MONITORING SOIL MOISTURE FOR MAXIMUM PROFIT IRRIGATION OF ALFALFA

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ABSTRACT

Insufficient soil moisture can reduce alfalfa water use or evapotranspiration, which in turn will reduce crop yield and profit. One method of ensuring adequate soil moisture is to monitor soil moisture with a soil moisture sensor. Many such sensors exist, but only a few are appropriate for alfalfa growers. These include the Watermark electrical resistance block, the GroPoint dielectric sensor, and the Echo dielectric sensor. All of these sensors are left in the ground during the irrigation season to help determine when to irrigate and the adequacy of the irrigation (did the water infiltrate deep enough. Examples of the use of Watermark blocks are provided.

Key Words: irrigation, alfalfa, soil moisture, electrical resistance block, dielectric soil moisture sensor

WHY MONITOR SOIL MOISTURE?

Evapotranspiration (ET) is the crop water use and consists of evaporation from leaves and evaporation directly from the soil surface. It is well known that crop yield, and thus profits, is directly related to evapotranspiration. Yield increases with ET to a maximum yield, which occurs at maximum ET. Maximum ET is controlled by climatic conditions such as solar radiation, wind, temperature, and humidity. However, if the ET is less than maximum, yield, and thus profit may be less than maximum. What causes ET to be less than maximum? The most common factor is insufficient soil moisture in the root zone, the results of inadequate irrigation. Insufficient soil moisture is caused by applying too little water during an irrigation or irrigating too infrequently. Soil moisture monitoring can help ensure the adequacy of irrigation (applying sufficient water to wet the root zone) and evaluate the appropriate irrigation interval, thus preventing inadequate moisture in the root zone. It can also help determine if over-irrigation occurs, which can result in excessive energy costs for pumping, and possibly increased disease problems.

HOW CAN I MONITOR SOIL MOISTURE?

Many sensors exist for monitoring soil moisture. Some measure soil moisture tension, which is a measure of the tenacity at which water is retained by soil. Others directly measure soil moisture content. However, only a few are appropriate for alfalfa growers. One condition for alfalfa growers is that no part of the sensor can stick up above the ground surface. Otherwise, it will be damaged during harvest.

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One device is the Watermark electrical resistance block (Irrometer, Inc.). This sensor consists of a porous ceramic-sand block with two electrodes imbedded in it (Fig. 1). An electronic readout device is attached to the resistance block to obtain measurements of soil moisture tension. This device is easy to install, read, and maintain, and is probably the most practical sensor to use in alfalfa fields. The following procedure is used to install these blocks (more detail on Watermark blocks and their use is in Orloff et al., 2001):

1. Soak the block in water prior to installation until the readings equal zero.
2. Use a soil probe to make a hole about 1-inch in diameter down to the desired depth of measurement.
3. Pour some water into the hole and then add some soil to the water to form a slurry in the bottom of the hole.
4. Push the Watermark block down the hole using a ½-inch diameter piece of PVC pipe. A small slot should be cut to the side of the pipe to prevent damaging the wire lead of the block during installation. Another option is to feed the wire up through the PVC pipe. Be careful to hold on to the end of the lead wire to prevent it from falling into the hole while the PVC pipe is being removed.
5. Backfill the hole with soil, periodically compacting the soil with the PVC pipe. This will prevent water from flowing down the hole during irrigation.

An alternative installation involves gluing the Watermark blocks to PVC pipe, and then installed into the ground. This allows the block to be retrieved at a later date. Instructions for attaching the block to PVC are provided by the manufacturer.

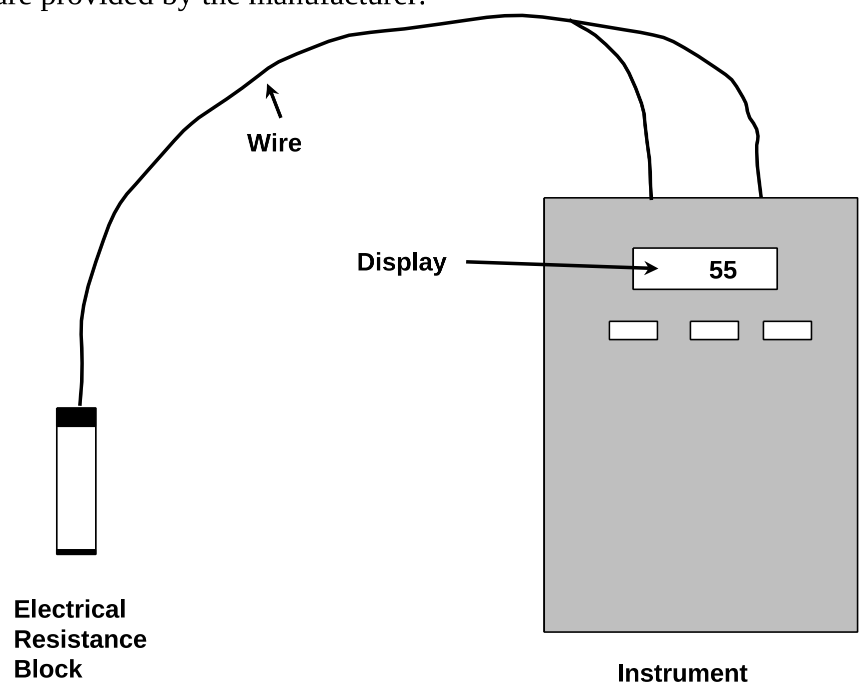

Figure 1. Watermark electrical resistance block.

Another device is the GroPoint dielectric sensor (Environmental Sensors, Inc.) (Fig. 2). This sensor measures the dielectric constant of the soil (an electrical property of the soil). A

Figure 2. GroPoint dielectric soil moisture sensor.

calibration equation built into the sensor's electronics converts the dielectric constant to soil moisture content. A hand-held readout device is used to measure the moisture content as a percent of the total soil volume. The measurement reflects the soil moisture content over about a one-feet depth interval. It works well in coarse to medium texture soil. It may not work well in fine-texture soil. Installing this sensor consists of:

1. Auger a 3-inch diameter hole down the desired depth interval.
2. Place the sensor upright in the hole.
3. Backfill the hole with soil using a piece of PVC pipe to compact the soil.

GroPoint sensors are left in the field during the irrigation season. Sensors placed at depths less than two feet can be retrieved. It will be difficult to retrieve sensors at deeper depths.

A third device is the Echo dielectric sensor manufactured by Decagon Devices, Inc. (not shown) This sensor measures soil moisture content as a percent of the soil volume. Its installation is similar to that of the GroPoint sensor.

WHAT DO THE READINGS MEAN?

For irrigation scheduling, a sensor should be installed at a depth of about one-fourth to one-third of the root zone depth. Another sensor installed near the bottom of the root zone can help determine adequacy of irrigation. A third sensor installed midway can help assess the actual depth of irrigation. Irrigate when soil moisture tension of the shallow sensor approaches the recommended values at which an irrigation should occur (Table 1) or when soil moisture content approaches the recommended soil moisture content at which irrigation should occur (Table 2). These sensors can also be used to determine the timing of the first irrigation by irrigating when the late spring soil moisture tension or content approaches the recommended value. Sensors should be installed in an area where the soil is representative of the field-wide soil.

Table 1. Recommended values of soil moisture tension at which irrigation should occur. (Orloff, et al., Undated).

Soil Type	Soil Moisture Tension (centibars)
Sand or loamy sand	40-50
Sandy loam	50-70
Loam	60-90
Clay loam or clay	90-120

Table 2. Recommended values of soil moisture content at which irrigation should occur. Values are based on a 50% allowable depletion of available soil moisture.

Soil Texture	Soil Moisture Content (%)
Sand	7
Loamy Sand	12
Sandy Loam	15
Loam	20
Silt Loam	23
Silty Clay Loam	28
Clay Loam	27
Sandy Clay Loam	24
Sandy Clay	22
Silty Clay	30
Clay	31

EXAMPLES

Figure 4 shows soil moisture tension readings for several depths of a sprinkler-irrigated alfalfa field. At the one-foot depth, soil moisture tension increased with time until the first irrigation after the first cutting. Soil is typically driest around the cutting time because irrigation ceases before cutting to allow the field to dry enough to facilitate hay cutting and curing. Soil moisture tension then decreased as the soil was wetted by the irrigation after cutting. Soil moisture tension again increased with time until the second cutting and subsequent irrigation. Soil moisture tension again decreased just after the irrigation and then increased with time due to moisture extraction by the alfalfa. A similar behavior in soil moisture tension with time occurred at the two-foot depth, but for the deeper depths, soil moisture tension increased with time throughout the growing season. This increase in tension at those deeper depths indicates root activity and moisture uptake. There was no response to irrigation indicating that irrigation water was not infiltrating to the three-foot depth and deeper. This behavior suggests inadequate irrigation amounts applied during the irrigations.

Figure 5 shows soil moisture tension readings in another alfalfa field. Note that few of the readings exceeded about 30 centibars, which indicates a very wet soil. This behavior of soil moisture tension with time indicates a field that was over-irrigated, resulting in an excessively wet soil throughout most of the growing season.

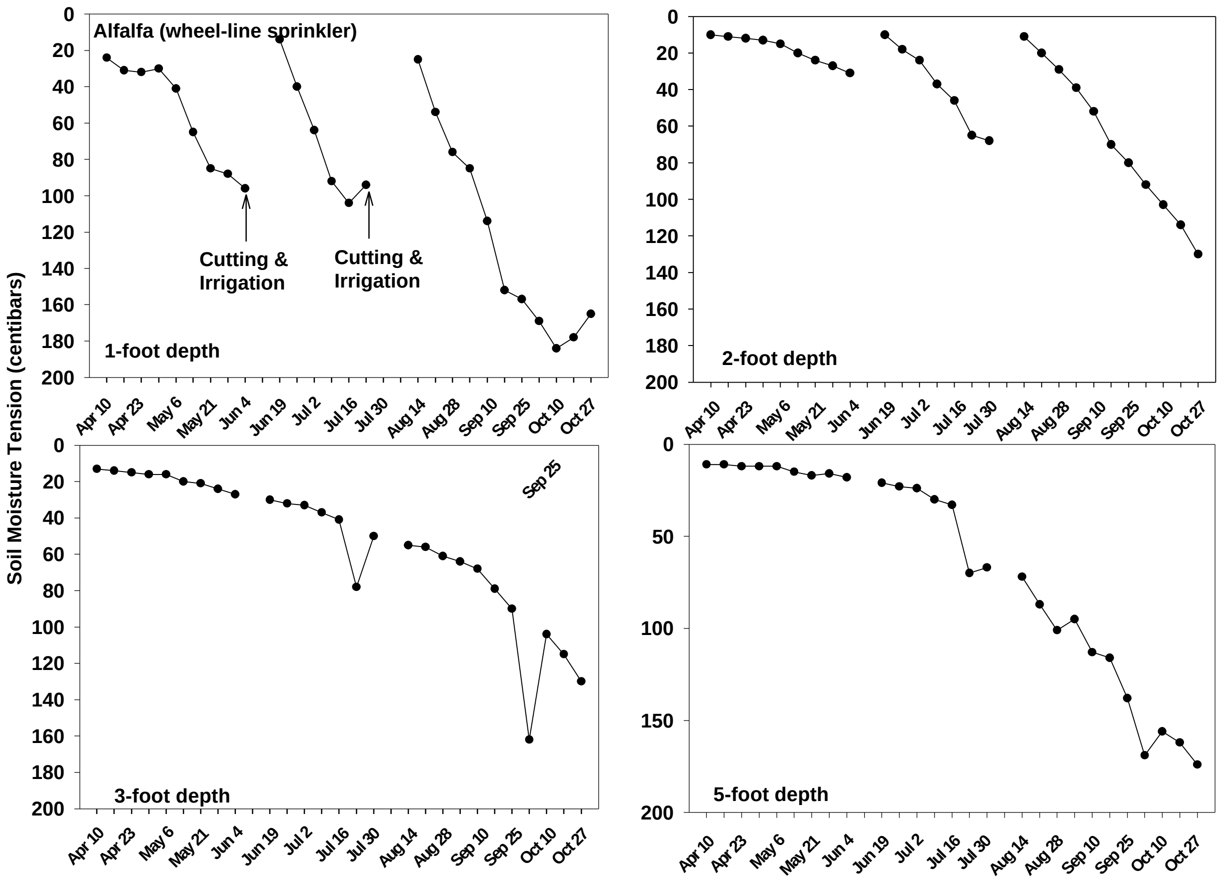

Figure 4. Soil moisture tension of a deficit-irrigated alfalfa field.

SUMMARY

Soil moisture sensors can help to evaluate irrigation water management practices, and thus prevent deficit irrigation and over-irrigation. The most practical sensor for alfalfa growers is the Watermark electrical resistance block, however, other moisture sensors are also appropriate for monitoring soil moisture in alfalfa fields. The examples in this article illustrate the value of soil moisture monitoring in understanding what is occurring in the soil.

For those using Watermark blocks, an Excel program that will graph the data is available at the University of California's alfalfa workgroup website (http://alfalfa.ucdavis.edu).

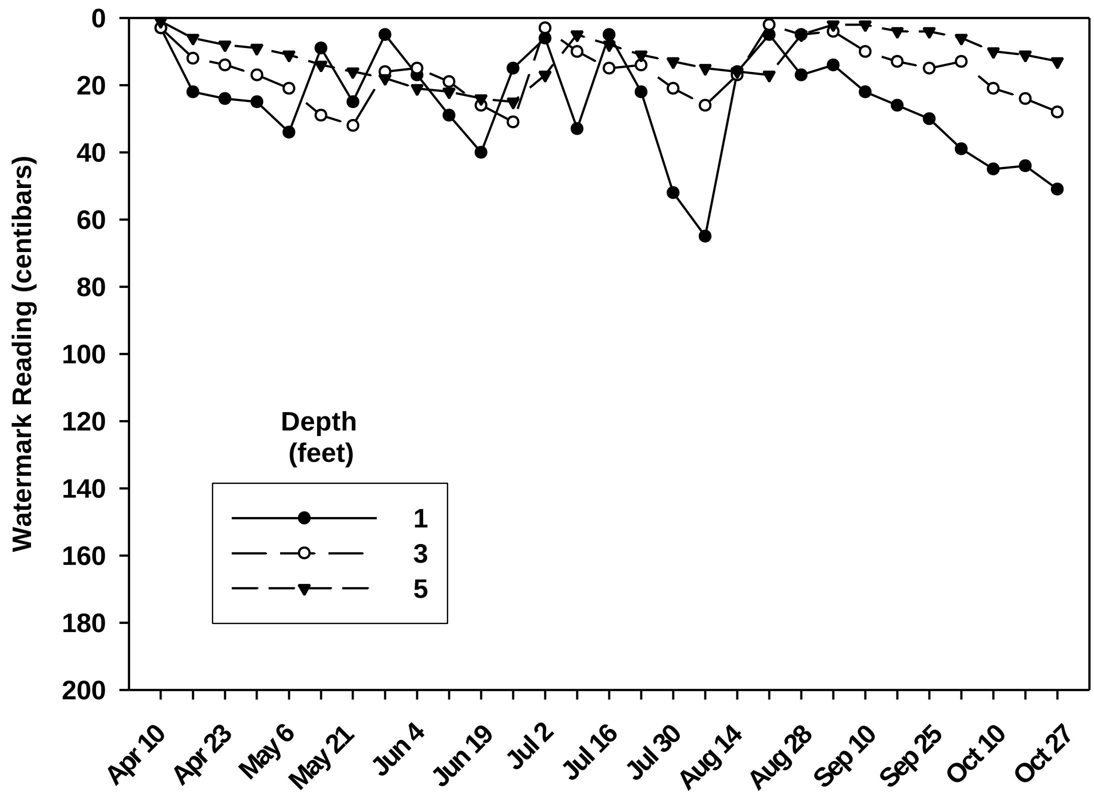

Figure 5. Soil moisture tension of an over-irrigated field.

REFERENCES

Orloff, S. B. Hanson, and D. Putnam. Undated. Soil-moisture Monitoring. 8 pg.