Managing Photosynthetic Light in a Greenhouse

Roberto Lopez, Purdue Univ.

Increasing Light Uniformity and Reducing Shading

- Light interception is greater in east/west orientated greenhouses (winter)
- Light uniformity is greater in north/south oriented greenhouses because the shadow from the gutter moves
- Orientation is dependent on crops being grown, latitude, and snow

Managing Light in a Greenhouse

- Light uniformity and distribution
- Factors that reduce photosynthetic light
- Methods and costs of increasing photosynthetic light during light limiting conditions

In regions with heavy snowfalls, snow will blow off of an E/W house more readily than a N/S house.
Curtain orientation and type can significantly effect shadows and uniformity

Under a East to West oriented shade curtain, bands of light and shade do not move

Under a North to South oriented shade curtain, shadows and light bands move across the crop

Black cloth should not be used as shade cloth

Effect of Overhead Obstructions (Trees)

Shading Increases as Plants Grow

Without plants

With plants

25% shading

42% shading

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Basket Color Plays a Role

White
Green baskets

13% shading
25% shading

Jim Faust, Clemson Univ.

Supplemental Lighting

Greenhouse supplemental/ photosynthetic or assimilation lighting (growth and quality) requires much higher light intensities than for photoperiodic lighting (day length and flowering):

- Photosynthetic lighting: 300 to 600 footcandles (40 to 80 µmol·m⁻²·s⁻¹)
- Photoperiodic lighting: 10 to 20 footcandles (2 to 4 µmol·m⁻²·s⁻¹)

Quantum Efficiency

Proportion of energy that is converted to light that can be used for photosynthesis

<table>
<thead>
<tr>
<th>Light source</th>
<th>Quantum efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photoperiodic Lighting</td>
<td></td>
</tr>
<tr>
<td>Incandescent</td>
<td>6 - 7</td>
</tr>
<tr>
<td>Fluorescent (tube or compact)</td>
<td>22 - 27</td>
</tr>
<tr>
<td>Supplemental Lighting (HIDs and LEDs)</td>
<td></td>
</tr>
<tr>
<td>Metal halide (MH)</td>
<td>20 - 21</td>
</tr>
<tr>
<td>High-pressure sodium (HPS)</td>
<td>29 - 31</td>
</tr>
<tr>
<td>Light-emitting diodes (LEDs)</td>
<td>25 - 48</td>
</tr>
<tr>
<td>Sun</td>
<td>43</td>
</tr>
</tbody>
</table>

Supplemental Lighting (SL) Guidelines

- Most crops benefit from SL, however it should only be used when increased growth and quality can be converted into added revenue (profitability)
- Growers most often use SL on plugs, cuttings, vegetables, and cut flowers, because in these cases increased growth rate and yields correspond to greater economic yield

Supplemental Lighting (SL) Guidelines

- The Beamflicker is not useful for SL because light exposure to plants is intermittent
- Goal is to provide 300 to 600 footcandles of supplemental lighting at plant level (400 to 500 footcandles is typical)
- Benefit of supplemental lighting greatest:
  - From October through March (North)
  - From November through February (South)
  - During non-sunny conditions (during the night and on cloudy days)
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Supplemental Lighting (SL) Guidelines

- Increased dry mass (higher quality)
- Greater root mass and stem caliper
  - More “pullable” plug for transplanting
- Heat from lamps
  - Increases rate of development
  - Reduces finish crop time
- Carryover effects for the finished plant

When is it Economical to Use Supplemental Lighting in Greenhouses?

How much Light (DLI) can you add with Supplemental Lighting?

- Common recommendation is to provide 400 to 500 footcandles at plant level, which adds 0.19 to 0.24 mol·m⁻²·s⁻¹ per hour lamps are on

<table>
<thead>
<tr>
<th>Duration (hours)</th>
<th>Footcandles (μmol·m⁻²·s⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>250 (33)</td>
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<tr>
<td>12</td>
<td>1.4</td>
</tr>
<tr>
<td>15</td>
<td>1.8</td>
</tr>
<tr>
<td>18</td>
<td>2.1</td>
</tr>
<tr>
<td>21</td>
<td>2.5</td>
</tr>
<tr>
<td>24</td>
<td>2.8</td>
</tr>
</tbody>
</table>

http://extension.unh.edu/Agric/AGGHFL/growing_tools.htm

- DLI CALC can help growers calculate the DLI provided by supplemental lights such as HPS or MH lamps
- DLI CALC can also assist growers in estimating the number of hours that they need to operate each lamp type in order to achieve a target supplemental DLI
- Other resources to help growers determine how to increase or reduce DLI are included

Installation Costs

- Typical installation costs for HPS lights are shown below
- Lighting level in both situations is for 500 footcandles (67 μmol·m⁻²·s⁻¹)

<table>
<thead>
<tr>
<th>Situation</th>
<th>Installation costs ($/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 400 W lamp/86 ft²</td>
<td>2.03</td>
</tr>
<tr>
<td>1 - 600 W lamp/143 ft²</td>
<td>1.96</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Situation</th>
<th>Lamps</th>
<th>Wiring</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 400 W lamp/86 ft²</td>
<td>0.87</td>
<td>2.90</td>
<td></td>
</tr>
<tr>
<td>1 - 600 W lamp/143 ft²</td>
<td>0.52</td>
<td>2.48</td>
<td></td>
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</tbody>
</table>

Operation Costs

- Operation costs are primarily electrical
- At 10.3 cents per KWH and a lighting level of 500 foot candle (67 μmol·m⁻²·s⁻¹), the electrical costs in cents per ft² week are shown below:

<table>
<thead>
<tr>
<th>Situation</th>
<th>12 hr/d</th>
<th>15 hr/d</th>
<th>18 hr/d</th>
<th>21 hr/d</th>
<th>24 hr/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 W lamp</td>
<td>4.6</td>
<td>5.8</td>
<td>7.0</td>
<td>8.2</td>
<td>9.3</td>
</tr>
<tr>
<td>600 W lamp</td>
<td>4.1</td>
<td>5.1</td>
<td>6.1</td>
<td>7.1</td>
<td>8.1</td>
</tr>
</tbody>
</table>
Take Home Message

• Photosynthetic light can be managed and maximized by:
  – Increasing uniformity
  – Knowing the effects of obstructions
  – Using supplemental lighting

• Supplemental lighting
  – Should only be used when increased growth and quality can be converted into added revenue (profitability)

For more Information on Managing Light
Visit: flowers.hort.purdue.edu
• Click on the Extension bulletin tab