Objectives

- What is a Vineyard Fertility Plan?
- Importance
- Principles of Vine Fertility
- Methods of Fertility Assessment
- Prevention & Correction of Fertility Issues
What is a VFP?

- A plan of action aimed at ensuring proper vine nutrition
- Should be done continually, but especially before you establish your vineyard
- “once the vines are in the fertility battle has begun”
- Yearly records are critical

Importance

- Have a prevention and correction plan that will ensure healthy vines with quality fruit
  - save time, effort, and money
- Prevent overuse of fertilizers
- Every vineyard site is different
  - need to know your vineyard (process)
Role of Nutrients

- Essential for proper vegetative and reproductive growth
  - nutrients deplete over time

- General deficiency issues include
  - retarded growth, yield reduction, poor fruit quality
  - foliar symptoms
  - increased disease occurrence and cold damage

- Over-application
  - excess vigor, poor fruit quality, increased disease, cold damage
  - toxicity and death

Principles of Vine Fertility

- all are essential
- motility and availability in soil and vine differ

### Essential Nutrients for Normal Grapevine Growth and Development

<table>
<thead>
<tr>
<th>Obtained from Atmosphere and Water</th>
<th>Macronutrients</th>
<th>Micronutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon (C)</td>
<td>Nitrogen (N)</td>
<td>Iron (Fe)</td>
</tr>
<tr>
<td>Hydrogen (H)</td>
<td>Phosphorous (P)</td>
<td>Manganese (Mn)</td>
</tr>
<tr>
<td>Oxygen (O)</td>
<td>Potassium (K)</td>
<td>Copper (Cu)</td>
</tr>
<tr>
<td></td>
<td>Magnesium (Mg)</td>
<td>Zinc (Zn)</td>
</tr>
<tr>
<td></td>
<td>Calcium (Ca)</td>
<td>Molybdenum (Mo)</td>
</tr>
<tr>
<td></td>
<td>Sulfur (S)</td>
<td>Boron (B)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chlorine (Cl)</td>
</tr>
</tbody>
</table>
Factors Affecting Availability

1. Climatic & weather patterns
   ◦ precipitation, flooding, waterlogging, leaching

2. Soil profile
   ◦ texture, pH, salinity, and CEC
   ◦ water holding capacity, drainage capability, erosion

3. Vineyard design & practices
   ◦ site, cover crops, weeds, cropping level, scion/rootstock
   ◦ “perennial crop dilemma”

Nutrients are removed from the vine

<table>
<thead>
<tr>
<th>Tonnage per acre</th>
<th>Lbs. N</th>
<th>Lbs. P</th>
<th>Lbs. K</th>
<th>Lbs. Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>2</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>18</td>
<td>3.5</td>
<td>30</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Adapted from: The Lodi Winegrowers Workbook. 2008.
**Soil – Cation Exchange Capacity**

- Affects mineral solubility
  - may be found in soil but not available
- Acidic soils
  - often find Mo, P, Mg, Ca less available
  - while Al, Fe, and Mn more available
- Alkaline soils
  - often find Fe and Zn less available
- Amending Soil
  - extremely challenging and costly

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  - often find Fe and Zn less available
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# Nutrient Mobility in Vine

<table>
<thead>
<tr>
<th>Mobile</th>
<th>Moderately Mobile</th>
<th>Immobile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>Manganese</td>
<td>Iron</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>Copper</td>
<td>Zinc</td>
</tr>
<tr>
<td>Potassium</td>
<td>Molybdenum</td>
<td>Boron</td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
<td>Calcium</td>
</tr>
</tbody>
</table>

- **primarily a function of solubility in phloem sap**
- **Mobile**: capable of moving from older to newer tissue
- **Immobile**: incapable, often see symptoms in new tissue

## Methods of Measurement

- Preventative vs. Corrective
Soil Sampling

Advantage
- gives potential nutrient availability
- may shed light on soil issues
- “baseline” so look for trends
- can be done pre-plant
- timing not as critical

Disadvantage
- does not show soil/vine interaction

Timing & Frequency

Pre-planting – *ideal time to make soil corrections*
- Often collected during Fall or early Spring
- Do not take when ground is frozen
- Every 3-5 years thereafter, unless major amendment is made
Methodology

1. Choose several random locations (Z or W pattern) per block
2. Collect 10-20 “top-soil” samples by digging 8” deep per block
3. Collect “sub-soil” sample by digging 15-20” deep
4. Do not mix top and sub-samples
5. Dry and place in appropriate container
6. Mail off to Lab

Analysis

- Use the same lab or a lab that performs similar diagnostic tests for consistency
## Target Values

<table>
<thead>
<tr>
<th>Elemental Nutrient</th>
<th>Soil (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>--</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>20-50</td>
</tr>
<tr>
<td>Potassium</td>
<td>75-100</td>
</tr>
<tr>
<td>Calcium</td>
<td>500-2000</td>
</tr>
<tr>
<td>Magnesium</td>
<td>100-250</td>
</tr>
<tr>
<td>Boron</td>
<td>0.3-2.0</td>
</tr>
<tr>
<td>Iron</td>
<td>20</td>
</tr>
<tr>
<td>Manganese</td>
<td>20</td>
</tr>
<tr>
<td>Copper</td>
<td>0.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>2</td>
</tr>
</tbody>
</table>

*Use petiole analysis to verify Nitrogen content because of many different nitrogen forms, which may change over time.

Nitrate is often the form tested on soil analysis.


### Interpretation

- **Note:** Lab test recommendations are often auto-generated and are generally geared towards annual crops rather than perennial.

- **Fertilizer calculator:**
  [http://soiltesting.tamu.edu/webpages/calculator.html]
Petiole Sampling

- **Advantage**
  - shows what the plant actually takes up
  - traditional “gold standard”

- **Disadvantage**
  - timing is more critical than soil sampling
  - more prep involved

Timing & Frequency

1. **Bloom** – 50% - 75% cap fall
   - micronutrient deficiencies can have season-long effect on fruit quality

2. 70 - 100 days post-bloom (veraison)
   - major phenological changes occurring

3. **Diagnostic samples**
   - may be taken any time of year

- Should perform annually from year 1-4, then on a 2 year cycle thereafter
Methodology

1. Select “data vines” for consistency
2. Collect from a single block and var. (ideal)
3. Z or W pattern throughout block
4. Test same time each year
5. Select from healthy leaves that receive ample sunlight
6. Morning is best

Methodology

1. Bloom
   - collect 60-100 petioles from leaves located opposite of the first or second flower cluster
   - no more than 2 petioles per vine, never on the same shoot (i.e. 30-50 data vines)
   - rinse petioles with distilled water/soap
   - place in brown bag (breathable)
   - dry at 80-90°F for 24 hours
Methodology

1. Veraison
   ◦ same as bloom but collect from youngest fully expanded leaves (5-7 leaves back from tip)

2. Diagnostic
   ◦ collect 100 petioles from symptomatic leaves regardless of shoot position
   ◦ same position on non-symptomatic or healthy vines
   ◦ keep samples separated

Petiole Target Values

Expressed as either a % or in ppm

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Bloom</th>
<th>Veraison</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1.2-2.5%</td>
<td>0.8-1.4%</td>
</tr>
<tr>
<td>P</td>
<td>0.15-0.4%</td>
<td>0.1-0.3%</td>
</tr>
<tr>
<td>K</td>
<td>1.5-3.0%</td>
<td>1.5-3.0%</td>
</tr>
<tr>
<td>Ca</td>
<td>1.2-3.0%</td>
<td>1.0-3.0%</td>
</tr>
<tr>
<td>Mg</td>
<td>0.5-0.75%</td>
<td>0.5-1.0%</td>
</tr>
<tr>
<td>Fe</td>
<td>30-100 ppm</td>
<td>30-100 ppm</td>
</tr>
<tr>
<td>Zn</td>
<td>30-100 ppm</td>
<td>30-100 ppm</td>
</tr>
<tr>
<td>Mn</td>
<td>25-1,000 ppm</td>
<td>100-1,000 ppm</td>
</tr>
<tr>
<td>B</td>
<td>25-100 ppm</td>
<td>30-100 ppm</td>
</tr>
<tr>
<td>Cu</td>
<td>6-25 ppm</td>
<td>6-25 ppm</td>
</tr>
<tr>
<td>Mo</td>
<td>0.5 ppm</td>
<td>0.5 ppm</td>
</tr>
<tr>
<td>Na</td>
<td>&lt;1,000 ppm</td>
<td>&lt;1,000 ppm</td>
</tr>
</tbody>
</table>

Table adapted from Jim Kamas – Growing Grapes in Texas
Interpretation

Actual Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Sample</th>
<th>Satisfactory Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Potassium</td>
<td>3.17</td>
<td>1.30 - 2.00%</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.202</td>
<td>0.10 - 0.30%</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.63</td>
<td>1.20 - 2.00%</td>
</tr>
<tr>
<td>Magnesium</td>
<td>.421</td>
<td>0.35 - 0.50%</td>
</tr>
<tr>
<td>Manganese</td>
<td>51.4</td>
<td>50 - 1000 ppm</td>
</tr>
<tr>
<td>+ Iron</td>
<td>24.0</td>
<td>30 - 100 ppm</td>
</tr>
<tr>
<td>Copper</td>
<td>12.7</td>
<td>5 - 15 ppm</td>
</tr>
<tr>
<td>Boron</td>
<td>40.1</td>
<td>30 - 50 ppm</td>
</tr>
<tr>
<td>+ Zinc</td>
<td>51.1</td>
<td>35 - 50 ppm</td>
</tr>
</tbody>
</table>

Visual Observations

- Corrective phase
- Look at vine
  - growth and vigor
  - crop size
  - vine balance
  - deficiency symptoms
  - toxicity symptoms

note: visual symptoms may be result of plant stress, pest/disease pressure, or herbicide toxicity
Now that you have your test results or you are noticing nutrient deficiencies in the field, what do you do next?

Macronutrients
**Nitrogen**

- Typically the most deficient nutrient in the vineyard
- Very mobile in soil (Nitrate is anion) and plant
  - corrections are more successful
- Bloom petiole readings ok, but visual inspection is reliable
  - sufficient N when trellis is full and basal leaves are dark green
- **Challenge**
  - leaches heavily because its negatively charged and will not resist movement in the soil
  - are often over applied or at wrong time

**Deficiency symptoms**
- yellow chlorotic foliage
- decreased shoot growth, short inter-nodal length, small foliage
- symptoms often occur on the lower older leaves (mobile nutrient)

**Overuse & Toxicity symptoms**
- cane dieback from frost
- leaf scorch with marginal browning (esp. young vines)
Nitrogen - Timing

- High N consumption during bud break to fruit-set
  - insufficient N leads to V/R competition
  - flower development and fruit-set can be diminished

1. After Spring Frost
   - traditional
   - applications halted in July

2. Post-Harvest
   - immediately post-harvest before frost
   - allows N to be stored until Spring for fast development
   - coincides with second flush of root growth

3. May also fertigate or apply foliar sprays for more immediate results

Nitrogen - Application

- **Dry Application**
  - leaching potential, important to split applications via band/ring under trellis
  - **High vigor** – no N
  - **Medium vigor** – 10-25 lbs. actual N/acre
  - **Low vigor** – 30-40 lbs. actual N/acre

- **Fertigation**

- **Foliar Spray**
  - may require multiple applications, toxicity an issue
Nitrogen -Sources

- Which source to use? Price, availability, quantity, salt index
- Read the label and abide by instructions

<table>
<thead>
<tr>
<th>Material</th>
<th>% N</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhydrous Ammonia (NH₃)</td>
<td>82</td>
<td>Very volatile lq/gas</td>
</tr>
<tr>
<td>Urea</td>
<td>46</td>
<td>Volatile dry material</td>
</tr>
<tr>
<td>Ammonium Nitrate (NH₄NO₃)</td>
<td>34</td>
<td>Less volatile</td>
</tr>
<tr>
<td>Ammonium Sulfate (NH₄)₂SO₄</td>
<td>21</td>
<td>Volatile high pH soils</td>
</tr>
<tr>
<td>UAN 28-32</td>
<td>28-32</td>
<td>Volatile injected via drip</td>
</tr>
</tbody>
</table>

Chart Courtesy of Jim Kamas

Phosphorous (P)

- Rarely an issue in Texas
- Deficiencies may be found in acidic soils
- Excess application can limit Zn and Fe
**Potassium (K)**

- Demand is highest during fruit ripening

- **Deficiency symptoms**
  - starts with color loss at leaf edge (often early-mid summer)
  - marginal chlorosis, **reddening**, curling, and necrotic foliage
  - poor vine vigor, berry size, coloration, reduced soluble solids

K deficiency with over-cropping
Potassium (K) – Timing & Application

- **Timing**
  - late Fall to early Spring
- **Dry**
  - furrow or banding over broadcast
- **Fertigation**
- **Foliar Application**
  - questionable efficacy

Micronutrients
Magnesium

- **Deficiency symptoms**
  - often found on high pH soil sites, heavy K fertilization, poor drainage
  - leads to reduced photosynthetic activity
  - marginal leaf “creamy” yellowing and/or reddening of basal leaves
  - noticeable especially during a heavy crop load and fruit ripening
Magnesium – Application

- **Timing**
  - if 20% + of leaf area is chlorotic over large area
  - Fall
  - can use **K-Mag** (0-0-21) if need both K and Mg

- **Dry**
  - furrow or banding

- **Foliar Application**
  - often done in spring up to two times

- **Fertigation**

Chelation

- Some micronutrients are easily oxidized or precipitate in soil/solution
  - Fe, Zn, Mn, Cu
- Utilization is inefficient
- Natural chemical ligands combined with micronutrient = chelate
- Prevents oxidation and precipitation
- Often applied dry
Zinc

Deficiency symptoms

- can occur in tandem with Iron deficiency
- younger leaves often symptomatic first
- small asymmetrical foliage along apex of shoots
- leaf veins light in color
- poor fruit-set “hens and chickens”

Zinc - Application

Timing

- 2-3 weeks prior to bloom
- incorporate as a yearly maintenance spray program if persistent

Foliar Application

- most effective method
- neutral Zn, or Zinc oxide
- chelated Zn more expensive, no known advantage
Iron

Deficiency symptoms
- mainly a problem on calcareous soils
- affects apical leaves early in season resulting in general chlorosis
- severe symptoms include ivory white or necrotic foliage, poor fruit-set

Toxicity
- rare
- primarily pH related (drops creating abundance of available Fe)
- dark green foliage, stunted growth of shoots & roots

Iron - Application

Timing
- 2 weeks before and after bloom for foliar spray

Foliar Application
- common but marginally effective
- Iron sulfate and chelate
- immobile so only benefits existing foliage

Soil Application
- must use chelated form of Iron
- best option
- Acidification of irrigation water may make iron more available
Boron

Deficiency symptoms
- classic symptom is low bud break followed by slow shoot growth and short internodes
- bushy stunted appearance
- younger leaves first affected
- foliage has mottled yellowing
- clusters may set small scraggly BB size unseeded berries

Boron – Application

Toxicity
- narrow threshold between deficiency and toxicity
- old leaves have speckled appearance on outer edge
- young leaves are cupped downwards
- > 1ppm in water, > 100 ppm petiole

Fertigation
- must be very cautious due to toxicity

Foliar Application
- effective method, applied 2-3 weeks pre-bloom or even post-harvest
Further Resources

- Growing Grapes in Texas – Jim Kamas
- Texas Grape Pest Management Guide
- TWGGA

Any Questions?

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‘Texas Viticulture’