Moisture Movement in Soils

experiments show moisture movement from one portion of soil to another and soil factors which influence that movement

S. J. Richards and L. V. Weeks

Elongation of Roots and moisture movement to roots influence the water uptake by plants.

Recent techniques for evaluating unsaturated flow of soil moisture have demonstrated that moisture movement is important.

The schematic drawing on this page shows an experimental means of demonstrating moisture extraction from a root free block of soil. A pot of soil 10″ in diameter has an inner container 2¾″ in diameter made of a porous ceramic material. Soil is placed in both containers, but plants are grown only in the outer annular soil volume. The pores in the ceramic wall of the inner container are fine enough to prevent roots from growing into the inner soil volume, yet water moves readily through such a wall.

By means of a dial type tensiometer in each soil container the soil moisture suction or relative wetness of the soil in the two portions of the system can be followed directly without further calibration or corrections for differences in soil type or bulk density. As the soil dries out, the soil moisture tension or suction—as read on the dial vacuum gauges—becomes larger. Two irrigation cycles are shown for each of two soils. Irrigation water is applied to all of the soil as indicated by the low suction readings.

In experiments with Fallbrook sandy loam and Holtville silty clay, plants were well established in the soils. The soil surface was covered with plastic sheet to limit evaporation. Suction values in the root zone following irrigation increased more rapidly than takes place under normal field conditions. In spite of the rapid drying of the tested soil, the suction values in the root-free zone followed the changes in the root zone indicating a free exchange of water through the ceramic wall.

The water exchange pattern in Fallbrook sandy loam showed no abrupt changes over the full range of moisture conditions measurable with tensiometers. Holtville soil is fine textured and shows a somewhat different drying characteristic; the suction values in the root-free zone follow the changes in the root zone until the suction values approach 500 millibars. Suction values continue to increase but less rapidly. Water continues to move out of the root-free soil.

Tensiometers will not measure soil suction over the entire range of soil moisture conditions. At the one bar—one atmos-

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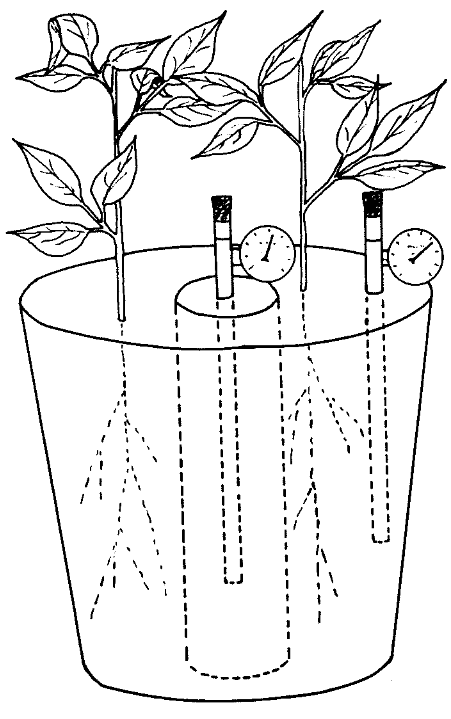
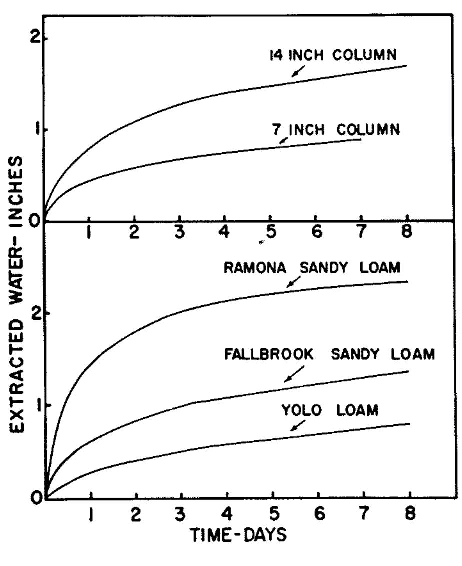
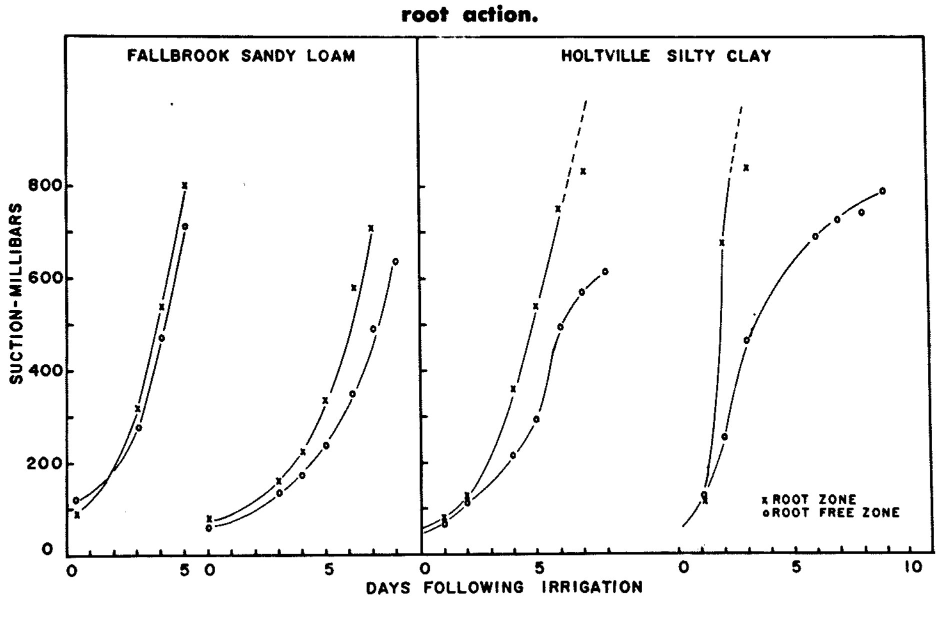


A root-free volume of soil is separated from soil containing roots by a porous ceramic wall through which water moves readily. Relative water extraction rates from the two zones are indicated by readings on the tensiometers.

Water extracted from horizontal soil columns by constant suction applied at the ends of the columns. The upper curves show more water was extracted from a longer soil column, indicating that soil 7″ or more from plant roots can contribute to the water extracted by a root system. The lower curves show a comparison of water extraction rates from various soils where the soil columns were all 14″ long.



For two widely varying soils tensiometer readings show that water moves from a root-free soil through a porous wall where it can be taken out of the soil by root action.



MOVEMENT

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phere suction value—about 75% of the available water has been removed from the Fallbrook soil and approximately 60% from the Holtville soil.

Further studies of moisture extraction from soils are being made under controlled conditions without using plants. Soil columns are positioned horizontally and brought to equilibrium with water at approximately 30 millibars. This is often a value read on tensiometers following an irrigation in the field. A constant suction is then applied at one end of a soil column, by applying a controlled vacuum to one side of a porous ceramic disc the other side of which is in direct contact with the soil. The lower left graph on page 24 shows the accumulated water extracted from soil columns when the suction of 900 millibars was maintained constant. The extracted water was measured in surface inches in relation to the area of the soil column.

In the same length of time, 80% more water was extracted from a column of soil 14″ long compared with the same column when it was cut down to 7″ in length. This would indicate that, for this Fallbrook sandy loam, root-free portions of the soil 7″ away from roots can make substantial contributions to water extracted by roots.

Soils vary greatly in their ability to conduct water. A comparison of three soil types shows that under the same controlled laboratory conditions the water extracted from a Ramona sandy loam soil was approximately twice as much as from a Fallbrook sandy loam and threefold that from a Yolo loam. The curves comparing various soils were all obtained using 14″ soil columns.

For these studies of soil moisture movement, fragmented soil samples were screened and compacted in the columns. Further studies will be made on undisturbed cores.

If only moisture flow rates are measured—to compare the ability of various soils to conduct water—the size and shape of the soil sample and suction equipment would need to be standardized. However, when continuous records of the moisture suction values are obtained at various locations along the soil column, as well as moisture extraction rates, computations can be made expressing the conductivity values of a soil as a function of the moisture suction. These values are characteristic of the soil and independent of the methods of measurement. They can be used to characterize different soils or study the effects of soil management practices on the same soil. Also, when suction values in the field are measured by tensiometers, flow rates can be estimated.

Studies of moisture movement in soils in the liquid phase are made under constant temperature conditions. Thermal gradients within the soil column, which result in water vapor diffusion, can cause significant disturbances to the measured liquid flow.

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PENETRATION

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In most cases not enough water can be stored in the soil to last throughout the season. Where water penetration is slow, more water can be applied by irrigating more frequently or by increasing the time the water is on the land surface at each irrigation. Both approaches have advantages and limitations. More frequent irrigation may be accomplished without any other change in the system or in practice, but has the disadvantage of higher labor costs. It may be an inadequate measure for the more difficult problems. Prolonged irrigation may require substantial changes such as converting from furrows to basins in which water can be ponded for long periods or using small furrows to insure better coverage of border strips with small streams. Irrigation of crops susceptible to injury or disease under prolonged irrigation can not be managed in this way, and the practice may encourage growth of water-loving weeds. However, such methods may be the only means of increasing the productivity of soils with very slow water penetration even though changes in cropping pattern or farming operations are required.

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TEMPERATURE

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ing facility must provide for maximum energy capture, discharge water at a temperature giving maximum rice yields, occupy a minimum land area, with reasonable installation and maintenance costs.

From experience in rice irrigation, water temperature may be expected to influence the growth of other crops. However, it is difficult to predict the influence of water temperature on yields because of its numerous direct and indirect effects on the plant. In addition to the cold water damage reported here, crop injury is sometimes associated with warm water.

As more is learned about its effects on irrigated crops, water temperature may become a factor of considerable importance in the selection of crops and their management for maximum yield and minimum unit cost.

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Bruce Wylie, Glenn County rice grower; the Glenn–Colusa Irrigation District, and Milton D. Miller, Extension Agronomist, University of California, Davis, participated in the studies reported in the above article.

MEASUREMENT

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grove was on a two week irrigation schedule. The irrigation water applied July 19 and August 3 reached the 12″ soil depth but did not wet the soil at the 18″ depth to field capacity.

The time and place to use either tensiometers or blocks depends to a large extent on climatic conditions and soil types and to a lesser extent on the nature of the crop. In inland areas of southern California where high water losses may cause stress conditions in plants, timing of irrigations becomes very important. Tensiometers have proved to be valuable tools for timing irrigations in citrus and avocado groves. However, in the more humid areas where irrigations are intermittent, along with rainfall, resistance blocks are used with satisfactory results. Resistance blocks made of gypsum rather than fiberglass or nylon are generally preferred in agricultural soils.

The neutron method is still a research tool although it might be valuable on large agricultural acreages.

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QUALITY

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in the Imperial Valley. Here Colorado River water is used for irrigation and contains large quantities of sulfate, which produces this toxic symptom.

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