Appendix

HIGHLIGHTS OF COMMITTEE ACTIVITIES (2016 - 2020)

1. *Cooperative Research & Publication:*

    a. *Developed Guidelines and Standards*

    Both, A.J., B. Bugbee, C. Kubota, R.G. Lopez, C. Mitchell, E.S. Runkle and C. Wallace. 2017. Proposed Label for Electric Lamps Used in the Plant Sciences, HortTechnology 27(4):544-549.

    Recent advances in light-emitting diode (LED) technology now provide the horticultural industry with multiple lighting options. However, growers are unable to compare technologies and LED options because of insufficient data on lamp performance metrics. This publication proposed a standardized product label that facilitates the comparison of lamps across manufacturers. This label includes the photosynthetically active radiation (PAR) efficacy, PAR conversion efficiency, photon flux density output in key wave bands, as well as the phytochrome photostationary state (PSS), red/far red ratio, and graphs of the normalized photon flux density across the 300–900 nm wave band and a horizontal distribution of the light output

    b. *Books and Book Chapters*

    Kozai, T., K. Fujiwara, and E.S. Runkle. 2016. LED Lighting for Urban Agriculture. 54 pp. Springer, Singapore.

    This book focused on light-emitting diode (LED) lighting, mainly for the commercial production of horticultural crops in plant factories and greenhouses with controlled environments, giving special attention to: 1) plant growth and development as affected by the light environment; and 2) business and technological opportunities and challenges with regard to LEDs.

    Lopez, R. and E. S. Runkle. 2017. Light Management in Controlled Environments. Meister Media Worldwide, Willoughby, OH. ISBN-13:978-1544254494, ISBN-10:1544254490

    This book presented the underlying biology of how light influences plant growth and development of specialty crops, especially those grown in greenhouses and controlled-environment growth rooms.

    Kozai, T. 2018. Smart Plant Factory: The Next Generation Indoor Vertical Farms. Springer Singapore, ISBN: 978-981-13-1064-5

    Kozai, T., G. Niu, and M. Takagaki (eds.). 2019. Plant factory: An Indoor Farming

System for Efficient Quality Food Production. Academic Press, Elsevier Publisher, Second Edition, pp. 487.

These books described the concept, characteristics, methodology, design, management, business, recent advances and future technologies of plant factories with artificial lighting (PFAL) and indoor vertical farms. The book discussed the basic and advanced developments in recent PFALs and future smart PFALs that emerged in 2016.

Zhang, Y. and M. Kacira. 2018. Air Distribution and Its Uniformity. In Smart Plant Factory: The Next Generation Indoor Vertical Farms. Ed. T. Kozai, Springer Singapore, ISBN: 978-981-13-1064-5

This book chapter described how air current speed affects the photosynthesis and transpiration processes of crops, the theory of leaf boundary layer and boundary layer resistance, and with example applications of improving air movement and uniformity in indoor vertical farming systems considering localized climate control.

Kubota, C. 2019. Understanding crop responses to controlled climates in greenhouses. Chapter 7. (P.205-223) In: (L.F.M. Marcelis and E. Heuvelink eds.) Achieving sustainable greenhouse cultivation. Burleigh Dodds Science, Cambridge, UK.

This book chapter summarized current understanding of interactions of key aerial environmental factors affecting plant growth and their strategic applications to improve the productivity, profitability and sustainability of greenhouse cultivation.

Lea-Cox, J.D. 2020. Advances in Irrigation Practices and Technology in Ornamental Cultivation. Chapter 12. M. S. Reid. (Ed.) Burleigh Dodds Science Publishing, Cambridge, UK. https://shop.bdspublishing.com/store/bds/detail/product/3-190-9781786763280

This chapter addressed these systemic issues, to increase the efficiency of irrigation applications, to reduce runoff volume and limit contaminant load, and make the most effective use of any capture or remediation capacity.

c. Conference Proceedings

Currey, C.J., R.G. Lopez, E.S. Runkle. 2016. VIII International Symposium on Light in Horticulture, ISHS Acta Horticulturae 1134. ISBN: 978-94-62611-09-2

Boyaci, F., M. Kacira, S. Hemming, Y. Tuzel. 2020. III International Symposium on Innovation and New Technologies in Protected Cultivation. Acta Horticultirae 1271. ISBN: 978-94-62612-69-3

d. Publications:

Calibrated environmental measurement instruments are available to members and provide a calibration reference for cooperating laboratories. A package of instruments obtained through a grant from NSF funds has been maintained and continuously updated as new instrumentation has become available. Sensor package includes quantum sensors, air temperature and humidity sensor and spectroradiometer. The instrument package is maintained by one laboratory with regular auditing of the instruments and is forwarded to anyone requesting it for a two week period of use with payment of a fee that provides funds for instrument maintenance and purchase of new instruments that become available. For additional information please see https://www.controlledenvironments.org/instrument-package/.

The NCERA-101group reported 134 publications on their station reports in 2020. A list of these publications is provided at the end. In addition to the publications listed, the NCERA-101 members reported numerous presentations at scientific meetings, workshops, grower conferences, educational outreach, and informational public events.

2. *Annual Meetings:*

2016	5th International Controlled Environment Conference/AusPheno 2016, September 18-23, Canberra, Australia,
2017	Annual Meeting, NASA Ames Research Center, Pacific Grove, CA, USA
2018	Annual Meeting, North Caroline State University, Raleigh, NC, USA
2019	Annual Meeting, McGill University, Montreal, Canada
2020	6th International Controlled Environment Conference, March 15-18, University of Arizona, AZ, USA [postponed due to COVID-19]

3. *Collaborative International Workshops / Meetings*

VIII International Symposium on Light in Horticulture. 2016. Conveners E. Runkle and R. Lopez., Michigan State University, East Lansing, MI, USA.

This international symposium, in collaboration and under the aegis of International Society of Horticultural Sciences, brought together more than 200 participants to discuss about lighting systems and technologies, crop responses to light intensity and quality. A symposium proceeding was published, Acta Horticulturae 1134.

1st International Workshop on Vertical Farming. 2019. Conveners L. Marcelis, F. Orsini, M. Kacira. Wageningen University, The Netherlands. 2019.

This international workshop, in collaboration and under the aegis of International Society of Horticultural Sciences, brought together more than 400 participants to discuss about challenges and opportunities in indoor vertical farming with topics on crop production, LED lighting, environmental control, technology, and engineering. A thematic issue was published on Vertical Farming in European Journal of Horticultural Sciences.

NCERA-101Website

Establishment and maintenance of a comprehensive electronic mailing list and a website, listing the committee's strategic goals and areas of activity, key publications, calibration instrument package capabilities, and upcoming events. All minutes and select presentations and conference proceedings from past NCERA-101 meetings are available electronically on the website (www.controlledenvironments.org).

4. Collaborative multi-state research projects

During the annual meetings and business meetings, Administrative Advisor and NIFA representative present about potential funding opportunities relevant to the NCERA-101Committee and Committee Members also discuss about potential collaborations among academic institutions along with partnerships with the Industry Members and collaborators. Some of these discussions led to large multi-state projects with participation from NCERA-101Committee members form academic institutions, USDA ARS labs, and industry and funded by USDA-NIFA SCRI, DOE-NIFA-InFEWs, and other funding agencies. The following are among these large-scale collaborative projects (*only participating NCERA-101members listed in the projects*):

- *LAMP: Lighting Approaches to Maximize Profits.* M. van Iersel (PI, Univ. of Georgia), with Co-PIs Neil Mattson (Cornell), A. J. Both (Rutgers), B. Bugbee (Utah State Univ.), J. Boldt and K. Harbick (USDA-ARS), J. Craver (Colorado State Univ.), and with various collaborators from NCERA-101Industry Member. Funded by USDA-SCRI.
- *OptimIA: Improving The Profitability And Sustainability Of Indoor Leafy-Greens Production.* E. Runkle (PI-Michigan State Univ.), with Co-PIs C. Kubota (Ohio State), M. Kacira (Univ. of Arizona), C. Mitchell (Purdue), R. Lopez, S. Valle de Souza (Michigan State Univ.), J. Boldt (USDA-ARS). and with various collaborators from NCERA-101Industry Member. Funded by USDA-SCRI.
- *Strategic FEW and Workforce Investments to Enhance Viability of Controlled Environment Agriculture in Metropolitan Areas.* N. Mattson (PI-Cornell), Collaborators K. Harbick (USDA-ARS), E. Mattos (GLASE). Funded by NSF InFEWs.

Recent scientific publications by the NCERA-101 membership

1. Asseng, S., J.R. Guarin, M. Raman, O. Monje, G. Kiss, D.D. Despommiere, F.M. Meggers, and P.P.G. Gauthier. 2020. Wheat yield potential in controlled-environment vertical farms. Proc. Natl. Acad. of Sci. www.pnas.org/cgi/doi/10.1073/pnas.2002655117.
2. Bartucca, Maria Luce and Del Buono, Daniele and Ballerini, Eleonora and Benincasa,

Paolo and Falcinelli, Beatrice and Guiducci, Marcello (2020), Effect of Light Spectrum on Gas Exchange, Growth and Biochemical Characteristics of Einkorn Seedlings. Agronomy, 10(7), 1042.

3. Bayley, Daniel (2020), Controlled Environment Production of Romaine Lettuce (Lactuca sativa). Thesis; School of Environmental Sciences, The University of Guelph, Ontario, Canada. url: https://hdl.handle.net/10214/21293
4. Both, A.J., K. Demchak, E. Hanson, C. Heidenreich, G. Loeb, L. McDermott, M. Pritts, and C. Weber. 2019. High tunnel production guide for raspberries and blackberries. Available at: https://www.tunnelberries.org.
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7. Callaghan, Joshua (2020), Development of Rapid Propagation Systems for Hemerocallis sp. (Daylilies). M.S. Thesis; Department of Plant Agriculture, The University of Guelph, Ontario, Canada. url: http://hdl.handle.net/10214/17751
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11. Craver, J., K. Nemali, and R. Lopez. 2019. Monitoring growth of bedding plant seedlings using images. Greenhouse Management 39(10):53−56.
12. Cui S, Inocente EAA, Acosta N, Keener HM, Zhu H, Ling PP. 2019. Development of Fast E-nose System for Early-Stage Diagnosis of Aphid-Stressed Tomato Plants. Sensors 2019, 19(16), 3480; https://doi.org/10.3390/s19163480
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14. Del Castillo Múnera, J., B.E. Belayneh, A.G. Ristvey, E. Koivunen, J.D Lea-Cox, and C. Swett, 2019. Enabling adaptation to water scarcity: Identifying and managing root disease risks associated with reducing irrigation inputs in greenhouse crop production–A case study in poinsettia. Ag. Water Management. 26, 105737. https://doi.org/10.1016/j.agwat.2019.105737
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