Aspects Related to Mineral Nutrition in Irrigated Grapevines

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# Mineral Nutrient Deficiencies and Excesses in Grapes

<table>
<thead>
<tr>
<th>Common</th>
<th>Less Common</th>
<th>Infrequently or not observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Phosphorus</td>
<td>Calcium</td>
</tr>
<tr>
<td>Potassium</td>
<td>Magnesium</td>
<td>Sulfur</td>
</tr>
<tr>
<td>Zinc</td>
<td>Iron</td>
<td>Copper</td>
</tr>
<tr>
<td>Boron</td>
<td>Manganese</td>
<td>Molybdenum</td>
</tr>
</tbody>
</table>

- **Excesses**
  - Nitrogen
  - Chloride
  - Boron
  - Sodium

Macronutrients - yellow
Micronutrients - white
Managing Mineral Nutrition

Knowledge of:

• Site/Soil characteristics and chemistry
• Vineyard production goals
• Fertilizer inputs
• Cultural practices
• Tissue and soil analysis
• Observation and judgment
Drip irrigation

“Farming in a flowerpot”

Relatively small proportion of total nutrients available
FERTILIZERS

• Fertilizers are a method of supplying supplemental elements where deficient or unavailable to the plant

• The most common element supplied by fertilizers to vineyards is nitrogen
Nutrient Mobility

• Another way of classifying nutrients is their behavior in water.

• Some move wherever water goes and some are held strongly by the soil.
Problem: Contamination of surrounding water bodies

Nitrates, Phosphorous

Eutrophication

Lakes and Streams

Groundwater

Nitrates
Nutrient Management

• Nitrogen basics:
  – Essential plant nutrient
  – Taken up by plants in both ammonium (NH$_4^+$) and nitrate (NO$_3^-$) forms
  – Majority of plant uptake is the nitrate form

• Nitrogen becomes an environmental problem when it moves off-site
  – Surface water, groundwater
  – Agriculture is only one of the nonpoint sources
Nitrogen Sources

- Soil reserves
- Irrigation water
- Fertilizer
- Cover crops
Nitrogen cycle

- Fixation
- Organic Matter
- Microbes
- Root uptake
- Solution: $\text{NH}_4^+ + \text{NO}_3^-$
- Crop removal
- Denitrification
- Ammonium volatilization
- Fertilizer, Residues, Amendments
- NH$_4^+$ on clay
Nitrogen cycle

Organic Matter

solution $\text{NH}_4^+ \text{ NO}_3^-$

$\text{NH}_4^+$ on clay

NO$_3^-$ Leaching

Runoff
Determine Fertilizer Requirements

- Determine nutrient contents of soil amendments
  - Manure, compost
Determine Fertilizer Requirements

• Evaluate well water for nutrient levels

1 ac/ft water with 10 ppm nitrate-N provides 27.9 lbs/N per acre

The nitrates from well water are indistinguishable from fertilizer nitrates, and function identically.
Apply Fertilizers Efficiently

- Time Fertilizer Application to Plant Uptake
- Consider split applications of materials

Nitrogen accumulation (g)

- Bud burst
- Bloom
- Veraison
- Fruit
- Harvest
- Leaf fall
- Pruning
- Bud burst

Fruit

Leaves

Shoots

Trunk

Roots

Apply Fertilizers Efficiently

- Time Fertilizer Application to Plant Uptake
- Consider split applications of materials
Apply Fertilizers Efficiently

Once crop nutrient requirements are determined:

Use fertigation to apply fertilizers, if feasible
Apply Fertilizers Efficiently

Irrigation system

- Practices to improve system efficiency & uniformity
Reduce Nutrient Movement

- From water, wind, eroding soil
  - Cover crops
  - Filter strips
  - Vegetative Buffer Strips

- Sequester nutrients, keep in organic form
- Reduce erosion
- Trap sediments
Reduce Nutrient Movement

- Manage irrigation and fertigation to avoid losses below root zone

- Avoid applying fertilizers prior to predicted rain events
Factors affecting nutrient uptake

**Absolute deficiency**

Nutrient is at inadequate levels for vine growth

**Induced deficiency**

Nutrient present in but uptake by grapevine roots affected by:

- Phylloxera or nematode damage
- Soil moisture status or irrigation patterns
- High levels of other mineral in the soil
- Variety or rootstock
- High crop levels
Tissue sampling

✓ Most reliable method for nutritional analysis
✓ Nutrients that the vine can remove from soil

Two sampling purposes:

1. General nutritional levels
2. Diagnosing visible vine disorders
A major limitation is that soil analysis is not a good indicator of nutrient availability.
In a nutrient management program, soil analysis is important to:

- Establish a benchmark for soil amendments
- Evaluate site uniformity
- Avoid the buildup of harmful elements
Soil fertility analysis

- Location of soil samples

Consider nutrient variability within root zone

- Fertigation delivers nutrients to confined area

- Nutrients preferentially extracted from wetted zone
### Soil Chemical Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measurement/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Acidity and Alkalinity</td>
</tr>
<tr>
<td>Salinity</td>
<td>EC (electrical conductivity)</td>
</tr>
<tr>
<td>Permeability</td>
<td>ESP (exchangeable sodium percentage)</td>
</tr>
<tr>
<td>Toxicity</td>
<td>Chloride, Boron, Sodium</td>
</tr>
<tr>
<td>Cation Exchange</td>
<td>Potassium, Calcium, Magnesium</td>
</tr>
<tr>
<td>Amending</td>
<td>Lime or gypsum requirement</td>
</tr>
<tr>
<td>Baseline nutrient levels</td>
<td>Background information and awareness</td>
</tr>
</tbody>
</table>
Soil chemistry components

pH effect on nutrient availability

![Soil pH Chart](chart.png)
Soil Fertility Analysis

- Changes in soil test level over time

### Test Level over Time (1994-2008)

- Optimum
- High
- Excessive
- Low

<table>
<thead>
<tr>
<th>Year</th>
<th>Test Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>94</td>
<td>Low</td>
</tr>
<tr>
<td>96</td>
<td>Low</td>
</tr>
<tr>
<td>98</td>
<td>Low</td>
</tr>
<tr>
<td>00</td>
<td>Low</td>
</tr>
<tr>
<td>02</td>
<td>Low</td>
</tr>
<tr>
<td>04</td>
<td>Low</td>
</tr>
<tr>
<td>06</td>
<td>Low</td>
</tr>
<tr>
<td>08</td>
<td>Low</td>
</tr>
</tbody>
</table>
Tissue Analysis - Phenology Stages

Bloom
- Survey Sampling
- Early information
- Easy sampling
- Useful for determining nutrient needs

Veraison
- Follow-up sampling
- Refining K needs

Midsummer to Harvest
- Problem solving, especially for Na, Cl & K
Monitoring Tissue Nutrient Levels

For evaluating fertilizer needs:
- Sample at full bloom
- Petioles from 75 -100 vines
- Sample leaf opposite a cluster
Veraison Follow-up Sampling

- Sample recently fully expanded matured leaves (6th or 7th back from tip)
Diagnosing Visible Symptoms

- Sampled when abnormal symptoms appear
  - Symptoms generally appear midseason or at harvest
- If symptoms show, sample affected leaves
- If toxicities a concern, sample both petiole and blade
- Sample non-symptom vines for comparison
Sampling

Intensity should reflect:

✓ Soil variability
✓ Varieties and rootstocks
✓ Intensity of farming
What plant analyses to make

**General**
- Nitrate-nitrogen ($\text{NO}_3^-$)
- Total Phosphorus (P)
- Total Potassium (K)
- Zinc (Zn)
- Boron (B)

**Trouble diagnosis**
- Chloride (Cl)
- Sodium (Na)
- Potassium (K)
- Magnesium (Mg)
- Manganese (Mn)

- Toxicity
- Deficiency
Nutrient Analysis

- Interpretation of laboratory results

- Adverse plant effects
- (-) Economic return
- Environmental issues
## Interpretive Guide for Grape Petiole Analysis at Bloom and Veraison

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Deficient (below)</th>
<th>Adequate (above)</th>
<th>Excessive (above)</th>
<th>Toxic (above)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO$_3$-N, ppm</td>
<td>350</td>
<td>500</td>
<td>2,000</td>
<td>8,000</td>
</tr>
<tr>
<td>N (total), %</td>
<td></td>
<td>0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P (total), %</td>
<td>0.10 (0.08)*</td>
<td>0.20 (0.15)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K (total), %</td>
<td>1.0 (0.5)*</td>
<td>1.5 (0.8)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg (total), %</td>
<td>0.2</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn (total), ppm</td>
<td>15</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (total), ppm</td>
<td>25</td>
<td>30</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

* Veraison values in parenthesis (Christensen 2000)
# Tissue Analysis Limitations

<table>
<thead>
<tr>
<th>Element</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate-N</td>
<td>Differs by cultivar, region, and weather</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Critical levels are more consistent</td>
</tr>
<tr>
<td>Potassium</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Lack of relationship to symptoms, contamination</td>
</tr>
</tbody>
</table>
N Critical Levels

* Petiole NO$_3$-N provides a wider spread between adequate and deficient levels as compared to % total N based on N rate studies
Assessment of Nitrogen Requirements

- Vine vigor
- Canopy density
- Cultural requirements of cultivar and site
- Rootstock influence on nutrient uptake
- Knowledge of N inputs
  - fertilizer, irrigation water, cover crop
- Soil and root conditions
- Tissue analysis to detect extreme values and trends over seasons
Nutrients removed in one ton of grapes
(Averages in literature)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>lbs/ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2.92</td>
</tr>
<tr>
<td>K</td>
<td>4.94</td>
</tr>
<tr>
<td>P</td>
<td>0.56</td>
</tr>
<tr>
<td>Ca</td>
<td>1.0</td>
</tr>
<tr>
<td>Mg</td>
<td>0.2</td>
</tr>
<tr>
<td>Zn</td>
<td>0.00115</td>
</tr>
<tr>
<td>B</td>
<td>0.00065</td>
</tr>
<tr>
<td>Fe</td>
<td>0.01050</td>
</tr>
</tbody>
</table>
Nitrogen practice – Drip Irrigation

Timing: Spring to early summer and/or Postharvest

Rate, lbs N/acre: 0 to 30

Rate is dependent on vine vigor level and production level

Apply in increments over time
Nutrient Management

• Retention is a problem in many soils

• Advantageous to apply nutrients in small increments as needed