Implementation of Smart Controllers in Orange County, Florida

Stacia L. Davis, M.E. E.I.T.

Agricultural and Biological Engineering Dept., University of Florida, 234 Frazier Rogers Hall, P. O. Box 110570, Gainesville, FL, 32611-0570, stacia@ufl.edu

Michael D. Dukes, Ph.D. P.E. C.I.D.

Agricultural and Biological Engineering Dept., University of Florida, 205 Frazier Rogers Hall, P. O. Box 110570, Gainesville, FL, 32611-0570, mddukes@ufl.edu

Consuelo C. Romero, Ph.D.

Agricultural and Biological Engineering Dept., University of Florida, 263 Frazier Rogers Hall, P. O. Box 110570, Gainesville, FL, 32611-0570, ccromero@ufl.edu

Abstract. *Water agencies are continually looking for better ways to help households reduce their outdoor water use without sacrificing landscape quality of their constituents. The main objective of this study was to evaluate two types of smart controllers to determine whether they can reduce irrigation application of high water users located in unincorporated Orange County. A total of 154 participants were recruited where 61 Rain Bird ESP-SMT ET controllers and 61 Baseline Watertec S100 soil moisture sensors were installed on single-family residential properties grouped in eight locations throughout Orange County, FL. Half of the participants receiving smart technologies also participated in a personal, on-site training session about their smart controller provided by the University of Florida. The on-site visit included optimization of program settings and additional educational materials to supplement the user manual. The results will include the participant selection, installation, and education phases of the study with preliminary data collection summaries.*

Keywords. Evapotranspiration, irrigation, maintenance, scheduling, smart controllers, soil moisture

Introduction

Smart irrigation controller technologies are becoming more popular in Florida based on their increasing implementation in the western United States. Some water agencies in California have mandated smart controllers for new irrigation systems or have provided rebates for water customers that chose to replace their current timer with a smart controller. Due to increasing popularity, it is important to determine if these technologies can be implemented widely in Florida to provide ta reduction in potable water demand.

Irrigation has been shown to account for 64% of average total household water use in central Florida (Haley et al., 2007). Irrigation scheduling based on evapotranspiration (ET_O) (Davis et al., 2009) or soil moisture (McCready et al., 2009) can reduce irrigation application by as much as half during dry periods compared to a recommended time based schedule. As a result, water agencies are looking toward these technologies to help households reduce their outdoor water use without sacrificing landscape quality.

The main objective of this study is to evaluate two types of smart controllers to determine whether they can reduce irrigation application of high water users located in unincorporated Orange County. This paper describes the participant selection, installation, and education phases of the study with preliminary data collection summaries.

Materials and Methods

Study Design

This study was designed to evaluate high water users located within eight location clusters in Orange County where half of the location clusters were considered to have flatwoods soils and the other half were considered sandy. Each location cluster contains five treatments replicated four times thus requiring twenty cooperators per location.

The smart irrigation technologies selected for this study are the ESP-SMT (Rain Bird, Azusa, CA) ET controller and the Watertec S100 (Baseline, Inc., Meridian, ID) soil moisture sensor. The ESP-SMT is an on-site ET controller that measures temperature and relative humidity to calculate ET_O. This ET controller directly measures rainfall using a tipping bucket rain gauge and is programmed with landscape characteristics for each zone to schedule irrigation based on ET_O and rainfall. The Watertec S100 measures volumetric water content through time-domain-transmissometry (TDT) technology. The sensor is buried in the irrigated area and wired to a solenoid valve. The sensor controller is wired to the existing timer and bypasses scheduled irrigation events when the measured soil moisture is greater than the threshold.

Half of the participants receiving smart technologies also participated in a personal, on-site training session about their smart controller provided by the University of Florida. The on-site visit included optimization of program settings and additional educational materials to supplement the user manual. Cooperators were encouraged to ask questions during this time and were directed toward contact information for additional questions or concerns. Prior to the on-site visit, cooperators that received a technology were given exemptions from watering restrictions and were programmed to allow irrigation daily.

For the ET controllers, general programming changes made during the on-site visit included limiting irrigation to 3 days per week and customizing application rates and plant types. For example, plant types for turfgrass zones were updated from default values of 3 inch root zones and monthly fluctuating crop coefficients to 8 inch root zones and a crop coefficient of 0.6. Ideally, fluctuating crop coefficients would have been maintained as a program setting but was not a selectable option when customizing the root zone depth.

Cooperators that received soil moisture sensors, regardless of receiving on-site training by the University of Florida, were re-programmed by the installer to irrigate every day for 20 minutes if the zone is primarily spray heads or 45 minutes if the zone is primarily rotors. The soil moisture sensors for the cooperators who did not receive an on-site visit were installed using the methodology selected by the installer that included loosely packing the soil around the sensor in a hole at a 6 inch depth. Cooperators that participated in the on-site training session received updated timer settings to apply 0.25 inches of irrigation, twice per day, three days per week, unless bypassed by the sensor. Additionally, the installer was asked to bury the sensor by inserting into the soil column at a 3 inch depth for all cooperators selected as receiving the on-site visit.

Homeowner Selection Process

This study was designed to target homeowners that were deemed high water users within the Orange County Utilities service area. Homeowners were selected for initial recruitment by comparing their monthly historical irrigation habits, collected from billing data, to monthly predicted gross irrigation requirement. The irrigation requirement was calculated using a daily soil water balance where local ET_O and rainfall information was collected from a publically available weather station. Monthly ratios of actual irrigation to a predicted irrigation requirement were calculated for all months between 2003 and 2009. Homeowners were considered "high" irrigation users and candidates for this study if they had at least three months per year for three years where their ratios were greater than 1.5 and less than 4. In general, this methodology would narrow recruitment to only high water users with habitual irrigation at least 1.5 times greater than the predicted requirement while eliminating outliers with extenuating circumstances (ratio > 4).

Letters were mailed to 7,407 utility customers located throughout the Orange County Utilities service area that met the ratio requirement described above. Within the letter, customers were asked to go to a University of Florida webpage. This webpage was set up to direct the customer to a link for the survey website as a part of the program sign-up process. Using the survey website, customers answered questions related to their irrigation scheduling habits, irrigation maintenance habits, irrigation knowledge and terminology, etc. There were 843 respondents to the survey.

Customers were immediately removed as potential participants if they did not meet the following requirements:

- Utilized automatic time clock for irrigation
- Irrigation connected to potable water supply (not reclaimed)
- Lived in home for more than 2 years (2008 - 2009)
- Year round resident
- Owned home (does not rent)
- Indicated automatic or manual irrigation habits

Additionally, some homeowners chose to be removed from the study citing the following reasons:

- Lack of trust in that there were no fees or products being sold
- Did not understand that there were future commitments after the questionnaire
- Decided that future commitments to the study were too much to handle

From the remaining customers that were eligible for participation, location clusters were identified to maintain continuity between treatments similar to a statistical blocking effect. Location-based effects that could affect irrigation may include localized rainfall, soil types, or other influences such as Homeowner Association (HOA) involvement. Five unique locations were identified where two were determined to be primarily of flatwoods soil type whereas the other three locations were considered a sandy soil. Within the two flatwoods locations, multiple clusters of twenty cooperators were identified thus totaling eight location clusters for evaluation.

Evaluations

Potential cooperators within the selected location clusters were contacted by the University of Florida and asked to schedule an irrigation evaluation. Each evaluation included recording their current timer schedule and running water for two minutes per zone to determine if there were any problems with the system. Additionally, square footage of the irrigated area was measured to compare and adjust property appraiser data for more accurate predicted irrigation requirement estimates. All information was recorded on carbonless copy paper so that the potential cooperator had a record of any problems with their system.

Potential cooperators that had multiple major problems with the irrigation system, where a major problem is considered a problem that results in a high volume water loss such as missing sprinkler heads and pipe leaks, were removed from the study. A major problem would also be considered as a broken solenoid or wiring issues that would result in irrigation that was different than the timer settings. Additionally, potential cooperators that had multiple minor problems such as clogged or leaking sprinklers but had good landscape quality were asked to make repairs to their system to remain in the study. To obtain enough cooperators eligible for participation, 284 evaluations were completed.

Application rates were used to predict average weekly irrigation application using the timer schedule collected for each cooperator during the irrigation evaluation. Application rates for each zone were not measured during the evaluation. However, the number and type of sprinkler heads for each zone were recorded. From this information, average application rates were selected as 1.75 in./hr. for spray heads, 0.75 in./hr. for rotor heads, and 1.25 in./hr. for zones that were mixed with spray and rotor heads. Watering restrictions mandated irrigation application to occur once per week during daylight savings time occurring from 7 November 2010 to 13 March 2011. Cooperators that were evaluated during daylight savings time and had timers that were programmed for once per week irrigation application were counted as 2 days per week to directly compare to the cooperators evaluated outside of the daylight savings time period. Additionally, cooperators that chose not to program start times for their primary irrigation schedule were counted as one start time per irrigation day.

Treatments

There were five treatments selected for each location: two treatments received ESP-SMT ET controllers and two treatments received Watertec S100 soil moisture sensors where one treatment for each technology includes an educational on-site visit. The final treatment is the comparison group that is monitoring only and did not receive a technology.

According to the study design, the study includes five treatments replicated four times (20 cooperators) at eight locations totaling 160 cooperators. Unfortunately, some cooperators in N. Tanner Rd Area allowed their landscapes to decline before treatment installation and were removed from the study. As a result, modified treatments were selected for this location so that there are two groups that received a technology with educational on-site visit and a comparison group. There are five replications of each treatment totaling 15 cooperators in this location only, ultimately resulting in 155 cooperators (Table 1). Treatments were installed from 23 March 2011 through 25 August 2011 for all locations except N. Tanner Rd Area. Installations began for the N. Tanner Rd Area on 12 September 2011 and are on-going.

Table 1. Count of cooperators selected for each treatment and for each location.

Location	**ESP-SMT**	***ESP-SMT + Edu***	***S100***	**S100 + Edu**	**Comparison**	**Total**

Hunters Creek A	4	4	4	4	4	20
Hunters Creek B	4	4	4	4	4	20
Keenes Pointe Area	4	4	4	4	3	19
N. Tanner Rd Area	0	5	0	5	5	15
Turtle Creek Area	4	4	4	4	4	20
Waterford Lakes – East	4	4	4	4	4	20
Waterford Lakes – South	4	4	4	4	4	20
Waterford Lakes – West	4	4	4	4	4	20
Total	28	33	28	33	32	154

Results and Discussion

Of the 284 evaluated homes, the average number of zones per home was 4.3 and the average area per zone was 1033 ft^2 (Table 2). Landscapes were much larger in the Keenes Pointe area where the number of zones averaged 6.0 and the average area per zone was 1267 ft^2. Both values being higher than the average indicates that the increase in number of zones was due to an increased landscape size and not arbitrarily based on design. A majority of the potential cooperators follow the day of the week watering restrictions with a maximum of 10% in violation at any one location. This suggests that following watering restrictions is important to homeowners in the Orange County Utilities service area.

Table 2. Summary descriptions determined during irrigation evaluations.

Location	**Number Evaluated**	**Average Number of Zones**	**Average Area per Zone (ft^2)**	**Irrigating on Non-watering Days (%)**
Hunters Creek Area	54	4.3	967	9
Keenes Pointe Area	37	6.0	1267	3
N. Tanner Rd Area	29	4.0	896	10
Turtle Creek Area	28	4.7	1102	0
Waterford Lakes Area	96	3.7	1060	10
Not grouped	40	4.6	879	10
Total	284	4.3	1033	8

There were a total of 415 minor problems and 59 major problems found across 284 evaluated homes (Table 3). Minor problems included issues that produce low volume losses such as sprinkler leaks or clogs whereas major problems included issues that produce high volume losses, faulty wiring, or solenoid problems. Though there were some homes that did not have any problems, many homes had multiple minor problems indicating maintenance neglect. Common locations for minor problems were along high traffic areas like the roadway, sidewalk, driveway, and doorways. Though there were fewer major problems, most homes that had a major problem also had multiple minor problems. Potential cooperators that had major and minor problems that may have indicated a reluctance to fix the problems or that the problems were long term issues were removed from the study.

Table 3. Count of major and minor problems found when evaluating potential cooperators.

Location	Number Evaluated	Minor Problems	Major Problems
Hunters Creek Area	54	58	10
Keenes Pointe Area	37	54	7
N. Tanner Rd Area	29	36	8
Turtle Creek Area	28	34	2
Waterford Lakes Area	96	183	22
Not grouped	40	50	10
Total	284	415	59

Assuming no rainfall, replacing ET of a warm season turfgrass during a high irrigation demand period in Florida would result in approximately 1.75 inches per week of irrigation. Using assumed application rates, predictions of irrigation application for each cooperator could be made using the timer schedule recorded during the evaluation (Table 4). The weekly irrigation indicated that Hunters Creek A, with a majority of weekly irrigation greater than 1 inch, applied more irrigation per week than Hunters Creek B where a majority of irrigation was less than 1.5 inches per week. The distribution of weekly irrigation for the Keenes Pointe Area resembled Hunters Creek A whereas the distribution of irrigation for N. Tanner Rd Area resembled Hunters Creek B. Turtle Creek and all three Waterford Lakes areas were similarly distributed with the largest number of cooperators irrigating between 1 to 1.5 inches per week. Considering rainfall occurs frequently in Florida, the locations of Hunters Creek B and N. Tanner Rd Area have a significant amount of slightly conservative irrigators whereas the majority of cooperators in all other locations can be confirmed as high water users.

Table 4. Percentage of cooperators irrigating various weekly depths of irrigation based on timer schedules recorded during the irrigation evaluation for the cooperators participating in the study.

Location	< 0.5 in.	0.5 to 1 in.	1 to 1.5 in.	1.5 to 2 in.	> 2 in.
Hunters Creek A	0	25	20	30	25
Hunters Creek B	12	47	24	6	12
Keenes Pointe Area	0	20	20	40	20
N. Tanner Rd Area	0	38	31	23	8
Turtle Creek	0	16	37	21	26
Waterford Lakes – East	0	16	52	16	16
Waterford Lakes – South	5	15	35	15	30
Waterford Lakes - West	0	15	40	30	15

Conclusion

Overall, the selection methodology to determine high water users was effective in finding irrigators who generally schedule large amounts of irrigation. Though using the methodology of calculating a ratio of irrigation application to predicted irrigation requirement for every billing customer in Orange County Utilities service area was expansive on a short term basis, targeting the more appropriate customers will increase the likelihood of success of the project thus helping to reach long term goals.

Improper maintenance of irrigation systems such as neglect of broken sprinkler heads or pipe leaks can significantly increase average household water consumption over time. There was significantly more maintenance issues found during irrigation evaluations than was expected. Many homeowners would benefit from regular maintenance on an annual or semi-annual basis.

Future research will include comparisons of irrigation application between treatments to determine differences between the technologies, educational interaction, and technology performance characteristics over time. Irrigation application during the study period will also be compared to the predicted irrigation requirement and historical average irrigation application.

Acknowledgements

The authors would like to thank the funding agencies that have contributed to this study. These agencies include Orange County Utilities, St. John's Water Management District, South Florida Water Management District, and the Water Research Foundation.

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