Exploring Nursery Growers' Perceptions, Attitudes and Opinions about Water Usage to Inform Water Conservation Education

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Research has shown the nursery industry needs to seek alternative water sources and adopt water conservation strategies to reduce water use in order to stay viable. This study used a qualitative approach to explore nursery growers' perceptions, attitudes, and opinions about water usage to inform the development of Extension programs that encourage adoption of water conservation strategies. Interviews were conducted with 24 nursery growers across the U.S. The findings indicated growers interact with water in various ways, including meeting plant water needs, facilitating chemical distribution, controlling product quality, and facilitating business operations. The participants felt protecting water was the right thing to do and could provide economic benefits to their business, but water management was perceived as a task enforced by regulations. They reported their future interaction with water would include combatting water issues, engaging in the development and implementation of government regulations, seeking water conservation technologies and information, and dealing with financial challenges. Extension educators should be aware of these needs to alleviate concerns about integrating new processes into business plans. Educational programs should assist in the promotion of water conserving products based on knowledge gaps and provide assistance for easier adoption of new technologies by growers.

Keywords: nursery industry, growers, water usage, water quantity, water quality, Extension education

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Introduction

Requiring water for crop production, the nursery industry consumes approximately 30 to 100 inches of potable water per acre per year (Chen, Beeson, Stamps, Yeager, & Felter, 2013). Because of the large volumes of water needed for nursery production, increased competition for water resources with public and other industrial users is a growing concern (Fulcher, LeBude, Owen, White, & Beeson, 2016). Recent pressure has been applied to the nursery industry to seek alternative water sources and to adopt water conservation technologies, helping to reduce competition with public water needs (Chen et al., 2013). Strategies are being adopted at the nursery/greenhouse level, such as recirculating subirrigation systems and using collected runoff water to reduce potable water use (Obreza et al., 2010). However, recycled water tends to have lower physical and biological quality when compared to water collected from municipal or well supplies (Fulcher et al., 2016; Meador et al., 2012).

The nursery industry is also being criticized for not protecting natural water resources. While runoff from greenhouses/nurseries is considered a nonpoint source of pollution, the runoff associated with nurseries, including fertilizers (Wilson, Albano, Mozdzen, & Riiska, 2010; Yeager et al., 1993), pesticides (Shukla, Mostaghimi, Shanholt, Collins, & Ross, 2000), and herbicides (Gilliam, Fare, & Beasley, 1992), were believed to be contaminating and impairing natural water bodies (Fulcher et al., 2016). Government agencies have yet to extensively regulate chemical use by the nursery industry in an effort to address water quality issues associated with their use (Fulcher et al., 2016). Nursery producers in some states (e.g., California, Oregon, Florida, and states within the Chesapeake Bay Area) have been required to implement best management practices to contain and mitigate contaminants within their runoff (Fain, Gilliam, Tilt, Olive, & Wallace, 2000; Fulcher et al., 2016; Yeager, 1992).

The Cooperative Extension Service (hereafter referred to as *Extension*) has been committed to providing educational programs through farm visits, meetings, workshops, and demonstrations to encourage growers' engagement in water conservation (Suvedi, Jeong, & Coombs, 2010; Yeager, Million, Larsen, & Stamps, 2010). Many growers have integrated science-based water conservation practices in their business models (Dennis et al., 2010; Yeager et al., 2010). Growers' use of these conservation practices might be based on their interest in understanding how science works in agriculture (Zoebl, 2002), or they might be influenced by the grower communities (McGuire, Morton, & Cast, 2013; Warner & Schall, 2015). However, many conservation practices were developed and implemented for political and economic reasons with limited feedback from growers and citizens (Zoebl, 2002). Although scientific evidence has revealed that water quality issues were impacted by improper agricultural management practices, many agricultural growers did not perceive they were responsible for these water issues (Lamm, Beattie, & Taylor, 2018; McGuire et al., 2013). However, some growers, such as the certified sustainable floriculture growers, considered themselves to be responsible for environmental quality (Hall, Dennis, Lopez, & Marshall, 2009).

A review of the existing literature found that research examining the environmental perspectives of nursery growers, their thoughts about science in general, and their opinions of water conservation technology were conducted using quantitative surveys (DeJong, Delate, Mellano, Robb, & Shaw, 2009; Dennis et al., 2010; Hall et al., 2009; Warner, Lamm, Beattie, White, & Fisher, 2018). A qualitative, in-depth approach has been rarely used to explore nursery growers' interactions with and relationship to water (Lamm, Warner, Taylor, Martin, White, & Fisher, 2017). A deeper look at the underlying perceptions, attitudes and opinions nursery growers have about water broadly could provide insight into Extension education focusing on horticulture about how to design and develop educational programs by integrating growers' opinions that may lead to improved growers' engagement in environmental practices and potential future adoption of water conservation technologies (Franz, 2015; Warner et al., 2018).

Theoretical Framework

The theoretical framework for this study was based on general systems theory developed by von Bertalanffy (1968). General systems theory is an interdisciplinary theory that discusses various aspects, "such as social groups, personality, or technological devices" in *organized entities,* which are so-called systems (von Bertalanffy, 1972, p. 410). The focus of the general systems theory is on the interrelationships between multiple elements, diverse structures, processes, and dynamics within a system. According to von Bertalanffy (1972), "general systems theory . . . consists of the scientific exploration of 'wholes' and 'wholeness' which . . . were considered to be metaphysical notions transcending the boundaries of science" (p. 415). Instead of being used to study general cases under one specific discipline, general systems theory was suggested to be useful to analyze and explore how each factor (e.g. physics, biology, psychology, and social sciences) exist within a phenomenon that can influence each other and lead to the occurrence of a phenomenon (von Bertalanffy, 1972).

To explore and understand a given issue or phenomenon, systems thinking, a concept derived from general systems theory, has been indicated as a promising approach to develop problem-solving strategies (Cabrera, Colosi, & Lobdell, 2008). In the realm of agriculture, sustainability as a concept has been examined using the general systems approach. The belief is that a goal of sustainability cannot be reached by simply focusing on the natural sciences or the social sciences, but the integrated scientific system instead (Slegers & Stroosnijder, 2008). System thinking has been used to study the dynamics between individuals, associated networks, and institutions, as well as knowledge, technologies, policies, and the decision-making process regarding management, such as investment in new conservation practices (Klerkx, Van Mierlo, & Leeuwis, 2012; Röling, 1992). Tress, Tress, Décamps, and d'Hauteserre (2001) indicated a need to systematically integrate the natural sciences, social sciences, humanities, and the arts in order to provide recommendations that can facilitate "communication about landscape-related issues—within academia and between science and society" (p. 137). By using an interdisciplinary approach to examine complex agricultural problems, the gap between natural and social sciences can be bridged, which may solve problems caused by the stratification of the world between science and action (Jansen, 2009).

Purpose and Research Questions

The purpose of this study was to gain an understanding of nursery growers' perceptions, attitudes, and opinions about water usage to provide insights into informing the development of educational programs aimed at encouraging nursery growers to protect the natural environment, specifically water resources. The research was guided by the following questions:

RQ_1: How does water play a role in nursery growers' operational decisions?

RQ_2: How do nursery growers feel about protecting water resources?

RQ_3: How do nursery growers intend to interact with water in the future?

Methods

This study was qualitative, using semi-structured interviews to collect rich narrative data from nursery growers to address the research questions. Since nursery growers in the U.S. were the population of interest, 24 nursery growers across the U.S. were selected using purposive sampling (Ary, Jacobs, Sorenson, & Razavieh, 2010). In 2018, there were 32,915 plant and flower growing businesses identified in the U.S. (IBISWorld, 2019). The participants of this study were targeted growers, owners of operations, and upper management personnel who had sufficient understanding of the operation and water use of their nurseries. They were identified by Extension specialists from 16 different land-grant universities, all of whom were investigators for a United States Department of Agriculture National Institute for Food and Agriculture (USDA-NIFA)-funded specialty crop research initiative, *Clean WateR3: Reduce, Remediate, Recycle*.

The interviews were conducted at the nurseries with seven located in California, four in Georgia, four in South Carolina, three in Virginia, two in Maryland, two in Oregon, one in Florida, and one in Michigan. Dispersed geographical locations were selected based on the major nursery industry locations in the U.S. and were found to be proportionally distributed based on the total population of nursery growers nationwide. The number of locations and interviews were selected to maximize diversity and participation in the nationwide study. The participants were recruited to ensure representation from different sizes of nursery and greenhouse operations throughout the U.S. Among the 24 participants of this study, only two were female.

Several participants were advisory board members and collaborative growers participating in the Clean WateR3: Reduce, Remediate, Recycle study. Given that a majority of the participants were involved in the USDA-NIFA-funded project focused on developing and dispersing new water conserving technologies, it is important to recognize that the participants may have been more engaged in water conversation efforts than the typical U.S. nursery growers. This is a limitation of the study.

Semi-structured interviews were conducted face-to-face. By using a qualitative approach, participants' perceptions could be collected in-depth and would reflect the participants' flow of thoughts to assist the researchers' understanding of the meaning of the topic being explored, in this case, their relationship with water (Ary et al., 2010; Creswell, 2007). The interview guide was developed by the researchers to identify growers' perceptions, attitudes, and opinions about water usage with broader questions about water included as the foundation for the analysis of this study (Rogers, 2003). A panel of experts specializing in water quality and conservation, water treatment technologies, educational programming, and qualitative research methods reviewed and approved the developed interview guide and Institutional Review Board approval was obtained from the University of Florida.

The interviews were conducted in a one-on-one setting to provide a more comfortable environment that could facilitate the experience and perception of sharing. The researcher requested access to the nurseries directly from the growers prior to the visits and built rapport at the beginning of the interview (Creswell, 2007). The interviews were initiated by asking the participants about their operation and production processes to build rapport and then moved to questions discussing water uses (e.g., technology and purpose of irrigation, water sources, source and experience to learn about water source technology, experience of water-related issues, water conservation, and opinions of water issues and conservation technology). By using semi-structured interviews, the interviewer asked formulated questions on the topics of interest, but was also able to "modify the format or questions during the interview process" when needed (Ary et al., 2010, p. 438), and even add additional questions to probe for more information and guide the direction of the interview (Bryman, 1988).

The 24 interviews were conducted by a single researcher with limited knowledge of the nursery industry but had been trained in qualitative interview techniques from a public health perspective. The rest of the research team had agricultural knowledge of the nursery industry and provided insight into the responses based on their previous experiences, allowing for an appropriate peer debriefing process. The interviewer and interviewees did not have existing relationships prior to the interviews. During each visit, the interviewer audio recorded the interviews, took notes, and observed and took photographs of each nursery and the surrounding environment, including water sources. The data were then transcribed and analyzed by another researcher trained in qualitative data analysis with an extensive background in the horticultural sciences. The purpose of this arrangement was to explore how nursery growers related to and interacted with water from the perspective of someone that had worked within the industry.

MAXQDA (Version 12; VERBI Software – Consult – Sozialforschung GmbH, 2015), a qualitative data analysis software package, was used in the interview data coding process

(Creswell, 2007). During data analysis, codes were identified and developed in an emergent fashion using the constant comparative method (Creswell, 2007). An audit trail was created during the coding process to ensure the credibility of the data (Lincoln & Guba, 1985). The data analyst also used peer debriefing (Lincoln & Guba, 1985) with an associate professor of Extension education, an associate professor of horticulture, and a research coordinator at the UF/IFAS Center for Public Issues Education to reach an agreement on "the description, interpretation, ... evaluation and thematics" (Eisner, 2017, p. 112). In addition, the accuracy of the data was ensured by using the field notes of the interviewer and nursery operation photographs for triangulation (Lincoln & Guba, 1985).

A demographic breakdown of the participants is displayed in Table 1. The size of the operation was defined by acreage, crop production volume, number of employees, and family-owned versus franchise operation. The use of recycled water indicated a grower was using water that was collected, treated, and recycled on-site, such as collecting irrigation water runoff or using brackish groundwater.

Table 1. Characteristics of Participating Nursery Growers and Their Operations (n = 24)

Characteristic		**Number**
Gender:		
	Female	2
	Male	22
Size of Operation:		
	Small	11
	Medium	5
	Large	8
Geographical Location:		
	Northeast	2
	Southeast	3
	Southwest	9
	Midwest	1
	Northwest	2
	West	7
Use of Recycled Water		
	Yes	21
	No	3

Findings

RQ_1: How Does Water Play a Role in Nursery Growers' Operational Decisions?

The participants were asked about irrigation and uses of water sources at their operations. The participants described how and why water played a role in their everyday lives. During the analysis, four major themes were identified: providing plants' water needs, facilitating chemical uses, better control over product quality, and facilitating business operation.

Providing plants' water needs. The participants described how they made decisions about the amount of water they should apply for irrigation. A small-scale southeastern grower that uses recycled water provided a short and straightforward answer: "For us, it's how much the plant needs is how much we irrigate." Many growers indicated they relied on their experiences observing the plants for irrigation decisions. Another small-scale southwestern grower that also used recycled water indicated he used "visual observation . . . based on sight, feel, and really, for the most part, how we irrigate is really just part of a routine and not a whole—it doesn't change dramatically."

Other participants indicated the importance of taking weather and climate into consideration when deciding the daily irrigation volume. A small-scale southwestern grower that uses recycled water stated, "The one thing that changes how we apply water as much as anything else are environmental conditions, and if we get a lot of rain, we don't irrigate a lot. If we don't, we know we have to irrigate a lot, but it's just really based on the health of the plant." Another grower mentioned,

> I will say we water when it's necessary. . . . [It] does vary throughout the years. We will adjust our controllers and things like that depending on what the weather's like and what the plant growth is. If it's during wintertime, we don't have to really do any watering unless it's been for a long dry spell, and then we'll give a shot of water just to keep the moisture in the soil. (Small-scale, western grower using recycled water)

Facilitating chemical uses. The participants also discussed the water used to deliver various chemical applications, such as fertilizers, pesticides, and fungicides. The participants reported using different types of fertilizers (i.e., granular slow-release fertilizer, polymer-coated controlled-release fertilizer, and water-soluble fertilizer [fertigation]) in combination with their irrigation system. For example, a small-scale western grower that does not use recycled water stated,

> We use granular incorporated into the soil mix. We also do some fertigation during the springtime. If we need to do some crops that need a little extra boost if they're not growing optimally, then we'll try to give them a little shot by hand or through the irrigation system that we have.

Another grower discussed how water use influenced her fertilizer and disease control:

> [When plants are underwatered,] the plant may not get big enough, so you would have to maybe add more water and fertilizer later to increase the growth, so you finish up to size on a particular crop. Underwatering can also, the same as overwatering, cause root diseases. Underwatering can burn root hairs, and then it is just an entry for pathogens into the roots, and you may have to do fungicide drenches because your roots are damaged from lack of water. (Large-scale northeastern grower using recycled water)

Better control over product quality. Many growers mentioned that water is important for quality control of the final products. For growers producing multiple varieties of plants in their nurseries, control over irrigation is critical to plant quality in their operation. A small-scale southwestern grower that uses recycled water discussed the need to group plants differently by their water needs stating, "If you . . . have a high-water requirement plant and a low-water requirement plant, somebody's either going to have too much water or too little water. It's out of necessity that we group them by . . . water needs." Another medium-scale southeastern grower who uses recycled water reiterated this as he discussed underwatering: "Underwatering . . . would be the lightest extreme [that] you have a variability of plant growth and inconsistent crops. That, again, creates a lot of secondary problems down the road."

Facilitating business operation. Many nursery growers linked their water use to their overall business operation, relating it to possible financial loss, savings, or profit. Some growers had applied specific irrigation technologies to save labor costs, while some growers still relied on labor for more specific care of the plants. One grower expressed how he cared about both financial efficiency, as well as water use:

> Using water, number one, we have to pull it up out of a well. That's electricity to run the well. Trying to be most efficient as we can saves me money. . . . The drip irrigation, it's a lot of initial install, but we save on fertilizer. We save on watering time, manual labor all by using the drip irrigation. (Small-scale western grower not using recycled water)

However, a small-scale southwestern grower using recycled water represented a different perspective. He preferred to rely on laborers stating, "I don't think there's any technology or anything that can duplicate or can mimic somebody in the field." A large-scale western grower using recycled water mentioned the necessity of irrigation laborers in his operation which supported the previous growers' statement:

> [The irrigation system] is sometimes overridden by employees that are doing the irrigation because they'll find dry areas within the crops that may not have been covered with irrigation. . . . [The] employees that are in charge of the irrigation might make a decision to provide additional irrigation on top of what has been provided by the [irrigation] system.

Some growers' production costs may be increased, and profits may be decreased, due to careless irrigation. One grower said,

> A lot of times, the underwatering quickly leads to the over-watering, but the greatest impact it has is overall root health and which ultimately affects plant health. You certainly under- and overwatering both contribute to lost sales. . . . The application of pesticides [is needed] to try to control or eliminate [the disease]. . . . [It's] probably the most costly chemical application we make. (Small-scale, southwestern grower that uses recycled water)

RQ2: How Do Nursery Growers Feel About Protecting Water Resources?

To identify how the participants felt about protecting water resources, three major themes were repeatedly found within the participants' responses: doing the right thing, the economic benefits, and regulatory enforcement.

Doing the right thing. Most participants indicated that they had an intrinsic motivation to save water, indicating it was the right thing to do. Several even expressed a responsibility to protect the water resources because they were precious. For example, one grower stated,

> I think you've got to work toward sustainability. We can't just be here sucking up the Earth's resources and be a zero-sum gain. It's got to be for the environment, it's got to be a bit of a win-win. We can't just be the taker. (Small-scale southern grower that does not use recycled water)

A small-scale midwestern grower that uses recycled water discussed the precious nature of water in regard to the relationship between water uses and wildlife:

> [Our state] is lucky to be in a place where we have adequate water for crop production and for a lot of other things, including the other wildlife that lives here. I'm proud to say we have herons and killdeer and other sandpiper-type birds that nest and live here. They seem to have enough to live on, but I'm very concerned that the widespread waste of water, the way water is used in our society, is not sustainable.

A large-scale western grower that uses recycled water indicated the positive contribution engagement in water conservation had to their broader community and their businesses' public image:

> There is a certain image that we like to project to our customers that we're doing our share . . . we're going to make a big deal about [water conservation] because it's totally environmentally conscious, and it would save a couple hundred acre-feet a year of potable water that the city could use somewhere else.

Moreover, another grower stated his concern about the impact of publicity on the industry:

> I think it's important for the future that we get to that point to where we're being good stewards to our land. . . . It's just a smart business mode. I think as far as business goes in today's climate, these issues are only going to get more important. Companies that are going to be proactive and get these issues handled before there's problems because we would rather have no publicity than bad publicity. We don't want to have something running downstream that ends up in the newspaper. Bad for business. (Small-scale southwestern grower that does not use recycled water)

Economic benefits. Several participants indicated that the economic benefits received from their protection of water resources drove their decisions regarding water conservation. A large-scale grower from the west that uses recycled water indicated, "[It's] a huge financial benefit, so if we reuse and recycle 150 million gallons of water, that's about $600,000 worth, so huge financial. It also provides us with insurance against a disruption in the water supply." In addition, saving on electricity was mentioned by a small-scale grower from the southwest that uses recycled water: "It's not so much … because the water's abundant, but you can save a lot of money with the least [sic] you run those 15 horsepower pumps, the more electricity you save. That's the main thing."

Regulatory enforcement. Participants also indicated their engagement in water resources protection was due to regulatory enforcement. A northeastern, large-scale grower that uses recycled water indicated, "we have the state telling us how much we can take, so we don't want to use more than we have to." The restrictions are not only about the quantity of water the growers can use, but also the quality. Another northeastern grower that also has a large operation that uses recycled water described the water quality restrictions:

> [There's] a lot of restrictions in [our state] . . . and one of the big issues is nutrient runoff. With all the fertilizer, not just horticulture, but one of the big offenders are agricultural farms and operations, because everything drains into waterways that'll eventually drain into the bay, and it's all in that protecting the health of the bay.

RQ_3: How Do Nursery Growers Intend to Interact with Water in the Future?

A number of commonalities were identified in the participants' responses about how they intend to interact with water resources in the future. Four major themes emerged from the data: combatting water issues, future movement in governmental regulation, seeking additional technology and information about water conservation, and financial challenges.

Combatting water issues. The participants indicated various water-related issues they may have to overcome in their operation in the future, including water quantity, water quality, and climate-induced issues. Many participants felt water would be limited in the future, so they have to be prepared and take action now. One grower stated,

> Water is more precious than gold. I think between just the availability of water and the standardization of what is clean water or what is considered contaminated water to move off-site is going to get more and more stringent. It’s happening every year in every state. Water is a big concern of ours. (Large-scale northwestern grower using recycled water)

The same grower also mentioned the possible practice he would like to apply, stating “the limited amount of our water, the availability with water rights and drought conditions, [reveals that] we need to have ponds that we can capture natural rain in the wintertime and/or the opportunity to recycle our water.” Even if some growers have applied reclaimed or recycling water systems, water quality of the recycled water may be an issue they need to resolve. For example, a large-scale western grower that uses recycled water indicated,

> [We’re] not yet where we have the water quality that we want [in the recycling water system], so we still have work to do. . . . [We’re] getting too much organic through the system, and so we tried some treatment to reduce chlorine. . . . Then reducing the salinity and the EC of the water [is another issue]. [We’re] starting to put the—we built some boxes that we put cannas, which are pretty effective at removing salinity from the water.

Some participants mentioned climate-related water issues that may impact production. For example, they showed concern about heavy rainfalls. A southeastern grower that has a medium-scale operation and uses recycled water stated, “pretty much any time there was rainfall over an inch, [then we have flooding]. [It] happens at least once, twice, sometimes three times a month.” On the other hand, some of the growers showed concerns about drought. A small-scale western grower that does not use recycled water stated, “[water might be limited] depending on, for us, what the drought is. I have hopes that we will get some rain this fall, so we won't have to be as worried about water.”

Future movement in governmental regulation. Many growers indicated their concerns about future changes in government regulations that may influence their water use. A medium-scale grower from the southwest that uses recycled water described his worries about possible future policy changes on water availability to growers: “[Our] concern is that at some point in time somebody’s going to come through and set a threshold that will limit the amount of water that we can use.” Many growers in the West indicated possible water cuts in the future that may impact their water use. A large-scale western grower that does not use recycled water explained,

> [Some] restrictions have been imposed on growers and landscape homeowners because we’re in a drought right now. [The restrictions] have been for some time, but it’s now being recognized, and there’s legislation that’s going to provide more restriction on water use. . . . That could be regulated here very soon, where it’s going to be the responsibility

> of each nursery and agriculture facility to reduce their water consumption by 30%. That's, of course, an issue.

Other than regulations for water quantity, water quality has also been regulated and has influenced the nursery growers' operations. The same grower went on to explain the situation:

> [In] a monsoon rain event, we . . . only can lose 10% of that water for runoff. They're regulating the phosphorous and nitrate runoff. Based on the sheet flow of movement runoff from the plots, we . . . need to be prepared to only lose 10% of that water that could possibly be shed into the environment offsite.

Seeking additional technology and information about water conservation. The participants showed a strong interest in learning more about water conservation technologies and emphasized that they believed growers have been motivated to use water more efficiently to enhance their business sustainability. A large-scale, northwestern grower that uses recycled water reiterated,

> If I can be more efficient with the water and use less water, it's better for everything, especially off-site erosion or compaction. We're here sustainably wanting to farm our land for a long period of time. We have to worry about what we're doing today for the future.

Most of the growers expressed being active in sharing information with one another and participating in events such as tradeshows to learn about the latest technologies. One grower indicated his participation in nursery tours:

> We share [operation] information. We'll have nursery tours that come through, and it's nurseries from all over the country, or we'll go on tours and go to different nurseries. When I go, I'm looking at specific things. . . . I'm looking at their irrigation system. . . . We'll have people that come, and that's all they want to see is our pump houses, what we're doing. (Large-scale, western grower that does not use recycled water)

Some growers have collaborated with researchers in an effort to seek out more efficient strategies to use water more efficiently. A large-scale northwestern grower that uses recycled water discussed his engagement in research: "We work with the scientific community looking at water irrigation technology and we do a lot of research here on the nursery. . . . We also sometimes invite researchers to come and do research on our property."

Financial challenges. Although nursery growers would like to learn about how to use water more efficiently and even apply new technologies to improve water use efficiency, many showed concern about the costs of application. One grower stated,

> [There] is no savings when you have to implement certain processes that take dirty water, or maybe not dirty water, but water that's been recaptured that has to be treated before it

> can be used. The result of that is your ability to stay in business and be able to grow plant material. Growers are going to have to invest in different technologies in order to stay in business. (Medium-scale southeastern grower that uses recycled water)

Other than investing in technology, another grower mentioned the possible additional investment on technical personnel:

> Some of the [water use technologies] gets so technical, and that's what the concern is with me. . . . It's so technical, you got to have an IT person that's babysitting that project. We can't afford that. We're just farmers. We're not that specialized in certain areas to afford to have that specific type of staff. If we did, we'd have to change our price structure. (Large-scale northwestern grower using recycled water)

Conclusions, Implication, and Recommendations

The findings of this study provided an in-depth view of the participating nursery growers' perceptions, attitudes, and opinions regarding water usage revealed how their opinions and perceptions were associated with the futures of their businesses, and how the futures of their businesses were tied to the availability of water resources. The nursery growers in this study indicated that the water issues they are addressing are inter-related with how critical water is to their financial success (von Bertalanffy, 1972), i.e., water is essential to plant growth and is also associated with their nutrient and health management practices, which may further impact the quality of the plant products and financial returns from sales. This finding is congruent with what Hall, Hodges, and Haydu (2005) and Taylor, White, Chandler, Klaine, and Whitwell (2006) found, in that the water used in the nursery industries in this study was managed to support plant need and health, while the management practices were related to the environmental conditions (weather and climate) and plant characteristics and conditions.

While Davies, Grossi, Carpio, and Estrada-Luna (2000) and Gori, Lubello, Ferrini, and Nicese (2004) indicated the importance of water quality toward nursery plant production, the participants in this study discussed water quantity issues more critically but rarely mentioned water quality issues. In this case, the growers were not expressing an interaction between water quality and water quantity issues. Therefore, this lack of a direct connection expressed by the growers between water quality and water quantity misaligns with general systems theory (von Bertalanffy, 1972), in that growers are not making the connections between their physical facilities, the biological aspects of plant science and nutrient management, and their social decisions related to water conservation and water treatment adoption.

When discussing water resource conservation, the participants all indicated their application of water conservation practices. However, some participants were more proactive in conserving water than others. Such findings showed similarities and differences when compared to previous research. For example, McGuire et al. (2013) indicated nursery growers tended not to consider themselves responsible for water quality issues while the participating growers in this study showed positive responses regarding their willingness and determination to take action to protect water resources, similar to the findings of Hall et al. (2009). These positive responses may be due to the participant recruitment approach, which led them to have more exposure to associated knowledge and experiences with water conservation technologies and techniques. The findings of this study also resonated with Zoebl's (2002) findings, as the water conservation practices applied by the participating growers may be driven by financial savings and government enforcement instead of being self-motivated.

Similar to Duram's (2000) findings, some nursery growers showed greater concern for the environment than others. However, the participating growers' knowledge of water-related environmental issues seemed higher than reported in the studies of Duram (2000) and McGuire et al. (2013). For example, some participants in this study discussed the state of their watershed, the regulations impacting their operation, and even how the regulations worked. Similar to what McGuire et al. (2013) found, some participants were more conservation-oriented and discussed the benefits of applying conservation practices toward environment health, while others were more production-oriented and tended to mention operational profit and financial issues more frequently.

In this study, the findings provided some additional information about the nursery growers' opinions regarding their application of water conservation practices. As these growers engaged in a water conservation project, they agreed that water is a precious resource for the environment and their business operation, and, therefore, they also agreed with the use of water conservation practices. Since they cared about the sustainability of their operation, they were motivated to learn about water conservation to overcome the uncertainties of future water use. However, the participants sought out how to balance water conservation, operational finance and practices, and sales profits when taking environmental and regulatory constraints into consideration.

The participants of this study were purposely recruited from the collaborating growers in a scientific project related to water conservation. Therefore, the participants' application of water conservation practices and active information seeking were expected (Lamm & Telg, 2015). As a result, the participants' active participation in tradeshows and conversations with other growers were revealed in this study. This confirmed the findings of McGuire et al. (2013) that growers' perceptions, decision-making, and behaviors associated with the environment may be influenced by other growers.

As water plays a key role in nursery production, changes associated with water use should draw nursery growers' attention. The responses from the participating growers revealed different water issues and that water regulations impacted growers' operations differently in different states. Growers from the West and Northwest were concerned more specifically with water availability due to drought and the resulting legislation. Growers from the Northeast referred to water quality issues, which may be tied more specifically to recent issues with the Chesapeake Bay. This finding implies the need to develop water conservation educational programs tailored to state-specific situations and possibly local situations, depending on what the water issues are and by what governmental entity the regulations are applied and enforced. Extension educators working with nursery growers should incorporate local water issues and state regulations associated with nursery production water uses in their programming processes. For example, Extension educators in the West might want to focus on drought situations and restrictions on water uses based on the state regulations in programming, while those in the Northeast and Midwest may want to address water quality issues.

In this study, the participants were aware of water issues and willing to conserve water by applying conservation practices and collaborate with researchers to learn about and adopt new conservation technologies, helping to improve the sustainability of water resources. This is in direct contrast to the lack of interest growers exhibited in a previous study that examined the level of importance growers' lent to developing water conservation practices (Zoebl, 2002). Therefore, researchers studying water conservation technologies should be aware of what nursery growers' attitudes are related to water usage and water conservation, where they are currently in the use of technology in these areas, and what their attitudes are about adopting new technology and techniques so they can develop appropriate projects and/or educational programming to address the nursery growers' needs related to water usage and conservation.

Additionally, researchers should collaborate with growers by incorporating their opinions into technology design and facilitating field trials of the newly developed technologies. By doing so, researchers can receive first-hand information from the growers about the technology and may further optimize the technology based on growers' feedback, which may even positively impact growers' adoption of the water conservation technology (Rogers, 2003).

The participants in this study indicated their concerns about public image and publicity related to their businesses. This finding implies that these nursery growers not only cared about factors impacting their production but also factors impacting their sales. Researchers and Extension educators should study how consumers perceive the nursery industry's efforts to conserve water, and if those perceptions impact their willingness to support their business. If consumer purchases of nursery products can be positively influenced by their awareness of nursery growers' application of water conservation practices, educational programs can be developed to help nursery growers to learn how to promote their products based on identified knowledge or information gaps about the nursery growers' water conservation efforts.

Moreover, educational programs targeting nursery growers may also be needed, particularly for *laggards*, i.e., those who have not actively incorporated water conservation practices in their operation. According to Rogers (2003), laggards is a term used to describe the last group of individuals adopting an innovation. Extension educators should enhance communication with laggard growers about the importance of water conservation and how it can benefit their business, as expressed in the responses of the growers in this study.

Even though some water conservation practices have been readily adopted by the nursery growers in this study, the participants in this study reported experiencing problems with applying practices that need to be solved before further adoption of those practices can take place, such as the potential problems associated with using recycled water. This implies that some nursery growers may need additional technical assistance, or the practice may need to be revised to facilitate its adoption. Researchers developing and encouraging adoption should consider providing technical advisory assistance for new technologies and practices so that growers can more easily adopt the practice and alleviate any possible water quality issues caused by applying a water conservation practice.

In addition to providing individual assistance, Extension educators can use local, statewide, or even nationwide tradeshows as opportunities to provide assistance and promote new technologies to growers. At the tradeshows, Extension educators can also promote opportunities for growers to get involved in research studies around new technology trials.

Based on the findings of this study, researchers and Extension educators should note that monetary investment and regulatory enforcement may be the major factors influencing nursery growers’ level of involvement in water conservation practices. While monetary investment may be a barrier, regulatory enforcement may turn into a mandatory motivation of adoption by growers of these conservation practices. Therefore, efforts should be made to develop low-cost water conservation technologies and to provide research-based information to both policymakers and growers about the challenges to the nursery industry when policy changes are being considered or are enacted. Three-way communication about water regulations may be needed between educators, policymakers, and nursery growers to reach a balance related to the regulation of water consumption within the nursery industry.

Future studies, replicating this study, are recommended to explore other nursery growers who are not part of water conservation projects/programs with researchers to reveal their opinions and perceptions and broaden the application of results from this study. Comparison studies can also be conducted to identify the differences in opinions and perceptions between conservation-engaged growers and non-conservation-engaged growers.

Moreover, newly developed water conservation technology and practices should be evaluated to explore growers’ use experiences for further adjustment and improvement of those technologies and practices based on growers’ feedback. By knowing more about nursery growers’ thoughts and needs related to water conservation technologies and practices, more user-friendly water conservation technologies and practices can be developed, and improved adoption rates can be expected.

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