Residential Irrigation Based on Soil Moisture

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As urban areas grow throughout the country, limited water resources will be stretched to fulfill urban, agricultural, and other needs. Recent studies in the United States indicate that 58 percent of potable water is used for landscape irrigation. A landscape and irrigation study aimed at determining residential irrigation water use in the Central Florida Ridge found that 62 percent of potable water was used for landscape irrigation during the 29-month monitoring period.

Residential landscape water-use research in Florida found that typical homeowners used an average of 142 mm (5.6 in.) per month. Homeowners using irrigation time clocks, set to seasonal plant-water requirements, used 16 percent less irrigation water on average. Typically, homeowners irrigate too much in the late fall and winter time periods. This often occurs due to lack of knowledge about the necessary length of irrigation times for specific plant material or because it is inconvenient to adjust the irrigation time clock.

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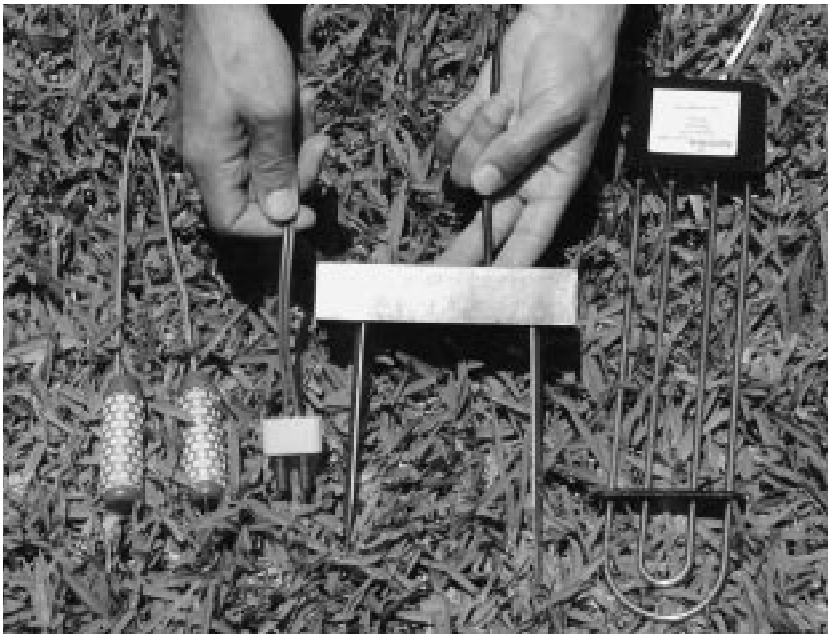

ECH_2O dielectric soil-moisture sensor with HOBO Microstation data logger used to independently monitor soil moisture on the University of Florida's Agricultural and Biological Engineering residential irrigation research project.

As a result, a University of Florida team began looking at technologies that provide feedback to the irrigation system on soil moisture conditions.

In 2004, a research project was initiated at the University of Florida's Agricultural and Biological Engineering facilities to test several commercially available soil-moisture-based irrigation controllers. The commercially available soil moisture sensors connect to conventional irrigation system time clocks. When the time clock sends a signal to initiate irrigation, the soil-moisture content is checked by the sensor, which has a user-adjustable set-point. If the measured soil moisture is above the set-point, irrigation is not allowed. These sensors are either connected to the last irrigation zone (i.e., valve) for the system or have a time delay so that once irrigation begins, all irrigation zones will receive water. The specific method of measuring soil moisture depends on the manufacturer, but all of the sensors rely on the ability of the soil to conduct electricity and the correlation of this conductivity with soil moisture.

At the time this project was initiated, the four commercially available controllers were selected for testing. All four sensors are still being tested with three watering frequencies – one, two, and seven days per week between the hours of 4 p.m. and 10 a.m. The one and two days per week watering frequencies represent typical watering frequencies when watering restrictions are imposed in Florida. The soil-moisture sensors are being compared to a time-based irrigation schedule with a rain sensor (similar to what a homeowner would use) that is set based on historical evapotranspiration (ET), a time-based treatment with a rain sensor, that is 60 percent of historical ET, and a historical ET-based irrigation schedule without a rain sensor.

Soil-moisture sensor research plots during establishment at the University of Florida, Gainesville.

(Historical ET is a measure of the turf grass water use and was determined by computing average grass ET based on weather data gathered in Florida over a 52-year time period.) Irrigation frequencies for the soil-moisture-based controllers were set such that the maximum amount of irrigation that could be applied was the same as the historical ET-based irrigation schedule without a rain sensor. In addition, there is a non-irrigated control treatment.

All experimental treatments are being replicated four times in a completely randomized design for a total of 64 plots. Each turf grass plot is 3.7 × 3.7 m (12 × 12 ft) and established with common Bermuda grass (*Cynodon dactylon*). Each plot is sprinkler-irrigated by four quarter-circle pop-up spray heads that are typical in residential irrigation systems. The soil moisture sensor that controls a particular treatment is buried in the center of one of the four replicates. During initial uniformity testing on the plots, the driest plots were identified for placement of the soil moisture sensors, according to recommendations by most of the manufacturers. All of the sensors remain placed in the top 7 to 10 cm (3 to 4 in.) of the soil, which is the densest portion of the turf grass root zone.

Pulse-type positive displacement flowmeters are used to continually measure irrigation volume to each plot. Turf quality measurements are conducted by a visual rating system no less frequently than seasonally. Independent soil moisture measurements are collected

Graduate student Bernardo Cardenas-Lailhacar with soil moisture sensor control systems and monitoring equipment at the research site.

from each plot by ECH_2O (Decagon Devices, Inc., Pullman, Wash.) capacitance-based soil-moisture probes.

The experimental site was fully operational in late July 2004. Irrigation and turf grass quality data were collected through mid-December 2004, when the turf grass became dormant and irrigation was stopped for the winter. Irrigation water use ranged from 57 mm (2.2 in.) on the lowest sensor-based treatment to 471 mm (18.5 in.) on the highest sensor-based treatment. All soil-moisture sensor-based treatments averaged 205 mm (8.1 in.) of irrigation water. These values compare to 328 mm (12.9 in.), 495 mm (19.5 in.), and 696 mm (27.4 in.) on the three timer schedules from most to least conservative. Thus, the soil-moisture sensors have saved from 5 to 88 percent and an average of 59 percent compared to the well-managed nonsensor system (time clock set according to historical ET with a rain sensor). However, through most of this time period, turf grass quality on the non-irrigated plots was similar to the irrigated plots. This observation indicates that irrigation in the late summer and most of the fall was not necessary to maintain acceptable turf grass quality due to 944 mm (37.2 in) of rainfall during this period. It is useful to note that regardless of irrigation need, most homeowners would have some type of irrigation schedule programmed into their time clocks.

Cardenas-Lailhacar and Dukes check flowmeters used to monitor irrigation volume applied to turf grass research plots.

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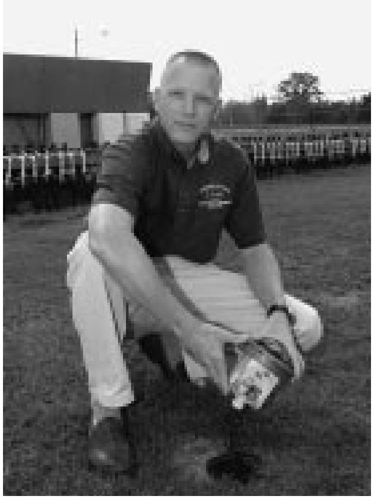
Thus, the soil moisture sensors could be expected to save a substantial amount of water.

Currently, the cost of available soil-moisture sensor-based controllers ranges from $75 to $350. In areas where the cost of water is relatively high, the devices could pay for themselves in a year or less as a result of water savings. As Florida's population and accompanying residential communities continue to expand, there will be an even greater drain on existing freshwater supplies. Soil moisture sensors are an inexpensive and effective way to conserve this important resource.



Dukes with data logger used to record soil-moisture data from the turf grass research plots.

The second phase of this project will demonstrate the technology on homes in southwest Florida. Similar devices have been successfully demonstrated to reduce irrigation water on sweet corn in Florida. Commercially available soil-moisture controllers and a custom soil-moisture-based controller developed at the University of Florida's Agricultural and Biological Engineering Department are also being tested on vegetables – squash, tomato, and green bell pepper – grown in plastic-mulched drip-irrigated production beds. R

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