United States Department of Agriculture
National Institute of Food and Agriculture

SCRI - CLEAN WATER³
REDUCE, REMEDIATE, RECYCLE

Clean WateR³ - Reduce, Remediate, Recycle – Enhancing Alternative Water Resources Availability and Use to Increase Profitability in Specialty Crops

Year 1 (2014-15) Progress Report Summary

Overview
A national team of scientists working to encourage use of alternative water resources by the nation's billion-dollar nursery and floriculture industry has been awarded funds for the first year of an $8.7 million, five year US Department of Agriculture – National Institute of Food and Agriculture –Specialty Crop Research Initiative competitive grant. The team will develop and apply systems-based solutions to assist grower decision making by providing science-based information to increase use of recycled water. This award from the NIFA's Specialty Crop Research Initiative will be managed by Project Director Sarah White of Clemson University. She will lead a group of 21 scientists from 9 U.S. institutions. The Clean WateR³ team will assist the grower decision-making process by providing science-based information on nutrient, pathogen, and pesticide fate in recycled water both before and after treatment, average cost and return-on investment of technologies examined, and model-derived, site specific recommendations for water management. The trans-disciplinary Clean WateR³ team will develop these systems-based solutions by integrating sociological, economic, modeling, and biological data into a user-friendly decision-support system intended to inform and direct our stakeholders' water management decision-making process.

Target Audience:
Target audiences include greenhouse and nursery producers, irrigation mangers, water treatment mangers, and allied service fields. As well as consumers, Extension agents and specialists, and graduate and undergraduate students.

Accomplishments

Researchers
Dr. Sarah White (project Director) manages 21 scientists from 9 institutions. Eleven undergraduate and 9 graduate students were hired. Communication was achieved through conference calls and meetings with researchers and our advisory board.

Educational resources
- Developed and published on the project website cleanwater3.org
- Water Management Workshop was held in Michigan
  - Twenty growers were interviewed to determine water management barriers and enablers.

How have results been disseminated?
- Presentations at trade-shows
- Educational seminars
- Workshops
- Partnership with the Water Education Alliance for Horticulture – giving the CleanWater3 team access to existing subscribers.
- The team newsletter was sent to subscribers to the CleanWater3.org website
- Website traffic since Sept. 2014 was 2,107
  - New visitors, 80%
  - International visitors, 30%
- Water Education Alliance, YouTube channel had over 8,070 views
  - International views, 67%

Top four videos:
  - Introduction to *Phytophthora*, 18%
  - ORP-Oxidation, 17%
  - Water pH and alkalinity, 14%
  - Ecological: Constructed wetlands, 9%

Research
Laboratory:
- Established three central laboratories for nutrient, pathogen, and pesticide analysis
- Design and construction in progress for two experimental research nurseries

Water treatment:
- Treatment evaluations began for rapid filters, granular activated carbon filters, floating-treatment wetlands, and filter socks for select contaminants.

Technology:
- Installed sensor networks at three research sites and two grower facilities

Economic management:
- Established protocols for cost estimation in economic models
- Developed Life Cycle Inventory at a collaborating nursery
  - Identify water footprints (WFs) and carbon footprints (CFs)

Models:

- Evaluated a container production model in STELLA to gain foundational data for the model.
    - Mapped water flow paths at seven production systems
    - Sampled water at critical control points

Training & professional development

- Workshop held in Michigan, July 2015 "*It's All About Water...Water Management Conference.*"
    - Addressing water quality and management issues

List of publications

1. Atland, J.E., Morris, L., Boldt, J., , Fisher, P., Rosa Raudales. (2015). Monitoring Paclobutrazol in Irrigation Water. *HortTechnology 25*: 769-773.
2. Fisher, P. (2016, April). Unclog drip emitters in your greenhouse, *Greenhouse Grower*, pp. 42-44.
3. Fisher, P. (2016, May). Pinpoint toxicity in your pond water. *Greenhouse Grower*, pp. 46, 48, 50.
4. Fisher, P., Grant, G., Zayas, V., Raudales, R., Atland, J., Boldt, J. (2016, May/June). New Technology Development in Water Treatment. *Greenhouse Grower Technology*, pp. 20, 22.
5. Lynch, J., Fox, L.J., Owen J.S. Jr., Sample, D.J. (2015). Evaluation of commercial floating treatment wetland technologies for nutrient remediation of stormwater. *Ecological Engineering 75*: 61-69.
6. Meador, D.P., Fisher, P.R., Guy, C.L., Harmon, P.F., Peres, N.A., Teplitski, M. (2016). Use of dehydrated agar to estimate microbial water quality for horticulture irrigation. *Journal of Environmental Quality*, doi:10.2134/jeq2015.03.0130.
7. Park, D.M., White, S.A., Menchyk, N. (2014, December). Assessing irrigation water quality for pH, salts, & alkalinity. *Journal of Extensions 52*.
8. Raudales, R.E., Irani, T.A., Hall, C.R., Fisher, P.R. (2014) Modified Delphi survey on key attributes for selection of water-treatment technologies for horticulture irrigation. *HortTechnology 24*: 355-368.
9. Raudales, R.E., Parke J.L., Guy, C.L., Fisher, P.R. (2014). Control of waterborne microbes in irrigation: A review. *Agricultural Water Management 143*: 9-28.

Objective 1: Develop and publish an online decision support system to help growers decide how to recycle water

1.1A. Understanding and overcoming barriers to change

Preliminary data of grower interviews indicate primary barriers to adopting water conservation technology are:

1. Financial costs and implementation of new technology
2. Mentality that "change is not needed"
3. Mentality that "we will not run out of water"

The primary enablers for water conservation are:

1. Need to "do the right thing"
2. Water critical for business
3. Internal need to "set an example"
4. External motivators–receiving recognition and awards innovation

1.1B. Consumer preference for plants produced using alternative water sources

- Regulated (IRB) approval 45CFR 46.118 was received

1.2. Economic analysis of water management strategies

- Key data collection points and data management protocols were established for each phase of economic analysis.
- An economic engineering approach was developed to estimate initial capital investment, production costs, and product prices for baseline and alternative nursery and greenhouse irrigation models.
- Models with representative characteristics of nursery and greenhouse operations included irrigation equipment and protocols for the crops being studied.
    - Preliminary results of a model container nursery on the Eastern U.S. coast for CF and WF of each protocol was presented at the 2015 annual project meeting.
        - Input products and non-irrigation processes contribute little to the WF or the CF of water management of this product.
        - Plastics appear to be an important contributor to the CF

1.3: Development of a generalized model framework to characterize container production systems

- A HYDRUS Model was used to simulate water and solute movement through #1 fallow containers containing soilless substrate.
- A container nursery STELLA® model is being evaluated to identify information gaps when compared to conventional nurseries. The data will drive monitoring and data collection at cooperating nursery sites. A web-based method for building and running the core STELLA model is being designed.
- Completed the site design for two experimental nursery facilities (*Chesapeake Bay Site* & *Great Lakes Site*) by three undergraduate students studying engineering at Virginia Tech.
    - The design won the Senior Design Excellence award
- Collaborating nursery sites were visited, operational water flow-path was mapped, and monitoring points selected. Monitoring for the presence of inorganic nutrients and *Phytophthora* sp. was conducted every two weeks (Feb. - April, 2015), and is currently being analyzed. Monitoring of nurseries in SC, CA, and MI was initiated in summer 2015.

Objective 2: Reduce contaminant loading

- Basic sensor networks were installed at three research sites (VA, MI, OR) and at two commercial operations in MD that recycle irrigation water.
- Commercial demonstration sites extend our pathogen management research from controlled conditions in the UMD greenhouse to commercial settings. Data from a commercial nursery study on effects of pathogen irrigation treatments on plant growth, pathogen infection, and disease development are being collected.
- Hazard analysis for pathogen contamination to identify Critical Control Points of a collaborating nursery in Oregon was conducted in late June 2015.
- Baseline data on pathogen loads in irrigation runoff is being collected every two weeks in varied seasons, depending on geographic location. The data support before and after comparison of treatment technology remediation efficacy for contaminants of concern.

Objective 3: TT evaluation to remediate contaminants

- The efficacy of rapid filters (e.g. sand/glass, paper/media, screen and reverse osmosis systems) before and after filtration was analyzed at 11 greenhouse and nursery operations with a total of 37 sampling sites.
    - We have worked with three growers (CA, FL, IN) and developed case studies based on rapid water filtration and treatment issues.
    - Onsite data was collected in NJ greenhouse on the effects of ozone treatment on paclobutrazol changes in irrigation water.
- Completed planning and design for the two, regionally-based (Piedmont SC and Coastal Plain VA) floating treatment wetland projects, experiments initiated, and data collection is ongoing.
- Deployed Filter Treatment Socks (Filtrexx® envirosoxx®) at two VA container nurseries in 2014.
- Filter socks retained 541 kg m^{-3} of sediment when water passed through the mesh and compost media.
- In storm events or high flow rates the bypass treatment technology retained 194 kg m^{-3} - a 64% reduction in efficacy.

Objective 4: Communicate project outputs to stakeholders

- CleanWateR3.org (watereducationalliance.org) website is compatible for use on mobile devices.
- 13 best management practice videos were added to the website
- FAQ component on home page was added for stakeholder interaction
- The first newsletter was sent out in May 2015, introducing the Clean WateR^3 grant
    - Included articles by SC on water remediation and FL on water treatment
- A bilingual poster (English and Spanish) on management of *Phytophthora* diseases and the use of clean irrigation water in nurseries was distributed to nurseries in Oregon.