Soil Fertility for Wine Grapes

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University of Minnesota

Michigan Wine Grape Vineyard Establishment Conference
January 22, 2014
General topics

- Soil testing and basic nutrient management for vineyards before planting
  - Taking a representative soil sample
  - Soil pH
  - Organic matter management
  - Macronutrients
  - Micronutrients

- Suggested amendments before planting
## Essential Plant Nutrients

14 nutrients derived from the soil and/or fertilizer

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

- Vine vigor
- Visual symptoms
  - Yield and quality already affected
- Soil testing
- Petiole analysis
Grapes are a Perennial Crop

- Making proper decisions based on soil testing prior to planting is essential.

- Once planted, only surface applications are possible.

- For some amendments surface applications are inefficient or ineffective.
Availability of Essential Mineral Nutrients

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

- Soil test before planting

- Test every 4 to 5 years after planting...
  - or when a problem is suspected

- Supplements petiole testing in established vineyards
Soil Testing

- **pH, P, and K**
  - Soil tests very well calibrated for adjusting these properties

- **Ca, Mg, S, Zn, B**
  - Soil tests also useful for detecting deficiencies (or excesses) of these nutrients

- **Organic Matter**
  - Used to adjust N rates
Soil Sampling

- Collect representative samples
  - Soil tests are only as accurate as the samples you submit
  - Sampling is often the weakest link in a soil testing program
Sampling Guidelines

- Divide fields into uniform areas
  - Soil type, slope, crop history, previous lime, fertilizer, manure applications
  - < 20 acres for a single sample
  - < 2-3 acres on uneven land

- Collect 15-20 soil cores per sample
  - Random, zig-zag pattern across the field
Soil Sampling

- Sample to a depth of 0 to 8”
- A second sample, 8 to 16” can also be submitted
- Thoroughly mix sub-samples in a clean, plastic container
  - Submit about a pint of composite sample to testing lab
- If soil is wet
  - Air dry
  - Oven dry at <97° F
### Pine Hill Vineyard

**Location Reference**
- Name: Pine Hill Vineyard
- Address: 123 Needle Lane, Big Lake, MN 55309

**Mail Report To**
- Name: 
- Address: 
- City, State, Zip: 
- Phone: 

**Sample Identification**

<table>
<thead>
<tr>
<th>Sample Identification</th>
<th>Crop History</th>
<th>Proposed Crops</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crop Grown Before Last</td>
<td>Last Crop Grown</td>
<td>Check</td>
<td>Check</td>
<td>Check</td>
</tr>
<tr>
<td>1</td>
<td>4+</td>
<td>57</td>
<td>4+</td>
<td>57</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>4+</td>
<td>57</td>
<td>4+</td>
<td>57</td>
<td>X</td>
</tr>
</tbody>
</table>

**Recommendations available for these crops**

**Small Grains**
- Barley
- Oats
- Wheat

**Legumes**
- Alalfa, New Seed
- Alalfa, Established

**Miscellaneous**
- Buckwheat
- Field Beans
- Fallow
- Fenugreek
- Grass Hay
- Grass Seed Prod.
- Grass Pasture
- Millet
- Rye/Triticale
- Lentil
- Radish
- Sweet Corn

**Miscellaneous (continued)**
- Rape/Mustard/Canola
- Sorghum Sudan
- Safflower
- Sunflowers
- White Rice

**Vegetables**
- Asparagus, New Planting
- Asparagus, Established Planting
- Beans, Snap
- Beets, Table
- Broccoli
- Brussels Sprouts
- Cauliflower
- Spinach

**Fruits**
- Apples
- Blueberries
- Grapes
- Raspberries/Brambles

**Turf**
- Cultured Sod

**Nursery, Field Stock**
- Suggested for use with: Regular Soluble Salts, Nitrates. For sampling instructions, please see Nursery Form M-85-3-60.
SOIL TEST REPORT
Farm and Field
FARMER DOE
ROUTE 1
ANYWHERE MN 55000

INTERPRETATION OF SOIL TEST RESULTS

<table>
<thead>
<tr>
<th>Soil Texture Code:</th>
<th>H</th>
<th>P</th>
<th>E</th>
<th>A</th>
<th>P</th>
<th>K</th>
<th>B</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>C (coarse):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sand, loamy sand,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sandy loam</td>
<td>H</td>
<td>P</td>
<td>E</td>
<td>A</td>
<td>P</td>
<td>K</td>
<td>B</td>
<td>Z</td>
</tr>
<tr>
<td>M (medium):</td>
<td>M</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>P</td>
<td>K</td>
<td>B</td>
<td>Z</td>
</tr>
<tr>
<td>loam, silt loam</td>
<td>M</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>P</td>
<td>K</td>
<td>B</td>
<td>Z</td>
</tr>
<tr>
<td>F (fine):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clay loam,</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>silty clay loam,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>silty clay</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SOIL TEST RESULTS

<table>
<thead>
<tr>
<th>Sample/Field Number</th>
<th>Estimated Soil Texture</th>
<th>Organic Matter %</th>
<th>Soluble Salts mmhos/cm</th>
<th>pH</th>
<th>Buffer Index</th>
<th>Nitrate NO3-N ppm</th>
<th>Olsen Phosphorus ppm</th>
<th>Bray 1 Phosphorus ppm</th>
<th>Potassium ppm K</th>
<th>Sulfur SO4 -S ppm</th>
<th>Zinc ppm</th>
<th>Iron ppm</th>
<th>Manganese ppm</th>
<th>Copper ppm</th>
<th>Boron ppm</th>
<th>Calcium ppm</th>
<th>Magnesium ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>3.0</td>
<td>5.5</td>
<td>6.5</td>
<td>30</td>
<td>85</td>
<td>0.5</td>
<td>1500</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RECOMMENDATIONS
Crop Before Last: Grapes; Last Crop: Grapes

<table>
<thead>
<tr>
<th>Crop and Yield Goal</th>
<th>Method</th>
<th>Lime #ENPA</th>
<th>N lb/A</th>
<th>P2O5 lb/A</th>
<th>K2O lb/A</th>
<th>S lb/A</th>
<th>Zn lb/A</th>
<th>Fe lb/A</th>
<th>Mn lb/A</th>
<th>Cu lb/A</th>
<th>B lb/A</th>
<th>Ca lb/A</th>
<th>Mg lb/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grapes</td>
<td>Broadcast</td>
<td>2500</td>
<td>30</td>
<td>50</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Row/Drill</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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Comments: 3,18,24,50,53,64

Client Copy
Department of Soil, Water, and Climate
Minnesota Extension Service
Agricultural Experiment Station

Page 1
Report No. 9
Laboratory No. 146999
Date Received 03/08/2005
Date Reported 03/20/2005
# 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>Phosphorus (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; 160 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>500 - 2000 ppm</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>- -</td>
<td>- -</td>
<td>&gt; 1 ppm</td>
<td>0.2 - 2.0 ppm</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>.75 - 1.0 ppm</td>
<td>- -</td>
<td>&gt; 6 ppm</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>- -</td>
<td>- -</td>
<td>&gt; 0.2 ppm</td>
<td>0.5 ppm</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>- -</td>
<td>- -</td>
<td>&gt; 7 ppm</td>
<td>20 ppm</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>- -</td>
<td>- -</td>
<td>&gt; 7 ppm</td>
<td>- -</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>- -</td>
<td>&gt; 7 ppm</td>
<td>&gt; 7 ppm</td>
<td>- -</td>
</tr>
</tbody>
</table>

  & Midwest Grape Production Guide (OSU Ext Bull. 919)
Soil pH

- Ideal pH range for grapes: 6.0 to 7.0
- Low pH easily modified before planting; high pH is often a problem – particularly with high carbonates
- Difficult to change after planting
Soil pH

- Microbial activity
- Nutrient availability
Modifying Soil pH

- Raising pH
  - Lime recommended if pH < 6.0
  - Rate based on buffer pH
  - Buffer pH depends on amount of clay and organic matter
  - Lime also adds Ca and Mg
    - Dolomitic lime contains Mg & Ca; Calcitic lime – mostly Ca
  - Incorporate lime 8 to 10 inches
    - Apply one year before planting
Modifying Soil pH

- Lowering pH is more of a challenge
  - Acidification of high pH soils is difficult and expensive
  - Elemental sulfur used to lower pH

- Most high pH problems are on soils derived from limestone

- High pH soil can cause severe iron deficiency
Iron Chlorosis

Photographed by Eli Bergmeier
Guidelines for Lowering Soil pH

• Soil pH between 6.5 to 7.0
  • No amendments needed

• Soil pH 7.0 to 7.5
  • Apply elemental sulfur to lower the pH to 6.5 or 6.0

• Soil pH above 7.5
  • Apply sulfur to lower the pH to 6.5 or 6.0 if free of carbonates
  • If carbonates present - Not recommended due to cost
  • Use soil applied iron chelates if chlorosis is a problem
Sulfur Required to Lower the Soil pH to 6.5
For a Carbonate-free Soil

Clay soil, High OM

Sandy soil, Low OM
Nitrogen Fertilizer Recommendations

- Of all the essential elements nitrogen is often the most limiting
- Soil tests for nitrogen are not that reliable – most recommendations adjusted to soil organic matter level
- Nitrogen is mobile in the soil, so preplant N applications are generally not needed for grapes
- Grapes are very efficient N users – too much N will result in excessive vine growth
Soil Organic Matter Content:

Nitrogen Released from Organic Matter

Need to adjust N fertilization practices based on the organic matter content of the soil.
Nitrogen Fertilizer Recommendations
(Non-Bearing Vines – 1st or 2nd year)

- Apply inorganic N sources after planting
  - Split applications on sandy soils to reduce leaching

- Account for N from manure, compost, legume cover crops

- General N recommendations:
  - 30 lb N/acre – high OM soils (>4.6%)
  - 45 lb N/acre – medium OM soils (3.1-4.5%)
  - 60 lb N/acre – low OM soils (<3.1%)
Nitrogen Nutrition Effects on Grapes

- **Deficient nitrogen**
  - Poor vine growth; pale yellow leaves
  - Low sugar content
  - Low yeast assimilable nitrogen in grapes

- **Excess nitrogen**
  - Excessive vine growth
  - Poor fruit color
Nitrogen Fertilizer Sources

- **Organic**
  - Manures, compost, legume cover crops
    - Apply manure/compost based on N content

- **Conventional**
  - Nitrate forms - Calcium nitrate:
    - Increases soil pH
    - Readily available to plants
    - Very subject to leaching
  - Urea - CO(NH$_2$)$_2$:
    - Taken up as urea, or converted to NH$_4$-N then to NO$_3$-N
    - Will volatilize with surface applications - esp. high pH soils
Nitrogen Fertilizer Sources (cont.)

- Ammonium forms – ammonium sulfate
  - Decreases soil pH
  - Converts to nitrate
  - Not prone to volatilization

\[
\text{ammonium} \xrightarrow{\text{conversion}} \text{nitrate}
\]
Fertilizer Additions  (Before Planting)

- Base P and K needs on a soil test
  - Also Mg, Zn, and B

- Very difficult to correct P and K deficiencies after vines are planted

- Broadcast and incorporate to a depth of 8 to 10 inches
Phosphorus Management

- Very immobile in the soil
  - Pre-plant soil analysis & amend before planting

- Generally not a problem for established grapes
  - Vines often do well on low P soils, but deficiencies can occur particularly on acid soils (pH < ~5.3)
    - Soil mycorrhizal organisms aid in making P available

- On low P testing soils
  - Apply manure or compost in the fall as an N source
  - Apply triple superphosphate (0-46-0) or mono ammonium phosphate (11-52-0)
## Preplant Phosphorus Recommendations

<table>
<thead>
<tr>
<th>Relative Soil Test P</th>
<th>Amount of Phosphate to Apply, lb P$_2$O$_5$/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>150</td>
</tr>
<tr>
<td>Low</td>
<td>125</td>
</tr>
<tr>
<td>Medium</td>
<td>100</td>
</tr>
<tr>
<td>High</td>
<td>75</td>
</tr>
<tr>
<td>Very High</td>
<td>25</td>
</tr>
</tbody>
</table>
Potassium Management

- Generally immobile in the soil
  - Pre-plant soil analysis & amend before planting

- Grapes susceptible to K deficiency - esp. when fruiting
  - Low K results in low fruit sugars
  - high K can increase fruit pH

- Soil K applications:
  - Potassium chloride (0-0-62)
  - Potassium sulfate (0-0-50)
  - Potassium magnesium sulfate, (0-0-22 + 22% S, 11% Mg)
## Preplant Potassium Recommendations

<table>
<thead>
<tr>
<th>Relative Soil Test K</th>
<th>Amount of Potash to Apply, lb K₂O/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>250</td>
</tr>
<tr>
<td>Low</td>
<td>200</td>
</tr>
<tr>
<td>Medium</td>
<td>150</td>
</tr>
<tr>
<td>High</td>
<td>100</td>
</tr>
<tr>
<td>Very High</td>
<td>0</td>
</tr>
</tbody>
</table>
# Potassium Stratification

<table>
<thead>
<tr>
<th>Soil Depth (inches)</th>
<th>K Level (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>250</td>
</tr>
<tr>
<td>3-8</td>
<td>95</td>
</tr>
</tbody>
</table>
Magnesium Management

- Can be a problem on sandy soils, particularly when potassium has been over applied.
- If the soil pH is low (acid), apply dolomitic lime to raise the pH to 6.0 or 6.5.
- Use Epsom salts (magnesium sulfate) or potassium-magnesium (sul-po-mag) if the soil pH is in the optimal range.
Preplant Magnesium Recommendations

<table>
<thead>
<tr>
<th>Relative Soil Test Mg</th>
<th>Amount of Magnesium to Apply, lb Mg/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>100</td>
</tr>
<tr>
<td>Medium</td>
<td>50</td>
</tr>
<tr>
<td>High</td>
<td>0</td>
</tr>
</tbody>
</table>
Micronutrients

- Most micronutrients are present in sufficient amounts in soils to meet plant needs.
- Deficiencies may occur on high pH or very sandy soils.
- Iron, zinc, manganese, and boron deficiencies may occur in grapevines.
- Managing soil pH will help to reduce micronutrient problems.
Micronutrients

- Use of compost or manure as a nutrient source will also provide micronutrients

- Once vines are established foliar fertilizer sources can be used

- Identify micronutrient needs with petiole analysis after the second or third year of growth
Preparing soil before planting is especially important for a perennial crop like grapes.

Use soil tests to determine preplant amendments:
- pH, organic matter (OM), P, K, Mg, S, Zn, B
- Adjust nitrogen needs based on OM

Once vines are established and growing, supplement soil tests with petiole analysis.