Michigan State University 2022-23 Station Report
NCERA-101: Committee on Controlled Environment Technology & Use

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New equipment

- Ph.D. student Nathan Kelly and Erik Runkle installed 18 new OSRAM Phytofy fixtures in the controlled-environment lighting laboratory (CELL). They have six independently tunable LED channels (UV-A, blue, green, red, far red, and white). These partially replaced legacy non-commercial Spartan fixtures that had seven LED channels.

Activities and accomplishment summaries

- We coordinated several outreach programs that delivered unbiased, research-based information on producing plants in controlled environments, including the 2022 Michigan Greenhouse Growers Expo and the 2022 Floriculture Research Alliance annual meeting.
- In collaboration with colleagues at Arizona, Michigan State, Purdue, Ohio State, and the USDA-ARS, we completed the third year of our research and outreach SCRI-supported project entitled "Improving the profitability and sustainability of indoor leafy-greens production".
- In collaboration with colleagues at Iowa State, Michigan State, North Carolina State, Tennessee, Texas Tech, and the USDA-ARS, we began the first year of our SCRI-supported research and outreach project entitled "Controlled Environment Agriculture Herb Extension and Research Base: CEAHERB".
- M.S. student Devin Brewer and Roberto Lopez investigated the influence of reducing the air temperature and providing blue + red end-of-production sole-source lighting on red-leaf lettuce. Results indicate that reducing the air average daily temperature to 8 or 14 °C increased anthocyanin content but negatively impacted fresh mass and rate of leaf unfolding.
- In collaboration with industry partners, M.S. student Charles Smith, Erik Runkle, and Roberto Lopez quantified how young plants rooted under supplemental lighting from light-emitting diodes (LEDs) develop undesirable purple foliage compared to those rooted under high-pressure sodium lamps. Preliminary results suggest that cool air and root-zone temperatures exacerbate the purpling.
- M.S. student Jessie Brown and Roberto Lopez investigated the influence of photoperiodic lighting on specialty cut flowers. Results indicate that flower initiation of both *Caryopteris* and *Craspedia* occurs regardless of daylength. However, floral development of *Caryopteris* only occurred under short daylengths.
- M.S. student Jessie Brown and Roberto Lopez studied the effect of vernalization duration and temperature and photoperiodic lighting on ranunculus cut flower production. Preliminary results suggest that vernalizing corms for 2 to 3 weeks at ≤7.5 °C and forcing plants under long days hastens flower development.

- In collaboration with a large breeding company, research technician Annika Kohler and Erik Runkle quantified flowering time of several petunia cultivars grown in greenhouses at a gradient of temperatures (12 to 24 °C) under a low or high light intensity. Light intensity had little effect on flowering time at the higher temperatures but had a greater effect at low temperatures.
- Ph.D. student Hyeonjeong Kang and Roberto Lopez investigated the influence of air temperature and light intensity and duration on growth and development of tropical foliage plants during production. Growth and development was promoted at air temperatures between 24 to 28 °C. However, 32 °C and continuous 24-h of light had a negative impact on all crops.
- Ph.D. students Jiyong Shin and Nathan Kelly, with Erik Runkle, collaborated with and LED company to study the effects of partly substituting some of the red light from cool-white LEDs with red LEDs Lettuce and kale were grown under different white LEDs plus red LEDs while keeping the photosynthetic light and blue light intensities the same. Plant growth was similar under the three treatments, indicating that a "Horti White" LED-based solution enabled greater use of the most efficient red LEDs.
- In collaboration with a large commercial greenhouse crop producer, Ph.D. student Jiyong Shin, research technician Nate Durussel, Roberto Lopez, and Erik Runkle utilized growth chambers to investigate the effects of air temperature, relative humidity, cheesecloth covering, and/or light intensity on tipburn of *Evolvulus*. The combination of higher relative humidity and cheesecloth covering decreased tipburn occurrence and severity.
- Ph.D. student Eric Stallknecht and Erik Runkle previously investigated a red-fluorescent greenhouse shading material that increased the biomass accumulation of floriculture, leafy green, and fruiting crops. We are currently conducting emulated lighting experiments indoors to determine if increasing or decreasing the concentration of the red-fluorescent plastic additive can be optimized to further increase biomass accumulation.
- Ph.D. student Eric Stallknecht, Erik Runkle, and collaborators at Michigan State University are conducting an experiment with transparent photovoltaic panels investigating trade-offs that exist between plant growth and energy generation when using materials that selectively absorb UV and blue light.

Impact statements

- The Michigan Greenhouse Growers Expo, Electronic Grower Resources Online, OptimIA, and The Floriculture Research Alliance meetings delivered unbiased, research-based information to over 3,000 greenhouse growers in 2022, plus additional growers and marketers of vegetable and fruit crops.
- Reducing the air temperature at the end-of-production significantly increased anthocyanin content of red-leaf lettuce in comparison to moderate blue or blue + red sole-source lighting alone.
- Increasing the air and/or root-zone temperature can significantly reduce foliage purpling of unrooted cuttings under LED supplemental lighting providing red + blue light.
- Air temperature has a greater impact on the growth and development of tropical foliage plants than daily light integral (DLI) or photoperiod. However, temperatures above 28 °C can be detrimental.
- We characterized two recent specialty cut flower introductions as day-neutral for flower induction.

- Providing vernalization treatments and photoperiodic lighting can hasten ranunculus cut flower production.
- Lettuce growth increases as red or green light are replaced by far-red light. However, when red light is mostly or fully replaced by far-red light, increases in growth do not continue. In addition, lettuce-leaf color and overall quality decrease as the far-red light percentage increases.
- Representative leafy green, floriculture, and culinary herb crops tolerated up to a moderate decrease in (extended) photosynthetically active radiation when grown under transparent photovoltaic panels from spring to fall in Michigan. However, there was a decrease in yield of fruiting crops (e.g., tomato), and tolerances to shading of most other crops are unlikely during seasonally light-limited conditions.
- Information generated on the effects of temperature and light on growth and flowering of petunia can be used by commercial growers to schedule plants more precisely for specific market dates.
- Partly substituting red and green light from white LEDs with red light from more effective red LEDs practically has no effect on growth and coloration of leafy greens grown indoors. Using this approach, energy consumption can be decreased by 15-25%, depending on the baseline spectrum and fixture characteristics.

Published written works (since 2022-23 report)

Scientific manuscripts

Kohler, A.E., E.M. Birtell, E.S. Runkle, and Q. Meng. 2023. Day-extension blue light inhibits flowering of chrysanthemum when the short main photoperiod includes far-red light. J. Amer. Soc. Hort. Sci. 148:89-98.

Meng, Q. and E.S. Runkle. 2023. Blue photons from broad-spectrum LEDs control growth, morphology, and coloration of indoor hydroponic red-leaf lettuce. Plants 12(5):1127.

Park, Y. and E.S. Runkle. 2023. Spectral-conversion film potential for greenhouses: Utility of green-to-red photons conversion and far-red filtration for plant growth. PLoS ONE 18(2):e0281996.

Spall. C.S. and R.G. Lopez. 2022. Daily light integral and/or photoperiod during the young plant and finishing stages influence floral initiation and quality of witchgrass and marigold cut flowers. Front. Plant Sci. https://doi.org/10.3389/fpls.2022.956157

Spall. C.S. and R.G. Lopez. 2023. Supplemental lighting quality influences time to flower and finished quality of three long-day specialty cut flowers. Horticulturae 9(1):73.

Stallknecht, E.J., C.K. Herrera C. Yang, I. King, T.D. Sharkey, R.R. Lunt, and E.S. Runkle. 2023. Designing plant-transparent agrivoltaics. Sci. Rep. 13:1903.

Tarr, S. and R.G. Lopez. 2023. Influence of day and night temperature and radiation intensity on growth, quality, and economics of indoor green butterhead and red oakleaf lettuce production. Sustainability 15(1):829.

Walters, K.J. and R.G. Lopez. 2022. Basil seedling production environment influences subsequent yield and flavor compound concentration during greenhouse production. PLoS ONE https://doi.org/10.1371/journal.pone.0273562

Vaštakaitė-Kairienė, V., A. Brazaitytė, J. Miliauskienė, and E.S. Runkle. 2022. Red to blue light ratio and iron nutrition influence growth, metabolic response, and mineral nutrients of spinach grown indoors. Sustainability 14:12564.

Trade articles

Kubota, C., E. Runkle, C. Mitchell, and R. Lopez. 2022. Answering key questions about indoor crops. Inside Grower Nov.:14-15.

Lopez, R.G. and A. Soster. 2022. Producing succulents with the speed of light. Greenhouse Management 42(11):28−30.

Lopez, R.G. and A. Soster. 2022. Superior succulents: Is the paradigm that indicates all succulents require high temperatures and DLI true? Greenhouse Management 42(12):50−52.

Lopez, R.G. and N. Durussel. 2022. Avoiding caladium conundrums, Part 2. GrowerTalks 86(7):62–65.

Lopez, R.G., C. Spall, and N. Durussel. 2022. Avoiding caladium conundrums. GrowerTalks 86(6):66–67.

Runkle, E. 2023. Advancements in horticultural lighting. Greenhouse Product News 33(3):10.

Runkle, E. 2023. Several consequences of growing too cool. Greenhouse Product news 33(1):12.

Runkle, E., J. Shin, and N. Kelly. A closer look at the effect of white LEDs on plant performance. Greenhouse Grower 41(1):26-28.

Runkle, E. 2022. Getting started with supplemental greenhouse LED lighting. Greenhouse Product News 32(11):42.

Runkle, E. 2022. Far-red light in greenhouse and indoor farming. Greenhouse Product News 32(10):50.

Runkle, E. 2022. The pros and cons of cool nights. Greenhouse Product news 32(9):42.

Spall, C. and R.G. Lopez. 2022. Emerging specialty cut flowers: A study of flower induction in marigold and witchgrass. GrowerTalks 86(3):76–82.