Plant Mineral Analysis

January 8, 2015

Winter Webinar Series
Plant Mineral Analysis

- total analysis
- limited to inorganic constituents
  - elements on the periodic table

sciencenotes.org
Agree or disagree?

Observing visual symptoms on crops is an effective way to identify nutrient insufficiency.
Plan for today ...

• general sampling issues
• plant-nutrient relationships
• purposes of plant mineral analysis
  – sampling approach for each purpose
• analytical process
• interpretation of mineral analysis data
What’s the Goal of Any Sampling & Testing?

• accurate analysis of a representative sample

• requires an understanding of the test subject
soil

manure

plant
Soil Sampling Issues

- mineral-organic material
  - chemically reactive
  - living component
- delay sampling for 6 months after nutrient application
- sampling time not highly critical
  - pH, P and K
Manure

• organic matrix
  – minor mineral component
  – labile (unstable) materials
  – rich in microbial life

• undergoes biochemical reactions when environmental conditions allow
What environmental conditions have a huge impact on biochemical reactions?
Sampling Manure: Things to Remember

• sample as close to time of crop utilization as possible

• sample between Thanksgiving and New Year for timely analysis AND plan development
Plant Sampling Issues

• living organisms
  - distinct developmental stages
  - nutrient levels differ across plant parts and over time
Nutrient Concentrations May Vary with Location on Plant

Fig. 3-12. Concentrations of certain nutrient elements in leaves of field-grown sugarcane plants in Hawaii. The leaves were numbered successively from the tip of the stem downward. (Data by Tanimoto quoted by Baver, 1960)
Nutrient Concentrations Decrease with Time

Scaife and Turner, 1983, Diagnosis of Mineral Disorders in Plants
Why Spend the Time and Money?

• for perennial fruit crops, it’s the primary basis of nutrient recommendations

• enhance understanding of nutritional environment for high value crops (monitoring)

• justify nutrient applications above the level recommended by soil tests

• diagnose problematic fields or areas of fields
More Reasons (of interest to researchers)...

• investigate fertilizer efficiency
• determine if contaminated sites are safe for food production
• determine if an amendment adversely impacts quality of plants for humans or animals
  – introduction of a potentially toxic non-nutrient into the food chain
  – sewage sludge (biosolids), fly ash, flue gas desulfurization gypsum
# Nutrient Status Terminology

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>deficient</td>
<td>level that severely reduces growth and production</td>
</tr>
<tr>
<td>critical range (value)</td>
<td>level below which growth is adversely impacted</td>
</tr>
<tr>
<td>sufficient/adequate/normal</td>
<td>optimal level</td>
</tr>
<tr>
<td>high</td>
<td>higher level than needed for optimal growth</td>
</tr>
<tr>
<td>excessive</td>
<td>level associated with reduced growth</td>
</tr>
</tbody>
</table>
Deficient: visible symptoms of deficiency
Marginal: no symptoms
Adequate: defined experimentally or derived from field observations
Excessive: may not show toxicity symptoms

Nutrient concentration in plant part

* Specified reduction in growth of yield (often 5%, 10% or 20%)

Figure 4.3 Diagrammatic representation illustrating the meaning of terms used to classify the nutrient status of plants.
Sampling Perennial Tree Fruit Crops

- plant part and location
- timing
- unbiased sampling pattern/multiple plants
Why Sampling Time is Critical

Modified from Westwood
## Interpretation Varies Across Species (NM-5)

<table>
<thead>
<tr>
<th>Potassium Level</th>
<th>Apples (%)</th>
<th>Brambles (%)</th>
<th>Blueberries (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>deficient</td>
<td>&lt;0.70</td>
<td>&lt;1.45</td>
<td>&lt;0.35</td>
</tr>
<tr>
<td>low</td>
<td>0.70 – 1.20</td>
<td>1.45 – 1.50</td>
<td>0.35 – 0.40</td>
</tr>
<tr>
<td>normal</td>
<td>1.20 – 2.01</td>
<td>1.50 – 2.50</td>
<td>0.40 – 0.65</td>
</tr>
<tr>
<td>high</td>
<td>&gt;2.01</td>
<td>&gt;2.50</td>
<td>&gt;0.65</td>
</tr>
</tbody>
</table>
5. Tissue Sampling and Testing

Step 5. Tissue Sampling and Testing (if applicable)

Tissue analyses are the bases for nutrient recommendations for fruit nutrient management plans.

The following worksheets and information sheets will assist you with the tissue sampling and testing step of nutrient management plan development.

- Sample Collection and Preparation for Perennial Fruit Crops Instruction Card
- Comparison of Some Labs Testing Plant Tissue (Updated 4-13-12)
- Field Information Sheet for Perennial Fruit Crops
- Fertilizer Recommendations for Bearing Perennial Fruit Crops

Nutrient Management Planning Tools Handbook

- 1. Data Collection
- 2. Soil Sampling and Testing
- 3. Manure Sampling and Testing
- 4. Compost Testing
- 5. Tissue Sampling and Testing
- 6. Calculating the Phosphorus Site Index
- 7. Generating
Orchards

- NM-5 "Nutrient Management for Tree Fruits and Small Fruits"
- SFG PF-1 "Nutrient Management Planning for Perennial Fruit Crop: An Overview"
- SFG PF-2 "Tissue and Soil Sampling for Perennial Fruit Crops"
- SFG PL-1 "Plant Tissue Analysis" (revised April 2010)
- The Nid-Atlantic\linegrape Grower’s Guide (scroll down to find guide)
SAMPLE COLLECTION & PREPARATION FOR PERENNIAL FRUIT CROPS

Tissue samples for perennial fruit crops are typically taken when nutrient levels in leaves are relatively stable. All leaves for a sample should be collected from the same cultivar. The sampling procedure should be as random as possible. It is best NOT to take multiple leaves from the same bush or tree but rather collect from a wide selection of plants throughout the block you are sampling. Refer to NM-5 “Nutrient Management for Tree Fruits and Small Fruits” for more information on tissue sampling.

Consult Table 1 to determine the appropriate time to sample, number of samples/plant part, and the location on the plant for each fruit crop. Figure 1 has additional information on the proper sampling location.
Sampling for Greater Understanding of the Nutritional Environment (or modify soil-test-based recommendations)

- sample the correct plant part
- sample at the correct stage of development
- sample in an unbiased manner from multiple plants
<table>
<thead>
<tr>
<th>Crop</th>
<th>Growth Stage</th>
<th>Plant Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>corn *</td>
<td>seedling stage (&lt;12” tall)</td>
<td>whole above-ground plant</td>
</tr>
<tr>
<td>broccoli</td>
<td>prior to heading</td>
<td>youngest mature leaf</td>
</tr>
<tr>
<td>pumpkins</td>
<td>early stage of growth</td>
<td>newest expanded leaf</td>
</tr>
<tr>
<td>wheat *</td>
<td>seedling stage (&lt;12” tall)</td>
<td>whole above-ground plant</td>
</tr>
</tbody>
</table>
## Sufficiency Ranges Vary Across Crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nitrogen (%)</th>
<th>Phosphorus (%)</th>
<th>Potassium (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>corn</td>
<td>3.5 – 5.0</td>
<td>0.30 – 0.50</td>
<td>2.5 – 4.0</td>
</tr>
<tr>
<td>broccoli</td>
<td>3.2 – 5.5</td>
<td>0.30 - 0.76</td>
<td>2.0 – 4.0</td>
</tr>
<tr>
<td>pumpkins</td>
<td>4.0 – 6.0</td>
<td>0.30 – 0.50</td>
<td>3.0 – 5.0</td>
</tr>
<tr>
<td>wheat</td>
<td>1.8 – 3.0</td>
<td>0.21 – 0.51</td>
<td>1.5 – 3.0</td>
</tr>
</tbody>
</table>

PSU Ag Analytical Services Lab; at recommended growth stage
Sampling for Diagnosis of Problematic Areas

• sample soil and plants from both healthy and problematic areas

• collect data on other possible contributing factors (soil compaction, root growth, disease and pest incidence)

• compare results to determine if problem is nutritional
An inadequate supply of a nutrient to a crop may be due to factors other than the soil’s nutrient supplying capacity.
Proposed Use of Plant Analysis to Modify P Recommendation (proposed 12-14)

“Except when subject to cold and wet growing conditions, crops determined to be deficient in phosphorus, as demonstrated by a representative tissue analysis by an accredited laboratory, may receive an application of phosphorus not to exceed 25 percent of the expected amount removed from the field by the crop or plant harvest immediately following the phosphorus application.”
Preparing Samples for Shipment

• most labs recommend placing the sample in a paper bag
• label the bag with sample ID
• allow the sample to dry for several days in the open bag
• tape/staple the bag closed and ship to the lab
How is Mineral Plant Analysis Performed?

• dry, grind and mix sample
• total destruction of organic matrix
  – mixture of very strong acids or hydrogen peroxide at high temperatures for several hours
  – ashing at very high temperatures in a muffle furnace for many hours
• analysis of acidic solution for each element of interest
  – ICP or inductively coupled plasma spectrophotometer
Plant Tissue Testing Services

• many ag labs test plant tissue

• laboratory techniques for plant analysis are relatively standardized

• results from different labs are usually similar

• total elemental content is measured
  – percentage (or parts per million, ppm) of tissue dry weight

• recommendations for addressing inadequate nutrient levels are typically not provided (except for perennial fruit)
Sources on Interpretive Information

• Penn State Ag Analytical Laboratory
  – 7 agronomic crops and 19 vegetable and annual fruit crops
  – some at multiple stages of growth
  – lab of choice for perennial tree and small fruit crops*

• University of Florida (HS 964)
  – 34 vegetable and annual fruit species
  – many at multiple stage of growth

• Plant Nutrition Handbook (multiple editions and publishers)
• Handbook of Plant Nutrition (CRC Press)
Beyond Mineral Nutrient Content

• nitrate-N
  – corn stalk, cotton petioles, potato petioles
  – forage and silage (nitrate toxicity)

• quality factors for animal feed
  – crude protein, net energy, acid detergent fiber, total digestible nutrients

• quality factors for human consumption
  – vitamins, essential oils, fatty acids
Questions, comments or concerns?