Substrates and Plant Nutrition (advanced pH management)

The blueberry reproductive cycle

Liner is transplanted spring
Vegetative growth long days, warm, summer

Turning blueberries into azaleas

The blueberry reproductive cycle

Liner is transplanted spring
Vegetative growth long days, warm, summer
Flower initiation short days, cool fall
The blueberry reproductive cycle

Liner is transplanted spring

Vegetative growth long days, warm, summer

Flower initiation short days, cool fall

Dormant

Chilling to break dormancy (200 to 1200 hours @ 40F)

Flower Development
Long days, warm

Pollination

Fruit development Long days, warm
The blueberry reproductive cycle

Liner is transplanted in spring → Vegetative growth in long days, warm, summer → Flower initiation in short days, cool fall → Evergreen keeps growing in warm weather → Fruit in spring → Pollination

Pollination and fruit set

- Grow a mix of cultivars, need pollinators

Gibberellic Acid (GA3) sets fruit without pollinators

- Not needed if pollinators are present
- A commercial practice when flowers are damaged by early frost
- Applied twice to open blooms

Outline on substrate and pH topics

1. Fertilizers
2. Plant species
3. pH solubility
4. Next steps
1) Fertilizers

**BASIC (increase pH)**
- Nitrate NO$_3^-$
- Lime

**ACID (lower pH)**
- Ammonium NH$_4^+$
- Alkalinity

**Species**

Substrate-pH and CCE

<table>
<thead>
<tr>
<th>Change in pH</th>
<th>1.0</th>
<th>0.5</th>
<th>0.0</th>
<th>-0.5</th>
<th>-1.0</th>
<th>-1.5</th>
<th>-2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pierre’s CCE per metric ton of fertilizer</td>
<td>-800</td>
<td>-600</td>
<td>-400</td>
<td>-200</td>
<td>0</td>
<td>200</td>
<td>400</td>
</tr>
</tbody>
</table>

CCE is calculated using Pierre’s model from the 1930’s

Based on field soils, applying solid fertilizer by the ton

Assumes:
1) Acidity from all S and Cl, $\frac{1}{3}$ of P, and $\frac{1}{2}$ of the N applied
2) Plant only takes up N as NO$_3^-$-N
3) All NH$_4^-$-N is nitrified
New Approach (Nitrogen CCE)

1. Electroneutrality or cation:anion charge balance
   - pH drift when there is an imbalance

2. Nitrogen rules
   - For every 1,000 atoms of N taken up by “average” crop:
     - 250 atoms K
     - < 125 atoms of all other essential macros, and
     - < 3 atoms of each essential micronutrient are taken up
     - Epstein & Bloom (2005)
Ammonium
Acid: (cation)

Nitrification (microbes)

\[ \text{NO}_3^- \xrightarrow{2\text{H}^+} \text{NH}_4^+ \]

\[ \text{pH} \downarrow \]

Urea Nitrogen

\[(\text{NH}_2)_2\text{CO} + \text{H}_2\text{O} + 2\text{H}^+ \rightarrow 2\text{NH}_4^+ + \text{CO}_2\]

[Urea hydrolysis, forms Ammonium-N]

Matching fertilizer to plant species & water alkalinity

Nitrogen CCE Calculator (Excel)
available on floriculturealliance.org

<table>
<thead>
<tr>
<th>Element</th>
<th>Nitrogen CCE Coefficients (Impatiens)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Meq acid or base per meq N</td>
</tr>
<tr>
<td>NH$_4^+$</td>
<td>-0.67</td>
</tr>
<tr>
<td>NO$_3^-$</td>
<td>0.07</td>
</tr>
<tr>
<td>Urea</td>
<td>-0.20</td>
</tr>
</tbody>
</table>

- 100 ppm N from ammonium
  - $= \frac{100}{14} \times 0.67$
  - $= 4.8$ meq acidity
  - balances 240 ppm alkalinity

- 50 ppm N from ammonium
  - $= \frac{50}{14} \times 0.67$
  - $= 2.4$ meq acidity
  - balances 120 ppm alkalinity
### Nitrogen CCE Coefficients (Impatiens)

<table>
<thead>
<tr>
<th>Element</th>
<th>Meq acid or base per meq N</th>
<th>Relative units to NH₄-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄⁺</td>
<td>-0.67</td>
<td>-100 (acid)</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>0.07</td>
<td>11 (base)</td>
</tr>
<tr>
<td>Urea</td>
<td>-0.20</td>
<td>-31 (acid)</td>
</tr>
</tbody>
</table>

- 100 ppm N from ammonium
  - \( \frac{100}{14} \times 0.67 \)
  - 4.8 meq acidity
  - balances 240 ppm alkalinity
- 100 ppm N from nitrate
  - \( \frac{50}{14} \times 0.07 \)
  - 0.5 meq basicity
  - adds 25 ppm alkalinity

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**Comparing Pierre’s CCE with Nitrogen CCE**

![Graph comparing Pierre’s CCE with Nitrogen CCE](image)

**BASIC (increase pH)**

- Nitrate NO₃⁻
- Lime
- Alkalinity

**ACID (lower pH)**

- Ammonium NH₄⁺
- Media
- Species

**pH balance**
2. Why do plants differ in their pH responses?

Why do plants differ in their pH effect?

1. Adaptive response (low P or low Fe)
   - Iron efficiency
   - Exude acid

2. Dumb response (inherent tendency)
   - Cation/anion balance

Experimental setup

<table>
<thead>
<tr>
<th>Initial Solution Concentrations (mg/L)</th>
<th>0% NH₄</th>
<th>10% NH₄</th>
<th>20% NH₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₄-N</td>
<td>0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>NO₃-N</td>
<td>100</td>
<td>90</td>
<td>80</td>
</tr>
<tr>
<td>Total N</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>P</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>K</td>
<td>117</td>
<td>117</td>
<td>117</td>
</tr>
<tr>
<td>Ca</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Mg</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>SO₄-S</td>
<td>38</td>
<td>55</td>
<td>67</td>
</tr>
<tr>
<td>Fe</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mn</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>B</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Cu</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Zn</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Mo</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>
1:1 relationship between net cation vs anion uptake and pH effect on solution

- Cation uptake = pH ↓
- Anion uptake = pH ↑

Species effects

0% NH₄ Solution

- All species pH ↑
- Pelargonium = least basic
- Petunia = most basic

Species effects

10% NH₄ Solution

- Pelargonium pH ↓
- Impatiens pH ↑
- Petunia pH ↑

Species effects

20% NH₄ Solution

- Pelargonium pH ↓
- Impatiens pH ↓
- Petunia pH ↓
What can you do about species differences?

- Be aware of crop tendencies
- Use a pH management strategy:
  - Lime rate and type
  - Fertilizer nitrogen form
  - Water alkalinity and acid
  - Grouping crops in pots and fertigation zones

3) Improved pH nutrient availability curves for container substrates

Jinsheng Huang, Dale Haskell, and Paul Fisher

Iron Chelate Stability

1 mg·L⁻¹ Fe from Fe-EDTA

Substrate-pH

4.4 4.7 5.1 6.0 7.0
Impatiens in peat/perlite, chelated micros.

Current lab studies (no plants)

- Different substrates: peat/perlite, peat/bark, peat/coir, peat/vermiculite (70% of peat by volume)
- Lime source: Ca(OH)$_2$ or Mg(OH)$_2$
- Micro-nutrients sources: EDTA
- Hoagland solution (200 ppm N, 100% NO$_3$-N), 250 mL per liter of substrate. Vary N, P, Ca, Fe.
Molybdenum (Mo)

Next Steps

4) Next Steps

- Develop new pH solubility charts
- Group species by effect on pH
- Test species adaptive responses (low P or low Fe)
- pH screening protocol for breeders

Next Steps

- Compost and degraded peat effects on pH
- Testing protocols for composts in propagation