Plant Nutrition
And Water Quality

Dr. Steve Millett
Leibig’s Law of the Minimum

- Lack of Water
- Poor Stand
- Poor Soil Structure
- Wrong Variety
- Weeds
- Insects & Disease
- Possible Production

Low Fertility
Liebig’s Law of the Minimum

Justus von Liebig (1803-1873)
German Chemist
Father of Fertilizers

\[ \frac{dO}{dt} = \min \left( \frac{I}{k_I + I'}, \frac{N}{k_N + N'}, \frac{P}{k_P + P} \right) \]
Elements in Plant Nutrition
Essential Elements

- Fresh plant material is 80 to 95% water
- 16-17 essential elements
- Plants cannot complete life cycle without them
- Action must be specific - no other element can take its place
- Element must be directly involved (structure, constituent, enzyme activator, etc.)
Nutrient Classification

**Macronutrients**
- From air and water: C, H and O
- From soil:
  - Primary - N, P and K
  - Secondary – Ca, Mg and S

**Micronutrients** (soil):
- Fe, B, Mn, Cu, Zn, Mo, Cl, Ni, Co
Chemistry Fuels Growing Plants

- http://www.webelements.org/
- http://www.americanchemistry.com/s_acc/sec_article.asp?CID=100&DID=1706
- http://www.ipni.net/
- http://www.agr.state.nc.us/cyber/kidswrld/plant/index.htm
- http://extension.oregonstate.edu/mg/botany/nutrition.html
Plant Nutrients

- C. HOPKNS
- Mo (Missouri) CaFe
- Mg (mighty good)
- Cl (clean)
- Mn B (managed by)
- CuZn Ni
  (cousin Nick)
Nutrient Status Diagnosis

- Visual symptoms
- Plant tissue analysis
- Soil testing
Deficiency Symptoms

- Vary with plant species
- Color
- Pattern
- Growth response
- Location & History
- New or old plant parts
Nitrogen

- Amino acids, proteins, nucleic acids, nucleotides and enzymes

Chlorosis on lower leaves
Light green rest of plant
Phosphorus

- Sugar phosphates - ATP
- Nucleic acids - DNA
- Coenzymes, membranes

Purpling of lower leaves
Potassium
- Enzyme activator
- Osmotic regulator
- Maintains electrical neutrality

Chlorosis, necrosis on edge of lower leaves
Magnesium

- Part of chlorophyll molecule
- Phosphate transfer

Intervienal chlorosis on lower leaves
Calcium

- Middle lamella of cell walls
- Involved in energy transfer

Leaf cupping

Blossom-end rot

Necrosis at base of leaves & quick growth areas
Iron

- Cytochromes, photosynthesis, $N_2$ fixation & respiration

Strong chlorosis at base of leaves

Interveinal chlorosis of the youngest leaves
Plant Nutrient Management

Water

Growing Medium

Fertilizer
Fertilizer Programs

- Preplant fertilization
- Postplant fertilization
- Selecting N form
- Secondary Macronutrients
- Fertilizing at finish
- Slow-release programs
Reading Fertilizer Bags

- Nitrogen (N)
- Phosphate (P$_2$O$_5$)
- Potash (K$_2$O)
Preplant Fertilization

- Starting off right
- Nutrients must be present and in useable forms
- Adjusting pH prior to planting is key
- Most grower mixes contain balanced water-soluble starter charge, wetting agent and dolomitic lime (Ca, Mg)
Nitrogen

- Incorporate a controlled-release fertilizer at or soon after the time of planting
- Supplement during growing season
  - liquid fertilizer or
  - top-dressing granular or
  - CRN
Phosphorus

- Incorporate into media before planting
- Supplement with liquid, CR or granular
- Incorporate with complete fertilizer
Potassium

- Required at higher concentration than P but lower than N
- Supply before planting through CR or complete granular
- Supplement during growing season with CR, complete granular or liquid fertilizer
Preplant Slow-release Fertilizers

- Incorporated in mix or as top dressing
- Adjust pre- and postplant programs

SR or CR
Postplant Fertilization

- Continuous liquid fertilization for N & K
- Soilless media
  - feed P as well
- Categorize plants as very light, light, moderate, heavy or very heavy
# Concentration Requirements*

<table>
<thead>
<tr>
<th>Crop</th>
<th>Conc. Category</th>
<th>Weekly oz/100 gal</th>
<th>Constant oz/100 gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding Plants</td>
<td>Very light</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Gloxinia</td>
<td>Light</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Geranium</td>
<td>Moderate</td>
<td>32</td>
<td>13.5</td>
</tr>
<tr>
<td>Poinsettia</td>
<td>Very Heavy</td>
<td>48</td>
<td>17</td>
</tr>
</tbody>
</table>

*Fertilizer containing 20 percent Nitrogen (20-10-20)
N:P:K

- Best ratio for **GENERAL** crops is:
  - 2 Nitrogen (N)
  - 1 Phosphorus (P$_2$O$_5$)
  - 2 Potassium (K$_2$O)
  - 20-10-20 industry standard
Postplant Fertilization

• **ONCE PER WEEK**
  - \( N = 240 \) to \( 720 \) ppm

• **EVERY WATERING**
  - \( N = 90 \) to \( 255 \) ppm
N Form

Nitrate (NO₃⁻)

Ammonium (NH₄⁺)

Acid lovers: azalea, rhodos

Urea

Response generally identical - urea must be converted to ammoniacal N for assimilation
Ammonium Toxicity

- Some plants are injured when >50% of total N is ammonium plus urea
- Aim for 40% or less ammonium plus urea
- “All nitrate plants” become “hard” – overall smaller size
- Greater risk in winter due to bacterial slow-down
Nitrogen Form and Plant Growth

- Rosarians use urea and ammonium fertilizers for lush growth
- Nitrate sources for hardening plants
Fertilizing at Finish

- Plants will last longer in retail if nutrients are reduced two weeks before market date
- Check media nutrient levels
- Constant feeding > weekly feeding
Slow Release Fertilization Programs

- Started in 1960s
- Lack of control
- Growth may need to be slowed (cool & cloudy)
- Mixed into media at preplant
- Topdressing
- Reduces labor
- Saves time
Sources

- http://www.tfi.org/
- http://www.fertilizer.org/ifa/
- http://4e.plantphys.net/article.php?ch=5&id=289
- http://www.ipni.net/
Water Quality Varies

- **Water Type 1** – Very Low Alkalinity
  - < 60 ppm (Ca = 0-60 ppm and Mg < 30 ppm)
- **Water Type 2** – Moderately Low Alkalinity
  - 60-150 ppm (Ca = 0-60 ppm and Mg < 30 ppm)
- **Water Type 3** – Moderately High Alkalinity
  - 150-200 ppm (Ca > 50 ppm and Mg < 30 ppm)
- **Water Type 4** – Very High Alkalinity
  - 200-240+ ppm (Ca > 50 ppm and Mg < 30 ppm)

- **Water Types 1 & 2**
- **Water Types 3 & 4**
- **Varied Water Types**
ABC System

• Web-based fertilizer decision system
• Proven N-P-K ratios based on decades of research on water quality & fertilizer performance
• Based on quality of water and crop
• *Scotts Exchange Spring 2008
• petersabc.com
Get your water tested!

- Test kit through Hummert International
- Results – handout
- Recommendations and “petersabc.com”
petersabc.com
exercise
### TABLE 1

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Recommended Feeding Rate ppm N</th>
<th>Periodic Feeding ppm N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding Plants</td>
<td>50 – 150</td>
<td>150 – 250</td>
</tr>
<tr>
<td>Containerized Woody Plants</td>
<td>50 – 100</td>
<td>200 – 350</td>
</tr>
<tr>
<td>Flowering Pot Crops</td>
<td>200 – 300</td>
<td>300 – 450</td>
</tr>
<tr>
<td>Potted Foliage</td>
<td>150 – 200</td>
<td>250 – 300</td>
</tr>
<tr>
<td>Plugs (All Types)</td>
<td>50 – 125</td>
<td>175 – 225</td>
</tr>
<tr>
<td>Landscape/Outdoors</td>
<td>200 – 300</td>
<td>400 – 600</td>
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</tbody>
</table>
# Amount of Fertilizer & EC

<table>
<thead>
<tr>
<th>Target Fertilizer Concentration (ppm N) After Dilution</th>
<th>Injector Ratios</th>
<th>EC mmhos/cm of Target Feed Rate After Dilution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:15</td>
<td>1:100</td>
</tr>
<tr>
<td>50</td>
<td>0.5</td>
<td>3.4</td>
</tr>
<tr>
<td>100</td>
<td>1.0</td>
<td>6.8</td>
</tr>
<tr>
<td>200</td>
<td>2.0</td>
<td>13.5</td>
</tr>
<tr>
<td>300</td>
<td>3.0</td>
<td>20.3</td>
</tr>
</tbody>
</table>
Handouts

• Jack’s chart
• Everiss chart
• Qwaterly
• Fertilizer
• Example water reports
Plant Nutrient Management

Water

Growing Medium

Fertilizer