Electrical Resistance Blocks

Electrical resistance blocks, sometimes referred to as gypsum blocks, are an inexpensive and simple soil moisture measurement tool. They are useful for timing irrigations, but do not provide information regarding the amount of irrigation water required. Electrical resistance blocks are installed permanently at a site and have the advantages of allowing their user to quickly monitor soil moisture at the same location throughout the season. Gypsum blocks monitor soil moisture indirectly by measuring the electrical resistance between two electrodes attached to a small, cast block of gypsum buried in the soil. Some electrical resistance blocks have electrodes mounted in fiberglass or in perforated metal-encased blocks containing a sand/gypsum mixture (Fig. 1). Wires, available in various lengths, lead from the blocks to the soil surface. The electrical resistance is read with a portable conductance meter. Conductance (1 / resistance) is actually what is measured using the gypsum blocks. Measuring conductance requires use of alternating current (AC), which the meter produces from its direct current (DC) battery. Use of a simple resistance or ohm meter to read the electrical resistance blocks will not give stable or reliable readings. Electrical resistance blocks and meters vary in cost by manufacturer with blocks ranging in cost from $6-$35 each and meters costing approximately $250. Since the meter is portable, only a single meter is required to monitor all the installation sites. At a normal site, a gypsum block may last 2 to 3 years, but in areas of frequent irrigation or high water table it may require annual replacement.

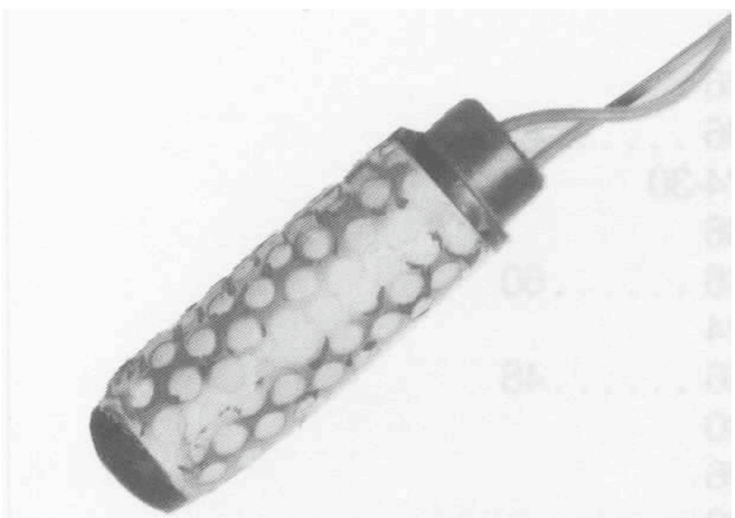

Fig. 1. Electrical resistance block.

One manufacturer produces a resistance block and meter which reads directly in centibars of soil water tension while most other manufacturers provide charts or tables to correlate the meter readings to soil water tension values. Soil water tension information indicates the timing of irrigations but does not tell the amount of irrigation water required. Indirectly, the irrigation amount can be arrived at through a trial-and-error procedure of monitoring the resistance blocks before and after irrigations. Blocks whose readings indicate wetter conditions after an irrigation reflect irrigation water reaching their depth. If a block does not reflect wetter soil conditions following an irrigation, it indicates that the irrigation was insufficient to reach the block's depth. Following the changes in resistance block readings through a number of irrigations will allow an irrigator to gauge the irrigation to match the soil moisture deficit.

Data logging devices (fig. 2) are also available which keep track of the readings of multiple resistance blocks connected to the logger. This has the advantage of keeping a "continuous" record of the soil moisture.

Installation

Electrical resistance blocks should be placed at several soil depths. At a minimum, blocks should be placed in the top one-third and bottom one-third of the root zone. Consultants who install soil moisture monitoring sites utilizing electric resistance blocks often place blocks at 1-foot intervals throughout the root zone. Soil moisture conditions are only monitored in the soil closely surrounding a resistance block. Wires from the blocks are brought to the soil surface to facilitate periodic connection to the portable meter, or permanent connection to the data logger. The matric potential of the blocks is assumed to be in equilibrium with the surrounding soil, so the blocks act much like the surrounding soil - taking up and releasing water as the soil wets and dries. The electrical conductance between the electrodes varies according to the water content of the block. The higher the water content, the higher the conductance and the lower the electrical resistance.

The placement of resistance block stations in an field depends primarily on the soils. Generally, monitoring stations are chosen to be representative of what is happening in the surrounding area. At a minimum, two stations per 40 acres is recommended with additional stations being added in problem areas or in areas with different soil conditions. Since gypsum is soluble, blocks slowly dissolve. The life of a block can be extended by 1 or 2 years by the addition of a small quantity of gypsum to the back-fill soil at the time of installation. A small quantity of lime ($CaCO_3$) may likewise be useful in a acid soil in prolonging the life of a block.

Most electrical resistance blocks monitor soil moisture more effectively in the drier range of soil water tensions (in excess of 0.33 bar). Consequently, blocks are more useful in the medium to heavy textured soils (loams and clays), which retain more available water in the higher soil water tension range. Sands and coarse-textured soils tend to release much of their water at low soil water tensions, where the blocks are not as accurate nor responsive. Blocks are also affected by highly saline-alkali soil conditions and may therefore not be appropriate for use under such conditions.

In trees and vines, the blocks can often be installed in the tree / vine row to protect them from traffic or cultivation damage. They should be installed within the drip line of the tree. When sprinkler irrigation is used, avoid placing the tensiometers in the drier "shadow" area caused by the tree blocking the sprinkler's spray.

In field and row crops, the resistance blocks can be installed where desired with the wire leads being placed underground, terminating at a protected location where they can be accessed for monitoring.

At a station, resistance blocks to be placed at various depths can either be sequentially stacked in the same hole or placed in separate holes. Placing blocks in separate holes has the advantage of locating the block in the soil environment closest to an undisturbed condition, but the disadvantage of requiring more work than installing multiple blocks in a single hole. Resistance block users have used both techniques successfully.

Prior to installation, each block should be tested by soaking it in water and hooking it up to its companion conductance meter. The installation hole should be only slightly larger than the block and can be made using a soil probe or small auger. The hole should be about 1 inch deeper than the depth at which you want to install the block. Before inserting the block, put a small quantity of loose, moist soil (to which you can add small quantities of gypsum and lime) into the hole. About 2 ounces of water should be added to the hole to further moisten the loose soil in the bottom of the hole.

To place the block in the hole, run the wire lead through an appropriate length of 1/2-inch diameter PVC pipe and put tension on the wire to hold the block on the end of the pipe. One manufacturer's block has a special collar which fits into the end of 1/2-inch PVC pipe to facilitate installation. Lower the block into the hole and push it firmly into the loose, moist soil in the bottom of the hole. Remove the PVC pipe and fill the hole with the soil removed in making the hole or with a soil-gypsum-lime mixture for several inches. Pack the soil firmly, preferably using a wooden rod such as a broom handle so as to avoid damaging the blocks or wires. Continue refilling the hole in stages making sure that the soil is firmly packed at each stage in an effort to simulate undisturbed conditions. Refilling the hole properly is important to ensure that water and roots do not penetrate the hole more easily than the surrounding soil.

When installing blocks in traffic or cultivated areas, you can trench or bury the lead wires to prevent damage. Identify the blocks by knotting the wire, color coding, or by tagging. If possible, protect the bare ends of the wire leads since they tend to become corroded. Scraping the wire leads with a knife blade or fingernail file prior to attaching the meter will facilitate a better connection.

How to use the information from the blocks

Electric resistance block information is best used by evaluating changes in block readings. A block which shows that the surrounding soil is becoming drier between irrigations, is a good indicator that water uptake by roots is occurring at that depth. Most frequently, plants preferentially take up water from the shallower depths; thus drying the shallow depths down prior to taking up water from deeper depths. The shallower-placed block therefore shows a change first. Some block users utilize this transition of water uptake from the drier, shallow depths to the deeper depths, along with a particular meter reading of the shallow block, as a signal to irrigate. These "signals" to irrigate are often arrived at over time by watching and comparing the tree response and block readings.

As mentioned earlier, the blocks do not provide information on how much to irrigate, only on when to irrigate. By trial-and-error, irrigation amounts can be estimated. Reading the blocks just prior to irrigation and then reading them 2-3 days after irrigation (drainage has nearly stopped) can provide information on the depths to which irrigation water penetrated. If a blocks reading's remained unchanged (assuming it is not already reading completely wet), indicates that water did not reach that depth. Assuming you wanted to wet to that depth, more water - a longer irrigation - would need to be applied.

If the block(s) at the deeper depths never change readings, this indicates that you may be able to go longer between irrigations or that there is no root activity at that soil depth. A lack of root activity can be due to saturated soil conditions (resulting from over-irrigation and /or a high water table), disease, or nematode problems. In addition, if the deeper-depth blocks continually read wet, you cannot tell if you are over-irrigating and losing water to deep percolation.

If there is a question as to the accuracy of a block(s) readings, often indicated by a block's readings remaining unchanged when you think it should be changing, checking a nearby location's soil moisture using a soil auger and the "feel" method is an excellent first check.

References

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