Nutrient Management in Vegetable Crops

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Holtville, CA 3 December, 2003
Objectives of Nutrient Management

- Optimize crop yield and quality
- Use inputs efficiently
  - Improve profits
  - Avoid pollution
- Improve soil quality and productivity
Keys for Successful Nutrient Management

- Identification of potential yield-limiting factors.
- If possible, control yield-limiting factors.
- Understand soil nutrient status.
- Understand plant nutrient demand.
- Use soil and tissue testing.
Yield-Limiting Factors

- Crop yield and quality will be limited by the most-limiting growth factor.
- Nutrients may not be the most-limiting factor:
  - Irrigation management
  - Salinity
  - Pests
**Plant Response to Inputs**

**What's Happening here?**

A: The input was not needed
B: The input was needed
C: Another factor limiting growth

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**Plant Response** vs. **Amount of Input**
Tools for Soil/Crop Management

- **Soil Knowledge**
  - Soil pH, salts, sodium (potential limiting factors)
  - Available soil nutrients
  - Knowledge of soil variability

- **Crop Knowledge**
  - Salt tolerance
  - Nutrient requirements
  - Nutrient uptake pattern
  - Crop nutrient status from tissue tests
Soil Sampling and Testing

- Soil sampling and testing is an excellent way to evaluate potential yield-limiting factors.

- Soil sampling is most often used for:
  - determining pre-season soil fertility and other potential soil problems (e.g. pH, salinity, etc.)
  - evaluating a wide range of potential soil problems simultaneously.
Soil Sampling

- Soil samples should be collected in a random manner within areas that are approximately uniform with respect to soil properties and management history.
- Collect a minimum of 15-20 samples per uniform area. Composite the 15-20 samples to form one combined sample.
- Collect to a depth of 12”
Soil Tests

<table>
<thead>
<tr>
<th>Lab #</th>
<th>pH</th>
<th>Calcium (Ca)</th>
<th>Magnesium (Mg)</th>
<th>Sodium (Na)</th>
<th>Potash (K)</th>
<th>Iron (Fe)</th>
<th>Zinc (Zn)</th>
<th>Manganese (Mn)</th>
<th>Copper (Cu)</th>
<th>Salinity (EC x K) dS/m</th>
<th>Nitrate Nitrogen (NO3-N)</th>
<th>Phosphorus (Bicarb - Soluble P)</th>
<th>Computed % Sodium</th>
<th>Sulfur (SO4-S)</th>
<th>Boron (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>547</td>
<td>8.1</td>
<td>6300 VH</td>
<td>290 VH</td>
<td>420 VH</td>
<td>190 H</td>
<td>6.0 H</td>
<td>2.8 H</td>
<td>10.0 VH</td>
<td>1.2 VH</td>
<td>3.8 H</td>
<td>18.0 M</td>
<td>11.0 M</td>
<td>5.0</td>
<td>160 VH</td>
<td>.90 L</td>
</tr>
<tr>
<td>548</td>
<td>8.2</td>
<td>6000 VH</td>
<td>240 H</td>
<td>560 VH</td>
<td>240 H</td>
<td>4.8 M</td>
<td>2.8 H</td>
<td>9.5 VH</td>
<td>1.2 VH</td>
<td>4.4 H</td>
<td>30.0 H</td>
<td>11.0 M</td>
<td>8.8</td>
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<td>270 VH</td>
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<td>.37 M</td>
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<td>14.0 VH</td>
<td>.55 M</td>
<td>7.4 VH</td>
<td>71.0 VH</td>
<td>7.1 L</td>
<td>9.5</td>
<td>250 VH</td>
<td>1.4 M</td>
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EC and Crop Growth

![Graph showing the relationship between Soil EC and crop yield for different crops. The x-axis represents Soil EC, ranging from 0 to 6. The y-axis represents % Yield, ranging from 0 to 100. The graph includes lines for Lettuce, Broccoli, Cantaloupe, and Sweet Corn, each labeled with a different color and marker. The graph indicates a decrease in yield as Soil EC increases, with a notable differentiation between "Non-saline" and "Saline" conditions.]
ESP

- Exchangeable Sodium Percentage
- A measure of sodium to calcium ratio on soil clays

Interpretation

- Soil ESP >8 is severe for clay loam to clay textures
- Soil ESP >13 is severe for other soil textures
- High ESP can result in poor water infiltration
Soil Variability

Soil salinity (EC) with EM-38
# Soil Tests

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<td>240 H</td>
<td>550 VH</td>
<td>240 H</td>
<td>4.6 M</td>
<td>2.8 H</td>
<td>9.5 VH</td>
<td>1.2 VH</td>
<td>4.4 H</td>
<td>30.0 M</td>
<td>11.0 M</td>
<td>6.6</td>
<td>150 VH</td>
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The University of Arizona
Tucson, Arizona
### Essential Plant Nutrients Needed as Fertilizers in Desert Soils

<table>
<thead>
<tr>
<th>“Macro” nutrients</th>
<th>“Micro” nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen $N$</td>
<td>Iron $Fe$</td>
</tr>
<tr>
<td>Phosphorus $P$</td>
<td>Manganese Mn</td>
</tr>
<tr>
<td>Potassium K</td>
<td>Copper Cu</td>
</tr>
<tr>
<td>Calcium Ca</td>
<td>Zinc $Zn$</td>
</tr>
<tr>
<td>Magnesium Mg</td>
<td>Molybdenum Mo</td>
</tr>
<tr>
<td>Sulfur S</td>
<td>Chlorine Cl</td>
</tr>
</tbody>
</table>

- **Red** = usually
- **Green** = occasionally
- **Black** = seldom

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![University of Arizona Logo](image)
# Measuring Nutrient Availability in Desert Soils

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Soil Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2M KCl extract</td>
</tr>
<tr>
<td>P</td>
<td>0.5 M NaHCO₃ extract</td>
</tr>
<tr>
<td>K</td>
<td>Ammonium acetate ext.</td>
</tr>
<tr>
<td>B</td>
<td>Hot water extraction</td>
</tr>
<tr>
<td>Fe, Mn, Cu, Zn</td>
<td>DTPA extraction</td>
</tr>
</tbody>
</table>
Meaning of Soil Test Values

<table>
<thead>
<tr>
<th>“Low”</th>
<th>“Medium”</th>
<th>“High”</th>
</tr>
</thead>
</table>

Crop Yield

Available Soil Nutrient
Available Soil Nutrients

- Preplant available N
  - Due to mobility of N, take samples as close to planting
  - 0-10 ppm NO₃-N “Low”
    - High probability of response to fertilizer
  - 10-20 ppm NO₃-N “Medium”
    - Moderate probability of response to fertilizer
  - >20 ppm NO₃-N “High”
    - Low probability of response to fertilizer
Available Soil Nutrients

- Preplant available P
  - 0-20 ppm “Low”
    - High probability of response to fertilizer
  - 20-40 ppm “Medium”
    - Moderate probability of response to fertilizer
  - >40 ppm “High”
    - Low probability of response to fertilizer
- One preplant sample is usually sufficient
## Micronutrient Soil Tests

From Western Fertilizer Handbook

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>&lt;5</td>
<td>5 – 15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Mn</td>
<td>&lt;2</td>
<td>2 – 10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Cu</td>
<td>&lt;0.8</td>
<td>0.8 – 1.2</td>
<td>&gt;1.2</td>
</tr>
<tr>
<td>Zn</td>
<td>&lt;0.7</td>
<td>0.7 – 1.5</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td>B</td>
<td>&lt;0.5</td>
<td>0.5 – 1.2</td>
<td>&gt;1.2</td>
</tr>
</tbody>
</table>

All values in ppm
## Crop Nutrient Uptake

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield (Ctn/ac)</th>
<th>N Uptake (lb/ac)</th>
<th>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt; uptake (lb/ac)</th>
<th>K&lt;sub&gt;2&lt;/sub&gt;O uptake (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lettuce</td>
<td>700</td>
<td>100</td>
<td>30</td>
<td>200</td>
</tr>
<tr>
<td>Broccoli</td>
<td>500</td>
<td>175 - 225</td>
<td>45 - 60</td>
<td>110 - 140</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>750</td>
<td>200 - 250</td>
<td>65 - 85</td>
<td>300 - 370</td>
</tr>
</tbody>
</table>
Cauliflower Nitrogen Uptake

Days After Planting

Daily N Uptake (lb/ac)
Plant Tissue Testing

- Uses the plant as an index of nutrient availability

- Advantages:
  - Direct measurement of nutrient uptake
  - Same tissue test can be used across many soils

- Disadvantage:
  - Nutrient content is a function of all factors affecting plant growth
Tissue to Sample

Vegetable Crops: Midribs and Petioles
Tissue Sampling for Vegetable Crops

- Petioles or midribs should be collected beginning at about the 4-6 leaf stage from the youngest fully-expanded leaf.
- Sample from >20 plants within uniform areas of the field.
- Avoid plants that are abnormally large or small, and diseased plants.
- Tissue samples are perishable--refrigerate or dry immediately.
Standard Tissue Analysis

- Tissue Analysis usually involves several steps:
  - Sampling
  - Sample drying
  - Sample grinding
  - Sample extraction
  - Sample analysis

- Time from sampling to results is usually 2-3 days, delaying fertilization.
Sap Testing

- A method that can allow immediate determination of plant N or K status.
- Sample petioles in the same manner as for petiole analysis, and extract sap.
- Sap nitrate or potassium is measured on a hand-held, calibrated meter.
- Guidelines are available for some, but not all, crops.
Cardy Meter
NO$_3$-N in Broccoli Petiole Sap

Excessive

Adequate

Warning

Deficient

Nitrate-N in Sap (mg/L)

4-6 Leaf 10-12 Leaf First Buds Head Pre-Harvest Development
NO₃-N in Cauliflower Petiole Sap

- Excessive
- Adequate
- Warning
- Deficient

NO₃-N in Sap (mg/L)

4-6 Leaf | 8-10 Leaf | Folding | Button
Quick plant sap tests are useful tools for monitoring plant N status. They will be most useful when:

- Sap concentrations are monitored frequently
- Combined with other evaluations of crop vigor
Summary—Steps for Good Nutrient Management

- Understand limiting factors to growth.
- Collect, analyze, interpret pre-season soil samples. Apply appropriate management practices.
- Understand soil variability.
- Collect and analyze in-season plant tissue samples to guide side-dress fertilizer applications or fertigations.
Questions?

Contact Tom Thompson at:
520-621-3670 or
thompson@ag.arizona.edu

Visit our subsurface drip irrigation website at:

http://ag.arizona.edu/azdrip