Water Management

Anthony LeBude

Section Editor

Monitoring Container Water Loss and Gain with a Data-Logging Scale

Jeff Million and Tom Yeager
Dept. of Environmental Horticulture, Univ. of Florida, IFAS, Gainesville, FL

jmillion@ufl.edu

Index words evapotranspiration, irrigation, monitoring tool

Significance to the Industry A simple weighing system is described that provides researchers and container nursery producers with a tool for measuring and monitoring plant water loss and irrigation water gain over time. This information provides an objective evaluation of irrigation effectiveness and can be used to adjust irrigation schedules to maintain adequate container moisture levels without excessive leaching.

Nature of Work The ability to weigh container-grown plants provides a unique opportunity to measure and monitor water loss and water gain during production. In this paper we describe an off-the-shelf scale and data logger that can be left in the field to continuously record container weights. With a short data-logging interval (e.g., 5 minutes), very detailed information can be gleaned from collected weight data. We will provide examples of how this data can be used to measure daily water loss as well as provide examples of how the data can be used to monitor irrigation effectiveness. Our intent is to provide researchers and producers with another tool to objectively evaluate water relations during plant production in containers.

Materials and Methods For our examples, we used a 15-kg bench scale for weighing trade 1-gallon and 3-gallon containers and a 60-kg bench scale for weighing trade 7-gallon and 15-gallon containers. The 15-kg scale (HV-15KG-NC; A & D Engineering, San Jose, CA) had a 10"x10" pan and the 60-kg scale (HV-60KG-NC; A & D Engineering, San Jose, CA) had a 13"x17" pan. These scales typically are ordered with a display mounted on a column attached to the pan. We chose the "no column" option so that the display could be housed in a water-proof tote. The wire connecting the load cell under the pan to the display was 6 feet which allowed some flexibility in placing the tote in the field. For logging weight data, we used a USB-logger (AD-1688; A & D Engineering, San Jose, CA) which could record weights at intervals ranging from 1 second to 1 hour. While the display could be powered with 120VAC, six D batteries provided 10-14 days of data recording in the field.

When conducting irrigation trials at nurseries, we place at least one scale in the irrigation zone to monitor water relations. From these trials, we selected a few examples of weight data to provide a glimpse of how the recorded weight data can be useful when monitoring irrigation. For discussion, we will show how 1) container evapotranspiration (ET) can be measured, 2) trends in container weights can reveal under-watering and over-watering, 3) excessive irrigation can be revealed, and 4) weights following rainfall can be used to establish a baseline for container capacity.

Discussion *Measuring container* *ET* Determining how much water a container loses during the day can be very useful. The weight of water loss can be converted to an equivalent depth of water when comparing water loss to irrigation amounts being applied. As an example, the measurement of water loss was recorded for a sprinkler-irrigated 'Burfordii' Chinese holly crop that was irrigated pre-dawn (Fig. 1). A stable wet weight value was established prior to sunrise. This is indicated by the pre-dawn plateau in Fig. 1. A dry weight measurement is obtained once ET water loss ceases (around sunset at earliest). The difference between dry weight value (kg) and the wet weight value (kg) is the ET water loss in kg/container. For the Fig. 1 example, the end of the day dry weight value of 6.55 kg is subtracted from the wet weight value of 7.25 kg to arrive at a container ET loss of 0.70 kg. Because the density of water is 1.0 g/cm3, 0.70 kg is equal to a volume of 700 cm^3. To calculate an equivalent depth of water, we need to divide the volume of water (cm^3) by the top surface area of the container (cm^2). Using the area=π × $radius^2$ formula, a container with a diameter of 10 inch (25.4 cm) would have an area of 507 cm^2. Given the surface area, 700 cm^3 of water would be equivalent to a depth of 1.38 cm or 0.54 inch. This latter value can be compared to the irrigation rate (i.e., inch/hour) or an amount of rain (inch) for making irrigation decisions, with the qualification that the plant canopy can affect the amount of irrigation and/or rain that is intercepted by the container (1).

Irrigation trends Another use for recording container weights with a data-logging scale is to evaluate trends in container weights over time. This can provide valuable information regarding irrigation effectiveness in maintaining container substrate moisture levels. For example, container weights recorded over a 10-day period for a sprinkler-irrigated 'Burfordii' Holly plant in trade 3-gal (10-inch) containers are given in Fig. 2. A downward trend in container weights can be seen by comparing the peak wet weights for each day. The second peak was 0.25 kg less than the first and the third peak 0.375 kg less than the second. Rain during the fourth day brought the container weights back to peak weight after Day 1's irrigation. Similar downward trends for the rest of the 10-day period resulted in a final container peak weight of 5.65 kg which was 1.6 kg less than the peak after Day 1's irrigation. For a 10-inch container with a substrate fill volume of 7.4 L, this 1.6 L volume of water represents 22% of the container substrate volume. Because typical substrates have only 25-30% plant available water, a deficit of 22% indicates that water stress will likely occur soon unless significant rain occurs.

An example of a positive trend in container weights is given in Fig. 3 for a Leyland Cypress tree in a trade 15-gal (17-inch) container irrigated three times a day. Peak weights following irrigation increased from Day 1 to Day 2 then remained uniform for the next four days indicating that irrigation is effectively resupplying water loss. Because drainage and water loss are occurring at the same time during the day when irrigation is scheduled, it is difficult to determine that the irrigation amount is efficient (not excessive), just that it is sufficient.

Excessive irrigation Observing the peak in wet weights following irrigation can often reveal if irrigation is excessive. This is particularly true for sprinkler-irrigated crops with a short data-logging interval such as given in Fig. 4 for a ‘Parsonii’ Juniper plant in a trade 3-gallon (10-inch) container. This crop was irrigated at 7:30am and weight data recorded every 5 minutes. The steep drop in weights immediately following the peak weight of irrigation on March 14 is evidence for excessive irrigation. Although not definitive, approximately 0.2 kg of excess water was applied. If the total applied was 0.7 kg, this indicates a leaching fraction of approximately 30%. For the following day, the irrigation amount resulted in minimal, if any, excess. Similar lack of excess irrigation would be indicated by the flat peaks in Fig. 1 and Fig. 2 where irrigation amount was shown to be insufficient.

Baseline wet weight Weight measurements following significant rain can provide a baseline value for establishing a container capacity of a given crop. For example, when monitoring container weights of a micro-irrigated Podocarpus plant in a trade 7-gal (14 inch) container (Fig. 5), the stable peaks following irrigation during the first six days suggest irrigation is bringing the container substrate up to container capacity. However, following rains during the next two days it can be seen that the container could hold 0.5-1 kg more water. This post rain baseline weight would likely be a better indicator of container capacity for determining if water deficits are approaching the lower limit of available water as previously discussed in the ‘Irrigation trends’ section.

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Tradenames and companies are provided for information purposes and do not constitute an endorsement. We thank Cherrylake and the Southwest Florida Management District (B404) for financial assistance.

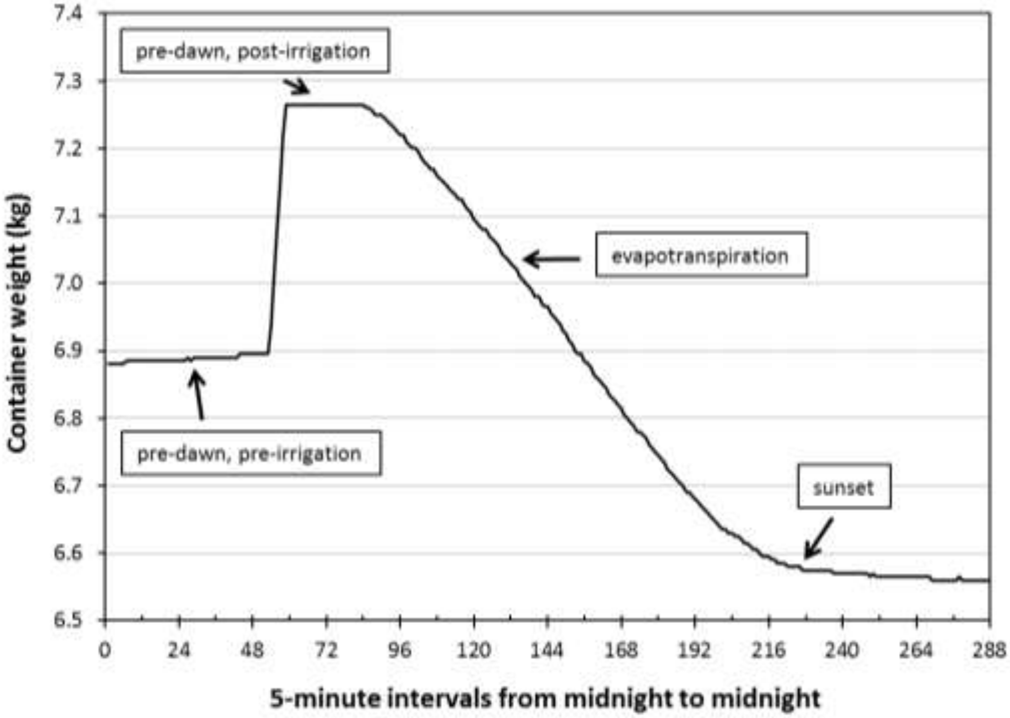

Fig. 1. Weight (kg) of one trade 3-gallon (10-inch) 'Burfordii' holly plant recorded every 5 minutes on 13 April 2018 at Hibernia Nursery, Webster, FL.

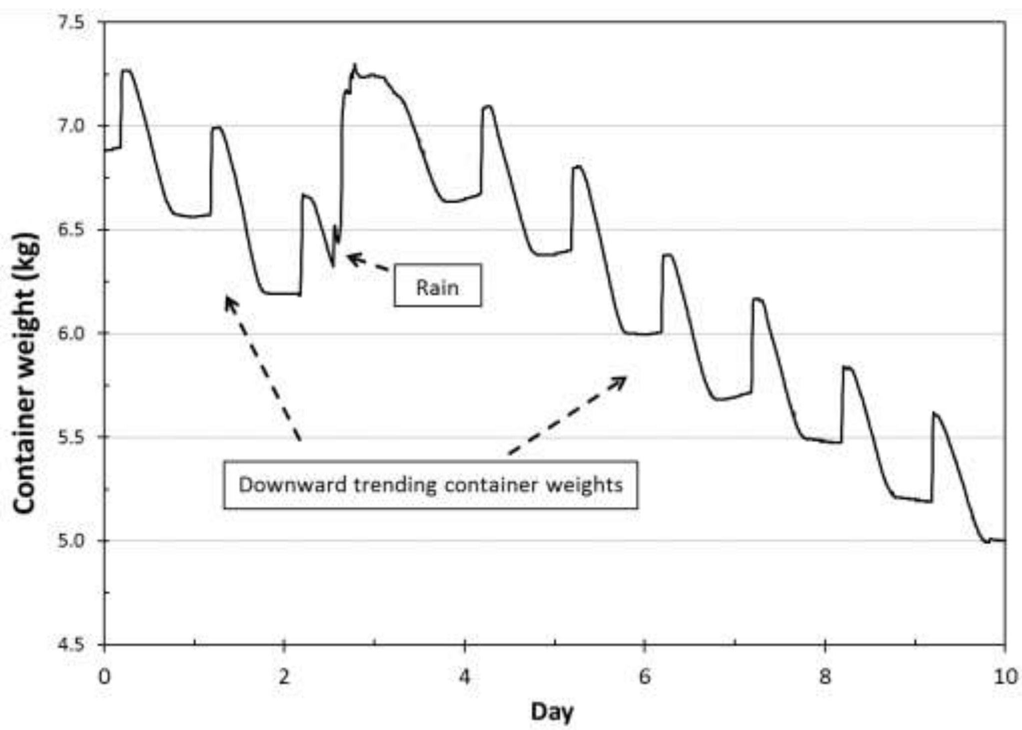

Fig. 2. Weight (kg) of one trade 3-gallon (10-inch) 'Burfordii' holly plant recorded every 5 minutes for 13-22 April 2018 at Hibernia Nursery, Webster, FL.

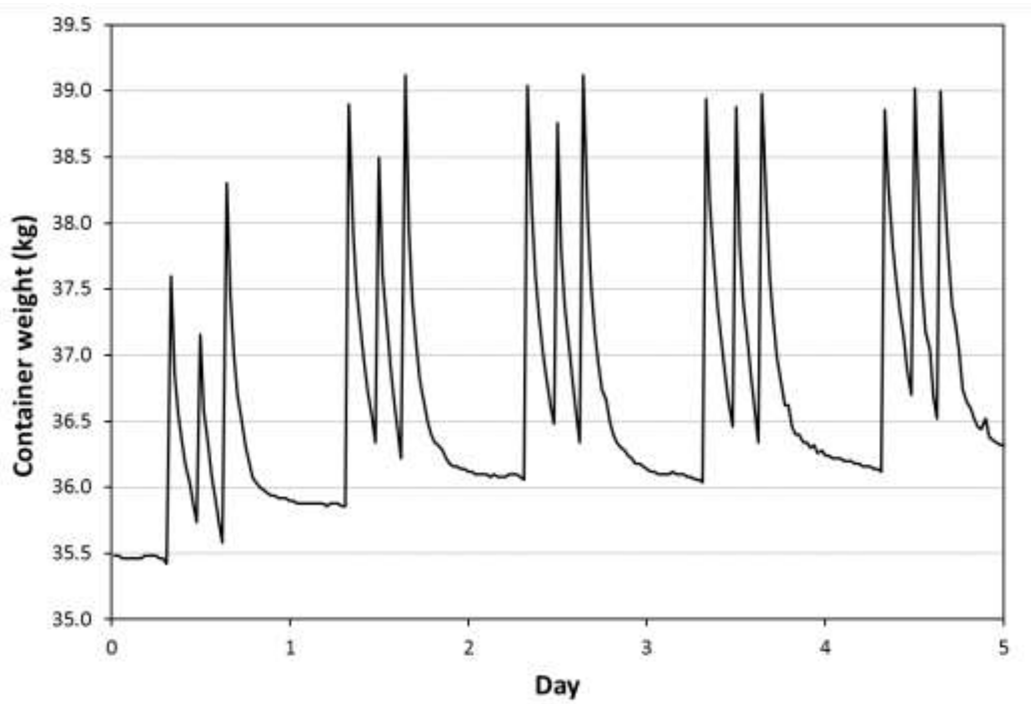

Fig. 3. Weight (kg) of one trade 15-gallon (17-inch) Leyland Cypress tree recorded every 30 min for 26-30 April 2018 at Hibernia Nursery, Webster, FL. Spray-stake irrigation was scheduled at 8:30am, 12pm, and 3:30pm.

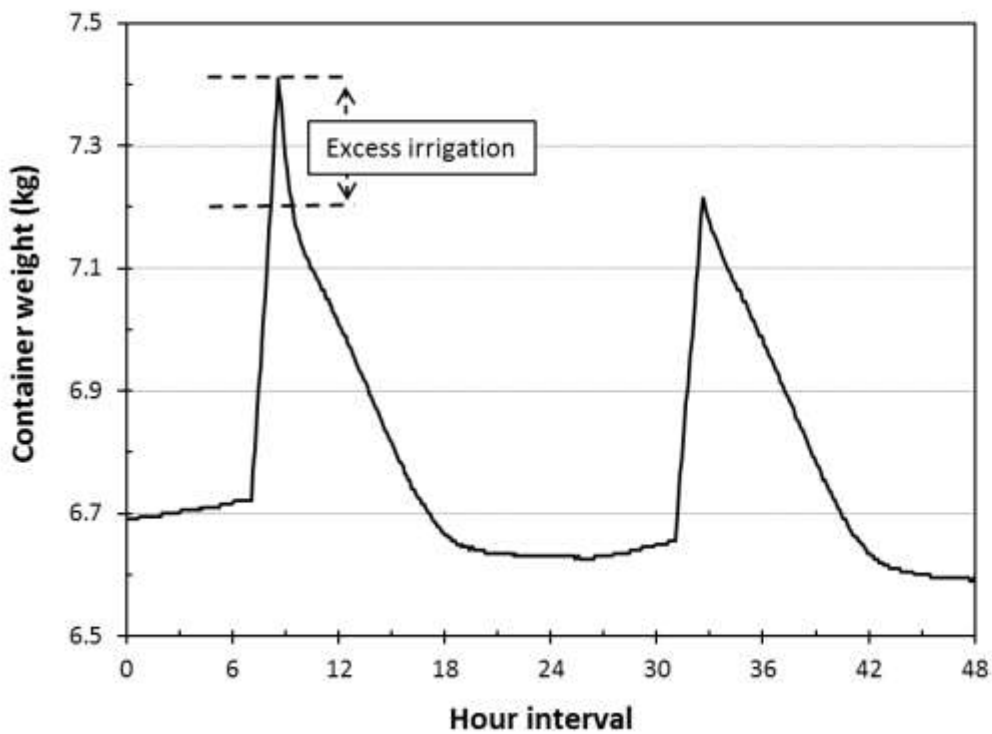

Fig. 4. Weight (kg) of one trade 3-gallon (10-inch) 'Parsonii' Juniper plant recorded every 5 minutes for 14-15 March 2018 at Cherrylake, Groveland, FL.

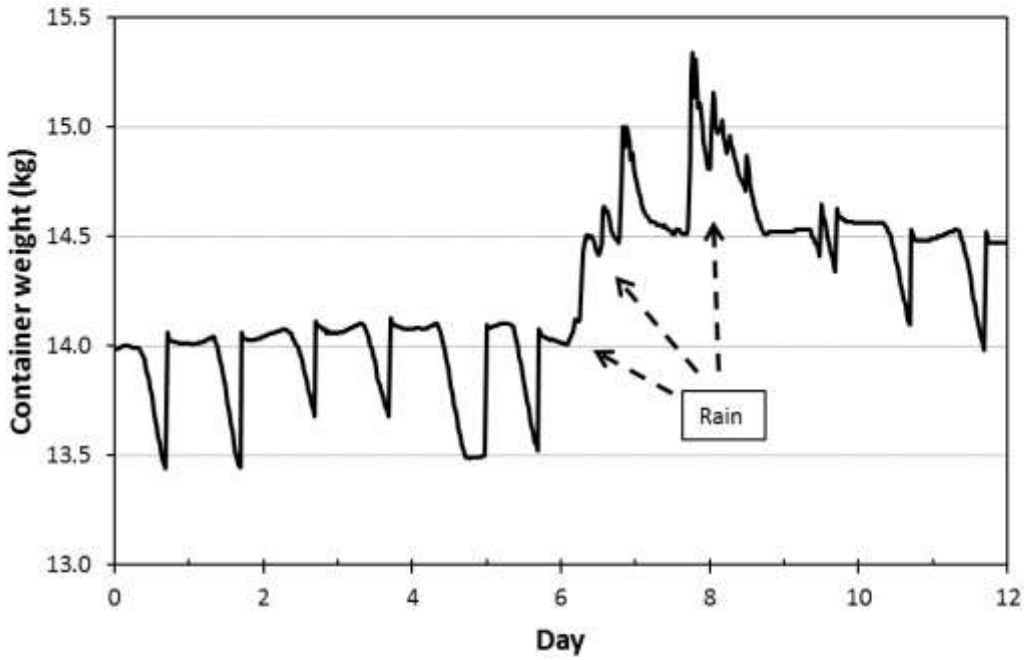

Fig. 5. Container weight (kg) of one trade 7-gallon (14-inch) Podocarpus plant recorded every 30 minutes for 1-12 December 2017 at the University of Florida, Gainesville.

Phosphorus Removal from Nursery Runoff Using Pilot Scale Filters

John C. Majsztrik[1], William H.J. Strosnider[2], Megan E. Chase[3],
Lauren M. Garcia Chance[3], and Sarah A. White[1]

[1] Department of Plant and Environmental Sciences, Clemson University
Clemson, SC 29634-0310
[2] Environmental Engineering Program, Saint Francis University, Loretto, PA 15940
[3]Environmental Toxicology Graduate Program, Clemson University
Pendleton, SC 29670

swhite4@clemson.edu

Index Words Phosphorus capture, eutrophication, filtration

Significance to the Industry Irrigation runoff from nursery and greenhouse operations often contains phosphorus (P) that can be either reused if the water is recycled, or released offsite if the water is not reused. In both cases, excess P can contribute to degradation of water quality, as algal communities and aquatic weed growth increases when excess P is available. To better manage water quality and treatment requirements both on- and off-site, it was necessary to develop a filtration system that efficiently captures P, preventing its continued movement in water conveyance structures. The pilot-scale filter we developed used passive water flow through a mixed iron oxide (i.e., FeOOH, Fe_2O_3, $Fe(OH)_3$) substrate to effectively remove P from recycled irrigation water. This technology shows promise in this application. Future work with these filters will evaluate pressurized flow through the system and potential for reusing P-saturated iron oxide as a substrate amendment and supplemental P source.

Nature of Work The availability of phosphorus (P) typically limits growth of plants grown in both soil or water. When excess P becomes available in freshwater systems, algal blooms and increased growth of aquatic weeds often follow, potentially contributing to both water management problems and degraded water quality. Specialty crops operations (e.g., nursery and greenhouse) often release excess P in their irrigation runoff. Our goal was to develop and test a pilot-scale filter designed to remove P from irrigation runoff. We evaluated the P removal efficacy of iron oxide established within a low-maintenance, gravity-flow filter and monitored concentrations of P in water both pre- and post-filtration to document filtration performance.

The iron oxide substrate evaluated is a waste product harvested from treatment of abandoned mine drainage and has a P sorption rate of 8 – 11 g P / kg of iron oxide (1). The pilot-scale filtration system was set up on-site at a Piedmont SC nursery in December 2017 (Figure 1). Water from one of the operation's ponds was pumped into the pilot scale filter system beginning January 2018. Before the water entered the filter system, it was pre-filtered through two layers of 2 cm coarse polyester aquarium filter followed by two layers of 2.5 cm dual density (course then fine) polyester aquarium filter (both from Aquatic Experts, Greensboro, NC) in a 19L cylindrical container to remove particulates from the water that could have clogged the substrate. After the pre-filter, inflow was split to flow into three filter units at 1.5 liters per minute (similar flow rate into each unit). The filter units were 100L, fitted with three baffles to help ensure complete saturation of the substrate and to prevent short-circuiting, and filled with approximately 40L of iron oxide substrate. The iron oxide substrate was not sieved prior to use and particle sizes ranged from less than 1 mm to 4 cm; thus, less-uniform particles sizes were present and could have influenced P removal efficacy. Every 3 hours, water was sampled as follows: one sample was collected post filtration but pre-iron oxide and three samples were collected post-iron oxide filtration, one from each unit using ISCO autosamplers (ISCO Teledyne, Lincoln, NE). The filters were run for 12 hours a day, with each day representing five pooled samples. The experiment lasted 8-weeks, until the substrate became clogged and water flow was no longer reliable.

Phosphorus removal efficacy as aided by the iron oxide filters averaged 50.6%. With P concentrations in influent averaging 0.101 mg/L P and P concentrations in effluent from the iron oxide filters averaging 0.041 mg/L P. Though consistency in removal was variable over the 8-weeks, this pilot-filtration system shows promise. We will further evaluate iron oxide substrate utility in these filtration systems after it has been sieved to exclude fine particles, to better ensure the capacity of unrestricted water flow through the system. If the clogging issue can be managed by pre-sieving the substrate, the utility of these systems may be such that widespread adoption for P management may be sensible. Such adoption could allow producers to increase sustainability by utilizing inexpensive waste products of another industry to mitigate production runoff challenges concerning environmental stewardship.

Acknowledgements
This material is based upon work that is partially supported by the SC Water Resources Center and by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2014-51181-22372. Special thanks to all Clean WateR^3 researchers, advisory board members, students, and technicians.

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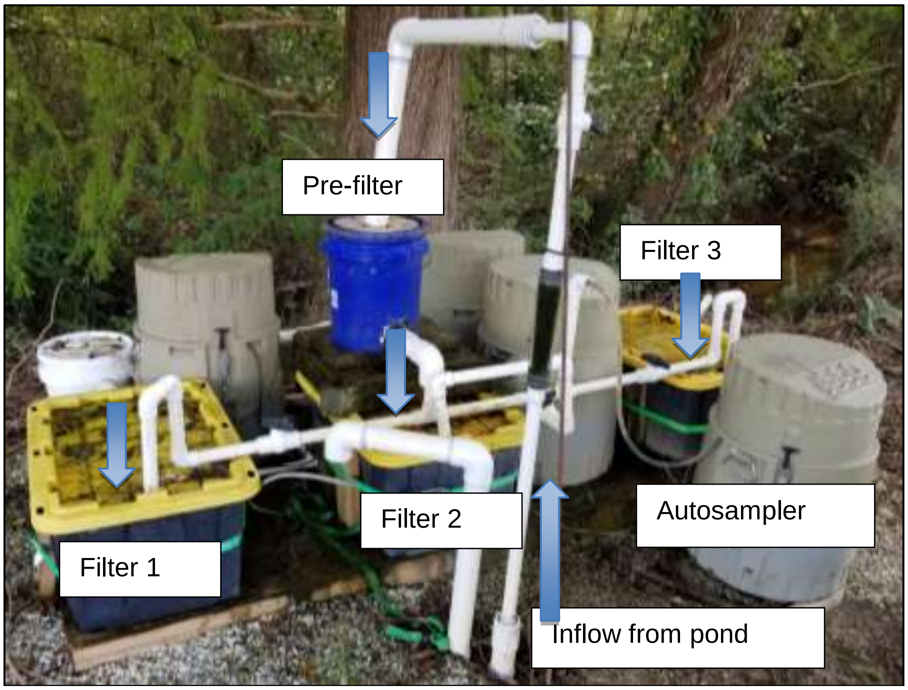

Figure 1. Pilot scale filters (*n* = 3) evaluated with regard to phosphorus removal effiacy from irrigation runoff. Three iron oxide filters were automatically monitored over 7 weeks.

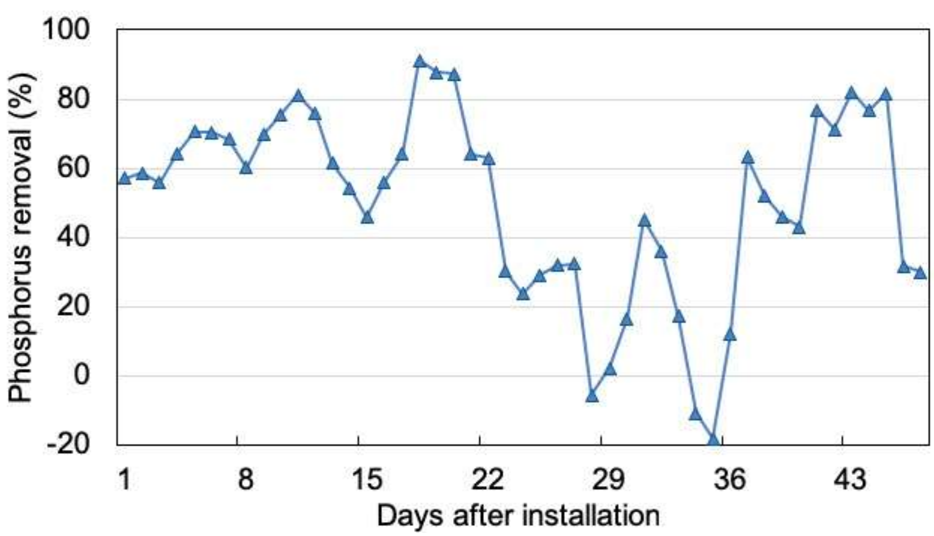

Figure 2. Phosphorus removal efficacy (3-day moving average) of a passive flow iron oxide filter (*n* = 3) installed at a SC nursery.

Sediment and Nutrient Movement in a Container Nursery: What Happens During an Irrigation or Storm Event?

Mohammad Nayeb Yazdi[1], David J. Sample[1], and James S. Owen, Jr.[2]

[1]Department of Biological Systems Engineering, Virginia Polytechnic Institute and State University, Virginia Beach, VA
[2]Department of Horticulture, Hampton Roads Agricultural Research and Extension Centre, Virginia Polytechnic Institute and State University, Virginia Beach, VA

jsowen@vt.edu

Index Words tailwater, total suspended solids, total nitrogen, total phosphorous, Storm Water Management Model (SWMM)

Significance to Industry Commercial nurseries conventionally produce containerized ornamental crops in unbuffered soilless substrates on semi-permeable production areas requiring frequent irrigation and fertilization. Runoff, known as tailwater, from the pads carries sediment, nitrogen (N), and phosphorus (P) (1-4). This can result in non-point source pollution (5-7) unless tailwater is collected and reused. We characterized and developed a model of container nursery tailwater at a mid-Atlantic nursery downstream from a 5.2 ha production area. Generalized relationships between loading of sediment, N, and P in tailwater as a function of rainfall depth and antecedent dry days were developed based upon a 10-year simulation (2008-2018) using the Storm Water Management Model (SWMM) model. Annual loads of sediment [total suspended solids (TSS)], total nitrogen (TN), and total phosphorous (TP) ranged from 9,230 to 13,300, 66 to 94, and 9 to 13 $kg{\cdot}ha^{-1}{\cdot}yr^{-1}$, respectively, based upon storm events and average irrigation.

Nature of Work Growing nursery crops in containers provides for an inexpensive solution for faster crop growth and easier handling, making container use a dominant practice (4). Containerized crops, however, require frequent irrigation. Unfortunately, porous substrates used in containers combined with semipermeable to impermeable production surfaces, produce more tailwater volume compared to field grown nurseries, thus conveying more pollutants during irrigation and storm events (5). Fate and transport of these pollutants depends upon production surface characteristics, slope, precipitation, length of the antecedent dry period, and timing of storm or irrigation events (5,8). Currently, many mid-Atlantic container nurseries are capturing and reusing 95% of runoff from the first 1.3 to 2.5 cm of rainfall as recommended by the Phase I Chesapeake Bay Watershed Implementation Plan (WIP) to reduce sediment and nutrient loading to the Chesapeake Bay estuary (9). Nurseries cite concerns regarding environmental stewardship and water security as reasons for voluntarily complying with the Phase II WIP guidance (10, 11). Limited on-farm research has been conducted to characterize and model the scale of nursery tailwater volume and quality of container production areas. Modeling provides a better understanding of container nursery tailwater transport and fate, which aids decision makers when deciding to improve management of tailwater before reuse or release into surrounding ecosystems. The objectives of this study were to develop an estimate of average annual loading of TSS, TN and TP from a nursery production area, and to generalize these projected annual loads as a function of key independent variables. To achieve these goals, an anonymous 200 ha container nursery in the Mid-Atlantic US was selected for this study. The contributing drainage area that was monitored was 5.2 ha, which consisted of 1.8 ha of roads and 3.4 ha of container pads, all of which drain to a central receiving ditch and then to a tailwater recovery basin (TRB) for treatment and reuse (Figure 1). A 0.6 m H-flume with maximum flow capacity of 350 $L{\cdot}s^{-1}$ (12), an automatic sampler (model 6712; ISCO, Lincoln, Nebraska), a rain gauge (model 674; ISCO), and a bubbler flow meter (model 730; ISCO) were installed to measure flows and collect equal volume samples across irrigation and storm runoff hydrographs at the outlet. A Storm Water Management Model (SWMM) was developed for the nursery sub-catchment using landscape variables including property boundaries, soils, land use, hydrography, and digital elevation models to yield runoff and water quality constituent loads and/or concentrations. Precipitation inputs were developed from the rain gage (ISCO model 674), or a nearby weather station rain gage [WAKEFIELD, 448800, National Oceanic and Atmospheric Administration (NOAA)]. The model was then evaluated using a group of statistical methods including: Nash-Sutcliffe Efficiency (NSE), coefficient of determination (R^2), and Percent bias (PBIAS) (13, 14). An R program was developed to integrate irrigation into precipitation data. The SWMM model was calibrated to the collected monitoring data, then the model was run for a 10-year period (2008-2018) to estimate average annual loading for TSS, TN, and TP.

Results and Discussion: Average daily loads of TSS, TN, and TP during irrigation events were 0.87, 0.09 and 0.01 $kg{\cdot}day^{-1}$, respectively. The average total load of TSS, TN, and TP during storm events was approximately 900, 35 and 50 times higher, respectively, than those of irrigation events. In addition, SWMM model simulated hydrology, TSS, TN, and TP concentrations for 10 years (2008 – 2018). Modelled annual pollutant load based on 10-year simulations (2008-2018) was calculated by multiplying flow by concentration. During storm events, annual loads for TSS, TN, and TP per ha were between 11,100, 80, and 11 $kg{\cdot}ha^{-1}{\cdot}y^{-1}$, respectively. In addition, annual loads during irrigation events for TSS, TN, and TP per ha were between 39, 4.3, and 0.5 $kg{\cdot}ha^{-1}{\cdot}y^{-1}$, respectively. Linear correlation between annual precipitation depth and the pollutants loads TSS, TN and TP was 0.5, 0.93 and 0.95 R^2, respectively (Figure 2). Three annual pollutant load for the nursery were developed using these regression equations and annual loads during irrigation events. Thus, annual pollutant loads for TSS, TN and TP per ha calculated based on Eqs.1, 2, and 3, respectively:

$$Annual\ TSS\ load\ (kg/ha.yr) = NDD \times 0.167 + 93.42 \times P_r - 1049.5 \quad (1)$$

$$Annual\ TN\ load\ (kg/ha.yr) = NDD \times 0.018 + 0.76 \times P_r - 18.76 \quad (2)$$

$$Annual\ TP\ load\ (kg/ha.yr) = NDD \times 0.002 + 0.11 \times P_r - 2.62 \quad (3)$$

where, P_r is precipitation depth (cm), and NDD is adjusted for number of days plants are irrigated during a year, since irrigation is applied during the growing season only.
In conclusion, 130 samples from 5 storm events and 7 irrigation events were taken.

SWMM was able to characterize the runoff quantity and quality from the production area well. This model, given sufficient data for calibration, could be applied to virtually any container nursery site to estimate tailwater water quality loading, and explore potential on-site and environmental mitigation management options. Such studies are a critical first step in providing tools for improving water quality in tailwater from container nurseries, which, in aggregate, constitutes a significant potential source of nutrients and sediment to estuaries and coastal waters.

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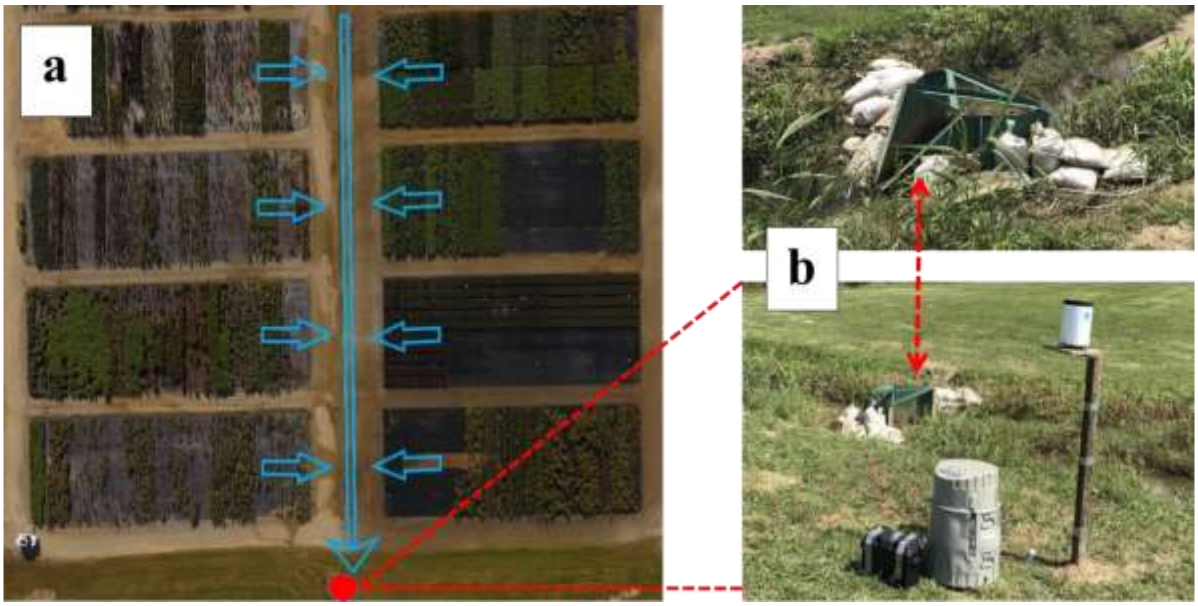

Figure 1. Location of (a) container pads and monitoring site outlet (filled red circle) and (b) H flume (top), automatic sampler and rain gage (bottom).

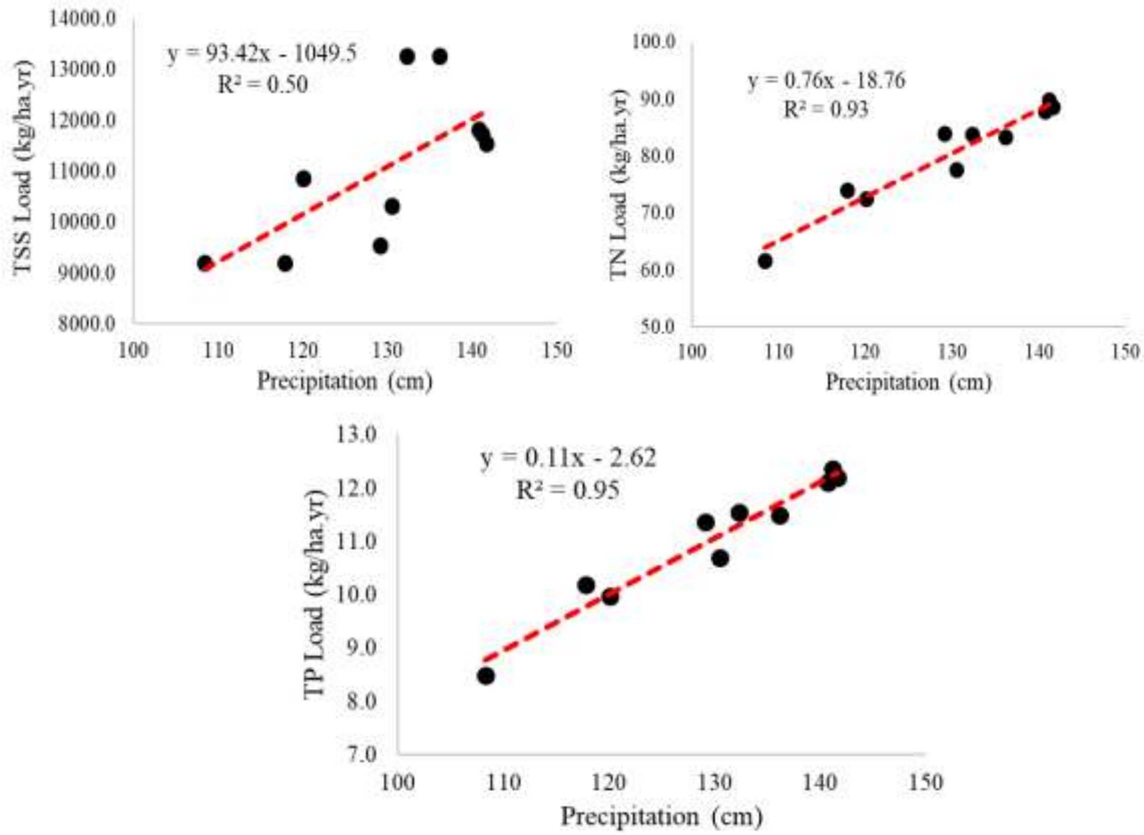

Figure 2. Relationship between annual precipitation depth and pollutants loads. TSS=total suspended solids, TN=total nitrogen, TP=total phosphorous.

South Carolina Irrigation Water Source and Methods for the Specialty Crops Production Industry

Lauren M. Garcia Chance, Natasha L. Bell, Megan E. Chase, W. Walker Spivey, Sarah A. White

Clemson University, 509 Westinghouse Rd, Pendleton, SC 29670

lgarci3@clemson.edu

Index words Well water, Surface water, Overhead, Drip, Greenhouse, Nursery

Significance to Industry Currently, knowledge related to irrigation water sources, irrigation application methods, and correlations between production type and water use for the greenhouse and nursery industry is severely limited. While time and research are directed to solve both irrigation and runoff problems for the industry, published baseline research describing water quality issues and producer-wide irrigation practices is scarce. As water resources dwindle and states look to restrict water usage, specialty crop growers can better safeguard their water resources and usage rates if they have baseline information regarding these practices. We collected data from nursery (field and container) and greenhouse operations across South Carolina, developed a database corroborating major water problems that will help to direct future research and resources, and collated information useful for both growers and policy makers regarding water quality and water use patterns.

Nature of Work Over the last few decades, water availability in South Carolina has steadily decreased due to reductions in average daily precipitation and increased severity and incidence of drought (1,2). Competition among domestic, agricultural and industrial water use within the state has increased due to decreasing supply. About 125 million gallons per day are used for irrigation purposes in South Carolina, accounting for roughly 10% of consumptive (excluding thermoelectric) water use in the state (3). In South Carolina, over 234,000 acres of harvested cropland and 65,000 irrigated acres are devoted to specialty crops production, with over 600 registered nursery, greenhouse, and floriculture farms operating in the state (4). Specialty crops accounted for almost $500 million in state revenue in 2012, with greenhouse, floriculture, and nursery products consistently contributing over half of cash receipts for crops in South Carolina (5). South Carolina ranks as one of the top five states in the country with the highest percentage contribution of the horticulture industry to gross state product (6). Though agricultural irrigation accounts for a considerable portion of consumptive water use in the state, there is a substantial knowledge gap concerning water use practices at nursery and greenhouse operations throughout South Carolina. A comprehensive statewide study of irrigation source water use practices was critically needed to inform long-term water use management, allocation, and policy decisions in South Carolina.

An assessment of irrigation quality, quantity, and source was conducted with 30 collaborating nursery and greenhouse growers throughout South Carolina. Ten growers were selected to represent each of the three ecoregions of the state: Coastal (Coastal Plain), Central (Southeastern Plain), and Piedmont (Fig. 1). Growers were asked to complete an online survey (IRB# 2018-086) that included questions related to water source, irrigation method, water volumes used, and best management practices implemented within their operation. This information was confirmed and expanded upon through on-site visits to each growing operation. During the visit, water sources were observed and interviews were conducted with either the owner or individual responsible for the irrigation of the operation.

Survey responses serve as a benchmark of irrigation sources for South Carolina in 2018, with future survey administration strongly encouraged to develop longitudinal analysis. Data are reported only as percentages to protect the anonymity of the respondents. Statistical analysis for the data presented were challenging due to the use of categorical, multi-response variables. In other words, respondents could select more than one response if, for example, a grower produces most of their crops in a container, with a small proportion produced in a greenhouse. Permitting this type of response violates an underlying assumption of most statistical analyses, that of the independence of responses, and results in unknown degrees-of-freedom (i.e., with 30 growers we received many more than 30 responses). Due to the use of multi-response questions, percentages discussed within this study can equal greater than one hundred percent.

Results and Discussion We specifically selected diverse operations to survey, both in terms of size and operation type. Operational sizes ranged from 33% of respondents with operations on >100 acres, 45% of respondents with operations on ≤15 acres, and the remaining 22% of respondents growing on 16 to 100 acres of land. Historic data and future survey collection could serve to further confirm this trend in operation size distribution. Operation size was not assessed by ecoregion to protect the anonymity of the respondents.

Plant production was broken out into three categories: greenhouse production, plants grown within an enclosed structure; container production, plants grown within a container outside of an enclosure (i.e., on a gravel or landscape pad; this includes pot-in-pot production); and field production, plants grown in the ground. In the Piedmont region of South Carolina, 70% of growers utilize field production, while only 20% in the Coastal region do (Fig. 2a). Conversely, 100% of growers in the Coastal region utilize container production, while only 40% do in the Piedmont. The high incidence of container production is most likely attributable to the high-water table, flooding, and sandy soils of the Coastal region which prevent efficient field production. The Central area of the state is an even mixture of the three production types, a blend of the Coastal and Piedmont conditions.

Irrigation of crops grown within the Piedmont region relies heavily upon well and surface water, with 80% of growers using one or both (Fig. 2b). Only 10% of growers in the

Piedmont region use a recycling or retention basin to capture and reuse their runoff. Coastal growers are far more reliant upon recycling and retention basins for irrigation, with 80% of growers capturing and reusing their runoff. Well water is used for irrigation by 80% of the Central region with only 10-20% of growers applying water from recycling or retention basins, surface water, or municipal water. One factor impacting use of these vastly different water sources is policy and regulation. Within the Coastal region, groundwater access is restricted by capacity use regulations limiting well withdrawals while other regions of the states are not regulated (7; Fig. 3). Furthermore, some Coastal operations have experienced salt water intrusion, further limiting surface and well water use (*personal communication*, interviews with growers). Freshwater is plentiful in the Piedmont region due to proximity to the foothills of the Appalachian Mountains in combination with an abundance of springs (8; Fig 4).

Irrigation methods used by surveyed growers included hand irrigation or manual application, drip/micro-sprinklers, sub-irrigation (e.g., flood floor, ebb and flow, etc.), and overhead application. Piedmont growers specialize in field tree production; because of this production system, 90% of Piedmont growers primarily irrigate using drip/micro-sprinklers (Fig. 2c). Only 30% regularly use overhead irrigation (some growers occasionally use overhead in holding bays prior to shipment and are not included). Conversely, 100% of Coastal growers regularly use overhead irrigation, supplemented by drip/micro-irrigation. As seen previously, the Central region is evenly divided between use of both drip/micro and overhead irrigation as their main irrigation method. In no case was an operation that solely used drip irrigation equipped with a recycling or retention basin for water reuse. This may be due to the high water application efficiency and low level of runoff associated with micro-irrigation (9,10). Therefore, while the Piedmont region had a low level of water reuse in comparison with the Coastal region (Fig. 2b), this could be attributable to a lack of water runoff to capture and reuse. Hand irrigation is used in 50% of operations within the state, but in all cases, was a secondary irrigation method. Only 10% of growers within the state, applied water using sub-irrigation, a highly efficient irrigation method (11). This lack of implementation is most likely linked to high system costs (12).

Ecoregion and production type impacted the primary source of irrigation water and how water was applied. Better understanding of these linkages could assist in development of best management practices and extension materials. Determining water quality problems and runoff implications are also pertinent to the future sustainability and security of specialty crop producers. Based upon survey results and in-person interviews, it is clear a “one size fits all” water policy would be detrimental for specialty crop growers in South Carolina because of the variability in water use patterns by ecoregion and production type. Many growers are engaged and interested in understanding their water use and are proactively reducing their water footprint. Involvement of the specialty crop industry in decision-making is key for future water policy and regulation implementation.

Acknowledgements This material is in part supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2014-51181-22372 and partial funding by the South Carolina Water Resources Center.

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Figure 1. The three major ecoregions of South Carolina are comprised of (1) the Coastal region or the Mid-Atlantic Coastal Plain, (2) the Central region or Southeastern Plain, and (3) the Piedmont region.

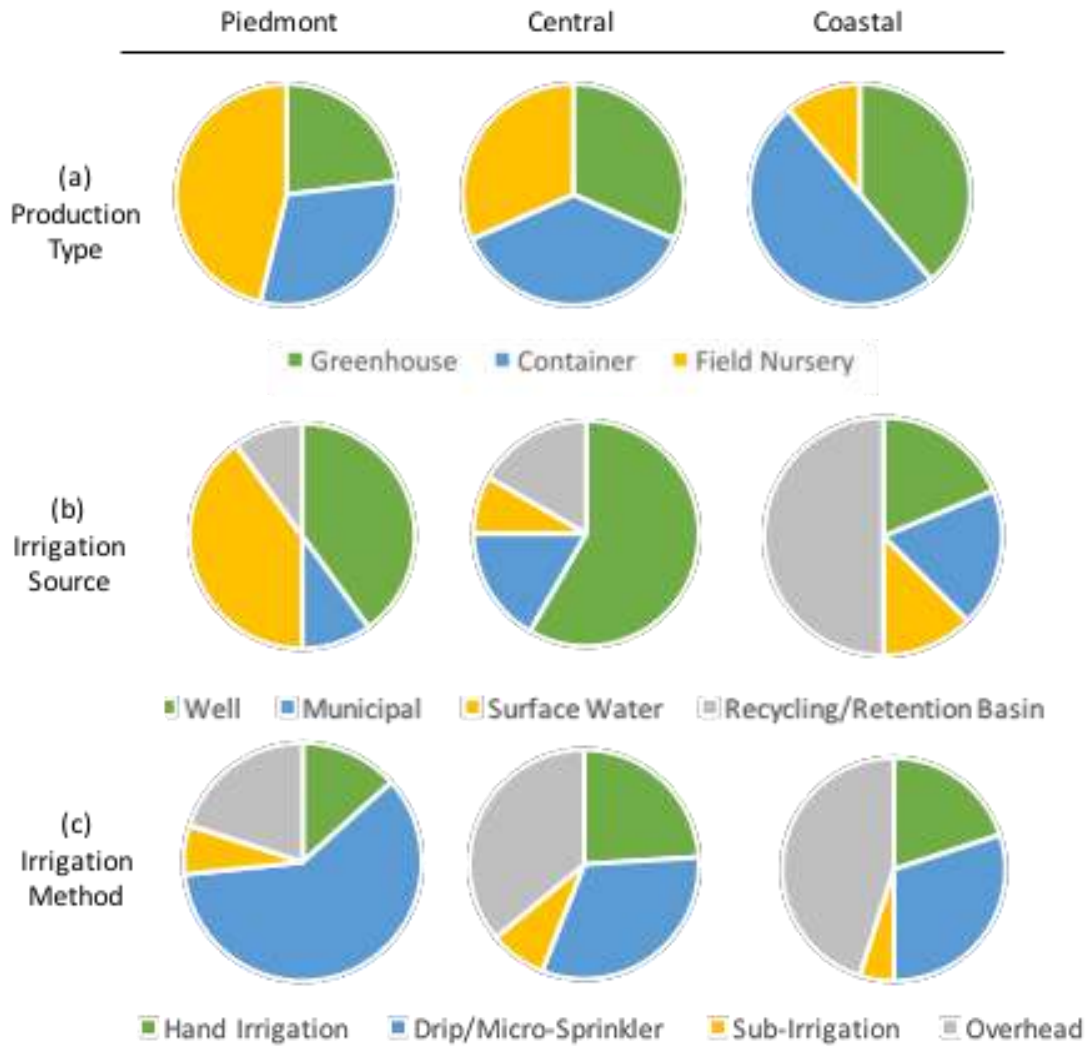

Figure 2. Distribution of responses when taken as a percent of the total for production type (a), irrigation source (b), and irrigation method (c) by region of South Carolina.

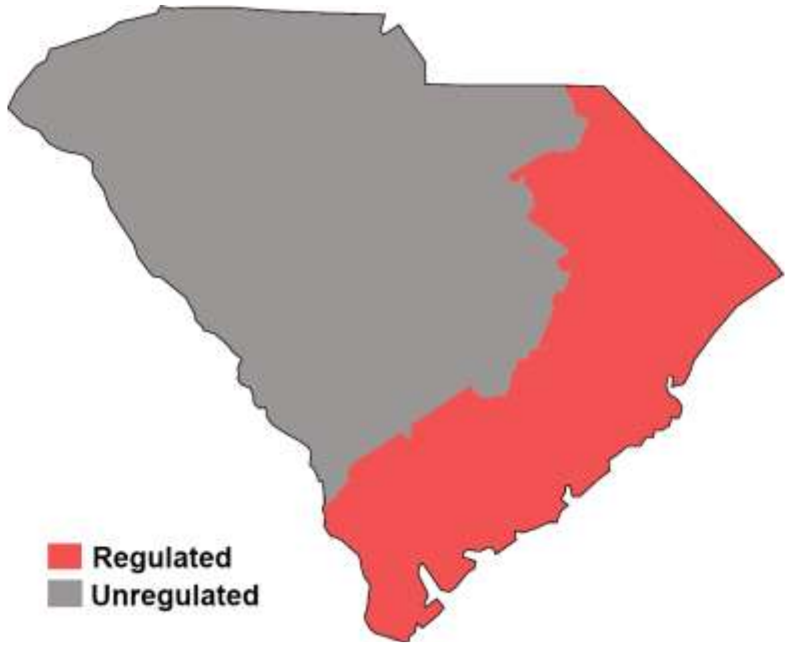

Figure 3. Regulated (red) and unregulated (gray) capacity use areas of South Carolina.

Figure 4. Location of springs within South Carolina denoted by red circle. (8)