BY DARA M. PARK, PH.D., AND KELSEY L. GORMAN

Cycling water sources

Freshwater affects saline-irrigated bermudagrass' quality and soil salinity

Water conservation is on everyone's minds these days. Proper water management ensures freshwater for human needs, the protection of ecosystem integrity and the sustainability of products (e.g., aquaculture) and services (e.g., recreational) provided by freshwater ecosystems (Richter et al. 2003). Considering less than 1 percent of the world's freshwater is accessible, according to the World Health Organization, and the world's increasing population (the World Water Council expect a 40- to 50-percent increase within the next 50 years), if water conservation isn't taken seriously, we're in trouble.

Subsequently, strict water regulation and restrictions are inevitable and on the horizon.

Using alternative water sources is one conservation mechanism that's becoming more popular. These sources include reclaimed wastewater, tidally influenced streams and rivers, reclaimed stormwater runoff and saline groundwater aquifers. In a national survey taken in 2007, 15 percent of all surveyed golf course facilities began using an alternative water source since 1996 (Lyman et al.).

While this is by far one of the most innovative and practical techniques to reduce freshwater use, using alternative water sources can be challenging to manage. For example, the No. 1 problem superintendents typically face when using reclaimed wastewater is salinity (Dion and Ray, 2008; Cisar et al., 2005). Actually, most of the alternative water sources mentioned above have some amount of solutes that must be controlled to maintain quality turfgrass. Even reclaimed stormwater runoff can have high amounts of salts (because of salt that's applied to roads to melt ice and other factors).

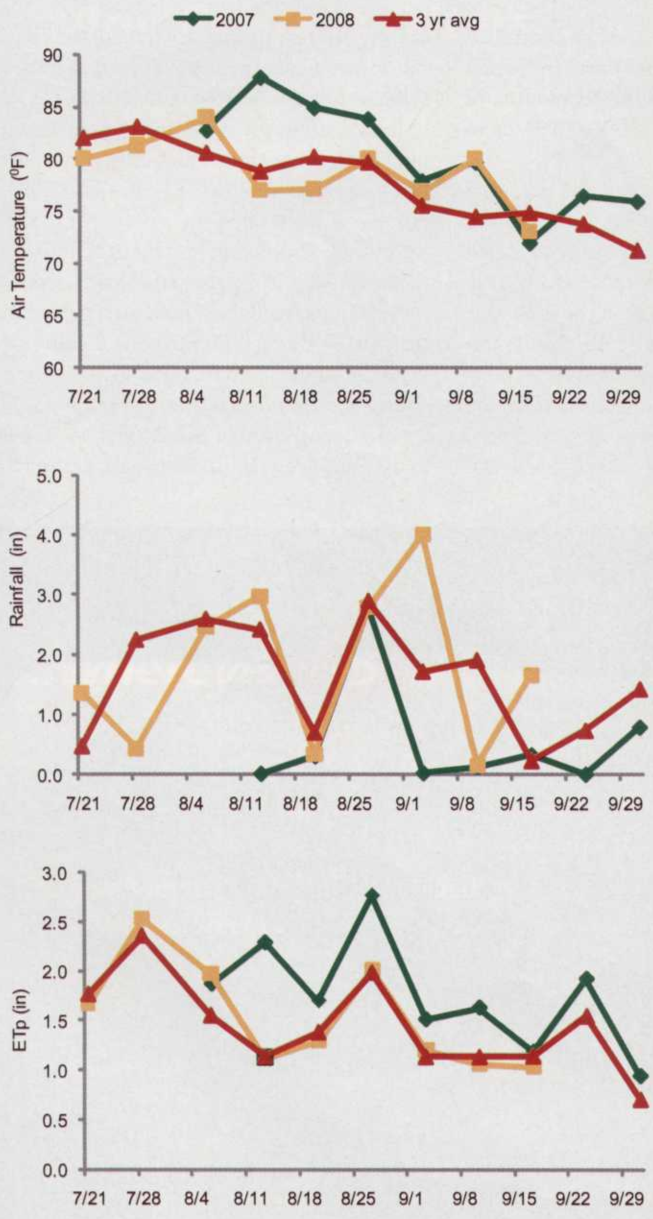
Past field-scale research about the potential and management of using saline water sources to irrigate golf course grasses has been conducted primarily in the Southwest with relatively little research conducted elsewhere in the U.S. This focus is most likely because of the arid conditions of the region. The research that has been conducted in the Southwest documents that the success of using saline water sources is dependent on turfgrass species (and cultivar), degree of salinity, the texture and structure of the underlying soil and management method. Ultimately, saline water can be used in many cases.

In one study, scientists maintained turfgrass by cycling saline water with freshwater for irrigation (Schaan et al., 2003). The freshwater helped dilute and leach deposited solutes from the intermittent saline water irrigations. Compared to the Southwest, irrigation in the Southeast is used only to supplement the somewhat regular rainfall that occurs throughout the year. If using saline water for supplemental irrigation, perhaps these natural freshwater irrigations (the rainfall) can act in a similar manner as what was documented in the Southwest. If so, water conservation from

Cores were collected before and after the experiment to determine if irrigating with saline water influenced stolon density and root mass.

2007 AND 2008 EXPERIMENTAL PERIODS

Figure 1. Air temperature, rainfall and predicted Evapotranspiration (ETp) during the two experimental periods and the three year average (2003-2006).



using saline water for irrigation documented in the Southwest may be conservative for the Southeast.

To test if rainfall was enough to supplement saline water irrigations in the Southeast, an experiment was conducted at Clemson University's Pee Dee Research and Education Center in Florence, S.C. The experiment was conducted for eight weeks during the summer, which is the time of least rainfall, high water demand for plants and high potable water demand along the South Carolina coast. The experiment was conducted twice, August through September 2007 and July through August 2008.

METHODS AND MATERIALS

A field-scale facility was constructed on the native loamy sand soil (Bonneau series). The facility and experiment were constructed to investigate multiple factors at any one time. This article addresses only the facility's use for investigating the influence of irrigation water source on bermudagrass quality, growth and soil salinity.

Sixteen 9.8-feet-by-12.1-feet plots were delineated and sodded with Tifway (419) bermudagrass (*Cynodon transvaalensis* Burtt-Davy x C. dactylon (L.) Pers.). The two irrigation treatments were freshwater (mean: 0.08 dS m-1, range: 0.07–0.09 dS m-1) and saline (mean: 3.19 dS m-1, range: 2.59–3.52 dS m-1) randomized with four replications. The freshwater source was from the Florence County municipality. The saline treatment stock solution was based on the salt composition of salt water off the South Carolina coast (35 dS m-1).

Salts were mixed in a 30-gallon mixing tank and then emptied into a 6,000-gallon holding tank in which the solution was diluted with freshwater. Each plot was irrigated using a subsurface drip irrigation system buried between 6- and 8-inches deep and spaced 32 inches apart. Irrigation was applied three times a week (Monday, Wednesday and Friday) to replace 100-percent potential evapotranspiration (ET) based on three years of pan ET data collected from a weather station located on site. If a rain event occurred resulting in greater than 0.33 inches of precipitation, the following scheduled irrigation was voided.

The bermudagrass was managed under fairway conditions, mowed three times a week (Monday, Wednesday and Friday) at a height of 1 inch. A complete fertilizer (Harrell's 18-4-6 SLR) was injected into the irrigation system at a rate of 0.25 pound of nitrogen per 1,000 square feet every two weeks to the bermudagrass.

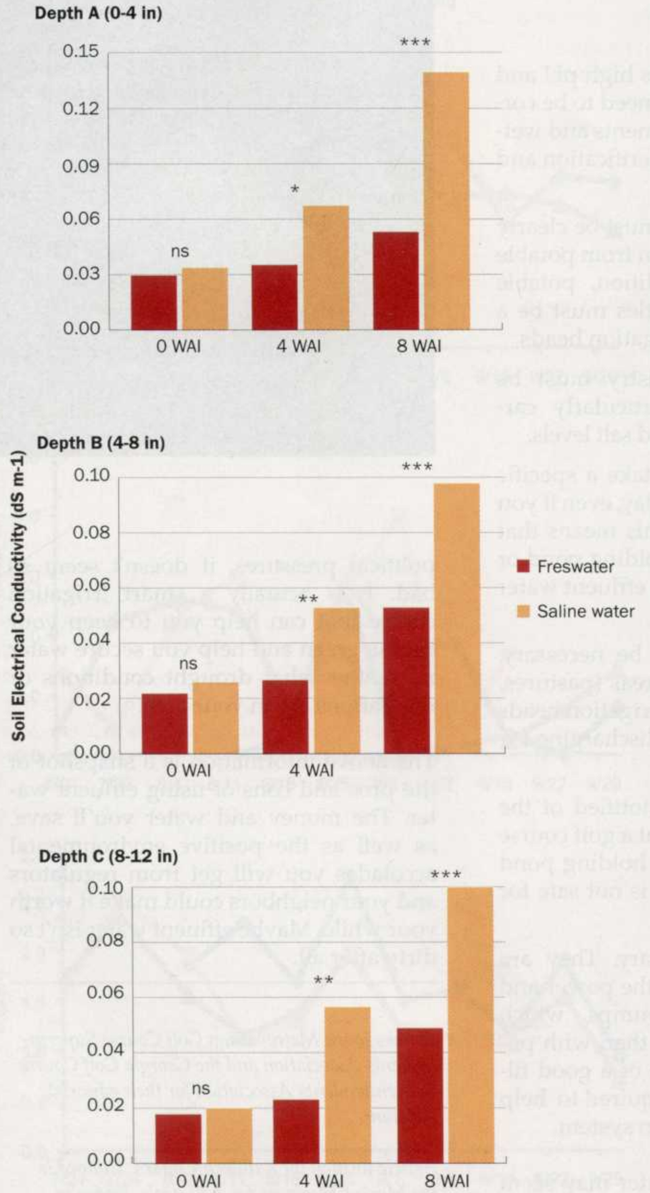
OBSERVATIONS AND MEASUREMENTS

Every Monday, turfgrass quality was assessed visually on a scale of 1 to 9 (9 = dark green turf, 1 = dead/brown turf, and 6 = minimally acceptable turf). To assess turfgrass growth, clipping samples were collected from a 16-square-foot area from each plot before every mowing. Clippings were combined throughout the week after drying at 140 F to measure dry-weight yield (pound per 1,000 square feet).

For each year, 2-inch diameter cores were taken to a depth of 12 inches at zero and eight weeks after initiation. The pelt was removed, and stolons were counted as a quantitative means to determine density. The remainder

2007 ELECTRICAL CONDUCTIVITY

Figure 2. During the 2007 experimental period, soil solutes accumulated with use of saline water as an irrigation source. WAI= weeks after initiation. ns= no significant difference between treatments. Increase in the number of stars means an increase in significant differences between treatments: *=P<0.10, **=P<0.05, and ***=P<0.01.



of the core was partitioned into two samples (0 to 6 inches and 6 to 12 inches), then washed of the mineral portion leaving just roots. Washed roots were ashed and weighed to evaluate below ground growth.

To monitor soil salt accumulation, 2-inch diameter cores from the 0 to 4, 4 to 8 and 8 to 12 inches of the soil (depths A, B, and C, respectively) were collected at zero, four and eight weeks after initiation. Cores were brought into the laboratory and soil electrical conductivity (ECe) was measured from a 1:2, soil/water mixture. Irrigation and rainfall water samples were collected periodically for electrical conductivity determination.

Significant means for all measurements and observations were identified by analysis of variance using the general linear model of SAS Software (Ver. 9.1, SAS Institute, Cary, N.C.).

RESULTS AND DISCUSSION

The two summers during which this experiment was conducted represented two different types of weather patterns in the South Carolina Coastal Plains (Figure 1, page 66). Low rainfall, higher than normal temperatures and ET dominated the 2007 experimental period. According the U.S. Drought monitor (http://drought.unl.edu/dm), the beginning of the 2007 experimental period was characterized as abnormally dry. By the end of the experimental period, it was characterized as an extreme drought.

These drought conditions made for a great time to examine what would happen under a worst-case scenario. During the 2007 experimental period, an irrigation event was voided only once. In contrast, the 2008 experimental period was more similar to the region's typical weather (Figure 1). Rainfall was plentiful, and 10 out of the 24 scheduled irrigations were voided.

Although some individual plots in the 2007 experiment were rated below the minimal acceptance criterion of 6, average quality was always above 6 for both water source treatments. Generally, quality increased throughout the experimental period from an average of 7 to 7.9. Only for weeks two, four and five, did freshwater-irrigated turfgrass have greater quality (7.8, 7.3 and 7.5 for weeks two, four and five, respectively) than saline water irrigated turfgrass (6.8, 7.1 and 7.0 for weeks two, four and five, respectively). The week before these ratings, minimal to no rainfall occurred.

Weekly composite clipping yields were the same regardless of water source and ranged from 0.88 to 2.15 pounds per 1,000 square feet.

At the end of the experiment, shoot density and root mass in the upper six inches were greater from saline-irrigated bermudagrass (77.5 stolons 10 in-2 and 0.051 oz 100 in-3 for shoot density and root mass, respectively) compared to freshwater-irrigated bermudagrass (54.8 stolons 10 in-2 and 0.038 oz 100 in-3 for shoot density and root mass, respectively).

This result may sound counterintuitive, but this positive response from irrigating with low level saline water can be attributed to the adaptive mechanisms bermudagrass commences once recognizing the solutes. Bermudagrass blades have salt glands to excrete saline ions, thus the more blades the more salt glands available for solute excretion (Marcum and Pessarakli, 2006). To increase water uptake, roots elongate creating more surface area, ultimately increasing mass, too (Dudeck et al., 1983).

As expected, ECe increased during the experimental period at each depth (Figure 2). However, even the highest of ECe value (0.30 dS m-1) was below the threshold values of 9 and 12 dS m-1 in which problems begin to occur.

While the 2007 experiment was conducted during drought conditions, the 2008 experiment was conducted during more typical weather patterns (Figure 1). Although rainfall was abundant and reduced the need for supplemental irrigation, irrigating with saline water resulted in weekly average quality scores to be 0.1-0.5 points (an average of 0.2) lower than when irrigating with freshwater. Quality from individual plots was always greater than 6, and was less variable week to week during the 2008 experimental period compared to 2007's experimental period.

As in 2007, clippings weren't influenced by water source. Neither were shoot density and root mass at the lower depth. However, root mass in the upper six inches was greater in saline-irrigated bermudagrass compared to freshwater-irrigated bermudagrass (0.053 and 0.038 oz 100 in-3 for saline and freshwater, respectively). Mostly attributed to the abundance of rainfall, ECe was similar for the two water source treatments.

CONCLUSIONS

Using saline water sources for irrigation during times of high freshwater demand can considerably reduce the pressure on freshwater resources. Based on Westcot and Ayers (1985), irrigation water sources greater than 0.75 dS m-1 can begin to cause problems for soil structure and plant use.

In this experiment, bermudagrass was irrigated with a saline water source that on average was 3.19 dS m-1, thus considered a high hazard to plants and soils. Under drought conditions, there were minimal quality differences between bermudagrass irrigated with freshwater compared to saline water. During times of severe drought stress, supplemental irrigation may be necessary depending on the aesthetics requirements. When rainfall was abundant, saline-irrigated bermudagrass had slightly lower quality, but the quality was still good and more consistent over time than during the drought period. At these times, no additional freshwater irrigation would be required.

Saline water irrigations didn't result in excessive top growth; thus, superintendents can expect not to have to change their mowing frequency when irrigating with saline water. If long-term use of saline water is expected with no cycling of freshwater (regardless if it's through irrigation or rainfall), superintendents are advised to monitor their soil salinity, especially in nonsandy textured soils. **GCI**

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IMPACT ON THE BUSINESS

Praying for rain

BY MARISA PALMIERI

Effluent water has been the primary irrigation source at the Royal Poinciana Golf Club in Naples, Fla., since 1989. The 36-hole club has a small emergency back-up of accumulated rainwater, but aside from that, it operates with 100-percent effluent water provided by the city of Naples.

At first, the facility's switch to effluent was voluntary, but now the South Florida Water Management District mandates effluent be used if it's available.

The main side effect – high sodium and bicarbonate levels – is something Matt Taylor, CGCS, pays close attention to. Taylor, director of golf course operations, says sodium levels are typically between 350 and 500 parts per million; bicarbonates register between 125 and 150 parts per million.

Royal Poinciana has Champion bermudagrass greens. One course has TifEagle tees and 419 bermudagrass fairways and roughs. The other is wall-to-wall Celebration bermudagrass.

"We test the water regularly right from the source," Taylor says about the tests that take place quarterly at least. "Then we measure what's in the soil. Between the two of those, we come up with our management plan."

The first part of the plan focuses on aerification.

"We is spike all the greens once a week," says Taylor, who has been at the club since 2000.

This practice keeps the top of the soil loose so water penetrates the surface and flushes out the sodium and bicarbonates.

Another strategy is to amend the soil. Taylor applies acidifying fertilizers to mitigate the bicarbonate issue and applies gypsum, also known as calcium sulfate, which helps move sodium through the soil.

Taylor applies gypsum once a month at a rate of 25 to 50 pounds per thousand square feet, depending on sodium levels.

In a perfect world, the club would have a dual system to cycle in freshwater occasionally, but it doesn't have the ability to do that because freshwater isn't available.

"Some superintendents try to run additional effluent water through to try to flush the greens that way," Taylor says. "We've tried that in the past, but I'm not sure how successful that is. You're just putting down more sodium and bicarbonates and potentially flushing the nutrients through, too. I'd rather regulate it with gypsum and pray for rain."

The Naples region receives about 53 inches of precipitation annually.

"When it rains, you can definitely tell," Taylor says. "If you get a half inch during the season, it brightens things up." GCI