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IRRIGATION
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SERIES

SCHEDULING IRRIGATIONS BY ELECTRICAL RESISTANCE BLOCKS

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Electrical resistance blocks and meters measure soil water to help decide when irrigation is needed. Drought stress at critical stages of growth can drastically cut yields, especially with corn. Delaying irrigation results in crop stress that can reduce yield potential by as much as 10 to 20 bushels of corn per acre for each inch of water. Likewise, too much water can adversely affect crops and waste water resources.

Electrical resistance block readings can help eliminate irrigation when soil water is adequate, translating in savings of $3 to $5 per acre, for each inch of water. Eliminating unnecessary irrigation will also help prevent environmental degradation and loss of nitrogen (nitrate) fertilizer. An inch of extra water can remove 10 to 30 pounds of nitrogen as it moves away from the root zone.

Electrical resistance blocks — also called gypsum blocks, resistance blocks, or moisture blocks — are permanently installed during the growing season at several soil depths. They are read with an electrical resistance meter to determine the amount of water at each depth. Table 1 gives interpretations for the meter readings.

Several types of electrical resistance blocks and meters have become accepted irrigation management tools. Soil water readings can be used to schedule irrigations or assist with checkbook methods. These help as a field check to validate evapotranspiration (ET) based water balance, whether done in a checkbook ledger or computer spreadsheet.

Blocks are fairly inexpensive when compared with the amount of fuel and water savings possible. Using two blocks per station and four stations per field, the cost for blocks and meter would run about $2 per acre for a quarter section. The blocks cost about $6 each, while the meter costs about $250. The meter can be used for multiple fields, greatly reducing the cost per acre. If the use of blocks to schedule irrigations saves a 1-inch application on a 130-acre center-pivot system, the fuel savings could easily exceed several hundred dollars, and save over three million gallons of water for later use.

Gypsum blocks are cast gypsum cylinders that contain two stainless steel electrodes. The electrodes are soldered to wires that lead from the buried block to the ground surface, where they can be attached to the portable resistance meter for reading. Figure 1 shows a gypsum block and a meter that are available.

The buried blocks act much like the soil — taking up and releasing water. The electrical resistance varies between the electrodes according to water content. The higher the soil water, the less the resistance.

Blocks are installed as soon as possible after the crop has emerged. The blocks are inexpensive enough that they are generally left in the soil at the end of the season. However, at season's end, the wire leads should be cut or pulled out so they will not get tangled in machinery. The gypsum blocks deteriorate over time.

Based on the same principle, other soil water blocks have been developed. Watermark blocks also

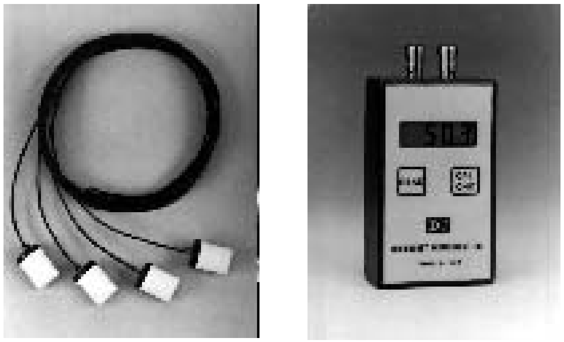


Figure 1. *Gypsum blocks and one of the many types of meters available to the irrigator*

Figure 2. *Watermark sensors*

operate on the basis of electrical resistance (Figure 2). The meter for this type of block is set to read up to 200 centibar of tension. Since most of the readily available water is used up at 2 bar, this provides an adequate range for monitoring soil water. Watermark sensors are fabricated with a stainless steel casing that is more durable and may be reused. If reuse is desired, the sensor can be glued to one end of a $^{7}/_{8}$” diameter PVC pipe, cut to the desired length. The block should be installed at several depths within the root zone and the assembled sensor should fit snugly into a soil probe hole, this helps in retrieval at the end of the season .

BLOCK INSTALLATION

Follow the manufacturer's recommendations for block installation. Generally, blocks are wetted, dried, and wetted again just before installation to eliminate trapped air.

Use a soil probe, auger, or small post-hole digger for installation. Place the hole in the row and angle it toward the furrow. Place the shallow blocks at the edge of the furrow and put the deeper blocks under the center of the furrow.

If you use a post-hole digger, insert the blocks in the same hole by placing them on the sides of the hole. Refill the post holes and tamp slightly to restore the soil's natural density.

Block installation is much easier using a small soil probe. When installing blocks with a probe, place one block to a hole. Insert the block into the hole by running the lead wire through the probe tip and holding the block firmly against the tip with the wire (Figure 3). A small amount of slurry in the hole is necessary to get good contact with the block and the soil. This is done by putting a portion of the crumbled soil that was removed back into the hole and pouring in a small amount of water. Insert the block into the hole and press firmly to make sure the block has good soil contact at the bottom.

Fill the hole 3 to 4 inches at a time, tamping the soil in the hole with a rod, making certain no voids are left and surface water cannot reach the block. It is a good practice to bring the soil back above the hole to make a raised mound. A depression can collect water, encouraging channeling.

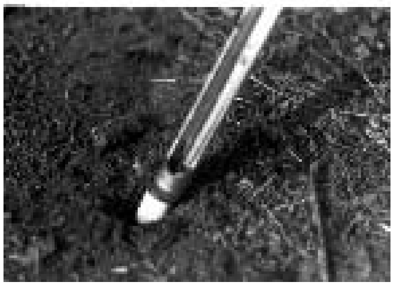


Figure 3. *Block installation using a soil probe*

Stake the wire leads at the surface of the ground and identify each lead according to depth by color code, knot, tag, or flag. Since the wire leads must be protected, the blocks must be in the row. To minimize root and crop damage, installation should be done as soon as possible after the rows are marked by crop emergence .

HOW TO LOCATE

Location of the blocks in the field generally depends on the type of irrigation system used. There will be at least four stations or locations for each set of blocks in each field.

If the blocks are installed in a flood-irrigated field, stations are generally located at the top and bottom of the first and last sets (Figure 4). Each station should be far enough in from the top or bottom of the field so it is not affected by initial wetting effect or by ponding of water. Generally, 150 feet in from either end of the field will be far enough.

Under a sprinkler system, use two stations on each side of the center pivot when it is in its normal stop position (Figure 5). Set one station on each side near the middle of the pivot, and one station on each side near the outer tower of the pivot, usually about the middle of the outer span. The stations should be far enough away from the center pivot so the sprinklers will not wet them when the system is stopped, or until after the system is moving. This system of positioning stations on flood or center-pivot systems will give start and stop indicators for the irrigation sequence. Start irrigation when the beginning block stations indicate soil water storage room is available, or before the last block stations to receive water are projected to reach critical depletion. Stop irrigation if the stations indicate sufficient soil water due to rain.

The block stations should be located in representative areas of the field. Try to avoid low or high spots and changing slopes. Select an area with a representative plant population. To keep the area around the blocks from becoming compacted, approach

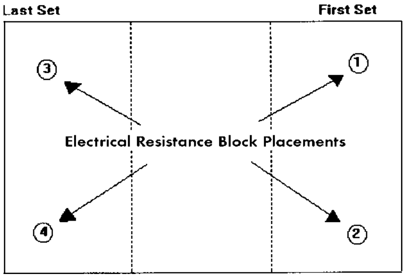


Figure 4. *Furrow and set-type station arrangement*

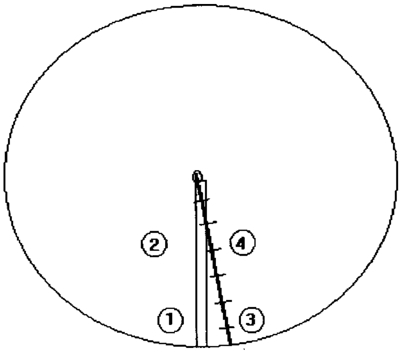


Figure 5. *Center-pivot station arrangement*

Table 1. *Electrical resistance meter readings as related to soil water tension for different soil type and available water inch/ft.*

Delmhorst KSDI	Watermark Digital	Soil Tension (centibars)	Sands	Sandy Loams	Loams	Silt and Clay Loams
99	10	10	1.0	1.70	2.20	2.40
98	20	20	0.80	1.50	1.85	2.00
96	30	30	0.70	1.20	1.60	1.80
94	40	40	0.60	1.05	1.40	1.60
91	50	50	0.50	0.90	1.20	1.40
88	60	60	0.45	0.80	1.10	1.20
86	70	70	0.40	0.70	1.02	1.05
84	80	80	0.36	0.65	0.95	0.95
80	90	90	0.33	0.60	0.87	0.87
77	100	100	0.30	0.50	0.80	0.83
52	199	200	0.22	0.40	0.60	0.70
32	----	500	0.10	0.20	0.30	0.40
10	----	1500*	0.0	0.0	0.00	0.0

*Permanent wilting point

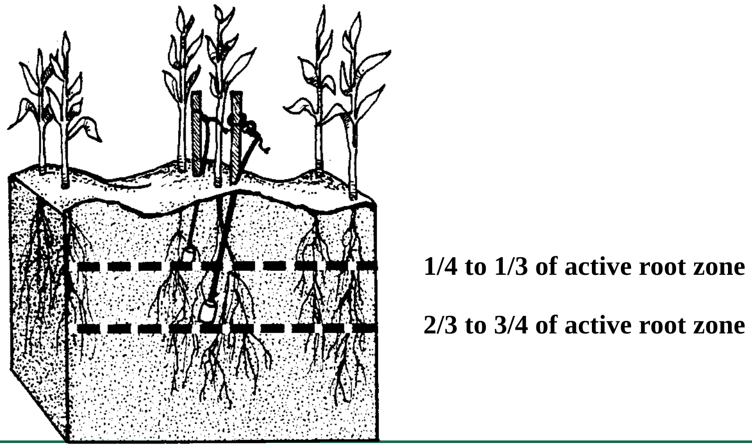
Readings above the shaded area indicate optimum soil water range for typical soils. Begin irrigation when readings are within the shaded area, depending on the soil texture, crop, and irrigation system capacity.

the stations two or three rows away from the row containing the station, or approach the blocks perpendicular to the row.

The depth of the crop roots will determine the depths at which the blocks should be installed. The active root zone for deep rooting crops such as corn, sorghum, alfalfa and wheat can be as much as 72 inches. However, the most active portion is above 3 to 4 feet. Water at depths greater than this may be lost to deep percolation. Management of this active root zone can be accomplished using two blocks; the upper block placed at about one-fourth to one-third depth of the root zone, while the lower block will be at two-thirds to three-fourths of the active root zone (Figure 6). This means block depth would be 12 to 18 inches for the shallow block and 30 to 36 inches for the deep block.

Other management factors, soil type, and experience will help determine the best situation for a particular field.

Figure 6.
Location of electrical resistance blocks in relation to the active root zone



Less deeply rooted crops such as sugar beets, soybeans, and field beans have actively growing roots at depths of 30 to 36 inches. Blocks for these crops should not be placed as deeply as those for the deeper rooted crops – 12- and 24-inch depths for two-block stations are suggested placement depths. If shallower-rooted crops are grown, or root development is restricted, adjust the depth of block placement accordingly. Experience may suggest a more suitable arrangement for a particular field. You can install additional blocks at each station. Three-block stations are also common, with the additional block in the upper root zone to help monitor early-season water use.

For three-block stations, use the top block extensively until the crop is about 18 inches tall. Then, after more growth and deeper rooting, use the intermediate block with the top block until the start of the reproductive stage.

After the roots are fully established, and all blocks are showing water extraction, use the average of all of the block readings.

The company from which you purchase the blocks and meter should send a conversion chart so you can convert meter readings to soil water depletion rates. A conversion chart giving approximate percent water used for given meter readings is shown in Figure 7. Many individuals initially use a soil probe to visually inspect the soil water content to compare to block readings. This confirms the reading and builds confidence. This may also be required to calibrate the readings if soil types vary widely between fields.

Along with the blocks, use a soil probe to make periodic field checks near the blocks, and at other places in the field where there are no blocks. This provides a better overall view of water distribution.

SCHEDULING IRRIGATIONS

An irrigator must know the soil water-holding capacity to make full use of the data obtained from the gypsum blocks. When scheduling irrigations with gypsum blocks, the soil type will determine when irrigation should be started based on the percent of soil water depletion. The values shaded in Table 1 are based on a management allowable depletion (MAD) level of 50 percent of total available water for the soil type. Irrigation may be started at or before reaching this level, keeping in mind the time required to complete the irrigation. This is necessary to avoid stress for the area that receives water later. These values work well for field crops and heavy soils. Sandy soils and specialty crops needing well-watered conditions may require irrigation at a higher value above the shaded line and a corresponding meter reading shown on the left side of Table 1.

Figure 7 shows a chart provided by one of the manufacturers of a gypsum block and meter. According to this chart, a meter reading of 60 indicates that 50 percent of available soil water has already been used (this may refer to a silty clay loam soil with high water holding capacity).

On sandy loams with a water-holding capacity of 1.7 inches per foot, turn on the water at a meter reading indicating tension of 60 centibar. On extremely sandy soils, with very low water-holding capacity, other types of monitoring devices, such as a tensionmeter, will be better suited. (See bulletin L-796)

On clay loams and silty clay loams, or soils with water holding capacities of 2.4 inches per foot or greater, start irrigation at 70 to 80 centibar. Soils at this point are 50 percent depleted. However, irrigation system capacity plays a role on when to begin irrigation. Low irrigation capacity may mean that an earlier starting point is required to avoid crop stress in the last set.

Irrigation charts are normally provided when ordering blocks or meters. Regular recording of soil water readings on the irrigation charts will make irrigation planning easier. As these readings are recorded on the chart, a soil water curve develops. The slope of the curve can extend to predict when the soil water level declines to a point where irrigation is required. Also record rainfall events on the irrigation chart, since they increase the soil water and postpone the need for irrigation.

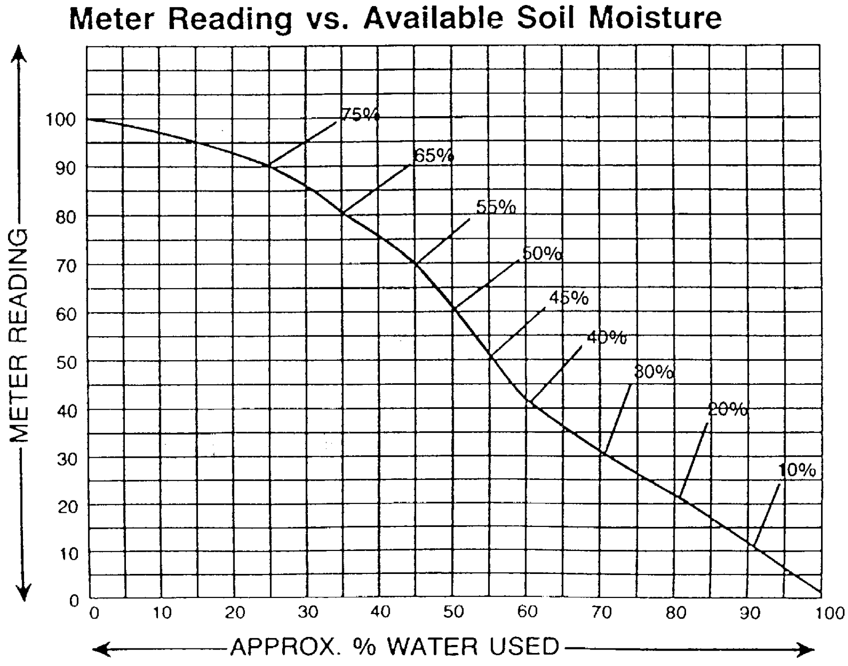


Figure 7. *Meter readings versus approximate percentage of water used*

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