LED Lighting for Common Bedding Plants

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Do you need more light?

- **The more sun, the more flowers**

Are LEDs Worth it for My Business?

- Grower objectives
- Crop Type
- Geography
- Time of year
- Outdoor vs Indoor DLI
- Supplemental needs
- Dimensions of growing area
- Cost per kwH

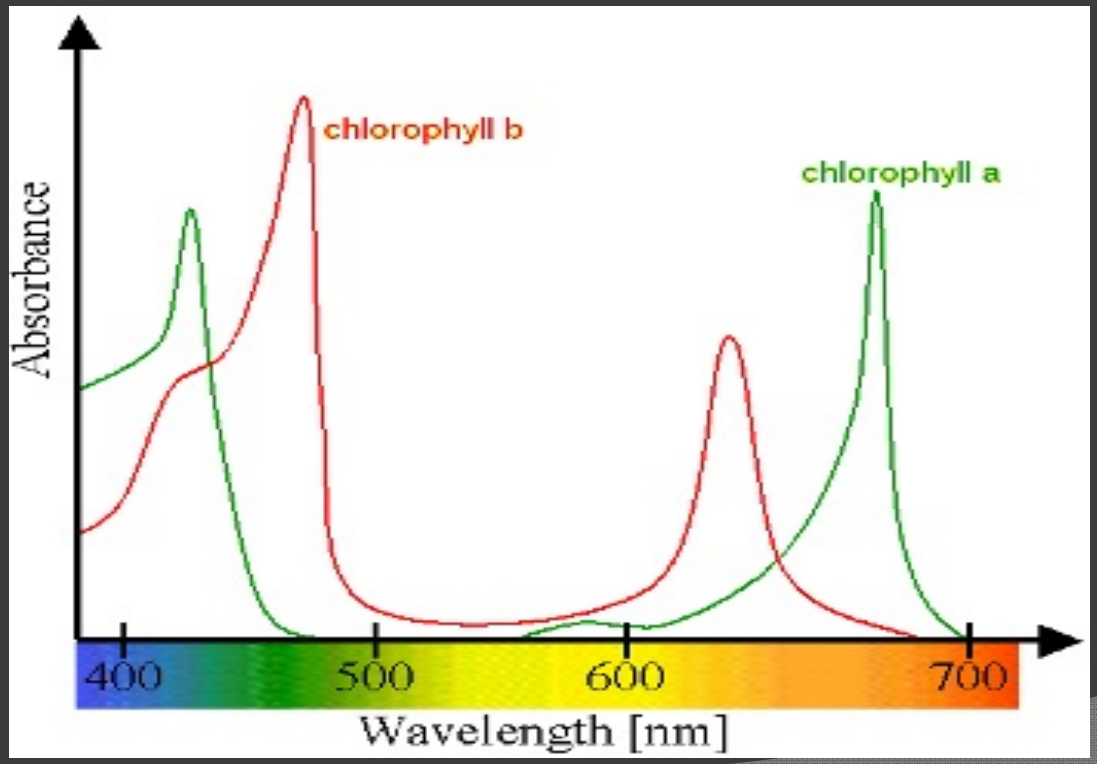
Adapted from: Abhay Thosar, Ph.D.
LED Lighting as a Commercial Possibility: Myth or Reality? Webinar

Questions

- **What do you want to know?**

Photosynthetically Active Radiation (PAR)

Spectral range of solar light from 400 to 700 nm is most useful in photosynthesis



Chlorophyll

- **most abundant plant pigment**
- **most efficient in presence of red and blue light**

METHODS OF MEASUREMENT

Irradiance –**energy** received; units are **watts per square meter (watts/m^2)** or **(µmol/m^2/s^1)**

- A quantum meter measures the part of the light spectrum from 400-700nm called (**PAR**
- A more accurate measure of light energy as used by plants

“Lumens are for looking at, watts are energy.”

Light Quantity - DLI

Irradiance – the amount of light energy received by the plant ($\mu mol/m^2/s$)

- Affects rate of photosynthesis and plant growth.
- Plant growth response is species and cultivar specific.

The daily light integral (DLI) is a measure of light accumulation in greenhouse crops.

Light Quantity - DLI

- **Goal in greenhouse production is to optimize light levels in order to maximize photosynthesis.**
  - Too little = poor growth
  - Too much = wasted resources

Optimal Light Quantity

Plant	Irradiance* µmol/m²/s	DLI* mol/m²/d
African violet	150 – 250	5-10
Foliage plants	150 – 250	7-15
Chrysanthemum	250 – 450	10-20
Easter lily	250 – 450	10-20
Geranium	250 – 450	10-20
Poinsettia	250 – 450	10-20
Lettuce	250 – 450	12-15
Carnation	250 – 450	12-20
Cucumber	250 – 450	20-30
Strawberry	250 – 450	20-30
Roses	450 – 750	25-30
Tomato	450 – 750	25-30

*Adapted from:

Plant Growth Chamber Handbook, Iowa Agriculture and Home Economics Experiment Station Special Report No. 99.

Light Management in Greenhouses, I. Daily Light Integral: A useful tool for the U.S. Floriculture industry. James E. Faust

Species	Average Daily Light Integral (Moles/Day)												
	Greenhouse												
	2	4	6	8	10	12	14	16	18	20	22	24	26
Lilium (asiatic and oriental)													
Lilium longiflorum (easter lily)													
Ageratum													
Antirrhinum													
Chrysanthemum (potted)													
Dianthus													
Gazania													
Gerbera													
Hibiscus rosa-siniensis													
Lobularia													
Pelargonium hororum (zonal geranium)													
Rose (miniature potted)													
Salvia splendens													
Schefflera													
Angelonia													
Aster													
Salvia farinacea													
Iberis													
Catharanthus (vinca)													
Celosia													

Table 2. DLI Requirements for Various Greenhouse Crops

Minimum aceptable quality
Good quality
High quality

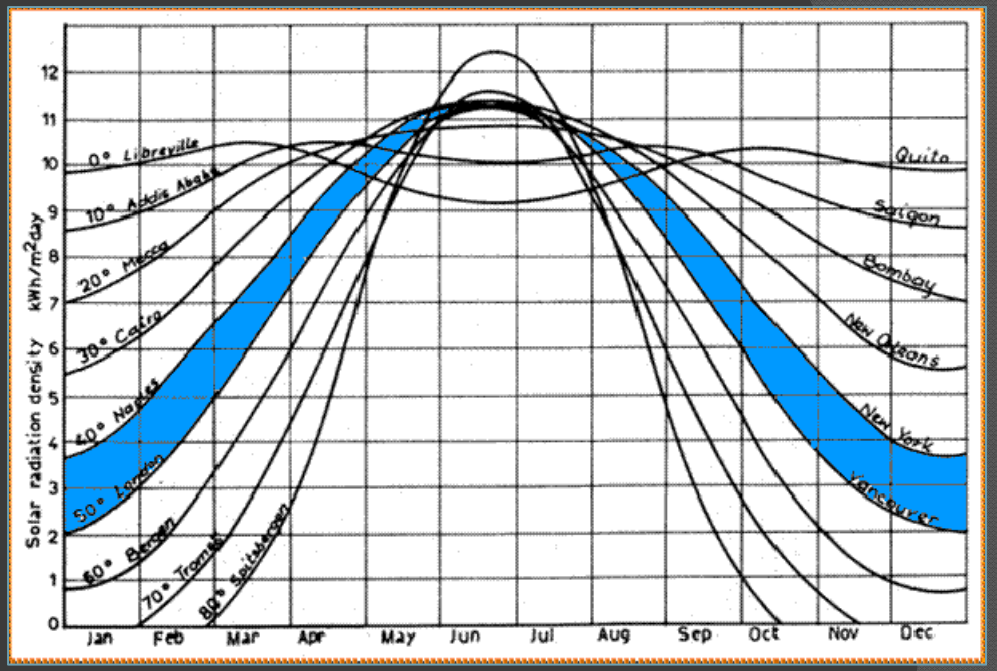
From: Measuring DLI in a Greenhouse
The LED Project Publication by: Torres and Lopez

Are LEDs Worth it for My Business?

- **Grower objectives**
- **Crop Type**

What is your target DLI?

Natural causes of Light variation



- Latitude
  - Radiation density (quantity)
  - Length of exposure (photoperiod)
- Air Quality
  - Radiation density (quantity)
- Location
  - Radiation density due to altitude
  - Photoperiod due to light pollution

Location: W088 01, N44 31

GREEN BAY, WISCONSIN
Central Standard Time

Astronomical Applications Dept.
U. S. Naval Observatory
Washington, DC 20392-5420

Duration of Daylight for 2017

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
01	08:55	09:51	11:11	12:47	14:15	15:20	15:29	14:38	13:13	11:42	10:11	09:05
02	08:56	09:54	11:15	12:50	14:17	15:21	15:28	14:35	13:10	11:39	10:08	09:03
03	08:57	09:57	11:18	12:53	14:20	15:22	15:27	14:33	13:07	11:36	10:05	09:02
04	08:58	09:59	11:21	12:56	14:23	15:24	15:27	14:30	13:04	11:33	10:03	09:01
05	08:59	10:02	11:24	12:59	14:25	15:25	15:26	14:28	13:01	11:30	10:00	08:59
06	09:00	10:04	11:27	13:03	14:28	15:26	15:25	14:25	12:58	11:27	09:58	08:58
07	09:01	10:07	11:30	13:06	14:30	15:27	15:23	14:23	12:55	11:24	09:55	08:57
08	09:03	10:10	11:33	13:09	14:33	15:28	15:22	14:20	12:52	11:21	09:52	08:56
09	09:04	10:13	11:36	13:12	14:35	15:28	15:21	14:18	12:49	11:18	09:50	08:55
10	09:05	10:15	11:39	13:15	14:38	15:29	15:20	14:15	12:46	11:15	09:47	08:54
11	09:07	10:18	11:42	13:18	14:40	15:30	15:18	14:12	12:43	11:12	09:45	08:54
12	09:09	10:21	11:45	13:21	14:42	15:31	15:17	14:10	12:40	11:09	09:42	08:53
13	09:10	10:24	11:48	13:24	14:45	15:31	15:15	14:07	12:37	11:06	09:40	08:52
14	09:12	10:27	11:52	13:27	14:47	15:32	15:14	14:04	12:34	11:03	09:38	08:52
15	09:14	10:30	11:55	13:30	14:49	15:32	15:12	14:02	12:31	11:00	09:35	08:51
16	09:16	10:33	11:58	13:32	14:51	15:32	15:11	13:59	12:28	10:57	09:33	08:51
17	09:17	10:35	12:01	13:35	14:53	15:33	15:09	13:56	12:25	10:54	09:31	08:50
18	09:19	10:38	12:04	13:38	14:56	15:33	15:07	13:53	12:22	10:51	09:29	08:50
19	09:21	10:41	12:07	13:41	14:58	15:33	15:05	13:51	12:19	10:48	09:27	08:50
20	09:23	10:44	12:10	13:44	15:00	15:33	15:03	13:48	12:16	10:45	09:24	08:50
21	09:26	10:47	12:13	13:47	15:02	15:33	15:02	13:45	12:12	10:42	09:22	08:50
22	09:28	10:50	12:16	13:50	15:03	15:33	15:00	13:42	12:09	10:39	09:20	08:50
23	09:30	10:53	12:19	13:53	15:05	15:33	14:58	13:39	12:06	10:36	09:18	08:50
24	09:32	10:56	12:23	13:55	15:07	15:33	14:56	13:36	12:03	10:33	09:17	08:50
25	09:34	10:59	12:26	13:58	15:09	15:32	14:53	13:34	12:00	10:30	09:15	08:50
26	09:37	11:02	12:29	14:01	15:11	15:32	14:51	13:31	11:57	10:28	09:13	08:51
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28	09:41	11:08	12:35	14:07	15:14	15:31	14:47	13:25	11:51	10:22	09:09	08:52
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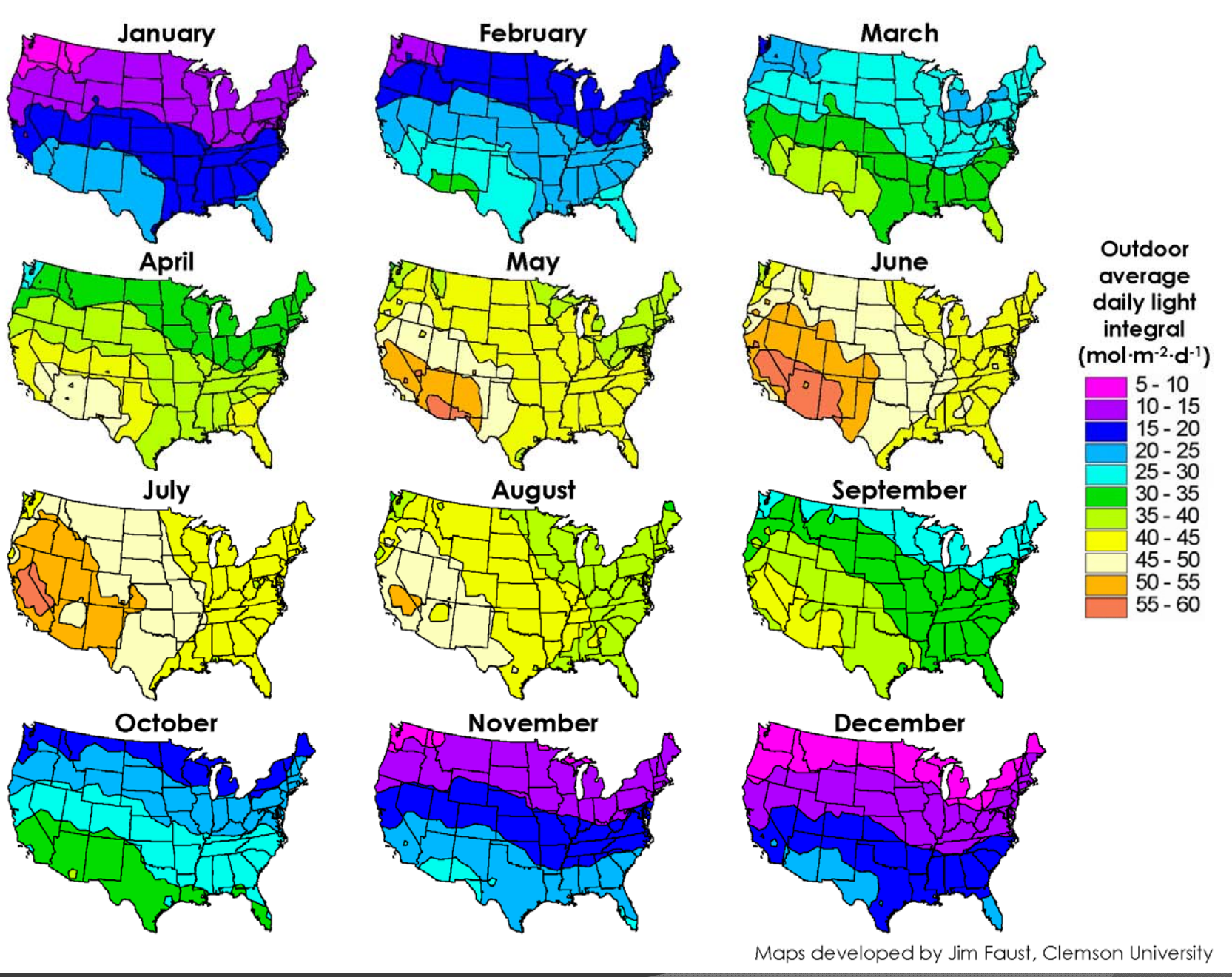
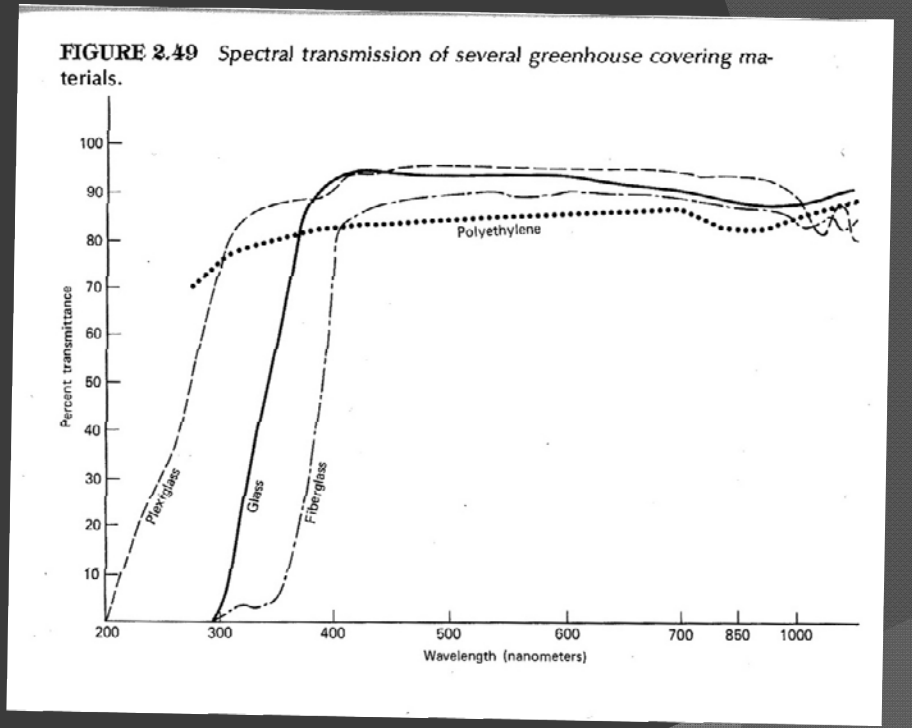
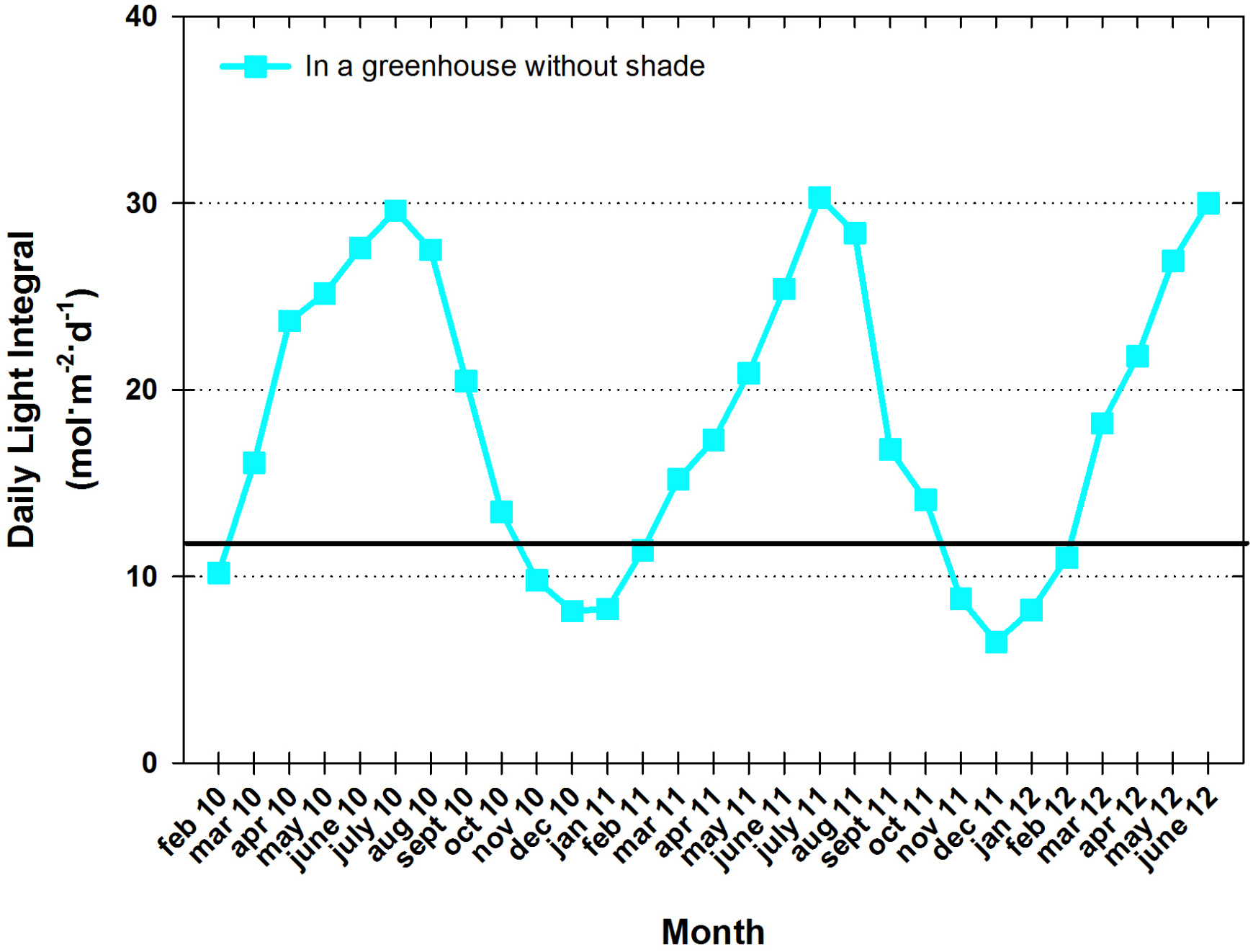


Outdoor daily light integrals across the continental United States over the course of one year. (Figure courtesy of Dr. Jim Faust, Clemson University.)

Greenhouse causes of light Variation

- Glazing
  - Radiation Density (quantity transmitted or diffused)
  - Spectrum (wavelengths blocked or transmitted)
- Structure
  - Radiation Density (40-50% shade)
  - CO_2 availability





Daily light integral in a double polyethylene greenhouse without shade curtains or white wash located in West Lafayette, Indiana over the course of several years. (Figure courtesy of Dr. Roberto Lopez, Purdue University.)

Are LEDs Worth it for My Business?

- **Geography**
- **Time of year**
- **Outdoor vs Indoor DLI (shading)**

What is the current DLI in my greenhouse?

Are LEDs Worth it for My Business?

- Target DLI - Available DLI =
- Supplemental needs

Managing The Daily Light Integral

- How long should I run my lights to achieve the recommended DLI for my crop?
- How much supplemental light do my fixtures provide for my crop?

http://extension.unh.edu/Agric/AGGHFL/dlicalc/index.cfm

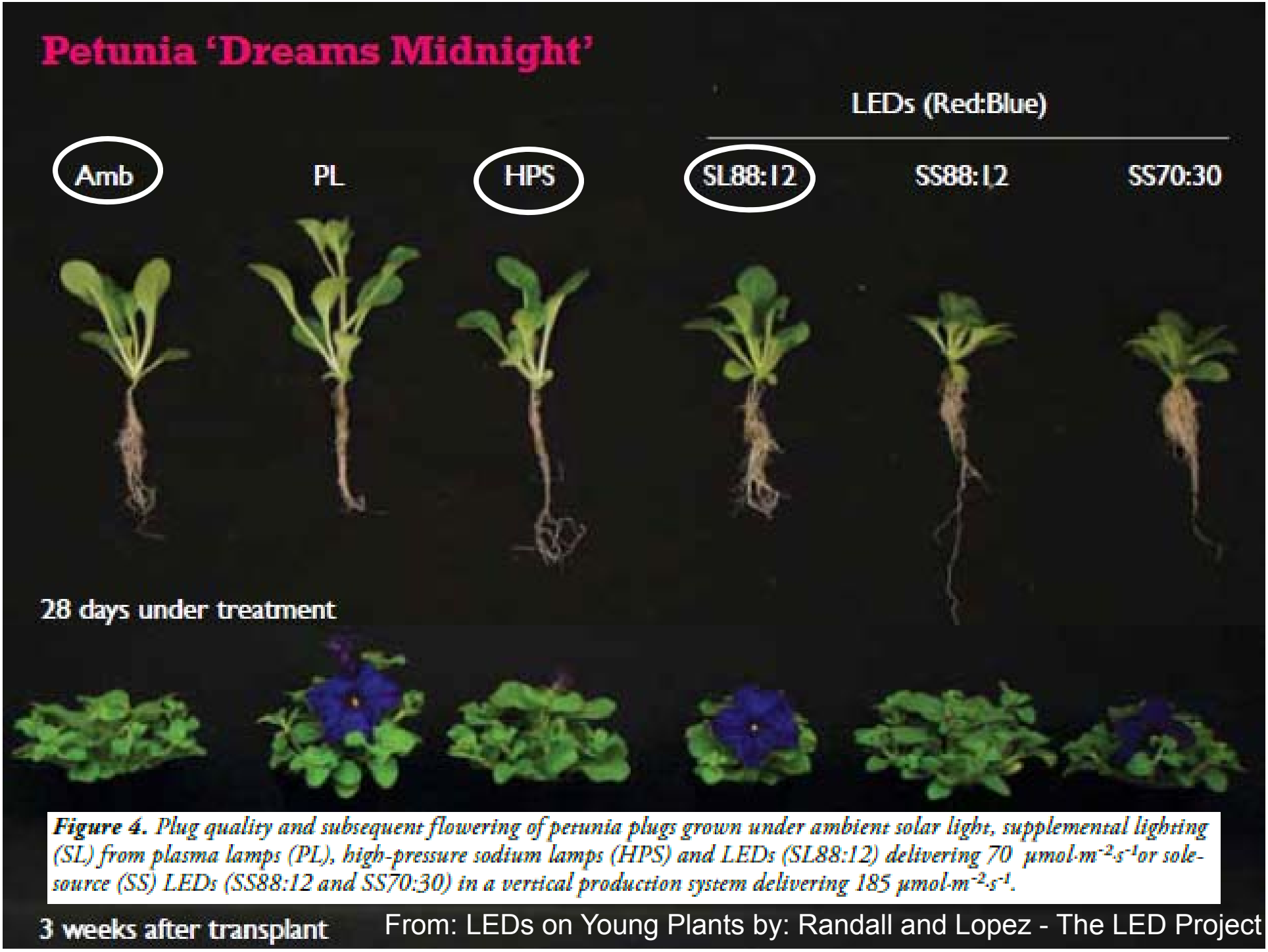


Figure 4. *Plug quality and subsequent flowering of petunia plugs grown under ambient solar light, supplemental lighting (SL) from plasma lamps (PL), high-pressure sodium lamps (HPS) and LEDs (SL88:12) delivering 70 µmol·m^{-2}·s^{-1}or sole-source (SS) LEDs (SS88:12 and SS70:30) in a vertical production system delivering 185 µmol·m^{-2}·s^{-1}.*

From: LEDs on Young Plants by: Randall and Lopez - The LED Project

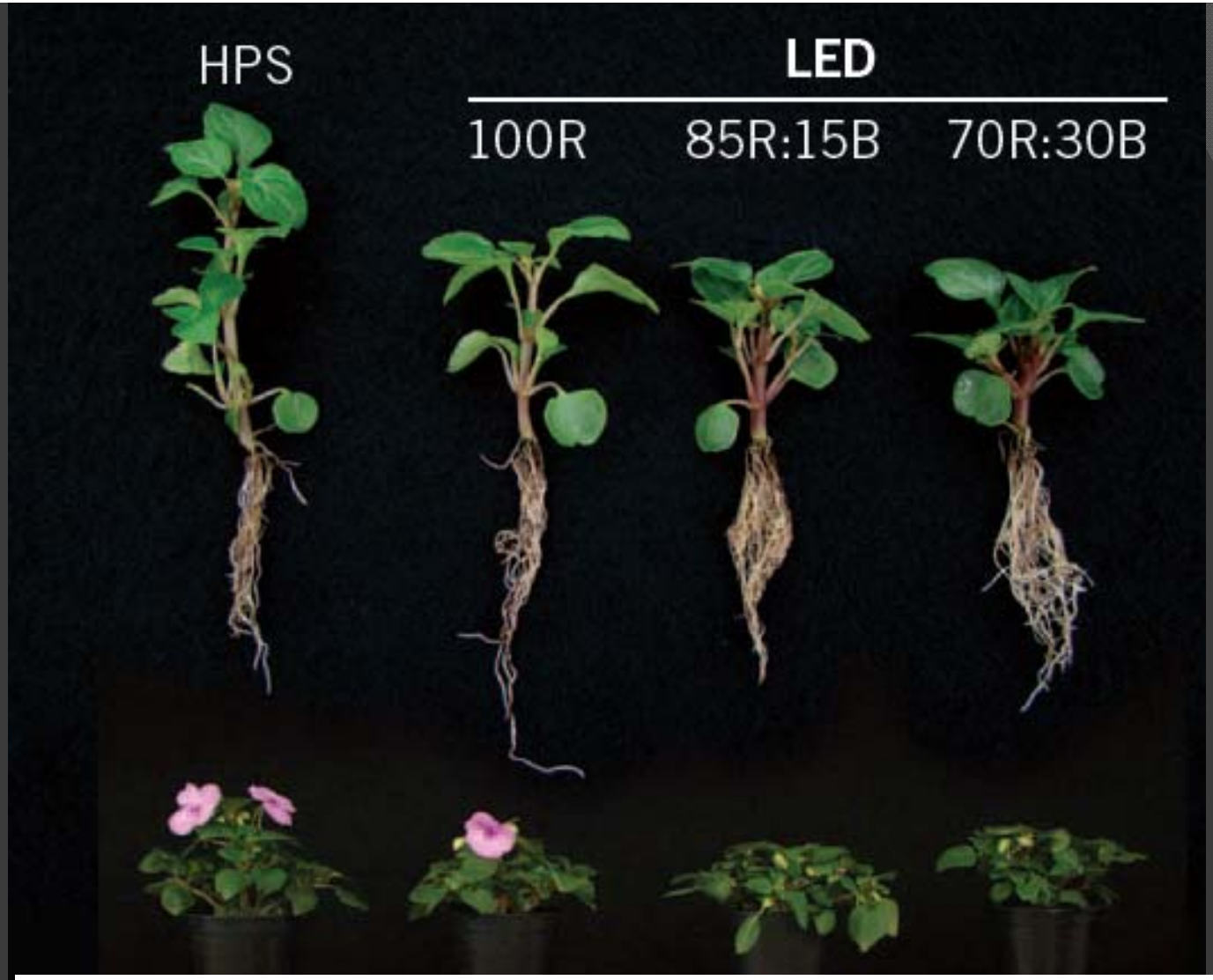


Figure 2. **Seedlings and flowering plants of *Impatiens* 'Dazzler Blue Pearl' propagated under 100 µmol·m^{-2}·s^{-1} of supplemental light from high-pressure sodium lamps (HPS) or light-emitting diodes (LEDs) varying in red:blue light ratios and finished in a common growing environment.**

From: Comparing LED Lighting to HPS Lamps for Young Plug Production
by: Randall and Lopez - The LED Project

Get the most from your lights

- Regular maintenance
  - Replace lamps
  - Clean reflectors
- Lighting plan
  - reflectors

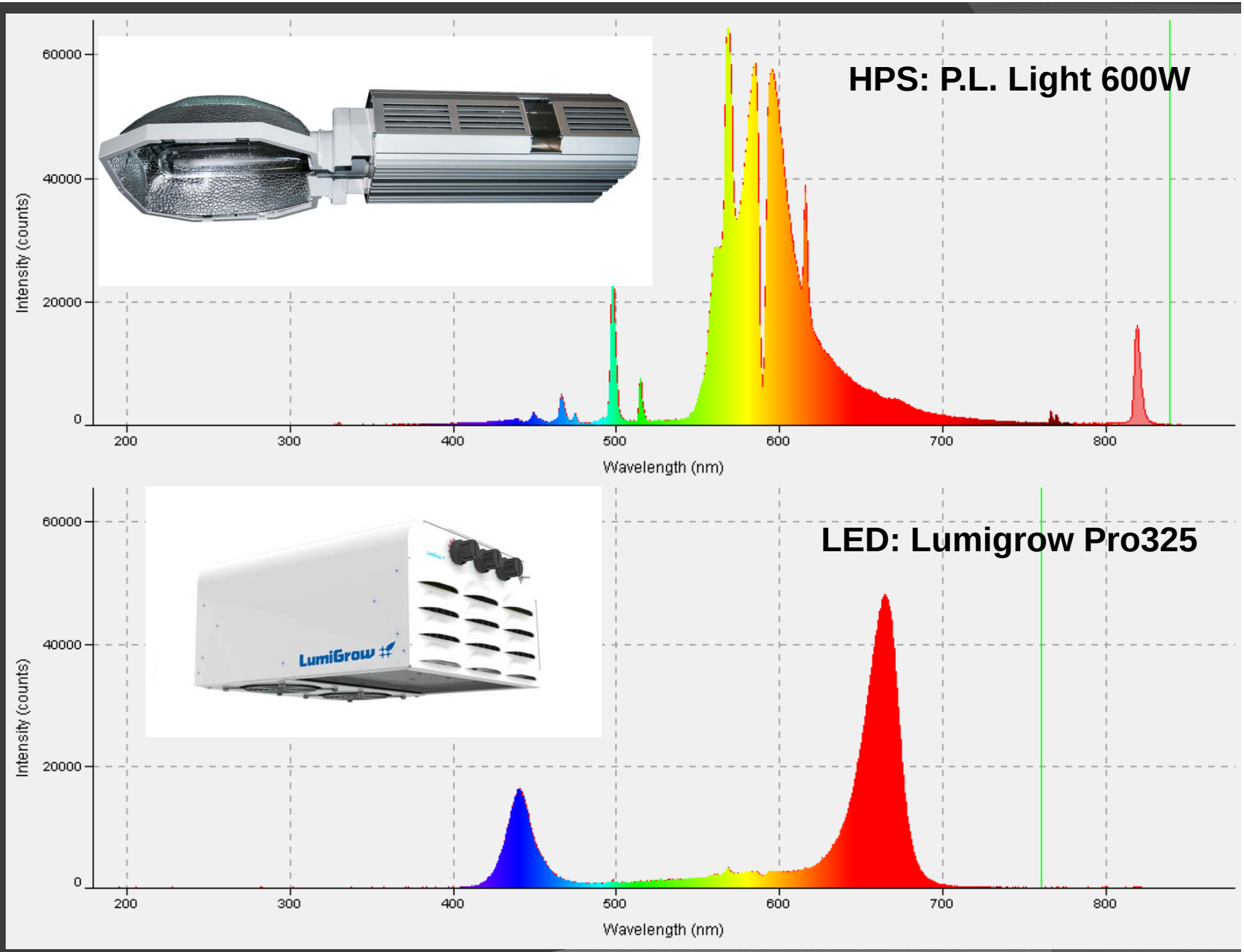
Are LEDs Worth it for My Business?

- **Dimensions of growing area**

  How many fixtures will you need?

Are LEDs your best choice?

Intensity (W/cm^2)



Wavelength (nm)

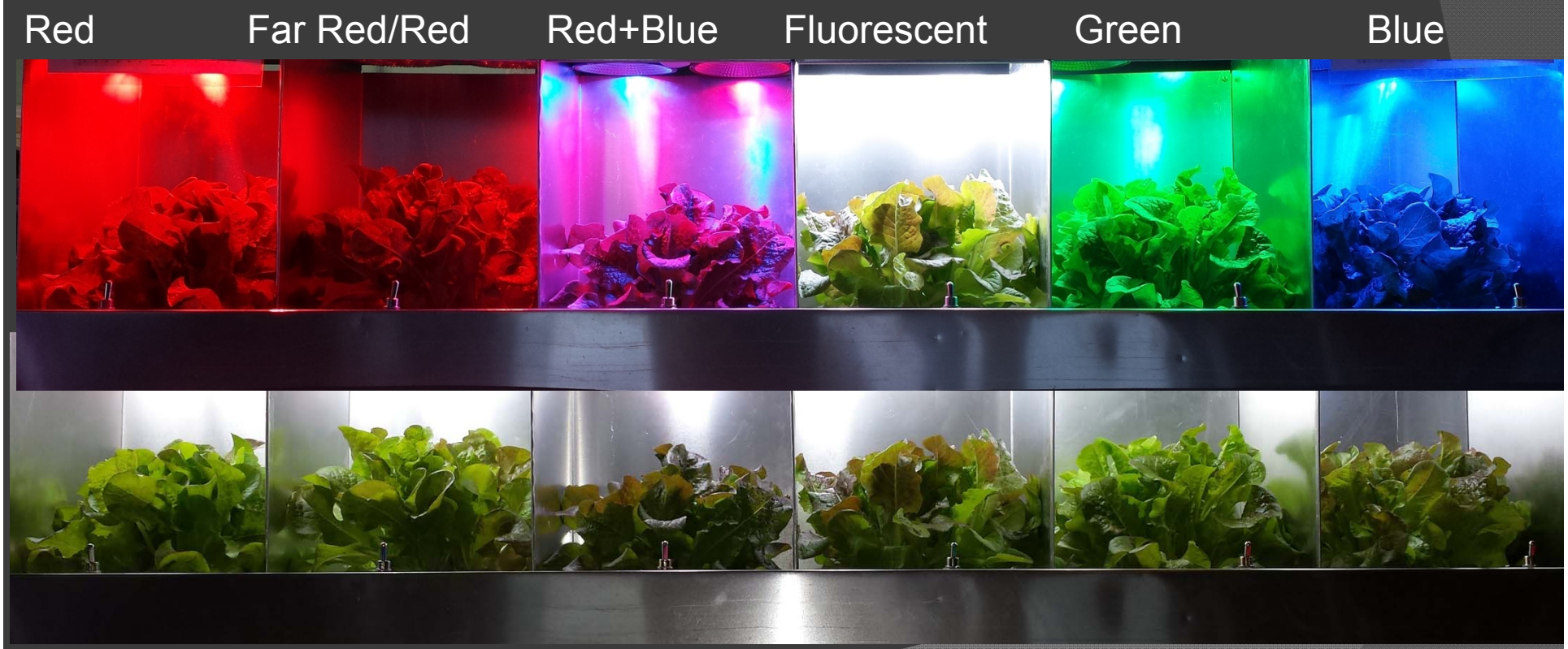
Graphs Courtesy of Bjorn Karlsson: UW Biotron

Benefits? of LEDs

- Instant on/off (no warm-up or cool-down time)
- No reflector
- Heat production (+/-)
  - Less heat radiated toward plants
  - Fixtures must be cooled
    - Heat sinks (passive cooling)
    - Fans (active cooling)

Benefits? of LEDs

- Color



Images Courtesy of Bjorn Karlsson: UW Biotron

Benefits? of LEDs

Extended Fixture Lifespan - 50,000 hours

- gradual loss of intensity – to ~70% of original output
- No bulbs or capacitors to replace – light produced by diodes soldered to circuit
- Fan on actively cooled units may not be rated for 50,000hrs

Is it worth the price?

	List price	Estimated lifespan
Lumigrow 325 LED	$815.00	50,000 hrs
400W HPS Fixture	$225.95	
400W HPS Lamp	$20.95	20,000 hrs
1000W HPS Fixture	$329.95	
1000W HPS Lamp	$45.95	20,000 hrs

Prices from Farmtek.com

Are LEDs Worth it for My Business?

- Grower objectives
- Crop Type
- Geography
- Time of year
- Outdoor vs Indoor DLI
- Supplemental needs
- Dimensions of growing area
- **Cost per kwH**

Are LEDs Worth it for My Business?

(type of fixture) x (lighting plan) x (energy rates)

(energy use) x (# of fixtures) x ($/kwh)

Round 1 - Summer (Jun-Aug) 2013	LED	HPS
Relative seed yield (%)	93.5%	100.0%
Lighting power consumption (W)	1840	4600
Electrical cost (lighting only) per cycle	$152.79	$362.88

Round 2 - Fall (Oct-Dec) 2013	LED	HPS
Relative seed yield (%)	100.0%	98.2%
Lighting power consumption (W)	1840	4600
Electrical cost (lighting only) per cycle	$152.79	$318.32

Data Courtesy of Bjorn Karlsson: UW Biotron

Cutting the Cost

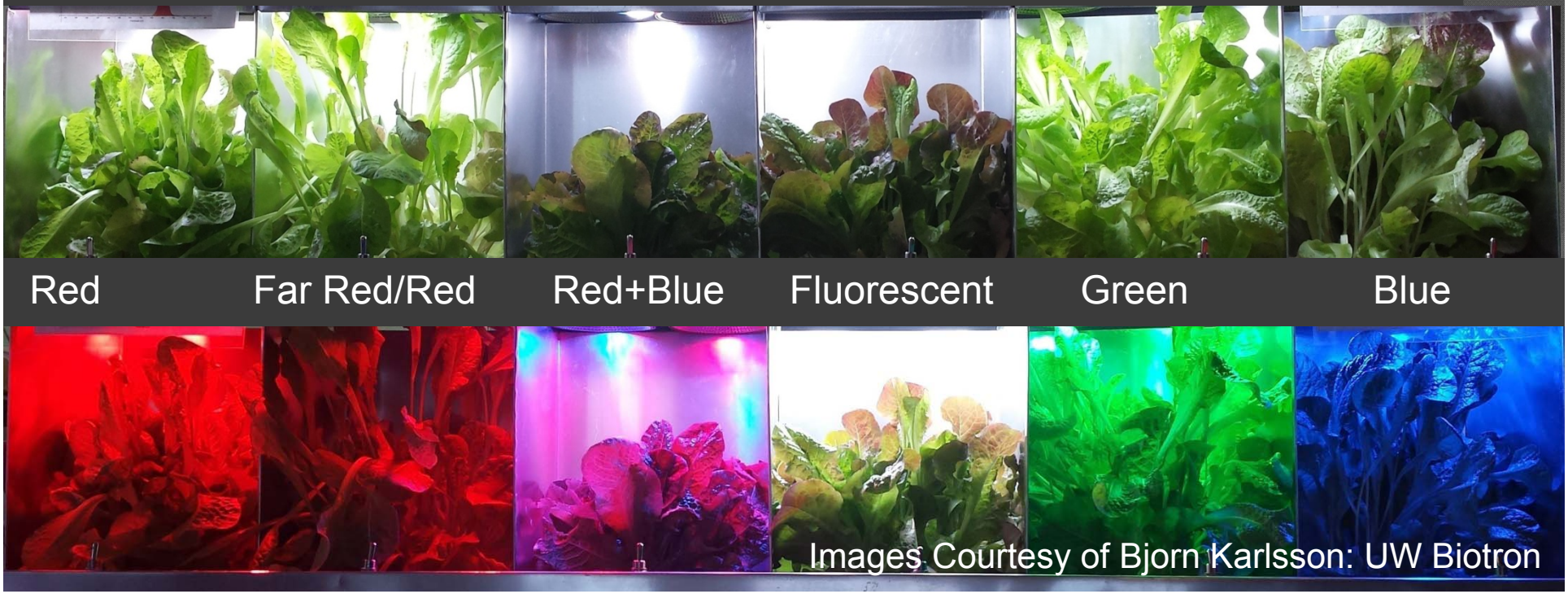
- Federal grant program – Rural Energy for America Program (REAP): https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency
- Focus on Energy: https://focusonenergy.com/business/ag-and-farms
- Other Grants: http://www.dsireusa.org/

Other uses for LEDs

- Flowering
  - Red LEDs are an alternative to incandescent and HPS for night interruption or daylength extension

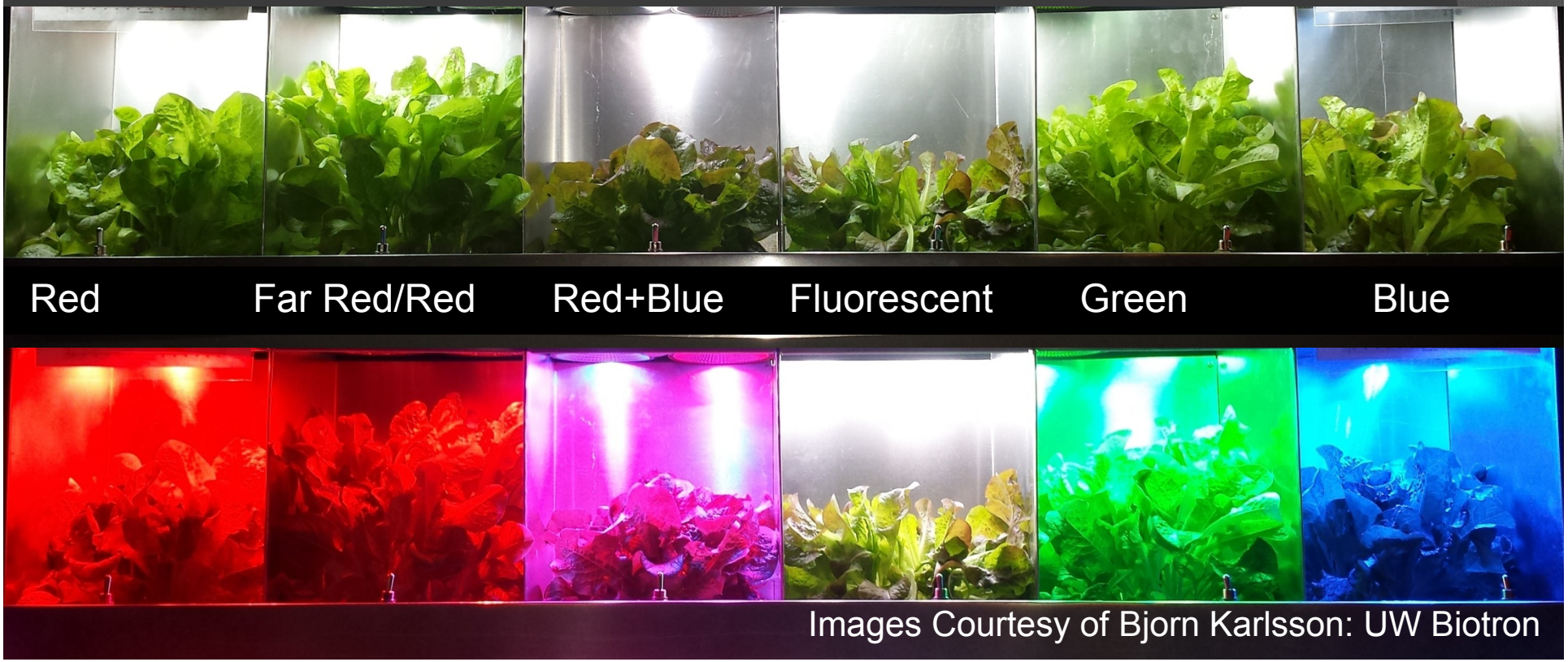
Other uses for LEDs

- Growth Regulation
  - A balance of Red and Blue wavelengths has been shown to reduce stem elongation and encourage compact growth



Other uses for LEDs

- Finishing
  - Blue LEDs help encourage red pigment production in foliage



Images Courtesy of Bjorn Karlsson: UW Biotron

Questions you should ask.

- Warranty and repair?
  - 3 year minimum (look for 5!)
- Will they provide a lighting plan?
- Is color output balanced? variable?
- How do they deal with heat output?

Other Uses for LEDs

- Coolers
- Headhouse
- Outdoors

- Check out Efficient Lighting Publications from UWEX Learning Store


Questions?
Thank you!