Agronomic Spotlight

Soil Water Sensor Use in Irrigation

- Soil moisture monitoring can provide valuable information to help evaluate irrigation management for field crops and maintain yield potential.
- Many soil moisture sensors are available for measuring either soil moisture or soil moisture tension. The latter measures the amount of water retained by the soil; the higher the tension, the drier the soil.
- Both soil moisture measurements and ET-based irrigation scheduling can be used as a tool to evaluate the effectiveness and accuracy of an irrigation strategy.

Irrigation management focuses on using water profitably, while maintaining yield potential at sustainable production levels. Irrigation needs to be applied only when soil moisture measurements and crop growth stage warrant water inputs, and with a method that limits any waste or excess.

Checkbook Method

The basic method for irrigation scheduling is referred to as the "Checkbook Method", which involves keeping a balance of the amount of soil water by measuring the amount of rainfall and then measuring or estimating the amount of water lost from crop use and evaporation.[1] This is based on the available water supply, soil water holding capacity, water intake rate, and crop water needs. Soil moisture sensors help measure directly or estimate indirectly soil water content.

Soil Moisture Sensors

Evapotranspiration (ET) soil water estimations should be periodically validated using soil moisture sensors. Comparing predicted soil moisture with actual soil moisture measurements every couple of weeks is a good strategy to confirm the ET-based scheduling method is accurate.

Soil moisture sensors can be placed at differing depths in the crop root zone to provide a direct measure of changes in soil water content. This can help determine when irrigation might be needed.

Examples of some common soil moisture sensing instruments include (Table 1):

- **Tensiometers** are most suitable for sandy or loamy soils. They measure soil water tension or suction. As soil dries, water is pulled from the porous cup at the lower end of a tube inserted in the soil, creating a vacuum and causing the vacuum gauge on the top of the tube to move.
- **Electrical resistance blocks**, also known as gypsum blocks or soil moisture blocks, measure the change in electrical resistance during wetting and drying cycles of the soil. Water moves into or out of the soil-buried blocks, depending on the moisture content of the soil. This creates a change in the resistance between the two electrodes that are embedded in the gypsum block.
- **Capacitance probes and frequency domain reflectometry (FDR)** measure the soil dielectric constant using two or more plates or rods, which are embedded into the soil.
- **Time domain reflectometry (TDR) and time domain transmissometry (TDT)** soil moisture sensors measure a soil's dielectric constant.

Accurate Measurements

For representative readings, measurements should be taken from representative soil types, within the active crop root zone, and away from high spots, depressions where water may collect, and slope changes. Soil water content may vary greatly within a field, so multiple measurements throughout the field and at appropriate depths will be required to reduce errors. A greater number of readings will be needed with soil moisture sensors that measure smaller volumes of soil, such as with capacitance probes.[1]

When choosing locations in the field to measure soil water, it may be most cost effective and efficient to take measurements in areas where soil and plant properties are most representative of the field.

The depth to which a particular method can measure soil moisture and the resolution at increasing depths should also be considered. Ideally for irrigation scheduling, soil water should be measured to well below the maximum depth of root water extraction, though this is not always attainable with most soil water measurement

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methods. Conventional TDR is one method that allows the flexibility of deeper measurements.

Typical installations include one or more sensors for each foot of active rooting depth. The variability amongst soil samples increases as soils dry, indicating that more measurements will be needed for accuracy as soil water content reaches the Management Allowable Depletion (MAD).[2] The latter refers to the amount of water allowed to be depleted from the root zone before irrigation is scheduled. The MAD is usually given as a percentage of maximum water-holding capacity of the soil. At the time of irrigation, the soil water deficit should be less than or equal to MAD.

Table 1. Advantages and disadvantages of different methods for measuring soil moisture.

Method	Advantages	Disadvantages
Gravimetric (oven drying)	High accuracy with increased sampling, direct measure	Very labor intensive, delays to obtain data
Tensiometers (soil water tension)	Instantaneous, approximates soil moisture content	High maintenance, tension breaks, freezing temperatures
Electrical Resistance	Instantaneous, increased range, approximates soil moisture content	Slower response, less sensitive at low moisture, affected by soil salinity
Capacitance and FDR (frequency domain)	High accuracy, volumetric water content and salinity	Highly influenced by adjacent moisture/voids
TDT and TDT (time domain)	High accuracy, volumetric water content and salinity, robust calibration	High installation cost, highly influenced by adjacent moisture/voids

Table modified from Crookston, M.A. 2011. Utilizing soil moisture readings in irrigation scheduling. Proceedings of the 23rd Annual Central Plains Irrigation Conference: 47-51. https://www.ksre.k-state.edu/

Sensor Installation and Calibration

Soil water sensors must be in direct contact with undisturbed soil in order to provide accurate readings. During installation, damage to roots and soil structure should be minimized and air voids, large roots, rocks, and other obstructions should be avoided.

All soil moisture sensors should be calibrated in the field for the specific soil type, even if the manufacturer suggests otherwise. Laboratory calibrations of the devices are often made on re-packed soils, where tight soil-access tube contact is ensured and variability in the soil is minimized. These laboratory measurements may not be transferrable to your field, particularly for the Capacitance or other FDR sensors. Field calibration can provide more accurate readings because the sensor is placed in the actual soil to be measured.

In summary, maintaining adequate soil moisture is essential, especially during the critical crop growth stages to help achieve maximum yield potential. Measuring soil water content with water sensors can help determine the timing of irrigation and amounts. Soil moisture measurements should be used in combination with ET-based irrigation scheduling. Before installing, in-field calibration should be conducted on the sensors to help provide accurate readings.

Sources

[1] Melvin, S.R. and Yonts, C.D. 2009. Irrigation scheduling: checkbook method. Publication EC709. University of Nebraska-Lincoln Extension. [2] Evett, S.R. 2007. Soil water and monitoring technology. Irrigation of agricultural crops. 2nd edition. Agronomy Monogram No. 30. ASA, CSSA, and SSSA. 25-84. Madison, Wisconsin. [3] Crookston, M.A. 2011. Utilizing soil moisture readings in irrigation scheduling. Proceedings of the 23rd Annual Central Plains Irrigation Conference: 47-51. https://www.ksre.k-state.edu/. Web sources verified 02/22/16. 140109161501.