# NC-1186 Complete Meeting Minutes, Individual Station Reports and NC-1186 Objectives

**JOINT MEETING: NE-1335 & NC-1186**

**June 22-24 Long Island, NY**

**Hosts:** Mark Bridgen, Nora Catlin and Mina Vescera from Cornell University, Long Island Horticultural Research & Extension Center.

**Meeting agenda:**

|  |  |  |
| --- | --- | --- |
| **Date** | **Activities** | **Location** |
| **June 22nd** | **Welcome, Graduate Student Poster Session** | Cornell University, [Long Island Horticultural Research & Extension Center](http://cuaes.cals.cornell.edu/farms/lihrec) (3059 Sound Ave. Riverhead, NY 11901) |
| 6:00-8:00 pm | * Poster session and dinner |
| **June 23rd** | **USDA NE-1335 & NC-1186 Joint Meeting** | [Cornell Cooperative Extension,](http://ccesuffolk.org/)  (423 Griffing Avenue, Riverhead, New York 11901) |
| 9:00-9:15 am | Welcome by host Mark Bridgen (Cornell Univ.) |
| 9:15-10:45 am | Introductions and station reports |
| 10:45-11:00 am | *Coffee break* |
| 11:00 am-12:30 pm | Continue station reports |
| 12:30-1:30 pm | *Lunch* |
| 1: 30-3:45 pm | Collaborative efforts and future steps |
| 3:45-4:00 pm | *Coffee break* |
| 4:00-5:00 pm | **Independent Business Meetings**   * Approval of the 2015 meeting minutes * Suggestions for new members * Administrative Advisor’s report * Possibility for future meeting * Nomination and election of incoming secretary * Meeting date(s) and location 2017 * Member announcements |  |
| 5:00 pm | Adjourn |  |
| 6:30 pm | Dinner on your own | TBA |
| **June 24th** | **Tour Greenhouse and Nurseries** |  |
| 8:00 am | Bus leaves | [Hyatt Place East End Hotel](http://longislandeastend.place.hyatt.com/en/hotel/home.html) (451 East Main St. in Riverhead, NY) |
| 6:00 pm | Back in the Hotel  Meeting adjourn, Safe travels! |  |

**Participants list:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Email** | **Institution** | **Working group** |
| A. J. Both | both@aesop.rutgers.edu | Rutgers University | NE1335 |
| Anthony LeBude | avlebude@ncsu.edu | NC State University | NC1186 |
| Gene Giacomelli | giacomel@ag.arizona.edu | University of Arizona | NE1335 |
| George Grant | gagrant@ufl.edu | University of Florida | NC1186 |
| Hye-Ji Kim | hjikim@purdue.edu | Purdue University | NC1186 |
| Jake Shreckhise | jshreck@vt.edu | Virginia Tech | NC1186 |
| James Altland | james.altland@ars.usda.gov | USDA-ARS | NC1186 |
| Jeb Fields | jsfields@vt.edu | Virginia Tech | NC1186 |
| Jim Owen | jsowen@vt.edu | Virginia Tech | NC1186 |
| John Majsztrik | jmajszt@clemson.edu | Clemson University | NC1186 |
| Jonathan Allred | jaa337@cornell.edu | Cornell University | NE1335 |
| Kale Harbick | harbick@cornell.edu | Cornell University | NE1335 |
| Loren Oki | lroki@ucdavis.edu | University of California | NC1186 |
| Mandy Bayer | abayer10@umass.edu | U. Massachusetts Amherst | NC1186 |
| Mark Bridgen | mpb27@cornell.edu | Cornell University | (Host) |
| Martin Gent | martin.gent@ct.gov | CT Ag Experiment Station, New Haven | NE1335 |
| Paul Fisher | pfisher@ufl.edu | University of Florida | NC1186 |
| Peter Ling | Ling.23@osu.edu | The Ohio State University | NE1335 |
| Raul Cabrera | [cabrera@aesop.rutgers.edu](mailto:cabrera@aesop.rutgers.edu) | Rutgers University | NC1186 |
| Robin Brumfield | brumfield@aesop.rutgers.edu | Rutgers University | NE1335 |
| Rosa Raudales | rosa.raudales@uconn.edu | University of Connecticut | Both |
| Sarah White | swhite4@clemson.edu | Clemson University | NC1186 |
| Stephanie Burnett | sburnett@maine.edu | University of Maine | NE1335 |
| Tom Fernandez | fernan15@msu.edu | Michigan State University | NC1186 |
| Tom Manning | manning@njaes.rutgers.edu | Rutgers University | NE1335 |

9:00 am: Welcome by Mark Bridgen, Cornell University.

9:15am: Station Reports: Reports from each member in attendance on current status of their research and extension efforts related to their working group (3 minutes per person with PowerPoint) connected via Webex (Adel Shirmohammadi).

A.J. Both, Rutgers University: Dr. George Wulster, Floriculture Specialist from Rutgers University passed away this year. A.J. is developing a series of horticultural lighting labels to assist growers in the decision-making process.

Kale Harbick (representing Neil Mattson), Cornell University: The team conducted several experiments relating light efficiency. The team compared LED with HPS in greenhouses, plant response to three light combinations using LEDs, energy costs of producing in greenhouse compared with plant factory, and compared two algorithms to compare daily light integral accumulation on lettuce.

Gene Giacomelli, University of Arizona: The Univ. of Arizona Controlled Environment Agriculture Center team has been conducting research on advanced sensing and climate control, economic analysis of supplemental lighting, and algae biofuels. Dr. Giacomelli also mentioned that the Lunar and South Pole project are ongoing.

Ellen Paparozzi and George Meyer, University of Nebraska: Sent video. They presented the research on greenhouse production and modeling of basil for growth and essential oils.

Mandy Bayer, University of Massachusetts: Her research program is related to sensor-controlled irrigation. Dr. Bayer will conducting growth control of container-grown ornamentals by applying timed drought stress using sensor-controlled irrigation both in the greenhouse and outdoors.

Stephanie Burnett, University of Maine: Stephanie announced that the University of Maine is hiring a Landscape Design specialist. She presented her research comparing sub-mist compared to overhead mist in propagation.

Sarah White, Clemson University: Introduced Clean WateR3 (http://cleanwater3.org/), project that resulted from the NC1186 working group interactions. The goal of the project is to encourage recycling and reuse of remediated runoff. Research is conducted on several aspects of contaminant (Pesticides, pathogens or nutrients) management. Her research program at Clemson, focuses on evaluating different plants that trap contaminants. Currently screening 7 plants in channels for removal of contaminants and that also have commercial value.

John Majsztrik, Clemson University: Research consists on consolidating data collected by the Clean WateR3 group and develop decision support tools based on models to help growers make informed-decisions.

Hye-Ji Kim, Purdue University: Research program focuses on managing N and P levesl in aquaponics systems. They are evaluating vegetable crops to remove nitrate from the solution. Another project evaluated parboiled hulls substrates affected growth and water use in zinnias and petunias. Experiment 2: Inert media with vermiculite and perlite which does not have P and tested different rates of P from 1- 30 mg/L on lantana. Optimum growth observed at 20mg/L P, under this rate plants were overall significantly smaller.

James Altland, USDA ARS: Conducted research on rice hulls for weed control. Rice hulls retained very little water and dehydrated very quickly. The layer of rice hulls provided a physical barrier between the seeds and growing media and the low water content at the top might also prevented weed seeds to germinate. A thick layer (0.5 inch, 500 g/m2) reduced weed germination on established containers. Ongoing research to determine optimum temperature of hot water and steam to control weeds left on old containers.

Jim Owen, Virginia Tech: Research program focuses on mineral nutrient fate, soilless substrate and agrochemical remediation. Filter socks to clean P and sediments. Currently, building experimental nursery and will evaluate water quality of runoff. Results from previous experiments: Evaluated CRF placement in the container, when placed on the top layer less leachate was captured. Developed Gro Zone Tracker which is designed to track water and soil quality on a map and will be launch at Cultivate ‘16. Jeb Fields (Ph.D. Candidate) research on how the amount of P affects the final concentration of P levels in the substrate. Jake Shreckhise (Ph.D. Candidate) evaluating how hydraulic properties of substrates affect water retention.

Anthony LeBude, North Carolina State University: Conducted water quality survey of water sources in North Carolina. Most samples had high pH and alkalinity. He discussed Wilkinson and Davies research that showed how pH of the solution can affect transpiration rates. As a follow up study, he will evaluate how water quality affects plant physiology at the farm level.

Martin Gent, Connecticut Agricultural Experiment Station: Effect of standard or partial saturation (75% of the full saturation) in sub irrigation combined with silicon application on incidence of Pythium root rot of poinsettias. Plants inoculated with *Pythium* sp. under standard saturation did not recover had higher diseases rating and lower dry weight.

Raul Cabrera, Rutgers University: Evaluating short and long term effects of graywater (“soapy”) irrigation on ornamental plants in the landscape. Ongoing project, recently established project and will be collecting chemical and physical properties of soil. Also involved with the Colombian national association of cut flowers to increasing nutrient efficiency (currently the efficiency is 50%) and reduce runoff. Will submit a grant to evaluate plasma as an alternative water treatments option.

Rosa Raudales, University of Connecticut: Research program focuses on understanding how water quality affects biofilm buildup on the inside of irrigation pipes, and how biofilm affects plant health. Presented water quality data from survey conducted to growers who indicated having biofilm clogging problems. Also presented preliminary results on how biofilm affect plant disease incidence in poinsettias.

Paul Fisher and George Grant, University of Florida: Remediation of paclobutrazol using granular activated carbon. Tested how different contact times and granular activated carbon materials affect removal efficacy of 50 ppb paclobutrazol. Based on a bioassay studies, increased contact time of removed the biological active residual concentration of paclobutrazol and no difference was observed between bituminous coal and coconut coir.

Loren Oki, UC Davis: Virus (TMV) removal with slow sand filtration after week 6 (sustained for 6 more weeks). Ongoing research is part of the Clean WateR3 project: Nursery runoff characterization will measure flow rate, residual chlorine, etc. Measuring salinity tolerance using microcalorimentry.

Peter Ling, The Ohio State University: New education program (2-year) on Greenhouse Engineering Technology at ATI. Plant health monitoring and passive watering: NASA project including sensors to monitor water use and prevent water leakage. Energy harvesting greenhouse: Recycle extra energy from daytime and use it at night.

Tom Fernandez, Michigan State University: Clean Water3 project: Currently, establishing an experimental nursery. First experiments are looking at the movement of P and pesticides and tracing residual concentrations. Runoff system will be catched at the pond and then treat with a bioreactor. Then they will irrigate with recaptured, remediated and fresh water. Project will include customer willingness to pay (Bridget Behe). RFID technology that reads all the tags of plants on the cart without unloading. Readers get 98% efficiency of readings. Drawback is that water impedes the signal, max distance 16 feet. Potential use to map where plants are located, and use it a precision agriculture in container agriculture.

12:40 pm: Break for lunch

1:50 pm: Collaborative efforts led by John Majsztrik

The group divided in three groups and then reported to the rest of the group:

1. Remediation of water sources: The group discussed the importance of characterizing water around the country and proposed doing a water source mapping to predict how growers would have to manage water in those regions. Potential idea for developing a grant (John Majsztrik offered to lead the effort). It was suggested to collect data by: (1) sampling, (2) data from commercial analytical labs, and (3) USDA geological groundwater survey.

2. Organic fertilizers and predictability of nutrient release: The group discussed how one of the limitations of organic production is the unknown predictability and lack of control on when nutrients are released. They discussed that it might be a good start to understand N balance. Previous research by Univ. of Maryland, found big gaps in N balance. Proposed future steps were to develop nitrogen curves for organic fertilizer, control nitrification, and interaction with microbes. A second topic, was to develop a decision tree to standardize management of composts (Hye-Ji Kim).

3. Controlled Environment and Conservation: The group discussed the importance on conducting research that compares plant factories with semi-close greenhouses in terms of ET modelling, recapturing wastewater and blending, semi-close energy and water systems and include economics of the different options.

4:00 pm: Business Meeting NC1186

Attendees: Anthony LeBude, George Grant, Hye-Ji Kim, Jake Shreckhise, James Altland, Jeb Fields, Jim Owen, John Majsztrik (Chair, Presided meeting), Loren Oki, Mandy Bayer, Martin Gent, Paul Fisher, Peter Ling, Raul Cabrera, Sarah White, and Tom Fernandez

BUSINESS MEETING: NC 1186

Nomination and election of incoming secretary: Amanda Bayer (UMass) was nominated for secretary and unanimously all voted in favor.

Meeting dates and locations:

June 2017: Asheville, NC. Suggested to do around the Rhododendrom Bloom meeting. Potential dates: June 12-14 or 14-16. Program will include: one day for business meeting, one day for tour and one-day for grower workshop.

March 2018: Gainesville, FL. Paul Fisher volunteered to host meeting in Gainesville, FL and include a daylong workshop. Alternative locations in Florida include Tampa, Orlando or Miami. Group requested tour of citrus growers with water issues. Potential date: June 2017.

June 2019: Northern California (Monterrey).

Suggestion to make a grower meeting every time the group travels. Work with local experiment station to sponsor the grower workshop.

2015 minutes approved.

Open discussion:

* Recruit more members by sending out NIMMS bulletin with description, reach groups involved in aquaponics, storm water runoff, NCR101 Controlled Environment Horticulture, and S1021 economic group.
* Do a Think tank discussion conference similar to the Seeley Summit. Get a moderator and let the growers present.
* Other water related associations:
  + Water Institute at the University of Florida- Focus on water policy and watershed related topics.
  + Water Resources Institute – Focus on water resource hydrology, big picture issues, small watersheds, water rights, and economic issues.
  + Universities Council of Water Resources- Will meet in Ft. Collins, Colorado June 14-16, 2017.
  + Irrigation association: Propose doing a workshop at their meeting.
* Irrigation Association Nursery Irrigation Chapter is out of date and needs to be rewritten in the Irrigation Association Certification Manual. Suggested task for NC 1186. Jim Owen will follow up after Jan 2017.
* Water Resource Symposium is in Raleigh, NC. Will contact to see if both groups can work together.
* James Altland will approach S1021 (Consumer Horticulture Extension, Research, and Education Coordinating Committee) to ask about joint meeting in 2019-Monterrey meeting.

4:40 pm: Meeting adjourn

# Individual station reports (alphabetical order)

## **California**

**NC-1186 Station Report Content:**

**1. Impact Nugget**

From a new member of the group, my research projects include: the development of a method to assess plant salinity tolerance using microcalorimetry, measurement of landscape plant water use, treatment of irrigation runoff using slow sand filters, characterization of nursery water movement (hydrology), and the evaluation of a new soil moisture sensor technology. I am Co-Director of the UC Nursery and Floriculture Alliance, an extension and outreach program that provides education and technical training to growers.

**2. New Facilities and Equipment.**

We are evaluating a new sensor technology developed by Waterbit, Inc. that uses electromagnetic inductance to measure soil moisture at three depths. This sensor is highly sensitive to soil moisture, utilizes wireless communication, measures at multiple depths, is low cost, and is not reliant on precise installation. Each sensor is capable of also controlling a device and other measurements such as electrical conductivity (EC) and temperature.

To measure irrigation runoff in nurseries for the California portion of the USDA SCRI funded Clean WateR3 project, we have installed flumes and channels at strategic points in two collaborating nurseries. At these nurseries, we have also installed equipment to measure water use from captured runoff and municipal sources.

**3. Unique Water/Production Related Findings**.

The research team has submitted for publication a manuscript describing the removal of *Tobacco mosaic virus* from captured runoff water using slow sand filters. It takes 6-9 weeks before the virus is removed after it is introduced into the water provided to the filters. This will be the first report of the removal of a plant pathogenic virus in a replicated study (Mathews, D.M., S. Bodaghi, E. Lee, D. Haver, B. Pitton, L. Nackley, and L.R. Oki. In review. Elimination of Tobacco mosaic virus from irrigation runoff using slow sand filtration.).

To date, we completed the determination of the water use of 78 landscape plants.

To date we have complete the evaluation of a total of 60 full sun plants and 18 shade plants since the inception of this project in 2006. There are 35 plants currently being tested. This information not only determines the water requirements of plants in landscapes but can be useful in managing irrigation of the plants in nurseries. A website discusses the project and presents reports and findings (ccuh.ucdavis.edu/Resources/plant-trials).

**4. Accomplishment Summaries.**

The PIs’ research groups continue to work on the California portion of the Clean WateR3 project characterizing nursery runoff, and have installed instruments and dataloggers at two cooperating nurseries to measure the volumes of water obtained from water sources (including captured runoff) and applied in irrigation. Water samples have been collected and are being analyzed for nutrients and water-borne plant diseases. This information will be used to determine methods to improve irrigation efficiency to reduce water use, examine challenges and develop solutions for recycling, and study remediation methods to remove pathogens and other pollutants prior to reuse.

We have submitted a manuscript for publicationdescribing the removal of *Tobacco mosaic virus* (TMV) using slow sand filters. We found that slow sand filters are capable of removing TMV from captured irrigation runoff so that the water can be reused for irrigation. This will be the first report of the removal of a plant pathogenic virus from runoff water in a replicated study using this method. Slow sand filters are a biological water treatment method that have been shown to successfully remove water molds from runoff water.

**4. Impact Statements.**

The California project PI is a Co Director of the University of California Nursery and Floriculture Alliance (UCNFA) that provides education and technical training to California greenhouse and nursery growers (ucnfa.ucanr.edu). In 2015, we provided the ABCs of Plant Pathology to 47 attendees in English and 42 in Spanish. The California Nursery Conference was held in October 2015 and presented topics on disease and pest management to 93 attendees. In 2014, 327 attendees were present at 8 workshops and a conference that covered topics on basic horticulture (in English and Spanish), biological control of pests, nursery and greenhouse pest control (in English and Spanish), and water conservation and irrigation efficiency.

**5. Published Written Works.**

*Book chapters*

Newman, J.P., J.N. Kabashima, D. Merhaut, D.L. Haver, J. Gan, and L.R. Oki. 2014. Controlling runoff and recycling water, nutrients, and waste. In: Container Nursery Production and Business Manual. J.P. Newman (ed.) University of California Division of Agriculture and Natural Resources, Richmond, CA. pp.95-118.

Oki, L.R. and J.H. Lieth. 2014. Mechanization and automation. In: Container Nursery Production and Business Manual. J.P. Newman (ed.) University of California Division of Agriculture and Natural Resources, Richmond, CA. pp.45-58..

*Refereed Journal Articles*

Nackley, L.L., C. Barnes, and L.R.Oki. 2015. Investigating the impacts of recycled water on long-lived conifers. AoB Plants. 7: plv035. doi: 10.1093/aobpla/plv035.

*Popular Articles*

Haver, D.L. (2014). Best management practices for nurseries-A water quality field for nurseries: Updated Southern California Edition. <http://ucanr.edu/sites/urbanwatermgmt/files/208722.pdf>

Bethke, J.A., M. Parrella, S. Tjosvold, D. Merhaut and L. Oki. 2015. The University of California serves the ornamental plant production industry. Greenhouse Product News. 25(8): 10-16. <http://www.gpnmag.com/article/university-california-serves-ornamental-plant-production-industry/>.

Oki, L., A. Filmer and L. Nackley. 2015. Environmental horticulture research at UC Davis. Greenhouse Product News. 25(12): 36-42. <http://www.gpnmag.com/article/environmental-horticulture-research-uc-davis/>.

Oki, L.R. 2015. Irrigating greenhouse and nursery crops based on soil moisture measurement. University of California Nursery and Floriculture Alliance News.19(2): 8-12. <http://ucnfanews.ucanr.edu/Articles/Feature_Stories/Irrigating_greenhouse_and_nursery_crops_based_on_soil_moisture_measurement/>

Oki, L.R. 2015. CDFA Nursery Advisory Board Report. University of California Nursery and Floriculture Alliance News.19(3): 22-23. <http://ucnfanews.ucanr.edu/Articles/CDFA_Nursery_Advisory_Board_Reports/Winter_2015__CDFA_Nursery_Advisory_Board_Report/>.

Oki, L.R. 2016. CDFA Nursery Advisory Board Report. University of California Nursery and Floriculture Alliance News.20(1): 23. <http://ucnfanews.ucanr.edu/Articles/CDFA_Nursery_Advisory_Board_Reports/Spring_2016_CDFA_Nursery_Advisory_Board_Report>.

**6. Scientific and Outreach Oral Presentations.**

Oki, L.R., L. Nackley, and J. Pollex. 2105. Microcalorimetry for rapid assessment of plant salinity tolerance. California Association of Nurseries and Garden Centers Research Advisory Committee. February 5, 2015. University of California, Riverside, CA.

Oki, L.R. 2015. Slow sand filters. A biological treatment method to remove plant pathogens from nursery runoff. University of California Agriculture and Natural Resources Environmental Horticulture Program Team Meeting. October 8, 2105. Davis, CA.

Oki, L.R. 2015. Slow sand filters. A biological treatment method to remove plant pathogens from nursery runoff. Western Region of the International Plant Propagators Society 56th Annual Meeting. September, 2015. Modesto, CA.

Oki, L.R. 2016. Slow sand filters. Removal of *Tobacco mosiac virus*. University of California Agriculture and Natural Resources Environmental Horticulture Program Team Meeting. April 18, 2016, Ventura, CA.

**7. Fund leveraging, specifically, collaborative grants between stations and members.**

9/1/2014–8/30/2019. USDA-Specialty Crops Research Initiative. “Clean WateR3 - Reduce, Remediate, Recycle: Informed Decision-Making to Facilitate Use of Alternative Water Resources and Promote Sustainable Specialty Crop Production.” SA White, JS Owen, B Behe, B Cregg, RT Fernandez, P Fisher, L Fox, CR Hall, D Haver, D Hitchcock, DL Ingram, S Kumar, A Lamm, J Lea-Cox, LR Oki, JL Parke, A Ristvey, D Sample, C Swett, LS Warner, PC Wilson. $8.7 M. Y1 funding $1,783,670.

Oki, L.R., D.L. Haver and B.J. Pitton. 2015. Increasing recycled water use at nurseries through evaluation of water and contaminant treatment technology. California Association of Nurseries and Garden Centers. $15,000.

**8. Other relevant accomplishments and activities.**

None

## **Connecticut**

**NC-1186 Station Report Content:**

1. Impact Nugget:

The University of Connecticut is conducting new research to identify the factors that affect biofilm accumulation on pipes and how biofilm can affects plant health.

1. New Facilities and Equipment.

*None*

1. Unique Water/Production Related Findings.
2. Accomplishment Summaries.

The University of Connecticut observed that when biofilm was present on the irrigation pipes Pythium root-rot in poinsettias was lower compared with plants irrigated with new pipes. This is the first study to evaluate the interaction of biofilm with plant pathogens in irrigation. In a separate study, we observed that biofilm accumulated faster and more abundant in PVC pipes compared with polyethylene pipes.

1. Impact Statements.

CT: Biofilm is a widespread problem in irrigation pipes. Current practices to control biofilm are reactive (aim to eliminate established biofilms) and not effective. Our program aims to understand how biofilm establishes and accumulates in pipes and aim to identify critical thresholds for treatment.

1. Published Written Works.

***Refereed Journal Articles***

Altland, J.E., L. Morris, J. Boldt, P. Fisher, and R. Raudales. 2015. Sample container and storage for paclobutrazol monitoring in irrigation water. HortTechnology 25:769-773.

Raudales, R.E., P. Fisher, C. Hall. *Submitted.* Cost Analysis of Water Treatments in Irrigation. Irrigation Science

***Popular Articles***

Fisher, P., Raudales, R. E., Huang J. 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., Raudales, R.E. 2016. Minimize iron buil-up on your water pipes. Greenhouse Grower. June 2016:66-70

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

Raudales, R. E., Pundt, L. 2016. Maintaining high quality plants in retail settings. E-Gro Alerts 5(31):1-6

Raudales, R. E. 2016. Algae on the nutrient solution and surfaces. E-Gro Edibles 1(6):1-44

Raudales, R. E., McGehee, C. 2016. Pythium root rot of hydroponic crops. E-Gro Edibles 1(4):1

***Other Creative Works***

Raudales, R.E., B. MacKay, P.R. Fisher. Waterborne Solutions: Online searchable database on efficacy of water treatments to control plant pathogens developed on www.backpocketgrower.com/waterbornesolutions.asp

1. Scientific and Outreach Oral Presentations.

Raudales, R. Nutrient Management for Hydroponics. Greehouse Production Shortcourse. Bordertown, NJ. March 7, 2016.

Raudales, R. PGRs from start to finish. Bedding Plant Meeting. Vernon, CT. February 25, 2016.

Raudales, R. PGRs from start to finish. Bedding Plant Meeting. Torrington, CT. February 23, 2016.

Raudales, R. Nutrient program: Selecting fertilizer, monitoring growing media, and diagnosing nutrient disorders. . Hands-on Plant Nutrition Workshop: In-house testing of water and growing media. New Haven, CT. February 11, 2016

Raudales, R. Monitoring water quality for irrigation.

Long Island Greenhouse & Floriculture Conference. Long Island, NY. Jan 19, 2016

Raudales, R. Plant diseases in container-grown ornamentals. Connecticut Nursery and Landscape Association Winter Meeting. Plantsville, CT. Jan 15, 2016

Raudales, R. Developing a nutrient program for greenhouse crops. Maine State Florist’s and Growers’ Association. Augusta, ME. January 13, 2016.

Raudales, R. Maintaining high quality plants in postharvest. Maine State Florist’s and Growers’ Association. Augusta, ME. January 13, 2016.

Raudales, R. Understanding water quality for irrigation. SiFLOR. Quito, EC. November 23-27, 2015.

Raudales, R. Building a hydroponic system. 4-H Adventures in STEM conferences. Storrs, CT. November 7, 2016

R. Raudales. Maintaining high quality plants in retails. Smart Marketing= More Customers. New Haven, CT. November 3, 2016

Raudales, R. Water conservation options and resources. Twilight Workshop. Climate Change Adaptation Strategies for CT. Windsor, CT. September 29, 2015

Raudales, R. Water conservation program. Evenint at the Greenhouse. Cheshire, CT. September 28, 2015

Raudales, R. Water conservation options and resources. Exploring Climate Change Adaptation Strategies for CT Agriculture. Woodbridge, CT. September 23, 2015

Raudales, R. E. Water disinfestants interacting with nutrient solutions and substrates. XVIII International Plant Protection Conference. International. Berlin, Germany August 26, 2015

Raudales, R. Waterborne pathogens: Problem and Management. Its All About Water and Increasing Your Bottom Line Workshop. Michigan. July 28, 2015

1. Fund leveraging, specifically, collaborative grants between stations and members.
2. Other relevant accomplishments and activities.

## **Florida**

**NC-1186 Station Report: University of Florida June 2016**

Representatives:

Dr. Paul R. Fisher [pfisher@ufl.edu](mailto:pfisher@ufl.edu) (Faculty Advisor)

George A. Grant [gagrant@ufl.edu](mailto:gagrant@ufl.edu) (Graduate Student)

Impact Nugget:

University of Florida has shown that granular activated carbon can potentially be an effective technology for removing paclobutrazol, a plant growth regulator from recirculated irrigation water.

Accomplishments:

University of Florida constructed a small-scale granular activated carbon system to test the removal capability of paclobutrazol. Paclobutrazol is an active ingredient used in plant growth regulators to control plant height. A 0.05 mg·L-1 paclobutrazol solution was passed through this small-scale, 0.50 to 4.75 mm particle size (8x30 mesh) coconut coir GAC system at 6L·minute-1. A randomized complete block design was used with six contact times (0, 12, 24, 36, 47, or 59 seconds), which corresponded to 0, 1.9, 3.7, 5.6, 7.5, or 9.4L of empty filter housing volume (excluding the carbon). 15mL of each GAC-treated solution were then applied to broccoli [*Brassica oleracea* ‘Waltham 29’] seed and begonia [*Begonia x semperflorens-cultorum* ‘Super Olympia White’] seedlings. Broccoli hypocotyls at 14 days were 103% longer and begonia dry mass was 36% greater when treated with solutions that had a contact time of 59 seconds GAC compared with the 0seconds GAC treatment. With the highest GAC level, begonia dry mass was the same as for plants treated with a zero paclobutrazol solution. However, the broccoli hypocotyl length was 10% shorter for plants treated with 59 seconds GAC compared with a zero paclobutrazol solution. Analysis of paclobutrazol concentration using liquid chromatography-mass spectrometry (LC-MS/MS) found that paclobutrazol concentration decreased by 90% or 99% with a contact time of 12 seconds or 59 seconds GAC, respectively. Overall, this experiment showed that granular activated carbon has the potential to remediate paclobutrazol from irrigation water to below biologically-active concentration.

Impact Statement:

Recapturing and recirculating irrigation water increases water use efficiency and availability for ornamental crop production. However, recirculated irrigation water can contain plant growth regulators, pesticides, herbicides, and other agrichemicals that can affect overall crop quality. Initial research at the University of Florida has shown that granular activated carbon may be a technically and financially feasible technology to remove the plant growth regulator paclobutrazol from irrigation water. The University of Florida is currently working with ornamental nursery operations that are interested in adopting this technology. With this collaboration, the ornamental industry can be directly shown the benefits of activated carbon technology.

Activated carbon may also be effective in removing various other agrichemicals from water. Further studies will take place to test the removal capability of acephate, bifenthrin, chlorpyrifos, and imidacloprid using granular activated carbon. The standard concentrations of these chemicals will be based off effluent concentrations measured from a controlled run-off experiment. Management strategies to monitor the effectiveness of granular activated carbon over time are also being developed, along with analysis of installation and operating cost. This can allow nurseries using this technology to determine the shelf-life of their carbon with minimal cost and labor. Overall, this water treatment technology can benefit the nursery industry by improving recirculated irrigation water quality and reducing the environmental impacts from crop production.

Published Written Works:

Oliveira, S.F., P.R. Fisher, J. Huang, and S.C. Mello. 2016. Strategies to provide fertilizer for both production and consumer phases of petunia. HortTechnology 26:164-175.

Meador, D.P., P.R. Fisher, C.L. Guy, P.F. Harmon, N.A. Peres, Max Teplitski. 2016. Using a dehydrated agar to estimate microbial water quality for horticulture irrigation. Journal of Environmental Quality Mar-Apr 2016. 0. doi:10.2134/jeq2015.03.0130.

Dickson, R.W., P.R. Fisher, W.R. Argo, D.J. Jacques, J.B. Sartain, L.E. Trenholm, T.H. Yeager. 2016. Solution ammonium:nitrate ratio and cation/anion uptake affect the acidity or basicity produced by three floriculture species in hydroponic nutrient solutions. Scientia Horticulturae 200:36–44.

Altland , J.E., L. Morris, J. Boldt, P.R. Fisher, and R.E. Raudales. 2015. Sample container and storage for paclobutrazol monitoring in irrigation water. HortTechnology 25:769-773.

Fisher, P., and R. Raudales. 2016. Minimize build up in your water pipes. Greenhouse Grower. June 2016:65, 66, 68.

Fisher, P. 2016. Pinpoint toxicity in your pond water. Greenhouse Grower. May 2016:46, 48, 50.

Fisher, P., G. Grant, V. Zayas, R. Raudales, J. Altland, and J. Boldt. 2016. New technology development in water treatment. Greenhouse Grower Technology. May/June 2016:20, 22.

Fisher, P.R. 2016. Unclog drip emitters in your greenhouse. Greenhouse Grower. April 2016:42-44.

Fisher, P.R., J. Huang, M. Paz, and R. Dickson. 2016. Having success with organic growing mixes. GrowerTalks Jan 2016:68-72.

Scientific and Outreach Oral Presentations:

Adegbola, Y. U. and P.R. Fisher. 2016. Benchmarking the efficiency of transplanting plant cuttings. ASHS 24571 (Hort. abstr.).

Dickson, R. and P.R. Fisher. 2016. Evaluating calibrachoa (Calibrachoa × hybrida Cerv.) variety sensitivity to iron deficiency at high substrate-pH. ASHS 24876 (Hort. abstr.).

Grant, G.A. , P.R. Fisher, J. E. Barrett, and C. P. Wilson. 2016. Remediating paclobutrazol from irrigation water using activated carbon. ASHS 24570 (Hort. abstr.).

Yafuso, E. J. 2016. The effect of oxygenation of water on dissolved oxygen measurements in irrigation water and container substrate. ASHS 24577 (Hort. abstr.).

Fund Leveraging/ Collaborative Grants between Stations and Members:

Specialty Crops Research Initiative project 2014-51181-22372.

Floriculture and Nursery Research Initiative project 58-3607-3-990.

Other Relevant Accomplishments and Activities:

CleanWateR3.org grower education website on water quality and treatment.

## **Indiana**

**NC-1186 Station Report Content:**

**1.** Impact Nugget:  A concise statement of advancements, accomplishments and impacts.  (Limit to 1-2 sentences)

Purdue University has identified phosphorus requirements of lantana during production, which will help contribute refining P fertilization for ornamental crops and reduce P use by over 80%.

**2.** New Facilities and Equipment. Include production areas, sensors, instruments, and control systems purchased/installed.

Six aquaponics systems have been set up at Purdue University, which provide not only research opportunities but also educational opportunities to general public and students regarding this emerging farming system.

**3.** Unique Water/Production Related Findings.  Include noteworthy findings in water management and quality for crop production & health.

P concentration at 20 mg·L-1 is sufficient to maintain optimal vegetative growth while reproductive growth does not require P concentrations over 10 mg·L-1 as it stimulates greater level of P accumulation in plant parts with little or no effect on growth and flowering, and biomass accumulation in lantana.

Peat-based substrate amended with 40% GRH, 20% perlite and 10% vermiculite can be an alternative containerized substrate to commercial potting mix for the production of petunia and zinnia as it can ensure equal quality as plants grown with commercial potting mix and help reduce water usage to finish crops.

Plant species play a critical role in N and P removal and conservation from aquaculture wastewaters. Depending on the plant species and production stage, N and P removal efficiencies and characteristics can be varied.

4. Accomplishment Summaries.  Draft one to three short paragraphs (2 to 5 sentences each) that summarize research or outreach accomplishments that relate to the NC-1186 objectives (see below).  Please use language that the general public can readily comprehend.

Little is known about the P accumulation patterns and P utilization efficiency in container crops and there are only a few reports on the effects of P fertilization on partitioning in relation to their productivity. Such information is critical as it will help design more efficient management strategies for P fertilizer by better aligning the P requirements of crops and the application amount and timing of the nutrient. The objective of our study was to critically analyze the effects of P on shoot and root growth, phosphorus (P) partitioning and P utilization efficiency in lantana. Our study refines the effects of P fertilization on plant growth, and provides critical information on the biomass accumulation during vegetative and reproductive growths, in relation to P accumulation and partitioning in lantana. Improved cultural practices will help growers to stay in business while complying with federal and state regulations, which are likely to become more stringent with time.

4. Impact Statements.  Please draft 2 or 3 impact statement summaries related to the NC-1186 objectives (listed below).  Statements should be quantitative when possible and be oriented towards the general public.  This is perhaps the most difficult yet most important part of the report.  Two examples are listed below.

In order to determine P requirements of ornamental plants, research was conducted at Purdue University using lantana which were grown at different P levels. Results indicate that plants require a relatively high P during the early stages of growth to promote vegetative growth, and sufficient P supply during reproductive growth to optimize plant productivity. This information is critical to better manage production systems and to mitigate the environmental concerns.

5. Published Written Works.  Include scientific publications, trade magazine articles, books, posters, websites developed, and any other relevant printed works produced.  Please use the formatting in the examples below.

*Scientific publications*

Kim, H.J.and X.X. Li. 2016. Effects of phosphorus on shoot and root growth, partitioning and phosphorus utilization efficiency in lantana. HortScience. (*Accepted*)

*Published abstracts*

Xu,L.Z., N. Liu andH.J. Kim.2015. Effects of Parboiled Rice Hull Amended Substrates on the Growth and Water Use of Petunia and Zinnia. HortScience 50(9): S286.

Xu,L.Z., N. Liu andH.J. Kim.2015. Physical and Chemical Properties of a Peat-based Substrate Amended with Parboiled Rice Hull. HortScience 50(9): S286.

*Symposium Proceedings*

Yang, T. and H.J. Kim. 2016. Conservation of aquaculture wastewater and nutrients through vegetable crop production. Agroenviron 2016. (*In press*)

6. Scientific and Outreach Oral Presentations.  Include workshops, colloquia, conferences, symposia, and industry meetings in which you presented and/or organized.  See below for formatting.

Yang, T. and H.J. Kim. 2016. Conservation of aquaculture wastewater and nutrients through vegetable crop production. Agroenviron 2016: 10th International Symposium on Agriculture and the Environment. May 23-27, 2016. (*Oral presentation*)

Yang, T. andH.J. Kim.2016. Effect of plant species on nitrogen and phosphorus recovery from aquaculture effluents. HLA Research Retreat. Four Points. May 9, 2016. *(Poster presentation)*

7. Fund leveraging, specifically, collaborative grants between stations and members.

8. Other relevant accomplishments and activities.

**Massachusetts**

**NC-1186 Station Report Content:**

**1. Impact Nugget.**

UMass is establishing a research program looking at how plant growth is effected by irrigation practices and water availability.

**2. New Facilities and Equipment.**

A new production area is in the process of being developed at the University of Massachusetts Turf Farm.

**3. Unique Water/Production Related Findings**

None

**4. Accomplishment Summaries.**

UMass is continuing to establish a research program to further examine how plant growth is effected by irrigation practices, how irrigation can be manipulated to control plant growth, and to look at how Massachusetts nurseries can improve irrigation efficiency.

**4. Impact Statements.**

No quantitative data to report.

**5. Published Written Works.**

Bayer, A., J. Ruter, and M.W. van Iersel. 2015. Optimizing Irrigation and Fertilization of Gardenia jasminoides for Good Growth and Minimal Leaching. HortScience. 50:994-1001.

**6. Scientific and Outreach Oral Presentations.**

 Bayer, A. Creating More Sustainable Landscapes. Weston Nurseries Green Up Academy. March 2016

Bayer, A. Producing Great Landscapes with Less Inputs. New England Regional Turfgrass Conference. March 2016.

Bayer, A., Improving Irrigation Efficiency with Sensor Technology. Connecticut Nursery and Landscape Association Winter Symposium. January 2016.

Bayer, A. Transitioning Container Grown Plants to the Landscape. New England Grows Sprint Session. December 2015.

Bayer, A. Understanding the Role of Containers in Successful Tree and Shrub Installations. Conneticut Chapter of the American Society of Landscape Architects Summer Field Day. August 2015.

**7. Fund leveraging, specifically, collaborative grants between stations and members.**

None

**8. Other relevant accomplishments and activities.**

Member of the Massachusetts Nursery and Landscape Association education committee and the New England Grows education committee.

## **Mississippi**

**Mississippi State University**

**2015-2016 Report for the Annual NC-1186 Meeting**

**June 23, 2016**

**1. Impact Nugget**

Former graduate student Xiaojie Zhao, reported in articles published in HortScience that tall bearded *Iris* ‘Immortality’ is capable of repeat blooming in a growing season, with the second blooming largely influenced by N fertilization rate (preferably a higher rate) used during the year of flowering (as opposed to N used in the prior year). Nitrogen use efficiency was greatest using a rate of 10 mM N rate via fertigation.

**2. New Facilities and Equipment**

None

**3. Unique Water/Production Related Findings**

Reblooming, tall bearded iris has potential as a cut flower crop, but little is known about how nitrogen fertilization affects growth, flowering, and nitrogen use efficiency of this crop. Studies conducted at Mississippi State University determined that relatively higher rates of nitrogen supplied via irrigation encouraged a second blooming of *Iris* ‘Immortality’ and indicated that a N rate of 10 mM was optimal for nitrogen uptake efficiency.

**4. Accomplishment Summary**

New cut flower crops, such as tall bearded iris, are of value to the floral industry, but little may be known about the nutrient requirements for the commercial productions of such crops. A study at Mississippi State University evaluated growth, flowering, and nutrient use efficiency of reblooming Iris ‘Immortality’ using nitrogen supplied via irrigation. This study determined that relatively higher rates of nitrogen encouraged a second blooming of *Iris* ‘Immortality’ and indicated that a N rate of 10 mM was optimal for nitrogen uptake efficiency. Also, higher N rates supplied the prior year are recommended to improve production of inflorescence stems in the spring.

**5. Impact Statement**

Because of their showy, colorful flowers and sword-shaped leaves, tall bearded iris (*Iris germanica*) has potential as a specialty cut flower. A better understanding of how reblooming, tall bearded iris responds to fertilizer N rates and how plants use stored N in relation to spring-applied N would help to optimize growth and flowering and improve N fertilizer management. Former graduate student Xiaojie Zhao determined that *Iris* ‘Immortality’ is capable of a second blooming in a growing season, with this second blooming dependent on N fertilization rate during the same year. A relatively high N rate is recommended to produce a second blooming. Nitrogen uptake efficiency was greatest using a 10 mM N rate of nitrogen via fertigation.

**6. Published Written Works**

Zhao, X, G. Bi, and R. Harkess. 2015. Nitrogen and phosphorus rates influence growth, flowering, and nutrient uptake in *Iris germanica* L. ’Immortality’. HortScience 50(9):S386 (poster presentation).

Zhao, X., G. Bi, R.L. Harkess, J.J. Varco, and E.K. Blythe. 2016. Spring nitrogen uptake, use efficiency, and partitioning for growth in Iris germanica 'Immortality'. HortScience 51:563-566.

Zhao, X., G. Bi, R.L. Harkess, J.J. Varco, T. Li, and E.K. Blythe. 2016. Nitrogen fertigation rates affect stored nitrogen, growth and blooming in Iris germanica 'Immortality'. HortScience 51:186-191.

**7. Scientific and Outreach Oral Presentations**

None.

**8. Fund Leveraging**

Mississippi Agricultural and Forestry Experiment Station. Renewal: Nutrient release and plant nutrient use efficiency using controlled-release and water-soluble fertilizers in container nursery production systems. 2015. E.K. Blythe. $5,000.00. (In support of collaborative projects with University of California, Riverside and USDA-ARS).

**9. Other**

Preparation of a series of manuscripts is underway for a study examining the effect of controlled-release fertilizer type on nutrient leaching and nutrient uptake in outdoor-grown waxleaf privet and greenhouse-grown azalea by Donald J. Merhaut (University of California, Riverside), Eugene K. Blythe (Mississippi State University), Joseph P. Albano (University of Florida), and Julie P. Newman (University of California Cooperative Extension). In these studies, we are quantifying nutrients lost through leaching and nutrients taken up by plants during an 11-month growing period using four different types of controlled-release fertilizers and standard nursery production procedures.

Report submitted by Dr. Eugene K. Blythe, Associate Research Professor, Coastal Research and Extension Center, Mississippi State University

## **New Jersey**

**NC-1186 Station Report June 30, 2016**

**Institution:** Rutgers University (New Jersey Agricultural Experiment Station)

**PI:** Raul I. Cabrera

**Impact Nugget:**

Rutgers University is evaluating the short and long-term effects of irrigation with graywater and reclaimed water on growth and quality of ornamental plants, and its impact on the chemical, physical and biological properties of soils and substrates. A greenhouse study is assessing the use of integrated nutrient diagnostic techniques to optimize fertilizer use and productivity in rose cut-flower crops.

**Accomplishments:**

Rutgers University has found that container-grown ornamental plants irrigated (short-term) with laundry graywater irrigation are similar in growth and quality to those irrigated with good quality water sources (municipal tap and well-water). Addition of bleaching agents (i.e. Clorox) to graywater, however, have been found to produce toxic effects on several plant species, attributed to the presence of high total and free chlorine concentrations (45 to 60 ppm). A preliminary landscape irrigation study with graywater has also shown that the presence of bleach in this water source leads to reduced soil biological biomass and diversity compared to control plants irrigated with well water.

Studies are underway to experimentally validate integrated nutrient diagnosis norms (DRIS= Diagnosis and Recommendation Integrated System, and CND= Compositional Nutrient Diagnosis) we have generated for greenhouse-grown cut roses. To date, theoretical validation of these norms has found that they are suitable for rose crop nutrient status diagnosis, allowing for the correlation of nutrient balance indexes with crop flower productivities across a range of cultivars, plant ages, rootstocks and production systems (i.e. soils, soilless substrates, hydroponics).

**Impact Statement:**

The use of alternative irrigation water sources is imperative to the green industries (nursery, greenhouse landscape), as their dependence on high quality water sources is jeopardized by climate change, competition and allocation to other priority uses. Studies on alternative irrigation water sources at Rutgers University are evaluating the short- and long-term effects of sources like reclaimed water and graywater on nursery, greenhouse and landscape plants in comparison to traditional, high-quality, water sources. Results to date suggest that systematic tracking of water quality parameters, and adjustments to irrigation management practices could allow for satisfactory use of these alternative water sources. The long-term effects of these water sources on the chemical, physical and biological properties of soils are currently being assessed.

**Published Written Works:**

*Refereed Journal Articles*

Wu, S., Y. Sun, G. Niu, J. Altland, and R.I. Cabrera. 2016. Response of 10 aster species to saline water irrigation. HortScience 51(2): 197-201.

*Symposium Proceedings*

Cabrera, R.I., S. Cooper, G. Niu, J. Altland and Y. Sun. 2015. Assessing use and management of alternative irrigation water sources for green industry activities. Proceedings of the Southern Nursery Association Research Conference 60: 245-249.

*Poster Presentations*

Chavarria, M., B. Wherley, M. Pendleton, A. Chandra, R.W. Jessup and R.I. Cabrera. 2015. Use of energy dispersive spectroscopy for elucidating salinity tolerance mechanisms in warm-season turfgrass species. Annual Meeting of the American Society of Agronomy, Minneapolis, MN. Abstract 144-8 (Poster Number 1003). *1st Place in Graduate Student Poster Competition: Turfgrass Breeding and Genetics, Stress Tolerance (Section C05 Turfgrass Science).*

*Scientific and Outreach Presentations*

Cabrera, R.I. 2015. Addressing Landscape Water and Soil Management Practices (*In Spanish*). 2015 Winter Workshop on Landscape Management, Texas Nursery & Landscape Association - Region II. Houston, TX.

Cabrera, R.I. 2015. Using and managing controlled-release fertilizers in ornamental crop production. Annual Growers Meeting of the New Jersey Nursery and Landscape Association, Millville, NJ.

Cabrera, R.I., G. Niu and J. Altland. 2015. Evaluating alternative irrigation water sources for nursery crops and landscape plants. Annual Meeting of the American Society for Horticultural Science. New Orleans, LA.

Cabrera, R.I. 2015. The mineral nutrition of cut-flower rose crops (In Spanish). Segundo Seminario Internacional de Nutricion Vegetal en Flores. Bogota, Colombia.

Cabrera, R.I. 2015. Evaluating alternative irrigation water sources for nursery crops and landscape plants. New England Grows 2015 Trade Show. Boston, MA.

Cabrera, R.I. 2015. Irrigation water quality and its effects on managed landscape plantings. 40th Annual New Jersey Green Expo, Atlantic City, NJ

## **North Carolina**

**NC-1186 Station Report Content: NC State, Mountain Horticultural Crops Research and Extension Center**

*Impact Nugget*

NC State has determined that more than 50% of growers in eastern North Carolina have poor quality source water that is used for irrigation as recommended by best management practices guide for producing container plants.

*Infrastructure*

NC State recently installed a controlled environment small scale irrigation system which will allow chemical injection into irrigation water to establish various treatments that mimic currently measured metrics in surface water throughout the state.

*Unique Water/Production Related Findings.*

In collaboration with Amy Fulcher, Jim Owen, Sarah White and Richard Beeson, we updated the vision for water resources for nursery producers in the southeast. Our efforts revisited some of the predictions made in a similarly titled seminal paper published in 2004 and updated them for the next 10 years. Generally, it seems that producers use the same volume of water per acre as they did 10 years ago and more water is being extracted from groundwater, perhaps, due to less available surface water. Technology to monitor water availability in containers and use that information to control irrigation frequency is gaining in both popularity and adoption.

*Accomplishment Summaries.*

NC State sampled source water quality growers use for irrigation in over 60 nurseries in 18 counties in eastern North Carolina during late summer 2015 (Table 1).

Table 1. Source water quality growers in North Carolina use for irrigation by supply type.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source | pH | Electrical Conductivity | Alkalinity | Iron |
|  | units±std | mS/cm±std | ppm±std | ppm±std |
| Pond | 7.8±1.1 | 0.2±0.1 | 47±40 | 0.5±0.7 |
| Riserz | 7.7±0.7 | 0.2±0.1 | 50±30 | 0.3±0.3 |
| Welly | 6.5±1.1 | 0.3±0.3 | 90±77 | 0.6±1.5 |

ZWater was not captured from the sprinkler head riser at every nursery. These averages are from 25 nurseries.

YWith the exception of a few nurseries, wells were not used for irrigation solely, but used to refill ponds when quantities were low.

They determined that more than 66% of nurseries are irrigating with high pH water (>7.0) in summer caused by algae production in surface waters. The effect of high pH irrigation water on plant growth and quality is under investigation while NC Cooperative Extension agents are working with local growers to decrease algae production in surface waters.

*Impact Statements*

NC State has determined that more than 50% of growers in eastern North Carolina have poor quality source water that is used for irrigation as recommended by best management practices guide for producing container plants. An integrated approach to reduce algae growth in surface waters as well as reduce irrigation water pH has the potential to increase plant growth by 10%.

*Refereed Journal Articles*

Fulcher, A., A.V. LeBude, J.S. Owen, Jr., S.A. White, and R.C. Beeson. 2016. The next ten years: Strategic vision of water resources for nursery producers. HortTech. 2:121-131.

*Popular press*

Fulcher, A., A.V. LeBude, J.S. Owen, Jr., S.A. White, and R.C. Beeson. 2016. Are we learning from the past? Nursery Management and Production, June. Accessed 17 Jun <http://www.nurserymag.com/article/are-we-learning-from-the-past/>.

*Scientific and Outreach Oral Presentations*

LeBude, A.V. 2016. Source water quality growers use for irrigation.

1. North Carolina Nursery and Landscape Association Trade Show, Nursery track, Greensboro, NC, Jan. 16.
2. Virginia Tech and Virginia Cooperative Extension Lunch and Learn Webinar, online, May 19.

*Funding*

LeBude, A.V. and A. Ammons. 2016. Reducing irrigation volume in North Carolina nurseries. North Carolina Nursery and Landscape Association. $5000 proposed.

LeBude, A.V. Improving water quality increases profits. North Carolina Department of Agriculture and Consumer Services Specialty Crops Block Grant. $101,082 proposed.

LeBude, A.V. Effect of high pH irrigation water on nursery crops. Horticulture research Institute. $5305 proposed.

## **Ohio**

**NC-1186 Station Report Content:**

1. Impact Nugget:

USDA-ARS in Wooster, OH, determined the mechanism by which rice hull mulch provides weed control in container crops.

USDA-ARS in Wooster, OH, determined the killing temperature of weeds seeds when using hot-water or steam to sterilize reused propagation pots and trays.

2. New Facilities and Equipment.

USDA-ARS recently completed installation of three new A1000 Conviron growth chambers. These chambers allow manipulation of light, temperature, relative humidity, and CO2 concentration to better understand how these environmental parameters affect crop growth. A key feature to these growth chambers is the ability to control and monitor CO2 levels above and below ambient concentrations.

1. Unique Water/Production Related Findings.

Rice hulls prevent the establishment of weeds primarily by their inherent water-repelling qualities and their inability to retain water.

Bittercress seed exposed to 70 °C hot-water for 30 minutes were killed 100%, while seed exposed to 90 °C hot-water for just 10 minutes were killed 100%.

1. Accomplishment Summaries.

USDA-ARS in Wooster, OH, determined the mechanism by which parboiled rice hulls provide weed control in container crops. Parboiled rice hulls are a clean, light-weight, OMRI-approved organic mulch product that can be used for controlling weeds in nursery containers. Weed seed and spores (from liverworts and mosses) that land on top of the mulch surface fail to establish due to volumetric water content of the mulch layer. Compared to pine bark and sphagnum peatmoss, rice hulls retain very little water from an irrigation event, and they dry quickly from what little water they do retain. For weed seeds present on the surface of the container at the time of mulch application, rice hulls must form a physical barrier to prevent weed establishment. A mulch layer at least 1.25 cm thick is needed to physically impede weed establishment from beneath the rice hull mulch layer.

Steam or how-water can be used to sterilize reused plastic propagation pots and trays and effectively kill weed seed attached to the plastic. Seeds of many weeds, most notably bittercress (*Cardamine flexuosa*) and creeping woodsorrel (*Oxalis corniculata*), stick to plastic containers and trays and are reintroduced into the production system when these containers and trays are reused. Bittercress seed exposed to 70 °C hot-water for 30 minutes were killed 100%, while seed exposed to 90 °C hot-water for just 10 minutes were killed 100%.

1. Impact Statements.

USDA-ARS in Wooster, OH determined the mechanism of action by which rice hulls provide weed control in nursery containers. Based on these results, more clear guidelines can be provided for nursery producers using rice hulls for weed control in newly potted containers or older and more established containers.

USDA-ARS in Wooster, OH has documented the temperature and exposure time needed for killing bittercress seeds attached to reused plastic propagation trays and containers. Refined temperature and exposure times will allow more precise management and energy conservation when using this technology for weed management.

1. Published Written Works.

Altland, J.E., Zellner, W., Locke, J.C., and Krause, C.R. 2015. Micronutrient availability from steel slag amendment in peatmoss substrates. HortScience. 50:1715-1720.

Zellner, W.L., Friedrich, R.L., Kim, S., Sturtz, D.S., Frantz, J., Altland, J.E., Krause, C.R. 2015. Continuing assessment of the 5 day sodium carbonate ammonium nitrate extraction assay as an indicator test for silicon fertilizers. Journal of AOAC International. 98(4):890-895.

Altland, J.E., L. Morris, J. Boldt, P. Fisher, and R. Raudales. 2015. Sample container and storage for paclobutrazol monitoring in irrigation water. HortTechnology 25:769-773.

Altland, J.E. and J.C. Locke. 2015. High rates of gasified rice hull biochar affect geranium and tomato growth in a soilless substrate. J. Plant Nutr. (Accepted, In Press).

Altland, J.E., Locke, J.C., and Zellner, W. 2016. Micronutrient availability from steel slag amendment in pine bark substrates. J. Environ. Hort. (Accepted, In Press).

Altland, J.E. and K.Y. Jeong. 2016. Dolomitic lime amendment affects pine bark substrate pH, nutrient availability, and plant growth: A review. HortTechnology (Submitted, In Review).

1. Scientific and Outreach Oral Presentations.  Include workshops, colloquia, conferences, symposia, and industry meetings in which you presented and/or organized.  See below for formatting.

Altland, J.E. 2015. Silicon uptake in nursery crops. Floriculture Research Alliance, Austin, TX.

Altland, J.E. 2015. Horseweed control in field nursery crops. Northeast Weed Science Society, Philadelphia, PA.

1. Fund leveraging, specifically, collaborative grants between stations and members.

## **South Carolina**

**NC-1186 Station Report: Clemson University**

**1. Impact Nugget:**

Pickerelweed (*Pontederia cordata*), planted in floating treatment wetlands (FTWs) absorbed 10.8 g N and 1.8 g P per plant (whole plant), while soft rush (*Juncus effusus*) accumulated 0.72 g N and 0.12 g P per plant. Translated to larger applications, 1 acre of FTWs could absorb 88 lbs of N and 15 lbs of P if planted with soft rush or 1,320 lbs of N and 255 lbs of P if planted with pickerelweed.

**2.** **New Facilities and Equipment.** None

**3. Unique Water/Production Related Findings.**

Results from our plant susceptibility trials indicate that three aquatic plant species (*Iris ensata* ‘Rising Sun’, *Canna flaccida* and *Canna* ×*generalis* ‘Bird of Paradise’ may not only be non-susceptible to species of *Phytophthora*, but also actively suppressed (18 - 46%) zoospore activity in aqueous systems.

**4. Accomplishment Summaries.**

Researchers at Clemson University evaluated aquatic plants species for their susceptibility to plant pathogens by screening eleven aquatic plant species in repeated laboratory trials to evaluate susceptibility to plant pathogens. Plant species screened include: *Agrostis alba, Andropogon glomeratus, Carex stricta, Canna flaccida, Canna* ×*generalis* ‘Bird of Paradise,’  *Iris ensata* ‘Rising Sun’, *Pontederia cordata, Sagittaria latifolia,* and *Typha latifolia*. Iris and canna speciessupported limited or no growth and reproduction of examined *Phytophthora* spp., indicating they are not susceptible to infection by *Phytophthora* and can be used in future studies of “designer” vegetative channels. Additional screening of plant species is planned to verify alternate susceptibility.

Researchers at Clemson University and Virginia Tech worked together to develop multiple “tools” grower can use to make decisions. The first developed model is related to water treatment – disinfection via various chemicals. The water treatment model will be tested and validated this year.

Researchers at Virginia Tech, Clemson University, North Carolina State University, and University of New Hampshire collaborated to develop and beta test a comprehensive crop production tool to help the technology-savvy grower manage water and fertilizer. This research funded by the Horticulture Research Institute and the American Floral Endowment will assist nursery and floriculture producers The “app” will assist growers in making on-the-go decisions, providing them with historical records, saving time and money.

**5. Impact Statements.**

Use of alternative water resources (e.g., recycled, municipal reclaimed water, etc.) by greenhouse and nursery growers is critical for their continued economic sustainability. Water quality in alternative sources may be poor, reducing crop growth. We are quantifying the quality of alternative water sources (in various regions within the US) and developing decision support tools to help growers make informed decisions about how to clean their water. Use of alternative water source will decrease grower demand for potable water sources, while maintaining access to viable water sources for crop production.

Reducing nitrogen and phosphorus levels in surface waters help to limit algal blooms. For most growers, water treatment options are limited by economic and site-specific constraints. We used floating treatment wetlands to reduce nutrient levels in ponds to control algae. Plants in the floating wetlands absorbed 17-290.6 g of N per m2 and 1.1 to 48.4 g of P per m2. Floating wetlands absorbed nutrients, limiting nutrients available to algae and improving water quality.

**6. Published Written Works.**

*Refereed Journal Articles*

Fulcher, A., A.V. LeBude, J. S. Owen, Jr., S. A. White and R. C. Beeson. 2016. The next ten years: Strategic vision of water resources for nursery producers. HortTechnology 26:133-140.

*Symposium Proceedings*

None

*Extension Bulletins*

P. Fisher, S.A. White, J.S. Owen, Jr., R.T. Fernandez, D. Hitchcock, J. Parke, C. Hall, A. Lamm, L. Oki, P.C. Wilson, J. Lea-Cox, D. Ingram, B. Cregg, P. Fisher, D. Sample, L. Sanagorski, S. Tjosvold, D. Haver.  Clean WateR3 - Reduce, Remediate and Recycle / Water Education Alliance for Horticulture: http://www.cleanwater3.org/

*Popular Articles*

None

**6. Scientific and Outreach Oral Presentations.**

White, S.A., J. S. Owen, Jr., B. Behe, B. Cregg, R.T. Fernandez, P. Fisher, C.R. Hall, D. Haver, D. Hitchcock, D. Ingram, S. Kumar, A. Lamm, J.D. Lea-Cox, L. Oki, J. Parke, A. Ristvey, D. Sample, L. Warner, P.C. Wilson. 2015. Clean WateR3 - Reduce, Remediate, Recycle: A Specialty Crops Research Initiative Project Focused on Management of Recycled Water for Ornamental Crop Production. HortScience 50(9):S31-S32. (abstr., oral co-presentation)

White, S.A., J. S. Owen, Jr., J. Majsztrik, R.T. Fernandez, P. Fisher, C.R. Hall, D. Hitchcock, D. Ingram, A. Lamm, J.D. Lea-Cox, J. Parke,. 2015. Clean WateR3 - Reduce, Remediate, Recycle: The genesis of a SCRI-CAP project. HortScience 50(9):S382. (abstr., poster)

Bell, N, DR Hitchcock, SA White. 2016. Plant Selections for Vegetated Buffers: Can Phytopathogens be Remediated from Irrigation Runoff Water? American Ecological Engineering Society. Knoxville, TN (June)

Majsztrik, JC, C Hall, SA White, E Lichtenberg. 2015. National survey of ornamental grower practices. American Society for Horticultural Science Annual Meeting, New Orleans, LA. (August). HortScience. 50(9):S118 (abstr.)

Majsztrik, JC. DR Hitchcock, D Sample, D Ingram, C Hall, S Kumar, SA White. 2015. (427) Development of a new tool for growers and researchers to better understand ornamental operations. American Society for Horticultural Science Annual Meeting, New Orleans, LA. (August). HortScience. 50(9):S368 (abstr.)

Huang, P., Lamm, A. J., Warner, L., Fisher, P., & White, S. (2016, February). Nursery growers’ relationships with water: What influences their opinions of water? Paper presented at the Southern Association of Agricultural Sciences Annual Meeting, Horticulture Section, San Antonio, TX.

Martin, E., Lamm, A. J., Warner, L., Fisher, P., & White, S. (2016, February). Diffusing water conservation and treatment technologies to nursery and greenhouse operations through extension programming. Paper presented at the Southern Association of Agricultural Sciences Annual Meeting, Horticulture Section, San Antonio, TX.

White, SA. 2016. “Can plant-based remediation systems mitigate phytopathogens from irrigation runoff?” University of Georgia, Department of Plant Pathology. Athens, GA (February).

White, SA. 2015. “Clean Water3: Tips for competitive grant writing success.” Clemson University, Environmental Toxicology graduate seminar. Pendleton, SC (September).

White, SA, JS Owen, Jr., JC Majsztrik, B Behe, B Cregg, RT Fernandez, PR Fisher, L Fox, CR Hall, D Haver, DR Hitchcock, DL Ingram, S Kumar, A Lamm, J Lea-Cox, LR Oki, JL Parke, A Ristvey, D Sample, S Swett, LS Warner, PC Wilson. 2015. “Clean WateR3 – Reduce, Remediate Recycle: Helping Growers Safely Recycle Water.” United States Department of Agriculture – Specialty Crop Committee, Washington, DC (October).

White, SA. 2015. “Clean WateR3: Developing an Online Toolbox to Support Grower Use of Recycled Water.” United States Department of Agriculture – Specialty Crop Committee, Washington, DC (October).

Majsztrik, JC, DR Hitchcock, S Kumar, D Sample, SA White. 2016. Counting the costs: Developing a tool to help growers understand the costs and benefits of water recycling systems.” American Society for Horticultural Science. Atlanta, GA (August)

Garcia, L, JC Majsztrik, NL Bell, SA White. 2016. Nutrient Remediation using Two Plant Species in a Floating Treatment Wetland System. Southern Region-American Society for Horticultural Science, San Antonio, TX (February)

Majsztrik, JC, DR Hitchcock, S Kumar, S Sample, SA White. 2016. Counting the costs: Developing a tool to help ornamental growers understand the costs and benefits of water recycling systems at their operation. Southern Region-American Society for Horticultural Science, San Antonio, TX (February)

Bell, N, DR Hitchcock, LM Garcia, JC Majsztrik, SA White. 2016. Remediation of Phytopathogen Contaminants from Irrigation Runoff Water using Floating Treatment Wetlands to Facilitate Increased Water Recycling. Southern Region-American Society for Horticultural Science, San Antonio, TX (February)

White, SA. 2016. Clean WateR3: Integrating Research and Extension to Help Specialty Crop Growers Recycle Water. 3rd International Symposium on Woody Ornamentals of the Temperate Zone, Minneapolis MN (August).

White, SA. N Bell, L Garcia-Chance, JC Majsztrik, DR Hitchcock, D Abdi, RT Fernandez. 2016. Clean WateR3: Evaluation of 3 Treatment Technologies to Remove Contaminants from Recycled Production Runoff. 3rd International Symposium on Woody Ornamentals of the Temperate Zone, Minneapolis MN (August).

Majsztrik, JC, DR Hitchcock, S Kumar, D Sample, SA White. 2016. Clean WateR3: Developing Tools to Help Specialty Crop Growers Understand the Costs and Benefits of Recycling Water. 3rd International Symposium on Woody Ornamentals of the Temperate Zone, Minneapolis MN (August).

**7. Fund leveraging, specifically, collaborative grants between stations and members**.

9/1/2014–8/30/2019. USDA-Specialty Crops Research Initiative. “Clean WateR3 - Reduce, Remediate, Recycle: Informed Decision-Making to Facilitate Use of Alternative Water Resources and Promote Sustainable Specialty Crop Production.” SA White, JS Owen, B Behe, B Cregg, RT Fernandez, P Fisher, L Fox, CR Hall, D Haver, D Hitchcock, DL Ingram, S Kumar, A Lamm, J Lea-Cox, LR Oki, JL Parke, A Ristvey, D Sample, C Swett, LS Warner, PC Wilson. $8.7 M. Y1 and Y2 funding $3,444,461.

**8. Other relevant accomplishments and activities.**

None

## **Tennessee**

**Report period: from last meeting to the current meeting**

**NC-1186 Station Report Content:**

1. Impact Nugget:  A concise statement of advancements, accomplishments and impacts.  (Limit to 1-2 sentences)

In 2016, the University of Tennessee continued 3 projects that were initiated in 2015 to test conservative irrigation systems (based on daily water replacement, leaching fraction, or on demand) using GS1 substrate moisture sensors at commercial nurseries. Water use, plant growth, and leachate volume are being monitored.

The University of Tennessee is investigating the role of biochar as a substrate amendment and two conservative irrigation scheduling techniques to reduce water use and leachate.

1. New Facilities and Equipment. Include production areas, sensors, instruments, and control systems purchased/installed.

N/A

1. Unique Water/Production Related Findings.  Include noteworthy findings in water management and quality for crop production & health.

The University of Tennessee found that probe position was not important for EC-5 sensor accuracy in 11.4 L containers filled with 85% pine bark and 25% peat but cultural practices may dictate the most ideal placement. For example a surface placement may be east to install and remove and a side placement through the container sidewall may be more secure during hand weeding and less affected during pesticide applications. A single severe drying event reduced sensor accuracy for 4 out of 5 positions and reduced the amount of water the container could hold. OD generally used less water than DWU and had either no or a positive impact on biomass in all but one trial. For 3.8 L plants, photosynthesis and stomatal conductance were consistently greater when irrigated by the OD program. Both treatments used significantly less water than the industry standard of 2.5 cm per day.

1. Accomplishment Summaries.  Draft one to three short paragraphs (2 to 5 sentences each) that summarize research or outreach accomplishments that relate to the NC-1186 objectives (see below).  Please use language that the general public can readily comprehend.

The University of Tennessee established 3 independently controlled irrigation plots at three commercial nurseries to examine water use, container drainage (leachate) volume, and plant growth. Plants include ornamental cherries, hydrangeas, junipers, and dogwoods. Plants were automatically irrigated by one of three sensor-based regimes: 1) an on-demand (OD) irrigation system based on a specific container substrate moisture content, 2) a leachate-based system, or 3) a daily water use system. In each case the system was compared with the nursery’s standard daily timer-based irrigation. In general, plants irrigated by the sensor-based systems stayed more moist, experienced fewer moisture level extremes, and use less water. All three treatments used significantly less water than the common industry practice of applying 0.7-1.0 inch per day. This research is on-going and will be continued over several seasons to determine if conservative, technology driven irrigation scheduling can reduce water consumption without reducing growth or slowing production time and determine, which, if any, of the sensor-based systems is best.

1. Impact Statements.  Please draft 2 or 3 impact statement summaries related to the NC-1186 objectives (listed below).  Statements should be quantitative when possible and be oriented towards the general public.  This is perhaps the most difficult yet most important part of the report.  Two examples are listed below.

Increasing regulation, public interest in sustainable practices, and droughts have increased nursery producer awareness of the need to more conservatively use natural resources such as water during agricultural production. The University of Tennessee has shown that sensor-based irrigation scheduling reduces water by 50% for cherries, 63% for junipers and hydrangeas, and between 44 and 70% for dogwoods, depending on species.

**6.** Published Written Works.  Include scientific publications, trade magazine articles, books, posters, websites developed, and any other relevant printed works produced.  Please use the formatting in the examples below.

*Book and Manual Chapters*

W. YearyM, A. Fulcher, and B. Leib. Nursery irrigation: A guide for reducing risk and improving production. UT Extension Publication PB 1836.

<https://extension.tennessee.edu/publications/Documents/PB1836.pdf>

*Refereed Journal Articles*

Fulcher, A., A.V. LeBude, J.S. Owen, S.A. White and R.C. Beeson. 2016. The next ten years: Strategic vision of water resources for nursery producers. HortTechnology 26(2):121.

*Multimedia*

None to report

*Proceedings*

Basiri Jahromi, N. M, A. Fulcher, and F. Walker. 2015. Effect of Biochar on Water Conservation and Growth of Soilless Container Grown ‘Green Velvet’ Boxwood and Pinky Winky® Hardy Hydrangea. Proc. Southern Nursery Association Research Conference. Proc. Southern Nursery Association Research Conference. 60:261-266.

Cypher, Q. M, W. Wright, and A. Fulcher. 2015. A cost effective tipping bucket assembly for real time container leachate measurements and irrigation management. Proc. Southern Nursery Association Research Conference. 60:250-260.

7. Scientific and Outreach Oral Presentations.  Include workshops, colloquia, conferences, symposia, and industry meetings in which you presented and/or organized.  See below for formatting.

Fulcher, A. Measuring Nursery Container Leachate. Nursery and Landscape Research Update. Tennessee Nursery and Landscape Association Field Day. June 14, 2016, Knoxville, TN.

BasiriJahromi, N.M Bochar as a Container Substrate for Nursery Production. Nursery and Landscape Research Update. Tennessee Nursery and Landscape Association Field Day. June 14, 2016, Knoxville, TN.

Fulcher, A., A.V. LeBude, J.S. Owen, S.A. White and R.C. Beeson. 2016. Are we learning from the past? Nursery Management. June 2016.

Fulcher, A. Introduction to Ag. and Nursery Water Issues. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

Fulcher, A. Cultural Practices That Can Reduce Water Use. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

Fulcher, A. Water Quality Testing, Reclaiming Water to Protect Watersheds. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

Fulcher, A. Scheduling Irrigation to Improve Plant Production and Conserve Water. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

McHugh, J. M Update on Irrigation Technology, UT Research. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

Fulcher, A. Measuring Irrigation Efficiency and Other Helpful Calculations. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

Fulcher, A. and J. McHughM. Site Visit: Irrigation Technology at Commercial Nursery and Hands-on Efficiency Calculations. Nursery Irrigation and Watershed Protection In-service. July 11, 2016. Winchester, TN.

Fulcher, A. Hydrangea Irrigation and Growth Control. Hydrangea Production Workshop. July 21, 2016. McMinnville, TN.

8. Fund leveraging, specifically, collaborative grants between stations and members.

Walker, F. and A. Fulcher. 2015-2017. Robinson Creek Restoration Project, Franklin County, Tennessee. Tennessee Department of Environment and Conservation. $55,176 (Fulcher: $15,000).

Chappell, M.R., S.K. Braman, J.-H. Chong, J. Derr, W. Dunwell, A. Fulcher, F. Hale, F. Hand, W. Klingeman, G. Knox, A. LeBude, C. Marble, J. Neal, N. Ward, S.A. White, J. Williams-Woodward, and A. Windham. 2015-2016. IPM for Shrubs in Southeastern U.S. Nursery Production. USDA-NIFA, Southern Region IPM Center. $39,532 (Fulcher: $0, no subawards allowed).

9. Other relevant accomplishments and activities.

## **Texas**

NC-1186 Station report from Texas

Genhua Niu, Texas A&M AgriLife Research Center at El Paso

Terri Starman, Department of Horticulture, Texas A&M University, College Station

1. Impact nugget:

Texas A&M Researchers have determined salt tolerance of additional 25 popular ornamental species by categorizing them into sensitive to tolerant groups. This information would guide the green industry professionals in plant selection when dealing with low quality irrigation water.

1. New facilities and equipment

none

1. Unique water/production related findings

none

1. Accomplishment summaries

We continue to study on the salt tolerance of important ornamental species and drought tolerance and irrigation management of ornamental plants. In the past 12 months, the following were studies.

1. Study 1: Salt tolerance of ten aster perennials was evaluated in a greenhouse experiment, including the following: damianita (*Chrysactinia mexicana*), gregg’s mistflower(*Eupatorium greggii*), shasta daisy(*Leucanthemum* × *superbum* ‘Becky’), blackfoot daisy(*Melampodium leucanthum*), lavender cotton(*Santolina chamaecyparissus*), aromatic aster(*Symphyotrichum oblongifolium*), copper canyon daisy (*Tagetes lemmonii*), four-nerve daisy(*Tetraneuris scaposa*), skeleton-leaf goldeneye (*Viguiera stenoloba*), and zexmenia(*Wedelia texana*). Plants were irrigated with nutrient solution at electrical conductivity (EC) of 1.2 dS∙m-1 (control) or saline solutions at EC of 5.0 or 10.0 dS∙m-1 (EC 5 or EC 10) for five weeks. Results indicated that gregg’s mistflower, skeleton-leaf goldeneye, and lavender cotton were the most salt tolerant species with less reductions in shoot DW at elevated salinity. Damianita and the four daisies, i.e., blackfoot daisy, copper canyon daisy, four-nerve daisy, and shasta daisy, and aromatic aster and zexmenia were salt sensitive.
2. Study 2: Nine ornamental species were irrigated with a nutrient solution and saline solution at three different electrical conductivity rates and were assessed for growth and physiological responses. The nine species are butterfly blue(*Scabiosa columbaria* ‘Butterfly Blue’), cardinal flower(*Lobelia cardinalis*), and eastern red columbine(*Aquilegia canadensis*)], three shrub-like perennials [mexican false heather(*Cuphea hyssopifolia*), mexican hummingbird bush (*Dicliptera suberecta*), and rock rose(*Pavonia lasiopetala*)], and three shrub species [‘Dark knight’ bluebeard (*Caryopteris × clandonensis* ‘Dark Knight’), flame acanthus(*Anisacanthus quadrifidus* var. *wrightii*), and orange peel jessamine (*Cestrum* ‘Orange Peel’). Results indicated that orange peel jessamine and mexican hummingbird bush were the most salt tolerant in the trials, while flame acanthus, rock rose, and ‘Dark knight’ bluebeard were moderately salt-tolerant. Cardinal flower, mexican false heather, and butterfly blue plants were moderately salt sensitive, while Eastern red columbine was the most salt sensitive among the species.
3. Study 3: the salt tolerance of six Lamiaceae species was determined by quantifying their growth and physiological responses. The six species are *Ajuga reptans* ‘Burgundy Glow’ (bugleweed), *Lamium maculatum* ‘Pink Pewter’ (spotted dead nettle), *Scutellaria suffrutescens* ‘Pink Skullcap’ (cherry skullcap), and *Stachys coccinea* (Texas betony), and two border plants, *Perovskia atriplicifolia* (Russian sage) and *Poliomintha longiflora* (Mexican oregano). Our results indicated that Texas betony was the most salt tolerant, Russian sage and spotted dead nettle were moderately tolerant, while bugleweed, Mexican oregano, and cherry skullcap were the least salt tolerant.
4. *Angelonia angustifolia* ‘Angelface Blue’ liners were grown until the marketable stage with irrigation at soil moisture content (SMC) of 20 or 40% using Watchdog 1000 series SMC monitors. Plants were allowed to dry down to the monitored SMC level beforehand watering to container capacity (CC). At the end of the production stage, plants were irrigated to CC and subjected to a simulated shipping in the dark for two days. After shipping, plants were placed back in the greenhouse and watered only when wilted i.e. leaves beginning to flag. At the end of production, 40% SMC plants had significantly larger growth index (GI=(width 1+width 2)/4 + height/2) and dry biomass than 20% SMC plants and 20% SMC plants had shorter internodes. The flower and bud numbers were not significantly different between the 40 and 20% SMC at the end of production or retail indicating lower SMC produced more compact plants without affecting their visual quality. The volume of water received by the 40% SMC during production was 20% greater and during simulated retail 10% greater than the 20% SMC. Morning water potentials were not different for SMC treatments during production and retail, but mid-day water potentials were significantly higher for plants grown at 40% SMC during retail. Plants grown in 40% SMC had higher photosynthesis rate during greenhouse production, but during retail, the photosynthesis rates were the same for both SMC treatments. This is physiological evidence suggesting plants that were water stressed during production were more acclimated to the retail environment. Our results demonstrate that while conserving water, controlled irrigation at a lower SMC can produce high quality plants that have equal or superior shelf life to those that are irrigated at high levels.
5. Impact statements

By using non-potable water sources such as reclaimed and brackish water to irrigate landscapes and nursery crops, the supply of freshwater can be extended and saved for other beneficial purposes.

1. Published written works

*Refereed Journal Articles*

Jacobson, A.B., T.W. Starman, and L. Lombardini. 2015. Substrate moisture content effects on growth and shelf life of *Angelonia angustifolia*. HortScience 50(2):272-278.

Wu, S., Y. Sun, G. Niu, G.L. Grimaldo and A. Castro. 2016. Responses of six Lamiaceae landscape species to saline water irrigation. Journal of Environmental Horticulture 34(1): 30-35.

Wu, S., Y. Sun, and G. Niu. 2016. Morphological and physiological responses of nine ornamental species to saline water irrigation. HortScience 51(3): 285-290.

Wu, S., Y. Sun, G. Niu, J. Altland, and R. Cabrera. 2016. Response of 10 aster species to saline water irrigation. HortScience 51(2): 197-201.

Wang, X., M. Gu, G. Niu, P.A. Baumann. 2015. Herbicidal activity of mustard seed meal (Sinapis alba ‘IdaGold’ and Brassica juncea ‘Pacific Gold’) on weed emergence. Industrial Crops and Products 77: 1004-1013.

Sun, Y., G. Niu, R. Wallace, J. Masabni, and M. Gu. 2015. Relative salt tolerance of seven strawberry cultivars. Horticulturae 1:27-43; doi:10.3390/horticulturae1010027.

Sun, Y., G. Niu, and C. Perez. 2015. Relative salt tolerance of seven Texas Superstar® perennials. HortScience 50:1562-1566.

Sun, Y., J. Masabni, and G. Niu. 2015. Simulated seawater flooding reduces the growth of ten vegetables. HortScience 50(5):694-698.

Sun, Y., G. Bi, and G. Niu. 2015. Foliar application of dikegulac sodium increases branching of *Hydrangea macrophylla* ‘Merritt’s Supreme’. HortTechnology 25(3):306-312.

*Technical Articles*

Nambuthiri, S., A. Fulcher, R. Geneve, G. Niu, D. Cochran, S. Verlinden and R. Conneway. 2015. Saving water and money: Irrigation for increased nursery profitability and efficiency. Tennessee GreenTimes. 16(2): 1-4.

Nambuthiri, S., A. Fulcher, R. Geneve, G. Niu, D. Cochran, S. Verlinden and R. Conneway. 2015. Pick your pot. Find out if container alternatives are right for your growing operation. Tennessee Green Times. 116(2):18-20.

Sun, Y., G. Niu, and D. Zhang. 2015. Effect of volumetric water content on the growth of *Nandina domestica*. Proceedings of Southern Nursery Association 60:45-51.

## **Virginia**

**NC-1186 Station Report Content:**

1. Impact Nugget:  A concise statement of advancements, accomplishments and impacts.  (Limit to 1-2 sentences)

Virginia Tech continues to explore the interaction of mineral nutrients – water – soilless substrate and subsequent crop response to improve water and fertility practices in containerized crop production yielding a better understanding how to reduce water and fertility.

1. New Facilities and Equipment. Include production areas, sensors, instruments, and control systems purchased/installed.

Experimental Nursery (Owen, VT; Fernandez, MSU)

1. Unique Water/Production Related Findings.  Include noteworthy findings in water management and quality for crop production & health.

*Filter Socks (Owen, VT; M. Ag. Sci. student: Brindley):* Completed on-farm research and conducted technology demonstrations on two additional nurseries. Designed and constructed simulated runoff ditches for controlled experiments.

*Water Transport Model (Owen, VT; PhD student: Fields):* Successfully generated 2D numerical model for water transport in soilless substrates and initiated 3D numerical model to better understand later water movement and containerized crop water use.

*Extending water via substrate engineering (Owen, VT; PhD student: Fields):* Engineered soilless substrates to increase water availability and subsequent crop water use efficiency in one taxa.

*Phosphorus Fate in Containerize Crop Production (Owen, VT; PhD student: Shreckhise):* Carried out preliminary experiments demonstrating interaction of agrochemicals with soilless substrate components and chemical amendments, thus reducing phosphorus load leached.

*Reducing Phosphorus Fertilization (Owen, VT; PhD student: Shreckhise):* Demonstrated phosphorus requirements vary by taxa and climate allowing for potential >25% decrease in phosphorus fertilization when producing some woody ornamental taxa.

*BMP Adoption (Owen, VT; M.S. student: Mack*): Identified cost as a key barrier to BMP adoption in Virginia. Environmental stewardship, resource savings and efficiencies were identified as key reasons Virginia growers have adopted current BMPs.

Accomplishment Summaries.  Draft one to three short paragraphs (2 to 5 sentences each) that summarize research or outreach accomplishments that relate to the NC-1186 objectives (see below).  Please use language that the general public can readily comprehend.

Surveyed nursery and greenhouse growers in Virginia regarding best management practices (BMPs). 60 respondents reported BMP use, which included buffer strips, irrigation scheduling and optimized irrigation efficiency, water capture and collection, plant need based water application, grouping plants by water needs, integrated pest management, and controlled-release fertilizers. Growers reported that their sources of information about BMP use included learning on their own (81%), observing what others in the industry did (62%), extension publications (60%), vendors (21%), and the BMP manual (13%).

Filter socks were successful at removing sediment and bound agrichemicals at grower collaborator sites; however, filter socks did result in undesirable water retention / damming in a few locations that resulted in a perceived increase in disease potential and wet roadways.

Owen and Altland investigated organic acids and solids leached from soilless substrates to better understand their interaction with soilless substrates chemical amendments, namely phosphorus, and subsequent water quality. A study was conducted utilizing three pine bark sources commonly used for containerized crop production in the southeastern, Midwest and mid-Atlantic US. Replicates of each bark from three source was packed 6” PVC columns and leached over a 12-day period. Effluent samples were collected every two days and analyzed for total suspended solids, organic constituents, and elemental concentration and content. Preliminary results indicate leaching of total suspended solids vary widely from each source, contributing 250 to 1000 mg of solids from a #1fallow container.

4. Impact Statements.  Please draft 2 or 3 impact statement summaries related to the NC-1186 objectives (listed below).  Statements should be quantitative when possible and be oriented towards the general public.  This is perhaps the most difficult yet most important part of the report.  Two examples are listed below.

Substrates were engineered using conventional components (i.e. bark, peat, coir) to reduce applied water while maintaining or increasing crop growth.

Soilless substrate amendments such as lime and micronutrients reduced effluent phosphorus and could potentially be a phosphorus best management practice.

Reduced phosphorus controlled release fertilizers were successful at producing *Ilex* *crenata* Thunb. ‘Helleri’ (holly) and *Hydrangea macrophylla*‘P11HM-11’ Bloomstruck™; however, each required varying amount of P to maximize growth demonstrating intra-taxa variability in P requirements.

1. Published Written Works.  Include scientific publications, trade magazine articles, books, posters, websites developed, and any other relevant printed works produced.  Please use the formatting in the examples below.

*Publications*

Fulcher, A., A.V. LeBude, J. S. Owen, Jr., S. A. White and R. C. Beeson. 2016. The next ten years: Strategic vision of water resources for nursery producers. HortTechnology 26:133-140.

Fields, J.S. and J.S. Owen, Jr. 2015. Utilizing the HYDRUS model as a tool for understanding soilless substrate water dynamics. Acta Hort. (in press, presented at ISHS Intl. Substrate and Compost Symposium)

*Popular articles*

Owen, J.S., Jr. 2015. The transparent container. Nursery Management 31(8):36-40.

Owen, J.S., Jr., A. LeBude, M. Chappell and T. Hoskins. 2016. Advanced irrigation management for container-grown ornamental crop production. Virginia Cooperative Extension Service Publication. (in press)

Shreckhise, J.H.\*, J.S. Owen, Jr., J.C. Brindley, A.X. Niemiera. 2015. Evaluation of phosphorus nutrient use efficiency in several woody ornamental nursery crops. Virginia Nursery Landscape Assoc. Nwsl. 84(3):48-51.

*Proceedings*

Mack, R., H. Scherer, J.S. Owen, Jr. and A.X. Niemiera. 2015. Teaching best management practices to secondary agriculture students. North Amer. Colleges and Teachers of Agr. J. 59(1): 81(abstr., poster)

Fields, J.S. and J.S. Owen, Jr. 2016. Comparing and contrasting moisture characteristic curves of coarse, highly porous soilless substrates measured by the evaporative or pressure extraction methods. Virginia Tech College of Agricultural and Life Science Graduate Research Symposium. Web publication, *available at*: <https://www.cses.vt.edu/news/NewsItems/abstract-symposium-2016c.pdf> (abstr., poster)

Fields, J.S.\*, J.S. Owen, Jr., H.L. Scoggins. 2015. Exploring the influence of particle size on plant water availability in pine bark substrates. Proc. Southern Nursery Assoc. Res. Conf. 60:19-27. (oral presentation)

Fields, J.S.\*, J.S. Owen, Jr., J.L. Heitman, and R.D. Stewart. 2015. Evaluating Conventional soilless substrates by measuring and modeling water dynamics. HortScience 50(9):S26. (abstr., oral presentation)

Mack, R., J.S. Owen, Jr., and A.X. Niemiera. 2016. Determining utilization and efficacy of best management practices for the Virginia nursery and greenhouse industries. Virginia Tech College of Agricultural and Life Science Graduate Research Symposium. Web publication, *available at*: <https://www.cses.vt.edu/news/NewsItems/abstract-symposium-2016c.pdf> (abstr., poster)

McPherson, S.\*, J.S. Owen, Jr., J. Brindley, and J.S. Fields\*. 2015. When to fertigate: The influence of substrate moisture content on nutrient retention in containerized crop production. Proc. Southern Nursery Assoc. Res. Conf. 60:28-33. (oral presentation)

Shreckhise, J.H., J.S. Owen, Jr., and A.X. Niemiera. 2016. Growth response of three containerized plant taxa to low pore water phosphorus concentrations. Virginia Tech College of Agricultural and Life Science Graduate Research Symposium. Web publication, *available at*: <https://www.cses.vt.edu/news/NewsItems/abstract-symposium-2016c.pdf> (abstr.)

Shreckhise, J.H.\*, J.S. Owen, Jr., J.C. Brindley, A.X. Niemiera. 2015. Evaluating growth response of three containerized ornamental taxa to varying low pore-water concentrations of phosphorus. HortScience 50(9):S24-S25. (abstr., oral presentation)

White, S.A., J. S. Owen, Jr., B. Behe, B. Cregg, R.T. Fernandez, P. Fisher, C.R. Hall, D. Haver, D. Hitchcock, D. Ingram, S. Kumar, A. Lamm, J.D. Lea-Cox, L. Oki, J. Parke, A. Ristvey, D. Sample, L. Warner, P.C. Wilson. 2015. Clean WateR3 - Reduce, Remediate, Recycle: A Specialty Crops Research Initiative Project Focused on Management of Recycled Water for Ornamental Crop Production. HortScience 50(9):S31-S32. (abstr., oral co-presentation)

White, S.A., J. S. Owen, Jr., J. Majsztrik, R.T. Fernandez, P. Fisher, C.R. Hall, D. Hitchcock, D. Ingram, A. Lamm, J.D. Lea-Cox, J. Parke,. 2015. Clean WateR3 - Reduce, Remediate, Recycle: The genesis of a SCRI-CAP project. HortScience 50(9):S382. (abstr., poster)

1. Scientific and Outreach Oral Presentations.  Include workshops, colloquia, conferences, symposia, and industry meetings in which you presented and/or organized.  See below for formatting.

Owen, J.S., Jr. 2016. Water movement, mineral nutrient transport and their subsequent fate in soilless substrates. Clemson University Agricultural and Environmental Science Department Seminar, Clemson, SC.

Owen, J.S., Jr. 2015. Piecing the puzzle to understand resource fate in containerized specialty crop production: North Carolina State University Horticultural Science Seminar, Raleigh, NC.

1. Fund leveraging, specifically, collaborative grants between stations and members.

Owen, J.S., Jr., J. Shreckhise\*, and A.X. Niemiera. 2016. Phosphorus fate in container substrate. Virginia Nurserymen's Association Horticulture Research Foundation Inc. - $4,500.

Owen, J.S., Jr., R. Mack\*, A. Niemiera, and J. Latimer. 2015. Determining utilization and efficacy of best management practices for the Virginia nursery industry. Virginia Agricultural Council - $19,607.

Owen, J.S., Jr., A.X. Niemiera, R. Mack\*, and J. Latimer. 2015. Determining utilization and efficacy of best management practices for the Virginia nursery industry. Virginia Nurserymen's Association Horticulture Research Foundation Inc. - $7,825.

Owen, J.S., Jr., J.S. Fields\*, and J. Brindley. 2015. Engineering soilless substrates for improved water use efficiency and available water in containerized production. Virginia Nurserymen's Association Horticulture Research Foundation Inc. - $7,850.

8. Other relevant accomplishments and activities.

**Examples of Content for NC-1186 Station Reports**(Courtesy of Dr. Marc van Iersel - for our consideration, from another Multi-State Research Project - so please adapt to content pertinent to NC-1186)

Impact Nugget Examples:

Michigan State University has developed and distributed software to bedding plant growers that can potentially reduce their energy consumption by up to 30% by optimizing temperature and light.

University of Georgia has developed recommendations for using automated irrigation controllers that may reduce water use by 40% to 70%.

Examples of Accomplishments:

Purdue University grew five day-neutral or everbearing cultivars of strawberry plants with three different day/night temperature regimes in growth chambers or in a greenhouse.  Chamber plants were hand pollinated, while greenhouse plants were pollinated by hand or by vibrating wand.  The coolest temperatures (18 C days/10 C nights) produced more berries with better flavor.  No effect of pollination method was found, possibly due to heavier insect loads on plants pollinated more intensively.

Rutgers University quantified the impact of a manually operated energy curtain on the recorded inside soil and air temperatures and daily light integrals during early season high tunnel production of tomato.  Data collected from late March through mid-May for two New Jersey locations and two growing seasons revealed that the use of an energy curtain inside a high tunnel increased the inside nighttime air temperature on average by 1.4 °C (or 13%) compared to a tunnel without a curtain.  The use of an energy curtain inside a high tunnel increased the inside nighttime soil temperature on average by 0.5°C (or 4%) compared to a tunnel without a curtain but also decreased the accumulated inside light by approximately 5%.

Examples of Impact Statements:

Lighting and temperature studies at Michigan State University have quantified the effects of growing bedding plants under different greenhouse conditions.  As a result, flowering time and plant quality can be more accurately predicted by commercial greenhouse growers to meet their scheduled market dates.  This information can be incorporated with energy consumption models to predict the amount of energy consumed when crops are grown at different temperatures. Growers who optimize temperature and light can potentially reduce their energy consumption by up to 30%.

The availability of water for agricultural use is under pressure, and more efficient use of the available water is increasingly important. Research at the University of Georgia has shown that efficiency can be increased by applying water based on the actual needs of the crops. This can be done using automated irrigation controllers that maintain substrate water content at a grower-determined level. Research indicates that a substrate water content of 15% (v/v) is adequate for most crops. Using automated controllers to maintain this substrate water level may reduce water use by 40% to 70%.

Format for Published Works (arrange alphabetically):

*Books*

Hartmann, H.T., D.E. Kester, F.T. Davies, Jr. and R.L. Geneve. 2002. Hartmann and Kester’s Plant Propagation: Principles and Practices. Seventh Edition. Prentice-Hall, Inc., Englewood Cliffs, NJ.

*Book Chapters*

Gent, M.P.N. and R.J. McAvoy. 2000. Plant growth retardants in ornamental horticulture. In: Plant Growth Regulators in Agriculture and Horticulture: Their Role and Commercial Uses. A.S. Basra, (ed.) Good Products Press, NY. pp. 89-146.

*Refereed Journal Articles*

Shimizu, H., E.S. Runkle, and R.D. Heins. 2004. A steady-state model for prediction of poinsettia plant shoot-tip temperature. J. Amer. Soc. Hort. Sci. 129:303-312.

Symposium Proceedings

Fleisher, D.H., H. Baruh and K.C. Ting. 2001. Model-based predictive control for biomass production in advanced life support.  Proceedings of the 2nd IFAC-CIGR Workshop on Intelligent Control for Agricultural Applications, Bali, Indonesia. August 22-24. pp. 198-203.

*Poster Presentations*

Padhye, S., E.S. Runkle, and A.C. Cameron. 2005. Quantifying the vernalization response of Dianthus gratianopolitanus ‘Bath’s Pink’. HortScience 40:1013 (poster presentation).

*Popular Articles*

Albright, L.D., R.S. Gates, K.G. Arvanitis and A. E. Drysdale. 2001. Control strategies for plant shoot and root environments on Earth and in space. IEEE Control Systems Magazine: Agriculture and the Environment 21(5):28-47.

Fausey, B., E. Runkle, A.C. Cameron, R.D. Heins, W.H. Carlson. 2001. Herbaceous perennials: Heuchera. Greenhouse Grower 19(6):50-62.

*Other Creative Works*

Donnell, M. and T.H. Short. 2001. An interactive economic analysis and business plan for hydroponic lettuce production. Program was developed on an OSUE hydroponics homepage site.

Prenger J. and P.P. Ling. 2001. Greenhouse condensation control – understanding and using vapor pressure deficit (VPD). Ohio State University Extension Fact Sheet, AEX-804-2001. The Ohio State University, Columbus, OH 43210.

*Format for Scientific and Outreach Presentations (arrange alphabetically)*

Lopez, R.G. and E.S. Runkle. 2006. Quantifying the thermal tolerance of non-rooted Impatiens hawkeri cuttings and their subsequent performance. XXVII International Horticultural Congress, Seoul, Korea.

Runkle, E.S. 2005. Controlling plant growth and development with environment. International Plug & Cutting Conference, Dearborn, MI.

# NC 1186 Objectives

**NC-1186 Project areas**:

1) Source water management and quality,

2) Irrigation management,

3) Runoff water management and quality

4) Substrate and nutrition management, and

5) Pathogens and crop health management.

**NC-1186 Outcomes/Impacts**:

1) Assist the ornamental nursery industry in efficiently and successfully utilizing available primary and secondary water sources.

2) Mitigate nutrient and pesticide runoff into the environment from nursery production facilities.

3) Better utilization of limited water resources through increased use of secondary water sources instead of primary potable water sources, will

4) increase the available of potable water for other consumer uses.

**NC-1186 Objectives:**

* Develop an effective multistate group to identify knowledge gaps in water management and quality for ornamental production.
* Organize trans-disciplinary teams to address these gaps, and leverage existing national programs to maximize impact.
* Develop effective outreach programs which
  + change behavior and implement best management practices
  + increase resource use-efficiency and minimize environmental impacts of practices
  + increase production efficiency and profitability and d) allow regulatory agency and public sectors to access baseline information which can be used for policy and other decision-making.
* Disseminate research results to the academic community through traditional means (e.g. peer reviewed journals, and extension programs) and also more novel web-based methods (knowledge centers, eXtension and social networks)
* Integrate projects, programs and results according to the following specific project objectives.
* Gather information regarding the quantity and quality of primary water sources currently available in various regions of the United States.
* Determine what water quality parameters limit ornamental plant production and how secondary water sources differ throughout different regions of the U.S.
* Determine national research priorities regarding water quantity and quality of primary and secondary water sources.
* Obtain funding and conduct research to address the physical and chemical limitations of primary and secondary water sources.
* Gather comprehensive runoff-related information from the following sectors: a) growers, b) regulatory agencies, c) university research and extension, and d) public.
* Assess the relative impacts of nursery runoff on surface and groundwater resources through detailed on-site investigations
* Determine priority areas for improving runoff management and obtain funding to address these specific research and extension needs.
* Determine the water requirements of a variety of ornamental plants and how these water requirements are affected by plant size and environmental conditions.
* Compare different irrigation methods (overhead, spray stakes, drip irrigation, subirrigation) to determine how they affect total water use, plant growth and quality, and runoff water quality.
* Quantify reductions in water use, leaching, and runoff that result from more efficient irrigation techniques.
* Develop new methods to provide growers with real time information regarding the water requirements of their crops, including crop water use models and sensor networks that can be easily deployed in greenhouses and nurseries.
* Determine the economic impact of more efficient irrigation practices (cost/benefit analyses).
* Gather information on what has been published in the area of substrate media and on commonly used components and formulated media per state per region.
* Gather information on available recycled organic components per region that have potential use for cost effective media mixes.
* Gather information on production quantity and cost of the components used across the regions.
* Assess physical and chemical properties of formulated media mixes and their impact on plant health and nutrient levels in leachates for a variety of plants considered of importance to these states/regions.
* Develop BMP guidelines for substrate/amendment management practices based on the above objectives.
* Characterize pests in irrigation reservoirs and other water sources.
* Elucidate the aquatic ecology of water molds and develop biologically-based water decontamination technology.
* Expand evaluation of and improve existing water treatments.
* Develop best management practices to improve crop health and reduce the amount of pests returning to runoff irrigation reservoirs