Comparison of Light Qualities and DLI for Sole-source Lighting of Microgreens and Bedding Plant Plugs

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Two Major Studies

• Study 1 – Microgreens
• Study 2 - Bedding plant plugs
• Both studies looking at sole-source lighting using LEDs
  – Quality (color or distribution)
  – Quantity (DLI)
Background

• Vegetables and herbs consumed at young stage (first set of true leaves)
• Food enhancement
  – Color
  – Flavor
  – Texture
• Health promoting
• High market value

Objective

• Quantify the effects of sole-source (SS) LED lighting providing different light intensities and qualities on: growth, morphology, and nutritional content of Brassica microgreens
Materials and Methods

Plant Material
- *Brassica oleracea* var. *gongylodes* (kohlrabi)
- *Brassica juncea* (mustard)
- *Brassica rapa* spp. *nipposinica* (mizuna)

Walk-in Environmental Chamber
- 16-h photoperiod
- 70/63 °F (21/17 °C) day/night (16 h/8 h)
- 50/60% day/night relative humidity
- 500 ppm CO₂

Materials and Methods

Substrate and Fertilization
- Polyethylene terephthalate fiber pad hydroponic tray
- 300 mL of a 25% Hoagland’s #1 nutrient solution added to each tray daily
Materials and Methods

Philips Green Power LED Production Modules

• Light qualities consisting of (%):
  - 87:13 red:blue = R:B
  - 84:7:9 red:far-red:blue = R:FR:B
  - 74:18:8 red:green:blue = R:W

Materials and Methods

• Daily light integral:
  - 6 mol·m⁻²·d⁻¹
    • 2 modules delivering 105 µmol·m⁻²·s⁻¹
  - 12 mol·m⁻²·d⁻¹
    • 4 modules delivering 210 µmol·m⁻²·s⁻¹
  - 18 mol·m⁻²·d⁻¹
    • 6 modules delivering 315 µmol·m⁻²·s⁻¹
Materials and Methods

• Data collected
  - Hypocotyl elongation
  - Leaf area
  - Dry weight
  - Carotenoids
  - Anthocyanin
  - Phenolics
  - Macro- and micronutrients

• Study repeated twice

Results - Kohlrabi

<table>
<thead>
<tr>
<th>DLI (mol·m⁻²·d⁻¹)</th>
<th>6</th>
<th>12</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>R:B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R:FR:B</td>
<td></td>
<td></td>
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<tr>
<td>R:W</td>
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</tbody>
</table>
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Results - Kohlrabi

- Hypocotyl length
  - Decrease with increasing DLI
  - Quality effect at low DLI
- Leaf area
  - Decrease with increasing DLI

Results - Kohlrabi

- Dry weight
  - Increase as the DLI increases
  - More total biomass but smaller leaf area
**Results - Kohlrabi**

- Total anthocyanins
  - Increase as DLI increases
  - Lower levels under R:W and DLI of 18
- Antagonistic effect of green light
- Reverse accumulation from blue light

**Results - Brassica juncea (mustard)**

<table>
<thead>
<tr>
<th>DLI (mol·m⁻²·d⁻¹)</th>
<th>6</th>
<th>12</th>
<th>18</th>
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<tbody>
<tr>
<td>R:B</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>R:FR:B</td>
<td></td>
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<tr>
<td>R:W</td>
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Energy Usage

<table>
<thead>
<tr>
<th>Light Quality (%)</th>
<th>Daily light integral (mol·m⁻²·d⁻¹)</th>
<th>6</th>
<th>12</th>
<th>18</th>
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<tbody>
<tr>
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<tr>
<td></td>
<td>Killowatt hours per day (kWh·d⁻¹)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>R:B</td>
<td>1.03 ± 0.02</td>
<td>2.06 ± 0.03</td>
<td>3.10 ± 0.05</td>
<td></td>
</tr>
<tr>
<td>R:W</td>
<td>1.02 ± 0.04</td>
<td>2.04 ± 0.08</td>
<td>3.06 ± 0.12</td>
<td></td>
</tr>
<tr>
<td>R:FR:B</td>
<td>1.03 ± 0.04</td>
<td>2.06 ± 0.07</td>
<td>3.09 ± 0.11</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

• Growth and Morphology
  – Biomass production increased under higher light intensities
  – Leaf area decreased under higher light intensities
  – Hypocotyl length decreased as DLI increased
• Increased DLI led to increased anthocyanin content
• Electrical savings are greatest with low light intensities
Light Quality and Quantity from Sole-source LEDs Influences Growth and Subsequent Flowering of Bedding Plant Plugs

Background

• Quality seedling
  – Compact
  – Stem caliper
  – Dry mass

• Delay in flowering for some plants when produced under LED sole-source red:blue lighting
Hypothesis and Objectives

**Hypothesis:** Young LD plants grown under LED sole-source lighting providing far-red (FR) light will flower earlier

**Objectives:**
- Quantify effect of FR light on seedling quality and subsequent time to flower
- Quantify effect of DLI on seedling quality and subsequent time to flower

Materials and Methods

**Environment and Culture**
- 70 °F (21°C) constant air temperature
- 70/80% day/night relative humidity (16 h/8 h)
- 16-h photoperiod
- 500 ppm CO₂
- 288-cell plug tray
- Fertilized with 100 ppm N Jack’s LX Plug Formula for High Alkalinity Water
Comparison of Light Qualities and DLI for Sole-source Lighting of Microgreens and Bedding Plant Plugs

Materials and Methods

• Three light quality treatments
  – R:B
  – R:FR:B
  – R:W

• Three DLI treatments
  – 6 mol·m⁻²·d⁻¹
  – 12 mol·m⁻²·d⁻¹
  – 18 mol·m⁻²·d⁻¹

Materials and Methods

• Seedlings evaluated at 14, 21, and 28 days
  – Stem elongation
  – Stem caliper (SC)
  – Leaf area
  – Root, shoot and total dry mass (TDM)
  – Root to shoot ratio (R:S)
  – Sturdiness quotient (SQ; stem caliper / stem length)
  – Quality index [TDM (R:S +SQ)]
## Preliminary Results

### Pansy – Stem Elongation (mm)

- Increasing DLI led to decreased stem elongation

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<th>12</th>
<th>18</th>
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</thead>
<tbody>
<tr>
<td>R:B</td>
<td>8.4 ab</td>
<td>9.0 a</td>
<td>8.9 a</td>
</tr>
<tr>
<td>R:FR:B</td>
<td>8.9 abc</td>
<td>7.2 abc</td>
<td>7.5 abc</td>
</tr>
<tr>
<td>R:W</td>
<td>7.2 abc</td>
<td>7.5 abc</td>
<td>6.1 c</td>
</tr>
<tr>
<td>R:B</td>
<td>6.1 c</td>
<td>5.7 c</td>
<td>5.7 c</td>
</tr>
<tr>
<td>R:FR:B</td>
<td>5.7 c</td>
<td>5.7 c</td>
<td>6.8 bc</td>
</tr>
<tr>
<td>R:W</td>
<td>6.8 bc</td>
<td>5.7 c</td>
<td>6.8 bc</td>
</tr>
</tbody>
</table>

Seedling data collected at 21 days

## Materials and Methods

- Five seedlings transplanted at 21 and 28 days
- Finishing environment
  - Photoperiod: 16-hr
  - DLI of 10-12 mol·m⁻²·d⁻¹
  - Air temperature: 68°F (20°C)
  - Fertilized with 200 ppm N
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Preliminary Conclusions

• Higher quality plugs under higher DLIs
  – Decreased stem elongation
  – Increased stem caliper
  – Increased root and shoot dry mass

• Light quality does not appear to have a significant effect within DLIs on plug quality

• Earlier flowering for some species under R:FR:B LEDs with higher DLIs

• Results are still preliminary
Acknowledgments

- We also thank the USDA-SCRI, private horticulture and lighting companies that support Purdue research including:

For More Information

http://flowers.hort.purdue.edu

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