Michigan State University 2023-24 Station Report
NCERA-101: Committee on Controlled Environment Technology & Use

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New equipment

- We installed the GrowWise Control System and LED lighting from Philips in 12 canopies of the controlled-environment lighting laboratory (CELL). Each canopy can be independently controlled to deliver a broad range of light spectra using dimmable blue, white, red, and far-red LEDs. These replaced the last remaining non-commercial Spartan legacy fixtures that were originally developed for CELL.

Activities and accomplishment summaries

- We coordinated outreach events that delivered unbiased, research-based information on producing plants in controlled environments, including the 2023 Michigan Greenhouse Growers Expo (in Grand Rapids, MI), the 2023 Floriculture Research Alliance annual meeting (in Park City, UT), and a Horticultural Lighting Workshop (in East Lansing, MI).
- We completed the fourth year of a research and outreach USDA-supported project entitled "Improving the profitability and sustainability of indoor leafy-greens production" in collaboration with colleagues at Arizona, Michigan State, Purdue, Ohio State, and the USDA-ARS. The project continues with a one year no-cost extension.
- We completed the first and started the second year of our research and outreach project entitled "Controlled Environment Agriculture Herb Extension and Research Base: CEAHERB". This project is supported by the USDA and is in collaboration with colleagues at Iowa State, Michigan State, North Carolina State, Tennessee, Texas Tech, and the USDA-ARS.
- Ph.D. student Jiyong Shin and Erik Runkle investigated the influence of red and far-red light intensity on the effect of the FR fraction (the fraction of far-red light to red and far-red light combined) in regulating growth attributes of kale and lettuce. They also investigated the influence of blue light intensity on the effect of the FR fraction in regulating various growth attributes of both crops. Plants were grown hydroponically indoors under LED lighting and controlled-environment conditions.
- Research technician Annika Kohler and Erik Runkle quantified growth and subsequent flowering of seedlings of several annual bedding plant crops grown indoors under a broad range of daily light integrals under sole-source LED lighting.
- M.S. student Bridget Knight and Erik Runkle investigated the interactions between blue and far-red light on the growth of young culinary herbs. The morphology of sweet basil, cilantro, parsley, sage, oregano, and mint were examined with the objective of eliciting compact growth without compromising biomass accumulation. Plants were grown in a peat-based substrate indoors under LED lighting and controlled-environment conditions.
- M.S. student Charlie Smith, Erik Runkle, and Roberto Lopez quantified the influence of air and/or root-zone temperature on reducing undesirable purpling of young plants rooted under LEDs. They also investigated if reducing light intensity during callus induction would impact the purpling.

- Ph.D. student Iro Kang and Roberto Lopez investigated the influence of air temperature, photoperiod, and daily light integral on the growth, development, and photosynthesis of tropical foliage plants.
- M.S. student Jessie Brown and Roberto Lopez investigated the influence of photoperiodic lighting on flower initiation and development of multiple specialty cut flower species in a greenhouse production environment. They also quantified the influence and interaction of vernalization temperature and duration and inductive photoperiod cycle of flowering responses.
- Research technician Sean Tarr and Roberto Lopez are conducting photoperiod studies for several floriculture species including bougainvillea, begonia, and dahlia.

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, plus additional growers and marketers of vegetable and fruit crops.
- Our research investigating the influence of light intensity on far-red light responses of leafy greens grown indoors provides insights into how these light dimensions regulate the harvestable yield and crop quality attributes. Information can be used by commercial vertical farmers who seek to utilize far-red light to promote crop growth.
- At least a moderate daily light integral for floriculture seedlings can improve growth and subsequent flowering of young plants. Information can be used to explore the economics of increasing light intensity considering capital and operational costs for lighting and benefits of shortened crop production cycles.
- Our lighting research with culinary herb transplants provides insights on how blue and far-red light can be used to regulate growth characteristics and increase quality. This information can be used by commercial growers in controlled environments to improve the quality of young culinary herbs.
- An increased air and root-zone temperature can be utilized to reduce undesirable purple pigmentation during rooting of herbaceous shoot-tip cuttings under LEDs.
- Photoperiods ≤16 h and daily light integrals between 4 to 8 $mol \cdot m^{-2} \cdot d^{-1}$ are sufficient to produce most foliage plants in controlled environments. Therefore, commercial growers in temperate climate can select crops that have lower optimum temperatures for leaf development to reduce energy costs and be competitive with growers located in other regions.
- Providing photoperiods that promote vegetative and reproductive growth can reduce production time and increase the quality and yield of specialty cut flowers. Additionally, labor savings can be achieved by quantifying the minimum number of days required for flower bud initiation under inductive photoperiods.
- Information gathered on the impact of photoperiod on growth and flowering of popular floriculture crops can be used by commercial growers to schedule plants more precisely for specific market dates and for minimizing production time.

Published written works (since 2022-23 report)

Theses and dissertations

1. Stallknecht, E.J. 2023. Plant growth and development under experimental transparent photovoltaic and red-fluorescent greenhouse coverings. PhD diss., Dept. of Hort., Mich. State Univ., East Lansing, MI.
2. Kelly, N. 2023. The effects of the photon spectrum on growth and quality attributes of leafy greens produced indoors. PhD diss., Dept. of Hort., Mich. State Univ., East Lansing, MI.
3. Brewer, D. 2023. Improving color and phenolic content of leafy greens and microgreens with end-of-production lighting and cooling. M.S. thesis, Dept. of Hort., Mich. State Univ., East Lansing, MI.

Scientific manuscripts

1. Stallknecht, E.J., C.K. Herrera, T.D. Sharkey, R.R. Lunt, and E.S. Runkle. 2023. Growth of snapdragon under simulated transparent photovoltaic panels for greenhouse applications. J. Environ. Hort. 41:170-179.
2. Kelly, N. and E.S. Runkle. 2023. Ultraviolet A and blue light transiently regulate total phenolic and anthocyanin concentrations in indoor-grown red-leaf lettuce. HortScience 58:1595–1602.
3. Stallknecht, E.J. and E.S. Runkle. 2023. Opportunities and challenges with advanced greenhouse glazing materials. Acta Hortic. 1377:205-218.
4. Abedi, M., X. Tan, E.J. Stallknecht, E.S. Runkle, J.F. Klausner, M.S. Murillo, and A. Bénard. 2023. Incorporating the effect of the photon spectrum on biomass accumulation of lettuce using a dynamic growth model. Front. Plant Sci. 14:1106576.
5. Browning, A., D. Smitley, J. Studyvin, E.S. Runkle, Z.Y. Huang, and E. Hotchkiss. 2023. Variation in pollinator visitation among garden cultivars of marigold, portulaca, and bidens. J. Econ. Entomol. 116:872-881.
6. Kelly, N. and E.S. Runkle. 2023. End-of-production ultraviolet A and blue light similarly increase lettuce coloration and phytochemical concentrations. HortScience 58:525-531.
7. Spall, C.S. and R.G. Lopez. 2023. Supplemental lighting quality influences time to flower and finished quality of three long-day cut flowers. Horticulturae 9(1):73.
8. Tarr, S., S. Valle de Souza, 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.
9. Spall, C.S., A.J. Soster, and R.G. Lopez. 2023. Spectrum of low-intensity screw-in horticultural light-emitting diode lamps influences time to flower and finished quality of long-day ornamental species. Scientia Horti. 320:1-11.
10. Walters, K.J. and R.G. Lopez. 2023. The influence of mean daily temperature and daily light integral on the growth, development, biomass partitioning, and color of purple basil, sage, spearmint, and sweet basil PLoS ONE 18(11):e0294905.

Industry articles

1. Kelly, N. and E. Runkle. 2024. Improving lettuce nutrition & coloration with lighting. Inside Grower Spring:28-29.
2. Runkle, E. 2024. LED lighting: A 2024 update. Greenhouse Product News 34(1):12-13.

3. Runkle, E. 2023. Crop acclimation. Greenhouse Product News 33(11):10-11.
4. Runkle, E. 2023. The importance of transpiration. Greenhouse Product News 33(9):12-13.
5. Runkle, E. 2023. Lighting plants indoors, without sunlight. Greenhouse Product News 33(5):10.
6. Gimondo, J. and E. Runkle. 2023. Understanding the forms of nitrogen in water-soluble fertilizers for greenhouse growers. MSU Extension Floriculture News, June 12.
7. Lindberg, H., E. Runkle, and J. Gimondo. 2023. Where can I learn more about how to grow this crop? MSU Extension Floriculture News, April 4.
8. Lopez, R.G. and J. Gimondo. 2023. Avoiding ammonium toxicity is easy! e-GRO edible Alert 12(21):1–5.
9. Lopez, R.G. Apr. 2023. Uneven lettuce growth in NFT systems. e-GRO Blog.
10. Lopez, R.G. Mar. 2023. Pour-thru on primula. e-GRO Blog.
11. Gimondo, J. and R.G. Lopez. 2023. Ammonium toxicity can cause chlorosis in pansies and other crops. MSU Floriculture Extension News, April 21.
12. Smith, C. and R.G. Lopez. 2023. The Problem with purple. GrowerTalks 87(7):36−40.
13. Brewer, D. and R.G. Lopez. 2023. Influencing red leaf lettuce. Inside Grower 24–25.
14. Lopez, R.G. 2023. Photoperiod management- Flower induction of specialty cut flowers. Greenhouse Product News 33(10): 6–8.
15. Lopez, R.G. and C. Spall. 2023. Dianthus adds volume to cut flower arrangements. Greenhouse Grower 36(8):10−12.
16. Iro, K. and R.G. Lopez. 2023. A focus on DLI: Successfully rooting foliage plants and succulents. GrowerTalks 87(2):54−58.
17. Iro, K. and R.G. Lopez. 2023. A Focus on root-zone temperature: Successfully rooting foliage plants and succulents. GrowerTalks 87(4):54−58.
18. Lopez, R.G. and C. Spall. 2023. Dianthus adds volume to cut flower arrangements. Greenhouse Grower 36(8):10−12.
19. Tarr, S. and R.G. Lopez. 2023. Optimize your production parameters. Produce Grower 13–16.
20. Tarr, S. and R.G. Lopez. 2023. Unlocking the potential of indoor lettuce production. Produce Grower 12–13.