Preventing, diagnosing and understanding nutrient deficiencies in plants

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Cropping Systems Specialist

35th Florida Master Gardener Continued Training Conference
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Oct. 16, 2017
What nutrient deficiency is this?

A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron

[Bar chart showing nutrient percentages]
What nutrient deficiency is this?

A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron
Diagnosing nutrient deficiencies: Soil pH and nutrient availability
Plant mobile vs. immobile

- All nutrients are xylem mobile: They move up the plant.
- “Immobile” nutrients = does not move in phloem.

<table>
<thead>
<tr>
<th>Mobile nutrients in plants</th>
<th>Immobile nutrients in plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remobilized to parts that have higher demand.</td>
<td>Locked in place after assimilation.</td>
</tr>
<tr>
<td>Older growth becomes deficient.</td>
<td>Newer growth becomes deficient.</td>
</tr>
</tbody>
</table>
Nutrient movement in soil

Diffusion

Interception

Shoot

Mass flow

Root
Nutrient movement in soil

• Mass flow
  – Movement of ions in water
  – Can move up (via ET) or down (leaching)
  – Major: NO$_3^-$, Cl$^-$, K$^+$, Mg$^{2+}$
  – Moderate: SO$_4^{2-}$
  – Others depending on physical & chemical soil characteristics

Nutrient movement in soil

• Diffusion
  – Concentration gradient
  – 1 cm/day for soluble ions
  – If bound to soil, takes longer
    • $\text{NO}_3^-$ about 3 mm/day
    • $\text{K}^+$ about 1 mm/day
    • $\text{PO}_4^{3-}$ about 0.1 mm/day
  – Important for P, K, S, Fe, Zn

Nutrient movement in soil

• Root interception
  – Root contacts CEC sites
  – Relatively minor absorption
  – Mycorrhizal infection effectively increases root area – P uptake
  – Mainly Ca, Mg, Zn, Mn

Soil texture effects on nutrient movement

- As % sand increases, NPK & S movement increases.
- Like OM, as % clay increases, NPK & S movement decreases.

http://www.canolacouncil.org/
Nitrogen

- Mobile in plant
- Forms amino acids, vitamins, proteins, cell division, chlorophyll
- Mobile in soil as NO₃⁻
- Immobile in soil as NH₄⁺
- Chlorosis in older leaves first, then in younger tissue
Nitrogen deficiency

Maize

Lettuce

Potato

Credits: IPNI Crop Nutrient Deficiency Image Collection
Phosphorus

• Somewhat mobile in plant
• Role: Energy storage and transfer, cell growth, root and seed growth, winter hardiness, water use/stomatal regulation
• Immobile in soil – but sand is different
• Moves to plant by diffusion and mycorrhizal fungi assn.
• Increased deficiency when temp is low

Credit: IPNI Crop Nutrient Deficiency Image Collection
P deficiency

Maize

Beet

Sweet potato

Credits: IPNI Crop Nutrient Deficiency Image Collection
Potassium

• Highly mobile in plant
• Metabolism, water regulation, fruit formation, winter hardiness, disease resistance
• Somewhat mobile in soil
  – Depends on texture, clay type
  – Finer soils = less mobile
  – Mica clays = more availability
• Deficiencies in dry conditions when there is sufficient soil K – lack of movement to roots
K deficiency

Credit: Bobby Golden, MSU

Credit: IPNI Crop Nutrient Deficiency Image Collection, C.R. Crozier

Eggplant

Soybean

Cucumber

Maize

Lettuce

Progression

Normal Early Obvious Advanced
Calcium

• Immobile in plant
• Cell division & formation, N metabolism, translocation, fruit set
• Somewhat mobile in soil
• Soil deficiency usually occurs:
  – Acid, sandy soils
  – Strongly acid peat and muck
Ca deficiency

Maize

Lettuce

Tomato

Wheat

Credits: IPNI Crop Nutrient Deficiency Image Collection
Boron

- Immobile in plant
  - Except peanut
- Pollen grain germination & tube growth, seed & cell wall formation, maturity promotion, sugar translocation
- Mobile in soil
  - In sands, you may need split applications
B deficiency

Maize

Soybean

Cauliflower

Peanut
Field diagnosis

Credit: IPNI Crop Nutrient Deficiency Image Collection
Field diagnosis

Old Leaves

Symptoms on entire plant:
- Plant light green. Lower leaves yellow, drying to brown

Symptoms on lower leaves only:
- Plant dark green with red or purple color. Lower leaves yellow, drying to dark green
- Older leaves yellow at the edges, but stay green in the center.
- Older leaves wilt or scorch. Edges necrotic with spots on leaves.

Nitrogen
Phosphorus
Magnesium
Potassium

Credit: Gene McAvoy
Field diagnosis

New Leaves

- Leaves distorted and/or necrotic
  - Terminal bud dies
    - Boron
      - New leaves distorted. Tips and edges necrotic.
        - Calcium
  - Terminal bud does not die
    - Plant stunted. Leaves bluish-green, small and distorted.
      - Copper

- Leaves chlorotic
  - Entire leaf chlorotic, spreading to entire plant
    - Sulfur
      - Stems shortened and rosetted
        - Zinc
          - Leaves without necrotic spots
            - Iron
              - Manganese
          - Leaves develop necrotic spots
  - Intervenial chlorosis
    - Stems not shortened or rosetted
      - Leaves with necrotic spots
Tissue sampling for nutrient deficiency

Preventing nutrient deficiency: It’s all about the soil!
First line of defense: Soil sampling

- Soil sample within management zones
- Sample in a W pattern
- Sample to rooting depth
- Variable fields need more samples
- Sample in early spring
Soil sampling equipment
The Master Variable: soil pH
Mailing Address (please print)

Name ___________________________ Date __________

Address ___________________________ FL, Zip _______ Phone ________

Email* *Please provide an email address to receive your results letter.

Signature *(Signature only required for UF personnel for approval of charged charges)

Fill in all requested information, using one line per sample. Use additional forms for more than 11 samples.

<table>
<thead>
<tr>
<th>Lab Use Only</th>
<th>Sample ID</th>
<th>County</th>
<th>Estimated Acreage*</th>
<th>Crop Code(s) (see page 2)</th>
<th>Test Code (see page 2)</th>
<th>Cost (see page 2)</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

* This information is used to compute the total acreage served by the UF/IFAS Soil Testing Program.

Check □ Money Order □ Cash □ Total __________
Please enclose payment and this sheet in the same package as sample(s). Please make checks and money orders payable to UNIVERSITY OF FLORIDA. Samples will not be processed without payment. Do not send cash through the mail.

Important Information for Soil Sample Collection and Submission

Before Sampling
1. Develop a soil sampling plan for your field. Samples should represent the area being tested, so collect samples from areas of the same soil type, appearance, or cropping history. Sample problem areas separately, if needed. From this plan, count the number of samples you will collect.
2. Soil sample bags, addressed shipping boxes, and test forms are available free from your county UF/IFAS Extension office. Obtain the materials you need before completing your sampling plan.

Collecting Samples
1. Collect soil from 20 or more spots in each area, mixing these samples in a clean plastic bucket.
2. Sample from soil surface to depth of tillage, usually 0-6 inches. For pastures, sample from 0 to 6 inches depth.
3. Spread the composted material on clean paper or other suitable material to air-dry. Do not send wet samples.
4. Mix the dry soil, and place about 1 pint of soil in a labeled sample bag.

Sending Samples to the Extension Soil Testing Laboratory
1. Enter each sample’s ID on its sample bag and in the Sample ID column. List each sample separately.
2. Lime and fertilizer recommendations are provided only if the Crop Code(s) is listed.
3. Include the Test Code for each desired test.
4. Enter costs from the Test Cost list found on page 2 of this form.
5. Add the costs of all samples and tests. Make check or money order payable to University of Florida. Checks written to other names will NOT be honored and will be returned, causing a delay in processing the samples.
6. Include the completed Producer Soil Test Form and the check or money order in the shipping box with the sample(s).

Test Results
A soil test report will be emailed/mail to you in 3–5 days after your sample arrives at the Extension Soil Testing Laboratory. Contact your county UF/IFAS Extension office if you have questions about the soil test report.
Crop and Test Codes for Producer Soil Test Form

Standard fertilizer and lime recommendations based on the soil test results will be supplied with the test results if you indicate a Crop Code. Please write the appropriate Crop Codes on page 1 of this form. If your crops are not in the list of codes below, routine soil tests may not be appropriate. In such instances, consult your local county UF/IFAS Extension agent about interpreting before taking samples.

### AGRONOMIC CROPS

<table>
<thead>
<tr>
<th>Crop Code</th>
<th>Crop Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Corn, irrigated</td>
</tr>
<tr>
<td>5</td>
<td>Corn irrigated</td>
</tr>
<tr>
<td>9</td>
<td>Cotton</td>
</tr>
<tr>
<td>7</td>
<td>Grain sorghum</td>
</tr>
<tr>
<td>8</td>
<td>Oats for grain</td>
</tr>
<tr>
<td>10</td>
<td>Peanuts</td>
</tr>
<tr>
<td>13</td>
<td>Rye for grain</td>
</tr>
<tr>
<td>11</td>
<td>Soybeans</td>
</tr>
<tr>
<td>12</td>
<td>Tobacco (blue cured)</td>
</tr>
<tr>
<td>27</td>
<td>Wheat for grain</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop Code</th>
<th>Crop Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>Alfalfa</td>
</tr>
<tr>
<td>26</td>
<td>Cool-season annual grasses (small grains and ryegrass)</td>
</tr>
<tr>
<td>22</td>
<td>Cool-season legumes or legume-grass mixtures (leptines, sweetclover, ritches, and all true clovers, white, red, arrowleaf, crimson, subterraneum)</td>
</tr>
<tr>
<td>32</td>
<td>Hay or silage (perennial grass)</td>
</tr>
<tr>
<td>25</td>
<td>Improved perennial grasses other than bahiagrass (bermuda, digi, star)</td>
</tr>
<tr>
<td>33</td>
<td>Limnophila (Hemarthria)</td>
</tr>
<tr>
<td>28</td>
<td>Perennial peanuts</td>
</tr>
<tr>
<td>14</td>
<td>Summer forages (e.g., millet or sorghum)</td>
</tr>
<tr>
<td>21</td>
<td>Warm-season legumes or legume-grass mixtures (aschynomene, sweetclover, desmodium, hairy indigo and other tropical legumes)</td>
</tr>
</tbody>
</table>

### VEGETABLE CROPS

Please use the Landscape and Vegetable Garden Test Form (SL136) for home gardens. Codes for particular vegetables will result in fertilizer recommendations for commercial vegetable production that are not appropriate for home vegetable gardens.

<table>
<thead>
<tr>
<th>Crop Code</th>
<th>Crop Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>217</td>
<td>Pea, Lima, pole, or snap</td>
</tr>
<tr>
<td>228</td>
<td>Beet</td>
</tr>
<tr>
<td>212</td>
<td>Broccoli</td>
</tr>
<tr>
<td>212</td>
<td>Brussel sprouts</td>
</tr>
<tr>
<td>207</td>
<td>Cabbage, head or Chinese</td>
</tr>
<tr>
<td>225</td>
<td>Carrot</td>
</tr>
<tr>
<td>212</td>
<td>Cauliflower</td>
</tr>
<tr>
<td>214</td>
<td>Celery</td>
</tr>
<tr>
<td>207</td>
<td>Collard</td>
</tr>
<tr>
<td>220</td>
<td>Corn, sweet</td>
</tr>
<tr>
<td>211</td>
<td>Cucumber</td>
</tr>
<tr>
<td>203</td>
<td>Eggplant</td>
</tr>
<tr>
<td>225</td>
<td>Kale</td>
</tr>
<tr>
<td>229</td>
<td>Leek</td>
</tr>
<tr>
<td>209</td>
<td>Lettuce, crisphead endive, escarole, or romaine</td>
</tr>
<tr>
<td>205</td>
<td>Muskhead</td>
</tr>
<tr>
<td>225</td>
<td>Mustard</td>
</tr>
</tbody>
</table>

### FRUIT CROPS

Except for pH and lime requirement, and in some cases P, soil tests are not used as a basis for fertilization of perennial fruit and nut crops in Florida. Program fertilization is practiced, and plant tissue testing is helpful in certain crops. Tissue testing is available from commercial labs. Consult with your local county UF/IFAS Extension agent about interpretation before taking samples.

<table>
<thead>
<tr>
<th>Crop Code</th>
<th>Crop Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>Blackberry (foraging)</td>
</tr>
</tbody>
</table>

### ORNAMENTAL HORTICULTURE

Do not use this form for potting media used in containers. Use the Container Media Test Form (SL134). For fertilization of plants in the landscape, use the Landscape and Vegetable Garden Test Form (SL136).

<table>
<thead>
<tr>
<th>Crop Code</th>
<th>Crop Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>601</td>
<td>Commercial nursery growing azaleas, camellias, gardenias, hibiscus, or roses in the ground</td>
</tr>
<tr>
<td>600</td>
<td>Commercial woody ornamental nursery growing plants other than azaleas, camellias, gardenias, hibiscus, or roses in the ground</td>
</tr>
<tr>
<td>71</td>
<td>Athletic field, golf green, tee, or runway</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Code</th>
<th>Test Name</th>
<th>Determinations Made</th>
<th>Test 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</td>
</tr>
<tr>
<td>2</td>
<td>Soil pH and Lime Requirement</td>
<td>pH and lime requirement</td>
<td>$3</td>
</tr>
<tr>
<td>3</td>
<td>Soil Micronutrients</td>
<td>Ca, Mg, Zn, and pH</td>
<td>$5</td>
</tr>
<tr>
<td>4</td>
<td>Organic Matter</td>
<td>percent organic matter</td>
<td>$10</td>
</tr>
<tr>
<td>5</td>
<td>Electrical Conductivity (soluble salts)</td>
<td>conductivity in 1/2 softwater</td>
<td>$2</td>
</tr>
</tbody>
</table>

* Included in standard soil fertility test. Do not request both codes 1 and 2 for the same soil sample.
**Feed Sample Information Sheet**

**Charge To:**
UNIVERSITY OF FLORIDA - WREC
5988 HWY 90, BUILDING 4900
MILTON, FL 32583

**Grower:**
UNIVERSITY OF FLORIDA - WREC
4153 EXPERIMENT RD, HWY 182
JAY, FL 32565

**Date Submitted:**

<table>
<thead>
<tr>
<th>LAB NUMBER</th>
<th>SAMPLE NUMBER</th>
<th>SAMPLE DESCRIPTION</th>
<th>FEED TEST REQUESTED</th>
<th>NITRATE NO.</th>
<th>INDIVIDUAL</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 2 3 4 5 6 7 8</td>
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</tbody>
</table>

**Total No. of Samples:**

**Phone #:** 850-382-5221

**Fax #:**

**Explanation of Test:**

- **FEED TEST 1:** Moisture And Crude Protein
- **FEED TEST 2:** Feed Test 1 Plus Calcium and Phosphorus
- **FEED TEST 3:** Moisture, Crude Protein, Crude Fat, and Crude Fiber
- **FEED TEST 4:** Feed Test 3 Plus Calcium and Phosphorus
- **FEED TEST 5:** Moisture, Crude Protein, Crude Fiber, and Total Digestible Nutrients
- **FEED TEST 6:** Feed Test 5 Plus Calcium and Phosphorus
- **FEED TEST 7:** Moisture, Crude Protein, Digestible Protein, Crude Fat, Crude Fiber, Nitrogen Free Extract, Total Digestible Nutrients, and Ash
- **FEED TEST 8:** Same as Feed Test 7 Plus Calcium and Phosphorus

**REMARKS:**
Soil test reports

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

Producer Soil Test Report

For further information contact:

Atkins, John (Michael Donahoe-cotton)
Santa Rosa County Coop Extn Service
6263 Dogwood Dr
Milton FL 32570-3500
Tel: 850-623-3868
Email: srcextag@ufl.edu

To:
WFREC-Jay/Mulvaney, Michael
4253 Experiment Rd Hwy 182
Jay FL, 32565

Client Identification: 1
Set Number: E40558
Lab Number: E102222
Report Date: 20-Jan-17

Crop: Corn, irrigated

SOIL TEST RESULTS AND THEIR INTERPRETATIONS

Target pH: 6.5  This is the pH at which the above crop will grow at its optimum
pH (1:2 Sample:Water) 5.9  This is the pH of your sample in the water medium
A-E Buffer Value: 7.63
Buffer pH is the pH of your soil in Adams-Evans Buffer (A-E Buffer). This is done to determine the lime requirement, which will help increase the soil pH to the target pH level desired by the crop.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (mg/Kg or ppm P)</td>
<td>94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium (mg/Kg or ppm K)</td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Magnesium (mg/Kg or ppm Mg)</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Calcium (mg/Kg or ppm Ca)</td>
<td></td>
<td>195</td>
<td></td>
</tr>
</tbody>
</table>
Soil test reports: Extractants, commercial vs. public labs

<table>
<thead>
<tr>
<th>Lab &amp; Extr.</th>
<th>P</th>
<th>K</th>
<th>Mg</th>
<th>Ca</th>
<th>soil pH</th>
<th>buffer pH</th>
<th>S</th>
<th>B</th>
<th>Zn</th>
<th>Mn</th>
<th>Fe</th>
<th>Cu</th>
<th>OM %</th>
<th>ENR</th>
<th>CEC</th>
<th>Base saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waters (M1)</td>
<td>117</td>
<td>91</td>
<td>68</td>
<td>453</td>
<td>5.7</td>
<td>7.7</td>
<td>22</td>
<td>0.3</td>
<td>5.9</td>
<td>15</td>
<td>25</td>
<td>2.3</td>
<td>0.82</td>
<td>16</td>
<td>3.9</td>
<td>3 7.2 28.8 61</td>
</tr>
<tr>
<td>UGA (M1)</td>
<td>117</td>
<td>96</td>
<td>58</td>
<td>359</td>
<td>5.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Waypoint (M3)</td>
<td>424</td>
<td>94</td>
<td>72</td>
<td>444</td>
<td>6.2</td>
<td>7.91</td>
<td>18</td>
<td>0.4</td>
<td>10</td>
<td>80</td>
<td>2016</td>
<td>4.4</td>
<td>1.6</td>
<td>76</td>
<td>1.8</td>
<td>6.7 16.7 61.7 11.1</td>
</tr>
<tr>
<td>UFL (M3)</td>
<td>188</td>
<td>100</td>
<td>60</td>
<td>390</td>
<td>5.9</td>
<td>7.63</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.09</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
## Soil test recommendations: commercial vs. public labs

<table>
<thead>
<tr>
<th>Lab &amp; Extr.</th>
<th>Crop rec.</th>
<th>Lime tons/ac</th>
<th>Gypsum tons/ac</th>
<th>N lbs/ac</th>
<th>P lbs/ac</th>
<th>K lbs/ac</th>
<th>Mg lbs/ac</th>
<th>S lbs/ac</th>
<th>B lbs/ac</th>
<th>Zn lbs/ac</th>
<th>Mn lbs/ac</th>
<th>Cu lbs/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waters (M1)</td>
<td>Corn (200 bu/ac)</td>
<td>1.0</td>
<td>-</td>
<td>280</td>
<td>60</td>
<td>230</td>
<td>35</td>
<td>23</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Waypoint (M3)</td>
<td>Corn (200 bu/ac)</td>
<td>0.5</td>
<td>-</td>
<td>183</td>
<td>0</td>
<td>125</td>
<td>17</td>
<td>11</td>
<td>1.5</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>UGA (M1)</td>
<td>Corn (200 bu/ac)</td>
<td>1.25</td>
<td>-</td>
<td>240</td>
<td>0</td>
<td>140</td>
<td>-</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>UFL (M3)</td>
<td>Corn (200 bu/ac)</td>
<td>0.8</td>
<td>-</td>
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<td>20</td>
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<td>80</td>
<td>15</td>
<td>8</td>
<td>0.7</td>
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<td>5</td>
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</tr>
<tr>
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Commercial labs tend to have higher recommendations than public labs.
What nutrient deficiency is this?

A. Nitrogen  B. Phosphorus  C. Potassium  D. Calcium  E. Boron
What nutrient deficiency is this?

A. Nitrogen
B. Phosphorus
C. Potassium
D. Calcium
E. Boron
Questions?

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