Increasing the Value of Horticultural Crops using LEDs

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First Things First

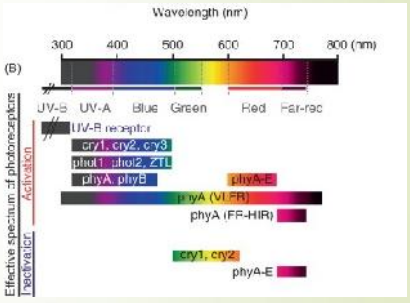
This is not photobiology…

First Things First

This is photobiology!

Photobiology Primer

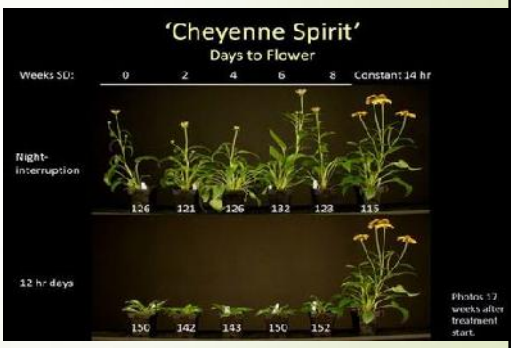
- Plants perceive light with a variety of proteins
  - Photoreceptors
- Photoreceptors turned "on" or "off" by specific wavelengths of light
- Photoreceptors interact with other proteins to drive gene transcription



Kami *et al.* Plant Development **91**, 29 (2010)

Photobiology Primer

- "Tricking" plants to induce flowering
  - Night Interruption
  - Shade Cloth
- Regulated by Phytochrome proteins
  - Interaction with proteins that regulate Circadian rhythm



Ryan Warner (2014)

What's Light Got to Do with It?

- Photoreceptors mediate the production of phytochemicals:
  - Carotenoids
  - Polyphenolics
  - Glucosinolates
- Light quality can influence the emission of volatiles
  - Derived from carotenoids, amino and fatty acids
  - Consumers recognize these compounds as flavors

Image courtesy of D.A. Kopsell

What's Light Got to Do with It?

- Broccoli Microgreens:
  - 20% Blue,80% red (250 µmol·m^{-2}·sec^{-1}): highest β-carotene, lutein, and total carotenoids
  - Per 7g seed, yielded 72g compared to 51g (Inc/Flor.)
  - All LED treatments had significantly higher total carotenoids compared to Inc/Flor. control

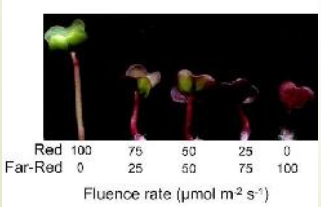
Inc/Flor **5:10:85 RBG** **5:95 RB** **20:10:70 RBG** **20:80 RB**

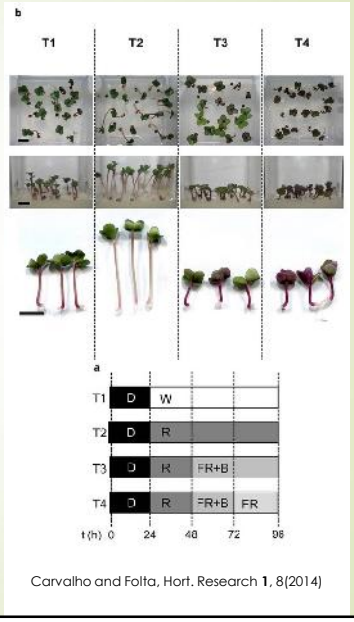
Kopsell et al., JASHS vol. 139(4): 469-477 (2014)

Images courtesy of D.A. Kopsell

What's Light Got to Do with It?

- Red Russian Kale Sprouts:
  - Anthocyanins affected by light quality and quantity
  - Glucosinolates increased from Far-Red light
  - Noticeable differences in morphology





Carvalho and Folta, Hort. Research **1**, 8(2014)

What's Light Got to Do with It?

- Baby 'Green Lance' Chinese Kale:
  - LED treatments (90:10, 80:20, 40:60 Red:Blue) (250 $\mu mol \cdot m^{-2} \cdot sec^{-1}$):
  - β -carotene and Lutein significantly higher compared to Inc/Flor control
  - Fresh and dry weight of all LED-grown plants lower than Inc/Flor control
  - Premium price for value added properties?

Image courtesy of D.A. Kopsell

Kopsell et al., 2014 Hort. Science, 49(9):S330. (2014)

What's Light Got to Do with It?

- Baby Leaf Lettuce:
  - Flor. Light supplemented UV-A, blue, green, red, or far-red LEDs
  - Phenolics increased with red light
  - β-carotene and xanthophylls increased in blue light
  - Far-red decreased anthocyanins, carotenoids, and chlorophyll, but had highest leaf dry mass and leaf area

Image from "Johnny's Seeds"

Li and Kubota. Environmental and Expt. Bot. 67:59-64 (2009)

What's Light Got to Do with It?

- Volatile Organic Compounds
  - Derived from carotenoids, amino, and fatty acids
  - Evidence that the aroma of petunias, tomatoes, blueberries, and strawberries can be manipulated with light (Colquhoun et al. 2013)
  - LEDs could be used postharvest to enhance the flavor of high-value produce
  - Lengthen shelf life?

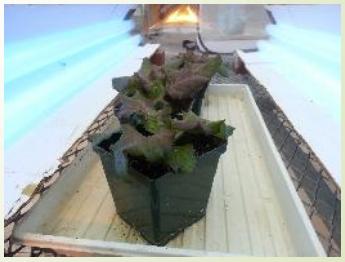
Njbmagazine.com

Supplementation of fruit clusters with Ultraviolet Radiation

Intracanopy supplementation with LEDs

Supplementing with UV-B Radiation

- UV-B is a powerful elicitor of secondary metabolism
- Blocked by greenhouse glass
- Could it be the difference between the taste of a garden-grown tomato and a greenhouse grown tomato?



Intracanopy LED Lighting

- Red, Blue, and Far-Red impact secondary metabolism
  - Regulate the accumulation of carotenoids and polyphenolics
- Could we enhance the healthfulness or flavor of greenhouse tomatoes with unique light recipes?
- How will these treatments affect plant growth and development?

Analyses

- Sugars, Acids, and Vitamin C
- Polyphenolics: LC-ESI(-)-MS
- Carotenoids: UV/Vis Spectrophotometry
- Gene Expression: qRT-PCR
- Volatiles: GC-MS
- Sensory Panels

Questions?

Images collected by William Meng

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