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THRIVE AGRITECH

Trends and Technologies in Horticultural Lighting

Designers Lighting Forum
Brian Bennett, LC
Tuesday March 7th, 2023

CONTINUING EDUCATION AIA

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Learning Objectives

At the end of this course, participants will be able to:

1. Obtain a deeper understanding of the benefits of LED lighting for horticulture over traditional technologies such as high pressure sodium.

2. Gain an understanding of the energy savings attributable to LEDs vs older technologies and typical rebates offered by utility companies.

3. Learn about the market drivers and key horticulture applications now and the emerging applications in the next 5-10 years.

4. Obtain an understanding of the regulatory standards used in horticulture lighting and how they are different from general lighting.

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Agenda

- Industry history and background
- Technical Aspects of horticultural lighting
- Overview of Market Segments and Dynamics

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Thrive Agritech

- Thrive Agritech was founded in 2015 after initial funding from Y-Combinator.
- Thrive designs and manufacturers LED lighting products for indoor, greenhouse, and vertical farming applications.
- We are a distributed team throughout the U.S. with manufacturing in China (and Thailand in 2023).

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Background

Agriculture:

The science or practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, clothing, and other products.

Controlled Environment Agriculture (CEA):

A technology-based approach to farming where certain aspects of the environment are controlled to reduce pest or disease, increase efficiencies, increase yields or save costs.

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Background

There are several stages in the history of agriculture, which have been shaped by technological advancement, societal changes and economic factors.

- **The Neolithic Revolution**: around 10,000 BC, marked the transition from hunting and gathering to settled agriculture
- **The Medieval Period**: around the 5th to 15th century AD, feudal systems of land ownership emerged and new technologies like the plow were introduced
- **The Industrial Revolution**: Beginning in the 18th century, introduction of new technologies such as the seed drill and steam engine enabled the shift from small subsistence farms to larger, commercial farms that greatly increased productivity and reduced food costs

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We are entering a new era

Recent advancements in genetics, data, sensors and communications are ushering in the next stage in the evolution of agriculture.

LED lighting is one such enabling technology….

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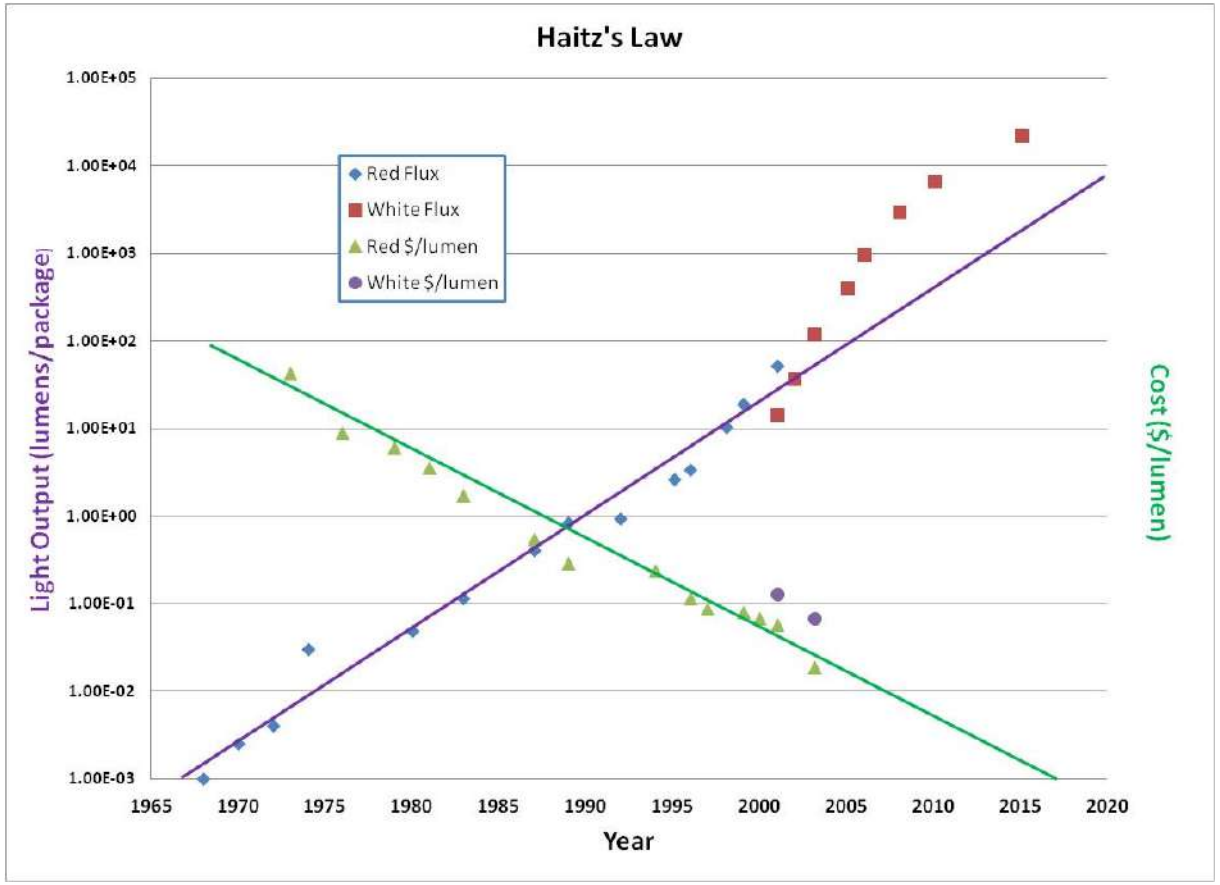
Why now?



- **Haitz's Law**
- LED technology has continuously improved over the last 50+ years
- Performance has just recently surpassed traditional technologies
- Exponential growth resulting in massive performance advantage

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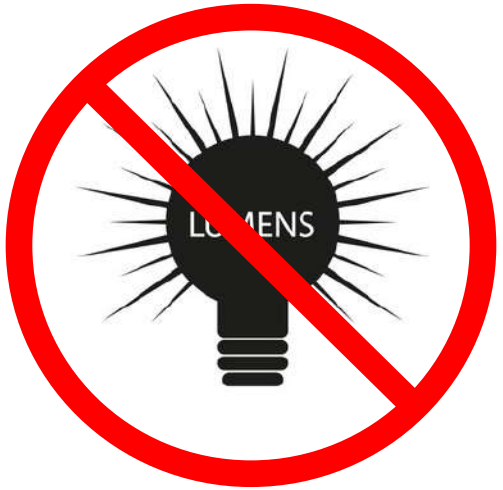
Lumens vs Photons

Plants Don’t Have Eyes

(Except for Potatoes)



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Language of Horticulture

Parameter	General Lighting	Horticulture Lighting
Light output	Lumens (lm)	PPF – Photosynthetic Photon Flux (µmols/sec) (Moles, 1 mol = 6.02x1023 photons)
Intensity / Irradiance	Lux or Foot-candles (lm/m2)	PPFD - Photosynthetic Photon Flux Density (umols/m2/sec)
Efficacy	Lumens/Watt (lpw)	umols/joule (µmols/sec/w)
Daily Light Integral		DLI = moles/m2/day
On-time		Photoperiod (hours/day)

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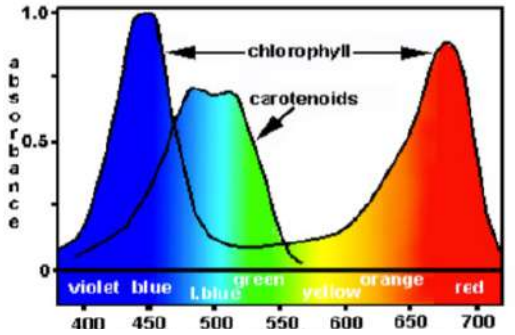
Spectrum

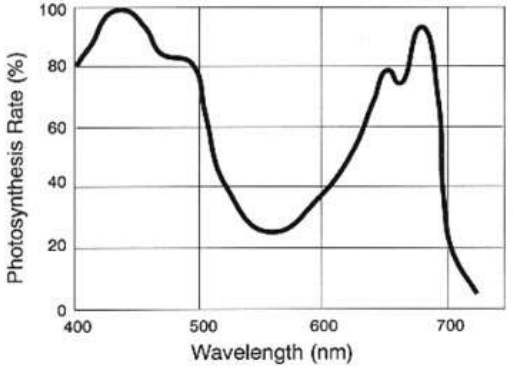
What is the "right" spectrum?

- Plant species?
- Primary vs. supplemental lighting?
- Human factors?



Photomorphogenesis (general trends)

- UV (300-400nm): Activates plant defenses
- Blue (400-500nm): Photosynthesis, inhibits elongation
- Green (500-600nm): Photosynthesis, inhibits anthocyanin
- Red (600-700nm): Photosynthesis, Promotes flowering/fruiting
- Far Red (700-800nm): Promotes elongation, shade response



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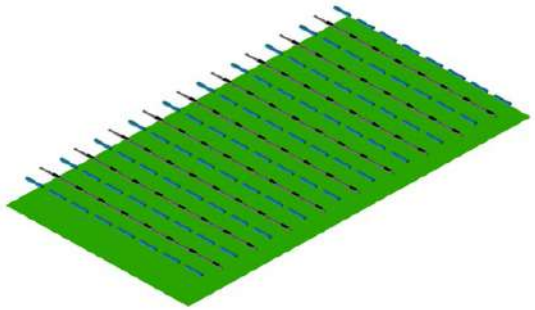
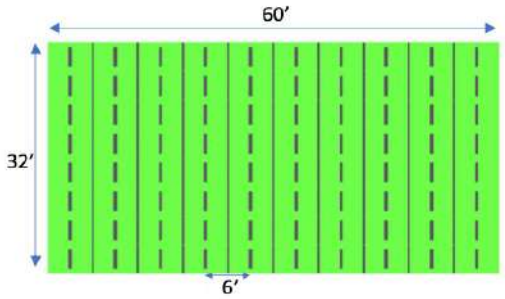
Farm Layouts/Modeling

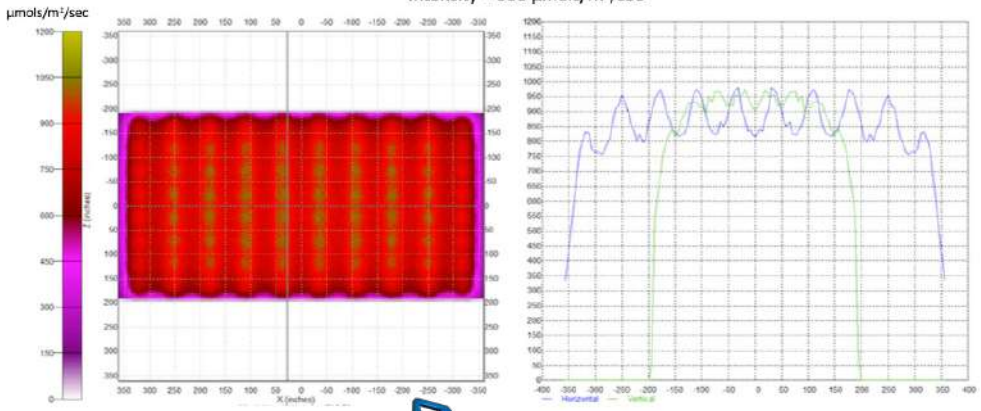
Isometric View

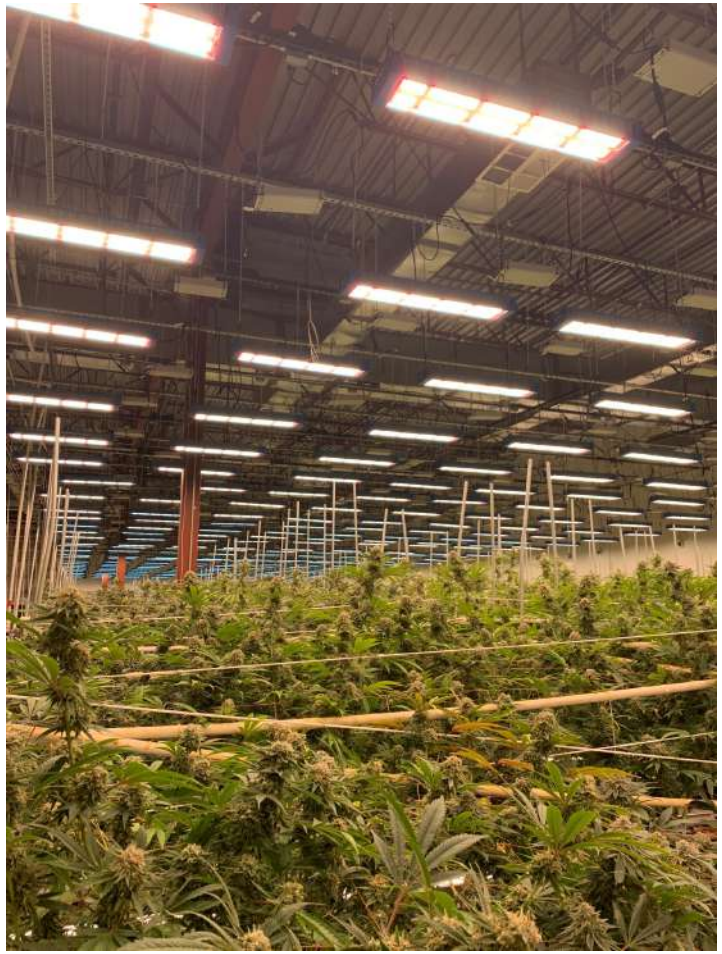


Top Down View



Light Intensity Map on 60' x 32' Canopy
Intensity = 900 µmols/m²/sec





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Primary Applications

Vertical Farming

Greenhouse

Cannabis

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Vertical Farming Market

Market Dynamics

- 25% CAGR from 2022-2029
- Largely Leafy Greens: Lettuce, Basil, Herbs
- Desire for fresh/local, organic food
- More sustainable (90% less water, 45% less power)
- Limited arable land (Middle East, Asia)

LEDs dominant technology

- Energy efficiency & proximity to the canopy
- Light intensity: ~200 µmols/m^2/sec
- About $400-$500M market by 2022 for LED grow lights

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Cannabis Market

Market Dynamics

- 25% CAGR from 2022-2030
- Driven by increased legalization and medical acceptance

LEDs gaining market share

- Vegetative Phase: 400-800 µmols/m2/sec
  - Displacing fluorescent and CMH
- Flowering Phase: 800-1600 µmols/m2/sec
  - Displacing High-Pressure Sodium fixtures

Vegetative Phase

Flowering Phase

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Greenhouse Market

Market Dynamics

- 8% CAGR from 2021-2028
- LED 14% CAGR
- Mature Market, growth with population
- Global market, majority in Western Europe

Most greenhouses not illuminated

- Supplemental to extend growing season
- 50-200 µmols/m2/sec
- HPS dominates installation base
- LEDs on the verge of substantial adoption

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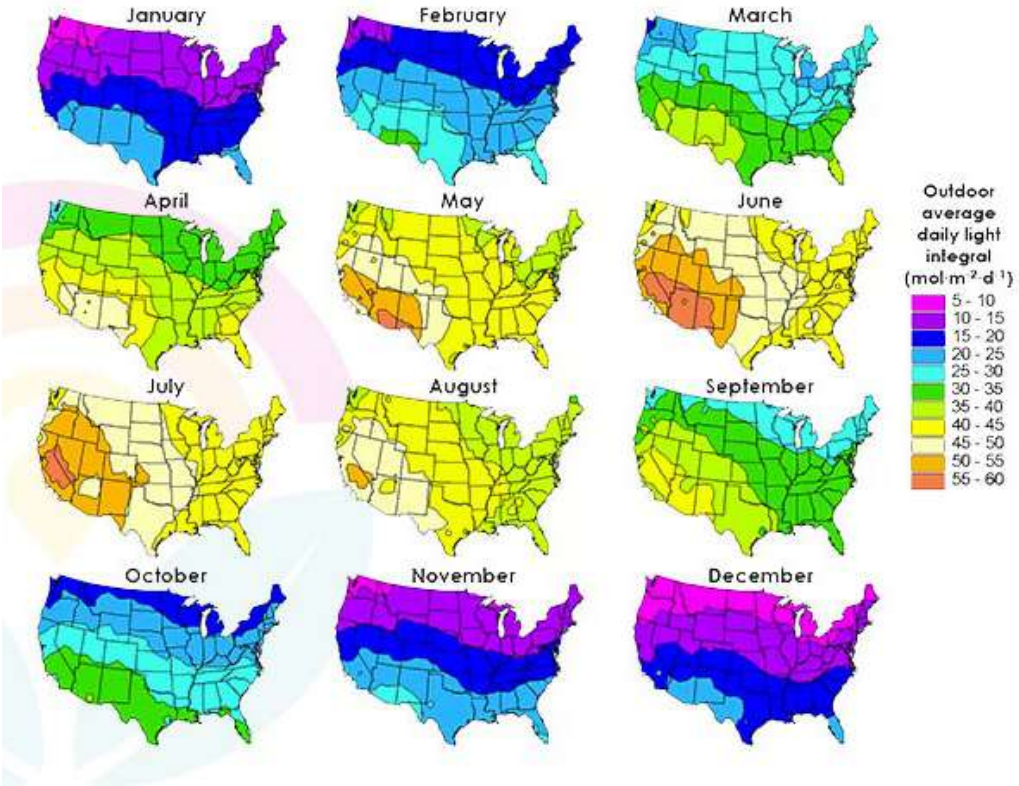
Greenhouse Lighting

Crop	DLI Requirement (moles/m2/day)
Lettuce	15-20
Strawberry	17-19
Cucumber	15-30
Tomato	30+
Pepper	30+
Potted Plants	5-10
Cut Flowers	5-30



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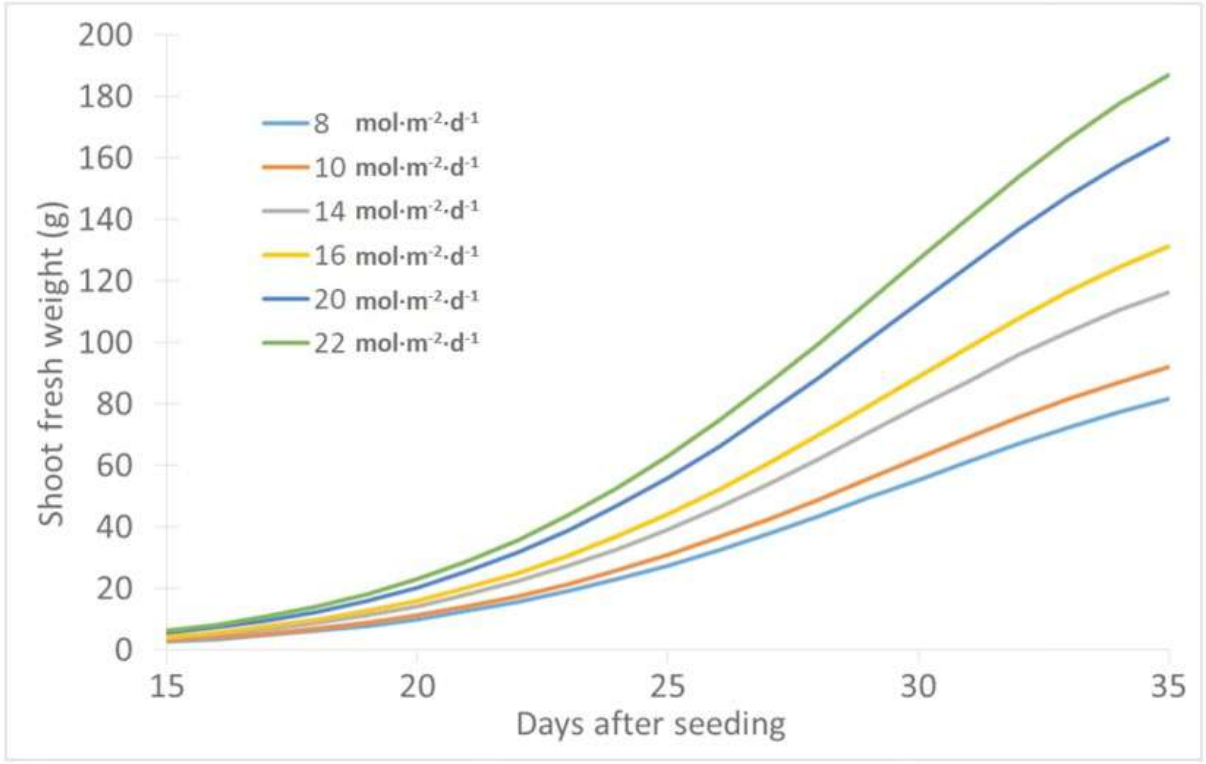
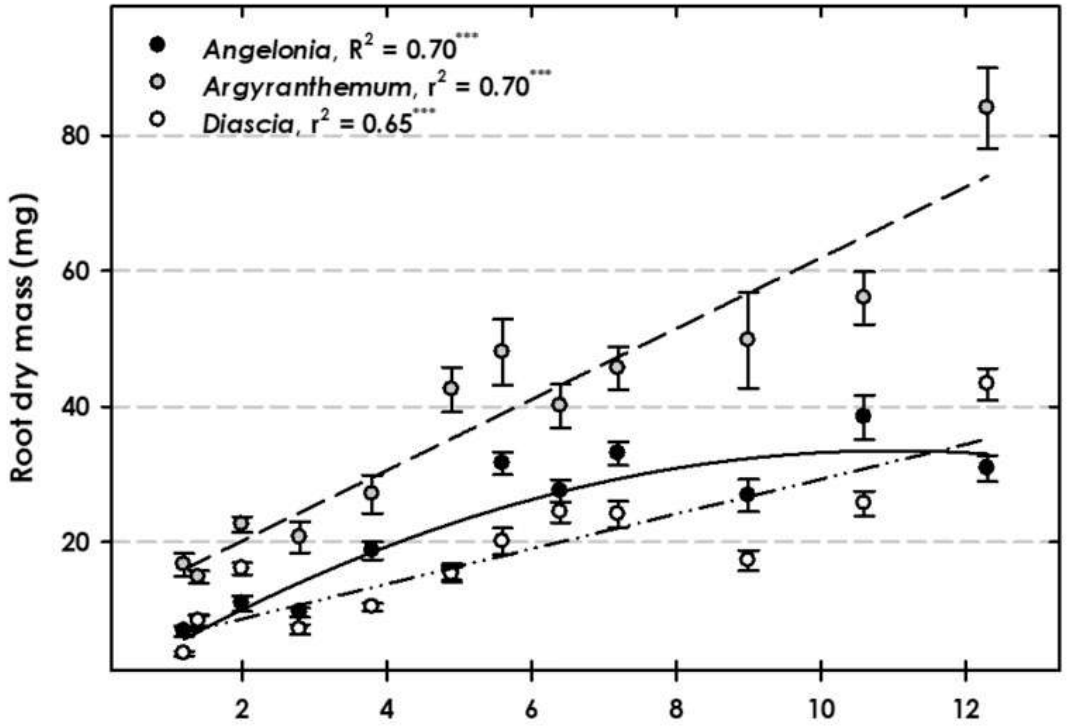
Greenhouse Lighting

LETTUCE GROWTH IS DIRECTLY PROPORTIONAL TO LIGHT



Adapted from Both et al., 1997, Acta Horticulturae 418:45-51

Root biomass increases with DLI



Currey et al., 2012

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Standardization

- ASABE – American Society of Agricultural & Biological Engineers
  - S640, X642 – Measurement of horticulture lights
- UL 8800
  - Safety standards for horticulture lighting
- DLC – Design Lights Consortium
  - Qualified Product Listing (QPL) for grow lighting began in 2019
  - Horticulture V3.0 – Testing & Reporting for LED horticulture lights (March 2023)

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Rebates and Regulations

Rebates

- Denver, CO: 4% of electricity usage is for cannabis production
- Rebates backed by state governments & local utilities
- Rebates = 25%-70% cost of lights

Regulations

- Massachusetts and Illinois: Max power for cannabis grow lights 36W/m2
- Forces the use of LEDs
- California Title 24: Minimum efficacy of 1.9 µmols/joule, effectively mandating LED

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This concludes The American Institute of Architects Continuing Education Systems Course

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