Using Light Spectra to Control Plant Growth and Other Aspects of LEDs

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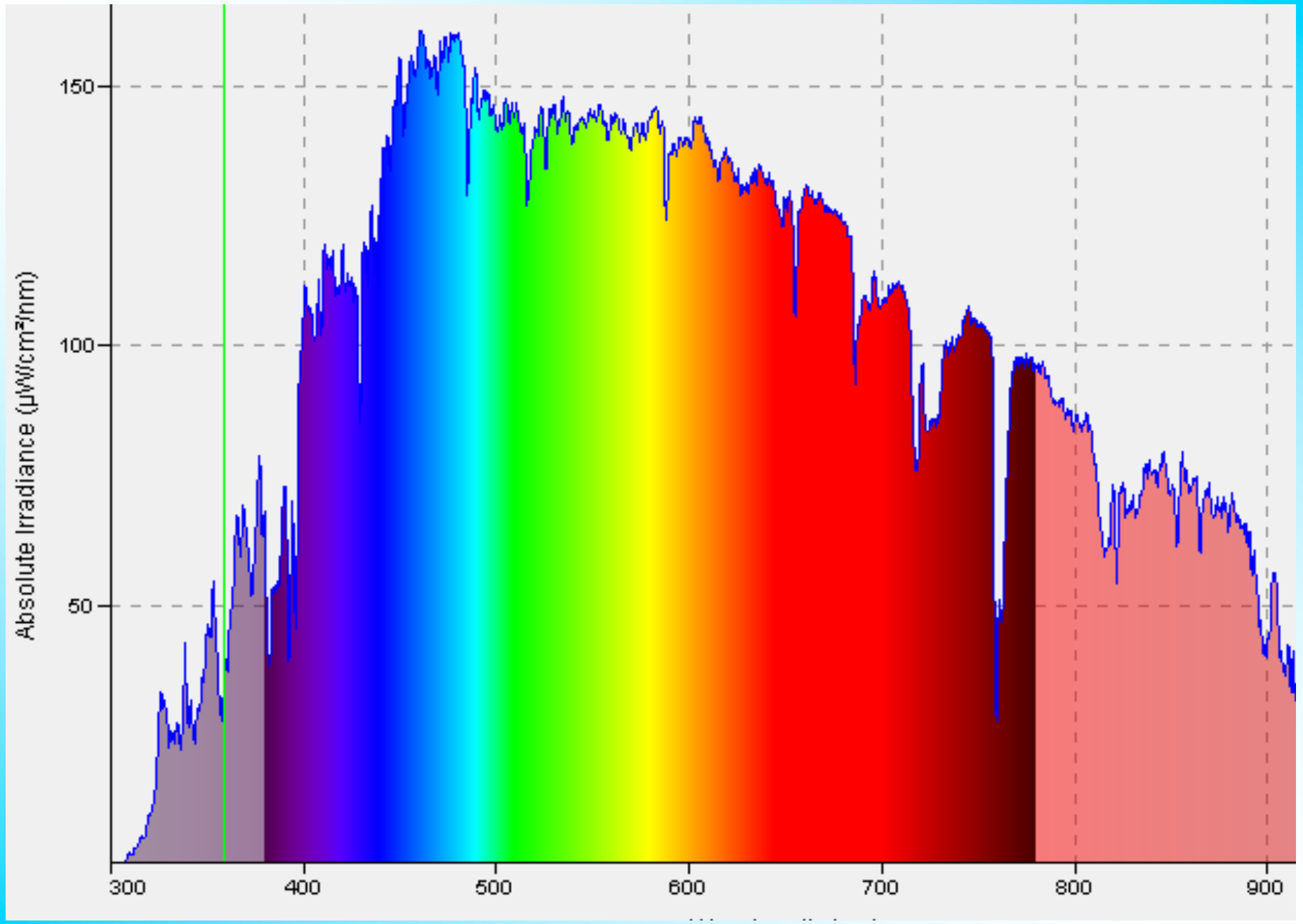
Why we need artificial lighting?

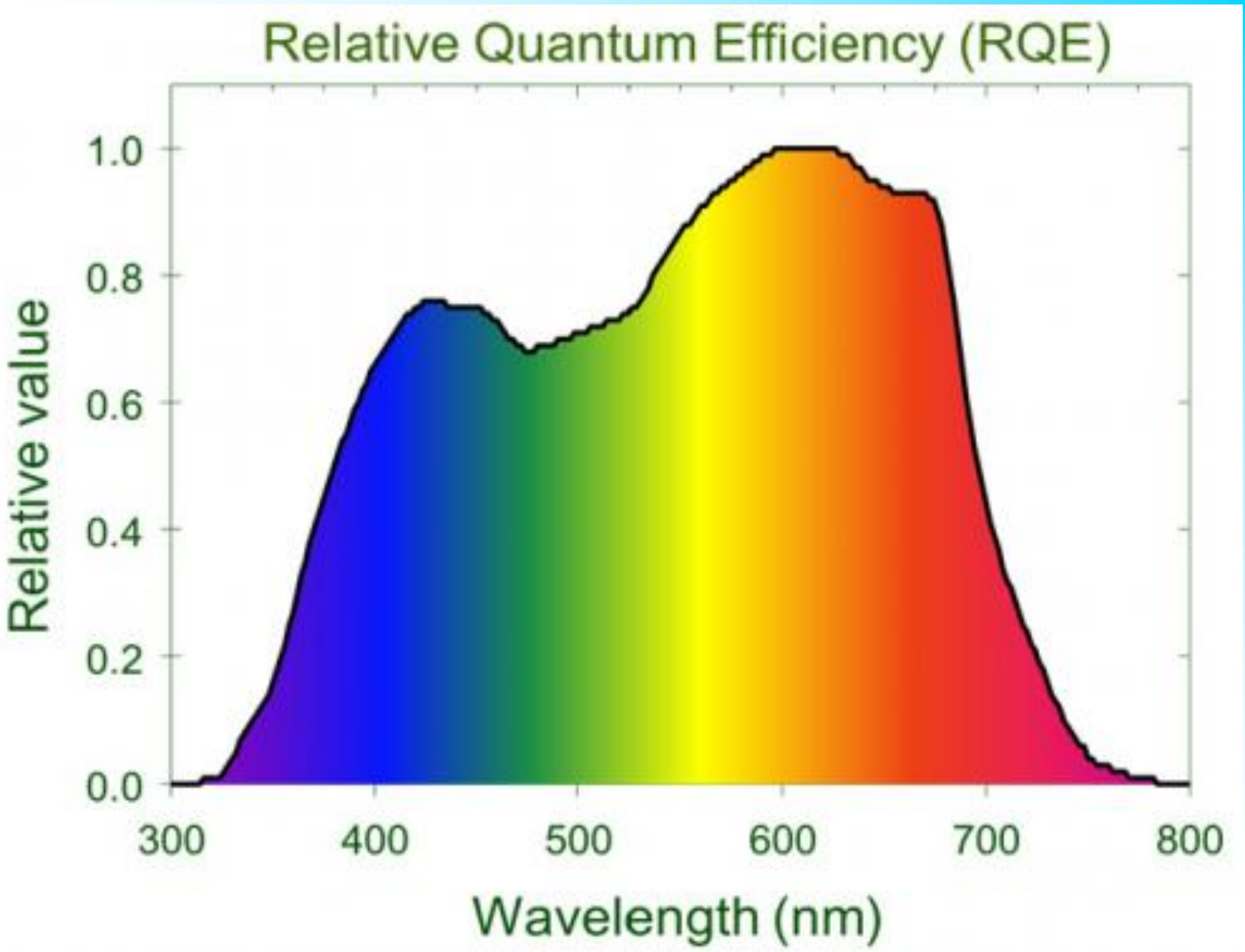
1. For photosynthesis
2. For morphology control
3. For flowering control

What light spectra are good for photosynthesis, plant growth?

100% indoor or in Greenhouse as supplemental light.



Llewellyn & Zheng, unpublished



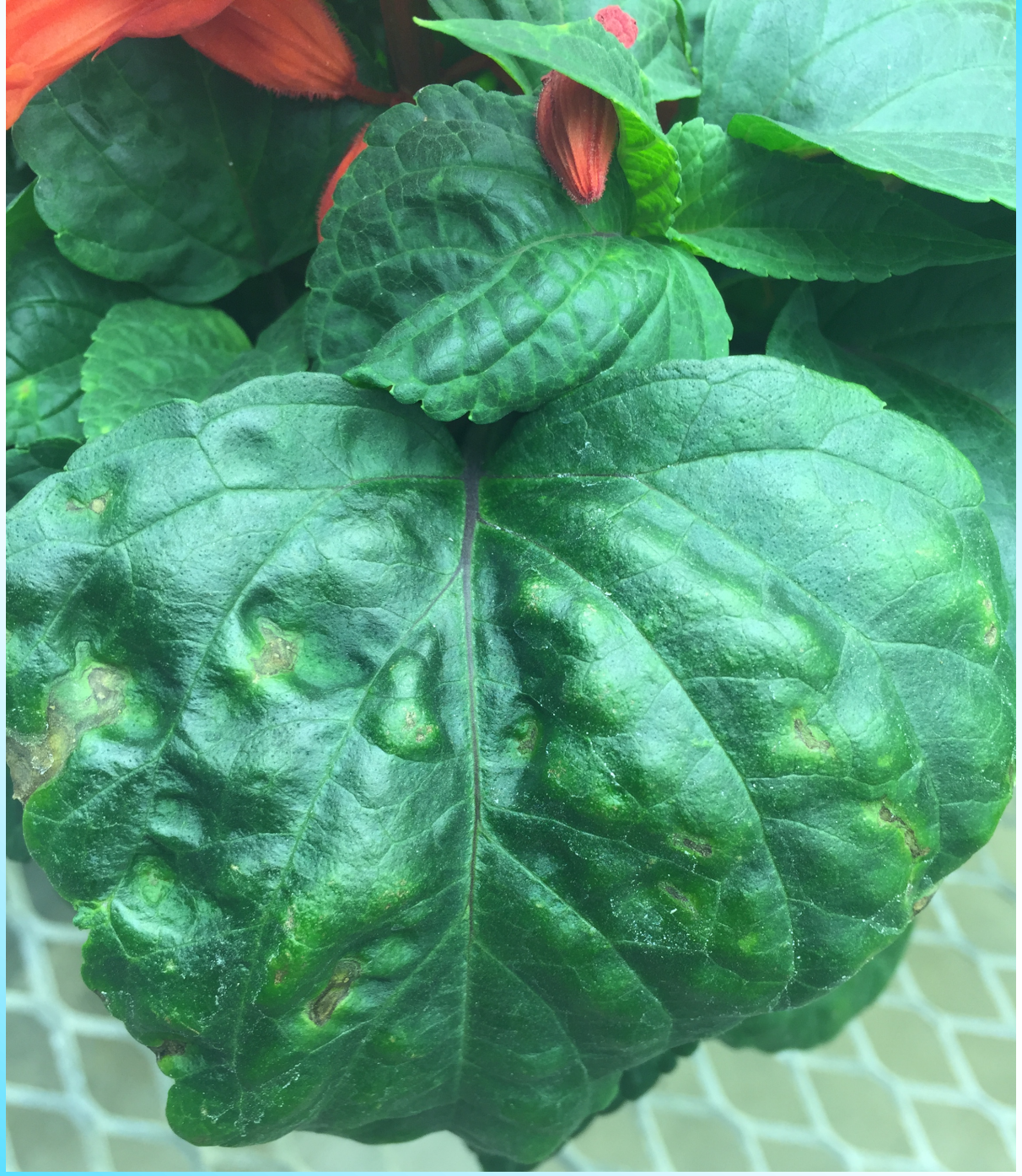
(Adapted by Erik Runkle from McCree, 1972. Agric. Meteorology 9:191-216.)

100% indoor

Parameter	RB	RGB
Leaf area (cm^2)	524.8 b[y]	689.9 a
SLA ($m^2 \cdot kg^{-1}$)	34.1 b	30.1 c
Shoot FW (g)	24.6 b	35.7 a
Shoot DW (g)	1.54 b	2.26 a
Pn (μmol $CO_2/m^2/s$)	9.3 a	8.6 a
Chl ($g \cdot m^{-2}$)	0.21 a	0.21 a
Canopy leaf temperature (°C)	20.5 a	20.4 a

Kim et al 2004

McVannel, Llewellyn & Zheng, not published



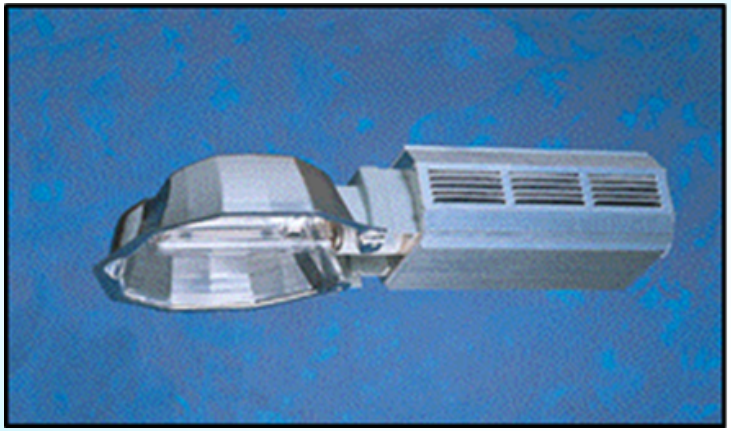
McVannel, Llewellyn & Zheng, not published

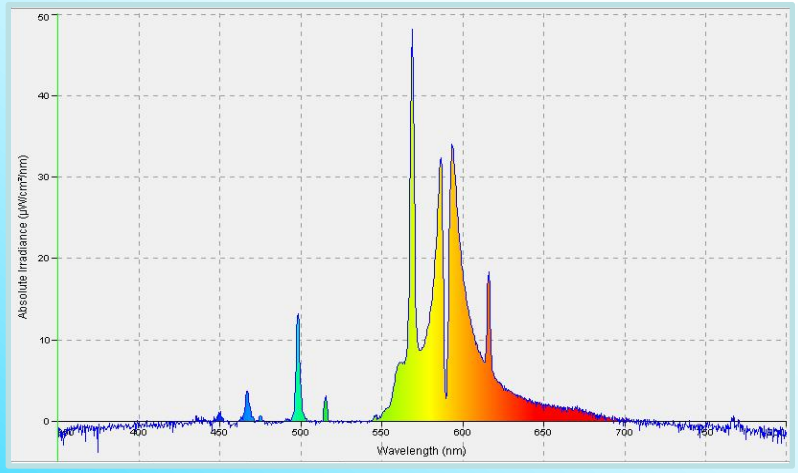
BRFRh BRFRl BR BRGl BRGl Fl

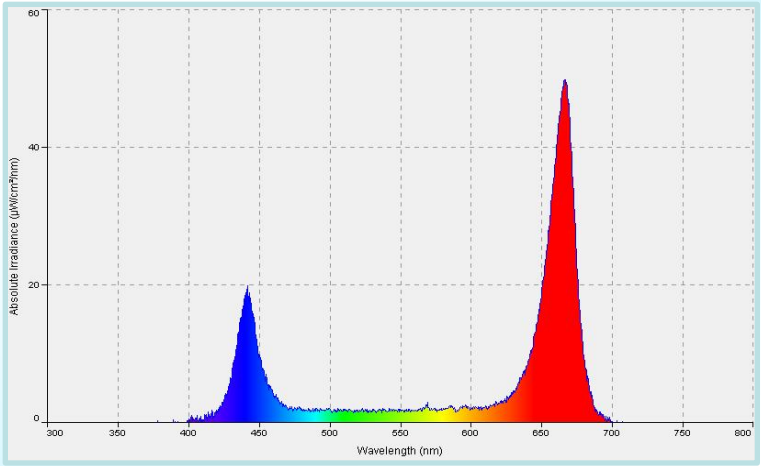
Ying, Lywellyn & Zheng unpublished

Take home message?

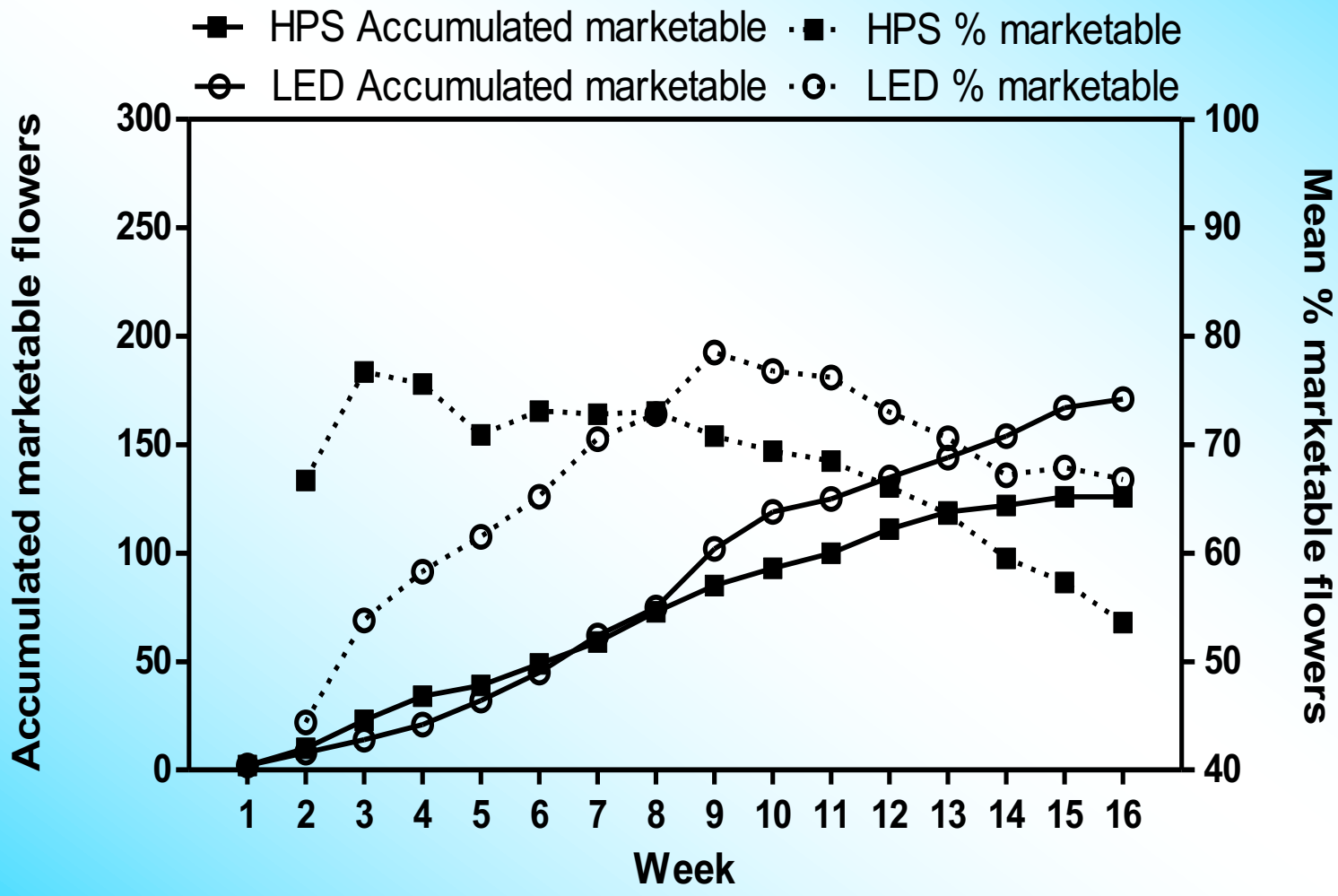
In Greenhouse as Supplemental Light







Heatwave

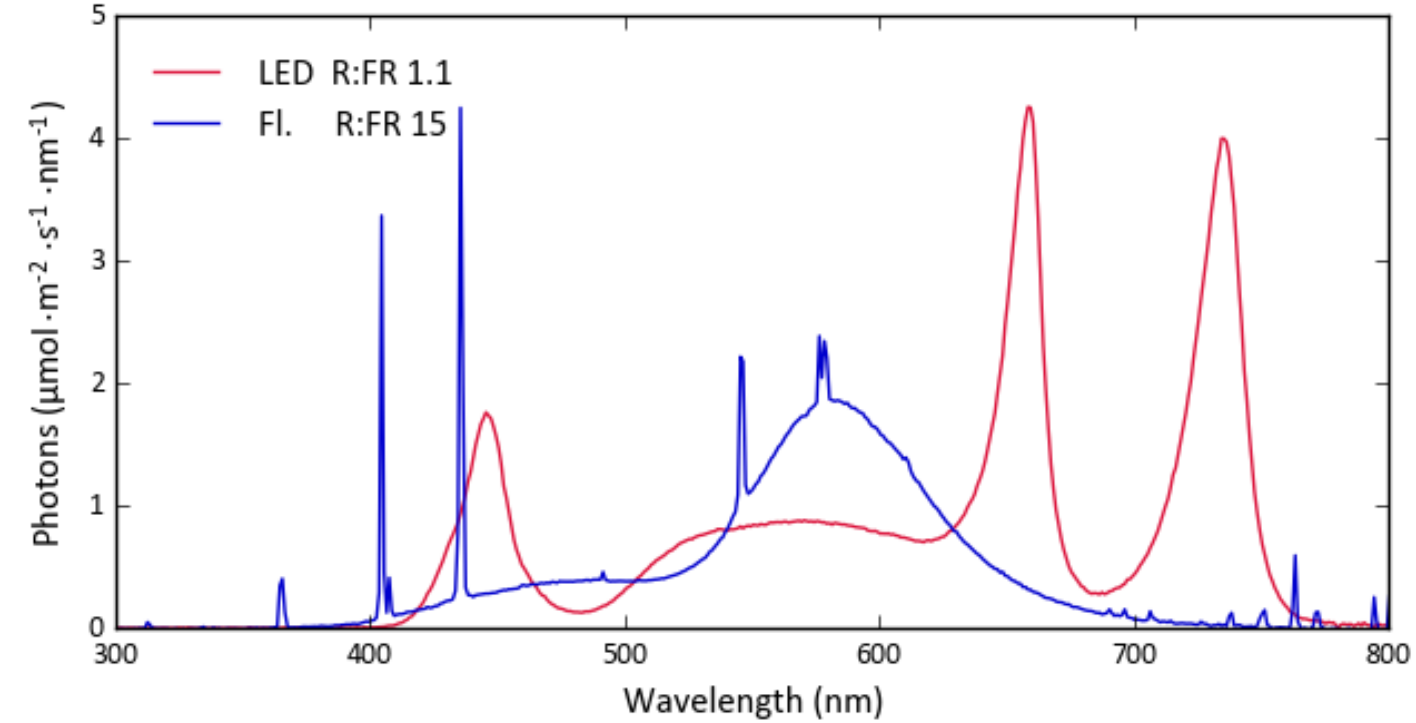


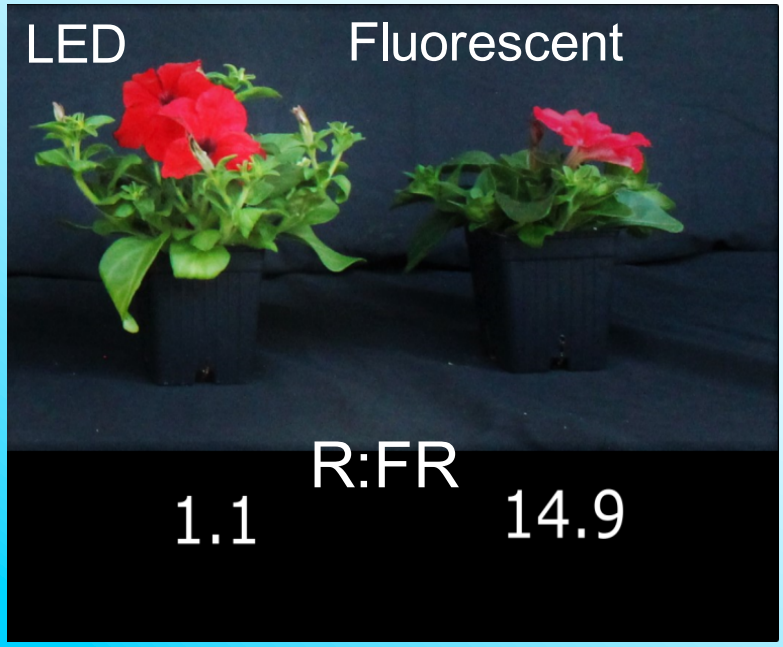
Zheng, Llewellyn & Vison, 2014

Zheng, Llewellyn & Kong, 2015

Take home message?

Light for Morphology Control





Mah, Llewellyn & Zheng (2017)

LED

Fluorescent

Mah, Llewellyn & Zheng (2017)

Llewellyn & Zheng, unpublished

Take home message?

For Flowering (photoperiod) Control

1-2 µmol/m^2/s

Photoperiodic Lamps that Work

General efficacy of different lamp types at regulating flowering.
✓ = Effective; X = Not effective; * = Some crops, esp. when DLI is high.

Lamp type		Short-day plants	Long-day plants
Incandescent		✓	✓
Fluorescent (including CFLs)		✓	X*
Mix incandescent + CFL		✓	✓
HID (HPS, MH, mercury, Beamflicker)		✓	✓
White LEDs		✓	X*
Red LEDs		✓	X*
Red + far-red LEDs		✓	✓
Far-red LEDs	At low intensity	X	X
Blue LEDs	At low intensity	X	X
Green LEDs	At low intensity	X	X

Runkle, 2016

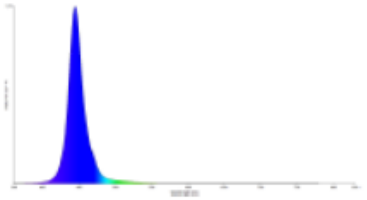
Not all the LEDs are the same!

P.L. Light Systems

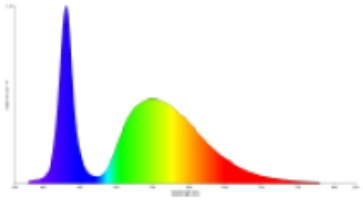
TECHNOLOGIES – LED COLOUR SPECTRA EFFICIENCY

LED color efficiency:

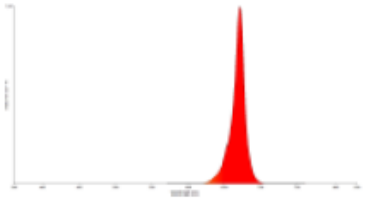
460nm deep blue 2,4 µmol/J



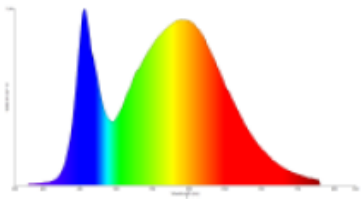
6500K cold white 2,0 µmol/J



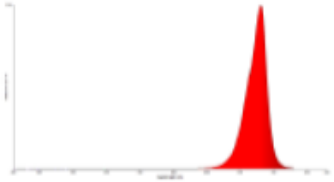
660nm hyper red 3,0 µmol/J



4000K neutral white 2,0 µmol/J



730nm farred 2,0 µmol/J



Different manufacturers may use different technologies and the LEDs can be very different!!

- Highest measured efficacies (so far)

Lamp type	Power consumption (W)	Efficacy (µmol/J)
INC	102.4	0.32
CFL	61.4	0.89
LED (INC replacement)	17.2	1.39
HPS (mogul)	700	1.56
HPS (double ended)	1,077/1234	1.59
LED (Horticulture)	214	2.39

From:
Wallace, C. and A.J. Both. 2016. Evaluating operating characteristics of light sources for horticultural applications. Acta Horticulturae 1134:435-443.

- Proposed horticultural lighting label

Quick Facts Lighting Label, Horticultural Applications

Brand	Valoya
Model	R150 NS1
Lamp type	LED

PAR flux (µmol/s)	191.4
PAR efficacy (µmol/J)	1.44
PAR efficacy (mol/kWh)	5.17

Voltage (VAC)	120
Current (A)	1.11
Power (W)	133.3

Luminous flux (lm)	12480
CCT (K)	4949
CRI (R_a)	80.0

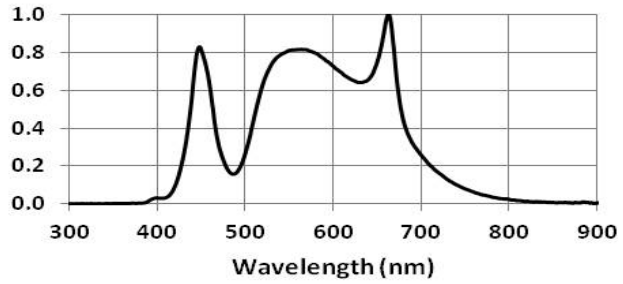
Case temperature (°C) 55.0

Photon flux (at 61 cm mounting height):

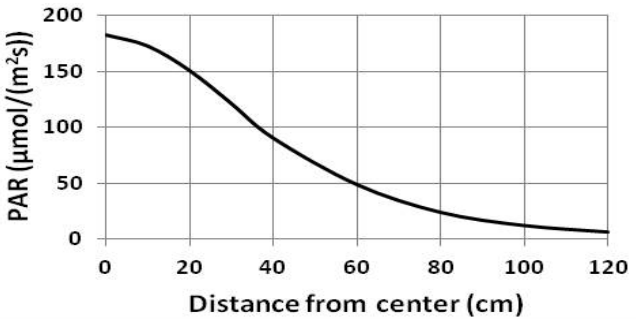
Waveband (nm)	Photon flux (µmol/(m²s))
300-399	0.7
400-499	35.1
500-599	77.9
600-699	70.4
700-799	11.2
800-900	1.3
300-900	196.6

Measurements performed according to IESNA LM-79-08: *Approved Method for Electrical and Photometric Measurements of Solid-State Lighting Products*

Normalized photon flux:



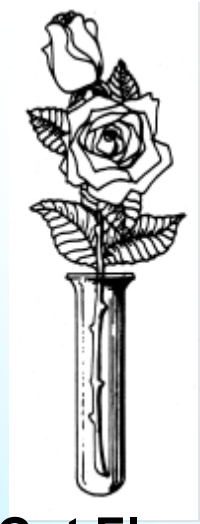
PAR intensity (at 61 cm mounting height):



Manuscript in preparation:
Both, A.J., B. Bugbee, C. Kubota, R. Lopez, C. Mitchell, E. Runkle, C. Wallace. 20xx. Proposed product label for electric lights used in horticulture and plant biology.

Then how do I choose the right one for my operation then?

THANKS



David Llewellyn
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International Cut Flower Growers Association
Joseph H. Hill Memorial Foundation, Inc

Ontario
Ministry of Agriculture, Food and Rural Affairs

heliospectra

LumiGrow
The power of spectrum control.

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THANKS