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MICHIGAN STATE UNIVERSITY

# Light intensity and photoperiod

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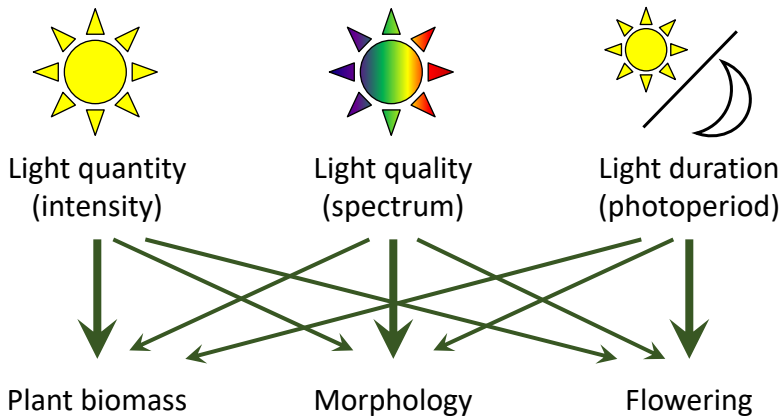
## Three Dimensions of Light for Plants




The different properties of light interact to control growth and development of plants

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## Photoperiod

- The number of hours of light per day
- The length of the night controls flowering of daylength-sensitive crops
- Many indoor crops are grown under 16- to 20-hour days
- Some solanaceous crops develop intumescence (edema) and abnormal growth under 20+ hours of light per day
- Plants perceive very low intensities (0.1-0.5 µmol·m$^{-2}$·s$^{-1}$, sometimes less)

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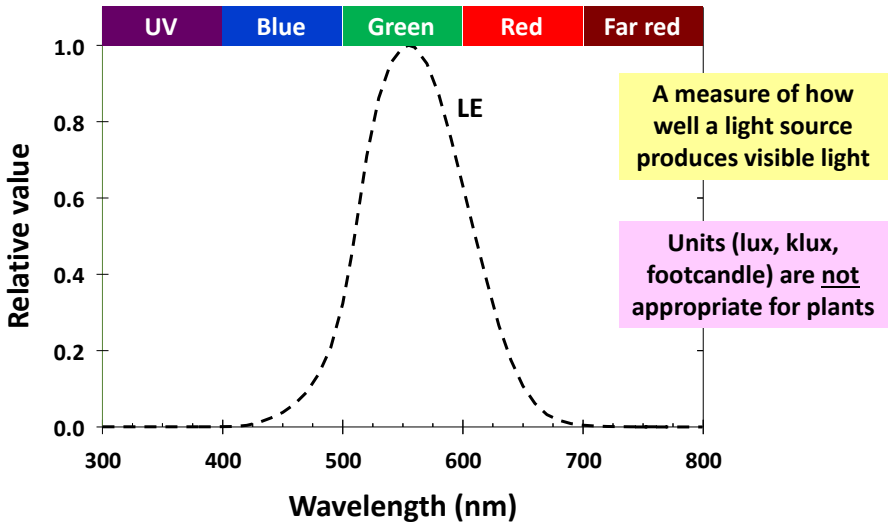
## Luminous Efficacy (LE)

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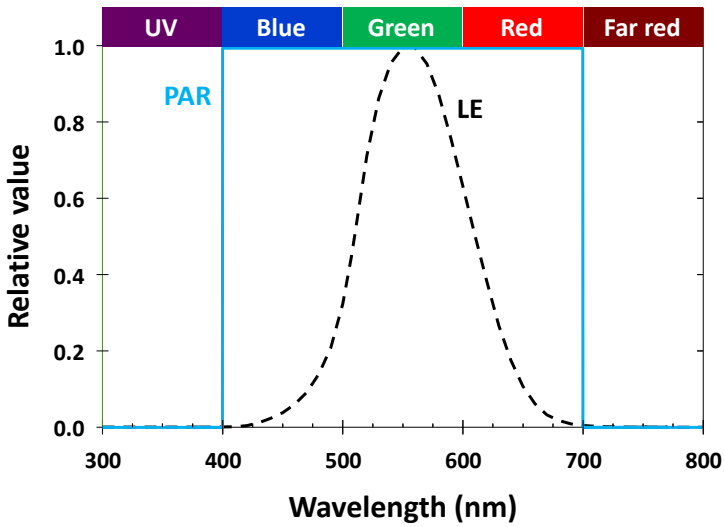
## Photosynthetic Active Radiation (PAR)

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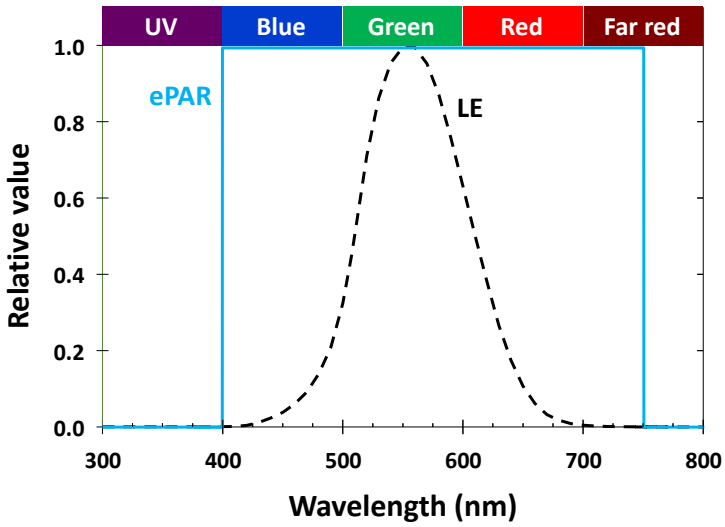
## Extended Photosynthetic Active Radiation (ePAR)

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# Light Intensity

**Instantaneous (per second)**

- Photosynthetic photon flux density (PPFD; 400-700 nm)
- Total photon flux density (TPFD; 300-800 nm)
- Unit: $\mu mol \cdot m^{-2} \cdot s^{-1}$

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- Total photon flux density (TPFD; 300-800 nm)
- Unit: $\mu mol \cdot m^{-2} \cdot s^{-1}$
- Measured by a quantum (PAR/ePAR) sensor/meter

Apogee Instruments

LI-COR


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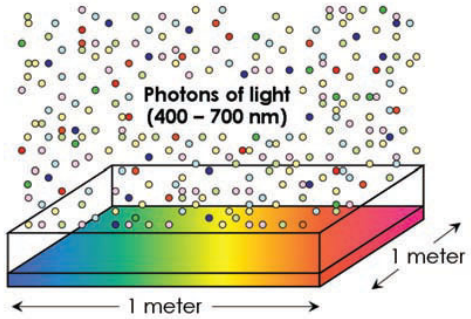
## Light Intensity

**Cumulative (per day)**

- Photosynthetic daily light integral (DLI), which is the integrated daily PPFD
- Unit: $mol \cdot m^{-2} \cdot d^{-1}$

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## Light Intensity

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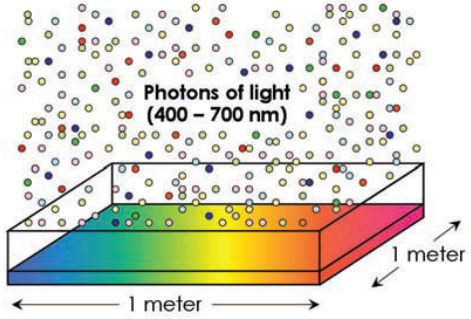
- Unit: $mol \cdot m^{-2} \cdot d^{-1}$
- For indoor lighting, can be calculated:
  PPFD × 3,600 s/h × h/d ÷ 1,000,000
- Example with 16-hour day:
  250 $\mu mol \cdot m^{-2} \cdot s^{-1}$ × 3,600 s/h × 16 h/d ÷ 1,000,000 = 14.4 $mol \cdot m^{-2} \cdot d^{-1}$

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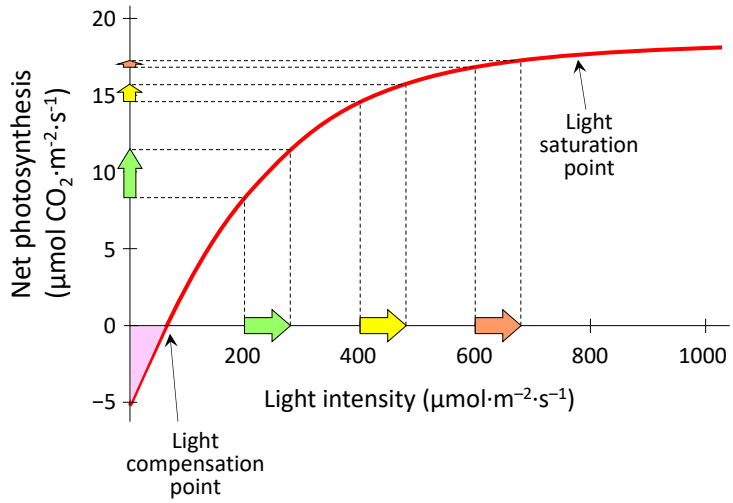
## Typical Plant Response to Light Intensity

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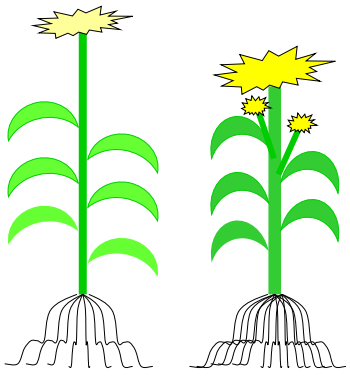
## General Plant Responses to DLI

- Leaves (smaller and thicker)
- Branching (increased)
- Stem diameter (increased)
- Root growth (increased)
- Time to flower (faster, due partly to temperature)
- Flowers (more and larger)
- Fruit (more and larger)

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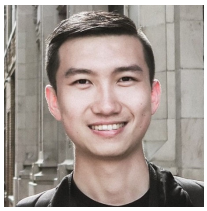
## Photoperiod × Light Intensity → DLI

Nathan Kelly



Qingwu Meng

Kelly, N., D. Choe, Q. Meng, and E.S. Runkle. 2020. Sci. Hort. (article 109565).

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March 2022

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## Photoperiod × Light Intensity → DLI

- Constant temperature of 72 °F (22 °C)
- Ambient $CO_2$ concentration
- 12 lighting treatments:
  - Photoperiods of 16, 20, or 24 hours
  - PPFDs from 120 to 270 $\mu mol \cdot m^{-2} \cdot s^{-1}$
  - DLIs from 6.9 to 15.6 $mol \cdot m^{-2} \cdot d^{-1}$

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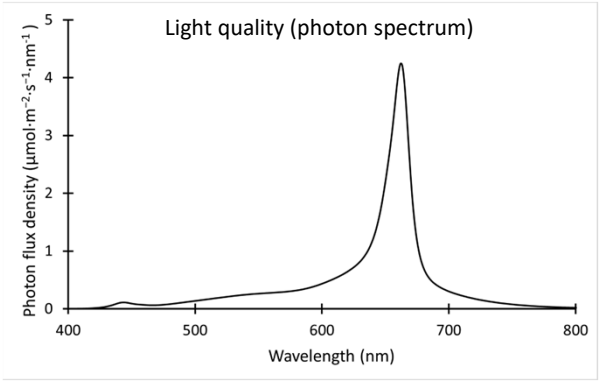
  - PPFDs from 120 to 270 µmol·m$^{-2}$·s$^{-1}$
  - DLIs from 6.9 to 15.6 mol·m$^{-2}$·d$^{-1}$
- 50% warm-white and 50% red LEDs
- Plants harvested 27 or 28 days after seed sowing

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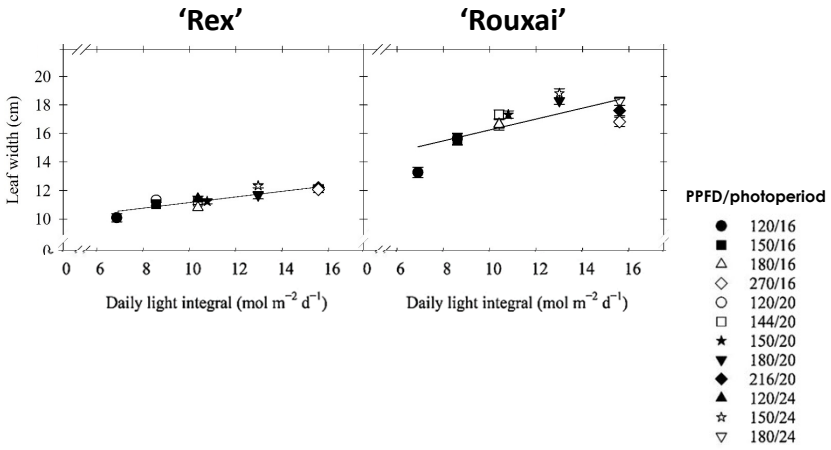


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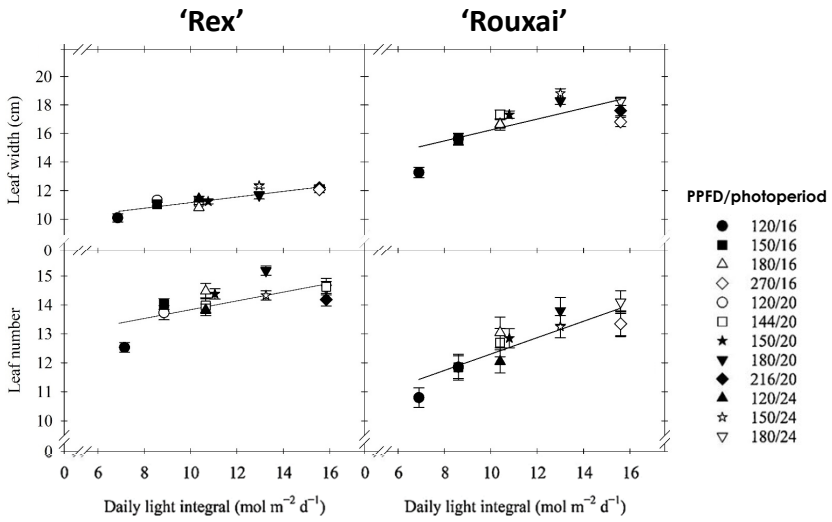


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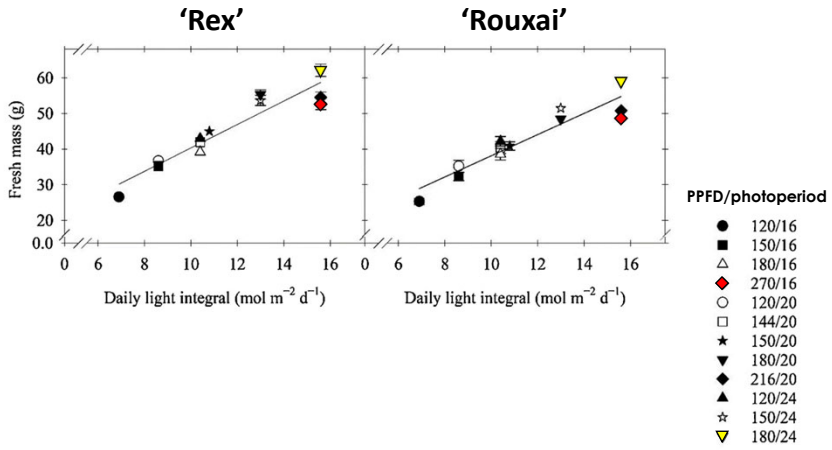


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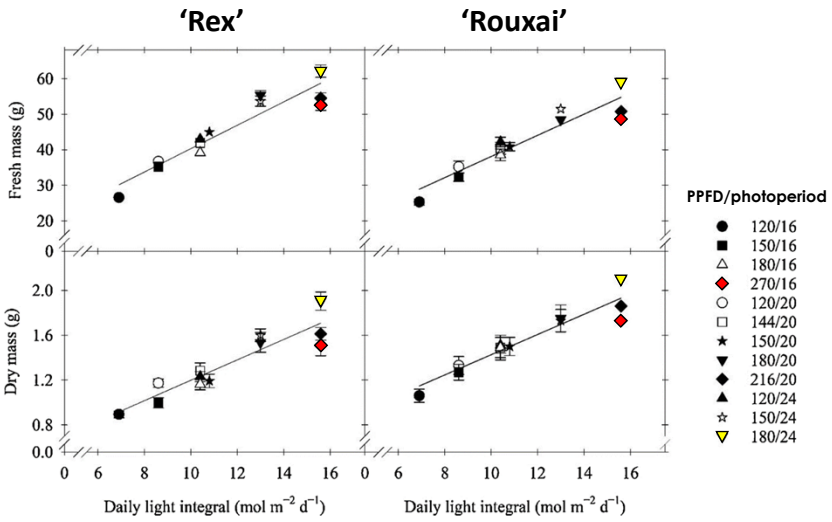


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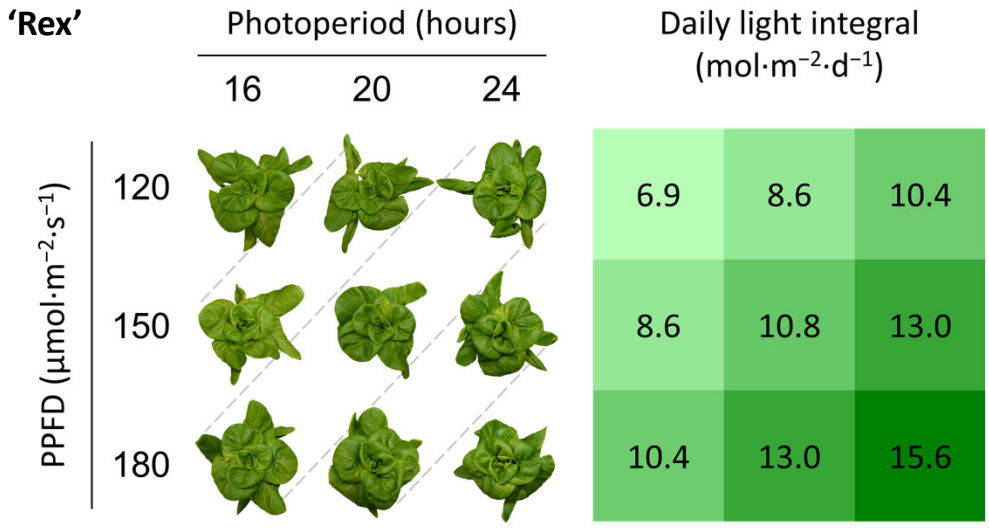


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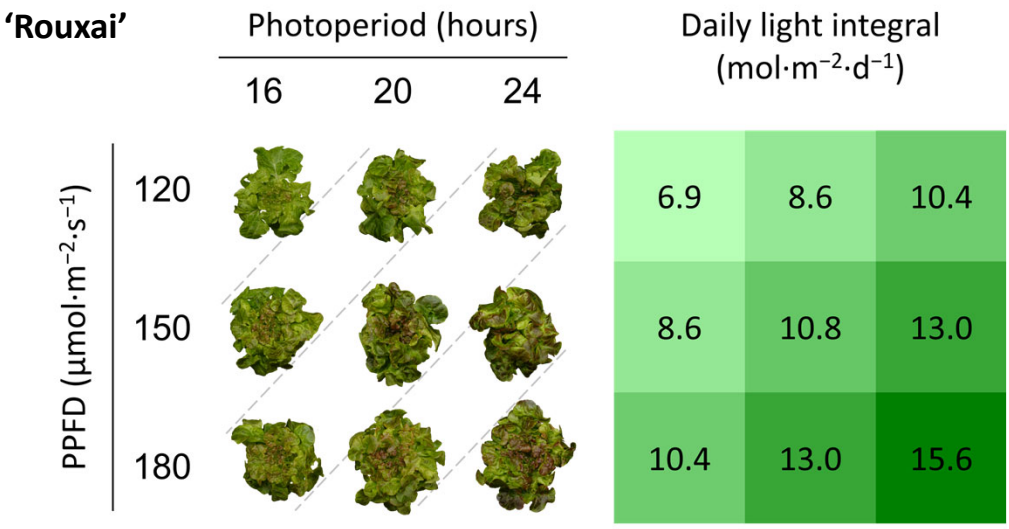


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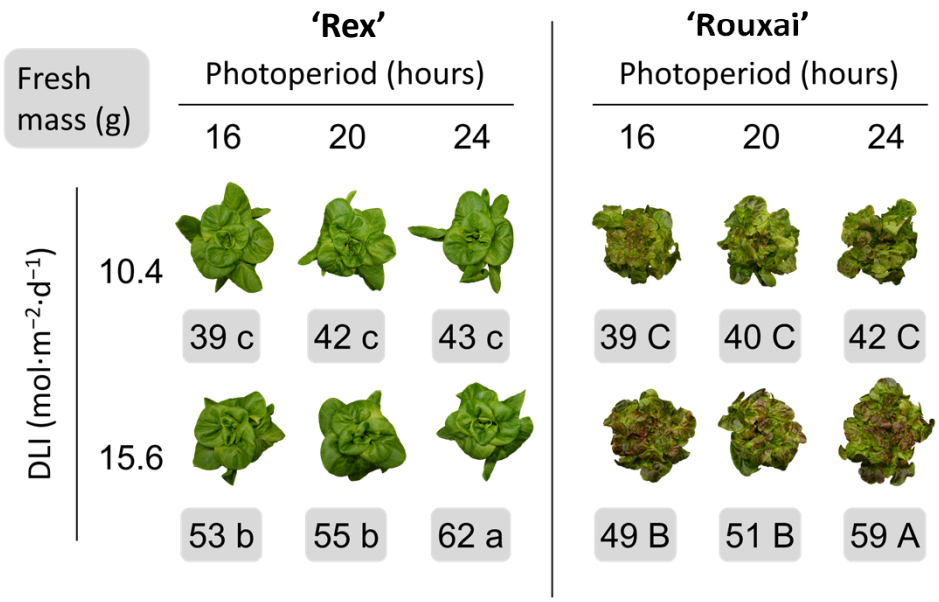


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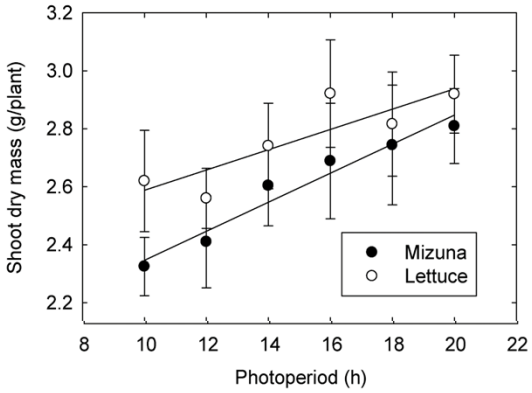
## Photoperiod × Light Intensity → DLI

- Constant temperature of 68 °F (20 °C) with 819 ppm $CO_2$
- 6 lighting treatments:
  - Photoperiods of 10 to 20 hours
  - PPFDs from 222 to 444 µmol·m$^{-2}$·s$^{-1}$
  - DLI of 16 mol·m$^{-2}$·d$^{-1}$
- Mostly cool-white with red LEDs
- Plants harvested 30 (mizuna) or 51 (lettuce) days after seed sowing




Palmer, S. and M.W. van Iersel. 2020. Agronomy 10(11):1659

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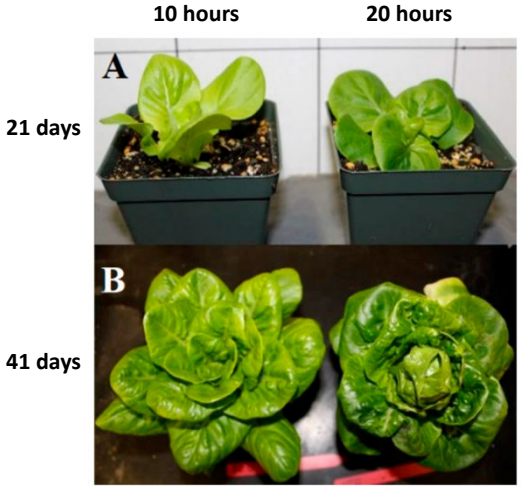


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## Indoor Lighting Guidelines

- Intensity and uniformity are equally important
- Non-uniform light intensity and spectrum leads to non-uniform plant growth
- As light intensity to crops increases:
  - Capital cost of lighting ↑
  - Operational cost of lighting (and HVAC) ↑
  - Biomass ↑ (to a point)
  - Utility of CO2 enrichment ↑

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For questions, please contact Erik Runkle: runkleer@msu.edu

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