

Purdue NCERA-101 Station Report-2013

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Impact Nugget (Lopez Lab): Supplemental lighting during propagation of herbaceous cuttings with red + blue LEDs resulted in similar rooting, growth, and development as overhead HPS lighting.

Impact Nugget (Mitchell Lab): Intracanopy red + blue supplemental LED lighting saved 75% and 55% electrical energy compared to overhead HPS lighting for equivalent high-wire tomato production during winter-to-summer and summer-to-winter greenhouse experiments, respectively.

New Facilities and Equipment (Plant-Growth Facility, Eddy):

An unprecedented number of upgrades and improvements were made to the Purdue Horticulture & Landscape Architecture plant-growth facility in 2012. Shade/energy fabric attached to motorized Wadsworth Push-Pull curtain systems was replaced in each greenhouse room. The new fabric is Ludvig Svennson ILS50 Harmony Revolux, with alternating strips of transparent plastic and diffusing white plastic and 51% light transmission. The manufacturer indicates the white strips “provide high level of light diffusion... stimulating growth.” Of great importance to us was that the fabric thread is much stronger than previous shade cloth we have used. In one room where we trialed fabric with this same thread, it has yet to show any tearing in eight years.

Priva environmental controls for the greenhouses and growth rooms were upgraded. A Dell Optiplex 7010 desktop computer host with Windows 7 runs Priva Office Direct software, version 4.1.2. Software was also updated for all 25 Priva Maximizers in the network. This upgrade provided much needed processing speed, security, increased data storage and programming functionality. We also installed Priva pH and conductivity probes into our irrigation lines, both for clear water as well as fertilizer solution. This allows us to monitor and record water quality and fertilizer strength, as well as using trending graphs as a diagnostic tool for fertilizer injector malfunction.



New pH and EC Probes

New supplemental lights were installed in the greenhouses, replacing a variety of lights graciously donated by the Indiana State Police over the last twelve years. This

project has improved both light intensity and uniformity, while streamlining maintenance. We hung 150 ParSource GL Sodium 1000W Attached Magnetic Ballasts, with GLX reflectors eleven feet off floor, about eight feet above bench tops. The lamps provided were Sylvania Lumalux LU1000/Eco, which had a disappointing failure rate, including several that melted and fell out of their sockets. We chose not to use glass lamp barriers due to the difficulty of cleaning them. We have experienced arc-tube ruptures of metal halide lamps in the past, a human safety and fire hazard, so removed most of metal halide fixtures. Where they were not removed, we replaced the lamps with HPS conversion lamps.

We also addressed replacement of T12 fluorescent lamps in our growth chambers. We chose two solutions depending on model of chamber. For our Conviron E8s, we replaced the ballasts with T5 ballasts. A removable plexiglass barrier was placed below the lights to keep them from being exposed to cold air. Ten T12 lamps were replaced with only eight T5s, but the efficiency of the lamps and the ability to fit a reflector in above them resulted in an increase in light intensity. A new set of solarized T12 lamps prior to replacement provided 203 $\mu\text{mol}/\text{m}^2/\text{s}$ at a distance of 36 inches below the lamp canopy. After project completion, the solarized T5s provided 287 $\mu\text{mol}/\text{m}^2/\text{s}$ at the same distance. Lamp model used was Philips F54T5/841 HO Alto. This retrofit was done by Purdue Facilities for a cost of \$750 per chamber. For our Conviron E15s with 6-foot fluorescent lamps, we chose to stockpile an eight-year supply of T12 lamps rather than replace ballasts. T5 lamps do not come in 6-foot lengths, and reconfiguring sockets and ballasts would have been too costly considering the expected life of the chambers.

All 26 of our evaporative cooling pads were dismantled and rebuilt by greenhouse staff. They were sagging and in some cases pulling away from the walls. Along with wasting water, leaks were causing stains and slippery floors. New wood framing was installed where rotten, and all gutter seams resealed. Step by step photographs were taken for sharing with other facilities. Each pad took 6-8 hours labor and about \$20 in materials.

In an effort to improve security of the facility, a Schlage electronic lock with cardswipe access was installed in one entry door. Users can swipe their Purdue identification card for access. This is the only entrance that can be used after hours and on weekends. Locks were changed on other doors so that existing keys no longer allowed access. This solved the problem of distributing keys and having so many unreturned. The lock also tracks who entered, and different entry access can be programmed for different individuals. Undergrads, for example, cannot enter after 10PM unless the faculty responsible indicates there is a legitimate reason.

Unique Plant Responses (Lopez Lab):

Greenhouse supplemental lighting for herbaceous cutting propagation. Objectives of the **Lopez Lab** were to quantify the impact of narrow spectra supplemental lighting from LEDs on growth, morphology, and gas exchange of cuttings compared to traditional HPS supplemental lighting. Cuttings of *Impatiens*

hawkeri W. Bull 'Celebrette Frost', *Pelargonium ×hortorum* L.H. Bailey 'Designer Bright Red', and *Petunia ×hybrida* Vilm. 'Suncatcher Midnight Blue' were received from a commercial propagator and propagated in a glass-glazed greenhouse at 23 °C air and substrate temperature set points. After callusing ($\approx 5 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ for 7 d), cuttings were placed under $70 \text{ }\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ delivered from HPS lamps or LED arrays with varying proportions (%) of red:blue light (100:0, 85:15, or 70:30). After 14 d under supplemental lighting treatments, growth, morphology, and gas exchange of rooted cuttings were measured. There were no significant differences among *Impatiens* and *Pelargonium* cuttings grown under different supplemental light sources. However, compared to cuttings propagated under HPS lamps, stem length of *Petunia* cuttings grown under 100:0 red:blue LEDs was 11% shorter, while leaf dry mass, root dry mass, root mass ratios, and root:shoot ratio of cuttings grown under 70:30 red:blue LEDs were 15%, 36%, 17%, and 24% higher, respectively. Supplemental light source had minimal impact on plants following transplant. Our data suggest that LEDs are suitable replacements for HPS lamps as supplemental light sources during cutting propagation.

Unique Plant Responses (Mitchell Lab):

Greenhouse supplemental lighting for tomato transplant production. Research related to the PhD project of **Celina Gomez** in the **Mitchell lab** compared effects of overhead supplemental lighting from ORBITEC's open-bar, overhead LED arrays with those from HPS-supplemented or unsupplemented control treatments on seedling growth and development responses. Tomato cultivars 'Maxifort', 'Komeett', 'Success', 'Sheva sheva', 'Liberty', and 'Felicity' were grown for 3 weeks each month throughout the year in a glass-glazed greenhouse. A constant daily light integral (DLI) of $5 \text{ mol}\cdot\text{m}^{-2}\cdot\text{day}^{-1}$ was provided to the seedlings receiving SL while natural solar DLI cycled throughout the year. LED treatments compared with controls and HPS included 100% red, 95% red + 5% blue, or 80% red + 20% blue. The experiment compared different growth parameters across seasons to determine when SL is needed for acceptable plant growth and when and how much blue light might be useful. The experiment is being validated in 2013 using a plastic greenhouse.

Greenhouse supplemental lighting for high-wire tomato production. Research related to the PhD project of **Celina Gomez** in the **Mitchell lab** is comparing supplemental lighting from either traditional overhead HPS lighting with that from intracanopy LED lighting from ORBITEC LED towers and with unsupplemented controls. Both winter-to-summer as well as summer-to-winter tomato-production experiments were conducted in 2012. The intracanopy LED lighting treatments were applied using ORBITEC lighting towers placed within the rows between every two high-wire tomato plants and irradiating red + blue LED light (95% and 5%) both ways within a row. The experiments compared plant growth, fruit yield, and energy consumption with naturally increasing solar DLI from winter-to-summer with fixed LED DLI in experiment #1 and increasing LED DLI in experiment #2 to

compensate for the natural decrease in solar DLI. No differences were observed between cultivars for any yield parameter evaluated. Equivalent increases in fruit number and mass were achieved with the two supplemental lighting treatments compared to the unsupplemented controls. Furthermore, significant energy savings were achieved using LED-ICL compared to the standard HPS-OHL treatments (75% and 55% for Expts. 1 and 2, respectively). Our results suggest that LED-ICL is a viable supplemental lighting alternative to the widely adopted HPS-OHL for high-wire greenhouse-tomato production.

Supplemental lighting effects on quality attributes of high-wire tomatoes.

Research related to the undergraduate research project of **Michael Dzkovich** in the **Mitchell lab** compared responses of consumer taste panels and physico-chemical (PC) parameters on tomatoe fruits harvested from unsupplemented control plants, plants grown under 600W HPS lamps, and plants grown using intracanopy LED towers. Tomatoes were harvested vine ripe, and purees were analyzed for Brix, pH, titratable acidity, citric acid content, electrical conductivity, as well as several ratios including Brix/TA. PC data were then correlated with the results of tasting panels. Volunteer tasters were asked to rate tomato wedges based upon color, aroma, mouthfeel/texture, acidity, sweetness, aftertaste, intensity, and overall acceptance in a single-blind study. Consumer-acceptance data helped establish relationships between PC properties and consumer preferences of fruits harvested from plants receiving the various supplemental lighting treatments. Before LED technology will be fully embraced by growers, potential effects on fruit quality must be established. Those studies are in progress.

Accomplishment Summaries: Accomplishment summaries are included in the *New Facilities and Equipment* and *Unique Plant Responses* sections of this report.

Impact Statements: Impact statements are included in the *New Facilities and Equipment* and *Unique Plant Response* sections of this report.

Published Written Works (Lopez Lab):

Scientific

Camberato, D.M., R.G. Lopez, and B.A. Krug. 2012. Development of 'Euphorbia pulcherrima' under reduced finish temperatures. *HortScience* 47(6):745–750.

Mitchell, C.A., A. Both, C.M. Bourget, J.F. Burr, C. Kubota, R.G. Lopez, R.C. Morrow, and E.S. Runkle. 2012. LEDs: The future of greenhouse lighting! *Chronica Horticulturae* 52(1):6–12.

Ortiz, M.A., K. Hyrczyk, and R.G. Lopez. 2012. Comparison of high tunnel and field production of specialty cut flowers in the Midwest. *HortScience* 47(9):1265–1269.

Miller, W.B., N.S. Mattson, X. Xie, D. Xu, C.J. Currey, K.L. Clemens, R.G. Lopez, M. Olrich, and E.S. Runkle. 2012. Ethephon substrate drenches inhibit stem extension of floriculture crops. *HortScience* 47(9):1312–1319.

Hutchinson, V.A., C.J. Currey, and R.G. Lopez. 2012. Photosynthetic daily light integral during root development influences subsequent growth and development of several herbaceous annual bedding plants. *HortScience* 47(7):856–860.

Currey, C.J., R.G. Lopez, B.A. Krug, I. McCall, and B.E. Whipker. 2012. Substrate drenches containing flurprimidol suppress height of 'Nellie White' Easter lilies. *HortTechnology* 22(2):164–168.

Currey, C.J., V.A. Hutchinson, and R.G. Lopez. 2012. Growth, morphology, and quality of rooted cuttings of several herbaceous annual bedding plants are influenced by photosynthetic daily light integral during root development. *HortScience* 47(1):25–30.

Hall, C.R., B.K. Behe, B.L. Campbell, J.H. Dennis, R.G. Lopez, and C. Yue. 2012. Market segmentation for US floral consumers based on attitudes towards biodegradable packaging. *Acta Hort.* 930:127–134.

Hall, C.R., B.K. Behe, B.L. Campbell, J.H. Dennis, R.G. Lopez, and C. Yue. 2012. The appeal of biodegradable packaging to US floral consumers. *Acta Hort.* 930:121–126.

Hall, T.J., J.H. Dennis, R.G. Lopez, and T.L. Cannady. 2012. A Net present value and financial feasibility analysis of converting from plastic pots to degradable paper pots. *Acta Hort.* 930:135–140.

Yue, C., C.R. Hall, B.K. Behe, B.L. Campbell, R.G. Lopez, and J.H. Dennis. 2012. Comparing willingness to pay estimation models for conjoint analysis: a case study of willingness to pay for biodegradable containers for plants. *Acta Hort.* 930:217–224.

Behe, B.K., B.L. Campbell, J.H. Dennis, C.R. Hall, R.G. Lopez, and C. Yue. 2012. Eco-attitudes and behaviours of annual, perennial and herb and vegetable buyers from four US States. *Acta Hort.* 930:43–48.

Currey, C.J. and R.G. Lopez. 2012. Biomass accumulation and allocation and leaf morphology of *Impatiens hawkeri* 'magnum salmon' cuttings is affected by photosynthetic daily light integral in propagation. *Acta Hort.* 956:349–355

Extension

England, K.M, D.M. Camberato, and R.G. Lopez. 2012. Water-soluble and controlled-release fertilization. HO-251-W:1–6. <http://www.extension.purdue.edu/extmedia/HO/HO-251-W.pdf>

Currey, C.J. and R.G. Lopez. 2012. Purdue and the global greenhouse. *Greenhouse Product News* 22(10):38–42.

Currey, C.J., V.A. Hutchinson, and R.G. Lopez. 2012. Producing high-quality rooted cuttings. *Greenhouse Grower* 30(11):33–37.

Currey, C.J., V.A. Hutchinson, and R.G. Lopez. 2012. Reduce flowering time. *Greenhouse Grower* 30(11):38–40.

Currey, C.J. and R.G Lopez. 2012. Purdue and the global greenhouse. *Greenhouse Product News* 22(9):38–42.

Krug, B.A., C.J. Currey, R.G. Lopez, and N.S. Mattson. 2012. Potted plants on CRFs. *Greenhouse Grower* 30(9):7–9.

Mattson, N.S., B.A. Krug, R.G. Lopez, and C.J. Currey. 2012. Don't neglect the root zone. *Greenhouse Grower* 30(9):4–6.

Currey, C.J., R.G. Lopez, N.S. Mattson, and B.A. Krug. 2012. Bedding plants and CRFs. *Greenhouse Grower* 30(9):2–3.

Beckerman, J.L., R.G. Lopez, and C.S. Sadof. 2012. Managing pests and diseases in the greenhouse. *Greenhouse Product News* 22(8):24–29.

Lopez, R.G. and J.H. Dennis. 2012. Marketing sustainability. *Greenhouse Product News* 22(7):28–33.

Lopez, R.G. and C.J. Currey. 2012. PGRs and Nutrition: Boilermaking Solutions. *Greenhouse Product News* 22(6):24–30.

Currey, C.J., R.G. Lopez, and N.S. Mattson. 2012. Grow better bedding plants in cold weather. *Greenhouse Grower* 30(8):2–5.

Currey, C.J. and R.G Lopez. 2012. The Greenhouse environment: Boilermaking solutions. *Greenhouse Product News* 22(5):36–40.

Lopez, R.G. and C.J. Currey. 2012. Managing photosynthetic light during liner production. *OFA Bulletin* 931:1, 5–7.

Currey, C.J., R.G. Lopez, B.A. Krug, I. McCall, and B.E. Whipker. 2012. Flurprimidol drenches- A new height control option for Easter lilies. *Greenhouse Grower*. 21(1):1–3.

Lopez, R.G. 2012. Floriculture and ornamentals education and extension at Purdue University. *Greenhouse Product News* 22(4):16–21.

Published Written Works (Mitchell Lab):

Massa, G. and C. Mitchell. 2012. Sweetpotato vine management for confined food production in a space life-support system. *Adv. Space Res.* 49: 262-270.

Mitchell, C.A., A. Both, C.M. Bourget, J.F. Burr, C. Kubota, R.G. Lopez, R.C. Morrow, and E.S. Runkle. 2012. LEDs: The future of greenhouse lighting! *Chronica Horticulturae* 52(1):6–12.

Mitchell, C. 2012. Plant lighting in controlled environments for space and earth applications. *Acta Hort.* 956: 23-36.

Gomez, C., R. Morrow, C. Bourget, G. Massa, and C. Mitchell. 2013. Comparison of intracanalopy light-emitting diode towers and overhead high-pressure sodium lamps for supplemental lighting of greenhouse-grown tomatoes. HortTechnology 23(1): 93-98.

Scientific and Outreach Oral Presentations (Lopez Lab):

Veronica Hutchinson and R.G. Lopez. When is Light Most Important for Bedding Plants? Oral presentation at the 2012 Indiana Flower Growers Association Bedding Plant Conference, Indianapolis, IN, February 2.

Ortiz, M. and R.G. Lopez. Assessing the Difference between Field and High Tunnel Specialty Cut Flower Production in the Midwest. Oral presentation at the 2012 Indiana Flower Growers Association Bedding Plant Conference, Indianapolis, IN, February 2.

Lopez, R.G, B. Krug, and N. Mattson. Using Controlled Released Fertilizers in the Greenhouse - Advanced Level. Oral presentation at the 2012 OFA Short Course, Columbus, OH, July 14.

Mitchell, C., E.S. Runkle, R.G. Lopez and J. Burr. Greenhouse Applications of Light-Emitting Diodes - Advanced Level. Oral presentation at the 2012 OFA Short Course, Columbus, OH, July 14.

Mattson, N. and R.G. Lopez. Finishing Spring Annuals in an Unheated High Tunnel. Oral presentation at the 2012 OFA Short Course, Columbus, OH, July 14.

Frantz, J., J. Erwin and R.G. Lopez. Economics & Impact of CO₂ & Supplemental Light on Plant Growth & Quality Part I. Oral presentation at the 2012 OFA Short Course, Columbus, OH, July 14.

Frantz, J., J. Erwin and R.G. Lopez. Economics & Impact of CO₂ & Supplemental Light on Plant Growth & Quality Part II. Oral presentation at the 2012 OFA Short Course, Columbus, OH, July 14.

Currey, C.J. and R.G. Lopez. LED Lighting Update. Oral presentation at the 2012 Indiana Flower Growers Association 30th Annual Meeting, West Lafayette, IN. October 11.

Lopez, R.G. Yellow Petunia Research Update. Oral presentation at the 2012 Indiana Flower Growers Association 30th Annual Meeting, West Lafayette, IN. October 11.

Lopez, R.G. and C.J. Currey. Biomass Accumulation and Allocation and Leaf Morphology of *Impatiens hawkeri* 'Magnum Salmon' Cuttings is Affected by Photosynthetic Daily Light Integral in Propagation. Oral presentation at LightSym2012: Wageningen UR, Netherlands, October 17.

Lopez, R.G. Economics and Impacts of Supplemental Lighting. Oral presentation at the 2012 Northeast Greenhouse Conference, Worcester, MA, November 7.

Lopez, R.G. Finishing Spring Annuals in Unheated High Tunnels. Oral presentation at the 2012 Northeast Greenhouse Conference, Worcester, MA, November 7.

Currey, C.J. Non-chemical height control. Oral presentation at the 2012 Saskatchewan Green Trades Conference, Saskatoon, Saskatchewan, Canada, November 10.

Currey, C.J. Basics of Monitoring, Part 2: Growing Media and Water Quality. Oral presentation at the 2012 Saskatchewan Green Trades Conference, Saskatoon, Saskatchewan, Canada. November 9.

Currey, C.J. Basics of Monitoring, Part 1: The Greenhouse Environment. Oral presentation at the 2012 Saskatchewan Green Trades Conference, Saskatoon, Saskatchewan, Canada, November 9.

Lopez, R.G. Going Green: Substrate Components and Biocontainers. Oral presentation at the 2012 Saskatchewan Green Trades Conference, Saskatoon, Saskatchewan, Canada, November 9.

Lopez, R.G. Using Controlled Release Fertilizers in the Greenhouse. Oral presentation at the 2012 Saskatchewan Green Trades Conference, Saskatoon, Saskatchewan, Canada, November 9.

Lopez, R.G. Economics and Impacts of Supplemental Lighting. Oral presentation at the 2012 Saskatchewan Green Trades Conference, Saskatoon, Saskatchewan, Canada, November 9.

Lopez, R.G. and C.J. Currey. Basics of Monitoring, part 1: The Greenhouse Environment. Oral presentation at the Elkhart County Greenhouse Grower Meeting, Goshen, IN, December 6.

Lopez, R.G. and C.J. Currey Basics of Monitoring, part 2: Growing Media and Water Quality. Oral presentation at the Elkhart County Greenhouse Grower Meeting, Goshen, IN, December 6.

Scientific and Outreach Presentations (Mitchell Lab):

Mitchell, C. 2012. Plant lighting in controlled environments for space and earth. Seminar presentation invited by the School of Plant Sciences, The University of Arizona, Tucson, April 24.

Mitchell, C., E.S. Runkle, R.G. Lopez and J. Burr. 2012. Greenhouse Applications of Light-Emitting Diodes - Advanced Level. Invited oral presentations at the OFA Short Course, Columbus, OH, July 14.

Dzakovich, M., C. Gomez, and C. Mitchell. 2012. LED vs. HPS supplemental lighting effects on fruit quality of greenhouse tomato. Oral presentation at the 2012 annual ASHS conference, Miami, FL, August 3.

Gomez, C., and C. Mitchell. 2012. Light-emitting diodes (LEDs) as a sustainable alternative for lighting greenhouse-grown tomatoes. Oral presentation at the 2012 annual ASHS meeting, Miami, FL, August 3.

Mitchell, C. 2012. LEDs from a plant scientist's point of view. Keynote presentation at International Controlled Environments conference, UK Controlled Environment Working group, Downing College, Cambridge University, England, September 10.

Mitchell, C. 2012. Plant lighting in controlled environments for space and earth applications. Keynote presentation at LightSym2012: Wageningen UR, Netherlands, October 15, and on Oct. 19 (to the WUR Master Class of PhD students).

Poulet, L., G. Massa, R. Morrow, C. Bourget, and C. Mitchell. 2012. Smart LED lighting for major reductions in power and energy for plant lighting in space. Oral presentation at the 2012 annual conference of the American Society for Gravitational and Space Research, New Orleans, December 1.

Other Relevant Accomplishments and Activities (Lopez Lab):

Christopher Currey Awards:

James K. Rathmell Scholarship for Horticultural Study Abroad, American Floral Endowment. 2011, 2012.

Excellence in Teaching Award, Committee for the Education of Teaching Assistants. 2012.

Early Career Research Exchange Seed Grant, Purdue University. 2012.

Joshua Gerovac received the P. Allen Hammer Scholarship, Indiana Flower Growers Association.

Wesley Randall received the P. Allen Hammer Scholarship, Indiana Flower Growers Association.

Other Relevant Accomplishments and Activities (Mitchell Lab):

Cary Mitchell received the 2012 American Institute of Aeronautics and Astronautics (AIAA) Jeffries Aerospace Medicine and Life Sciences Research Award, San Diego, CA, July 18.

Michael Dzakovich won first-place awards for 1) outstanding undergraduate student oral research presentation and 2) general horticulture competency test at the 2012 ASHS annual conference, Miami, FL, July 31 to August 3.

Celina Gomez won third place for outstanding graduate student oral research presentation in the Controlled Environments category at the 2012 annual ASHS conference, Miami, FL, July 31 to August 3.

Cary Mitchell was co-recipient of the NASA Space Act Award for development of High Efficiency Lighting with Integrated Adaptive Control (HELIAC) determined to be of value in the conduct of a space activity, October.