Vineyard Nutrition

Petiole / Soil Sample Results Are Back, Now What?

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Developing a Fertilizer Program for a Vineyard

Need to know & understand your soil.

• **Begins before planting** = **Soil Sampling.**
  – Optimizing the soil pH for Grapes (5.5, 6.0, 6.5 or 7.0?).
  – Amending to optimize the level of major nutrients (P, K).
  – Understanding its internal drainage characteristic.

• **After planting** = **Petiole Analysis** to adjust your fertilizer program based on:
  – Soil’s fertility level (O.M. content) & vineyard needs.
  – Variety characteristics (vigor, cold hardiness).
  – Cropping potential.
Availability of Essential Mineral Nutrients

- Composition of the soil parent material.
- Soil pH
- Soil Texture
  - Soil weathering / leaching
  - Internal drainage characteristics of the soil.
- Competition between nutrients for uptake by the plant.
- Soil organic matter content.
- Previous fertilizer history.
Pre-plant Soil Testing

- Test for: pH, Buffer pH, P, K, Mg, Zn, CEC, O.M. maybe for: S
- Separate sample for each soil type.
- Separate samples for different cropping histories.
- Submit samples collected from 2 depths:
  - 0 to 8 inch (0-6 inch) depth.
  - 8 or 16 inch (6-12 inch)
    - To 24 inches for S.
- K-State Agronomy Soil Testing Lab
- Commercial Laboratories
## Pre-Plant Soil Testing Sufficiency Ranges

<table>
<thead>
<tr>
<th>Test</th>
<th>OSU*</th>
<th>ISU</th>
<th>U of MN</th>
<th>NRAES-145**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>5.5 - 6.5</td>
<td>6.0 - 6.5</td>
<td>6.0 to 7.0</td>
<td>**</td>
</tr>
<tr>
<td>Phosphorous (P)</td>
<td>20 - 50 ppm</td>
<td>&gt; 30 ppm</td>
<td>&gt; 25 ppm</td>
<td>20 - 50 ppm</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>125 - 150 ppm</td>
<td>&gt; 150 ppm</td>
<td>&gt; 150 ppm</td>
<td>75 - 100 ppm</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>100 - 125 ppm</td>
<td>100 - 125 ppm</td>
<td>~ 100 ppm</td>
<td>100 - 250 ppm</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>4 - 5 ppm</td>
<td>3 - 4 ppm</td>
<td>&gt; 1 ppm</td>
<td>2 ppm</td>
</tr>
<tr>
<td>Organic matter</td>
<td>2 - 3 %</td>
<td>2 - 3 (4) %</td>
<td>&gt; 600 ppm</td>
<td>3 - 5 %</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>- -</td>
<td>- -</td>
<td>&gt; 1 ppm</td>
<td>- -</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>.75 - 1.0 ppm</td>
<td>- -</td>
<td>&gt; 6 ppm</td>
<td>0.2 - 2.0 ppm</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>- -</td>
<td>- -</td>
<td>&gt; 0.2 ppm</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>0.5 ppm</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>- -</td>
<td>&gt; 7 ppm</td>
<td>- -</td>
<td>- -</td>
</tr>
</tbody>
</table>


** Soil pH:**
- **5.0 V. Labrusca**
- **6.0 hybrids**
- **6.5 V. vinifera**
Soil pH

Affects the availability of the essential nutrients.

Macro Nutrients:
- Nitrogen (N)
- Phosphorous (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

Micro Nutrients:
- Iron (Fe)
- Manganese (Mn)
- Boron (B)
- Copper (Cu)
- Zinc (Zn)
- Molybdenum (Mo)
Adjusting the Soil pH
Before Planting a Vineyard

- Soil pH below 6.0
  - Apply lime to bring the pH up to 6.0 or 6.5 based on the Buffer pH.
  - Limestone (Ca) or Dolomitic lime (Mg)?

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**Lime Requirement to Raise the Soil pH to 6.0 and 6.5**

![Graph showing lime requirement vs. buffer pH for pH 6.0 and pH 6.5]
Iron Chlorosis
Adjusting the Soil pH Before Planting a Vineyard

- **Soil pH between 6.5 to 7.0?**
  - Do nothing? (V. labrusca types vs V. vinfera & interspecific hybrids)
  - Apply sulfur to lower the pH to 6.5 or 6.0 *or*
  - Take other measures to lower the soil pH
    - Acidifying forms of N fertilizer

- **Soil pH 7.0 to 7.5**
  - Apply sulfur to lower the pH to 6.5 or 6.0 *and*
  - Take other measures to lower the soil pH
    - Acidifying forms of N fertilizer

- **Soil pH above 7.5**
  - Apply sulfur to lower the pH to 6.5 or 6.0 *??
    - Cost
    - Presence of free carbonates in the soil.

**Forms of Sulfur:**
- Elemental (1x)
- Aluminum sulfate (6x)
- Ferrous sulfate (8x)

**N Source (1 lb) neutralized**
- Ammonium sulfate: 5.4 lbs of lime
- Urea: 1.8 lbs of lime
- Mono-ammonium phosphate: 5.0 lbs of lime
- Manure, compost, etc: variable lbs of lime
Sulfur Required to Lower the Soil pH to 6.5
in the Top 8 inches of a Carbonate-free Soil

Lbs per Acre

Soil pH

Adapted From: Spectrum Analytic, Inc Soil pH Management
Fizz Test for Calcareous Soils*

Applying a few drops of household vinegar to a soil sample and listen and observe for bubbling.

<table>
<thead>
<tr>
<th>Fizz test result</th>
<th>Estimated carbonates present (%)</th>
<th>Annual addition of elemental sulfur (ton/acre)</th>
<th>Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>none</td>
<td>None</td>
</tr>
<tr>
<td>Heard (barely audible)</td>
<td>0 – 1</td>
<td>.5 – 1</td>
<td>1</td>
</tr>
<tr>
<td>Slight (few bubbles)</td>
<td>1 – 2</td>
<td>1</td>
<td>1 – 2</td>
</tr>
<tr>
<td>Moderate (several bubbles)</td>
<td>2 – 3</td>
<td>1</td>
<td>2 – 3</td>
</tr>
<tr>
<td>Vigorous (many bubbles)</td>
<td>&gt; 3</td>
<td>1</td>
<td>3 +</td>
</tr>
</tbody>
</table>

Optimizing Nutrients Before Planting

• **Phosphorous (P)**
  - Very immobile in the soil.
  - **Optimize to 30.5 ppm of P**
    • Equals 61 pp2m = 61 lbs/A per plow slice of 8 inches.
  - **P fertilizer analysis** is measured as % $P_2O_5$
    • lbs of P / A x 2.3 = lbs of $P_2O_5$ / A
    • 61 lbs of P / A x 2.3 = 140 lbs of $P_2O_5$ / A
  - **Amount of $P_2O_5$ to apply /A** = Optimum lbs of $P_2O_5$ /A — the exchangeable $P_2O_5$ /A from the soil test results.
    • If soil test shows 10 ppm exchangeable P = 20 pp2m or 20 lbs of P /A x 2.3 = 46 lbs of $P_2O_5$ /A
      • Amount of $P_2O_5$ to apply /A = 140 lbs of $P_2O_5$ /A - 46 lbs exchangeable $P_2O_5$ /A from the soil test results = 94 lbs of $P_2O_5$ /A is required.
  - **The amount of fertilizer containing the $P_2O_5$ required /A** = lbs of $P_2O_5$ /A divided by the % analysis of the fertilizer product.
    • If **Ammonium monophosphate** (11-52-0) is applied:
      • Lbs 11-52-0 require /A = 94 lbs $P_2O_5$ / 0.52 = 181 lbs/A
Optimizing Nutrients Before Planting

• **Potassium (K)**
  – Moves very slowly in the soil.
  – **Optimize to 150 ppm**
    • Equals 300 pp2m = 300 lbs/A per plow slice of 8 inches
  – **K fertilizer analysis** is measured as % K₂O
    • Lbs of K / A x 1.2 = Lbs of K₂O / A
    • 300 lbs of K / A x 1.2 = 360 lbs K₂O /A
  – **Amount of K₂O to apply /A** = Optimum lbs of K₂O /A — the exchangeable K₂O /A from the soil test results.
    • If soil test shows 50 ppm exchangeable K = 100 pp2m or 100 lbs of K /A x 1.2 = 120 lbs of K₂O /A
    • Amount of K₂O to apply /A = 360 lbs of K₂O /A — 120 lbs exchangeable K₂O /A from the soil test results = 240 lbs of K₂O /A is required.
  – **The amount of fertilizer containing the K₂O required /A** = lbs of K₂O /A divided by the % analysis of the fertilizer product.
    • If *Potassium chloride* (0-0-62) is applied:
      • Lbs 0-0-62 require /A = 240 lbs K₂O / 0.62 = 387 lbs/A
Optimizing Nutrients Before Planting

- **Potassium (K)**
  - **Inhibition of K uptake by excessive soil Mg.**
  - If the ratio of exchangeable K / Mg is equal to or less than 0.3
  - **Optimize K at 40% of the exchangeable Mg content.**
    - If a soil test shows **120 ppm K** and **500 ppm Mg**.
    - Ratio of exchangeable K / Mg = 120 / 500 = .24
  - **Optimizing K at 40% of the exchangeable Mg.**
    - **500 ppm Mg x .4 = 200 ppm K.**
  - **Amount of K (ppm) required = Optimum K (40% exchangeable Mg) – exchangeable K from soil test.**
    - **200 ppm optimum K – 120 ppm exchangeable K = 80 ppm K required.**
    - Equals **160 pp2m or 160 lbs/A per plow slice of 8 inches.**
    - **Lbs/A of K₂O require = 160 lbs K/A x 1.2 = 192 lbs of K₂O /A**
  - **The amount of fertilizer containing the K₂O required /A = lbs of K₂O /A divided by the % analysis of the fertilizer product.**
    - If Potassium chloride (0-0-62) is applied:
      - Lbs 0-0-62 require /A = **192 lbs K₂O / 0.62 = 310 lbs/A**
After Planting: Soil vs Petiole Analysis

Soil Analysis:
• 2nd year & beyond:
  – Monitor the soil pH.
  – Basis for K rate if petiole analysis indicates a short supply.

Petiole Analysis:
• 1st year:
  – Not accurate
  – Reflects growing conditions in the nursery.
• 2nd year & beyond (*begin when vines come into production*):
  – Measures the amount of nutrients the vines are able to take up from the soil.
  – Sampling time is important.
  – Annual analysis allows for fine-tuning of the fertilizer program, & correcting shortages before they become a problem.
# Normal Nutrient Ranges for Grapes

## Based on Petiole Analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>At Bloom (for American hybrids) *</th>
<th>Mid-July to Mid-Aug.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>1.6 to 2.8 %</td>
<td>0.9 to 1.3 %</td>
</tr>
<tr>
<td>Phosphorous (P)</td>
<td>0.20 to 0.60 % ?</td>
<td>0.16 to 0.29 %</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>? 1.50 to 5.00 % ?</td>
<td>1.50 to 2.50 % ?</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>0.40 to 2.50 % ?</td>
<td>1.20 to 1.80 %</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.13 to 0.40 %</td>
<td>0.26 to 0.45 %</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>No data (&gt;0.1%)</td>
<td>No data (&gt;0.1%)</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>18 to 100 ppm</td>
<td>31 to 150 ppm</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>40 to 180 ppm</td>
<td>31 to 50 (200) ppm</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>25 to 50 ppm</td>
<td>25 to 50 ppm</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>5 to 10 ppm</td>
<td>5 to 15 ppm</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>20 to 100 ppm</td>
<td>30 to 50 ppm</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>0.2 to 0.4 ppm</td>
<td>0.3 to 1.5 ppm</td>
</tr>
</tbody>
</table>


# Normal Nutrient Ranges for Grapes

Based on Petiole Analysis

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>NRAES 145*</th>
<th>70-100 Days After Bloom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At Bloom</td>
<td></td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>1.2 to 2.2 %</td>
<td>0.8 to 1.2 %</td>
</tr>
<tr>
<td>Phosphorous (P)</td>
<td>0.17 to 0.30 %</td>
<td>0.14 to 0.30 %</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>1.5 to 2.5 %</td>
<td>1.20 to 2.00 %</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1.0 to 3.0 % ?</td>
<td>1.0 to 2.0 %</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.3 to 0.5 %</td>
<td>0.35 to 0.75 % ?</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td><em>No data</em></td>
<td><em>No data</em></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>25 to 1,000 ppm ? ?</td>
<td>25 to 1,500 ppm ?</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>20 ppm</td>
<td>30 to 100 ppm</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>25 to 50 ppm</td>
<td>25 to 50 ppm</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>5 to 15 ppm</td>
<td>5 to 15 ppm</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>30 to 60 ppm</td>
<td>30 to 60 ppm</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>.5 ppm</td>
<td>.5 ppm</td>
</tr>
</tbody>
</table>

Annual Growth Cycle of a Grapevine

Sampling Time

Bloom

Relative Change

CHO Reserves
Shoot Growth
Berry size
Brix

IOWA STATE UNIVERSITY
Extension and Outreach

From: Winkler, General Viticulture
Changes in Nutrient Concentrations during the Growing Season

**Increase**
- Calcium (Ca)
- Magnesium (Mg)
- Boron (B)
- Iron (Fe)
- Manganese (Mn)

**Decrease**
- Nitrogen (N)
- Phosphorous (P)
- Potassium (K)
- Sulfur (S)
- Copper (Cu)
- Zinc (Zn)
Changes in Nutrient Concentrations during the Growing Season

IOWA STATE UNIVERSITY Extension and Outreach

Collecting a Petiole Sample

• Collect at the same time each year!
• Do not mix varieties into one sample!
• If a planting is located on more than one soil type, collect separate samples for each soil type.
• If a planting received different fertilizer applications, separate samples should be collected.
• A sample should consist of 100 petioles, or 150-200 for varieties with small petioles.
Full Bloom vs Mid-Summer

Opposite of the first cluster.

Most recently fully expanded leaf.

Figures adapted from: Grapevine Nutrition and Fertilization in the San Joaquin Valley. 1978 Univ. of California publ. 4087
Interpreting a Petiole Analysis

Petiole analysis is not an exact science.
• Can tell if you need to apply more or less of a nutrient.
• The more information available, the better.
• Annual testing allows you to fine-tune your fertilizer program.

To assist, additional information suggested:
  – The vigor & health of the vines.
  – Soil type, texture and internal drainage classification.
  – Soil moisture conditions (excess, drought?)
  – Previous soil test results.
  – Production potential for current and previous season.
  – Current and past fertilizer program.
  – Spray materials applied prior to collecting the sample.
    • Micro-nutrient containing fungicides
    • Foliar nutrient sprays
Normal Nutrient Ranges for Grape Petioles
Mid-July to Mid-August (early veraison) Sampling

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficient</th>
<th>Below Normal</th>
<th>Normal</th>
<th>Above Normal</th>
<th>Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (%)</td>
<td>0.30 - 0.70</td>
<td>0.70 - 0.90</td>
<td><strong>0.90 - 1.30</strong></td>
<td>1.40 - 2.00</td>
<td>&gt;2.10</td>
</tr>
<tr>
<td>P (%)</td>
<td>≥0.12</td>
<td>0.13 - 0.15</td>
<td><strong>0.16 - 0.29</strong></td>
<td>0.30 - 0.50</td>
<td>&gt;0.51</td>
</tr>
<tr>
<td>K (%)</td>
<td>0.50 - 1.00</td>
<td>1.10 - 1.40</td>
<td><strong>1.50 - 2.50</strong></td>
<td>2.60 - 4.50</td>
<td>&gt;4.60</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.50 - 0.80</td>
<td>0.80 - 1.10</td>
<td><strong>1.20 - 1.80</strong></td>
<td>1.90 - 3.00</td>
<td>&gt;3.10</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>≥0.14</td>
<td>0.15 - 0.25</td>
<td><strong>0.26 - 0.45</strong></td>
<td>0.46 - 0.80</td>
<td>&gt;0.81</td>
</tr>
<tr>
<td>S (%)</td>
<td>No data</td>
<td>No data</td>
<td>&gt;0.10</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>Mn (ppm)</td>
<td>10 - 24</td>
<td>25 - 30</td>
<td><strong>31 - 150</strong></td>
<td>150 - 700</td>
<td>&gt;700</td>
</tr>
<tr>
<td>Fe (ppm)</td>
<td>10 - 20</td>
<td>21 - 30</td>
<td><strong>31 - 100</strong></td>
<td>101 - 200</td>
<td>&gt;200</td>
</tr>
<tr>
<td>B (ppm)</td>
<td>14 - 19</td>
<td>20 - 25</td>
<td><strong>25 - 50</strong></td>
<td>51 - 100</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Cu (ppm)</td>
<td>0 - 2</td>
<td>3 - 4</td>
<td><strong>5 - 15</strong></td>
<td>15 - 30</td>
<td>&gt;31</td>
</tr>
<tr>
<td>Zn (ppm)</td>
<td>0 - 15</td>
<td>16 - 29</td>
<td><strong>30 - 50</strong></td>
<td>51 - 80</td>
<td>&gt;80</td>
</tr>
<tr>
<td>Mo (ppm)</td>
<td>0.3 - 1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What if petiole analysis shows a need for a nutrient?

How much should be applied?
When should it be applied?
How often should it be applied?
How should it be applied? (soil vs foliar)

Factors that need to be considered:

- Mobility of the nutrient.
- Soil texture / cation exchange capacity.
- Soil pH as it affects nutrient availability/solubility.
- Soil organic matter content.
Nitrogen (N)
(OSU: 0.9 – 1.3 %)
(NRAES: 0.8 – 1.2% )

<table>
<thead>
<tr>
<th>Source</th>
<th>Fate</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Fertilizer</td>
<td><strong>Lost from Soil:</strong></td>
</tr>
<tr>
<td>• Legumes</td>
<td>• Leaching</td>
</tr>
<tr>
<td>(Fix up to 300 lb / A / yr)</td>
<td>• De-nitrification</td>
</tr>
<tr>
<td>• Soil organic matter</td>
<td><strong>Taken up by Plants:</strong></td>
</tr>
<tr>
<td>(Releases ~20 lb / A / % OM / yr)</td>
<td>• Recycled:</td>
</tr>
<tr>
<td>• Lightning</td>
<td>Leaves &amp; Prunings</td>
</tr>
<tr>
<td>(Fix ~10 lb / A / yr)</td>
<td>• Removed: Fruit</td>
</tr>
<tr>
<td></td>
<td>• Tied up: Old wood</td>
</tr>
</tbody>
</table>
How Much Nitrogen is Needed?

Mid-Atlantic Wine Grapegrower’s Guide:

• Grapes ~ 0.18% N, Canes ~ 0.25% N
• Nitrogen removed:
  - Grapes: 3.6 lb / A / ton
  - Canes: 1.7 lb / A / lb of prunings / vine
• For a 5 ton crop & 3 lb prunings / vine:
  - Grapes: 18 lb / A + prunings 5.1 lb / A = 23.1 lb/A total

From: Midwest Grape Production Guide. Ohio State Univ. Ext. Bul. 919
“Need between 40 and 80 pounds of actual N / acre per year.”

• Sod occupies 2/3’s of the land and requires ~ 1 lb N / 1000 sq ft (~30 lb / A).
• Grapes are receiving from 10 to 50 lb of N per acre.
Soil organic matter content:

Nitrogen Released from Organic Matter

Need to adjust N fertilization practices based on the organic matter content of the soil.
How Much Nitrogen is Needed?

1. **Have to consider the N released for the soil organic matter (~20 lb/A/% OM/yr) & vine vigor.**
   - Less than 2% OM: Consider increasing the N rate by 10-20%
   - 2 to 3% OM: 40 to 30 lb actual N/acre is probably adequate.
   - > 3%: Consider reducing the N rate/acre by the amount of N derived from the OM.
   - Adjust up or down based on vine vigor & experience.

2. **How much could be leached out of the root zone?**
   - Sandy soils are more prone to leaching.
     - Consider split N applications – half pre-bud break & the other half ~ 4-6 weeks after bud break.
     - With trickle irrigation, apply multiple applications spread out from bud break to about early-July.
### Nitrogen Management

### Dr. Carl Rosen, Univ. of Minnesota

**Nitrogen Fertilizer Recommendations**

Based on Petiole Analysis (mid-July to mid-August)

<table>
<thead>
<tr>
<th>Petiole N (0.9 – 1.3%)</th>
<th>N Fertilizer to Apply (lb N / A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 1.5</td>
<td>0</td>
</tr>
<tr>
<td>1.3 – 1.5</td>
<td>20</td>
</tr>
<tr>
<td>0.9 – 1.3</td>
<td>30</td>
</tr>
<tr>
<td>&lt; 0.9</td>
<td>40 - 50</td>
</tr>
</tbody>
</table>

**Other concerns: petiole K & Zn content**
Annual Growth Cycle of a Grapevine

N sufficiency range @ bloom: 1.6 – 2.8%

Relative Change

- CHO Reserves
- Shoot Growth
- Berry size
- Brix

Sampling Period:
- Bloom
- Mid-season

From: Winkler, General Viticulture
What form of nitrogen should be used?

Soil pH:

- Acid soils (pH < 6.0): nitrate forms to raise the pH.
- Optimal soil pH (6.0 to 6.5 or 7.0): urea (46-0-0)
- Alkaline soils (pH > 6.5 or 7.0): ammonia forms to lower the pH.

The associated element if there is a need.

- **Cations:** calcium nitrate, potassium nitrate
- **Anions:** ammonium mono phosphate, ammonium sulfate

Complete fertilizers (13-13-13):

- Only if there is a need for each of the nutrients.
  - Expensive
  - Immobility of P and K.
  - Risk of K-induced Mg deficiency on sandy soils.
What form of nitrogen should be used?

Nitrogen availability:

- **Nitrate forms - NO₃:**
  - Readily available to plants.
  - Very subject to leaching.

- **Urea - CO(NH₂)₂:**
  - Can be taken up by plants as urea, or converted to ammonia (NH₄) then to NO₃-N.
  - Will volatilize under warming temperatures when surface applied.
  - Will volatilize when surface applied on higher pH soils.

- **Ammonia forms – NH₄:**
  - Slowly available, must convert to NO₃-N before it can be taken up by plants.
  - Requires soil temperatures above 50° F to convert to NO₃-N.
  - Can be tied up on soil particles.
    - Less prone to leaching.
Effect of Temperature on the Volatilization of Surface Applied Urea

% of Added N Volatilized

Days After Application

From: Volatilization of Urea Affected by Temperature and Soil pH.
http://www.ag.ndsu.edu/procrop/fer/ureavo05.htm
Effect of Soil pH on the Volatilization of Surface Applied Urea

From: Volatilization of Urea Affected by Temperature and Soil pH.
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IOWA STATE UNIVERSITY
Extension and Outreach
Effect of Soil Temperature on the Nitrification of Ammonia

When Should Nitrogen be Applied?

Most needed at bloom.

- **Nitrate forms - NO₃:**
  - Closer to the time of bloom.
    - Readily available to plants.
    - Very subject to leaching.

- **Urea - CO(NH₂)₂:**
  - Early spring or in the fall when growth stops.
    - Can be taken up by plants as urea, or converted to NH₄-N then to NO₃-N.
    - Volatile under warming temperatures when surface applied.

- **Ammonia forms – NH₄:**
  - Early spring or in the fall when growth stops.
    - Slowly available, must convert to NO₃-N before it can be taken up by plants.
    - Requires soil temperatures above 50° F to convert to NO₃-N.
    - Can be tied up on soil particles.
    - Less prone to leaching.

- **Manure (NH₄):**
  - In the fall, after harvest and growth has stopped.
    - Food safety issue
Phosphorous (P)
(OSU: 0.16 – 0.29 %)
(NRAES: 0.14 – 0.30%)

- Practically immobile in the soil.
  - Pre-plant soil analysis & amend before planting.
- Generally not a problem.
  - Plants often do well on low P soils.
    - Unavailable ↔ Exchangeable ↔ Available P in the soil.
    - Soil mycorrhizal organisms aid in making P available.
- Can be a problem on sandy, low CEC soils.
  - Apply manure in the fall as an N source.
    - N (1-3%), P (0.3-3.2%), K (.5-2.9%); OM (30-74%)
  - Winery pomace (dried).
    - N (1-2%), P (~1.5%), K (.5-1.0%); OM (80%)
  - Apply ammonium mono phosphate (11-52-0) as a N source.
  - Apply P as a foliar application (refer to labels).
Potassium (K)
(OSU: 1.50 – 2.50 %)
(NRAES: 1.20 – 2.00%)

Moves very slowly in the soil.
• For perennial crops, high rates of K are needed to move the K down into the root zone.

• If petiole analysis shows a need for K.
  – Conduct a soil test to determine how much K is need to optimized soil K and apply as a band application.
  – Test magnesium (Mg) to make sure that:
    • Excessive Mg is not inhibiting the uptake of K.
    • Additional K will not affect the uptake of Mg.
## Potassium Fertilizer Recommendations

**Based on Petiole Analysis (mid-July to mid-August)**

<table>
<thead>
<tr>
<th>Petiole K (1.5 – 2.5%)</th>
<th>K Fertilizer to Apply (lb K$_2$O / A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 2.0</td>
<td>0</td>
</tr>
<tr>
<td>1.5 – 2.0</td>
<td>100 – 200</td>
</tr>
<tr>
<td>1.0 – 1.5</td>
<td>200 – 300</td>
</tr>
<tr>
<td>&lt; 1.0</td>
<td>300 - 400</td>
</tr>
</tbody>
</table>
Potassium Management

Potassium (K) soil applications:
• **Apply when the need has been identified:**
  – Potassium chloride (0-0-62)
  – Potassium sulfate (0-0-50)
  – Potassium magnesium sulfate, Sul-Po-Mag (0-0-22 + 22% S, 11% Mg)
• **Apply in the spring:**
  – Potassium nitrate (13-0-44)

Foliar K applications:
• Often needed in addition to soil applications to correct deficiencies for the first year or two.
• **Begin applying early in the season:**
  – Potassium nitrate (44% K, 13% N)
  – Potassium sulfate (53% K, 18% S)
    • Apply at 6 to 10 lb / 100 gallons (1 to 3 applications/season).
  – Vigor-K™ (20% K) follow label directions
  – Nutri-K® (15% K) follow label directions

Apply a straw mulch under the vines.
Calcium (Ca)
(OSU: 1.20 – 1.80 %)
(NRAES: 1.0 – 2.0 %)

Generally not considered a problem in grapes.

Could become a problem on sandy soils.

• If the soil pH is low (acid), apply lime to raise the pH.
• If the soil pH is in the optimal range, apply Ca as gypsum (calcium sulfate).
• Use calcium nitrate as your N source
  – 15.5% N, 21% Ca
Magnesium (Mg)  
(OSU: 0.26 – 0.45 %)  
(NRAES: 0.35 – 0.75 %)

Can be a problem on sandy soils, particularly when K has been over applied.

- If the soil pH is low (acid), apply dolomitic lime to raise the pH to 6.0 or 6.5.
- If the soil pH is in the optimal range, apply:
  - 50 to 100 lb magnesium oxide (MgO) /A.
  - 300 to 600 lb Epson salt (MgSO₄) /A.
- Foliar applications of Epson salt at 10 lb/100 gal.
  - Apply as 2 post-bloom applications.

Excessive Mg can be a problem on some calcareous and glaciated soils.

- Inhibits K uptake.
Sulfur (S) (> 0.10 %)

• No reliable data on a sufficiency level for grapes.
  – Sulfur has often been included in spray programs.
  – Sulfur has historically been an air pollutant.
• If petiole S is > 0.10 %, considered adequate.
• If petiole S drops < 0.10 %:
  – Check the soil pH and take measures to acidify if necessary.
  – Use S-containing forms of fertilizer in your fertility program.
  – Apply liquid lime sulfur in the dormant for anthracnose control.
  – Use S-containing fungicides in your disease control program if the varieties are not S-sensitive.
Boron (B)  
(25 – 50 ppm)

Can be low in many Midwest & high pH soils

• B is involve in fruit set.
  – Improves the rate of pollen tube growth and thereby improves fertilization of the flowers.

• If there is a need for B.
  – 4 to 6 lbs B / A as a soil application.
  – Pre- and post-bloom foliar applications of Solubor (20% B) at a rate of 2 to 4 lbs/A per application.
    • First application at about the 3-inch stage of shoot growth.
    • Post bloom application, if needed.
    • Tight vs loose clustered variety?
Copper (Cu) (5 – 15 ppm)

Can be low on sandy or high pH soils.

• If Cu is low.
  – Include a few applications of Bordeaux (copper sulfate + hydrated lime) or a fixed copper + hydrated lime in the disease control program.
  – Avoid applying during or just following cool, wet weather.
    • Greater absorption & risk of phytotoxicity.
    • Can begin at about the 10-inch growth stage.
  – If it is a Cu-sensitive variety, apply a dormant application of Cu.
    • It has some benefit in controlling grape anthracnose.
Manganese (Mn)
(OSU: 31 – 150 ppm)
(NRAES: 25 – 1,500 ppm)

Can be low on sandy and high pH soils.

• If Mn is low.
  – Include a Mn-containing fungicide in your early season
disease control program.
    • mancozeb (Dithane M-45, Maneb, Penncozeb)
      – Contains 16% Mn.
      – 66 day pre-harvest interval.
    – Apply a chelated form of Mn as a foliar spray (refer to label).

Can be excessive (> 700 ppm) on low pH soils.

• Apply lime to raise the soil pH.
Zinc (Zn)  
(OSU: 30 – 50 ppm)  
(NRAES: 30 – 60 ppm)

Can be low on sandy, high pH, eroded, terraced or leveled soils.

• If Zn is low:
  – Soil application of zinc sulfate (36% Zn) to bring the available Zn up to 6-8 lb/A.
  – Include a Zn-containing fungicide in your early season disease control program.
    • mancozeb (Dithane M-45, Maneb, Penncozeb)
      – Contains 2% Zn.
      – 66 day pre-harvest interval.
    • Ziram
      – Contains 16% Zn.
      – 21 day pre-harvest interval.
  – Apply a chelated form of Zn as a foliar spray (refer to label).
Iron (Fe)
(OSU: 31 – 50 (200) ppm)
(NRAES: 30 – 100 ppm)

Can be low on high pH soils (> 7.4) and some sandy soils.

• If Fe is low.
  – Apply Fe chelate as a foliar spray at a rate of 1-2 lb/A. per application.
    • Start early and repeat every 10-20 days (refer to label).
  – Take measures to lower the soil pH.
High pH Soils

Can go to foliar applications of the micro nutrients.

Macro Nutrients:
- Nitrogen (N)
- Phosphorous (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)
- Sulfur (S)

Micro Nutrients:
- Iron (Fe)
- Manganese (Mn)
- Boron (B)
- Copper (Cu)
- Zinc (Zn)
- Molybdenum (Mo)
Summary of Grape Fertilizer Management

• **Pre-plant:**
  – Soil Test: pH, P, K, Mg, Zn, CEC, O.M.
  – Amend soil as needed and incorporate.

• **First year:** Apply some N after planting (~.5 oz actual N/vine), to get vines off to a good start.

• **Second year:** Apply 30-40 lbs actual N/acre, adjusted based on the soil organic matter content.

• **When production begins:**
  – Begin petiole analysis on an annual basis.
  – Adjust N fertilizer rates based on test results and vine vigor.
  – Apply other nutrients as needed based on petiole analysis results.

• **DO NOT** apply any nutrients unless there is a need!