IRRIGATION MANAGEMENT

Using Electrical Resistance Blocks to Measure Soil Moisture

by Hal Werner, Extension irrigation specialist

Using resistance blocks and meters to measure soil moisture can pay big dividends when you need to decide if it's time to irrigate. Delaying irrigation too long can result in crop stress and reduce yield potential by as much as 10 to 20 bushels of corn per acre for each inch of water. Conversely, when soil moisture is adequate, resistance block readings can provide the information needed to save $2 to $5 per inch per acre by eliminating unnecessary irrigations.

Resistance blocks and meters have become accepted irrigation management tools. Soil moisture readings can be used to schedule irrigations or to assist with other methods of scheduling such as the checkbook method.

What is the electrical resistance method?
The electrical resistance method uses a small block that changes resistance as soil moisture changes. The block is buried in the soil and lead wires connected to the block are brought above ground level. When the meter is connected to the wire leads, block resistance is read. The reading is related to the moisture content of the soil. The drier the soil, the greater the electrical resistance and vice-versa. Reading the resistance of the block with a portable meter gives the user a measure of the amount of water in the root zone.

Most blocks are constructed of wires or a wire grid embedded in a gypsum material. The block may be entirely gypsum or covered with a porous material such as sand, fiberglass, or ceramic. After burial, the moisture block comes to equilibrium with the soil moisture. Figure 1 is a diagram of a common block.

Meters are portable and are intended for use in reading a large number of blocks throughout one or more fields. The specially designed meters can be either analog or digital. The readings on the meter are calibrated to give reading that relate to the soil moisture content. One meter brand may not work with a different brand of block.

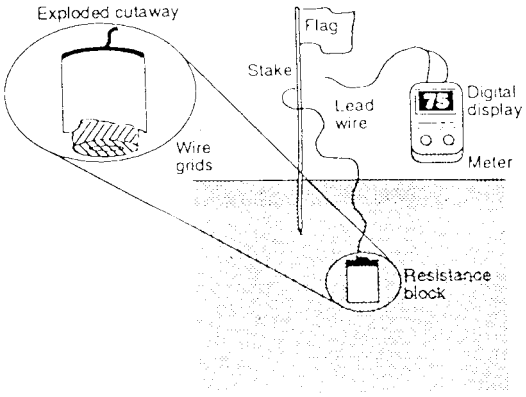

Figure 1. Gypsum block and electronic digital meter.

Resistance block methods are suitable for most soils, and the readings cover most of the soil moisture ranges of concern to irrigation management. The blocks tend to deteriorate over time, and it may be best to use them for only one season. Problems may occur with highly acid or highly saline soils.

Locating moisture blocks in the field
Install blocks in at least two locations in the field (four is preferable), one near the start of the irrigation cycle and one near the end of the cycle (Figure 2). Use two locations for each crop where more than one crop is in the same field. Four locations are desirable for surface-irrigated fields.

Where there is more than one soil type, place the blocks in the predominant soil types. Avoid locations such as low areas, hill tops, beneath the coverage of the end gun, or under the first tower of a center pivot, near the edges of fields that may get uneven irrigation, or any other place that is not representative of the field.

Locate the blocks where they will be accessible from a road or trail. It is very important to place the blocks where they can be found easily for repeated reading, especially as crop growth increases. Do not locate the block sites too far from field roads so that extra effort is required to find and read them. Put markers or flags in the row and on the edge of the field.

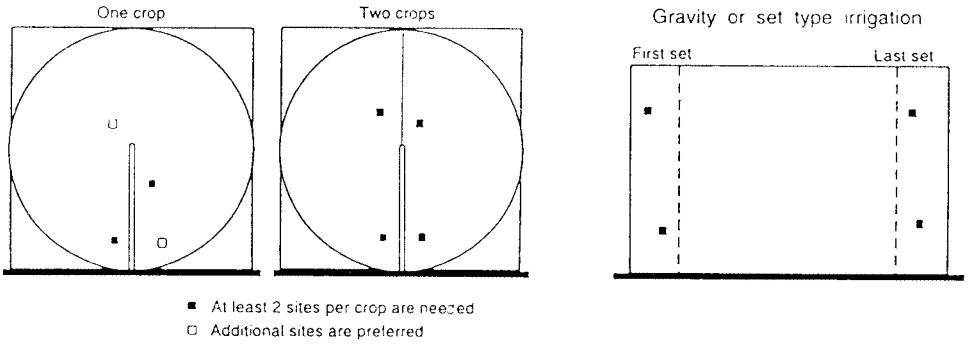

Figure 2. Locating soil moisture blocks in the irrigated field.

Placing blocks in the soil

Install at least two blocks at each site except for shallow-rooted crops or for very shallow soil underlain by gravel. When soil depth is less than normal rooting depth, use actual soil depth to determine how deep to place the blocks.

Place the blocks in the crop rooting zone at 1/3 and 2/3 of the crop rooting depth (Figure 3). For most soils without restrictive layers, about 70% of the roots are in the top 50% of the root zone. Table 1 gives normal rooting depths for common crops along with recommended block depths.

Remember, these are rooting depths for mature crops. Root development progresses at a rate similar to top growth.

Install the blocks early in the growing season so that the roots grow around the blocks. For row crops, place the blocks between plants in the row. Avoid locations where field equipment or pivot wheels could run over the location. Reduce foot traffic around the sensors to minimize soil compaction.

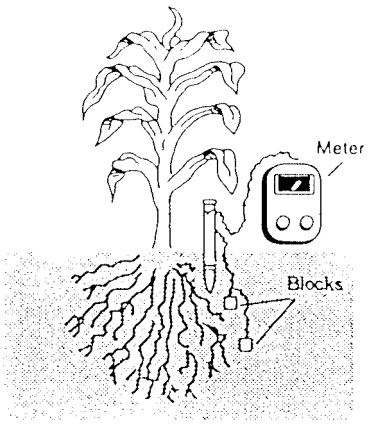

Figure 3. Placing soil moisture blocks in the root zone.

Preparing and installing blocks

Follow the manufacturers' instructions for the type of block being used. For most of the blocks, it is a good practice to soak and dry the new blocks before placing them in the soil. Use clean water (preferably distilled). Soak the blocks for two to four minutes, then let them dry for five to 10 minutes. Repeat this process for two to three cycles. This removes air from the block and primes it. The blocks should be wet when they are placed in the soil. Do not store the blocks in water or leave them in water for more than a few minutes as this may dissolve them.

Always keep the blocks clean and don't handle the porous part of the blocks with anything that could make them dirty. Make sure used blocks are in good condition before reusing. Very few are usable after two years, and many may be damaged or decomposed after one season of use. Never use a block if it is damaged or has parts of the wire electrodes exposed. Check the lead wires to make sure they are okay.

A standard soil probe works well to install many types of blocks in the soil. Make a pilot hole in the soil to the depth desired. Crumble a small amount of the last soil removed back into the hole and add some water to make a soil slurry in the hole which will help obtain good soil contact. Use the soil probe or a section of 1/2" conduit to insert the block in the hole. If possible, insert the block slightly deeper into the hole than the pilot hole. Make sure there is good, firm contact between the block and the surrounding soil. Use care to avoid damage to the block and lead wires.

Add a small amount of similar soil around the block and pour water in the hole to get good contact with the block. Backfill the hole with soil and pack to prevent surface water from running down into the hole.

After installing the blocks, use the meter to test the lead wires and block. The reading should indicate

nearly saturated soil. Readings will not indicate true soil moisture for one to two days because of the water added around the block. Wrap the lead wires around a stake and mark them for future reading.

Check to make sure the meter and adjustments work properly. Meter readings of zero or full scale indicate a malfunction. Check the meter and lead wires first if the readings are off-scale. If there is still a problem, the block may be defective and may need to be replaced.

Using moisture blocks for irrigation management

Measuring soil moisture benefits irrigation water management by giving more accurate soil moisture information and is an integral part of any irrigation scheduling program. Soil moisture readings can be used by themselves to schedule irrigations, but they are most valuable when used in combination with other methods such as the Checkbook method (see Extension Circular 897) or a computer model. Soil moisture readings can help you determine initial soil moisture balances and update these balances throughout the irrigation season. Where the readings are used to update other scheduling methods, readings once or twice per week may suffice.

Where soil moisture readings are the basis for scheduling irrigations, take readings at least every other day. Use the shallow block to judge when to start irrigating. The deep block can be used to determine if irrigation is keeping up with crop water needs. If readings of the deep block indicate the soil is getting drier even after irrigating, continue irrigating or apply more water with each irrigation. If the readings of the deep block show the soil is too wet (less than 20 centibars tension), apply less water during each irrigation since there is a greater chance of over watering and leaching of nutrients should heavy rainfall occur.

During periods of lower water use and after rainfall, it is especially important to

Table 1. Crop rooting depths and soil moisture block placement depths.

Crop	Rooting depth (ft)	Block depth (in) Shallow	Deep
Corn	3-5	12-18	24-36
Alfalfa	4-6	18	36
Soybeans	2-3	12	24
Potatoes	2-3	12	24
Small grains	3-4	12	24
Field beans	2-4	12	24
Sugar beets	2-4	12	24
Pasture or grass	1-2	12	18-24
Sorghum	3-4	12-18	24-36
Turf and lawns	1	6	12
Annual vegetables	1-2	6-12	12-18
Small fruits	1-2	6-12	12-18
Asparagus	2-3	12	18-24

Figure 4. An example of soil moisture deficit calculations using Delmhorst blocks and KSD1 meters.

Example:

Field: Pivot #1
Crop: Corn
Soil: Fordville loam

Resistance block readings and soil moisture deficits

	Start of field Reading	Deficit (inches)	End of field Reading	Deficit (inches)
Shallow (12")	98	.5	90	1.5
Deep (24")	96	.9	94	1.2
Total		1.4		2.7

Table 2. Soil moisture deficit in inches per foot for soil moisture readings.

Soil tension (centibars)	Watermark digital	Delmhorst KSD1	Sands	Sandy loams	Loams	Silt and clay loams
10	10	99	0	0	0	0
20	20	98	0.2	0.3	0.35	0.4
30	30	96	0.3	0.5	0.6	0.7
40	40	94	0.4	0.65	0.8	0.9
50	50	91	0.5	0.8	1.0	1.1
60	60	88	0.55	0.9	1.1	1.3
70	70	86	0.6	1.0	1.18	1.4
80	80	84	0.64	1.05	1.25	1.47
90	90	80	0.67	1.1	1.33	1.53
100	100	77	0.7	1.2	1.4	1.6
200	200	52	0.78	1.3	1.6	1.8
500		32	0.9	1.5	1.9	2.2
1500*		10	1.0	1.7	2.2	2.6

*Permanent wilting point.
Shaded area = optimum range for typical soils.

Table 3. Example meter readings for Delmhorst blocks and KSD1 meter.

	Sandy loams	Loams	Clay loams
Start irrigation*	97-98	94-96	92-94
Optimum range	90-98	88-96	86-94
Minimum reading	89-91	87-89	80-86

*"Start irrigation" allows time for completion of irigation cycle without part of the field suffering moisture stress.

monitor the black readings. Stop irrigation when both the shallow and deep readings indicate the soil moisture is wet and could not hold another irrigation without over watering and deep leaching.

Record the soil moisture readings along with rainfall and irrigation amounts to help the management and planning. Diligent use of soil moisture readings will allow you to develop an art to knowing how and when to irrigate on your farm. Table 2 gives the soil moisture deficit for two common types of blocks. The shaded area on the table is the optimum range for typical soils and most crops. Generally, optimum soil tension for most crops is a value from 30 to 50 centibars. Remember that the dryer the soil moisture reading, the harder it is for the plant to use the water remaining in the soil profile.

Use soil moisture readings to schedule irrigation so the irrigation cycle can be completed before crop stress occurs. Block readings only show current moisture levels in the soil and cannot predict future readings. It is possible for readings to change rapidly from one day to the next. Table 3 is an example of readings to use with the Delmhorst blocks and KSD1 meter.

Most irrigation systems do not pump enough water to keep up during periods of high water use. Starting irrigations early is important during these periods or during critical growth stages to prevent excessive depletion of the soil moisture reserve. Taking soil moisture readings regularly, together with rainfall, irrigation information, and weather forecasts, can help you predict future crop water use and irrigations.

Figure 4 shows an example of soil moisture deficit calculations using Delmhorst blocks and KSD1 meters. Blocks are set at 12" and 24" at the start and end of the irrigation cycle. The 12-inch block readings represents the top 1.5 feet of the root zone and the 24-inch block readings represent the next 1.5 feet, so the deficit is 1.5 times the appropriate value from Table 2. Irrigation has been completed for the blocks at the start of the field.

Because crop demands and sensitivity to water stress often are lower early and late in the season, it may be possible to deplete more soil moisture at those times without loss of crop yield. This will allow more effective use of rainfall and minimize leaching of chemicals and nutrients below the root zone. Terminate irrigation if adequate soil moisture reserves are available for the crop to mature.

It is possible to use blocks to automate irrigation scheduling Many electronic controllers on irrigation systems will accept input from blocks and trigger irrigation based on the readings.

Caring for blocks in the off-season

In some cases, blocks can be removed from the soil by digging them up. If they are in good condition, wash them with clean water, dry, and store them in a dry area over winter. Blocks installed in alfalfa or permanent crop may be left in the soil. If blocks are not saved after the season, they may be abandoned in the soil. Cut off the lead wires at ground level.

Replace meter batteries annually or as needed. Store the meters in a dry, non-freezing place. Remove the batteries during the winter to prevent corrosion.

Cost of blocks

Resistance blocks range in price from about $5 to $30. Meters cost from $150 to $300. Total cost for one irrigated field will be approximately $180 to $400 or from $1.50 to $5 per acre. The cost is certainly less than $1 per acre on an annual basis and will pay for itself manyfold if the moisture blocks are used conscientiously.

Suppliers of blocks

There are a number of known suppliers for the various types of resistance blocks and meters:

Watermark® blocks and meter
Irrometer Company, Inc.
P.O. Box 2424
Riverside, CA 92516-2424

Gypsum blocks and meter

Delmhorst Instrument Company
51 Indian Lane
East Towaco, NJ 07082

Blocks and meter

Soilmoisture Equipment Company
P.O. Box 30025
Santa Barbara, CA 93105
(805) 964-3525

Blocks and meter

Beckman Instruments, Inc.
89 Commerce Road
Cedar Grove, NJ 07009
201) 239-6200

Blocks and meter

NASCO Agricultural Sciences
901 Janesville Ave.
Ft. Atkinson, WI 53508-901
(800) 558-9595

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