General

Capacitance-based soil moisture sensors, also referred to as soil moisture probes, are electronic sensors that use an oscillator to generate an AC field which is applied to the soil in order to detect changes in soil dielectric properties linked to variations in soil water content. Often multiple sensors are configured in a 'probe' which is inserted into a tube installed in the soil. The multiple sensors then provide a soil moisture reading at multiple depths in the same location. The tube can either be a permanent housing for probes left in the ground or an access tube for portable probes. Some models actually allow the sensor positions to be adjusted by the end-user. Other models consist of two or more electrodes (i.e., plates or rods) that are inserted directly into the soil without use of an access tube.

Capacitance-based soil moisture sensors must be connected to a vendor-specific electronic device (datalogger or reader) in order to obtain a soil moisture status reading. As the name implies, a datalogger records the soil moisture status for later use whereas the reader simply gives the user a measurement at that point in time. Some systems offer the option for remote access to soil moisture data via radio, cell phone, or satellite communication.

The data from these sensors is in volumetric soil moisture (percentage of water in a given amount of soil). Thus a reading of 0% would indicate a completely dry soil and a reading of 100% would indicate a complete liquid - the higher the reading, the higher the soil moisture. Most typical ag soils have soil moisture values between 5% and 40%. For a sandy loam soil, a grower would want to keep soil moisture levels between 10% and 22% for optimal plant growth.

Location

The sites selected for installation should be representative of the surrounding field conditions. Isolated low, wet areas or high, dry areas should be avoided. Sensors should be placed within the plant canopy in positions where they will receive typical amounts of rainfall and irrigation. In a pecan grove, for example, locate the sensor under the tree canopy, in line with the tree row, in a location where it will be within the emitter's spray pattern, since water will not move horizontally very far in the soil. For patterns with individual streams, turn the emitter so that a stream hits the sensor.

Placement of sensors with depth is critical. For shallow-rooted (less than 12 inches) crops, only one sensor may be required. It should be centered in the crop root zone, but at least 4-6 inches
below the surface.

For deeper rooted crops, such as cotton, peanuts, and corn, a minimum of two sensors should be used. The shallower one should be placed in the zone of maximum root concentration. This is normally at 4-6 inches or about one-third of the active rooting depth. The deeper sensor, installed in the lower part of the active rooting depth, for example at 18 inches, can be an indicator of under or over irrigation. Other depth combinations may be used where appropriate. If using probe with multiple sensors, one probe would handle multiple depths and suffice the deep root requirement. Fields using single sensors with exposed electrodes will need multiple sensors to measure soil moisture at multiple depths to complete one set.

If site conditions vary considerably, use more than one set of sensors.

**Preparation and Installation**

Sensor readings are heavily influenced by moisture content and air gaps in the soil volume nearest the electrodes. With access-tube models, particularly, it is extremely critical to have good sensor-tube-soil contact for reliable estimation of soil moisture.

Default calibrations are often available that provide indicative correlation of soil moisture content across a range of soils from sands to clays. The sensors can also be calibrated to the each soil on-site to provide even a higher degree of accuracy. The calibration process is vendor-specific.

If using a tube model, user must prepare a hole in the soil to the proper depth.

Tubes come in different lengths and diameters. For most ag applications the length will be from 2-5 feet. The diameter will be from 1 – 4 inches. Successful installation has been done using several different methods but the end result should be a snug fit to the soil with no air gaps. Soil sampling probes, soil augers and powered hole punchers can all be used to create the initial hole. The hole diameter can be just large enough for a snug insertion of the tube without causing any damage or slightly larger and then backfilled with a soil and water slurry after insertion. The depth is usually slightly deeper than the tube length to accommodate any soil dropping into the bottom of the hole during installation. The hole should be as close to vertically plumb as possible. For access tubes place stoppers in the top of the tube to keep water and trash out. For permanent tube/probe installations attach all cables trying to keep them in the row as much as possible to avoid damage from farm equipment. Placement of the tubes should be close to a normally growing plant or between two. Don’t place in a low area to keep excess water from draining to and around the tube.

If using a sensor with exposed electrodes, the sensor should be inserted into the soil to the proper depth, making sure that there is good contact between the soil and the sensor electrodes.

After installation, it may take several hours for the sensor reads the correct soil moisture values as the disturbed soil must re-consolidate. After initial equilibrium period, the sensor will
accurately indicate the soil moisture status and it will closely follow changes in soil moisture as they occur in the soil.

**Maintenance**

Soil moisture sensors are relatively delicate instruments and should be protected from harm both before and after installation. They should be handled carefully and protected from impact by equipment or animals in the field. Cables connecting sensors to dataloggers or readers should be protected from harm as well. Most sensors of this type should be removed after the crop season is over (usually before harvest). These sensors are not capable of withstanding extreme hot or cold conditions.

A continually high or low reading may indicate a defective sensor or probe if the reading does not match field conditions.

**Irrigation Water Management**

Sensors are only one tool for irrigation scheduling. Plant wilt, appearance of the soil, amount of irrigation water applied and rainfall should also be closely checked. Contact your local NRCS office or mobile irrigation lab for assistance in developing an irrigation water management plan. This plan may include an irrigation schedule and how long to irrigate.

It is important to identify the location of sensors by recording a valve or site number, the depth of the sensor being read, and the date and time of taking the reading.

The sensor readings are recorded and transmitted electronically to a computer at least three times daily; morning, noon, and evening. In addition, rainfall and irrigation dates along with amounts are also transmitted. The electronic transmission can be by cellular phone, wireless cloud, or radio.

To demonstrate soil moisture over time, the sensor readings are plotted on a electronic graph utilizing software provided by the sensor vendor. A graph provides an excellent method to visualize changes in soil moisture levels. The graph is documentation that irrigation water management was successfully achieved.