Soil Moisture Sensors Vs. Rain Sensors

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Strategies for conserving water with automated irrigation systems

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A sensor is buried in the turfgrass rootzone of the area that is irrigated. It is either wired to the control interface or to the nearest valve that allows communication back to the control interface.
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This time of year as the weather warms and irrigation to maintain turf and landscapes becomes a conscious thought for many people, I normally get questions on rain sensors (RSs) and soil moisture sensors (SMSs). We have tested both types of sensors extensively since 2003 when we started research on smart controllers. Generally the types of questions center around which technology is best, how much maintenance is required and how much water can be saved.

In Florida, RSs have been mandatory on at least new irrigation systems since the 1990s. Florida Statute 373.62 states, “Any person who purchases and installs an automatic landscape irrigation system must properly install, maintain and operate technology that inhibits or interrupts operation of the system during periods of sufficient moisture.”

This essentially mandates either an RS or an SMS for new systems, but the statute goes on to state, “A licensed contractor who installs or performs work on an automatic landscape irrigation system must test for the correct operation of each inhibiting or interrupting device or switch on that system. If such devices or switches are not installed in the system or are not in proper operating condition, the contractor must install new ones or repair the existing ones and confirm that each device or switch is in proper operating condition before completing other work on the system.”

This is an effort to mandate these technologies on all systems, at least those that receive maintenance from professionals in the business. Many other states and municipalities have also developed rain sensor ordinances requiring these devices.

The most common RS devices used in the industry are expanding disk type. Many have adjustable thresholds that allow a user to set different depths of rainfall before the RS switches to “interrupt” mode where the signal from a timer is interrupted before it engages a valve preventing an irrigation cycle. A hygroscopic material in the sensor expands when wet, hence the name of these sensors.

Getting started with SMSs

When we began our research, the SMSs available were for the most part single sensor add-on technologies. With these devices, an SMS control interface is wired to the timer and a sensor is buried in the active rootzone of the irrigated area and either wired to the control interface or to the nearest valve, which allows communication back to the control interface. These devices could be an interrupt or bypass configuration.

Click image to enlarge.

Rain sensors have been mandatory on new irrigation systems in Florida since the 1990s. A licensed contractor who installs one on an automatic landscape irrigation system must test for its correct operation, too.

The bypass configuration makes a decision at the initiation of a timer irrigation cycle whether or not to allow the pre-programmed time schedule to occur for all irrigation zones. This decision is based on a soil moisture measurement from the irrigated rootzone compared to a user adjustable threshold on the SMS control interface. If soil moisture content exceeds the threshold at the day and time of irrigation, that entire cycle would be bypassed.

We began evaluating expanding disk rain sensors as almost an extra side project to the SMS evaluation because we all know that RSs don’t work, right? At least that is what we heard a lot from practitioners and end users. We wanted to put that to the test by objectively evaluating both technologies.

Click image to enlarge.

This landscape irrigation timer is configured with multiple soil moisture sensor (SMS) control interfaces. SMS controllers can make landscape irrigation more efficient.

Laying the groundwork

That initial project evaluated just one popular expanding disk RS with different set points and four SMS devices that ranged in type of technology from capacitance based to simple resistance based. These devices were evaluated across a range of weather conditions of higher than normal rainfall frequency to drought conditions. Both technologies were established with a two-day-per-week irrigation schedule based on UF-IFAS recommendations during the growing season of approximately mid-March through early December. The research site consisted of bermudagrass plots in Gainesville. Later at this same site we added additional RSs, such as newer devices with instantaneous response and no user adjustable threshold, wireless expanding disk RSs and units having a user adjustable irrigation delay. These units underwent long-term evaluation from November 2006 through December 2009.

In 2006, we initiated additional RS and SMS research at another site south of Gainesville with Floratam St. Augustinegrass plots, the dominant landscape turf in Florida. Similar to the previous work, we had a base irrigation schedule and different RS thresholds. In this study we tested several levels of the user adjustable SMS threshold.

The initial work with RSs resulted in over 30 percent irrigation reduction in rainy years and 0 to 30 percent (depending on RS set point and irrigation frequency) in dry years maintaining good turf quality across both bermudagrass and St. Augustinegrass sites. Results were similar on both turfgrasses with good quality as long as RS thresholds were not programmed too low with infrequent weekly cycles scheduled.

For example, with two-day-per-week allowed irrigation, we recommend a 0.25-inch RS set point and for one-day-per-week no more than 0.5-inch for two days a week on sandy soils. More frequent weekly irrigation windows would allow one to use lower RS thresholds since any interval with stress would be relatively short. In addition, heavier soils could use higher RS thresholds, but I would caution use of a threshold beyond 0.5-inch since soil water storage is limited in the relatively shallow turfgrass root systems.

Our initial work with RS testing found that one type of sensor had a rainfall triggering accuracy of 77 percent to 98 percent and dried out within 36 hours greater than 80 percent of the time. After several years in the field, dry out occurred 95 percent of the time within 36 hours. These same sensors were evaluated after three years in the field and we found accuracies of 27 percent to 64 percent. In long term testing, the maximum savings from these devices with a two-day-per-week irrigation schedule was 8 percent to 11 percent.

As a result, we recommend the expanding disk material be changed at least annually to maintain the best performance.

Auto calibration

Some SMS controllers on the market have an auto calibration feature where upon initiation the sensor is to be saturated, usually with a bucket of water and the controller waits a period of time from 12 to 24 hours to allow the soil to drain to its equilibrium point also known as field capacity. The SMS threshold can be set at this point or slightly lower to allow storage for rainfall. Except for saturation of the soil, this process is automatic. This process can be carried out manually, by setting the threshold after drainage has been allowed to occur.

In our early work we set the sensor threshold at field capacity on the coarse soils common in Florida and achieved good results. Setting the threshold below field capacity with one- or two-day-per-week irrigation frequency did not allow adequate irrigation and resulted in unacceptable stress and turf quality during dry periods.

Our initial studies on SMSs happened to occur during relatively wet years (rain events on average every two to three days for most of the periods), thus irrigation was reduced 72 percent for one-, two- and seven-day-a-week intervals across all four brands. Within brands, savings ranged from 69 percent to 92 percent savings for three of the four brands tested. For the entire 360-day study, all brands averaged 72 percent irrigation savings, two times more than the RS devices set at .25-inch threshold.

Click image to enlarge.

Several brands of soil moisture sensors were evaluated across a range of weather conditions of higher than normal rainfall frequency to drought conditions.

Since results from the SMS controllers were promising based on plot research results, we moved to deploying sensors on homes in southwest Florida. Overall, the study had 58 homes with approximately one-quarter each having SMS controllers, RSs set at .25-inch, RSs and guidance on recommended seasonal adjustments for their timer, and finally no additional technology added to the timer that existed on all homes' automatic irrigation systems.

After 26 months of data collection beginning in 2007, only the homes with SMS controllers resulted in significant savings compared to the homes with no added technology, 65 percent, while maintaining good quality landscapes. Several homes remained in this study and are still occupied with functional SMS sensors after five years.

We currently have a project with Orange County Utilities in the greater Orlando area with 66 SMS homes, 66 homes with Evapotranspiration (ET) controllers, and 35 homes that just have the timer (comparison homes) common with in-ground automated irrigation systems. These comparison homes have RSs for the most part but we did not assess functionality as part of this project since they are meant to be "typical" for comparison purposes.

After one year SMS homes have initial irrigation reductions of 41 percent from the comparison homes thus reinforcing our confidence that SMS controllers can be valuable components of an irrigation system to apply water as efficiently as possible.

In summary, both RS and SMS technologies offer water conservation potential in automated irrigation systems. Although RS devices can be effective, they are much less so then the SMS devices that have tested with SMS controllers typically reducing irrigation two to three times more than RS devices.

Publications detailing the work on smart irrigation controllers such as soil moisture sensor controllers and ET controllers, as well as rain sensors can be found at *http://abe.ufl.edu/mdukes/publications/index.shtml*.

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