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Irrigation by Evapotranspiration-Based Irrigation Controllers in Florida

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Abstract. *Despite limited water resources, the need for irrigation will continually grow with increased population without change in the demand for aesthetically pleasing landscapes. The objective of this study was to evaluate the ability of three ET-based controllers to schedule irrigation compared to a time irrigation schedule representative of a homeowner. Twenty plots were partitioned into 65% St. Augustinegrass and 35% mixed-ornamentals to represent a typical Florida landscape plant composition. The five replicated treatments were: ET controller A, ET controller B, ET controller C, a time-based treatment determined by UF-IFAS recommendations and a time-based treatment that is sixty percent of the previous time-based treatment. Results showed that the ET controllers resulted in 35%-42% average water savings compared to a time clock schedule without a rain sensor while maintaining acceptable turfgrass quality. Also, average potential water savings by using a rain sensor at a 6 mm threshold was 21% over the study period.*

Keywords. Controllers, Evapotranspiration, Florida, Irrigation, Turfgrass, Water Conservation

Introduction

Similar to the water shortages seen in other parts of the United States, Florida has become increasingly aware of the limitations in the availability of its water resources. It is estimated that over half of total fresh water is used for irrigation (Hutson et al., 2004). It was found in recent research that 71% of residential water use was used for irrigation (Baum et al., 2003). As a result, new methods must be explored for outdoor water conservation to maintain the high demand for aesthetically pleasing urban landscapes from continually increasing populations in Florida.

Evapotranspiration (ET), defined as the evaporation from the soil surface and the transpiration through plant canopies (Allen et al., 1998), is the exchange of energy for outgoing water at the surface of the plant (Allen et al., 2005). The components used to estimate ET are solar radiation, temperature, relative humidity, and wind speed (Allen et al., 2005). Evapotranspiration-based controllers, also known as ET controllers, are irrigation controllers that use an estimation of ET to schedule irrigation. These controllers are typically programmed with landscape-specific conditions making them more efficient (Riley, 2005).

The objective of this study was to evaluate the ability of three brands of ET-based controllers to schedule irrigation by comparing irrigation application to a time clock schedule intended to mimic homeowner irrigation schedules. The controllers should also be able to maintain acceptable turfgrass quality regardless of water savings results.

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Materials and Methods

This study was primarily conducted at the University of Florida Gulf Coast Research and Education Center (GCREC) in Wimauma, Florida. There were a total of twenty plots that measured 7.62 m x 12.2 m. Each plot consisted of 65% St. Augustinegrass (*Stenotaphrum secundatum* 'Floratam') and 35% mixed ornamentals to represent a typical residential landscape plant composition in Florida. This research reports on the turfgrass portion of each plot. Landscapes were maintained through mowing, pruning, edging, mulching, fertilization, and pest and weed control according to current UF-IFAS recommendations (Black and Ruppert, 1998; Sartain, 1991). Each plot contained separate irrigation zones for turfgrass and mixed ornamentals.

Five treatments were established and replicated four times for a total of twenty plots in a completely randomized block design. The irrigation treatments were as follows:

- ET controller A;
- ET controller B;
- ET Controller C;
- TIME, a time-based treatment determined by UF-IFAS recommendations (Dukes and Haman, 2002); and
- RTIME, a time-based treatment that is 60% of T4.

The ET controllers were as follows: Intelli-sense (Toro Company, Inc., Riverside, CA) utilizing the WeatherTRAK ET Everywhere service (Hydropoint Datasystems, Inc., Petaluma, CA), SL1600 controller with SLW15 weather monitor (Weathermatic, Inc., Dallas, TX), and Smart Controller 100 (ET Water Systems LCC, Corte Madera, CA). All treatments utilized rain sensors set at a 6 mm threshold.

There were five periods of data collection:

- 13 August, 2006 through 30 November, 2006 as fall 2006;
- 1 December, 2006 through 26 February, 2007 as winter 2006-2007;
- 27 February, 2007 through 31 May, 2007 as spring 2007;
- 1 June, 2007 through 31 August, 2007 as summer 2007; and
- 1 September, 2007 through 30 November, 2007 as fall 2007.

Data collected over these time periods included irrigation water applied per plot from totalizing flow meters and turfgrass quality measurements. More information on the additional results from this research can be found in Davis (2008).

The ET controller treatments were programmed with two days per week watering restrictions during fall 2006 and winter 2006-2007, Wednesday and Saturday, and no watering between 10 am and 4 pm. Also, the controllers were programmed with maximum system efficiencies over these periods that resulted in 95-100% efficiencies depending on the maximum efficiency value allowed by the individual controllers. All ET controllers were updated to allow irrigation everyday with an 80% efficiency determined from on-site uniformity testing from spring through fall 2007.

The time-based treatments were programmed with two days per week watering restrictions for all five periods. Fall 2006 and winter 2006-2007 applied 60% of the net irrigation requirement derived from historical ET and effective rainfall specific to south Florida (Dukes and Haman, 2002) and RTIME applied 60% of the irrigation depth calculated from TIME equaling 36% of the net irrigation requirement. TIME was increased to apply irrigation to replace 100% of the net irrigation requirement instead of 60% used during the first two periods. Once again, RTIME applied 60% of TIME resulting in the reduced treatment applying 60% of the net irrigation requirement. Irrigation runtimes for these treatments were adjusted monthly.

Results were quantified by comparing all treatments to a time-based treatment without a rain sensor (TIME WORS). The time-based treatment without a rain sensor was derived from TIME by including water application from irrigation events that were bypassed due to rain and was not an actual treatment. Turfgrass quality was measured monthly using the National Turfgrass Evaluation Program (NTEP) standards (Shearman and Morris, 2006). The turfgrass was rated on a scale from 1 to 9 where 1 represented dead turfgrass or bare ground, 9 represented an ideal turfgrass, and 5 was considered minimally acceptable quality for a residential setting.

SAS statistical software (SAS Institute, Inc., Cary, NC) was used for all statistical analysis, utilizing the General Linear Model (GLM) procedure with a confidence interval of 95%. Means separation was conducted using Duncan's multiple range test.

Results and Discussion

All treatments resulted in substantial savings compared to the TIME WORS treatment for fall 2006 (Table 1). RTIME showed the most savings at 55% due to an error in the October schedule for south Florida (Dukes and Haman, 2002) causing extremely low water application for this month. TIME had 28% savings also due to the low watering schedule in October. Savings from the ET controller treatments A and B fell between the other treatments by saving 38% and 39%, respectively. The ET controller C did not function during this period due to circuitry problems and results were not reported.

Fall 2006 average turfgrass quality ratings were below the minimally acceptable value of 5.0 for all treatments due to pest problems and fungal disease. All of the turfgrass plots suffered from an infestation of chinch bugs (*Blissus insularis* 'Barber') and a fungal disease known as Curvularia. Damaged turfgrass was replaced with new sod during the week following 26 September, 2006; no more than 25% of any plot was resodded and most of the damage was located along the edges of the plots where irrigation coverage was marginal.

Winter water application was less than any other period due to the reduced climatic demand. The ET controller A saved 50% and ET controller B saved 60% compared to TIME WORS (Table 2). TIME and RTIME respectively had savings of 20% and 49%. Both ET controller treatments, A and B, applied less water than RTIME unlike any other time of year. The ET controller C remained nonfunctional during this period. The ET controller treatments showed the potential to save over 50% of water applied in subsequent winter periods. Turfgrass quality ratings were above minimum acceptability ranging from 5.7 to 6.0 and were not different across treatments.

Spring 2007 water savings by all treatments compared to the TIME WORS treatment ranged from 9% by ET controller A to 50% by the RTIME (Table 3). The ET controller B and TIME had similar savings of 15% and 18%, respectively. The time-based schedules, TIME and RTIME, applied irrigation during every scheduled event for the months of March and May due to lack of rainfall. Irrigation savings by the ET controller treatments were based purely on their ability to match irrigation application with environmental demand and not affected by the variability of the rain sensor during these two months. All treatments maintained similar turfgrass quality ratings above the minimally acceptable level, averages ranging from 6.1 to 6.4, and were not different from each other (Table 3). Despite the reduced watering by RTIME in the spring 2007 period, the reduced time-based schedule still had an above average turfgrass quality rating.

The ET controller C resulted in 30% savings compared to TIME WORS (Table 3) in the Spring of 2007. The ET controller C frequently had poor signal strength and the irrigation schedule was not updated from 9 April, 2007 through 23 May, 2007 causing the 9 April schedule to continually apply until communication was re-established. Thus, the water application rate stayed constant throughout the spring period while the other treatments increased the irrigation rate (i.e., frequency) based on increased climatic demand and little rainfall. The 30% irrigation savings attributed to this controller was an over-estimate due to the constant irrigation rate in the spring. This controller also would not recognize a rain sensor despite repeated attempts with customer service to repair.

Water savings for summer 2007 by all treatments compared to the TIME WORS treatment (Table 4) ranged from 31% by TIME, to 63% by RTIME. Savings from the ET controller treatments, B and C, fell between the other treatments by saving 41% and 45%, respectively. Turfgrass quality ratings were not different across treatments (P=0.933) and remained above the minimally acceptable levels. A power outage caused by lightning occurring on 8 June, 2007 damaged the equipment associated with ET controller A, which resulted in a gap in calculated ET for that controller. Since ET controller A did not operate based on an ET schedule, data for this controller was removed for this period. The ET controller C continued to apply irrigation every day without a functional rain sensor.

Fall 2007 savings were once again seen by all treatments compared to TIME WORS (Table 5). The ET controller A saved 43% compared to TIME WORS while ET controllers B and C saved 59% and 50%, respectively. Both TIME and RTIME also showed water savings from 15% to 50%. Turfgrass quality was similar across all treatments and higher than the minimally acceptable value of 5, ranging from 6.4 to 7.1; quality was not different between treatments (P=0.170).

When operating properly, all ET controller treatments exhibited considerable savings compared to TIME WORS for every period except spring 2007. This occurred because the time-based treatments were developed considering historical effective rainfall. However, the spring 2007 period experienced very little rainfall and an increase in the demand for irrigation. Even though more irrigation occurred compared to the time-based treatments, the ET controllers were reacting to climatic demands based on real-time conditions and as opposed to historical weather data.

Water savings by the ET controller treatments were similar between the brands when compared over the same periods.

TIME, developed from 100% replacement of the net irrigation requirement, consistently applied more cumulative irrigation compared to the ET controller treatments. Also, RTIME applied the least amount of water in all periods except winter 2006-2007 and fall 2007. However, turfgrass quality remained above the minimally acceptable level for both treatments with no statistical differences between the ratings. As a result, 60% replacement of net irrigation requirements is appropriate for effective water application assuming good uniformity and average weather conditions.

Conclusions

All treatments applied less water compared to TIME WORS. The average potential water savings across all periods averaged 35% - 43% for ET controllers. Maximum and minimum savings were seen over winter 2006-2007 and spring 2007, respectively, as responses to climatic demand. Also, average potential water savings by using a rain sensor at a 6 mm threshold was 21% over the entire study period. These savings occurred even during dry conditions due to scheduling only two irrigation events per week.

The reduced time-based treatment, T5, resulted in similar water savings as ET controllers with no differences in turfgrass quality. As has been shown in previous research in Florida, changing time clock settings throughout the year can result in substantial irrigation savings. The reduced time-based schedule (T5) only replaced 36% of the net irrigation requirement in Fall 2006 and winter 2006-2007, but still irrigated more in the winter compared to the ET controller treatments. Time-based treatments were developed from the historical net irrigation requirement for the area resulting in less water applied than if scheduled without using historical ET and effective rainfall. However, time-based schedules do not fluctuate with changing weather conditions and typical homeowners will not manually adjust on a regular basis. Thus, the ET controllers show promising results for consistent water savings.

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Table 1. Fall 2006 savings compared to the time WORS treatment[1] using cumulative period totals and turfgrass quality[2]

Controller	Savings compared to time WORS	Turfgrass quality[3]
A	38%	4.8 *a*
B	39%	4.9 *a*
C	--[4]	--
TIME	28%	4.7 *a*
RTIME	55%	4.8 *a*

[1]The time WORS treatment refers to the time-based treatment without a rain sensor theoretically derived from T4.
[2]Turfgrass quality ratings used a 1 to 9 scale where 1 was of lowest quality, 9 was of highest quality, and 5 was minimally acceptable.
[3]Numbers with different letters in columns indicated differences at the 95% confidence level using Duncan's Multiple Range Test.
[4]Indicates nonfunctional treatments.

Table 2. Winter 2006-2007 savings compared to the time WORS treatment[1] using cumulative period totals and turfgrass quality[2]

Controller	Savings compared to time WORS	Turfgrass quality[3]
A	50%	5.7 *a*
B	60%	5.9 *a*
C	--[4]	--
TIME	20%	6.0 *a*
RTIME	49%	5.7 *a*

[1]The time WORS treatment refers to the time-based treatment without a rain sensor theoretically derived from T4.
[2]Turfgrass quality ratings used a 1 to 9 scale where 1 was of lowest quality, 9 was of highest quality, and 5 was minimally acceptable.
[3]Numbers with different letters in columns indicated differences at the 95% confidence level using Duncan's Multiple Range Test.
[4]Indicates nonfunctional treatments.

Table 3. Spring 2007 savings compared to the time WORS treatment[1] using cumulative period totals and turfgrass quality[2]

Controller	Savings compared to time WORS	Turfgrass quality[3]
A	9%	6.2 *a*
B	15%	6.4 *a*
C	30%[4]	6.3 *a*
TIME	18%	6.2 *a*
RTIME	50%	6.1 *a*

[1]The time WORS treatment refers to the time-based treatment without a rain sensor theoretically derived from T4.
[2]Turfgrass quality ratings used a 1 to 9 scale where 1 was of lowest quality, 9 was of highest quality, and 5 was minimally acceptable.
[3]Numbers with different letters in columns indicated differences at the 95% confidence level using Duncan's Multiple Range Test.
[4]Savings were a partial result of low signal strength and no updates to the irrigation schedule.

Table 4. Summer 2007 savings compared to the time WORS treatment[1] using cumulative period totals and turfgrass quality[2]

Controller	Savings compared to time WORS	Turfgrass quality[3]
A	--[4]	--
B	41%	6.1 *a*
C	45%	6.1 *a*
TIME	31%	6.1 *a*
RTIME	63%	5.8 *a*

[1]The time WORS treatment refers to the time-based treatment without a rain sensor theoretically derived from T4.
[2]Turfgrass quality ratings used a 1 to 9 scale where 1 was of lowest quality, 9 was of highest quality, and 5 was minimally acceptable.
[3]Numbers with different letters in columns indicated differences at the 95% confidence level using Duncan's Multiple Range Test.
[4]Indicates nonfunctional treatments.

Table 5. Fall 2007 savings compared to the time WORS treatment[1] using cumulative period totals and turfgrass quality[2]

Controller	Savings compared to time WORS	Turfgrass quality[3]
A	43%	6.4 *a*
B	59%	7.1 *a*
C	50%	7.0 *a*
TIME	15%	6.6 *a*
RTIME	50%	6.5 *a*

[1]The time WORS treatment refers to the time-based treatment without a rain sensor theoretically derived from T4.

[2]Turfgrass quality ratings used a 1 to 9 scale where 1 was of lowest quality, 9 was of highest quality, and 5 was minimally acceptable.

[3]Numbers with different letters in columns indicated differences at the 95% confidence level using Duncan's Multiple Range Test.