Getting the Skinny on Phosphorus

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Department of Horticultural Science

Phosphorus Nutrition

- Maximum Growth
- Color Enhancement
- Reproductive Stage Deficiency

Phosphorus Nutrition: Maximum Growth

- Low P nutrition limits internode stretch, keeping plants compact

Phosphorus Nutrition: Maximum Growth

**Phosphate vs. Compactness**

$P_2O_5$ as a % of N in post-plant fertilizer

<table>
<thead>
<tr>
<th>% P2O5</th>
<th>100 ppm P2O5</th>
<th>43 ppm P</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>15%</td>
<td>7.5%</td>
</tr>
<tr>
<td>15%</td>
<td>7.5%</td>
<td>0%</td>
</tr>
<tr>
<td>0%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Example* 20-10-20 @ 200 ppm N provides:

100 ppm $P_2O_5$ → 43 ppm P
Phosphorus Nutrition: Maximum Growth

- Current research recommends P rates <10 ppm for growth control
  - The challenge: Soilless substrates have a low P holding capacity, so it is easy to go too low
    - This poses some questions

Questions

Using commercial floriculture production practices:

What P rates maximize growth?

- OR -

What P rates control growth?
Experiment

• Grew several species with range of P rates holding other nutrients constant
  • Used 0 – 80 ppm

• Measured height, diameter, and dry mass
  • Determined growth index

\[
\text{Growth Index} = \frac{\text{height} + \text{diameter} + \text{dry mass}}{3}
\]

Petunia ‘Surprise Sky Blue’

1. Maximum Growth

Petunia Regression Analysis

Max: ~48 ppm

Quadratic Regression Model:

\[
y = 7.59 + 0.576x - 0.00396x^2
\]

\[r^2 = 0.63\]
Maximum Growth

- 5 – 15 ppm P resulted in maximum growth index values
  - 2.5 ppm P or less resulted in deficiency symptoms
- 3 – 5 ppm P provided growth control

<table>
<thead>
<tr>
<th>Plant Species</th>
<th>Phosphorus Concentration (mg L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternanthera braziliensis</td>
<td>5.50</td>
</tr>
<tr>
<td>Angelonia angustifolia 'Sungelonia Blue'</td>
<td>8.78</td>
</tr>
<tr>
<td>Angelonia angustifolia 'Sungelonia White'</td>
<td>7.27</td>
</tr>
<tr>
<td>Capsicum annuum</td>
<td>13.1</td>
</tr>
<tr>
<td>Catharanthus roseus</td>
<td>6.74</td>
</tr>
<tr>
<td>'Pacifica XP Blush'</td>
<td>6.43</td>
</tr>
<tr>
<td>Impatiens hawkeri</td>
<td></td>
</tr>
<tr>
<td>'Pure Beauty Red on Pink'</td>
<td>12.4</td>
</tr>
<tr>
<td>'Tamarinda Dark Red'</td>
<td>9.64</td>
</tr>
<tr>
<td>Petunia atkinsiana</td>
<td></td>
</tr>
<tr>
<td>'Potunia Neon'</td>
<td>9.08</td>
</tr>
<tr>
<td>'Surprise Sky Blue'</td>
<td>8.72</td>
</tr>
</tbody>
</table>

Conclusions

- Depending on species, 5 – 15 ppm P resulted in maximum growth
- Low P fertilization can successfully control growth without negative issues of P deficiency symptoms

Publications
Josh Brady Henry – NCSU M.S. Thesis
HortScience: 52(10) Nov 2017
ISHS Substrates Acta Hort: 2018
Phosphorus Nutrition: Effects on Coloration

- Red leaf color is a desirable trait found in several ornamental species
- P deficiency increases red leaf pigmentation
  - Anthocyanins increase due to P deficiency
    - Betacyanins produced in limited species, effect of P deficiency undocumented

2. Color Enhancement

Question:
Can low P fertilization enhance foliar coloration in red leafed species?

Methods

- Grew alternanthera with 0 – 20 ppm P
  - Half of the plants switched to 0 ppm P after 4 weeks
- Measured growth and color parameters
  - Growth Index
  - Chlorophyll levels
  - Color ratings
  - Betacyanin concentrations

Alternanthera ‘Purple Prince’

Alternanthera Chlorophyll

<table>
<thead>
<tr>
<th>Phosphorus Rate (ppm)</th>
<th>0</th>
<th>2.5</th>
<th>5</th>
<th>10</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous Fertilization</td>
<td>cd</td>
<td>ab</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Restricted Fertilization</td>
<td>cd</td>
<td>d</td>
<td>d</td>
<td>bc</td>
<td>a</td>
</tr>
</tbody>
</table>
2. Color Enhancement

**Alternanthera Betacyanin Concentration**

Suddenly limited growth, excess metabolites

- Low P fertilization resulted in significantly redder plants
  - Increases red pigments
- Size up plants first with 10 ppm P, then lower P fertilization to enhance red coloration
  - Similar results with zonal geranium, but make sure to apply some P (~2.5 ppm)

**Conclusions**

**Topic Outline**

- **Phosphorus Nutrition**
  - **1 Maximum Growth**
  - **2 Color Enhancement**
  - **3 Reproductive Stage Deficiency**

**Phosphorus Nutrition: Deficiency**

- P deficiency symptoms occur when plant tissue comprises less than 0.2% P
- Mobile within plants
  - Source-sink relationships among tissues
  - Deficiency symptoms typically occur lower foliage

**Publications**

Josh Brady Henry – NCSU M.S. Thesis
HortTech: submitting
3. Reproductive Stage Deficiency
Phosphorus Movement Within the Plant

Phosphorus Nutrition: Deficiency

• Typical symptoms
  • Foliar reddening or purpling, darker green coloration, stunted growth, and delayed flowering

• Other symptoms
  • Olive green and necrotic leaf spotting

Phosphorus Nutrition: Reproductive Stage Deficiency

• Recent P deficiency symptoms confirmed on the upper foliage
  • Chlorosis, necrosis, olive green spotting
Phosphorus Nutrition: Reproductive Stage Deficiency
• Symptoms resulted in significant losses for growers
  • ~$130,000
• Why have these symptoms not been reported before?
  1. Likely have occurred, but not been associated with P
  2. With increased popularity of low P fertilization strategies, some growers limited P too greatly

Question:
What causes these atypical symptoms on the upper foliage?

Methods
• Grew ornamental peppers with 0 – 20 ppm P
  • Half restricted to 0 ppm P after 6 weeks
• Grew chrysanthemums with 10, 15, or 20 ppm P
  • Half restricted to 0 ppm P after 4 weeks
• Plants divided into separate parts to analyze tissue P concentrations throughout the plant
  • Illustrate P movement
3. Reproductive Stage Deficiency

‘Tango Red’ Peppers

Continuous Phosphorus Fertilization

Restricted Phosphorus Fertilization

Phosphorus Rate (ppm)

0  2.5  5  10  20

10 ppm P after 3 weeks without P

3. Reproductive Stage Deficiency

Initial Rate of 10 ppm P

Restricted P
(5 weeks without P)

Continuous P

3. Reproductive Stage Deficiency

Plant Division

Tissue P Concentrations

Initial Phosphorus Rate (ppm)

‘Crystal Misty Purple’ Chrysanthemum

Initial Phosphorus Rate (ppm)
3. Reproductive Stage Deficiency

‘Crystal Misty Purple’ Chrysanthemum

Necrotic curling of the leaf margins
Overall purpling with green spots
(Reported by Whipker, 2014)

3. Reproductive Stage Deficiency

‘Little Rock’ Chrysanthemum

‘Little Rock’ Tissue P Concentrations

(Reported by Whipker, 2014)
Discussion

Source-sink interactions led to differences in P allocation

- Continuous P Fertilization
- Restricted P Fertilization

<table>
<thead>
<tr>
<th></th>
<th>-50%</th>
<th>-86%</th>
<th>-83%</th>
<th>-78%</th>
<th>(100%)</th>
</tr>
</thead>
</table>

Conclusions

• Restricting P upon floral initiation resulted in upper leaf symptomology
  - Conditions of sufficient P earlier, restricted later
  - Lower initial P rates led to typical lower leaf symptoms

• P tissue analysis results support bypass hypothesis
  - P preferentially translocates to developing flowers and fruit

Overall Conclusions

• From these experiments, growers can obtain numerous benefits from low P fertilization
  - Growth Control (3 – 5 ppm P)
  - Enhanced Coloration

• Due to poor nutrient holding capacity of soilless substrates, P must be supplied to avoid deficiency
  - Symptom development in 2 – 3 weeks
  - For most species, 5 – 10 ppm P will prevent symptom development

Additional Info?

Details – GrowerTalks series: June, July, August, & September 2017

Questions?

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