Monitoring & Maintaining the pH and EC of the Root Environment

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Substrate pH

Maintaining proper substrate pH will PREVENT most nutrient problems.
Nutrient Availability

Affected by changes in pH
Problems Associated With Out-of-Range Substrate pH

Toxic: Fe, Mn, Zn, Cu
Deficient: Ca, Mg
Sensitive: NH$_4$
Leached: PO$_4$
Crops can be divided into three major groups based on pH needs
General Crops
Range

5.4 to 6.8
Low pH Range

5.4 to 5.8
High pH Range
6.0 to 6.8
4 Forces Affect Substrate pH

- Substrate components and amendments
- Irrigation water alkalinity
- Fertilizer acidity / basicity
- Plant species being grown
Substrate Components

- Peat moss is very acidic
- Perlite & vermiculite have little impact
- MOST substrates use lime to raise pH
- A few components (coir fiber) may be alkaline and raise pH
Water Alkalinity

Significance

- Alkalinity is “buffering capacity” of water
- Major component is bicarbonate ion $[\text{HCO}_3^-]$ 
- Alkalinity causes pH to rise over time
Alkalinity: pH Rises

Carbonic acid

\[ \text{HCO}_3^- \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

\[ \text{CO}_3^- = \text{CO}_2 + 2\text{H}_2\text{O} \]
Alkalinity & Bicarbonates

Neutralization of bicarbonates WILL prevent high pH-related problems!
Grower A
pH = 9.3  alkalinity = 1.42 meq/L

Grower B
pH = 8.3  alkalinity = 6.20 meq/L

Grower B needed more than 4 times the acid to reach a pH of 5.8 than Grower A.
Acidification Procedures

- Citric, nitric, phosphoric, and sulfuric acids can be used.
- Select an acid based on:
  - cost
  - availability
  - handling
  - ion being injected (N, P, S)
Acid Calculations

- Developed an acidification calculator for precise control
- Excel 5.0 spreadsheet
- Download a copy FREE from: www2.ncsu.edu/floriculture/
- Check for $10 to N.C. Ag. Foundation
This spreadsheet provides the recommendations for the amount of acid to add to irrigation water in order to modify the pH and alkalinity levels. In addition, the spreadsheet calculates the amount of added phosphorus and nitrogen that the corresponding acids will provide, plus an economic comparison of each acid.

### Your Sample Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The pH of your sample</td>
<td>7.4</td>
</tr>
<tr>
<td>The alkalinity of your sample</td>
<td>5.4</td>
</tr>
<tr>
<td>Target alkalinity or pH</td>
<td>5.8</td>
</tr>
</tbody>
</table>

*(pH must be below 7.2)*

### Calculated Information for your sample

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity before acid addition</td>
<td></td>
</tr>
<tr>
<td>- meq:</td>
<td>5.40</td>
</tr>
<tr>
<td>- ppm of HCO₃:</td>
<td>329.5</td>
</tr>
<tr>
<td>- ppm of CaCO₃:</td>
<td>270.2</td>
</tr>
<tr>
<td>Alkalinity after acid addition</td>
<td></td>
</tr>
<tr>
<td>- meq:</td>
<td>1.27</td>
</tr>
<tr>
<td>- pH = 5.80</td>
<td></td>
</tr>
<tr>
<td>- ppm of HCO₃:</td>
<td>77.5</td>
</tr>
<tr>
<td>- ppm of CaCO₃:</td>
<td>63.6</td>
</tr>
</tbody>
</table>
## Alternative Acids to Add to Irrigation Water

### Amounts

<table>
<thead>
<tr>
<th>Acids</th>
<th>Phosphoric Acid (75%)</th>
<th>Phosphoric Acid (85%)</th>
<th>Sulfuric Acid (35%)</th>
<th>Sulfuric Acid (93%)</th>
<th>Nitric Acid (61.4%)</th>
<th>Nitric Acid (67%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Small Volumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ml per liter</td>
<td>0.335</td>
<td>0.275</td>
<td>0.460</td>
<td>0.115</td>
<td>0.309</td>
<td>0.277</td>
</tr>
<tr>
<td>fl. oz. per gallon</td>
<td>0.043</td>
<td>0.035</td>
<td>0.059</td>
<td>0.015</td>
<td>0.040</td>
<td>0.036</td>
</tr>
<tr>
<td>ml per gallon</td>
<td>1.267</td>
<td>1.039</td>
<td>1.743</td>
<td>0.437</td>
<td>1.171</td>
<td>1.050</td>
</tr>
<tr>
<td>For a 1:100 Injector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fl. oz. per gallon (conc.)</td>
<td>4.28</td>
<td>3.51</td>
<td>5.89</td>
<td>1.48</td>
<td>3.96</td>
<td>3.55</td>
</tr>
<tr>
<td>ml per gallon (conc.)</td>
<td>126.65</td>
<td>103.93</td>
<td>174.28</td>
<td>43.68</td>
<td>117.08</td>
<td>105.00</td>
</tr>
<tr>
<td>For a 1:128 Injector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fl. oz. per gallon (conc.)</td>
<td>5.48</td>
<td>4.50</td>
<td>7.54</td>
<td>1.89</td>
<td>5.07</td>
<td>4.54</td>
</tr>
<tr>
<td>ml per gallon (conc.)</td>
<td>162.12</td>
<td>133.03</td>
<td>223.08</td>
<td>55.91</td>
<td>149.86</td>
<td>134.39</td>
</tr>
<tr>
<td>For a 1:200 Injector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>fl. oz. per gallon (conc.)</td>
<td>8.57</td>
<td>7.03</td>
<td>11.79</td>
<td>2.95</td>
<td>7.92</td>
<td>7.10</td>
</tr>
<tr>
<td>ml per gallon (conc.)</td>
<td>253.31</td>
<td>207.85</td>
<td>348.56</td>
<td>87.37</td>
<td>234.16</td>
<td>209.99</td>
</tr>
</tbody>
</table>

### Nutrients Added by Each Type of Acid

<table>
<thead>
<tr>
<th>Nutrients Added:</th>
<th>Phosphorus</th>
<th>Phosphorus</th>
<th>Sulfur</th>
<th>Sulfur</th>
<th>Nitrogen</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount Added (ppm):</td>
<td>125.3</td>
<td>125.3</td>
<td>66.7</td>
<td>66.7</td>
<td>57.8</td>
<td>57.8</td>
</tr>
</tbody>
</table>

Use the information above for modifying your fertility program.
<table>
<thead>
<tr>
<th>Acid</th>
<th>Percent</th>
<th>Acid Price/Gallon</th>
<th>Treatment Cost* per 1000 Gallons</th>
<th>Treatment Cost* per 1000 Liters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitric</td>
<td>61.4</td>
<td>$4.00</td>
<td>$1.24</td>
<td>$0.33</td>
</tr>
<tr>
<td></td>
<td>67</td>
<td>$5.00</td>
<td>$1.39</td>
<td>$0.37</td>
</tr>
<tr>
<td>Phosphoric</td>
<td>75</td>
<td>$7.00</td>
<td>$2.34</td>
<td>$0.62</td>
</tr>
<tr>
<td></td>
<td>85</td>
<td>$8.00</td>
<td>$2.20</td>
<td>$0.58</td>
</tr>
<tr>
<td>Sulfuric</td>
<td>35</td>
<td>$1.90</td>
<td>$0.87</td>
<td>$0.23</td>
</tr>
<tr>
<td></td>
<td>93</td>
<td>$12.00</td>
<td>$1.38</td>
<td>$0.37</td>
</tr>
</tbody>
</table>

* Reflects only treatment costs and does not include cost savings due to decreased fertilizer needs associated with phosphoric and nitric acids.
Acidification Calculator

Available on the Web:

http://www2.ncsu.edu/floriculture/
Fertilizer Acidity/Basicity

Fertilizer salts alter substrate pH

- pH changes as plant roots absorb essential elements
- Nitrate-N ($\text{NO}_3^-$) raises pH
- Ammonium-N ($\text{NH}_4^+$) lowers pH
- Other elements also affect pH changes (ex: Ca)
[+] Uptake: pH Falls

\[ \text{NH}_4^+ \Rightarrow \text{H}^+ \]
[-] Uptake: pH Rises
Species Effect on pH

- The same program can result in different pH due to species effect.
- Effect is not always good for the plants:
  - Vinca needs low pH.
  - Celosia and Dianthus need high pH.
Alkaline water

“optimum” range

NH$_4^+$ fertilizers

Time
Nutritional Monitoring

*Visual monitoring may be too late...*

Need to monitor:
- pH
- EC
- Nutrients
- Tissue analysis
Management

We manage what we measure!
Monitoring

- < 25% of all growers monitor pH and EC on a regular basis
- Better monitoring = better control
Substrate pH Regulation

- **Monitor** pH and EC regularly and keep records
- **Maintain** the proper pH and EC for best nutrient status
M&M’s
M & M’s

- Simple technique for measuring pH and EC
- Charts for plotting pH & EC
- Recommended ranges for crops
M&M’s Measuring Technique

- PourThru
- Modification of VTEM
- Simple - fast
- Non-destructive
- Values closer to SME than 2:1
Pourthru

Irrigate your crop one hour before testing
PourThru

Place saucer under pot
PourThru Collect leachate
PourThru

Use 50 ml of leachate
pH Ranges

- General crops: 5.4 to 6.8
- Low pH crops: 5.4 to 5.8
- High pH crops: 6.0 to 6.8
EC Ranges

mmhos/cm

Low: < 1.5
Desirable: 1.5 to 3.5
Moderately High: 3.5 to 5.0
Danger: > 5.0
Monitor pH

- Measure pH
  - Weekly for pots/flats
  - Every 3 days for plugs
- Measure species separately, if they require different pH regimes
- Record data
More Information

Check our Web sites:

- NCSU Floriculture
  - http://www2.ncsu.edu/floriculture/
- Horticultural Substrates Laboratory
  - http://www2.ncsu.edu.hortsublab/
pH M&M’s

“Just Do It…”