Greenhouse Lighting and Systems Engineering (GLASE)
2019 NCERA-101 Station Report
Author: Erico Mattos, GLASE Executive Director
Lead Researchers: Neil Mattson, Kale Harbick and Tim Shelford (Cornell University), Tessa Pocock and Matthew Urschel (Rensselaer Polytechnic Institute), and A.J. Both (Rutgers University)

1. New Facilities and Equipment

The Center for Lighting Enabled Systems and Applications (LESA) includes a Plant Research Lab which supports GLASE activities at Rensselaer Polytechnic Institute. The facility is equipped with a general purpose hydroponics system and 5 environmental growth chambers (Conviron A1000). Three of those chambers are retrofitted with custom LESA-designed advanced multi-wavelength (400nm, 420nm, 450nm, 520nm, 660nm and 735nm), dynamically adjustable LED lighting systems and real-time, remote chlorophyll fluorescence sensors developed at LESA (Urschel and Pocock, 2018). The Plant Research Lab is equipped with an infrared gas analyzer (PP Systems, CIRAS-3), multiple spectrometers (Ocean Optics, JAZ and STS), a PAM Fluorometer (Walz PAM-2500), along with standard analytical test and laboratory equipment.

2. Unique Plant Responses

At Cornell University, responses to strawberry and tomato to CO_2 enrichment under varying daily light integrals have been examined. The research takes place in 4 Plexiglas mini growth chambers under T5 Fluorescent lights for 10 to 15 days during the vegetative growth stage for tomato and early flowering stage for strawberries. For tomato, cultivar ‘Merlice’ has exhibited quite severe edema symptoms (a physiological disorder due to insufficient UV light or sometimes associated with excessive humidity/water imbalances). The disorder has limited our ability to detect plant growth responses, but we have used the chambers to screen tomato cultivars for sensitivity to edema. For both species, photosynthesis light and CO_2 response curves have been collected.

3. Accomplishment Summaries

GLASE researchers at Rensselaer Polytechnic Institute (RPI) have designed and built two dynamic research LED modules designed for crop cultivation in CEA systems in growth chambers and greenhouses. The LED modules designed for growth chambers have six individually programable wavelengths which can operate in either analog or pulse width modulation (PWM) modes and are capable of high speed pulsed operation. The LED modules designated for greenhouses were designed by Lumileds and have the same wavelengths as the growth chamber modules. On a complementary effort GLASE researchers at RPI have completed the basic design of a gallium nitride (GaN) based high efficiency power supply for horticultural LED fixtures. The new power supply will be integrated into the two dynamic research LED modules.

GLASE researchers at RPI developed a new remote chlorophyll *a* fluorescence (ChlF) sensing device capable to provide direct, remote, real-time physiological data collection for integration into tunable LED lighting control systems, thereby enabling better control of crop growth and energy efficiency. Data collected by this device can be used to accurately model growth of red lettuce plants. In addition to monitoring growth, this system can predict relative growth rates (RGR), net assimilation rates (NAR), plant area (PA), and leaf area ratio (LAR).

GLASE researchers at Cornell University are developing equations modeling interactions of daily light

integral (DLI) and CO_2 concentration versus photosynthetic parameters, morphology and biomass for tomatoes and strawberry. These equations will be used to simultaneously control CO_2 enrichment and

supplemental lighting to optimize light use efficiency in CEA systems.

GLASE researchers have implemented the Lighting and Shade System Implementation (LASSI) in two commercial greenhouses (Sustainable Aqua Farms (SAF) Produce, Berlin NY and Wheatfield Gardens, Buffalo NY). GLASE researchers are already working on the next generation lighting control named Day Ahead Market (DAM) LASSI. DAM LASSI is currently programmed in Matlab and is being developed into a usable controller written in Python running on a Raspberry Pi controller. Future improvements include the incorporation of CO_2 supplementation to the lighting control algorithm and the validation against traditional LASSI.

GLASE researchers at Rutgers University have performed energy efficacy and radiometry measurements in two commercial horticultural LED fixtures. Results were presented under the proposed horticultural lighting label format (AJ Both et al, 2017). The team is now developing a protocol to test a water cooled horticultural LED fixture inside an iterating sphere.

4. Impact Statements

From April 2018 to April 2019 GLASE has signed 21 industrial members; established a new website (https://glase.org); published 8 newsletters to an audience of 500+ people; hosted 2 webinars (*Funding Opportunities for CEA Energy Efficiency* and *A proposed horticultural lighting labe*l) to an audience of 170+ people; hosted 1 Industry Talk (*Effects of lighting on phenolics production in crops cultivated in CEA systems*); hosted the 1st GLASE meeting (*Guidelines for new Controlled environment Agriculture energy-efficient technology adoption*) to an audience of 130+ people on November 5th in Ithaca, NY.

In March 2019 GLASE has disclosed its first Intellectual Property filed at RPI entitled Remote Plant Chlorophyll Fluorescence Monitor (U.S. patent app. #62/802,886 filed 2/8/2019). A low cost (< $400) fluorescence sensing device is described that provides remote, real-time chlorophyll fluorescence data collection for integration into tunable LED lighting control systems, thereby potentially enabling energy efficiency and better control of crop growth. Data collected by this device can be used as a proxy for mean growth dynamics of target plants. In addition to monitoring growth, this system could predict relative growth rates, net assimilation rates, plant area and leaf area ratio.

5. Published written work

Refereed Journal Articles

Urschel, M. R. and Pocock, T. 2018. Remote Detection of Growth Dynamics in Red Lettuce Using a Novel Chlorophyll *a* Fluorometer. Agronomy 8(10),227.

Trade Journal article

Mattos, E.R. 2019. How GLASE is Blazing a New Frontier in Lighting. Greenhouse Grower Magazine. February Issue. pp. 40-42

Pocock, T. 2018. The McCree Curve Demystified. Photonics Media, BioPhotonics. June Issue

Technical Reports

Harbick, K. 2018. Comparison of Energy Simulation Engines. Prepared for the New York

State Energy Research and Development Authority (NYSERDA)

6. Other Relevant Information

In partnership with EnSave, GLASE is developing a national CEA database. Using the Farm Energy Audit Tool (FEAT) GLASE is collecting baseline information about energy use, crop production, and equipment used in commercial US greenhouses. The data gathered through this tool will be used to develop a comprehensive energy benchmarking resource for greenhouse operators, guide new research at GLASE and provide guidelines for future government regulations and energy use standards for greenhouses.

Working towards industry standardization GLASE has established a partnership with Intertek to offer its partners a complementary lighting test to characterize horticultural lighting fixtures following the proposed lighting label published by AJ Both et al. (2017). This is an effort to provide growers a reliable comparative platform to select among the available lighting technologies that best fit their unique needs.

For more information, please visit the GLASE website at www.glase.org or contact GLASE executive director Erico Mattos at em796@cornell.edu.