Michigan State University 2018 Station Report
NCERA-101: Committee on Controlled Environment Technology & Use

Erik Runkle and Roberto Lopez
Department of Horticulture, East Lansing, MI 48824

New Equipment and Facilities

- A Portable spectrometer (LI-180) was purchased to measure photon flux density from 380 to 780 nm in 1-nm increments, as well as several other parameters.
- An MC-100 chlorophyll concentration meter was purchased, to quantify chlorophyll, CCI, and SPAD.
- One existing walk-in growth chamber was retrofitted with RAY66 Fluence LED fixtures, CO_2 injection, and four Apogee ST-100 thermistors.
- To expand our greenhouse hydroponic research capacity, 7 modular deep flow hydroponics systems were built.

Accomplishment Summaries

- Led by Ph.D. candidate Jose Llera in Engineering, we used a multi-objective evolutionary algorithm (NSGA-II) to evolve the setpoints for microclimate control in a greenhouse simulation with two objectives: minimizing variable costs and maximizing the value of the tomato crop yield. Results show that the evolved setpoints can provide the grower a variety of improved solutions, resulting in greater profitability compared to prior simulated results.
- Post-doctoral researcher Yujin Park and Erik Runkle determined whether early flowering of petunia under a mint-white LED could be attributed to greater green radiation or far-red radiation. The results suggest that early flowering was caused by a relatively small amount of far-red radiation that is emitted by the mint-white LED.
- Ph.D. candidate Qingwu Meng evaluated the efficacy of green radiation (LEDs with peak emission of 521 nm) at regulating flowering of ornamentals during truncated short days in the greenhouse. Increasing the green photon flux density from 0 to 25 $\mu mol \cdot m^{-2} \cdot s^{-1}$ as a 7-h day extension accelerated flowering of all long-day plants and delayed flowering of all short-day plants.
- Ph.D. student Kellie Walters and Roberto Lopez evaluated the influence of light intensity, average daily temperature, and carbon dioxide concentration on consumer preference of sweet basil. consumers preferred basil grown under 200 $\mu mol \cdot m^{-2} \cdot s^{-1}$ compared to 100, 400, or 600 $\mu mol \cdot m^{-2} \cdot s^{-1}$ because these samples had a less bitter taste, milder aftertaste, deeper green color, crisper texture, more moderate flavor, and more pleasant aroma. Consumers indicated no differences in flavor between the CO_2 treatments. However, they preferred the appearance, texture, and color of basil grown under higher temperatures (26 or 29 to 35 °C) compared to 23 °C.
- Ph.D. student Kellie Walters and Roberto Lopez quantified the influence of temperature and daily light integral (DLI) on growth and development of greenhouse-grown dill, parsley, purple basil, sage, spearmint, and watercress to develop temperature response curves.

- M.S. student Charlie Garcia and advisor Roberto Lopez evaluated the photoperiodic responses of coriander 'Santo', oregano 'Greek', dill 'Bouquet', lavender 'Bandera Pink', watercress, spearmint 'Spanish', and marjoram. Lavender, oregano, spearmint, and watercress can be classified as long-day plants.
- M.S. student Charlie Garcia and advisor Roberto Lopez evaluated the interaction between light intensity and photoperiod, and the influence on the growth and development of 'Genovese Basil' 'Sweet Thai', 'Red Ruben', 'Nufar OG', 'Holy Basil', and 'Lime Basil'. Flowering of all cultivars was hastened under a 16-h photoperiod.
- M.S. student Charlie Garcia and advisor Roberto Lopez quantified the effects of supplemental light quality on cucumber, tomato, and pepper transplants for high-wire production, in an effort to optimize transplant production. Most responses were generally species-specific. However, the most compact transplants were those grown under a ratio of 75:25 red:blue radiation.

Impact Statements

- In the production of vegetable crops inside greenhouses, the environment influences crop growth (including the harvestable yield) as well as the amount of energy consumed to maintain desired air temperatures. Information generated in our greenhouse simulations compare the trade-offs that exist between fruit yield of tomato and input costs for heating.
- We have a greater understanding of the roles of far-red radiation (700 to 800 nm) on growth of leafy green vegetables as well as growth and subsequent flowering of ornamentals. There are compelling reasons to include far-red radiation in a sole-source lighting spectrum.
- A common misconception is that green radiation (500 to 600 nm) is less (or not) useful to plants for photosynthesis, and that green light is not perceived as a long-day stimulus. We have demonstrated that many plants perceive a low intensity of green radiation when delivered for a prolonged (e.g., hours) period of time during an otherwise long night.
- Light intensity and temperature can influence sweet basil secondary metabolite production and flavor. We have demonstrated that altering the growing environment influences taste and have identified consumer preferences.
- By understanding and modeling the effect of temperature and DLI on culinary herbs, growers can conduct cost-benefit analysis to increase profitability and group plants with similar light and temperature responses in a common environment.
- Lavender, oregano, spearmint, and watercress can be classified as long-day plants. This information is of great benefit for many greenhouse growers who struggle to maintain herb crops such as vegetative. Growers can use the information to modify practices and prolong their harvest period.
- We have demonstration that the addition of green radiation to supplemental lighting containing red and blue radiation can promote leaf expansion and biomass accumulation of vegetable transplants.

Published Written Works (*denotes peer reviewed)

1. Both, A.J., N. Mattson, and R. Lopez. 2018. Utilizing supplemental and sole-source lighting in urban crop production environments. Produce Grower:12-14.
2. Currey, C., R. Lopez, B. Krug, W.G. Owen, and Whipker B. 2018. Greenhouse toolkit series: How to measure greenhouse light. Greenhouse Grower 36(2):48-51.

3. *Craver, J.K., J.K. Boldt, and R.G. Lopez. 2018. Comparison of supplemental lighting provided by high-pressure sodium lamps or light-emitting diodes for the propagation and finishing of bedding plants in a commercial greenhouse. HortScience 53:1407-1415.
4. Kacira, M., N. Mattson, R. Dickson, and R. Lopez. 2018. Urban crop production in vertical farms: Optimizing resource use such as for energy, water, nutrients, and CO_2 is essential for the long-term viability of vertical farm systems. Produce Grower:10-12.
5. Krug, B.A., R. Lopez, B.E. Whipker, W.G. Owen, and C.C. Currey. 2018. Greenhouse toolkit series: Using data loggers in the greenhouse. Greenhouse Grower 36(4):30−32.
6. *Lindberg, H.M., R.A. Cloyd, and E.S. Runkle. 2018. Floriculture College of Knowledge online course series: Demographics and impact. J. Natl. Assoc. County Agr. Agents 11(2).
7. *Llera, J.R., E.D. Goodman, E.S. Runkle, and L. Xu. 2018. Improving greenhouse environmental control using crop-model-driven multi-objective optimization. GECCO '18 Proc. Genet. Evolution Computation Conf. Companion 292-293.
8. Lopez, R.G. Propagation light learning. 2018. GrowerTalks 82(4):64−65.
9. Lopez, R.G., B. Krug, W.G. Owen, B. Whipker, and C. Currey. 2018. Greenhouse toolkit series: Monitoring carbon dioxide in the greenhouse. Greenhouse Grower 36(3):48-51.
10. Meng, Q. 2018. Improving yield and quality of indoor food crops with precise light regimens. PhD diss., Dept. of Hort., Mich. State Univ., East Lansing, MI.
11. *Meng, Q. and E.S. Runkle. 2018. Regulation of flowering by green light depends on its photon flux density and involves cryptochrome. Physiol. Plant.
12. *Meng, Q. and E.S. Runkle. 2018. Using radiation to enhance quality attributes of leafy vegetables: A mini-review. Acta Hortic. 1227:571-578.
13. *Owen, W.G., Q. Meng, and R.G. Lopez. 2018. Promotion of flowering from far-red radiation depends on the photosynthetic daily light integral. HortScience 53:465-471.
14. *Owen, W.G. and R.G. Lopez. 2018. Propagation daily light integral and root-zone temperature influence rooting of single-internode *Pennisetum* ×*advena* culm cuttings. HortScience 53:176-182.
15. Park, Y. 2018. Controlling the radiation spectrum of sole-source lighting to elicit desirable photomorphogenic traits and regulate flowering of floriculture seedlings. PhD diss., Dept. of Hort., Mich. State Univ., East Lansing, MI.
16. Park, Y. and E. Runkle. 2018. Growing ornamental seedlings under white LEDs. Greenhouse Grower 36(11):23-26.
17. *Park, Y. and E.S. Runkle. 2018. Far-red radiation and photosynthetic photon flux density independently regulate seedling growth but interactively regulate flowering. Environ. Exp. Bot. 155:206-216.
18. *Park, Y. and E.S. Runkle. 2018. Investigating the interaction between photosynthetic photon flux density and far-red radiation in petunia seedlings under sole-source lighting. Acta Hortic. 1227:541-548.
19. *Park Y. and E.S. Runkle. 2018. Spectral effects of light-emitting diodes on plant growth, visual color quality, and photosynthetic photon efficacy: White versus blue plus red radiation. PLOS ONE 13(8):e0202386.
20. Runkle, E. and J. Faust. 2018. New, high-resolution, interactive DLI maps. Greenhouse Product News 28(10):46.
21. Runkle, E. 2018. Accelerating growth: What works and what does not. Greenhouse Product News 28(4):38.

22. Runkle, E. 2018. An update on LED lighting efficacy. Greenhouse Product News 28(7):58.
23. Runkle, E. 2018. Causes of flower bud abortion. Greenhouse Product News 28(3):42.
24. Runkle, E. 2018. DLC requirements for LED fixtures. Greenhouse Product News 28(12):42.
25. Runkle, E. 2018. Horticultural lighting applications. Greenhouse Product News 28(6):58.
26. Runkle, E. 2018. Maximizing the benefits of supplemental lighting. Greenhouse Product News 28(1):46.
27. Runkle, E. 2018. Purple vs. pink vs. white LED fixtures. Greenhouse Product News 28(9):62.
28. Runkle, E. 2018. Temperature integration. Greenhouse Product News 28(2):38.
29. Runkle, E. 2018. Using GA to increase plant height. Greenhouse Product News 28(8):42.
30. Runkle, E. 2018. UV radiation and applications in horticulture. Greenhouse Product News 28(5):50.
31. Runkle, E. 2018. White LEDs for plant applications. Greenhouse Product News 28(11):42.
32. *Walters, K.J. and R.G. Lopez. 2018. Ethephon foliar sprays are influenced by carrier water alkalinity and ambient air temperature at application. HortScience 53:1835-1841.
33. Whipker, B, J. Henry, W.G. Owen, B. C. Currey, B. Krug, and R. Lopez. 2018. Greenhouse toolkit series: Keeping in front of the curve: pH and EC monitoring. Greenhouse Grower 36(1):62-70.
34. Zhang, M. 2018. Manipulating light quality to improve growth attributes of high-value specialty crops in controlled environments. MS thesis, Dept. of Hort., Mich. State Univ., East Lansing, MI