**Annual Meeting**

Joint meeting with NCERA-101, McGill University

Montreal, Canada

April 14-17, 2019

**Multistate Research Project**

**Annual Station Publications Report**

PROJECT NUMBER: NE-1835

TITLE: Resource Optimization in Controlled Environment Agriculture

PROJECT DURATION: October 1, 2018 – September 30, 2023

EXPERIMENT STATION: New Jersey, Maine, Nebraska, Indiana, Ohio, Michigan, Arizona, and Florida

PARTICIPANTS: NJ: Robin Brumfield, A.J. Both, Tom Manning, Tim Shelford; ME: Stephanie Burnett; NE: Ellen Paparozzi and George Meyer; IN: Hye-Ji Kim, Teng Yang, Meng-Yang Lin; OH: Peter Ling, Chieri Kubota, and Mark Kroggel; MI: Roberto Lopez; AZ: Gene Giacomelli and Murat Kacira; FL: Celina Gómez

REPORTING PERIOD**:** October 1, 2018 – May 21, 2019

REPORT DATE: May 21, 2019

PUBLICATIONS:

**Dissertations, Theses (Published):**

NJ

Blott, M.B. 2018. Characterizing farm polyethylene plastic film high tunnels. Rutgers University Libraries. 119 pp. (A.J. Both served as a member of the dissertation advisory committee).

NE

Stevens, E. 2018. Dynamic Classification of Moisture Stress Using Canopy and Leaf Temperature Responses to Step Changes of Incident Radiation. Undergraduate Honors Thesis, University of Nebraska-Lincoln. (Available: UNL Digital Commons).

AZ

Okada, K. 2018. Modeling and optimization of crop production and energy generation for economic profit in an organic photovoltaics integrated greenhouse. Master Thesis, The University of Arizona, Tucson, AZ.

 Caplan, B. 2018. Optimizing carbon dioxide concentration and daily light integral combination in a multi-level electrically lighted lettuce production system. Master Thesis, The University of Arizona, Tucson, AZ.

McBride, S. 2018. Distribution Center Paired Greenhouse Production for Private Labels. Master Thesis. The University of Arizona., Tucson, AZ.

**Books (Published):**

None

**Book Chapters (Published):**

ME

Burnett, S.E. and M.W. van Iersel. 2018. Watering, irrigation systems, and their control, p. 11-45. In: D. J. Merhaut, K.A. Williams, and S.S. Mangiafico (eds.). Water, root media, and nutrient management for greenhouse crops. Univ. California Agr. Natural Resources Communication Serv., Davis, CA.

OH

Kubota, C., M. Chao, S. Masoud, Y.J. Son, R. Tronstad. 2019. Advanced technologies for large-scale plant factories – integration of industrial and systems engineering approach in controlled environment crop production.P.353-362. In: (M. Anpo, H. Fukuda, and T. Wada, eds.) Plant factory using artificial light. Elsevier, Amsterdam, The Netherlands.

Kubota, C., A. de Gelder, and M. Peet. 2018. Greenhouse tomato production. P.276-313. In: (E. Heuvelink, ed.) Tomatoes, 2nd Edition. CAB International, Boston, USA.

AZ

Zhang, Y. and M. Kacira. 2019. Air Distribution and Its Uniformity. Chapter In: Smart Plant Factory: The Next Generation Indoor Vertical Farms. Ed. T. Kozai, Springer Nature Singapore Pte Ltd.

Giacomelli, G. A. (2018). Preface. In "Basic Principles of Growing by Plant Empowerment" by P.A.M. Geelan, J.O. Voogt, P.A. van Weel © Plant Empowerment

**Refereed Journal Articles (Published):**

NJ

Brumfield, R.G., L.B. Kenny, A.J. DeVincentis, A.K. Koeser, S. Verlinden, A.J. Both, G. Bi, S.T. Lovell, and J.R. Stewart. 2018. Analysis of Economic and Social Costs of Growing *Petunia × hybrida* in a Greenhouse Production System Using Alternative Containers. HortScience 53(8): 1179–1185.

NE

Paparozzi, E.T., G.E. Meyer, V. Schlegel, E. E. Blankenship, S. A. Adams, M. E. Conley, B. Loseke and P. E. Read. 2018. Strawberry cultivars vary in productivity, sugars and phytonutrient content when grown in a greenhouse during the winter. Scientia Hort. 227: 1-9.

ME

Peterson, B., S. Burnett, and O. Sanchez. 2018. Submist is effective for propagtion of *Syringa* and *Ilex* by stem cuttings. HortTechnology 28:378-381.

Peterson, B.J., O. Sanchez, S. Burnett, and D.J. Hayes. 2018. Sub-Mist is an effective alternative to overhead mist for the propagation of coleus by stem cuttings. HortTechnology 28:143-148.

IN

Kim, H.J.\*, K.M. Ku, S.H. Choi†, and M. Cardarelli. 2019. Biostimulant enhances adventitious rooting in cuttings of basil, tomato, and chrysanthemum via brassinosteroid-mediated processes. Agronomy 9(2): 74 <https://doi.org/10.3390/agronomy9020074>

Kim, H.J.\*, M.Y.Lin†, and C. Mitchell. 2018. Light spectral and thermal properties govern biomass allocation among vegetative and reproductive structures of tomato through morphological and physiological changes. Environmental and Experimental Botany. <https://doi.org/10.1016/j.envexpbot.2018.10.019>

Colla, G., H.J. Kim, M.C. Kyriacous, and Y. Rouphael. 2018. Nitrate in fruits and vegetables. Scientia Horticulturae 237: 221-238.

Kim, H.J.\*, T. Yang†, M-Y, Lin†, and P. Langenhoven. 2018. Plant propagation for successful hydroponic production. Acta Horticulturae 1212, 109-116 DOI: 10.17660/ActaHortic.2018.1212.22.

OH

Newby, Adam, J. Altland, D. Struve, C. Pasian, P. Ling, P. Jourdan, J.R. Kessler, M. Carpenter. 2018. Integrating Moisture Characteristic Curves with Gravimetric Data in the Management of Substrate Moisture Content for Annual Vinca. HortScience 53(8):1197-1202.

Cui, Shaoqing, Peter P. Ling, Heping Zhu, Harold M. Keener. 2018. Plant pest detection using an artificial nose system: A review. Sensors 28;18 (2).

Xiao, Liping, H. Zhu, M. Wallhead, L. Horst, P. Ling, C. R Krause. 2018. Characterization of biological pesticide deliveries through hydraulic nozzles. Transactions of the ASABE. 61(3): 897-908.

Yan, Tingting, Heping Zhu, Sun Li, Xiaochan Wang, Peter Ling. 2018. Detection of 3-D objects with a 2-D laser scanning sensor for greenhouse spray applications. Computers and Electronics in Agriculture. Volume 152, September:363-374.

Yan, Tingting, Xiaochan Wang, Heping Zhu, and Peter Ling. 2018. Evaluation of Object Surface Edge Profiles Detected with a 2-D Laser Scanning Sensor. Sensors, 18(11), 4060; https://doi.org/10.3390/s18114060

Masoud, S., Y.J. Son, C. Kubota, and R. Tronstad. 2018. Evaluation of simulation based optimization in grafting labor allocation. Applied Engineering in Agriculture. 34(3): 479-489.

Samtani, J.B., C.R. Rom, H. Friedrich, S.A. Fennimore, C.E. Finn, A. Petran, R.W. Wallace, M.P. Pritts, G. Fernandez, C.A. Chase, C. Kubota, and B. Bergefurd. 2019. The status and future of the strawberry industry in the United States. HortTechnology <https://doi.org/10.21273/HORTTECH04135-18>

MI

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(10):1407-1415.

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(3):465-471.

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(2):176-182.

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(12):1835-1841.

AZ

López-Cruz, I.L., E. Fitz-Rodríguez, R. Salazar-Moreno, A. Rojano-Aguilar, M. Kacira. 2018. Development and analysis of dynamical mathematical models of greenhouse climate: a review. European Journal of Horticultural Sciences, 83(5): 269-280.

Zhang, G., C. Choi, T. Bartzanas, I. Lee, M, Kacira. 2018. Computational Fluid Dynamics (CFD) research and application in Agricultural and Biological Engineering. Computers and Electronics in Agriculture, 149: 1-2.

FL

Clavijo, L.J., E. van Santen, and C. Gómez. 2018. Growth, water-use efficiency, stomatal conductance, and nitrogen uptake of two lettuce cultivars grown under different percentages of blue and red photon flux ratios using LEDs. *horticulturae* 4:2–16.

Gómez, C. and L.G. Izzo. 2018. Increasing efficiency of crop production with LEDs. AIMS Agriculture and Food 3:135–153.

Chinchilla, S. L.G. Izzo, E. van Santen, and C. Gómez. 2018. Growth and physiological responses of lettuce grown under pre-dawn or end-of-day sole-source light-quality treatments. *horticulturae* 4:2–10.

**Symposium Proceedings Articles (Published):**

OH

Samarakoon, U.C.; Palmer, J.; Ling, P.; Altland, J. (2018). Quantifying the Effects of Electrical Conductivity, pH and Foliar Application of Calcium Chloride on Yield and Tipburn of *Lactuca sativa* L. Grown Using Nutrient Film Technique (NFT). HortScience, 53(9), s214.

AZ

Zhang, Y. and M. Kacira. 2019. Enhancing Resource Use Efficiency in Plant Factory. ActaHorticulturae [*In Review*]

Kai Staats, Iurii Molavanov, John Adams, Jason Deleeuw, Katherine Morgan, Gregory Schoberth, Thomas Curry, Gene A Giacomelli, 2019. An agent-based model for high-fidelity ECLSS and bioregenerative simulation, 49th International Conference on Environmental Systems ICES-2019-368 7-11 July 2019, Boston, Massachusetts.

Sean Gellenbeck, Barry Pryor, and Gene Giacomelli, 2019. Mushrooms on Mars: A Subsystem for Human Life Support, 49th International Conference on Environmental Systems

 ICES-2019-259 7-11 July 2019, Boston, Massachusetts

Sean Gellenbeck , Roberto Furfaro, Gene Giacomelli, and Robert Lepore4, 2019. A Predictive Model for the Production Rates of a Bioregenerative Life Support System, 49th International Conference on Environmental Systems, ICES-2019-258 7-11 July 2019, Boston, Massachusetts

FL

Gennaro, L.I., M.A. Mickens, G. Aronne, and C. Gómez. 2018. Gas exchange and leaf anatomy of lettuce in response to blue and red LEDs as a sole-source lighting. Proc. 69th Intl. Astronautical Congress. Bremen 1-5 Oct. 2018, Paper 47879.

**Popular (Trade Journal) Articles (Published):**

NJ

Shelford, T, T. Manning and A.J. Both. 2018. Vapor pressure deficit revisited. GrowerTalks, November issue. pp. 66, 67, 69.

Both, A.J. and T. Shelford. 2018. Afraid of your shadows? GrowerTalks, June issue. Available at: <https://www.growertalks.com/Article/?articleid=23645>

Brumfield, R.G. and C. Singer. 2018. Economics of Urban Ag: Targeting high-value, niche markets or products, and adapting a social business model can help urban greenhouses derive profit. Produce Grower. October issue. pp. 18-20. https://www.producegrower.com/article/economics-urban-ag-agriculture-series-rutgers-university/.

ME

Burnett, S. 2019. Why grow dry? Greenhouse Product News. <https://gpnmag.com/article/why-grow-dry/>

Garland, K. and S. Burnett. 2018. Cultivating community. Produce Grower. http://www.producegrower.com/article/urban-agriculture-cultivating-community/.

OH

Ling, Peter and Mary Wicks. 2018. Hydroponic Crop Production Workshop. Ohio Country Journal. January issue.

Wicks, Mary and Peter Ling. 2018. The root of all production. Ohio Country Journal, Mid-December issue.

MI

Both, A.J., N. Mattson, and R. Lopez. 2018. Utilizing supplemental and sole-source lighting in urban crop production environments. Produce Grower:12-14.

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.

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(10):1407-1415.

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 CO2 is essential for the long-term viability of vertical farm systems. Produce Grower:10-12.

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.

Lopez, R.G. Propagation light learning. 2018. GrowerTalks 82(4):64−65.

Lopez, R.G., B. Krug, W.G. Owen, B. Whipker, and C. Currey. 2018. Greenhouse toolkit series

FL

Gómez, C., P. Fisher, and M. Paz. 2018. Getting a piece of the indoor food gardening market. GPN Magazine.

Fisher, P., C. Gómez, C., M. Paz, and E. Solis. 2018. Ensuring customer success with indoor home gardening. Produce Grower Magazine.

 **Presentations (Papers):**

NJ

Brumfield, R.G., B. Özkan, and R. Vezne. 2019. Using Workbooks and E-Learning Videos using adult learning techniques to help Small Scale Vegetable Farmers better manage their farms. Presented at the Extension Risk Management Educators National Conference, Louisville, KY. April 3-4.

Brumfield, R.G. 2018. Food Production in Guyana. Paper Presented at the Annual Conference of the American Society for Horticultural Science (ASHS), Washington, D.C., July 30 – August 3. https://ashs.confex.com/ashs/2018/meetingapp.cgi/Paper/27953.

Brumfield, R.G., B. Özkan, R. Vezne, and E. Ilbasmis. 2018. Empowering Turkish Women Farmers with Agricultural Business Management Training. Paper Presented at the Annual Conference of the American Society for Horticultural Science (ASHS), Washington, D.C., July 30 – August 3. <https://ashs.confex.com/ashs/2018/meetingapp.cgi/Paper/27943>.

NE

Wu, Q., W.W. Stroup and E. T. Paparozzi. 2018. Applications of Generalized Additive Models on Extreme Time-Series Sensor Data in Horticulture. 30th Annual Conference on Applied Statistics in Agriculture. \*\*45 statisticians from land grant and other universities in attendance.

IN

Kim, H.J. 2018. Improving crop productivity and resource efficiency for global food production. Shanghai Center for Plant Stress Biology. Jun. 7, 2018 (n=40).

Kim, H.J. 2019. ISDA-Indiana Grown Hydroponics and Aquaponics Seminar, Purdue University, IN. Jan. 2019.

Yamane, K., K. Takahashi, A. Ikeguchi, M. ligo, I. Maeda, and H.J. Kim. 2018. A case study: the growth of leaf lettuce in an aquaponics system. International Conference on Agriculture and Agro-Industry (ICAAI2018). Chiang Rai, Thailand. Nov. 15-17. (poster)

 M.Y. Lin† and H.J. Kim. 2018. Effects of light quality on high-wire tomato ion uptake, partitioning, and fruit quality. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (poster).

M.Y. Lin†, A. Liceaga, and H.J. Kim. 2018. Far-red light-emitting diodes during production improves quality and flavor of tomato fruits. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (poster).

M.Y. Lin†, and H.J. Kim. 2018. Light resource influences high-wire tomato ion accumulation, partitioning, and fruit quality. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (oral).

Yang, T†. and H.J. Kim. 2018. Performance and yield of vegetable crops are affected by water flow-rate in aquaponics systems. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (oral).

Yang, T†, Y.J. Wang†, and H.J. Kim. 2018. Performance of crop species with different thermal requirements in aquaponics systems. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (poster).

Wang, Y.J.†, T. Yang†, A. Deering, and H.J. Kim. 2018. Evaluating the presence of foodborne pathogens in aquaponics in comparison to hydroponics. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (poster).

Choi, S.H.†, H.S. Lee‡, and H.J. Kim. 2018. Effects of plant-derived protein hydrolysate biostimulant on adventitious rooting in cuttings of basil, tomato, and chrysanthemum. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (poster).

Choi, S.H.†, G.Zhou‡, and H.J. Kim. 2018. Effects of plant-derived protein hydrolysate biostimulant on the productivity and quality of lettuce and tomato. American Society for Horticultural Science, Washington, D.C., WA. Jul. 30-Aug. 3. (poster).

MI

Garcia, C. and R.G. Lopez. 2018. Photoperiod effects growth and development of basil species

and cultivars. HortScience, 53(9), S88. (Oral)

Walters, K.J. and R.G. Lopez. 2018. Improving critical thinking and writing through scientific

 literature review in a greenhouse production course. HortScience, 53(9), S261. (Poster)

Walters, K.J. and R.G. Lopez. 2018. Quantifying the influence of light intensity and CO2

concentration during sweet basil seedling production on subsequent growth, development, and volatile content. HortScience, 53(9), S89. Second Place Award (Oral)

Owen, W.G. and R.G. Lopez. 2018. Propagation of herbaceous perennials under sole-source

light-emitting diodes or greenhouse supplemental lighting from high-pressure sodium lamps. HortScience, 53(9), S152. (Oral)

Owen, W.G. and R.G. Lopez. 2018. Influence of propagation daily light integral and root-zone

temperature on rooting of single-internode *Pennisetum* ×*advena* culm cuttings. HortScience, 53(9), S186. (Oral)

Walters, K.J. and R.G. Lopez. 2018. Improving critical thinking and writing through scientific

literature review in a greenhouse production course. Michigan State University Future Academic Scholars in Teaching (FAST) Symposium, 03 May 2018. East Lansing, MI. (Oral)

Walters, K.J. and R.G. Lopez. 2018. Improving critical thinking and writing through scientific

literature review in a greenhouse production course. Michigan State University Teaching & Learning Spring Conference, 09 May, 2018. East Lansing, MI. (Poster)

Craver, J., K.J. Nemali, and R.G. Lopez. 2018. Physiological acclimation of petunia seedlings

to varying light quality, light intensity, and carbon dioxide concentration for indoor production. NCERA 101: Committee on Controlled Environment Technology and Use Annual Meeting. 09-12 Apr., 2018. Raleigh, NC. (Oral)

Garcia, C. and R.G. Lopez. 2018. Photoperiod influences growth and development of basil

species and cultivars. NCERA 101: Committee on Controlled Environment Technology and Use Annual Meeting. 09-12 Apr., 2018. Raleigh, NC. (Oral)

Walters, K.J. and R.G. Lopez. 2018. Temperature and daily light integral influence sweet basil

growth and development. NCERA 101: Committee on Controlled Environment Technology and Use Annual Meeting. 09-12 Apr., 2018. Raleigh, NC. (Oral)

Walters, K.J. and R.G. Lopez. 2018. Long-day photoperiods influences flowering of foliage

annuals. NCERA 101: Committee on Controlled Environment Technology and Use Annual Meeting. 09-12 Apr., 2018. Raleigh, NC. (Poster)

Walters, K.J. and R.G. Lopez. 2018. Long-day photoperiods influences flowering of foliage

annuals. Michigan State University Plant Science Graduate Student Research Symposium. 30 Mar., 2018. E. Lansing, MI. First Place (Poster)

Walters, K.J. and R.G. Lopez. 2018. Ethephon applications are influenced by carrier water

alkalinity and ambient air temperature at application. Michigan State University Plant Science Graduate Student Research Symposium. 30 Mar., 2018. E. Lansing, MI. (Oral)

AZ

Giacomelli, G. 2018. Adapting controlled environment food production technology for human life-support on other planets. IHC International Symposium on Innovation and New Technologies in Protected Cultivation Strategies and Technologies, Istanbul, Turkey

Giacomelli, G. 2018. Horticultural Science & Engineering Critical for our Future on Earth and in Space. International Horticultural Congress IHC2018 Opening Ceremony, Istanbul Congress Center (ICC), Üsküdar Hall, Istanbul, Turkey. 12 August 2018.

**Other Creative Works:**

NJ

Both, A.J. 2019. Two presentations: *Greenhouse standards* and *Research, trends and partnerships*. Presented as part of the National Greenhouse Manufacturers Association spring meeting. April 8. Austin, TX.

Manning, T.O. 2019. *Energy in greenhouses*. Abstract in the Proceedings of the 64th New Jersey Agricultural Convention and Trade Show. February 5. Atlantic City, NJ. pp. 71-73.

Both, A.J. 2019. *Supplemental light in greenhouses*. Abstract in the Proceedings of the 64th New Jersey Agricultural Convention and Trade Show. February 5. Atlantic City, NJ. pp. 74-75.

Both, A.J. 2019. *High tunnel ventilation*. Extension presentation for the High Tunnel Bramble Workshop organized by the TunnelBerries project team during the Mid-Atlantic Fruit and Vegetable Convention. January 28. Hershey, PA.

Brumfield, R.G. 2018. *Empowering Women Farmers with Agricultural Business Management Training* (EMWOFA). Worked with a team from Turkey, Germany, Spain, and Malta to develop an educational program training manual and e-learning videos to train extension educators and others to teach women farmers business management, production, and computer skills and a hands-on workbook which leads women farmers through the process of developing a business plan for their farm. <http://www.emwofa.eu/>.

NE

Software: MATLAB Fuzzy Logic Clustering, ANFIS, Mamdani Classification Modeling Script System. Featured in UNL BSEN 951 Advanced Modeling Class.

Campbell CR1000 Script for SDI-12 operation of Decagon GS3 Soil sensors, Campbell CS215 temperature and humidity sensors.

IN

COA Learning community: Study Plants @Purdue, Introduction of Indoor Farming, Nov. 12, 2018. (n=15).

Host for the HORT Greenhouse aquaponics tour groups (Indiana high school students) from 2018 The World Food Prize (WFP) Youth Institute, Apr. 18, 2018 (n=100+)

OH

Kroggel, M. and C. Kubota. 2018. Hydroponic nutrient solution for optimized greenhouse tomato production. (factsheet). Ohio State University Extension https://ohioline.osu.edu/factsheet/hyg-1437

Kubota, C., C. Miles and X. Zhao. (eds.) 2018. Grafting Manual: How to Produce Grafted Vegetable Plants. (http://www.vegetablegrafting.org/resources/grafting-manual/)

Kubota, C. 2018. History of Grafting. In: C. Kubota, C. Miles, and X. Zhao (eds.) Grafting Manual: How to Produce Grafted Vegetable Plants. www.vegetablegrafting.org/resources/grafting-manual

Zhao, X., C. Miles and C. Kubota. 2018. Why Graft? In: C. Kubota, C. Miles, and X. Zhao (eds.) Grafting Manual: How to Produce Grafted Vegetable Plants. www.vegetablegrafting.org/resources/grafting-manual

Kubota, C. and C. Miles. 2018. Healing and Acclimatization Methods and Design Principles. In: C. Kubota, C. Miles, and X. Zhao (eds.) Grafting Manual: How to Produce Grafted Vegetable Plants. www.vegetablegrafting.org/resources/grafting-manual

Kubota, C. 2018. Automation in Vegetable Grafting Nurseries. In: C. Kubota, C. Miles, and X. Zhao (eds.) Grafting Manual: How to Produce Grafted Vegetable Plants. www.vegetablegrafting.org/resources/grafting-manual

Kubota, C. 2018. Designing Logistics/Workflow of Grafting Nurseries. In: C. Kubota, C. Miles, and X. Zhao (eds.) Grafting Manual: How to Produce Grafted Vegetable Plants. www.vegetablegrafting.org/resources/grafting-manual

*Website and social media*

Indoor Ag Science Café YouTube Channel: <https://www.youtube.com/playlist?list=PLjwIeYlKrzH_uppaf2SwMIg4JyGb7LRXC>

Kubota Lab (Controlled Environment Plant Physiology and Technology): http://u.osu.edu/cepptlab

Facebook for Controlled Environment Plant Physiology and Technology Lab: <https://www.facebook.com/CEPPTLAB/>

AZ

Student Team Mentor (Giacomelli): FLL “Growing Food in Space” Challenge 5th - 6th Graders Team “Redstone Mechanics” First place State of Maryland, and one of 20 teams worldwide invited to Global Innovation Award event, San Jose, CA, June 30-July 2.

**Workshop Sponsor:**

NJ

Specca, D. and A.J. Both. 2019. Organized a two-day short course titled *Greenhouse Crop Production*. D. Specca, A.J. Both, and R.G. Brumfield delivered presentations. D. Specca and A.J. Both hosted tours. March 21-22. Bordentown, NJ.

Brumfield, R.G. 2018. Developed a one-day workshop on *Urban Ag* and posted materials at: http://farmmgmt.rutgers.edu/UrbanWorkshop.html. A.J. Both and R.G. Brumfield delivered presentations. December 14, New Brunswick, NJ.

OH

The 2019 Greenhouse Management Workshop was organized by Peter Ling and Chieri Kubota with 48 participants (including 19 online). This year’s focus was ‘Root-zone optimization in hydroponics and substrate-based culture systems’ covering both ornamental and vegetable crops.

A new workshop series “Basics of the Greenhouse Environment for K-12 Educators” was first offered in 2018. The workshop was organized by Uttara Samarakoon, Kimberly Sayers, and Peter Ling with 24 participants.

7 one-day private workshops were offered to 16 parties to learn basics of physiology and technologies of soilless strawberry and tomato production.

AZ

18th Annual Greenhouse Crop Production and Engineering Design Short Course. The University of Arizona, Controlled Environment Agriculture Center, March 2019. [M. Kacira, G. Giacomelli, S. Tollefson, B. Pryor, D. Pantoja]

**Workshop Participant:**

NJ

Brumfield, R.G. 2018. Rutgers Cooperative Extension Webinar on *The Economics of Urban Agriculture*. November 22. New Brunswick, NJ.

Brumfield, R.G. 2018. *Economic Trends in Horticulture*. Fall Tri-State Greenhouse Meeting. October 31. Berlin, PA.

Brumfield, R.G. 2018. Professional Development Training for Department of Development and Reform in Hunan Province, China. Topics presented: *Identifying Business Financial Needs*, and *The Economics of Urban Agriculture*. October 19.

Brumfield. R.G. and A.J. Both. 2018. Jiangxi Agriculture Professional Training Program. Topics presented: *Farms of New Jersey*, *Economics of Urban Agriculture*, *Greenhouse Technology, Energy and Lighting*. July 25. New Brunswick, NJ.

Brumfield, R.G. 2018. *Economic Considerations to Keep Your Business Relevant*. University of Arizona Greenhouse Crop Production and Engineering Design Short Course. March 14. Tucson, AZ.

ME

3rd Annual American East Hackathon focusing on Small Agriculture. March 2-3, 2019. Orono, ME.

AZ

Kacira, M. 2019. Monitoring Your Greenhouse Environment: Simple Tools to Technology Trends, March 12, Tucson, Arizona.

Giacomelli, G. 2019. Greenhouse Design and Environmental Control, March 11, Tucson, Arizona

Giacomelli, G. 2019. Greenhouse Energy Conservation Technologies, March 12, Tucson, Arizona

**Refereed Journal Articles (Pending):**

NJ

Li, Y., C.A. Wyenandt, A.J. Both, and J.R. Heckman. 2019. Applying Wollastonite to soil to adjust pH and suppress powdery mildew on pumpkin. In preparation for resubmission to HortTechnology.

Lewus, D. and A.J. Both. 2019. Using computational fluid dynamics (CFD) to improve high tunnel ventilation. Refereed conference proceedings article to be presented at the upcoming GreenSys meeting in Angers, France (June).

Manning, T.O. 2019. Energy modeling in greenhouses: Suitability and utility for specific applications. Refereed conference proceedings article to be presented at the upcoming GreenSys meeting in Angers, France (June).

Shelford, T., C. Wallace, and A.J. Both. 2019. Calculating and reporting key light ratios for plant research. Refereed conference proceedings article to be presented at the upcoming GreenSys meeting in Angers, France (June).

Shelford, T. and A.J. Both. 2019. Plant production in controlled environments. Book chapter submitted for review to ASABE for a new textbook aimed at undergraduate engineering students.

NE

Meyer, G.E., E. Stevens, and E.T. Paparozzi. Classification of Abiotic Plant Stress Conditions Using Canopy Temperature Responses to Step Changes of Incident Radiation, Computers and Electronics in Agriculture (Elsevier).

IN

Choi, S. H.†, L.Z. Xu†, and H.J. Kim\*. Influence of physical properties of peat-based potting mixes substituted with parboiled rice hulls on plant growth under two irrigation regimes. (submitted to Horticulture, Environment, and Biotechnology)

Yang, T†. and H.J. Kim\*. Nutrient management regime affects water quality, crop growth, and nitrogen use efficiency of aquaponic systems. (submitted to Scientia Horticulturae)

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