Soil Moisture Sensors to Reduce Reclaimed Water Irrigation of Landscapes

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Abstract. *Soil moisture sensor systems (SMSs) have demonstrated that they can reduce irrigation application in Florida. However, SMSs have not been tested under Florida soils irrigated with reclaimed water, which contains salts that can affect the measured soil water content. The objective of this research was to assess the potential water savings of different methodologies, including SMS controllers, in homes that use reclaimed water to irrigate their landscapes. Research was conducted in Pinellas County, Florida, in 64 cooperating homes that had pre-existing automated in-ground irrigation system. A dedicated irrigation flowmeter was installed at every participating home. Additional equipment was installed to complete the treatments, as follows: a) 16 homes with a rain sensor, b)16 homes with a rain sensor and educational materials, c) 16 homes with a SMS, and d) 16 homes with no additional equipment (typical for the region), which were monitored only (MO). Preliminary results (16 months) show that homes with SMSs averaged 1.5 irrigation events/week, while all other treatments averaged 2.4—2.9 events/week. Consequently, SMSs was the only treatment that resulted in significant water savings (58%) compared to treatment MO. Turfgrass quality was not significantly different between treatments. This study is expected to continue through 2013.*

Keywords. Reclaimed water, rain sensor, soil moisture sensor, turfgrass quality, water savings.

Introduction

Of the commercially available soil moisture sensor systems (SMSs) for residential use, the most common type is known as an “add-on” device. These SMSs consist of a probe to be inserted in the root zone and a controller to be connected to the time clock, or timer, of an automated irrigation system. On the controller, the user can set a soil water content threshold and, by this means, the SMS will allow or bypass a scheduled irrigation cycle, depending on the soil water content at the programmed start time.

Research performed with these types of SMSs has demonstrated that they can save water under both turfgrass plot conditions (Cardenas-Lailhacar et al., 2008 and 2010; McCready et al., 2009; Grabow et al., 2012) and homeowner settings (Grabow et al., 2010; Haley and Dukes, 2011), while maintaining acceptable turfgrass quality. However, SMSs have not been tested under homeowner conditions where the landscape is irrigated with reclaimed water. This source of irrigation usually contains more salts than potable water. These salts may alter the dielectric permittivity of the soil and, hence, affect the readings of SMSs when measuring the soil water content.

The goal of this on–going research is to evaluate the performance and water conservation potential of a soil moisture sensor system (SMS) in homes that use reclaimed wastewater (RW) as their source for irrigation. Additionally, other water conservation methods that could improve the efficiency of irrigation water application—including rain sensors and educational materials—are being used and compared.

Materials and Methods

To recruit cooperating homes, Pinellas County Utilities (PCU) sent to the University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS) a list of home addresses that were already connected to RW. From that list, UF/IFAS selected five subdivisions in the vicinity of the city of Palm Harbor, Pinellas Co., Florida, and sent letters inviting them to participate in this research project and, if interested, asked them to respond an on-line survey regarding their irrigation systems and practices.

Taking into account the responses to the survey, a total of 98 homes were pre-selected with already installed automated in-ground irrigation systems, connected to RW, and established St. Augustinegrass (*Stenotaphrum secundatum* [Walt.] Kuntze) to limit variability in water use and turfgrass quality across treatment groups. All of these irrigation systems were evaluated at no cost to the homeowners. The objectives of these evaluations were: to check if the homes met the project requirements, to assess if there were some repairs required before the project initiation, to measure the irrigated area, to evaluate which treatment they would be most suitable, and to define the location of any additional equipment.

From the houses visited, 64 were recruited for the study. On every home, a dedicated positive-displacement flowmeter (25.4 mm C-700, Elster AMCO Water, Inc., Ocala, Fla.) was installed to measure the amount of RW used for irrigation. An automatic meter reading (AMR) system (Datamatic, Ltd., Plano, Tex.), which consists of a sensor and a datalogger, was affixed to every installed flowmeter to record, at hourly intervals, the frequency and amount of RW used per irrigation event. Knowing the amount of water applied per irrigation event at each home, as well as their irrigated area, the depth of water applied was then calculated and compared between the different homes and treatments.

The 64 homes selected were split into 4 treatments, with 16 replicates (homes) each, as follows: a) 16 homes with no additional equipment (typical for the region), which were monitored only and used for control/comparison purposes, coded as MO; b) 16 homes with an additional soil moisture sensor system, coded as SMS; c) 16 homes with an additional rain sensor, coded as RS; and d) 16 homes with an additional rain sensor, and where the homeowners received educational materials with instructions on adjusting their irrigation timers seasonally. These materials are customized considering their irrigation system and area under irrigation; coded as EDU. The comparison treatment (MO) did not have any control technology other than the existing timer, common to all homes.

The location of the different rain sensor and soil moisture sensor units was determined in situ, during the irrigation system evaluations. The SMS probes (Acclima/SCX/Digital TDT, Acclima Inc., ID) were buried in a representative zone on each treatment home, following UF/IFAS recommendations (Dukes et al., 2009). The auto-calibration feature of the SMS described in the product's manual was used to set the site-specific thresholds. The wireless RSs (RS-1000, Irritrol Systems Inc., Riverside, CA) were set at a threshold of 6 mm (¼"). The SMS and RS technologies installed correspond to "add-on" devices that were connected to the existing timers. After installing the equipment, project personnel purposefully limited interaction with all cooperators, to obtain results that corresponded to actual homeowner practices.

In addition to water use data collection, turfgrass quality was rated bi-monthly and turf photographs were taken. Initial turfgrass quality ratings were taken for each home during the irrigation evaluations, as a baseline comparison for each home and to estimate potential turfgrass quality decline based on treatments. The turfgrass quality assessment is a subjective process following the National Turfgrass Evaluation Procedures (Shearman and Morris, 1998) based on visual estimates. The rating scale is from 1 to 9, with 1 being poorest or dead and 9 being highest quality possible. A rating of 5 was considered minimally acceptable for home landscapes. The same person conducted turf quality ratings throughout the study.

Partial data reported here were obtained from November 2010 through February 2012. Statistical analyses for irrigation and turfgrass quality data were performed using SAS (2008) with the general linear model procedure (proc GLM) and the mixed model procedure (proc MIXED). Analysis of variance was used to determine treatment effects, and Duncan's multiple range test was used to identify mean treatment differences. Differences were considered significant at a confidence level of 95% or higher ($p \leq 0.05$).

Results and Discussion

Table 1 contains the average irrigation applied per event, the average number of irrigation events per week, the average irrigation depth per week, and the cumulative irrigation for the testing period (November 2010-February 2012) by treatment. It also shows the water savings of treatments RS, EDU, and SMS, compared to treatment MO.

There were no statistical differences in the average depth of water applied per irrigation event between the different treatments during this study (Table 1) and, therefore, differences in water application should be the effect of the different methods/technologies tested to control irrigation. Treatments MO, RS, and EDU recorded significantly more irrigation events per week (between 2.4 and 2.9) than treatment SMS (1.5 irrigation events per week). The number of irrigation events per week for treatments MO, RS, and EDU, agrees with the regular RW restrictions of 3 days per week for Pinellas County Utilities customers (PCU, 2012) during the dry season (April 1 to June 30 and October 1 to November 30). However, this average seems high considering the lower net irrigation requirement during the summer rainy months and the lower evapotranspiration during the two winter seasons tested.

The greater amount of irrigation events per week for treatments MO, RS, and EDU (compared to SMS), resulted in a depth of water applied by these treatments (36 to 43 mm per week) that was significantly higher than treatment SMS (19 mm per week). This last value agrees with the generally recommended single application amount for a sandy soil in Florida (Dukes, 2011).

The cumulative depths of water applied over the 16-month data collection period (Table 1) by treatments MO, RS, and EDU were, again, not different from each other, but significantly different from SMS. This suggests that SMSs can save a significant amount of water compared to the other methods/technologies tested. In this study SMSs saved an average of 58% of the water applied by the homes with no additional irrigation technology other than the irrigation timer (MO). In addition, these water savings did not have a detrimental effect on the turf quality. These results are similar to those found in a study carried out in this same testing area, over a period of 26 months, in homes irrigating with potable water, where SMSs reduced irrigation 65% relative to the comparison group (MO). Similar results were obtained on other studies in Florida, under field plot conditions, where SMS savings averaged 72% during frequent rainfall conditions (Cardenas-Lailhacar et al. 2008) and 54% during dry weather conditions (Cardenas-Lailhacar et al. 2010).

Throughout the 16 months of data collection, no significant differences in average site turfgrass quality ratings were detected among homes based on treatment group (data not shown). In general, turfgrass quality was always above the minimum acceptable (i.e., >5) and, in some cases, even rated as exceptional quality (i.e., 8–9), indicating that irrigation was not restricted in a way that could be detrimental for turfgrass quality.

Conclusions

The SMS treatment was the only group of homes significantly different to the comparison treatment, MO; reducing the average number of irrigation events per week (1.5 vs. 2.9 events/week, respectively), decreasing the depth of the weekly irrigation (19 vs. 43 mm, respectively) and reducing the total cumulative irrigation depth (1091 vs. 2620 mm, respectively). Consequently, SMSs reduced irrigation by 58% compared to the MO group over the 16 months of data collection period. This percent reduction of irrigation water use concurs with those yielded in controlled plot studies and in residential settings using potable water as their irrigation source. Consequently, the amount of salts contained in the RW used for irrigation in this study does not seem to be affecting the SMS readings of the soil water content and, therefore, letting SMSs to adequately bypass unnecessary irrigation events.

These water savings occurred without detriment to the turfgrass quality (which was always above the minimum acceptable rate of 5), and no significant differences in average site turfgrass quality ratings were detected among homes based on treatment group.

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Table 1. Average actual irrigation applied per event, number of irrigation events per week, irrigation depth per week, and cumulative irrigation (November 2010-February 2012) by treatment, and water savings compared to treatment MO.

Treatment[Z]	Actual Irrigation				Water savings (%)
	Per event (mm)	Events per week (#)	Per week (mm)	Cumulative (mm)	
MO	15.2 n/s[x]	2.9 a	43 a[y]	2620 a	0
RS	17.0 n/s	2.4 a	40 a	2440 a	7
EDU	14.9 n/s	2.4 a	36 a	2194 a	16
SMS	13.0 n/s	1.5 b	19 b	1091 b	58

[Z] Treatments are: MO, timer only; RS, timer plus rain sensor; EDU, timer plus rain sensor plus educational materials; SMS, timer plus soil moisture sensor system.

[y] Different letters within a column indicate statistical difference at $P<0.05$ (Duncan's multiple range test).

[x] n/s = No significant difference .