Developing LED Lighting Technologies and Practices for Greenhouse Crop Production

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5 Floriculture MICHIGAN STATE UNIVERSITY

American Society for Horticultural Science

Waikoloa, Hawaii

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ORBITEC's BioProduction Systems Division

- Patented LED lighting systems for biological and marine habitats
- Vehicle lighting
- Supplemental greenhouse lighting
- Science research

Light Source Development

Control Systems

- Patent pending integrated lighting and environmental controls
- High efficiency driver and electronics design
- Off-grid power integration

Mechanical Design

- Thermal management
- Cooling system integration
- Functional design and analysis

Production Optimization

- Commercial lighting systems production
- Controlled Environment facility rental
- Lighting effects research

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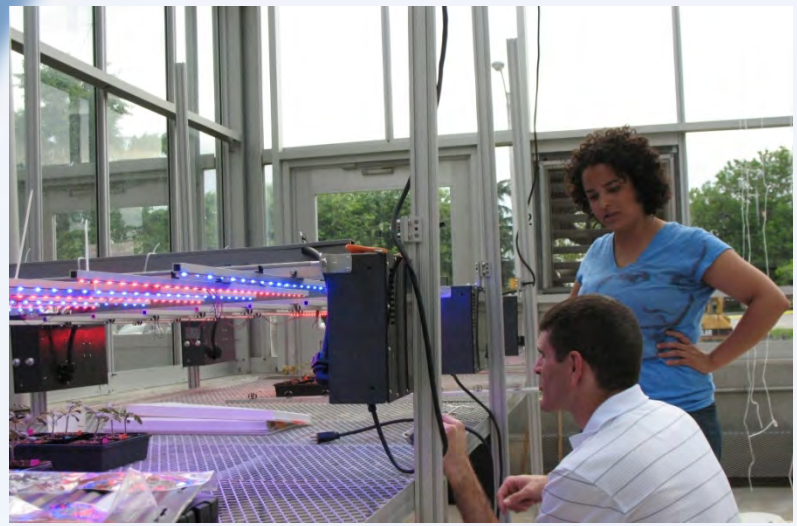
ORBITEC's LED System Configurations

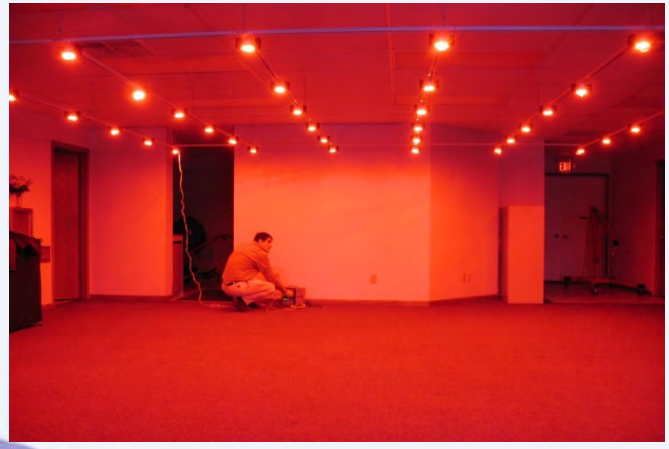
- Overhead panels, bars, or intracanopy configurations
- Single or multiple wavelengths
  - Violet/UV
  - Blue
  - Green
  - Red
  - Far red
  - White
- Intensities from 300 µmol/m^2/s to >1800 µmol/m^2/s
- Air or water cooled
- Digital or analog control options

ORBITEC's LED Lighting Applications

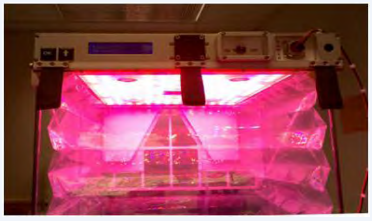


Supplemental greenhouse lighting tests

Testing of 1800 µmol $m^{-2}s^{-1}$ LED array



Photoperiodic lighting system



LED lighting for growing plants on Space Station

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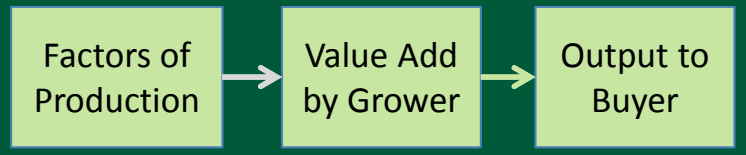
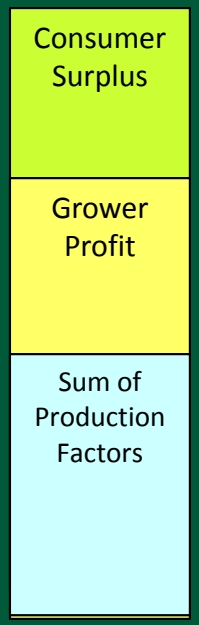
Objective

- For each type of specialty crop quantify factors of production per appropriate unit
  - Seed(lings)
  - Energy; heat and light
  - Water
  - Chemicals
  - Time
  - Labor
  - others?
- With conversion to LED, both in lab and in field, understand:
  - Change in factors of production
    - Includes variable and fixed costs
  - Change in value to buyer





Value to Buyer (Willingness to Pay)

Price to Buyer

Cost of Production

John Burr

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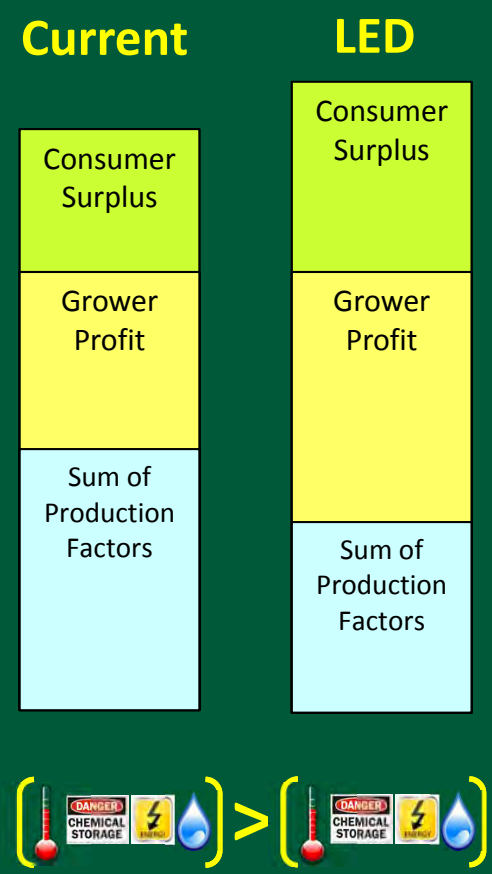
- Hypothesis – conversion will reduce cost of production AND increase value to buyers
  - E.g. LED's may allow better control of plant growth with reduced energy and chemicals
  - Benefits will likely vary by type of crop

Objective

- Understanding of adoption factors
  - Economic drivers and risk perception
  - Compatibility and complexity
- Analysis of existing lighting industry impact
  - LED's represent a disruptive technology
  - Competitive response is likely
- Life cycle cost comparison



LED lighting system testing and evaluation

Goals:

- Testing of existing and prototype LED lighting systems
  - Spectral output
  - PAR output
  - Electrical consumption
  - Overall system efficiency

- Development of measurement protocols and guidelines, eventually resulting in industry standards for LED applications in horticulture

- Conducting plant growth experiments
  - Photoperiod lighting
  - Photosynthesis lighting

Logan Logendra

A.J. Both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LEDs for Photosynthetic Lighting of Ornamentals during Vegetative Propagation

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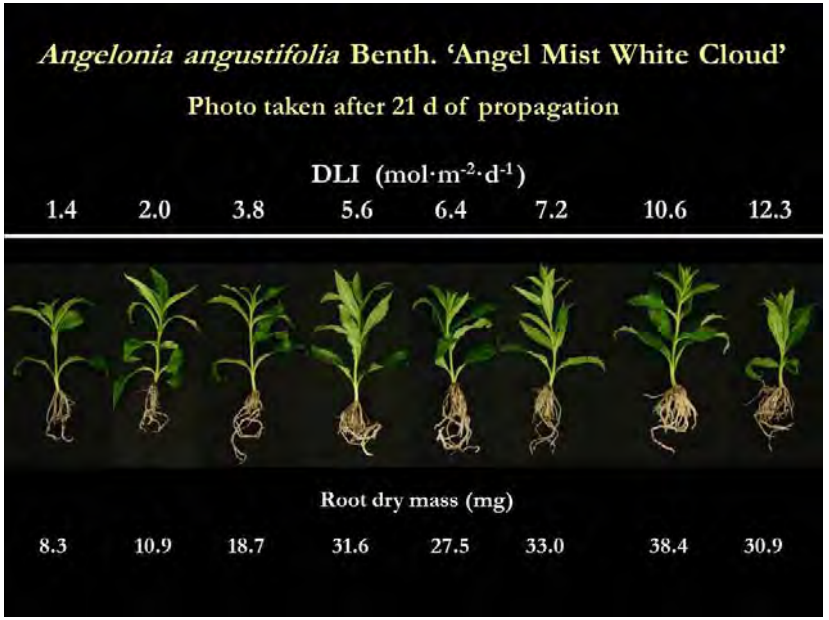
Supplemental light quality requirement for ornamental cuttings under different background solar light integrals

Michael Ortiz, Chris Currey, and Roberto Lopez



LEDs for Photomorphogenic Lighting

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End-of-day (EOD) light quality treatment for controlling morphology of ornamental seedlings

- To quantify the minimum EOD R and FR dose (intensity and duration) that influence internode elongation of ornamental seedlings.
- To determine if EOD and/or LED lighting are feasible non-chemical means to control plant height of seedlings and/or cuttings?

Using LEDs to Determine Effective Ratios of Red and Far-Red Light for Photoperiodic Lighting




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Photoperiodic Lighting

- Flowering of many specialty crops , particularly floriculture crops, is influenced by the day length, or photoperiod.
- Low-intensity (photoperiodic) lighting is used to create an artificial short night to promote flowering of long-day plants (e.g., petunia) and inhibit flowering of short-day plants.

Most petunia varieties flower earlier under a long day (short night).

- Incandescent lamps are commonly used because of their low cost, but they are energy inefficient and may not be available in the future.
- Past research shows that fluorescent lamps emit a less effective spectrum.

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Primary Objective and Research

Objective

- To use LEDs to quantify how the ratio of red (R) and far-red (FR) light influences flowering and plant architecture of a wide range of specialty crops.

Research in Progress

- Specialty crops are currently being grown in controlled-environment research greenhouses with 4-h night-interruption lighting emitting seven different R:FR ratios from LEDs, as well as from incandescent lamps (control).

Floriculture research greenhouses with LED treatments at Michigan State University.

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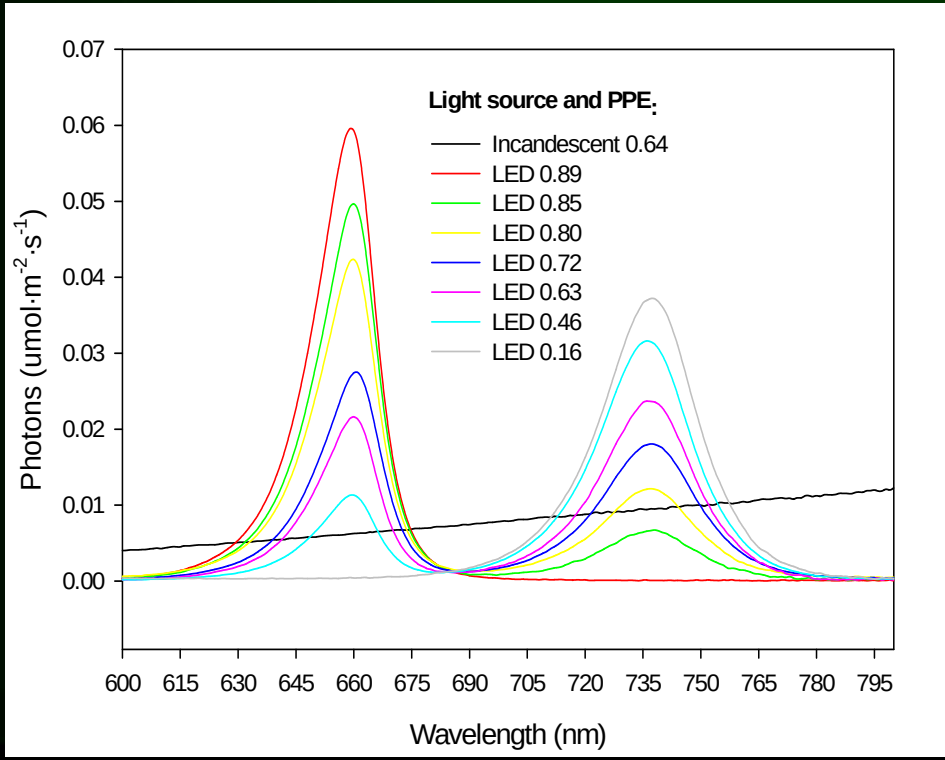
LEDs in Current Experiments

- LED lamps were developed for this project by one of our industry partners (CCS, Kyoto, Japan).
- Based on the research results, LED prototypes with the prescribed R:FR will be developed and tested on a wider range of crops, in concert with university and industry partners.



Spectral attributes of LED treatments and incandescent lamps, with predicted phytochrome photoequilibrium (PPE).

Experimental LED lamp

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LEDs for Photosynthetic Lighting:
Supplemental light quality requirement for vegetable seedlings under different background solar light integrals (DLI)

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Ricardo Hernandez and Chieri Kubota

LEDs for Photomorphogenic Lighting: End-of-day light quality treatment for controlling morphology of vegetable seedlings

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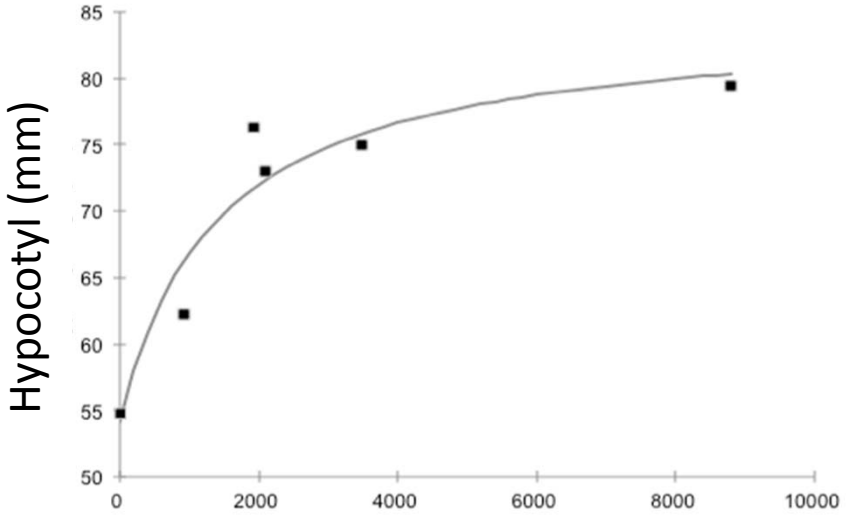
EOD Far-red Dose (0 – 9000 µmol/m^2/d)

Tomato rootstock seedlings

EOD Far-red Dose (0 – 9000 µmol/m^2/d)

Squash rootstock seedlings



(Chia and Kubota, 2010; Kubota et al., 2011)

Developing LED technology for sustainable tomato propagation and production in northern climates

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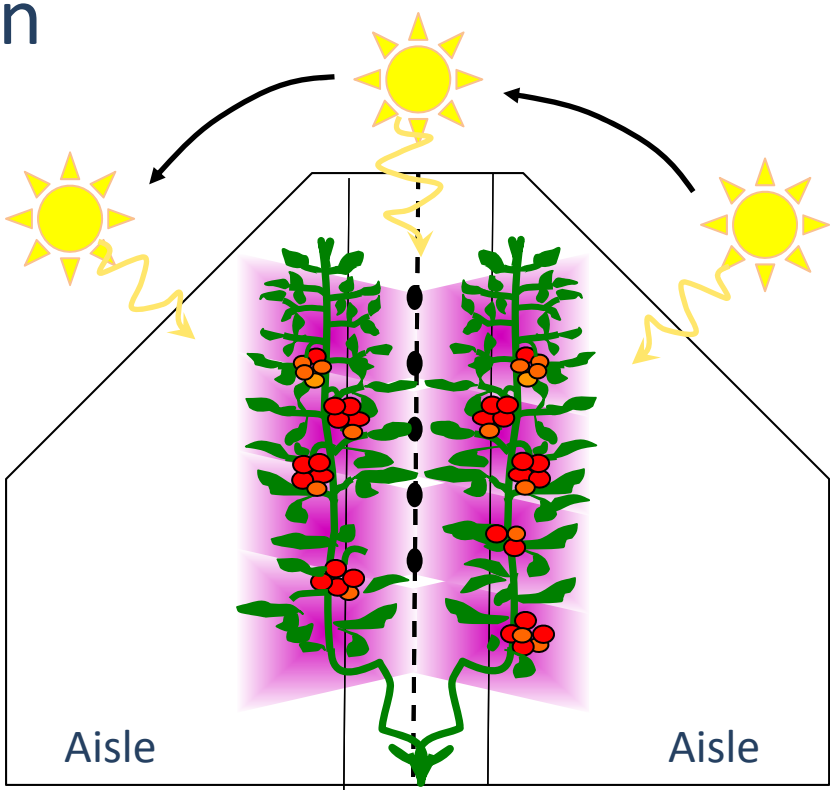
Celina Gómez Cary Mitchell



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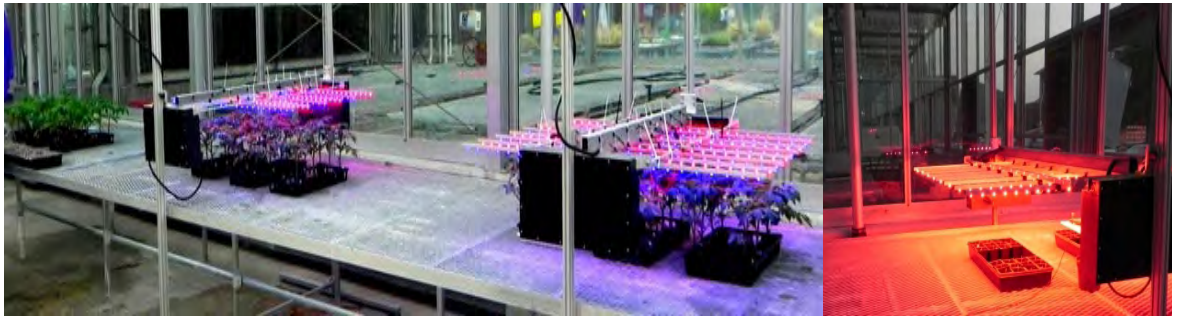


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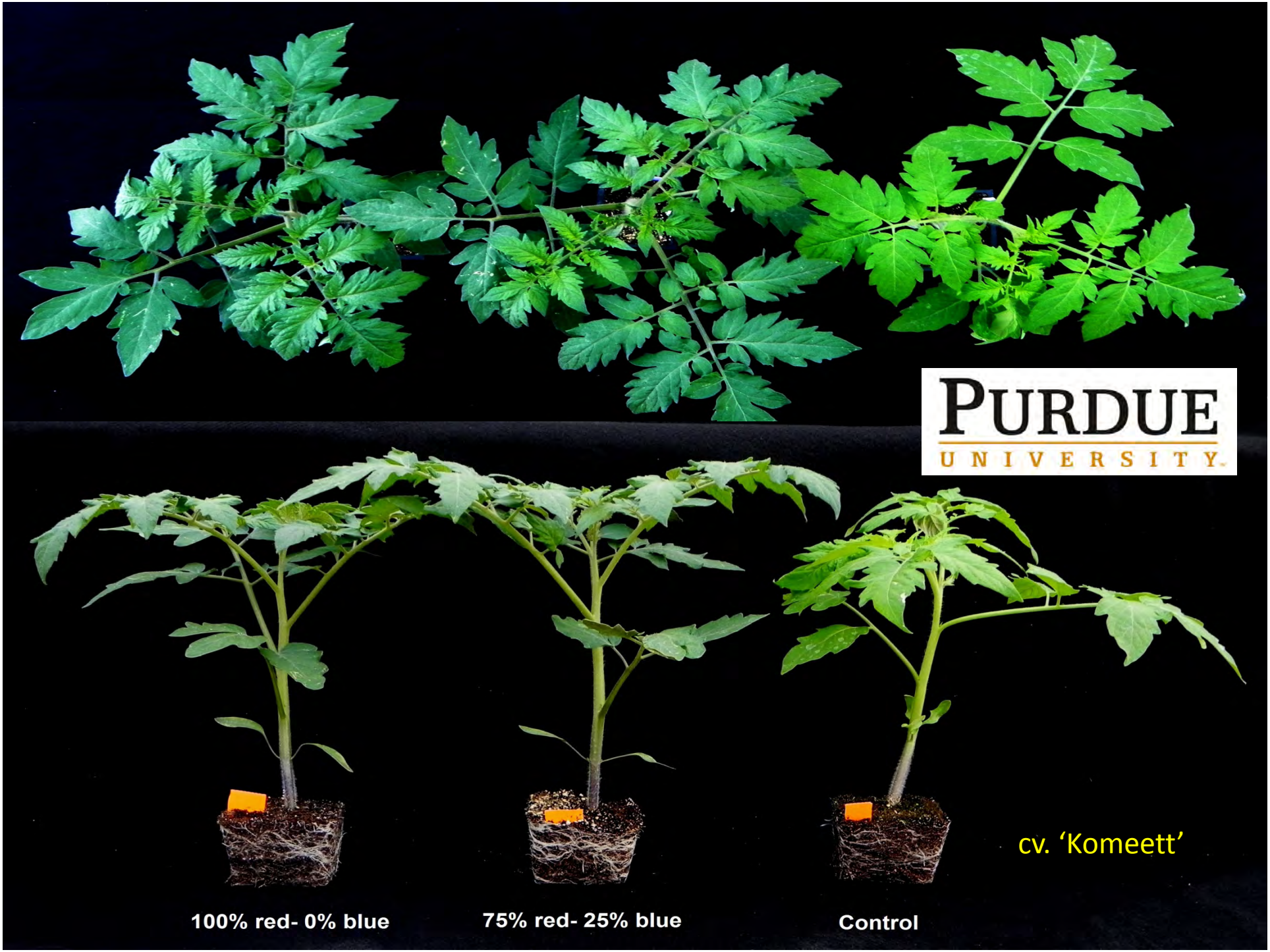
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cv. 'Komeett'
100% red- 0% blue
75% red- 25% blue
Control

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http://leds.hrt.msu.edu