Grapevine Nutrition
Approaches to Balancing NPK

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Know the commonly deficient nutrients in your site/region

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How Soil pH Affects Availability of Plant Nutrients

<table>
<thead>
<tr>
<th>pH</th>
<th>Strongly Acid</th>
<th>Medium Acid</th>
<th>Slightly Acid</th>
<th>Very Slightly Acid</th>
<th>Very Slightly Alkaline</th>
<th>Slightly Alkaline</th>
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<tbody>
<tr>
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<td>8.0</td>
<td>Copper &amp; Zinc</td>
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<td>9.5</td>
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<td>10.0</td>
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</table>
Understand how nutrients are taken up by roots

**Nutrients that move with water solution (mass flow)**
→ Rapid transpiration enhances nutrient uptake

**Nutrients that are adsorbed by contact of growing root (diffusion)**
→ Dominant form of uptake for most nutrients
How do nutrients leave the vineyard?

Fruit (per ton)

\[ \begin{align*}
N &= 2-6 \\
P &= 0.4-0.8 \\
K &= 3-8 \\
Mg &= 0.1-0.4 \\
Ca &= 0.4-2
\end{align*} \text{ Pounds/Ton} \]
Overcropping

- Other deficiencies intensified by heavy crop load
  \((N, K, Mg)\)
Sampling for Nutrient Management

Petiole or Leaf analysis tells us what the vine has taken up from the soil.

Soil analysis tells us what mineral nutrients are available in the soil for vines to access.
Blades and Whole Leaves

• Little difference between
• Storage organ
• Little sensitivity to conditions
When and Where

Table 1. When, where, and how to extract grape leaves for nutrient analysis.

<table>
<thead>
<tr>
<th>Sampling Time</th>
<th>Leaf Position (Figure 3)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom (30–60%)</td>
<td>Leaf opposite basal cluster of a primary shoot</td>
<td>• 50–100 leaves (target of 25 leaves per acre)</td>
</tr>
<tr>
<td>Veraison (40–60%)</td>
<td>Fifth leaf (If the vineyard has been hedged, use untrimmed canes.)</td>
<td>• Random collection from both canopy and sides</td>
</tr>
</tbody>
</table>

Figure 3. Grape vine shoot at bloom (left) and veraison (right) with appropriate leaf for sampling circled. (Please note that the three smallest leaves appear flat in this illustration, whereas on the actual shoot they would be curled in towards the shoot tip.)
Petiole/Leaf Sampling at Bloom

Beginning of flowering or trace bloom
0 to 30% caps fallen

Bloom or full bloom
50-75% caps fallen

Flower Cap

Photo: UC Davis
Petiole/Leaf Sampling at Veraison

Veraison 40-60%
## Target Values

**Table 2. Critical ranges for whole grape leaf samples used for tissue analysis.**

<table>
<thead>
<tr>
<th>Nutrient**</th>
<th>Bloom</th>
<th>Veraison</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Juice and Wine grapes</td>
<td>Juice grapes</td>
</tr>
<tr>
<td>N (nitrogen %)</td>
<td>2.50–3.50</td>
<td>2.10–3.00</td>
</tr>
<tr>
<td>P (phosphorus %)</td>
<td>0.15–0.45</td>
<td>0.15–0.45</td>
</tr>
<tr>
<td>K (potassium %)</td>
<td>0.75–1.50</td>
<td></td>
</tr>
<tr>
<td>Ca (calcium %)</td>
<td>1.00–3.00</td>
<td></td>
</tr>
<tr>
<td>Mg (magnesium)</td>
<td>0.25–0.50</td>
<td></td>
</tr>
<tr>
<td>B (boron ppm)</td>
<td>30–100</td>
<td></td>
</tr>
<tr>
<td>Zn (zinc ppm)</td>
<td>25–100</td>
<td></td>
</tr>
<tr>
<td>Fe (iron ppm)**</td>
<td>&gt; 75</td>
<td></td>
</tr>
<tr>
<td>Cu (copper ppm)</td>
<td>6–20</td>
<td></td>
</tr>
<tr>
<td>Mn (manganese ppm)</td>
<td>30–100</td>
<td></td>
</tr>
</tbody>
</table>

*Excessive concentration of plant nutrients, particularly micronutrients, can be toxic to vines. If tissue nutrient concentrations are significantly higher or lower than these values, contact an Extension specialist to help you review your results.

**Molybdenum (Mo) is rarely found to be deficient or excessive in grape, and nickel (Ni) or cobalt (Co) are not established as truly essential in grape.

***Iron (Fe) concentrations can exceed 75 ppm without being problematic for plants; no upper limit has been found for this nutrient in inland Pacific Northwest grapes.
Interpretation

• A nutrient is in the normal range
  – Continue current practices
  – Consider vine vigor and crop load
  – Look at previous season (trend)

• A nutrient is outside of the “normal” range:
  – Modest Adjustment
  – Consider seasonal conditions
    • rainfall, solar radiation
  – Consider vine vigor and crop load
## Example Laboratory Report

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen %</th>
<th>Sulfur %</th>
<th>Phosphorus %</th>
<th>Potassium %</th>
<th>Magnesium %</th>
<th>Calcium %</th>
<th>Sodium %</th>
<th>Boron ppm</th>
<th>Zinc ppm</th>
<th>Manganese ppm</th>
<th>Iron ppm</th>
<th>Copper ppm</th>
<th>Aluminum ppm</th>
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</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>1.00</td>
<td>0.12</td>
<td>0.29</td>
<td>2.26</td>
<td>0.16</td>
<td>0.99</td>
<td>0.08</td>
<td>29</td>
<td>54</td>
<td>372</td>
<td>57</td>
<td>15</td>
<td>25</td>
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<tr>
<td>Normal Range</td>
<td>0.80</td>
<td>0.13</td>
<td>0.15</td>
<td>1.20</td>
<td>0.35</td>
<td>1.00</td>
<td>0.00</td>
<td>25</td>
<td>30</td>
<td>100</td>
<td>30</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.51</td>
<td>0.36</td>
<td>0.35</td>
<td>2.50</td>
<td>1.26</td>
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<td>71</td>
<td>80</td>
<td>1000</td>
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<td>20</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>N/S</th>
<th>N/K</th>
<th>P/S</th>
<th>P/Zn</th>
<th>K/Mg</th>
<th>K/Mn</th>
<th>Ca/B</th>
<th>Fe/Mn</th>
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</thead>
<tbody>
<tr>
<td>Actual Ratio</td>
<td>8.3</td>
<td>0.4</td>
<td>2.4</td>
<td>53.7</td>
<td>14.1</td>
<td>60.8</td>
<td>341.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Expected Ratio</td>
<td>4.7</td>
<td>0.6</td>
<td>1.0</td>
<td>45.5</td>
<td>2.3</td>
<td>33.6</td>
<td>364.6</td>
<td>0.1</td>
</tr>
</tbody>
</table>

### Graphical Representation

- **Very High**
- **High**
- **Sufficient**
- **Low**
- **Deficient**

### Contact Information

A&L Eastern Laboratories
7621 Whitepine Road, Richmond, Virginia 23237
(804) 743-9401 Fax (804) 271-6446

www.aleastern.com
Nitrogen (N): Why it matters

Chemical component of:

• Nucleic acids → DNA → Genes
• Amino acids → Proteins → Enzymes
• Chlorophyll → Light interception
• Hormones → Communication
• Secondary metabolites → Color, flavor
NITROGEN
N Deficit

- Shoot growth ↘↘
- Root growth ↘
  → Drought susceptibility ↘
- ABA ↘, cytokinins ↘
- Leaf photosynthesis ↘
  → Chlorophyll ↘
  → Sugar, starch ↘
  → Anthocyanins ↘
- Leaf senescence
  → Nutrient recycling to sinks (young leaves…)

α
Nitrogen uptake and processing

- $\text{N}_2$ in atmosphere (80%) useless for grapevines, not legumes
- Mostly nitrate ($\text{NO}_3^-$) in soil water
- Soil water [NO$_3^-$] $\ll$ Tissue [NO$_3^-$]
- Active uptake via H$^+$-ATP pump and H$^+$/NO$_3^-$ cotransport $\rightarrow$ Soil pH $\nRightarrow$
- Uptake requires B (for ATP pump)
  $\rightarrow$ Insufficient B may result in N (& K) deficiency
- Transport (xylem), storage (vacuole), or assimilation
  $\rightarrow$ Amino acids $\rightarrow$ Proteins
- Assimilation requires Mo, Mg, Mn or Co and sucrose
  $\rightarrow$ Expensive (requires sugar supplied by leaves)
  $\rightarrow$ Mo, Mg, Mn, Co deficiency may result in NO$_3^-$ accumulation
Too much N? (Keller, 2005)

- High application rates of N may increase a vine’s susceptibility to drought, because nitrogen favors shoot growth over root growth.

- Growth is the “pacemaker” for nutrient uptake by the vine (smaller vines require less nutrients).
Remobilization of N

• Dense shaded canopies – N remobilizes from shaded leaves to shoot tips or sun exposed leaves

• Remobilization also occurs in senescing leaves for storage in perennial vine parts = spring growth
Remobilization of N

• Majority of nutrient demand is from bud break to bloom when shoot growth is most rapid…. But most growers do not sample tissue until bloom!

• Late season sampling can tell the grower what is needed to meet demands from bud break to bloom in following season & application can be at veraison, post harvest, and again between bud break and bloom.
Common Fertilizers

N

Urea
Ammonium sulfate
Calcium nitrate
Diammonium phosphate
Monoammonium phosphate
10-10-10, 13-13-13, etc.
Timing N Fertilizer Application

- Storage reserves for budbreak (through bloom)
- Uptake mostly during rapid growth (>6-leaf stage)

![Graph showing vine N demand and soil N supply over the year.](image-url)
Post Harvest Fertilization

- Ideally there are minimal deficiencies at harvest

- Mobile nutrients may become deficient if consumed by ripening fruit

- Nutrients removed from vineyard with fruit & canes

- Roots can take up nutrients between harvest and leaf drop... if the canopy is healthy
Spring Growth

- First growth driven by positive root pressure and remobilization of stored nutrients and starch

- After bud break, water/nutrient flow maintained by active transpiration of leaves
Irrigation effects N (Keller, 2005)

- Regulated deficit irrigation in combination with low to moderate N rates between bloom & veraison:
  - Reduced canopy size
  - Reduced berry size, yield
  - Accelerated ripening
  - Improves color
  - Reduces disease

- Too severe a deficit can limit assimilate supply and cause excessive fruit exposure
Potassium (K): Why it matters

• Not assimilated (no organic compounds)
• Occurs as cation (K\(^+\)) in cells and apoplast
• Osmotic solute of cells
  → Cell expansion
  → Stomatal action (opening/closing)
• Neutralizes anion negative charges
• Counterbalances proton movement (K\(^+\)/H\(^+\))
• Facilitates phloem loading of sucrose
  → Sugar transport
• Reduces xylem hydraulic resistance
  → Sap flow
Potassium deficiency symptoms

Chardonel, K = 0.71%
EXAMPLES OF MAGNESIUM DEFICIENCY SYMPTOMS

- Symptoms typically on basal to mid-shoot leaves
- More common with low soil pH (< 5.5)
- Impact on fruit yield and quality not well quantified.
Potassium Deficiency

- Disturbed soils with subsoil at surface
- Sandy soils in high rainfall region
- Soils with high Ca or Mg

Photos from Tom Zabadal
Michigan State Univ.

Photo: Tony Wolf
Virginia Tech Univ.
K Deficit

- Common on high-pH soils
- Root growth ↲
- Shoot growth ↲
- Phloem loading ↲ (Sugar trapping)
  → Photosynthesis ↲
  → Fruit set ↲
  → Ripening ↲
  → Storage reserves ↲
- Berry shrinkage (not BS)
- Xylem sap flow ↲ ↲ → Drought stress
- Leaf senescence
  → Nutrient recycling to sinks
    (Heavy crop → More severe symptoms)
- Powdery mildew vulnerability ↲
Effects of Excess Potassium

- High fruit pH
- Reduced color of red grapes
- Early leaf senescence moves K into fruit
Common Fertilizers

K

Potassium chloride
Potassium sulfate
Potassium nitrate
K-mag, Sulpomag
Fertilization: Potassium (K)

Soil Application

• 1-3 lbs potassium sulfate per vine
• Late Fall to early Spring
• Furrow application – placed deep
• Response may take up to 2 years
Fertilization: Potassium (K)

Drip Application

**Mild**  0.5 to 1 lb potassium sulfate per vine

**Severe**  2 lb potassium sulfate per vine

**Maintenance** (through drip, K thiosulfate)

10 to 15 pounds of K per acre per week

beginning after budbreak for 5-10 weeks
Fertilization: Potassium (K)

- Many products, Questionable Efficacy
- 5 lb Potassium nitrate NOT EFFECTIVE
Phosphorous deficiency in Merlot
Riesling on low pH soil (R.M. Pool)

Merlot on low pH soil

Pinot noir. (R.M. Pool)
Common Fertilizers

P

Triple superphosphate
Diammonium phosphate
Monoammonium phosphate
Phosphoric acid
10-10-10, 13-13-13, etc.
(time with active root growth)
Nutrient ions may compete for uptake

- High soil Na\(^+\) (salinity) limits K\(^+\) (and water) uptake
- High soil Cl\(^-\) (salinity) limits NO\(_3^-\) uptake
- High soil NH\(_4^+\) (acid soils, < pH 5.5) limits K\(^+\) and Mg\(^{2+}\) uptake
- High soil P limits Zn and Fe uptake due to complexation
Nutrient ions may compete for uptake

- High soil K\(^+\) limits Ca\(^{2+}\) and Mg\(^{2+}\) uptake (especially in young, grafted vines in acid soils)
- High soil Mg\(^{2+}\) limits K\(^+\) (and P) uptake
- High soil pH (>7.5) favors Ca\(^{2+}\) and Mg\(^{2+}\) uptake and limits K\(^+\) uptake

Watch fertilizer form (e.g. KCl?) under water deficit
Application Methods & Timing

- Ground application
  - Broadcast or banded

- Foliar application

- Irrigation application “fertigation”
Foliar application

Keep foliar nutrient applications 10-14 days apart.

N, Mg  B, Zn, Fe
Fertigation

Examples of common incompatible fertilizer mixtures

Calcium + Phosphate or Sulfate
Ammonium Sulfate + Potassium Chloride
Magnesium sulfate + Di or Monoammonium Phosphate
Phosphoric acid + Sulfates of Iron, Zinc, Copper, Manganese
Phosphorus applications in high pH water may precipitate if water is high in salts.
Broadcasting vs. Banding of Fertilizers

Westover Vineyard Advising, LLC
VineyardAdvising.com
Fritz@VineyardAdvising.com
Comparison of "organic" fertilizer source materials and common synthetic fertilizers

<table>
<thead>
<tr>
<th>Product</th>
<th>%N</th>
<th>%P</th>
<th>%K</th>
<th>%Ca</th>
<th>%Mg</th>
<th>Availability</th>
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<tr>
<td><strong>Raw Vegetative Material</strong></td>
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<td>Grape pomace</td>
<td>0.4</td>
<td>0.4</td>
<td>0.1</td>
<td>0.1</td>
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<td>mod</td>
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<tr>
<td>Cottonseed meal</td>
<td>6</td>
<td>2.5</td>
<td>1.5</td>
<td>0.4</td>
<td>0.9</td>
<td>slow</td>
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<tr>
<td>Kelp</td>
<td>1.5</td>
<td>0.75</td>
<td>8</td>
<td>2</td>
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<td><strong>Compost &amp; Manures</strong></td>
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<td>Compost (varies)</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>mod</td>
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<td>Beef - feedlot</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>mod</td>
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<tr>
<td>Poultry</td>
<td>3.6</td>
<td>1.7</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>rapid</td>
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<td><strong>Animal by-products</strong></td>
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<tr>
<td>Bone meal</td>
<td>1 - 6</td>
<td>12</td>
<td>0</td>
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<td></td>
<td>slow/rapid</td>
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<tr>
<td>Blood meal</td>
<td>12</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>rapid</td>
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<td>Feather meal</td>
<td>12</td>
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<td>mod</td>
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<td>Fish meal</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
<td>rapid</td>
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<td><strong>Minerals</strong></td>
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<td>Calcium carbonate lime</td>
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<td>32</td>
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<td>pH dependent</td>
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<td>Gypsum (calcium sulfate)</td>
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<td></td>
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<td>22</td>
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<td>Magnesium sulfate</td>
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<td></td>
<td>8</td>
<td>2</td>
<td>10</td>
<td>rapid</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td></td>
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<td></td>
<td></td>
<td>50</td>
<td>mod</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td></td>
<td></td>
<td>3- 8 (avail)</td>
<td>2</td>
<td>50</td>
<td>slow</td>
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<tr>
<td>Dolomite limestone</td>
<td></td>
<td></td>
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<td></td>
<td>25</td>
<td>pH dependent</td>
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<td><strong>Synthetic Fertilizers</strong></td>
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<tr>
<td>Calcium nitrate (CAN-17)</td>
<td>15</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>12-26-26</td>
<td>12</td>
<td>26</td>
<td>26</td>
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<tr>
<td>Ammonium phosphate</td>
<td>10</td>
<td>34</td>
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</table>
Stockpiling of Grape Waste

Areas of concern:
• pH (3.5-3.8)
• High moisture content
• Self-sealing

Benziger Winery
Compost can contain weed seeds
Application Methods & Timing
Application Methods & Timing
Mulch spreader side dressing compost
### Method 1: Determine the rate of compost to apply based on desired available nitrogen in year one.

Fill in the green boxes based on the analysis results from the lab or suggested default.  
Fill in the yellow boxes with your desired criteria.  
Results for estimated nitrogen from compost and application/order rates appear in the red box.

<table>
<thead>
<tr>
<th>Analysis Numbers from Lab</th>
<th>Estimated Nitrogen Available Year 1</th>
<th>Estimated Release lbs/Ton Compost</th>
<th>Desired Nitrogen Per Acre (lbs)</th>
<th>Compost Rate Tons/Acre</th>
<th>Total Acres</th>
<th>Total Compost Order (tons)</th>
<th>Total Compost Order (yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N % wet lb/yd³ lb/ton</td>
<td>2.62</td>
<td>21.2 52.4</td>
<td>0.20</td>
<td>10.5</td>
<td>4.8</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Wt/Vol lb/yd³</td>
<td>810</td>
<td>Range is 800 to 1000 lbs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Method 2: Determine the available nitrogen based on the rate of compost applied.

<table>
<thead>
<tr>
<th>N lb/ton</th>
<th>Compost Rate Applied</th>
<th>Total lbs N Applied</th>
<th>Estimated Nitrogen Available Year 1</th>
<th>N Availability By Time of App. (From Table 1)</th>
<th>N Availability By App. Method (From Table 2)</th>
<th>Available Nitrogen Per Acre (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.4</td>
<td>4.8</td>
<td>252</td>
<td>0.20</td>
<td>0.3</td>
<td>0.65</td>
<td>49.0</td>
</tr>
</tbody>
</table>

#### Table 1:
Nitrogen availability based on time of application before bud break.

<table>
<thead>
<tr>
<th></th>
<th>0.5</th>
<th>0.4</th>
<th>0.3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Month Before</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Months Before</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Months Before</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Table 2:
Nitrogen availability based on application method.

<table>
<thead>
<tr>
<th></th>
<th>0.85</th>
<th>0.75</th>
<th>0.65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worked into soil or rained in same day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worked into soil or rained in next day</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left on surface for more than 2 days</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To download an updated version of this compost rate calculator click [here](#).
## Compost Rate Worksheet

**Date:** 2/16/2012  
**Vineyard Block:** Example  
**Compost Source:** Comgro Soil Amendments  
**Compost Type:** Grape Pomace  
**Source Contact:** Johnny Massa

<table>
<thead>
<tr>
<th>Compost Nutrients</th>
<th>Estimated Nutrient Available % wet</th>
<th>Estimated Release lbs/Ton Year 1</th>
<th>Compost lb/yd³</th>
<th>Compost lb/ton</th>
<th>Estimated Nutrient Per Acre (lbs.)</th>
<th>Compost Rate Tons/Acre</th>
<th>Total Acres</th>
<th>Total Compost Order (tons)</th>
<th>Total Compost Order (yd³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2.62</td>
<td>0.20</td>
<td>21.2</td>
<td>52.4</td>
<td>0.20</td>
<td>10.48</td>
<td>5</td>
<td>24</td>
<td>59</td>
</tr>
<tr>
<td>P</td>
<td>0.99</td>
<td>0.40</td>
<td>8.0</td>
<td>19.8</td>
<td>0.40</td>
<td>7.92</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>3.13</td>
<td>0.60</td>
<td>25.4</td>
<td>62.6</td>
<td>0.60</td>
<td>37.56</td>
<td>179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>1.14</td>
<td></td>
<td>9.2</td>
<td>22.8</td>
<td>[up]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>0.55</td>
<td></td>
<td>4.5</td>
<td>11.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.20</td>
<td></td>
<td>1.6</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td>0.11</td>
<td></td>
<td>0.9</td>
<td>2.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wt/Vol</td>
<td>810</td>
<td>Range is 800 to 1000 lbs</td>
<td>810</td>
<td>810</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td>7.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*If you apply 5 tons of compost/acre, 50 pounds N/acre will be available in year one, as will 38 pounds/acre P and 179 pounds/acre K.*

**Notes:**  
Compost rates based on (limited by) desired N rates  
Actual N based on 20% release in year 1. 1st year release considered only.  
P and K release estimated as 40% and 60% respectively.  
PPM converted to %: 1% is equal to 10,000 ppm or 1 ppm is 0.0001%
NPK Fertility in Young Vines

- Different nutrients in different locations
  - (leaching: $\text{NO}_3^-$ $>>$ $\text{K}^+$ $>>$ $\text{H}_2\text{PO}_4^-$)
  - Shallow roots: immobile nutrients
  - Deep roots: mobile nutrients ($\text{NO}_3^-$)
- Mycorrhizal fungi extend root zone

Chardonel, $K = 0.71\%$
Advice

- **Before planting your vineyard:**
  - Add needed fertilizer and amendments before planting and incorporate to rooting depth (based on soil tests)

- **After your vineyard is planted:**
  - Add only the fertilizers that are needed, and at only the rates needed (based on plant tests and visual observation)

- **Add fertilizer at the time of optimal vine uptake**
  - Based on fertilizer and application method
The Science of Grapevines: Anatomy and Physiology is an introduction to the physical structure of the grapevine, its various organs, their functions, and their interactions with the environment. Based on the author's years of teaching grapevine physiology, as well as his research experience with grapevines and practical experience growing grapes, it provides an important guide to understanding the entire plant.

The book begins with a brief overview of the botanical classification, anatomy, and growth cycles of grapevines. It then addresses the basic concepts in growth and development, water relations, photosynthesis, respiration, mineral uptake and utilization, and carbon partitioning. These concepts aid the reader in better understanding plant-environment interactions, including canopy dynamics, yield formation, fruit composition, and interaction with other organisms. While this book focuses on the physiology of whole plants rather than the metabolism of cells, it also discusses basic functions at the cellular and organ level in order to establish a firm understanding of whole-plant function.

Readers will find that many of the concepts discussed in this text are applicable to other plants, though the focus is clearly on grapevines. The broad breadth of coverage makes this an ideal text for viticulture and enology students, researchers, and industry professionals.

**KEY FEATURES**

- Focus on the physiology of the whole plant to enhance the reader's understanding of grapevine function
- Global coverage of grapevines in their natural and agricultural environment, including regional differences, similarities, and challenges
- Insights into what to expect from the expanding use of land for vineyards, the impact of global climate change, and issues related to water availability
Fact Sheets

Grapevine Nutrition
- Nutrients Commonly Low in Vineyards (client access)
- Instructions for Grape Petiole Sampling
- New! Instructions for Grape Leaf Blade Sampling

Pest and Disease Management
- Phosphorus Acid Products for Controlling Downy Mildew of Grapes
- Grape Berry Moth Identification Guide for Pheromone Trapping
- Example Grape Spray Guide - Non-Bearing (client access)
- Example Spray Guide for Blanc Du Bois, Lenoir and Norton (client access)
- Photos of Common Fungal Diseases of Blanc Du Bois and Lenoir (registered subscribers)

Planting and Trimming New Vines
- Trimming and Planting Own Rooted Vines (registered subscribers)

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