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UTILIZING SOIL MOISTURE READINGS IN IRRIGATION SCHEDULING

M.A. Crookston
Manager, Irrigation Management Department
Northern Water
Berthoud, Colorado
Voice: 970-622-2262 Fax: 877-851-0018
Email: mcrookston@ncwcd.org

BACKGROUND

Need to Check Soil Moisture

Irrigation scheduling is deciding when and how much to irrigate. A variety of procedures are available, but all involve monitoring of some indicator(s) to determine irrigation need. Checking soil moisture content is one of the most common procedures. This can range from kicking clods, turning it with a shovel, pulling cores with a soil probe, using the 'appearance and feel method' to estimate soil water content, or using sensors to measure soil moisture.

Crop water use or ET methods of irrigation scheduling also require periodic checks of soil moisture. These are commonly referred to as the water budget or 'checkbook method' of irrigation scheduling. However, it is important to validate the 'checkbook balance' at least every one or two weeks by comparing it to field-measured soil moisture. If there is a discrepancy, reconcile the 'checkbook balance' by using the measured soil moisture content going forward.

Types of Soil Moisture Readings

Soil moisture measurements can be obtained many ways, some more readily than others. However, effective use of soil moisture readings requires experience and judgment . . . and, in many cases, just good old common sense. They are another tool, another source of information. They should be duly evaluated and considered before relying upon them for critical decisions.

Some measurements are semi-qualitative while others provide greater quantitative accuracy. Several of the more common and well known are included below.

Method	Advantages	Disadvantages
Appearance and Feel	Easy, simple, accuracy improves with experience.	Lower accuracy, labor intensive.
Gravimetric (oven drying)	High accuracy with increased sampling, direct measure.	Very labor intensive, delays to obtain data.
Tensiometers (soil moisture tension)	Instantaneous, approximates soil moisture content.	High maintenance, tension breaks, freezing temperatures.
Electrical Resistance (soil matric potential)	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.
TDR and TDT (time domain)	High accuracy, volumetric water content and salinity, robust calibration.	Highly influenced by adjacent moisture/voids.
Water Budget or Checkbook	Estimates the soil moisture balance.	Needs calibration and periodic adjustments.
Neutron Probe	High accuracy, relative ease of deep readings, repeatable.	High cost, regulatory requirements.

METHODS AND PROCEDURES

Quantity vs. Quality

Regardless of the method utilized to measure soil moisture, it is critical the irrigator understand that one measurement is almost never representative of the entire field. A single soil moisture measurement is for one point at a given time. It cannot reasonably be assumed to represent the entire field. It is essential to obtain additional measurements. However, this does not mean that purchasing more hardware is always required.

The ‘checkbook method’ is inherently an average for the field, but it does need the periodic ‘reality check’ to make sure it is representative of soil moisture levels in the field. This can be accomplished by hand probing and use of the ‘appearance and feel method’. It could also utilize an automated soil moisture monitoring station sited in a representative area of the field. Significant improvements in soil moisture sensors have occurred in recent years, making them more accurate, reliable, and economical.

Selecting Locations

Placement of soil moisture sensors is very important. For representative readings the sensor must typically be installed in the principle soil type, within the active crop root zone, and avoiding high spots, slope changes, or depressions where runoff may collect. If the sensor requires periodic visits for service or to obtain readings, it is also important for it to be reasonably accessible.

Insertion or Slurry Bedding of Sensors

It is not okay to simply dig a hole and backfill around a soil moisture sensor. Destruction of roots and soil structure must be minimized. Water settling is also taboo. For soil moisture sensors to provide accurate readings, they must be in full direct contact with undisturbed soil whenever possible. Air voids, large roots, rocks, etc. must be avoided. Direct, clean insertion of sensors into naturally consolidated soil is typically preferred. It provides for near immediate availability of representative moisture readings.

However, sometimes the soil is too dry, hard, or gravelly to safely allow installation by insertion, even with a pilot slot or hole. The soil would then be screened, mixed into a slurry (consistency of thick pudding) and the sensor installed undamaged with full soil contact, howbeit not natural and undisturbed. However, it may be some time before this excess moisture is depleted, especially at greater depths and in heavier soils. Several weeks may pass before the sensor will provide readings representative of field conditions. The deeper the sensor is to be installed, generally the greater the difficulty with proper installation.

Avoiding the potential for preferential flow of surface water to the sensor is very important. Small surface mounding of soil around the sensor to avoid surface puddling, good compaction and sealing around wires, etc. will help prevent extra water from reaching the sensor and falsely elevating the readings.

Protection of Sensors

Unnecessary replacement of hardware should be avoided. Besides the expense of purchasing and re-installing replacement equipment, the desired soil moisture information is also lost for some period of time.

‘Losing’ the location of sensors installed in tall corn because of poor flagging and mapping is expensive (and embarrassing), especially when eventually ‘found’ by the silage cutter. Inexpensive hand-held GPS units are a great tool for preventing such mishaps.

Tensiometers are liquid filled and will freeze and break if installed too early in the spring or left in the field too late in the fall. Always use distilled water and the anti-bacterial dye provided by the manufacturer to prevent plugging of the ceramic tip.

Rodents (and even deer) love to chew on exposed sensor wires, etc. Placing them inside PVC conduit or braided stainless steel sheathing has proven effective. Rodents have been known to tunnel adjacent to sensors installed at shallow depths and wreak havoc in multiple ways.

If a field is grazed after harvest and sensors are left over-winter, the sensors must be protected from damage. This is not unusual in alfalfa hay fields. Be sure the ‘protection’ does not alter the soil moisture conditions from being representative of the rest of the field. A sensor station fenced off will often become drier because of taller vegetation and increased crop water use during the shoulder seasons.

Automated Soil Moisture Stations

Installation of an automated soil moisture station can provide continuous measurement of soil moisture levels. When the data is processed graphically, the changes in soil moisture due to extraction by the crop and replenishment by rainfall and irrigation are readily grasped and understood. With sensors at multiple depths, the slow drying of the deeper soil levels typical under many center-pivot sprinklers becomes evident.

The benefits of utilizing sensors that provide accurate *volumetric* measurement of soil moisture is readily realized with automated stations. The calculated soil moisture balance directly reflects the depth of effective rainfall, the net depth of applied irrigation by a center pivot sprinkler, etc. This direct correlation to known events helps strengthen grower confidence in the equipment and procedures.

When coupled with radio telemetry, this information can be available to the irrigator 24/7. When he needs to make an irrigation decision, the real-time status of soil moisture levels is at his fingertips. This is a great advantage, but one that comes at some cost. Not all irrigators are equally motivated to adopt these improved practices, even when subsidized, whole or in part.

THE NORTHERN WATER EXPERIENCE

Manual Readings

Beginning in 1982, Northern Water provided a limited irrigation scheduling service for area producers. The program was intended to be educational and assist producers for only one to two years in a couple of their fields. These demonstrations used the 'checkbook method' coupled with soil moisture readings obtained from tensiometers. The program proved popular but was limited to the number of fields a single technician could service each week to manually obtain the soil moisture readings.

Automated Monitoring

The program evolved to include automated soil moisture monitoring stations. Sensors were installed in each of the four top feet of root zone and connected to a small data logger with battery and solar panel. Data was downloaded as frequently as once per day via cellular phone telemetry. Graphical summary reports were routinely provided to growers via email.

Although the computer programs utilized the 'checkbook' method of maintaining a soil water balance, that balance was 'reconciled' at the end of each day with the soil water content measured by the soil moisture sensors. The procedure was heavily weighted to follow the sensor readings. However, the crop water use information obtained from local weather stations did fill-in periods when soil moisture data was not available, such as early in the spring or late in the fall. It also provided estimates or predictions of future crop water use for trending, etc.

Unfortunately, the staff position at Northern Water necessary to continue this irrigation scheduling service was eliminated in 2007. Local soil conservation districts have expressed interest in continuing similar services for their producers.

Summary and Conclusions

Historically, advanced irrigation scheduling has not been for everyone. Many times, simpler methods seemed wholly satisfactory. However, increasing pressures are directed towards irrigated agriculture to produce more, with reduced inputs, and without cost increases to consumers. It is highly unlikely this can be attempted without utilizing the best available tools, including advanced methods of irrigation scheduling. Fortunately, improved methods and better equipment are available today than was available just a few years ago.