Soil Moisture Sensing

Use of Soil Moisture Sensors for Irrigation Scheduling

By Ruixiu Sui, PhD

Irrigation scheduling determines the time and amount of water to apply. One of the most popular methods for irrigation scheduling is to measure soil moisture levels in the plant root zone and apply water if there is a water shortage for the plants. Soil moisture sensors are able to measure soil moisture content. Various types of soil moisture sensing devices have been developed and are commercially available for water management applications.

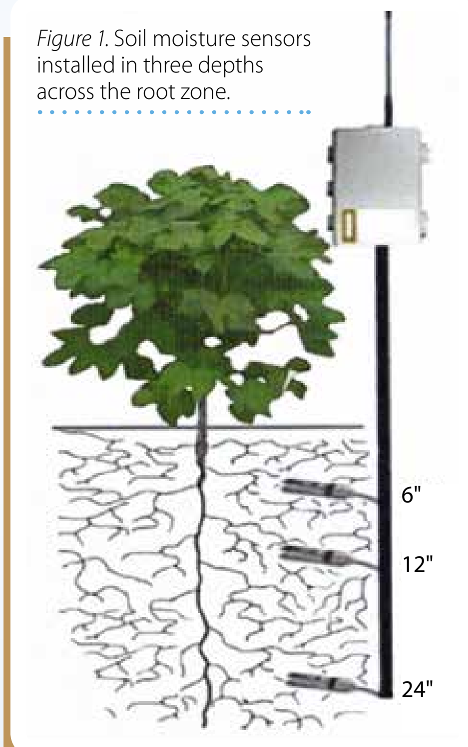
Each type of soil moisture sensor has its advantages and shortcomings in terms of accuracy, reliability and cost. The neutron probe has been shown to be a reliable tool for determining soil water content. However, its use of a radioactive source, the maintenance requirement and the cost have restricted its application. Meanwhile, resistive- and capacitive-based sensors and time domain reflectometry sensors have been rapidly developed and adopted for soil water measurement in recent years. Some of these sensors are integrated with wireless data communication devices making them capable of wirelessly transferring the soil moisture data. Research shows that soil moisture sensors could be used as an irrigation tool for saving water. However, procedures for proper installation, calibration and maintenance of soil moisture sensing devices are critical for the success of soil moisture sensor-based irrigation scheduling. The following is an example of a practical use of soil moisture sensors for irrigation scheduling in a humid region.

The field is located in a research farm of the USDA-ARS Crop Production Systems Research Unit in Stoneville, Mississippi. The predominant soil type of the field is silt loam. Crops were grown under a center pivot irrigation system.

Sensor Installation & Maintenance

Soil water content sensors were installed in the predominant soil of the field to measure soil volumetric water content in the crop root zone. The sensors were installed at depths of 6 in. (15 cm), 12 in. (30 cm) and 24 in. (61 cm), respectively (see fig. 1). To install the sensors, a hole was drilled at the center of the crop row using a soil auger. Soil water content sensors were inserted horizontally into the soil at the designated depths. The sensors were connected to a wireless data logger installed near the sensors on the crop row.

Figure 1. Soil moisture sensors installed in three depths across the root zone.



Caution: When installing sensors, minimize disturbance of the soil and ensure the prongs are well in contact with the soil. Place the sensor to prevent it from being damaged during field practices and by wild animals. After the growing season, the data logger can be disconnected from the sensors and removed from the field. The sensors can remain in the soil for use the next season.

Sensor Calibration

The sensors were calibrated with the soil from the field. Soil water content of the soil was measured using the soil moisture sensors and also determined by the gravimetric method. Sensor-measured water content was compared to the water content by the gravimetric method, and their relationship was developed and used to calibrate the sensors.

Caution: Soil types have an effect on soil moisture sensor measurements. The sensors should be calibrated with specific soils intended for measurement.

Data Acquisition & Interpretation

Data loggers were set up to continuously make one measurement of soil water content every minute and calculate the hourly average of the measurements. Readings of the soil water content from the logger were wirelessly transmitted online for download. A bendable antenna mount was developed and used to place the antenna above the plant canopy for wireless data transmission while not interfering with the operation of field equipment (see fig. 2). Soil water content measured at the three depths were interpreted using a weighted average method to reflect the importance of soil water in different depths across the plant root zone. A weight was assigned to each sensor measurement based on the sensor depth.

Caution: The weights assigned to the measurements at different depths should be adjusted according to crop type and crop growth stages due to variation of crop root distribution patterns in the root zone.

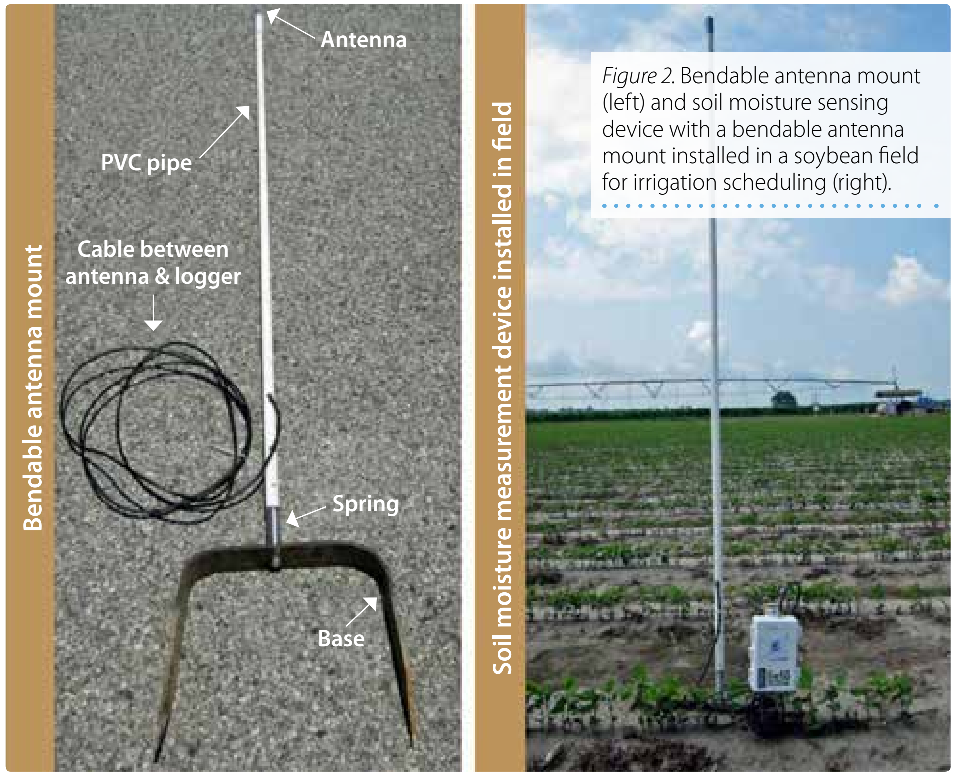


Figure 2. Bendable antenna mount (left) and soil moisture sensing device with a bendable antenna mount installed in a soybean field for irrigation scheduling (right).

Irrigation Scheduling

The weighted average of the soil water content was used for irrigation scheduling. The weighted average measured by the sensors at 48 hours after the soil was saturated was used as the sensor-measured field capacity (FC). Irrigation was triggered when the soil water content (SWC) dropped close to the level of approximately plant available water (PAW) of 50 percent (see fig. 3). The plant available water is calculated as follows: PAW = 100 × [(Sensor-measured SWC) – (SWC at wilt point)] / (FC – SWC at wilt point).

Caution: This requires understanding the soil FC, PAW and soil water level to trigger irrigation events for different crops.

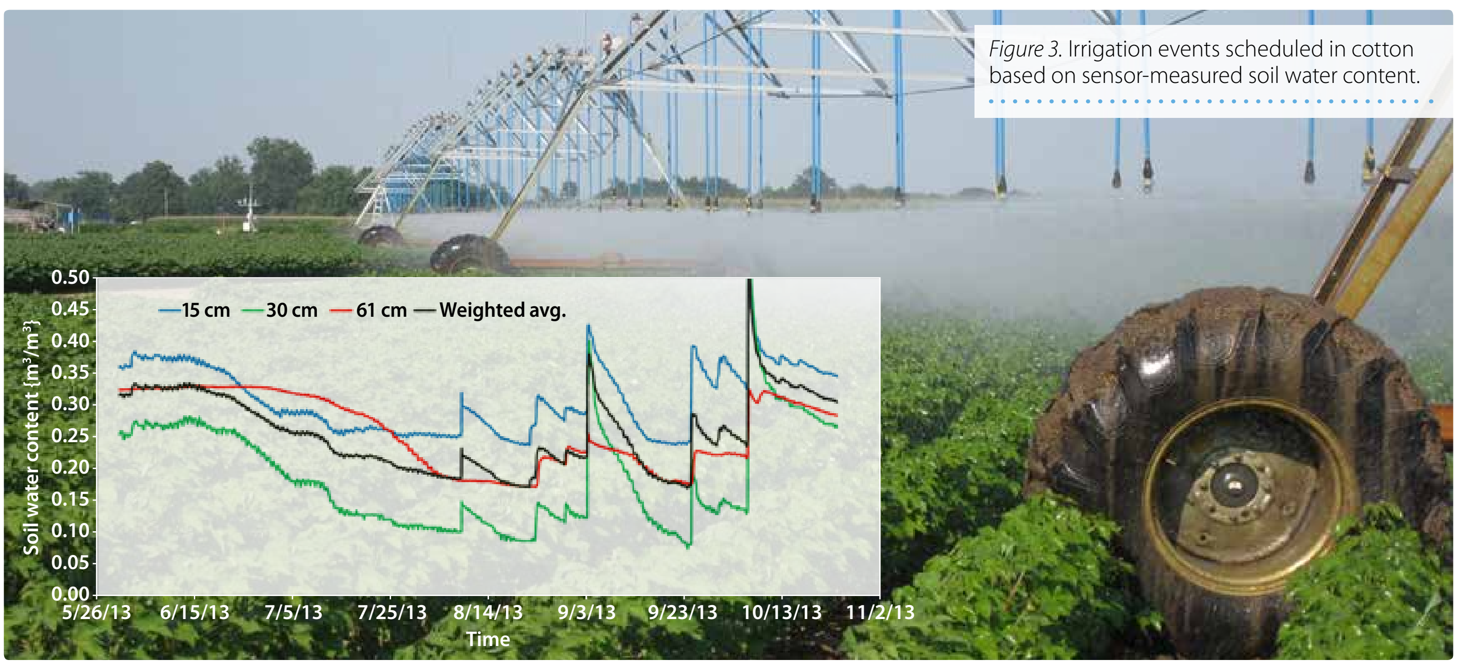


Figure 3. Irrigation events scheduled in cotton based on sensor-measured soil water content.

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