
<td></td>
<td>LSu, ESp</td>
<td>4.5-7.5</td>
<td>38F</td>
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<tr>
<td>Rye p. 98</td>
<td></td>
<td></td>
<td></td>
<td>LSu, W in 8+</td>
<td>5.0-7.0</td>
<td>34F</td>
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<tr>
<td>Wheat p. 111</td>
<td></td>
<td></td>
<td></td>
<td>LSu, F</td>
<td>6.0-7.5</td>
<td>38F</td>
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<tr>
<td>Buckwheat p. 90</td>
<td></td>
<td></td>
<td></td>
<td>Sp to LSu</td>
<td>5.0-7.0</td>
<td>50F</td>
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<tr>
<td>Sorghum–sudan. p. 106</td>
<td></td>
<td></td>
<td></td>
<td>LS, Sp, ES</td>
<td>6.0-7.0</td>
<td>65F</td>
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<tr>
<td>Mustards p. 81</td>
<td></td>
<td></td>
<td></td>
<td>Sp, LSu</td>
<td>5.5-7.5</td>
<td>40F</td>
<td></td>
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<tr>
<td>Radish p. 81</td>
<td></td>
<td></td>
<td></td>
<td>Sp, ES</td>
<td>6.0-7.5</td>
<td>45F</td>
<td></td>
</tr>
<tr>
<td>Rapeseed p. 81</td>
<td></td>
<td></td>
<td></td>
<td>E, Sp</td>
<td>5.5-8</td>
<td>41F</td>
<td></td>
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<tr>
<td>Berseem clover p. 118</td>
<td></td>
<td></td>
<td></td>
<td>ESp, EF</td>
<td>6.2-7.0</td>
<td>42F</td>
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<tr>
<td>Cowpeas p. 125</td>
<td></td>
<td></td>
<td></td>
<td>ESu</td>
<td>5.5-6.5</td>
<td>58F</td>
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<tr>
<td>Crimson clover p. 130</td>
<td></td>
<td></td>
<td></td>
<td>LSu/ESu</td>
<td>5.5-7.0</td>
<td>41F</td>
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<tr>
<td>Field peas p. 135</td>
<td></td>
<td></td>
<td></td>
<td>E, ESp</td>
<td>6.0-7.0</td>
<td>41F</td>
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<tr>
<td>Hairy vetch p. 142</td>
<td></td>
<td></td>
<td></td>
<td>EE, ESp</td>
<td>5.5-7.5</td>
<td>60F</td>
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<tr>
<td>Medics p. 152</td>
<td></td>
<td></td>
<td></td>
<td>EE, ESp, ES</td>
<td>6.0-7.0</td>
<td>45F</td>
<td></td>
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<tr>
<td>Red clover p. 159</td>
<td>subclover</td>
<td>CSA</td>
<td></td>
<td>LSu, ESp</td>
<td>6.2-7.0</td>
<td>41F</td>
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<tr>
<td>Subterranean clover p. 164</td>
<td></td>
<td>P/SP</td>
<td></td>
<td>LSu, EF</td>
<td>5.5-7.0</td>
<td>38F</td>
<td></td>
</tr>
</tbody>
</table>

Soil Quality

• Soil quality is the capacity of soils within landscapes to sustain biological productivity, maintain environmental quality, and promote plant and animal health.

http://soils.usda.gov/sqi/index.html
Soil Health Definition

Definitions

– Interactions between soil quality and plant/animal/human quality

– Sustaining and improving soil quality over the long term

Watch the short video “The Science of Soil Health Video Series Trailer” – see https://www.youtube.com/watch?v=IHOF6NfLm7M&list=PL4J8PxoprpgF1wFYsXFu-BW_mMatlElt0

Watch the short video “Soil health lesson in a minute: how healthy soil should look” – see https://www.youtube.com/watch?v=4NKGS4bj7cc
“The Solvita® soil-life test kit provides an important new tool for gardeners, farmers and scientists to evaluate soil microbial respiration rate in an efficient and cost-effective manner. Soil respiration is an important aspect of soil quality and a good indicator of soil fertility.”

“The Solvita test enables you to:
• estimate annual nitrogen release based on soil biological activity
• evaluate organic matter sufficiency of soils
• make overall judgements to fit into "soil quality" interpretation

Watch the video “Solvita CO2-Burst Test for Soil Health“ – see http://www.bing.com/videos/search?q=youtube+solvita&view=detail&mid=FC15D03BA6FEFC2B711EFC15D03BA6FEFC2B711E&FORM=VIRE
Humus Testing using LaMotte humus index test

Fresh worm compost = 5

Improved garden soil = 3.0

Newer garden soil with mulch = 1.0

Near-by Ag field (with subsoil) = 0
Alternative Soil Test ‘Tool’ Example: “Soil Foodweb” (a.k.a., Biodiversity)

Soil Foodweb Analysis

<table>
<thead>
<tr>
<th>Organism Biomass Data</th>
<th>Dry Weight</th>
<th>Active Bacterial (µg/g)</th>
<th>Total Bacterial (µg/g)</th>
<th>Active Fungal (µg/g)</th>
<th>Total Fungal (µg/g)</th>
<th>Hyphal Diameter (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>Comments</td>
<td>In Good Range</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>3</td>
</tr>
<tr>
<td>Expected Range</td>
<td>Low</td>
<td>0.45</td>
<td>1</td>
<td>175</td>
<td>1</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>0.85</td>
<td>6</td>
<td>300</td>
<td>5</td>
<td>300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organism Biomass Data</th>
<th>Protozoa Numbers/g</th>
<th>Amoebae</th>
<th>Ciliates</th>
<th>Total Nematodes #/g</th>
<th>Percent Mycorrhizal Colonization</th>
<th>ENDO</th>
<th>ECTO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>Comments</td>
<td>Flagellates</td>
<td>5810</td>
<td>1688</td>
<td>70</td>
<td>7.38</td>
<td>5%</td>
</tr>
<tr>
<td>Expected Range</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Good</td>
<td>5000</td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organism Biomass Ratios</th>
<th>Total Fungal to Total Bacterial</th>
<th>Active to Total Fungal</th>
<th>Active to Total Bacterial</th>
<th>Active Fungal to Active Bacterial</th>
<th>Plant Available N Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results</td>
<td>Comments</td>
<td>Low</td>
<td>Good</td>
<td>Low</td>
<td>Good</td>
</tr>
<tr>
<td>Expected Range</td>
<td>Low</td>
<td>High</td>
<td>0.8</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>
**Alternative Soil Test “Tool’ Example “Soil Health”**

### Cornell Soil Health Test Report

**FARM NAME/FARMER:** GATES FARM  
**ADDRESS:**

**FIELD/TREATMENT:** PLOW TILL NO COVER CROP  
**AGENT:**

**TILLAGE:** //  
**DRAINAGE:**

**CROPS:** //  
**SOIL TEXTURE:** SILTY

#### Indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Value</th>
<th>Rating</th>
<th>Constraint</th>
<th>Percentile Rating*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Stability (%)</td>
<td>17.0</td>
<td>1.0</td>
<td>aeration, infiltration, rooting</td>
<td></td>
</tr>
<tr>
<td>Available Water Capacity (m³/m³)</td>
<td>0.18</td>
<td>2.0</td>
<td>water retention</td>
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<tr>
<td>Surface Hardness (psi)</td>
<td>147</td>
<td>7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsurface Hardness (psi)</td>
<td>266</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic Matter (%)</td>
<td>2.4</td>
<td>1.0</td>
<td>energy storage, C sequestration, water retention</td>
<td></td>
</tr>
<tr>
<td>Active Carbon (ppm)</td>
<td>557</td>
<td>2.0</td>
<td>soil biological activity</td>
<td></td>
</tr>
<tr>
<td>Potentially Mineralizable Nitrogen (µgN/g dw soil/week)</td>
<td>4.0</td>
<td>1.0</td>
<td>N supply capacity, N leaching potential</td>
<td></td>
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<tr>
<td>Root Health Rating (1-9)</td>
<td>5.5625</td>
<td>5.0</td>
<td></td>
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</tr>
<tr>
<td>pH (see CNAL Report)</td>
<td>7.2</td>
<td>10.0</td>
<td></td>
<td></td>
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<tr>
<td>Extractable Phosphorus (see CNAL Report)</td>
<td>9.85</td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extractable Potassium (see CNAL Report)</td>
<td>52.375</td>
<td>7.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor Elements (see CNAL Report)</td>
<td></td>
<td>10.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Overall Quality Score (out of 100):** LOW 52.1

Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient requirements, consult your local extension agent.
Plant Nutrition Deficiency
Visual Diagnosis ‘Tool’: Corn Example

- **Drought**: Causes the corn to have a grayish-green color and the leaves roll up nearly to the size of a pencil.
- **Magnesium deficiency**: Causes whitish strips along the veins and often a purplish color on the underside of the lower leaves.
- **Nitrogen deficiency**: Hunger sign is yellowing that starts at the tips and moves along the middle of the leaf.
- **Potash deficiency**: Appears as a browning or drying along the tips and edges of the leaves.
- **Phosphorus shortage**: Marks leaves with reddish-purple, particularly on young plants.
- **Healthy leaves**: Shine with a rich dark green color when adequately fed.

Drawings: Maynard Reese
Visual Diagnosis “Tool”

http://hort.ufl.edu/database/nutdef/index.shtml
“Farmscaping” is a whole-farm approach for insect pest management & pollinator conservation.

It can be defined as the use of hedgerows, insectary plants, cover crops, and water reservoirs to attract and support populations of beneficial organisms such as insects, bats, and birds of prey.
Pollinator “Tools”

- Urban beekeeping uses vacant lot resources, thus increasing urban crop yields and providing local fresh honey too.

Watch a short video - [https://www.pbs.org/newshour/show/urban-beekeeping-rising-trend-major-cities](https://www.pbs.org/newshour/show/urban-beekeeping-rising-trend-major-cities)

- About 130 food crops are pollinated by bees

- Providing habitat for native bees also increases urban populations of pollinators

- UF/IFAS Bee College Education Resource

[http://entnemdept.ufl.edu/honeybee/](http://entnemdept.ufl.edu/honeybee/)
Whew!
Let’s take a break!
10 minutes