Grapevine Nutrition

Mark L. Chien
Penn State Cooperative Extension
Lancaster, PA
mlc12@psu.edu
Goals of Vine Nutrition

• Maintain a healthy, productive, sustainable vine
• Getting fruit and wood fully ripe as soon as possible
• Agronomy vs. Viticulture
• With fertilizers, more is not always better
• The special case of “N”
• Promote wine quality through proper nutrition
• Fit these goals into a sustainable viticulture program – do no harm
Vine Balance and Size

- Create a small to moderate size vine
- Balance amount of foliage and crop
  + better light, air and spray penetration into interior of canopy, improved bud fruitfulness, less disease, lower management costs, riper fruit, easier to manage fruit zone, cold hardiness
  - Lots of shade, increased humidity in canopy interior, more disease, increased MPs, more labor and gas (shoot positioning, hedging, thinning, pruning, etc), bull canes, higher pH wines (K+)
Different amounts of vine size and balance: which one applies to you?
Nitrogen levels will affect wine quality

The graph shows the relationship between nitrogen levels as a percentage of plant dry weight and % maximum growth. The x-axis represents N as % of plant dry weight, ranging from 0 to 8. The y-axis represents % maximum growth, ranging from 0 to 100. There are four stages: Deficient, Adequate, Luxury, and Toxic. The critical deficiency and toxicity points are marked with arrows. The graph indicates that nitrogen levels are crucial for optimal plant growth.
Nutrition begins before the first vine is planted…

- **Site assessment**
  - Soil chemistry testing
    - Find a reliable lab with viticulture experience
    - Interpreting the data
  - Sensory assessment of the field
    - Above: Vegetation and topography
    - Below: color, texture and aromas
Essential Plant Nutrients for Growth
Derived from soil and/or fertilizer

<table>
<thead>
<tr>
<th>Macronutrients</th>
<th>Micronutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary:</td>
<td>Zn – Zinc</td>
</tr>
<tr>
<td>N – Nitrogen</td>
<td>B – Boron</td>
</tr>
<tr>
<td>P – Phosphorus</td>
<td>Fe – Iron</td>
</tr>
<tr>
<td>K – Potassium</td>
<td>Mn – Manganese</td>
</tr>
<tr>
<td>Secondary:</td>
<td>Cu – Copper</td>
</tr>
<tr>
<td>S – Sulfur</td>
<td>Mo – Molybdenum</td>
</tr>
<tr>
<td>Mg – Magnesium</td>
<td>Ni – Nickel</td>
</tr>
<tr>
<td>Ca - Calcium</td>
<td>Cl - Chlorine</td>
</tr>
</tbody>
</table>

Obtained from water and air: Carbon, Hydrogen and Oxygen
### Elements Most Essential to Plant Structure and Activities

<table>
<thead>
<tr>
<th><strong>Structure</strong></th>
<th><strong>Action</strong></th>
<th><strong>Transpiration</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Membranes</td>
<td>Photosynthesis</td>
<td>Potassium</td>
</tr>
<tr>
<td>Calcium</td>
<td>Phosphorus</td>
<td>pH Regulator of Cell Sap</td>
</tr>
<tr>
<td>Manganese</td>
<td>Potassium</td>
<td>Zinc</td>
</tr>
<tr>
<td>Boron</td>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td>Cell Walls</td>
<td>Carbon Dioxide Fixation</td>
<td>Magnesium</td>
</tr>
<tr>
<td>Calcium</td>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>Manganese</td>
<td>Nitrogen Fixation</td>
</tr>
<tr>
<td>Iron</td>
<td>Zinc</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>Zinc</td>
<td>Copper</td>
<td>Nitrogen Fixation</td>
</tr>
<tr>
<td>Copper</td>
<td>Nickel</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>Boron</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>Resistance</td>
<td>Root Growth</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Potassium</td>
<td>Calcium</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Potassium</td>
<td>Zinc</td>
</tr>
<tr>
<td>Potassium</td>
<td>Zinc</td>
<td>Copper</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Magnesium</td>
<td>Leaf Growth</td>
</tr>
<tr>
<td>Manganese</td>
<td>Zinc</td>
<td>Sulfur</td>
</tr>
<tr>
<td>Zinc</td>
<td>Copper</td>
<td>Calcium</td>
</tr>
<tr>
<td>Copper</td>
<td>Nickel</td>
<td>Magnesium</td>
</tr>
<tr>
<td>Molybdenum</td>
<td></td>
<td>Iron</td>
</tr>
<tr>
<td>Nucleic Acids</td>
<td>Cell Division</td>
<td>Cell Elongation</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Calcium</td>
<td>Calcium</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Copper</td>
<td>Molybdenum</td>
</tr>
<tr>
<td>Boron</td>
<td>Zinc</td>
<td>Nitrogen Fixation</td>
</tr>
<tr>
<td>Organic Acids</td>
<td>Stomata Open &amp; Close</td>
<td>Potassium</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Potassium</td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>Molybdenum</td>
<td></td>
</tr>
<tr>
<td>ATP, GTP</td>
<td>Hormones</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td>Oils</td>
<td>Iron</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Zinc</td>
<td></td>
</tr>
</tbody>
</table>
Nutrition Monitoring: 3 parts

• Scout for visual symptoms of deficiency and toxicity. See and observe
• Soil tests – pre-plant and every 3-5 years
• Tissue testing – every 1-2 years
All Elements are not created equal…

The ones you really care about:
- N
- K
- Mg
- Ca
- B
- Zn

The ones you sort of care about:
- P
- Fe
- Mn
- Mo
Soil Testing

- When: before planting and every 3-5 years
- Or when visual symptoms indicate a problem
- Supplement with petiole tests in established vineyards. Use both, not one or the other.
- What to test for: macro and micro nutrients, pH, cation exchange capacity, base saturation, organic matter (also texture if offered)
- The lab and method matter
- Interpreting the results correctly is critical!
SOIL ANALYSIS REPORT

Sample Number: 48152

Date of Analysis: 11/1/2005
Date of Report: 11/4/2005

Analytical Method(s): Moisture I

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Lab. No.</th>
<th>% Organics</th>
<th>pH</th>
<th>KH</th>
<th>NH4</th>
<th>PO4</th>
<th>NO3</th>
<th>Zn</th>
<th>Mg</th>
<th>Ca</th>
<th>K</th>
<th>Na</th>
<th>Cu</th>
<th>Mn</th>
<th>Brook</th>
<th>CEC</th>
<th>P</th>
<th>% Organic Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>1012</td>
<td>1.3</td>
<td>6.4</td>
<td>66</td>
<td>12</td>
<td>40</td>
<td>5.0</td>
<td>5.3</td>
<td>7.7</td>
<td>10</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>60</td>
<td>1.4</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>2A</td>
<td>6104</td>
<td>0.4</td>
<td>48</td>
<td>16</td>
<td>16</td>
<td>35</td>
<td>23</td>
<td>14</td>
<td>10</td>
<td>7</td>
<td>1</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>20</td>
<td>1.5</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>5A</td>
<td>6105</td>
<td>0.8</td>
<td>48</td>
<td>20</td>
<td>16</td>
<td>24</td>
<td>15</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>50</td>
<td>1.5</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>5B</td>
<td>6106</td>
<td>0.4</td>
<td>38</td>
<td>17</td>
<td>17</td>
<td>23</td>
<td>16</td>
<td>16</td>
<td>12</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>40</td>
<td>1.5</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*Note: All values are means of triplicate analyses. The data was analyzed using Microsoft Excel 2003. The values are reported in parts per million (ppm) unless noted otherwise.

**Recommendations:**

**Limestone and Magnesium:**
- Calcitic Limestone (calcium carbonate equivalent): NONE
- Magnesium (Mg): NONE

**Plant Nutrient Needs:**
- Nitrogen (N): 75 lb/acre
- Phosphorus (P2O5): NONE
- Potassium (K2O): 110 lb/acre

**Messages:**
- No additional amendments or recommendations are necessary.

**Laboratory Results:**
- pH: 6.1
- Exchangeable Ca: 1.4
- Exchangeable Mg: 0.5
- Exchangeable K: 2.1
- Calcium Saturation of CEC: 11.8
- Magnesium Saturation of CEC: 4.5

**Optimum Tests:**
- Nitric Acid / Potassium Persulfate

**Analysis:**
- Soil pH
- Exchangeable Nutrients
- Calcium Saturation of CEC
- Magnesium Saturation of CEC

**Test Method:**
- Soil pH
- Exchangeable Nutrients
- Calcium Saturation of CEC
- Magnesium Saturation of CEC

**Conclusion:**
- The soil is well-drained and suitable for a wide range of crops. No additional amendments or recommendations are necessary.
Soil pH: why it matters a lot…

- pH and its relation to vine size
- Cornell example
  - pH 5.5 vs 6.5
  - Effects on vine size and wine quality

pH is the measure of acidity to alkalinity. Soil pH affects nutrient uptake and microbial activity. Vines will grow from pH 4.0-8.5, but below 5.5 and above 8 will depress yields and create vine problems. pH will drift down with use of fertilizers and sulfur.
Adjusting Soil pH

• Best to do it with a clean and open field
• Remember: soils will progressively acidify with normal farming practices
• Find the right range according to viticulture and wine making goals and pH status
• Low pH – problems with Al toxicity and P deficiency
  – Adjust with lime or gypsum (1000x more soluble)
  – Lime also adds Ca and Mg (dolomitic)
  – Incorporate as deep as possible
• High pH can affect vine growth
• Recommended range: 5.5-7.0
New Vines: easy does it

- Most soils in Eastern N.A are fertile
- How much growth is enough?
- Wait and see approach
- Read the tests: how much organic matter? < 3% vines may benefit
- Small amounts of “complete” fertilizer like 10-10-10 at 20 lbs actual N per acre. Apply to vine not broadcast. Apply correctly as a slow release to kick-start vine
## Target values for soil, bloom petiole, and late-summer petiole samplings

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil</th>
<th>Bloom petiole</th>
<th>Late-summer petiole</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nitrogen</strong></td>
<td>--$^z$</td>
<td>--</td>
<td>1.2 - 2.2 %</td>
</tr>
<tr>
<td><strong>Phosphorus</strong></td>
<td>20 - 50 ppm</td>
<td>0.17 - 0.30 %</td>
<td>0.14 - 0.30 %</td>
</tr>
<tr>
<td><strong>Potassium</strong></td>
<td>75-100 ppm</td>
<td>1.5 - 2.5 %</td>
<td>1.2 - 2.0 %</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>500 - 2000 ppm</td>
<td>1.0 - 3.0 %</td>
<td>1.0 - 2.0 %</td>
</tr>
<tr>
<td><strong>Magnesium</strong></td>
<td>100 - 250 ppm</td>
<td>0.3 - 0.5 %</td>
<td>0.35 - 0.75 %</td>
</tr>
<tr>
<td><strong>Boron</strong></td>
<td>0.3 - 2.0 ppm</td>
<td>25 - 50 ppm</td>
<td>25 - 50 ppm</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>20 ppm</td>
<td>30 - 100 ppm</td>
<td>30 - 100 ppm</td>
</tr>
<tr>
<td><strong>Manganese</strong></td>
<td>20 ppm</td>
<td>25 - 1000 ppm</td>
<td>100 - 1500 ppm</td>
</tr>
<tr>
<td><strong>Copper</strong></td>
<td>0.5 ppm</td>
<td>5-15 ppm</td>
<td>5 - 15 ppm</td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
<td>2 ppm</td>
<td>30-60 ppm</td>
<td>30 - 60 ppm</td>
</tr>
<tr>
<td><strong>Aluminum</strong></td>
<td>*&lt; 100 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organic matter</strong></td>
<td>3 - 5 %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^z$ Soil nitrogen is not normally evaluated for vineyards.
Compost: easy does it!

- Easy to get too much of a good thing
  - The case of Roth Vineyard
- It must be properly “composted”
- Hot compost can damage vines, especially young ones
- Commercial vineyard compost guide from Penn State at:
  [http://fpath.cas.psu.edu/compostguide.pdf](http://fpath.cas.psu.edu/compostguide.pdf)
Tissue (petiole) Analysis

• Determine vine nutrient status at that moment – sample for maintenance and troubleshooting
• Develop a nutrition history for the vineyard
• Factors that may impact tissue analysis include:
  – Crop load
  – Cultivar and rootstock
  – Cultural practices
  – Growing conditions, i.e. stresses on the vine
• When to sample
  – Bloom (May) for N P K
  – Veraison (mid-July to mid-August) for micronutrients
  – Check with your specific lab for bloom or veraison standards
What to look for now

Potassium deficiency

Magnesium deficiency
Potassium Fertilizers

- Potassium chloride (0-0-60)
- Potassium sulfate (0-0-50)
- Potassium-magnesium sulfate - Sul-Po-Mag (0-0-22)
- Potassium nitrate (13-0-44)
  - Foliar K applications – use sulfate of nitrate forms
  - 6 to 10 lb/100 gal
  - If needed, apply after pollination
Correction of Mg deficiency

• Tissue analysis test of mature vineyard:
  – Desired bloom-time values of 0.30 - 0.50%

• Example:

• petiole sample shows 0.19 % Mg
  – Immediate foliar application of Epsom salts at 5 lbs/acre in sufficient water to ensure coverage
  – long-term correction by magnesium sulfate application to soil (banded).
Foliar Fertilizers for Grapes

- Most nutrients for grapevines are derived from the soil
- Foliar fertilizers are very soluble fertilizers applied in relatively low quantities
- Generally not satisfactory for supplying N, P, K needs
  - Consider as a supplement only
- Band-aid method: can be used to temporarily correct a deficiency
- Particularly useful for micronutrient problems
  - Iron
  - Zinc
  - Boron
  - Manganese
Want to know more about vine nutrition? Read these two great books...
<table>
<thead>
<tr>
<th>Magnesium</th>
<th>Target Values</th>
<th>AND</th>
<th>THEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Bloom Petiole</td>
<td>Fall Petiole</td>
<td>Soil Bloom Petiole</td>
<td>Fall Petiole</td>
</tr>
<tr>
<td><strong>IF &lt;</strong></td>
<td>50 ppm</td>
<td>0.30 %</td>
<td>0.35 %</td>
</tr>
<tr>
<td><strong>IF &lt;</strong></td>
<td>50 ppm</td>
<td>0.30 %</td>
<td>0.35 %</td>
</tr>
<tr>
<td><strong>IF &lt;</strong></td>
<td>0.30 %</td>
<td>0.35 %</td>
<td>Neutral or Alkaline soil</td>
</tr>
<tr>
<td><strong>IF =</strong></td>
<td>50-80 ppm</td>
<td>0.30 – 0.50 %</td>
<td>0.35 – 0.75 %</td>
</tr>
<tr>
<td><strong>IF &gt;</strong></td>
<td>0.50 %</td>
<td>0.75 %</td>
<td>Dry year</td>
</tr>
<tr>
<td><strong>IF &gt;</strong></td>
<td>0.50 %</td>
<td>0.75 %</td>
<td>Normal year – neutral soil</td>
</tr>
</tbody>
</table>

**Notes**
Low magnesium availability typically associated with low soil pH. If soil K/Mg ratio is greater than 3, magnesium deficient may develop. Can be aggravated in acid soils with high K application. Adjust with dolomitic limestone in low pH vineyards. Use Epsom salts in neutral and high pH soils. Excessive soil Mg (either natural or fertilizer applied) may cause K deficiency and vine size reduction. Monitor petiole K and Mg.

**Sources**
- Dolomitic limestone (variable % Mg), most common
- Epsom salts (magnesium sulfate, 10% Mg)
- Sulpomag (22% K2O, 11% Mg), has both K and Mg, more expensive

**Rates**
- Soil test shows 50 lbs/acre Mg and pH of 6.1 (want 100 to 160 lbs/acre)
- Rx: adjust pH with dolomitic lime to raise pH to 6.8. This is likely to bring Mg within recommended range.
- If pH acceptable, adjust Mg with MgSO4 (300 to 600 lbs/acre, depending upon soil deficit.
- Foliar applications of Epsom salts (5 – 10 pounds/acre in 100 gallons water) can be used for short-term correction.

---

Sample from Wine Grape Production Guide for Eastern North American
Other Recommendations

- Before you apply an ounce of fertilizer. STOP. Ask “why am I doing this.”
- There is no recipe for nutrition management
- Low to moderate fertility can improve wine quality
- Multiple applications are better than a single large one
- Soil treatments are usually more durable than foliar
- Foliar feed micronutrients and soil treats the macronutrients
- If you already have acidic soils, try to use pH neutral fertilizers
- Most fertilizers, soil and foliar, are best applied between fruit set and veraison, with the exception of B and Zn
- Don’t pollute. Manage nutrients as you would pesticides
Soil and Tissue Analysis Labs

- A&L Eastern, Richmond, VA – www.al-labs-eastern.com
- Penn State Agricultural Analytical Lab Services http://www.aasl.psu.edu/plant_tissue_prog.html
- Brookside Labs, OH - http://www.blinc.com/
- Cornell Nutrient Analysis Lab: http://cnal.cals.cornell.edu/
Thank You!

- Dr. Carl Rosen, Dept of Soil, Water and Climate. University of Minnesota
- Mark Greenspan, Advanced Viticulture, Napa, CA
- Dr. Tony Wolf, Virginia Tech and Fritz Westover, Texas A&M University