Use of Soil and Tissue Testing for Sustainable Crop Nutrient Programs

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FDACS-OAWP BMP Manuals

- Vegetable & Agronomic Crops
- Container Nursery
- Sod
- Cow/Calf
- Specialty Fruit & Nut
- Commercial Equine
- Consolidated Citrus
BMP Manuals

Provides BMPs on:

- Land preparation
- Nutrient management
- Irrigation management
- Drainage Management
- Sediment and erosion control
- Water resource protection
- Integrated pest management

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Benefits of Implementing BMPs

- A presumption of compliance with state water quality standards for the pollutants addressed by the BMPs.
- Release from fines for damages from pollutants addressed by the BMPs.
- Technical assistance with BMP implementation.
- Eligibility for cost-share for certain BMPs (as available).
- The Florida Right to Farm Act generally prohibits local governments from regulating an agricultural activity that is addressed through rule-adopted BMPs.
- Producers who implement FDACS-adopted BMPs might qualify for exemptions from WMD surface water permitting and/or satisfy other permitting requirements.
Agricultural Nutrients

- Excess nitrogen and phosphorus are the most common causes of water quality impairments in Florida. These nutrients can enter surface waters through stormwater or irrigation runoff, or leach through soils into ground water.
- In aerobic well-drained soils, urea and ammonium forms of nitrogen are usually transformed by bacteria to nitrate which is a plant-available form. Due to its high mobility, nitrate can also leach into ground water.
- Phosphorus is another primary plant nutrient and moves into water sources with sediments or leaching.
- N and P tend to be the (growth) limiting nutrient for lakes.
Agriculture and Water Quality

• Elevated levels of phosphorus, nitrogen, sediment, bacteria, and organic material contribute to the degradation of water quality.

• The potential for discharges from agricultural operations to cause water quality problems varies, depending on soil type, slope, drainage features, and nutrient and irrigation management practices.

• Nutrient-related pollutant discharges can come from:
  – excess use,
  – inefficient placement,
  – or poor application timing of commercial fertilizer
BMPs and Fertilizer

Best Management Practices (BMPs) adopted all current UF/IFAS recommendations.

Adequate fertilizer rates may be achieved by combinations of UF/IFAS recommended base rates and supplemental applications.

Fertilizer recommendations were determined based on Mehlich-1 (M1) extractable nutrients prior to planting. We have now changed to Mehlich-3.
Crop Nutrition

- Nutrient Best Management Practices
- Essential nutrients
- Nutrient deficiency symptoms
- Nutrient cycling
- Soil and Plant sampling, analysis and interpretation
Nutrient Best Management Practices

Ecologically based nutrient management with low impact on profitability
Improving Nutrient Use

Efficient water and nutrient use will:

- Use nutrient management plan to accurately determine nutrient applications
- Maintain adequate water and soil nutrient levels to maximize plant growth and health
- Increase growth and yield
- Decrease production cost and resource depletion: facilitates sustainable production
- Reduce nutrient losses and environmental impacts
Additional Benefits of Best Management Practices

• Promote rapid canopy development
• Increases crop resistance to disease and insect
• Potentially lower irrigation required
• Increased canopy growth can aid in weed control
Improving Nutrient Use Efficiency

Efficient water and nutrient use will:

- Maintain adequate water and soil nutrient levels to maximize plant growth and health
- Increase growth and yield
- Decrease production cost and resource depletion: facilitates sustainable production
- Reduce nutrient losses and environmental impacts
Limitations on Potential Crop Production

Potential annual production limitations:

- Soil type characteristics
  - pH, organic matter, water-holding capacity, and cation exchange capacity
- Production methods
  - Irrigation, and drainage systems
- Variety
  - Size, water and nutrient efficiency, yield
Nutrient Management Plan

• Annual plan should include:
  – Soil test results
  – Plant tissue test results
  – Realistic production goals
    • Based on past production, or potential production

• Nutrient budget for N, P, and K
  – Rates, Methods, Materials, and Timing

• Manage soil pH for optimum uptake
Nutrient Management

An increasingly accepted and successful approach called the 4R Nutrient Stewardship Program that captures the key elements of effective nutrient management:

- **Right Source** – a balanced supply of essential nutrients, considering both naturally available sources and specific products, in plant available forms;
- **Right Rate** – nutrients applied to the soil to supply nutrients to satisfy plant demand;
- **Right Time** – consideration of crop uptake, soil supply, nutrient loss risks, and field operation logistics; and
- **Right Place** – based on root-soil dynamics, nutrient movement, and soil variability within the field to maximize plant uptake and limit potential losses from the field.
The 5th R, Right Irrigation

- Water is the carrier for nearly all pollutants. Managing irrigation inputs and drainage to keep moisture and fertilizer primarily in the root zone will reduce nutrient-related impacts. Irrigating in excess of the soil’s water-holding capacity or excessive drainage will lead to increased runoff or leaching, and may lead to higher production costs or lower marketable yields.
Soil and Plant Tissue Analysis and Interpretation

Proper collection of samples and interpretation on results are as important as the analysis.
What is are Essential Plant Nutrients

N – P – K

Plant uses a lot. Easily lost from soil.

Plant uses a lot. Can be “fixed” in clay soil, or leached from sandy soil.

Plant uses a moderate amount. Many soils “fix” P, rendering it unavailable to plants.

elements that functions in plant metabolism and is essential for completion of the plant life cycle.
### Relative essential element composition of an average plant

<table>
<thead>
<tr>
<th>Element</th>
<th>No. atoms relative to Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molybdenum</td>
<td>1</td>
</tr>
<tr>
<td>Copper</td>
<td>100</td>
</tr>
<tr>
<td>Zinc</td>
<td>300</td>
</tr>
<tr>
<td>Manganese</td>
<td>1,000</td>
</tr>
<tr>
<td>Boron</td>
<td>2,000</td>
</tr>
<tr>
<td>Iron</td>
<td>2,000</td>
</tr>
<tr>
<td>Chlorine</td>
<td>3,000</td>
</tr>
<tr>
<td><strong>Sulfur</strong></td>
<td>30,000</td>
</tr>
<tr>
<td><strong>Phosphorus</strong></td>
<td>60,000</td>
</tr>
<tr>
<td>Magnesium</td>
<td>80,000</td>
</tr>
<tr>
<td>Calcium</td>
<td>125,000</td>
</tr>
<tr>
<td><strong>Potassium</strong></td>
<td>250,000</td>
</tr>
<tr>
<td><strong>Nitrogen</strong></td>
<td>1,000,000</td>
</tr>
<tr>
<td>Oxygen</td>
<td>30,000,000</td>
</tr>
<tr>
<td>Carbon</td>
<td>35,000,000</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>60,000,000</td>
</tr>
</tbody>
</table>

**MICRO-NUTRIENTS** Required in small amounts

**MACRO-NUTRIENTS** Required in large amounts
### Macronutrients in plants

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Concentration in plants (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>0.1 – 0.4</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.1 – 0.4</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.1 – 0.4</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.2 – 1.0</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.0 – 5.0</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.0 – 5.0</td>
</tr>
</tbody>
</table>

- P is essential for plant growth
- Much less P is needed compared with N and K
## Essential Nutrients – macronutrients

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Critical level</th>
<th>Optimal</th>
<th>Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>S (%)</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Fe (mg kg(^{-1}))</td>
<td>--</td>
<td>50-105</td>
<td>&gt;105</td>
</tr>
<tr>
<td>Mn (mg kg(^{-1}))</td>
<td>--</td>
<td>12-100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Zn (mg kg(^{-1}))</td>
<td>15</td>
<td>16-32</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Cu (mg kg(^{-1}))</td>
<td>3</td>
<td>4-8</td>
<td>&gt;9</td>
</tr>
<tr>
<td>B (mg kg(^{-1}))</td>
<td>4</td>
<td>--</td>
<td>&gt;45</td>
</tr>
</tbody>
</table>
Nutrient Mobility in Plants

• Mobile Nutrients
  – Move readily through the plant
  – Move from older leaves to younger leaves
  – Appear more in actively growing tissues
  – N, P, K, Na, Mg, sometimes S
  – Deficiency appears in older leaves

• Fixed Nutrients
  – Do NOT move from tissue to tissue in plants
  – Tissue concentrations related to uptake rate from the soil
  – B, Ca, Cu, Fe, Mn, Zn
  – Deficiency appears in younger leaves
Soil and Leaf Testing

• Nitrogen and Potassium leach rapidly in Florida sandy soils, only tested in leaves

• Most minor nutrients also leach or are made unavailable in soil

<table>
<thead>
<tr>
<th>Property or nutrient</th>
<th>Soil testing</th>
<th>Leaf testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Organic matter</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>P</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>K</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Ca</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mg</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cu</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Zn, Mn, Fe, B</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Soil Analysis or Plant Tissue Analysis

- Soil Analysis typically used to determine application needs prior to planting
- Extractable vs. available
- Deficiencies, toxicities and imbalances
- Plant analysis typically used during the season to determine if proper amount of nutrient are available “potential uptake conditions”
Soil Sampling Method

• Take sample cores to a 15 cm (6 inch) depth
• Composite 5-10 samples by management unit
• One sample per management unit
• Minimum of 20-30 cores per 15 hectares (~ 30 ac)
• Random patterns across field avoiding edges
Soil Sampling

• Objectives:
  – Provide an index of nutrient availability for plant growth
  – Predict the probability of obtaining profitable response to fertilizer application
  – Provide a basis for recommendations on the amount of fertilizer to apply
Soil Test Results

- Soil test results are extractable nutrients
- An index of available nutrients
- Not a measure of plant-available nutrients
- Not be used to calculate available nutrients

The probability of response to added fertilizer decreases as Soil Test Index increases.
Soil Test Interpretation

Example: Citrus

<table>
<thead>
<tr>
<th>Soil test rating</th>
<th>M1 Soil-test P (ppm)</th>
<th>Probability that crop will respond to P fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>&lt; 10</td>
<td>Very good</td>
</tr>
<tr>
<td>Low</td>
<td>10 – 15</td>
<td>Good</td>
</tr>
<tr>
<td>Medium</td>
<td>16 – 30</td>
<td>It might, it might not</td>
</tr>
<tr>
<td>High</td>
<td>31 – 60</td>
<td>About zero</td>
</tr>
<tr>
<td>Very high</td>
<td>&gt; 60</td>
<td>No chance</td>
</tr>
</tbody>
</table>

- Soil test results are extractable nutrients
- An index of available nutrients
- Not a measure of plant-available nutrients
- Not be used to calculate available nutrients
Extractants

- Soil test results are an index of available and cannot be used to calculate available nutrients.
- Water extracts only nutrient in solution.
- Bray 1 can only be used for soil with pH less than 7.4.
- Mehlich 1 and 3 best results on soils below pH 7.2 but can be used on higher pH soils.
- Olsen should only be used for Calcarious soils.
Soil Nutrients Recommendations Using Mehlich-3

- Changed from Mehlich 1 to Mehlich 3 in 2014
- Most Florida soils have increased in pH
- Mehlich 3 best extractant to provide fertilizer recommendations

<table>
<thead>
<tr>
<th>Table 1. Comparison of Mehlich-1 and Mehlich-3 soil extractants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mehlich-1</strong></td>
</tr>
<tr>
<td>Valid pH Range</td>
</tr>
<tr>
<td>Extraction of P</td>
</tr>
<tr>
<td>Extraction of Micronutrients</td>
</tr>
<tr>
<td>Exchangeable Cations</td>
</tr>
</tbody>
</table>
Comparing Soil Test Results for Mehlich 1 and Mehlich 3

- **Mehlich-3 Extractable Soil P (mg kg⁻¹)**
  - Graph showing a linear relationship with the equation $M3 = 1.24M1 + 9.57$, $R^2 = 0.83$.

- **Mehlich-3 Extractable Soil K (mg kg⁻¹)**
  - Graph showing a linear relationship with the equation $M3 = 1.00M1 + 0.93$, $R^2 = 0.93$.

- **Soil Mg concentrations with M3 extraction, mg kg⁻¹**
  - Graph showing a linear relationship with the equation $M3 = 1.0178M1 + 0.6314$, $R^2 = 0.9402$.

- **Soil Mg concentrations with M1 extraction (mg kg⁻¹)**
  - Graph showing a linear relationship with the equation $M3 = 1.0178M1 + 0.6314$, $R^2 = 0.9402$. 

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**University of Florida**

**IFAS**
## Current Mehlich 3 Soil Test Interpretation

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>≤25</td>
<td>26–45</td>
<td>&gt;45</td>
</tr>
<tr>
<td>K</td>
<td>≤35</td>
<td>36–60</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Mg</td>
<td>≤20</td>
<td>21–40</td>
<td>&gt;40</td>
</tr>
</tbody>
</table>
Availability

- P increasingly available with increased pH
- P increasingly not available above pH 7.0 in high Ca soils
- P most available in the pH range of 5.5 to 6.5
- P soil tests suggest that P can accumulate and remain available for years
Phosphorus

- Reduced Availability
  - "Fixed" by soil calcium
  - Available to plant for short period of time
  - Accumulates over time in insoluble forms

\[
\begin{align*}
H_2PO_4 & \rightleftharpoons Ca \\
CaHPO_4 \cdot 2H_2O & \rightleftharpoons Ca \times \left[ Ca_8H_2[PO_4]_6 \cdot 5H_2O \right] \\
& \rightleftharpoons Ca_{10}H_2[PO_4]_6 \cdot 5H_2O \\
& \rightleftharpoons Ca_{10}F_2[PO_4]_6 \cdot 5H_2O
\end{align*}
\]
P Availability Over Time

- Available P mostly water and some bicarbonate extractable
- Increasingly less soluble (less available) with increase as you move up Bar
- Indication of reduced concentration of dilute acid and water extractable P with time
Soil pH

• Optimum range – 5.5 to 6.5
• Determines micronutrient availability
• Reduced effect on N and P transformation
• Adjusted using Ca and S
• pH management is used to supply Ca, S and Mg
Effect of Soil pH

- Cumulative volatilization with time is dependent on soil pH
- Minimum volatilization below pH 5

Soil/P retention capacity

**RPA**  (Relative P Adsorption capacity)  
0.0  --  1.0  
very low  --  very high

**P_{max}**  (P adsorption maximum)  
units of ppm
Leaf Analysis

• Nutrient level varies through growth period
• Leaf petiol sap testing
• Leaf analysis
• Two methods of interpreting analytical results:
  – Critical Nutrient Level
  – Diagnosis and Recommendation Integrated System (DRIS)
Leaf Analysis - Interpretation

- Samples for Critical Nutrient Level recommendation must be taken at Stage 4 “grand growth” period
- Samples for Diagnostic Recommendations Integration System (DRIS) recommendations not sensitive to tissue age
Leaf Petiol Sap testing
# Tomato Leaf Sap Sufficiency Range

Table 17. Critical (deficiency) values, adequate ranges, high values, and toxicity values for macronutrients for vegetables (most-recently-matured whole leaf plus petiole (MRM leaf) unless otherwise noted).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Plant Part</th>
<th>Time of Sampling</th>
<th>Status</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>MRM leaf</td>
<td>5 leaf stage</td>
<td>Deficient</td>
<td>&lt;3.0</td>
<td>0.3</td>
<td>3.0</td>
<td>1.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adequate</td>
<td>3.0</td>
<td>0.3</td>
<td>3.0</td>
<td>1.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>range</td>
<td>5.0</td>
<td>0.6</td>
<td>5.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td>&gt;5.0</td>
<td>0.6</td>
<td>5.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>MRM leaf</td>
<td>First flower</td>
<td>Deficient</td>
<td>&lt;2.8</td>
<td>0.2</td>
<td>2.5</td>
<td>1.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adequate</td>
<td>2.8</td>
<td>0.2</td>
<td>2.5</td>
<td>1.0</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>range</td>
<td>4.0</td>
<td>0.4</td>
<td>4.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td>&gt;4.0</td>
<td>0.4</td>
<td>4.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>MRM leaf</td>
<td>Early fruit set</td>
<td>Deficient</td>
<td>&lt;2.5</td>
<td>0.2</td>
<td>2.5</td>
<td>1.0</td>
<td>0.25</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adequate</td>
<td>2.5</td>
<td>0.2</td>
<td>2.5</td>
<td>1.0</td>
<td>0.25</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>range</td>
<td>4.0</td>
<td>0.4</td>
<td>4.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>High</td>
<td>&gt;4.0</td>
<td>0.4</td>
<td>4.0</td>
<td>2.0</td>
<td>0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Leaf Sampling Technique

- A sampled citrus grove block should be no larger than 20 acres
- Each leaf sample should consist of about 100 leaves taken from non-fruiting twigs of 15 to 20 uniform trees
- Select only one leaf from a shoot and remove it with its petiole (leaf stem)
Leaf Nutrient Concentrations

- Leaf nutrient concentrations continuously change.
- As leaves age from spring through fall, N, P, and K concentrations decrease, Ca increases, and Mg first increases and then decreases.
- Leaf mineral concentrations are relatively stable from 4 to 6 months after emergence in the spring.
Leaf Nutrient Concentrations

These standards are based on long-term field observations and experiments conducted in different countries with different citrus varieties, rootstocks, and management practices, and are used to gauge citrus tree nutrition throughout the world.
# Interpretation of Leaf Analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>What if it is less than optimum in the leaf?</th>
<th>What if it is greater than optimum in the leaf?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What if it is less than optimum in the leaf?</td>
<td>Options:</td>
</tr>
<tr>
<td></td>
<td>2. Check tree health.</td>
<td>2. Review N fertilizer rate.</td>
</tr>
<tr>
<td></td>
<td>3. Review water management.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Review N fertilizer rate.</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>1. Apply P fertilizer (see Chapter 8).</td>
<td>1. Do nothing.</td>
</tr>
<tr>
<td>K</td>
<td>1. Increase K fertilizer rate (see Chapter 8).</td>
<td>1. Decrease K fertilizer rate.</td>
</tr>
<tr>
<td></td>
<td>2. Apply foliar K fertilizer.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Check soil test Ca status.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Consider applying lime or soluble Ca fertilizer depending on soil pH.</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>1. Check soil test Mg status.</td>
<td>1. Do nothing.</td>
</tr>
<tr>
<td></td>
<td>2. Check soil pH.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Consider applying dolomitic lime or soluble Mg fertilizer depending on pH.</td>
<td></td>
</tr>
<tr>
<td>Micronutrients</td>
<td>1. Check soil pH and adjust if needed.</td>
<td>1. Check for spray residue on tested leaves.</td>
</tr>
<tr>
<td></td>
<td>2. Apply foliar micronutrients.</td>
<td>2. Do nothing.</td>
</tr>
<tr>
<td></td>
<td>3. Include micronutrients in soil-applied fertilizer.</td>
<td></td>
</tr>
</tbody>
</table>
DRIS – Diagnosis and Recommendation Integrated System

- Nutrient ranked in order of relative deficiency
- Considers nutrient interactions and balances
- Moderates effect of growth stage, geographic area, sample variability
- Potential problem – indices must add up to 0 so fertilizer recommendation is determined when one may not be needed
# DRIS Indices

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Balanced</th>
<th>Imbalance</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/P</td>
<td>7.91 – 9.51</td>
<td>&lt;7.11 or &gt;10.32</td>
</tr>
<tr>
<td>N/K</td>
<td>1.36 – 1.72</td>
<td>&lt;1.19 or &gt;1.89</td>
</tr>
<tr>
<td>K/P</td>
<td>4.94 – 6.33</td>
<td>&lt;4.24 or &gt;7.03</td>
</tr>
<tr>
<td>Ca/N</td>
<td>0.13 – 0.17</td>
<td>&lt;0.11 or &gt;0.20</td>
</tr>
<tr>
<td>Ca/P</td>
<td>1.08 – 1.54</td>
<td>&lt;0.84 or &gt;1.77</td>
</tr>
<tr>
<td>Ca/Mg</td>
<td>1.13 – 1.64</td>
<td>&lt;0.87 or &gt;1.90</td>
</tr>
<tr>
<td>Mg/N</td>
<td>0.10 – 0.13</td>
<td>&lt;0.08 or &gt;0.15</td>
</tr>
<tr>
<td>Mg/P</td>
<td>0.80 – 1.17</td>
<td>&lt;0.61 or &gt;1.36</td>
</tr>
<tr>
<td>Mg/K</td>
<td>0.13 – 0.20</td>
<td>&lt;0.09 or &gt;0.23</td>
</tr>
</tbody>
</table>
Conclusion

• Crop nutrition program should be based on:
  – Economically sound practices
  – Ecologically sound practices
  – Knowledge of essential nutrients
  – Understanding of nutrient cycles in the soil
  – Effects of soil/plant interaction with nutrients
  – Proper soil and tissue testing
  – Appropriate test interpretations
Conclusions

• Soil and Leaf sampling is a key BMP
• Information on leaf and soil samples should be taken in a consistent manner over a period of years to provide the best information
• Soil sample extraction has changed but the sampling practices have not, and interpretation is similar
• Leaf nutrient ratios differ during the growing season and must be maintained to insure tree health
• Nutrient ratios may be key to sustaining yields with greening trees (work continues)
Thank you for your attention

Questions

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