**Annual Meeting**

University of Nebraska, Lincoln

Lincoln, NE

June 29-30, 2017

**Multistate Research Project**

**Annual Station Publications Report**

PROJECT NUMBER: NE-1335

TITLE: Resource Management in Commercial Greenhouse Production

PROJECT DURATION: October 1, 2013 – September 30, 2018

REPORTING PERIOD**:** June 24, 2016 – June 30, 2017

REPORT DATE: August 25, 2017

PUBLICATIONS:

**Dissertations, Theses (Published)**

Allred, J.A. 2017. Environmental and cultural practices to optimize the growth and development of three microgreen species. M.S. Thesis. Cornell University.

Brace, S.A. 2017. Vermicompost application as a fertilizer source and substrate amendment for seedlings and transplants: practical application and microbial activity analysis. Ph.D. Dissertation, Cornell University.

Grossman, M.C. 2017. Controlling Growth of Echinacea Hybrids. Ph.D. Dissertation, Virginia Polytechnic Institute and State University.

Mack, R.E. 2016.Best Management Practice Use and Efficacy for the Virginia Nursery and Greenhouse Industry. M.S. Thesis. Virginia Polytechnic Institute and State University.

Wei, Wan. 2016. Winter Greenhouse Production and Tissue Culture of Basil. Master of Science Thesis, University of Nebraska-Lincoln. Lincoln, Nebraska.

**Books (Published)**

**Book Chapters (Published)**

Both, A.J. and J.E. Faust. 2017. Light transmission: The impact of glazing material and greenhouse design. Chapter 6 in ‘*Light Management in Controlled Environments*’ (R.G. Lopez and E.S. Runkle, eds.). Meister Media Worldwide, Willoughby, OH. pp. 59-66.

Both, A.J., J.M. Frantz, B. Bugbee. 2017. Carbon dioxide enrichment in controlled environments. Chapter 9 in ‘*Light Management in Controlled Environments*’ (R.G. Lopez and E.S. Runkle, eds.). Meister Media Worldwide, Willoughby, OH. pp.82-90.

Currey, C.J., Kopsell, D.A., Mattson, N.S., Craver, J.K., Lopez, R.G., Erwin, J.E. and C. Kubota. 2017. Supplemental and sole-source lighting of leafy greens, herbs, and microgreens. Chapter 18 in ‘Light Management in Controlled Environments’ (R.G. Lopez and E.S. Runkle, eds.). Meister Media Worldwide, Willoughby, OH. pp. 170-180.

Erwin, J., Mattson, N., and R. Warner. 2017. Light effects on bedding plants. Chapter 13 in ‘Light Management in Controlled Environments’ (R.G. Lopez and E.S. Runkle, eds.). Meister Media Worldwide, Willoughby, OH. pp. 119-134.

Fisher, P., A.J. Both, and B. Bugbee. 2017. Supplemental lighting technology, costs and efficiency. Chapter 8 in ‘*Light Management in Controlled Environments*’ (R.G. Lopez and E.S. Runkle, eds.). Meister Media Worldwide, Willoughby, OH. pp. 74-81.

Raudales R.E. 2016. Nutritional Disorders of Florists’ Crops. In: Handbook of Florist's Crops Diseases- Handbook of Plant Disease Management. R.J. McGovern and W.H. Elmer (eds) Springer Meteor, Switzerland 1-27.

Runkle, E. and A.J. Both. 2017. Delivering long-day lighting – Technology options and costs. Chapter 10 in ‘*Light Management in Controlled Environments*’ (R.G. Lopez and E.S. Runkle, eds.). Meister Media Worldwide, Willoughby, OH. pp. 91-99.

**Refereed Journal Articles (Published)**

Burnett, S., N. Mattson, and K. Williams. 2016. Substrates and fertilizers for organic container production of herbs, vegetable transplants, and herbaceous ornamental plants grown in greenhouses in the United States. Sci. Hort. 208:111-119.

Dickson, R.W., Fisher, P.R., Padhye, S.R., and Argo, W.R. 2016. Evaluating calibrachoa (*Calibrachoa* × *hybrida* Cerv.) genotype sensitivity to iron deficiency at high substrate pH. HortScience 51(12): 1452-1457.

Dickson, R. W., Fisher, P. R., Argo, W. R., Jacques, D. J., Sartain, J. B., Trenholm, L. E., & Yeager, T. H. (2016). Solution Ammonium: Nitrate ratio and cation/anion uptake affect acidity or basicity with floriculture species in hydroponics. Scientia Horticulturae, 200, 36-44.

Dickson, R.W., Fisher, P.R., and Argo, W.R. 2017. Quantifying the acidic and basic effects of fifteen floriculture species in peat-based substrate. HortScience. *In press.*

Foster, J.J., S. Burnett, and L.B. Stack. 2017. Effects of light, soil moisture, and nutrition on greenhouse propagation of *Linnaea borealis*. HortTechnology (in press).

Harris, W.K., J.R. Freeborn, J. Latimer and H.L. Scoggins. 2016. Overwintering Survival and Vigor of Container-Grown Fountain Grass: Influence of Protective Covers, Fertilizer Rate and Substrate Moisture Content. HortTechnology 25(6):791-795.

Jin, Q., Hu, X., Li, X., Wang, B., Wang, Y., Jiang, H., Mattson, N. and Xu, Y., 2016. Genome-wide identification and evolution analysis of Trehalose-6-phosphate synthase gene family in Nelumbo nucifera. Frontiers in Plant Science, 7, 1445 doi:10.3389/fpls.2016.01445

Jin, Q., Xu, Y., Mattson, N., Li, X., Wang, B., Zhang, X., Jiang, H., Liu, X., Wang, Y. and Yao, D., 2017. Identification of submergence-responsive microRNAs and their targets reveals complex miRNA-mediated regulatory networks in lotus (Nelumbo nucifera Gaertn). Frontiers in plant science, 8.

Jin, Q., Wang, Y., Li, X., Wu, S., Wang, Y., Luo, J., Mattson, N. and Xu, Y., 2017. Interactions between ethylene, gibberellin and abscisic acid in regulating submergence induced petiole elongation in Nelumbo nucifera. Aquatic Botany, 137, pp.9-15.

Li, Y. and N.S. Mattson. 2016. Effect of different commercial substrates on growth of petunia transplants. HortTechnology. 26(4):507-513.

Raudales R.E., C.R. Hall, P.R. Fisher. 2017. The cost of irrigation sources and water treatment in greenhouse production. Irrigation Science 35: 43-54

**Symposium Proceedings Articles (Published)**

Fisher, P.R. and Dickson, R.W. 2016. Improving irrigation practices in container stock plant production of herbaceous plant cuttings. International Symposium on Protected Cultivation in Tropical and Temperate Climates. Acta Hort. *In press.*

Gent, M.P.N. and Ido Seginer. 2016. Dynamic Carbohydrate Supply and Demand Model of Vegetative Growth. Acta Horticulturae 1154:73-81.

Gent, M.P.N. 2016. Effect of Temperature on Composition of Hydroponic Lettuce. Acta Horticulturae 1123:95-100.

Harbick, K., Albright, L.D., and Mattson, N.S. Electrical savings comparison of supplemental lighting control systems in greenhouse environments. 2016 ASABE Annual International Meeting. American Society of Agricultural and Biological Engineers, 2016. 8 pp. DOI: 10.13031/aim.20162460478

Kubota, C., M. Kroggel, A.J. Both, J.F. Burr, and M. Whalen. 2016. Does supplemental lighting make sense for my crop? – Empirical evaluations. Acta Horticulturae 1134:403-411.

Wallace, C and A.J. Both. 2016. Evaluating operating characteristics of light sources for horticultural applications. Acta Horticulturae 1134:435-443.

**Popular Articles (Published)**

Both, A.J. 2017. Consider evaluating the benefits of LED lighting for your crops. Greenhouse Grower online publication. March 17. (<http://www.greenhousegrower.com>)

Cabrera J., R.E. Raudales. 2017. Monitoring pH and EC of Growing Medium. e-Gro Alert 6.37:1-6.

Dickson, R. and P. Fisher. Why do geraniums drop pH? GrowerTalks. May 2017.

Dickson, R. and P. Fisher. High pH is often caused by excessive leaching. Greenhouse Management. June 2017.

Dickson, R. and P. Fisher. Edible crop species differ in their pH effect in hydroponics. Produce Grower. July 2017.

Fisher P., RE Raudales, J Huang (2016) Select the Right Filter for Ebb-and Flood Irrigation. Greenhouse Grower Magazine: New Technology Development in Water Treatment Series. Greenhouse Grower July 2016: 46-50

Fisher P., RE Raudales. (2016). Minimize iron build-up on your water pipes. Greenhouse Grower. June 2016:66-70

Fisher P., G Grant, V Zayaz, RE Raudales, J Altland, J Boldt (2016). New Technology Development in Water Treatment. Greenhouse Grower Technology. May/June 2016: 20-22

Latimer, J. G. (2016). Using Branching Agents on Woody Ornamentals in the Nursery. Retrieved from http://www.fine-americas.com/

Latimer, J. G. (2016). Early Growth Regulation with Liner Soaks vs Liner Drenches. Retrieved from https://www.youtube.com/watch?v=wuKlTO0iX40

Latimer, J. G. (2016). PGR Efficacy vs Phytotoxicity: The Role of Drying Conditions. Retrieved from <https://www.youtube.com/watch?v=-cfmGcTDQSU>

Latimer, J. G. (2016). Growth Control of Perennial Ferns. Retrieved from http://www.fineamericas.com/blog/growth-control-of-perennial-ferns

Latimer, J. G. (2016). What’s the PGR Recipe for my XYZ Crop?. Retrieved from http://www.fineamericas.com/blog/whats-the-pgr-recipe-for-my-xyz-crop

Latimer, J. G. (2016). More on Liner Soaks vs. Liner Drenches. Retrieved from https://www.youtube.com/watch?v=6jyWzMlnu2A

Latimer, J. G. (2016). Improve the Quality of Herbaceous Perennial Liners with Configure. Retrieved from <https://www.youtube.com/watch?v=J16qFDpVviE>

Mattson, N. and T. Merrill. 2017. Symptoms of common nutrient deficiencies in hydroponic arugula. Inside Grower. June:30-33.

Mattson, N. and T. Merrill. 2016. Symptoms of common nutrient deficiencies in hydroponic basil. Inside Grower. October:30-33.

Mattson, N. 2016. Growing hydroponic leafy greens. Greenhouse Product News. 26(10):16-20.

Raudales R.E., P. Fisher, C Hall .2017. The Cost of Filtration. GPN Magazine. March 2017 .pp. 13-16.

Raudales R.E., P. Fisher, C. Hall. .2017. How Much Does it Cost to Sanitize your Water? GPN Magazine April 2017 .pp. 30-35.

Raudales R.E. 2017. Best Practices in Chlorination. e-Gro Alert 6.34.:1-6

Raudales RE (2017) Case Study on Irrigation: The cost of clogging and the benefit of unclogging. e-Gro Research Update 2017.01

Raudales RE, C McGehee (2017) Biofungicides for Control of Root Diseases on Greenhouse-Grown Vegetables. e-Gro Edible Alert 2(7):1-4

Raudales RE, P Fisher, C Hall(2017). What is the true cost of your water? GPN Magazine May 2017(pp. 41-42)

Raudales RE, L Pundt (2016). Maintaining High Quality Plants in Retail Settings. e-Gro Alert 31(5):1-6.

Raudales RE (2016). Algae on the nutrient solution and surfaces. E-Gro Edible Alert 6(1): 1-4.

Raudales RE, C McGehee (2016). Pythium Root Rot of Hydroponic Crops. e-Gro Edible Alert 1(4):1-5.

**Presentations (Papers)**

Allred, J. and N. Mattson. 2016. Effects of daily light integral and carbon dioxide on microgreens. Abstract and poster at the Fifth International Controlled Environment Conference. Canberra, Australia, September 18-23, 2016.

Allred, J. and N. Mattson. 2016. Seed density, fertilizer concentration, temperature, and substrate depth effect on three microgreen species of the Brassicaceae family. Abstract and presentation at Annual ASHS Conference. Atlanta, GA, August 8-11, 2016.

Cabrera J.C., R.E. Raudales. 2017 Effect of irrigation pipe material and irrigation frequency on biofilm accumulation. University of Connecticut Graduate Student Forum. Storrs, CT.

Foster, J., Burnett, S., and L. Stack. 2016. The effects of light and soil moisture on propagation of Linnaea borealis. August 8-11, 2016. Orlando, FL. American Society for Horticulture Science Meeting.

Grossman, M., Aiken, M., Scoggins, H., & Latimer, J. (2016). Plant Growth Regulators Affect Branching and Flowering in Three Echinacea cultivars. In Proceedings of the 42nd Annual Meeting of the Plant Growth Regulation Society of America Vol. 42 (pp. 127-133). Kona, HI. Retrieved from <http://pgrsa.org/proceedings?nid_entityreference_filter=657>

Grossman, M., Aiken, M., Scoggins, H., & Latimer, J.G. (2016). Controlling Height in Echinacea Hybrids. In C. Gunter (Ed.), Proceedings of the 43rd Annual Meeting of the Plant Growth Regulation Society of America Vol. 43 (in press). Raleigh, NC.

Latimer, J.G., Allen, R.S., & Mullins, C. (2016). Extension Education Programs: Getting Started in Greenhouse Production. In *7th National Small Farm Conference*. Virginia Beach VA.

Latimer, J. G. 2016. PGR Strategies for Herbaceous Perennials Production. Athens, GA

Latimer, J.G. (2016). Issues and Opportunities for PGRs in Commercial Production of Ornamental Plants. In Proceedings of the 42nd Annual Meeting of the Plant Growth Regulation Society of America Vol. 42 (pp. 99-105). Kona, HI. Retrieved from <http://pgrsa.org/proceedings?nid_entityreference_filter=657(Keynote)>

Lyons, E., Aiken, M., Grossman, M., Scoggins, H., & Latimer, J. (2016). Evaluation of Plant Growth Regulators on Penstemon x mexicali 'Red Rocks' and 'Pike's Peak Purple'. In Proceedings of the 42nd Annual Meeting of the Plant Growth Regulation Society of America Vol. 42 (pp. 30-39). Kona, HI. Retrieved from <http://pgrsa.org/proceedings?nid_entityreference_filter=657>

McGehee C., R.E. Raudales. 2017. Testing pathogenicity and inhibition of Pythium spp. in vitro. University of Connecticut Graduate Student Forum. Storrs, CT (poster presentation).

Osborn, C., M. Elizabeth Conley, Wan Wei and Ellen T. Paparozzi. 2016. Winter production of Basil (Ocimum basilicum) for fresh market and essential oil production. HortScience 51 (9): S345 (Abstr.)

Peck, L.K., Owen, J., Latimer, J.G., Aiken, M., & Scoggins, H.L. 2016. The Impact of Deficit Irrigation on the Postharvest Vase Life of Cut Delphinium 'Guardian Blue' Flowers. HortScience9 (pp. S288). Atlanta, GA.

Peterson, B.J., O. Sanchez, S. Burnett, and D.J. Hayes. 2016. Sub-Mist is an effective alternative to overhead mist for the propagation of coleus by stem cuttings. August 8-11, 2016. Orlando, FL. American Society for Horticulture Science Meeting.

Vallotton, A. D., Latimer, J., & Behe, B. (2016). Virginians Perceptions of Fresh Produce Food Safety. ASHS, Atlanta, GA.

**Other Creative Works**

Both, A.J. 2017. Electrical safety for farms and greenhouses (presentation). 62th New Jersey Agricultural Convention and Trade Show. February 8. Atlantic City, NJ.

Both, A.J. 2017. High tunnel construction (abstract and presentation). Proceedings of the 62th New Jersey Agricultural Convention and Trade Show. February 7. Atlantic City, NJ. pp. 62.

Both, A.J. 2017. The latest in greenhouse LED research (presentation). Mid Atlantic Fruit and Vegetable Convention. January 31. Hershey, PA.

Foster, J., Burnett, S., and L. Stack. 2016. The effects of light and soil moisture on propagation of *Linnaea borealis*. HortScience 51:259-260.

International Committee for Controlled Environment Guidelines. 2016. Guidelines for measuring and reporting environmental parameters for experiments in greenhouses (booklet). 34 pp.

Latimer J. and D. Close (content editors). 2017. 2017 Pest Management Guide: Home Grounds and Animals. Virginia Cooperative Extension 456-018.

Latimer, J., & Owen, Jr., J. 2016. Resources for Greenhouse and Nursery Operations and Operators*.* Virginia Cooperative Extension 430-104 (HORT-188P).

Latimer J. and Whipker B. 2016, Plant Growth Regulators for Floricultural Crops, University of Maryland Extension Bulletin 363.

Manning, T. and A.J. Both. 2017. Insulation, heating, cooling, and weatherization (presentation). Rutgers University Farm Energy Efficiency and Water Conservation Workshop. February 22. Pittstown, NJ.

Mattson, N. 2017. How many light fixtures do I need? e-Gro Edible Alert 2(5). 4 pp. http://www.e-gro.org/pdf/E205a.pdf

Mattson, N. 2017. Don’t be dim! Watch out for low light on leafy green seedlings. e-Gro Edible Alert 2(4). 5 pp. http://www.e-gro.org/pdf/E204.pdf

Mattson, N. 2017. Bolting of hydroponic lettuce and spinach. e-Gro Edible Alert 2(1). 4 pp. http://www.e-gro.org/pdf/E201.pdf

Mattson, N. and T. Merrill. 2017. Symptoms of common nutrient deficiencies in hydroponic arugula. e-Gro Research Update #2017.02. 10 pp. http://www.e-gro.org/pdf/2017-2.pdf

Niewolny, K., Latimer, J., Bendfeldt, E. S., Scott, K., Miller, C., Nartea, T.,…Tyler-Mackey, C. 2016. Community, Local, and Regional Food Systems (CLRFS) Forum Report(ALCE-156NP). Retrieved from <http://www.pubs.ext.vt.edu/ALCE/ALCE-156/ALCE-156.html>

Niewolny, K., Latimer, J., Bendfeldt, E. S., Scott, K., Miller, C., Nartea, T., . . . Neale, S. (2016). VCE Model of Community, Local, Regional Food Systems(ALCE-154NP). Retrieved from http://www.pubs.ext.vt.edu/ALCE/ALCE-154/ALCE-154.html

Peterson, B.J., O. Sanchez, S. Burnett, and D.J. Hayes. 2016. Sub-Mist is an effective alternative to overhead mist for the propagation of coleus by stem cuttings. HortScience 51:260.

Raudales R.E. 2016. Plant Growth Regulators. In: New England Floriculture Guide 2017-2018. Stack L. (ed) New England Floriculture Inc, MA. D1-88

University of Nebraska – Lincoln, revision/update of CEA website – visit agronomy.unl.edu/cea.

**Workshop Sponsor**

Campbell B, L Pundt, RE Raudales. Smart Marketing= More Customers. New Haven, CT. November 3, 2016

Pundt L, RE Raudales, Bedding Plant Meeting. Vernon, CT. February 16, 2017

Pundt L, RE Raudales. Bedding Plant Meeting. Torrington, CT. February 18, 2017

Raudales RE, L Pundt. Practical Applications in Greenhouse Nutrient Management. New Haven, CT. November 9, 2016

Raudales R, L Pundt, CGGA. Financial Decisions for Greenhouse Businesses. New Haven CT. August 29, 2016

Tewksbury E, R Raudales. Northeast Greenhouse Conference. Boxborough, MA. November 8-10, 2016

**Workshop Participant**

2016 e-GRO’s PGR University Webinar Conference, Whipker, B. and J. Latimer, organizers and presenters, 4-hour webinar conference that included three other speakers. All presentations were recorded and posted on the e-GRO Webinars YouTube channel at <https://www.youtube.com/channel/UCH-u0VBGulYyVsqYyz3Drxg>

Cabrera JC, RE Raudales. Hydroponic systems for New Farmers. Solid Ground Farmer Trainings. Stamford, CT. October 26, 2016

Raudales RE. Controlled Release Fertilizers for Container Production. Connecticut Bedding Plant Meeting. Torrington, CT February 18, 2017

Raudales RE. Controlled Release Fertilizers for Container Production. Connecticut Bedding Plant Meeting. Vernon, CT February 16, 2017

Raudales RE. Diagnóstico de enfermedades y desordenes nutricionales. Casertano Greenhouses. February 14, 2017

Raudales RE. Nutrient Programs for Hydroponic Crops. e-Gro Nutrient Webinars. January 27, 2017

Raudales RE. Principios de Nutrición Vegetal en Producción de Contenedores. Connecticut Nursery and Landscape Association Winter Symposium. Plantsville, CT. Jan 26, 2017

Raudales RE. Plant Nutrition in Container Production. Connecticut Nursery and Landscape Association Winter Symposium. Plantsville, CT. Jan 26, 2017

Raudales RE. Greenhouse Plant Nutrition: Fertilizing Container Crops with Water Soluble and Controlled Release Fertilizers. UMASS Greenhouse Management and Production. Sturbridge, MA. Jan 11, 2017

Raudales RE. Hydroponic Production of Lettuce and Herbs Connecticut Vegetable & Small Fruit Growers Conference. South Windsor, CT. January 9, 2017

Raudales RE, JC Cabrera. Hands-on Monitoring Growing Media. Northeast Greenhouse Conference. Boxborough, MA. Nov 10, 2016

Raudales RE. Diagnóstico: ¿Enfermedad, desorden abiótico o normal? Northeast Greenhouse Conference. Boxborough, MA. Nov 9, 2016

Raudales RE, R Dickson, JC Cabrera. Water and Media Testing Practical Applications in Greenhouse Nutrient Management. New Haven, CT. September 27, 2016

Raudales RE. Selecting fertilizers: Step by Step. Practical Applications in Greenhouse Nutrient Management. New Haven, CT. September 27, 2016

Raudales RE. Production and Problem Management: Unscripted. Plug and Cutting Conference– Carlsbad CA. September 21, 2016

Raudales RE. Enfermedades: Identificación y Control. Plug and Cutting Conference– Carlsbad CA. September 21, 2016

Raudales RE. Control de Crecimiento en Plántulas. Plug and Cutting Conference– Carlsbad CA. September 20, 2016

Raudales RE. Calidad de Agua para Plántulas. Plug and Cutting Conference– Carlsbad CA. September 20, 2016

**Refereed Journal Articles (Pending)**

Both, A.J., B. Bugbee, C. Kubota, R.G. Lopez, C. Mitchell, E.S. Runkle, C. Wallace. 2017. Proposed product label for electric lamps used in the plant sciences. Accepted for publication in HortTechnology.

Johnson, M., T.S. Villani, J.E. Simon, A.J. Both. 2017. Effects of nitrogen, CO2 and harvesting method on *Parachlorella kessleri* grown on a vertical attached growth system. In revision.

Li, Y., J.R. Heckman, C.A. Wyenandt, and A.J. Both. 2017. Applying Silicon to suppress powdery mildew in pumpkin. In preparation.

Mack, R., J.S. Owen, Jr., A.X. Niemiera, and J. Latimer. 2017. Virginia nursery and greenhouse grower survey of best management practices. HortTechnology.(in press)

Paparozzi, Ellen T., George E. Meyer, Vicki Schlegel, Erin E. Blankenship, Stacy A. Adams, M. Elizabeth Conley, Ben Loseke and Paul E. Read. 2017. Strawberry cultivars vary in productivity, sugars and phytonutrient content when grown in a greenhouse during the winter. Scientia Horticulturae (accepted).