AmericanHort Presents Cultivate'23

Essentials of Hydroponics Production
July 15, 2023

Supplemental lighting technology for crop production

RUTGERS

A.J. Both
Dept. of Environmental Sciences

- What am I talking about?
  - Solar radiation (UV + visible light + heat): 200 - 3,000 nm*
  - Visible light (colors of the rainbow): 380 - 770 nm
  - Photosynthetically active radiation (PAR): 400 - 700 nm
  - Extended PAR (ePAR): 400 - 750 nm
  - Measuring the impact of solar radiation on plants:
    - Pyranometer, units: $W \cdot m^{-2}$ (radiant watt)
  - Measuring the impact of PAR/ePAR on plants:
    - Quantum sensor (designed to measure PAR or ePAR)
      - $\mu mol \cdot m^{-2} \cdot s^{-1}$ (instantaneous intensity)**
      - $mol \cdot m^{-2} \cdot d^{-1}$ (Daily Light Integral, DLI)
  - Measuring the impact of light spectrum on plants:
    - Spectroradiometer, units: $\mu mol \cdot m^{-2} \cdot s^{-1} \cdot nm^{-1}$
    - Waveband determined by instrument

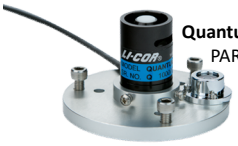
*1 nanometer (nm) equals $1 * 10^{-9}$ meter (human hair: 20,000 - 180,000 nm)
**1 mole of photons (quanta) equals Avogadro's number ($6.022 * 10^{23}$) of photons

- Light meters/sensors

Visible light

http://img.directindustry.com

http://img.directindustry.com



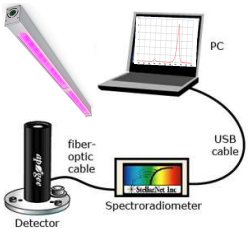
Quantum sensor
PAR/ePAR

Pyranometer
Solar radiation

https://www.licor.com/

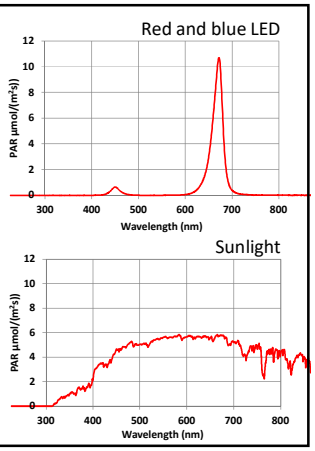
https://www.campbellsci.com/

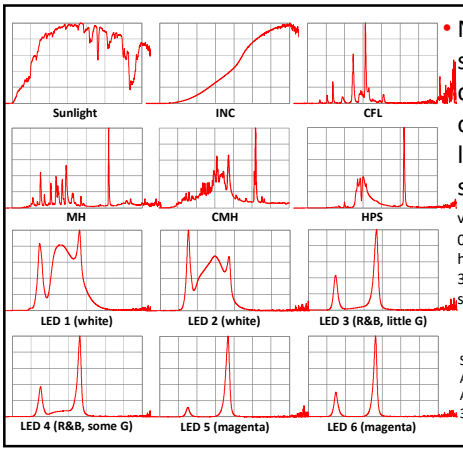
- Spectroradiometer



https://www.apogeeinstruments.com/

Mostly a scientific instrument

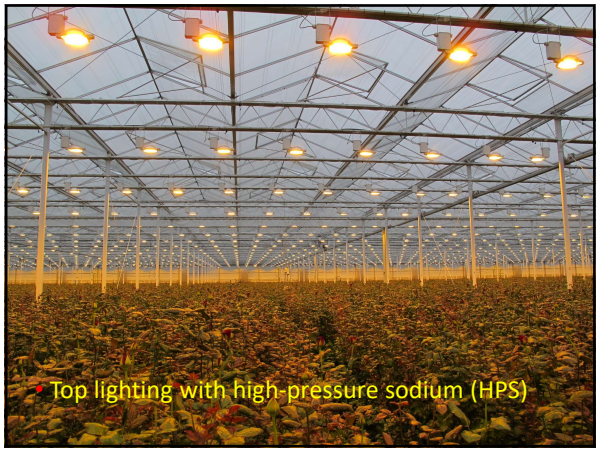




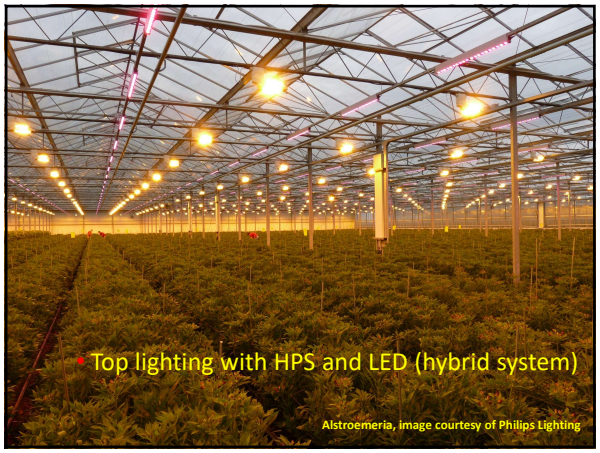
- Normalized spectral distribution of different light sources

vertical scale: 0-1 in steps of 0.2, horizontal scale: 300-1,000 nm in steps of 100 nm

Shelford, T.J. and A.J. Both. 2021. AgriEngineering 3:716-727

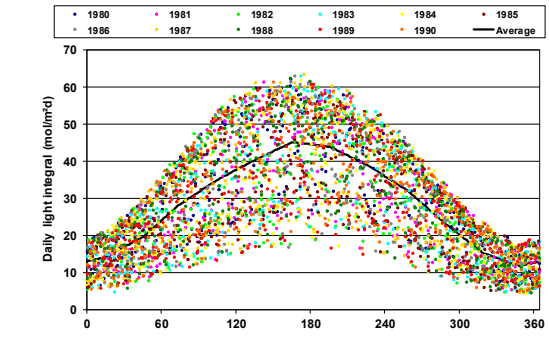


- Top lighting with high-pressure sodium (HPS)



- Challenges
  - People underestimate the amount of light plants need for photosynthesis
  - As a result: Large electrical installations are needed
  - Installation and operating costs
  - All fixtures produce heat (65-75% of input energy)
  - Radiant heat (HPS) is more difficult to deal with
  - LED technology provides more options: Learning curve
  - Best lighting recipes can be crop and cultivar specific
  - Measuring light (sensor location, calibration)
  - Finding the best fixture for a specific application
  - Environmental impact (source of electricity, disposal)
  - Variability of solar radiation (temporal, spatial)
  - Light transmission through the growing structure

- Outside daily light integrals (DLIs) for Newark, NJ

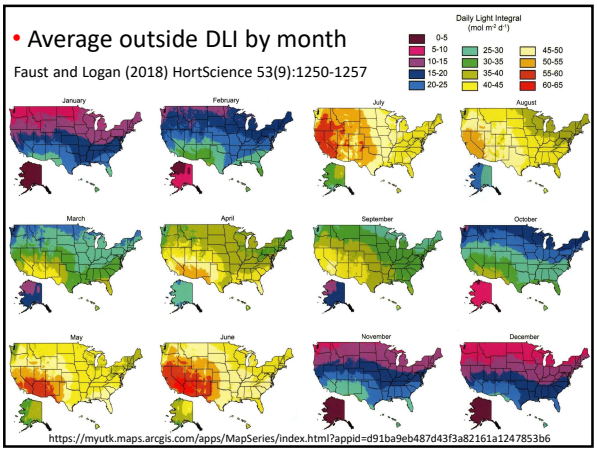


Columbus, Ohio has approximately the same latitude (40°N)

Data source: National Renewable Energy Laboratory

- Average outside DLI by month

Faust and Logan (2018) HortScience 53(9):1250-1257



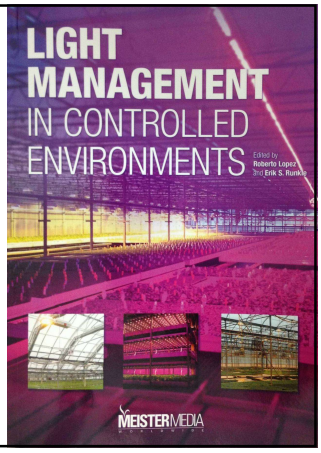
- Light transmission through the growing structure
  - Depends on:
    - Time of year (season) and time of day
    - Location and orientation of the structure
    - Roof angle
    - Glazing material
    - Structural design and components
    - Overhead equipment and/or plants
    - Use of any energy/shade curtain
  - Average annual values: 50-70%

- Lighting control options
  - On-off (manual or on a timer)
  - Computer
    - Integrated with other environmental parameters
    - Adjusting intensity (dimming)
    - Adjusting the spectrum (daily or as the plant develops)
    - Delivering a target DLI (aiming for predictable growth)
    - Continuous (remote) monitoring
    - Running multiple zones using different targets/set points
    - Keeping a detailed record (assessment/future decisions)

- Useful resources
  - Project LAMP (https://www.hortlamp.org/)
    - Includes lighting cost calculators for greenhouses
  - Project OptimIA (https://www.scri-optimia.org/)
    - Focuses on indoor agriculture
  - GLASE (https://glase.org/)
    - Focuses on lighting and control systems
  - Horticultural lighting manufacturers
    - Detailed fixture specifications
    - Installation designs
  - DesignLights Consortium (https://www.designlights.org/)
    - Database with fixtures meeting certain standards

- Recommended reference
  - Topics:
    - Photosynthesis and plant growth
    - Plant morphogenesis
    - Photoperiod lighting
    - Sole-source lighting
    - Light transmission and shading
    - Technology and costs
    - CO_2 enrichment
    - Crops:
      - ✓ Young plants
      - ✓ Bedding plants
      - ✓ Herbaceous perennials
      - ✓ Potted plants
      - ✓ Cut flowers
      - ✓ Fruiting vegetables
      - ✓ Leafy greens

2017



Thank You!!!

Questions?

both@sebs.rutgers.edu