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Lighting resources online: Project LAMP website

Electricity for lighting has been estimated to cost the greenhouse and indoor agriculture industry in the U.S. \$1 billion annually. While lighting technology has evolved over time and become more energy efficient it is still expensive upfront. LED lighting brings several control capabilities (dimming, spectral control) many times these capabilities are not being fully utilized due to a lack of research-based information or lack of research on how to best implement them.



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Research Briefs

LAMP Research Update
Contact us: info@hortlamp.org

Cornell University
March 2022
www.hortlamp.org

Far-red radiation supplied to basil seedlings improves yields

Nathan J. Hylands and Neil S. Mattson



The Problem: Many LED fixtures do not incorporate far-red radiation (FR: 670-700 nm) into their LED lighting spectrum. More research is needed on plant responses to FR.

Our Study: We investigated the effects of adding FR into the lighting spectrum at the seedling stage of basil grown under sole-source lighting. We wanted to know how long it should be supplied and at what intensity. Basil plants (cv. 'Genovese', 'Toscano', and 'Spiky Bush') were grown under 200 μmol m⁻² s⁻¹ white LED lamps (20-h photoperiod) with various amounts of supplemental FR (5, 10, 20, or 30 μmol m⁻² s⁻¹) for 5 or 10 days. Plants were transplanted into an NFT hydroponic system at 12 days from seed where the light intensity was increased to 250 μmol m⁻² s⁻¹ (16-h photoperiod) and the supplemental FR was equal for all plants at 5 μmol m⁻² s⁻¹. Mature basil plants were harvested at 35 days from seed to quantify the effects of supplemental far-red radiation provided at the seedling stage.

Our Findings: Basil seedlings that received higher intensities of far-red radiation (20, 30 μmol m⁻² s⁻¹) for longer durations (10 days) produced 44 and 23% greater fresh weight (grams) yields at time of transplant and at harvest, respectively.

Take home message:

- Far-red radiation incorporation is critical in LED sole-source lighting to increase yields.
- Replacing only the lights in your propagation area will lead to greater yields at harvest.



Lighting Approaches to Maximize Profits | USDA | NIFA | United States Department of Agriculture | National Institute of Food and Agriculture

Far-red radiation supplied to basil seedlings improves yields

LAMP Research Update
May 2020

Influence of far-red intensity during the seedling stage on hydroponic lettuce

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The Problem: Light levels are among the most limiting factors in controlled environment agriculture (CEA). LEDs can be used to provide light using less electricity. Far-red light can be delivered using LEDs but has traditionally not been considered beneficial (and thus added unnecessary electricity cost). Strategic use of far-red light along with white LEDs may provide some benefits at the seedling stage but little is known about the critical quantity required for lettuce seedlings and if effects will carry over to harvest.

Our Study: Applications of light waves outside the typical photosynthetic active radiation (PAR) spectrum have long been understood to create "undesirable" morphological responses in agricultural crops. However, recently the scientific community has rediscovered the useful applications of light outside of PAR, such as far-red (FR, 700-750 nm). In this experiment, three cultivars of lettuce seedlings (Grand Rapids, Red Oak, and Red Fire) were exposed to identical amounts of white LED light supplemented with 5, 10, 20, or 30 μmol m⁻² s⁻¹ of FR LED radiation throughout the seedling stage. The strategic purpose of which was to increase leaf area / increase canopy size of seedlings and thus light capture. Seedlings were subsequently transplanted into a hydroponic nutrient flow technique (NFT) system for each treatment. After transplanting, plants no longer received FR treatments and were only supplied with a constant white LED spectrum.

Our Findings: At the transplant stage (12 d), all cultivars significantly increased in fresh weight and plant height under higher intensities of far-red radiation. Other metrics, such as dry weight, leaf area, and specific leaf area, also increased under higher intensities. The degree of far-red benefit varied by cultivar. However, after 35 d in the NFT system, treatment differences recorded in seedlings were no longer prevalent in mature plants.

Take home message:

- Lettuce seedlings exposed to higher intensities of far-red radiation outperform others during the seedling stage. More research is required to investigate the length of far-red exposure as that benefits carry over to mature, harvested plants.




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Influence of far-red intensity during the seedling stage on hydroponic lettuce

LAMP Research Update
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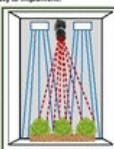
The University of Georgia
July 2019

Canopy Fluorescence Imaging: a Simple, Non-Destructive Method to Monitor Crop Growth

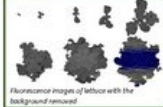
Margaret Narayanan, Marc van Iersel, and Mark Haskelber

The Problem: Monitoring crop growth is important in controlled environment agriculture research and production. Ideally such a method would be non-destructive, rapid, and easy to implement.

Our Study: When exposed to light, plants give off a small amount of light in the red and far-red part of the spectrum (fluorescence). This fluorescence can be induced using blue LED light and captured using a camera equipped with a filter that allows the camera to see the fluorescence, but not the blue light. To do so, we equipped the camera with a 680–740 nm bandpass filter. The diagram below shows a schematic of the setup.



Our Findings: Fluorescence imaging is an effective way to image a canopy (see images on bottom right). The intensity of each pixel in the image is much higher (i.e., brighter) for leaves as compared to the background. This allows for simple separation of canopy from background using "intensity thresholding" in ImageJ or other image analysis software. However, algae fluoresces as well. To separate algae from leaf, a 2nd image, using white light is taken. Algae are bright in the image with blue light, but dim in the image with white light. This allows for separation of leaves and algae. Image analysis can be automated using a macro developed for ImageJ.



Take home message:

- Fluorescence imaging under blue light is a simple way to quantify prepped canopy size.
- When algae are present, a second image under white light can help distinguish algae from leaves.

Lighting Approaches to Maximize Profits | USDA | NIFA | United States Department of Agriculture | National Institute of Food and Agriculture

Canopy Fluorescence Imaging: a Simple, Non-Destructive Method to Monitor Crop Growth

Project LAMP (lighting approaches to maximize profit) is a team of researchers that focuses on helping growers get more value out of their lighting systems. LAMP was founded by the late Professor Marc van Iersel at the University of Georgia and is now led by Dr. Rhanito Ferrarezi at UGA. Other team members are based at Clemson University, Colorado State University, Cornell University, Rutgers University, Texas A&M, University of Minnesota, and Utah State University, and the USDA ARS in Toledo, OH. Our team combines several academic disciplines: horticulture, economics, agricultural & electrical engineering, computer engineering, impact assessment, and information systems, to help us better understand the impacts and economics of plant lighting decisions.

Project LAMP recently updated their website, now available at: <https://hortlamp.uga.edu/> and the objective of this e-Gro Alert is to highlight a few sections that may be particularly useful to the CEA industry.

Research Briefs

This section of the website features about 20 one-page research briefs which summarize research findings from the team into accessible nuggets of information. Briefs cover several topics such as: understanding lighting and energy units, supplemental lighting of herbs and leafy greens, canopy sensing methodologies and how these correlate to biomass, and several studies on the benefits of far-red radiation under sole-source lighting. In one of the more fascinating research topics, the team reports on the strategy of delivering the same DLI but spreading it across more hours of the day. This strategy was tested for lettuce and mizuna using dimmable LEDs. Spreading the same DLI over 20 hours vs. 10 hours per day led to an increase in fresh weight of 12% for lettuce and 20% for mizuna.

Lighting Instructional Videos

Team members are building an archive of short videos addressing lighting topics. Our aim (not always successful) is that videos are 3 to 5 minutes long. Topics so far include supplemental vs. photoperiodic lighting, carbon dioxide enrichment, understanding electricity cost vs. demand charge and many more. We'll continue to post new videos as the project proceeds.

LAMP Lighting Calculators

A signature LAMP effort has been developing a series of calculator tools to aid greenhouse operators in making lighting system decisions. The calculators have inputs such as zip code (for ambient sunlight information), greenhouse dimensions, daily light integral target (DLI), greenhouse light transmission, efficacy of the lighting system, and electricity cost. The “How large should my lighting system be” calculator allows you to specify how many days of the year you want to be able to reach a target DLI.

The calculator will determine the required lighting capacity to reach the target DLI and graphs the expected greenhouse DLI over an average year. Electricity use and demand costs are also calculated. This calculator is particularly useful for the design of new lighting installations. The “How often to reach DLI” calculator takes the opposite approach: the user specifies the capacity of the lighting system and the calculator estimates how many days of the year you can reach your target DLI. Finally, the “lamps needed” calculator is a downloadable spreadsheet that can estimate the number of light fixtures needed in your greenhouse. You can also input information on two light fixtures and determine estimated up-front cost and calculate a simple payback for a more expensive but energy-efficient fixture. This calculator is described in greater detail in [e-Gro Alert 8.14](#).

LAMP Lighting Calculators

- [LAMP 'How often will I reach my Target DLI?' Calculator](#)
- [LAMP 'How large should my lighting system be?' Calculator](#)
- [LAMP 'Unlimited' Lighting Calculator](#)
- [Excel Spreadsheet version of the LAMP Unlimited Lighting Calculator](#)
- [Lamp Needs Calculator](#)
- [US Daily Light Integral Maps](#)

LAMP 'How often will I reach my Target DLI?' Calculator




How often to reach DLI-Calculator

This calculator is like the LAMP 'Unlimited' Lighting Calculator (which you will find below) but it takes the opposite approach: users specify the capacity of their


I invite you to take a few minutes to explore the project LAMP site. We hope you will find some resources that help in your horticulture lighting journey. Please feel free to share feedback to me at: nsm47@cornell.edu

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Lighting Approaches to Maximize Profits

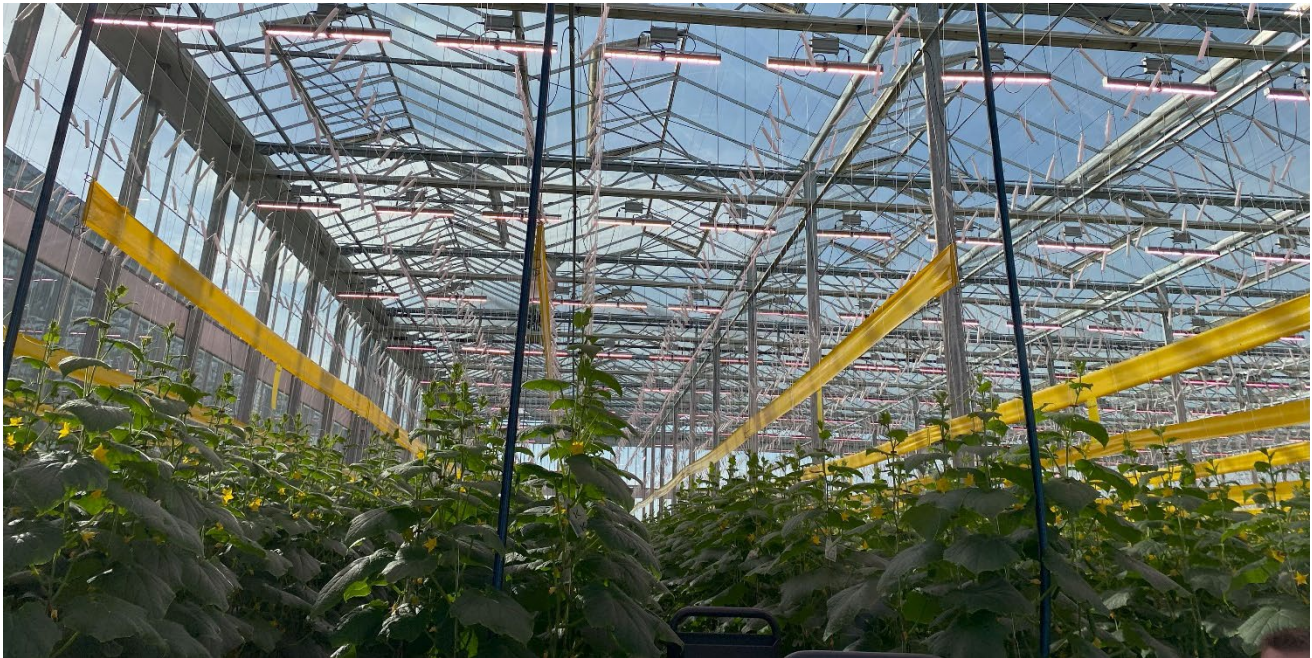


United States Department of Agriculture



National Institute of Food and Agriculture

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