W 809-D

How Soils Hold Water: A Home Experiment

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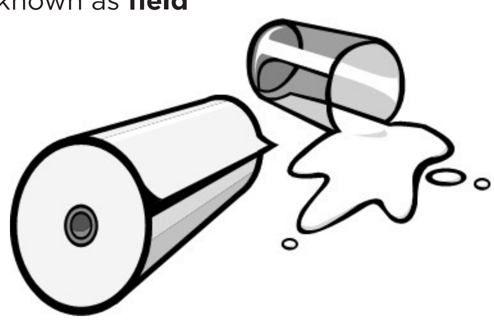
The short answer to how soils hold water is pores and the tension or suction that pores exert to retain water. The pores or openings between the soil particles provide space for water to reside and surface area on which water can adhere. The interactions between soil and water can be complex, but it is possible to run a simple home-based experiment to better understand how a porous media like soil and soil pores behave in the presence of water. Yes, this experiment is safe for children to try at home.

The porous media to be studied is the common but extraordinary paper towel. First, submerge the paper towel in a bowl of water. *Participants should agree that all pores are now filled with water.* In the same way, a soil can have all its pore space filled with water, a status known as **saturation**. Saturation is good for forming wetlands, but most agricultural crops will not grow in a soil devoid of air, and tractor performance is less than desirable in this soupy condition.

Next, remove the paper towel and hold it above the bowl for one minute. *Participants will observe water draining out of the pores and should agree that drainage will stop before all of the moisture is removed from the paper towel*. Similarly, the larger pores in a saturated soil will drain progressively until only the smaller pores are able to hold their water against the force of gravity, a status known as **field capacity**. All soils will drain to field capacity unless a restrictive layer or water table prevent the downward movement of water. In well-drained fields, the condition of field capacity is usually reached in one or two days after a heavy rain. One goal of irrigated agriculture is to keep soil moisture at or below **field capacity**.



Over-irrigation and excess rainfall can increase soil water above field capacity. The excess water above field capacity can percolate past the bottom of root zone and leach agricultural fertilizer and chemicals toward groundwater.

After the paper towel has finished draining, proceed to squeeze it firmly and then squeeze a second time as tightly as you can. *Participants should note that at first a lot of water is released with little effort, then little water is released with a lot of effort, and finally, there is water remaining in the paper towel that cannot be squeezed out.* In a similar way, plant roots exert their own tension forces to remove water from soil pores. Plants can extract water from soil until the remaining soil water is held too tightly by the smallest pores, a status known as **permanent wilting point**. The range from field capacity to wilting point is known as the **available soil water holding capacity**. Even though water is available to plants as soil moisture decreases to wilting point, the goal of irrigated agriculture is usually not to stress the plant. For each crop, a **management allowable depletion** (MAD) has been established as the percentage of available soil water holding capacity that can be removed without unduly stressing the crop. Traditionally, the goal of irrigation scheduling has been to irrigate before reaching MAD and to return the soil moisture to field capacity, an approach known as **full irrigation**. However, in a humid region, the goal should be to irrigate before reaching MAD but not return soil moisture to field capacity, allowing for the capture of rainfall, a method referred to as **Managed Depletion Irrigation** (MDI). The MDI approach has been specifically applied to cotton[1] and soybean[2] in University of

Tennessee Institute of Agriculture experiments and publications. The **soil water continuum** for an MDI approach is illustrated in Figure 1.

General values for available soil water holding capacity by texture are shown in Table 1 and MAD values for row crops are illustrated in Table 2. The Tennessee specific water holding capacity by soil type can be found in the NRCS Soil Surveys[3] and a study conducted by the University of Tennessee Institute of Agriculture (Longwell et al., 1990).[4] The MAD values for most crops can be found at United Nations – Food and Agriculture (UN-FAO) Website.[5]

As a final note, marketing would have us believe that some paper towels can absorb more moisture than others. This is definitely true of soils. A loamy sand will hold around 1 inch of water per foot of soil, while a silt loam will hold more than 2 inches per foot. If lettuce with a 1.5-foot root zone and a MAD of 35 percent are grown on loamy sand, the effective storage of soil water will only be around half an inch. In contrast, cotton (4-foot root zone and 65 percent MAD) grown in silt loam could effectively store more than 5 inches of water. The combination of soil and crop can significantly affect the soil water reservoir and the need to irrigate in terms of initiation timing, frequency and the amount of water applied. Therefore, knowing soil type and its corresponding water holding capacity is an integral part of every irrigation decision.

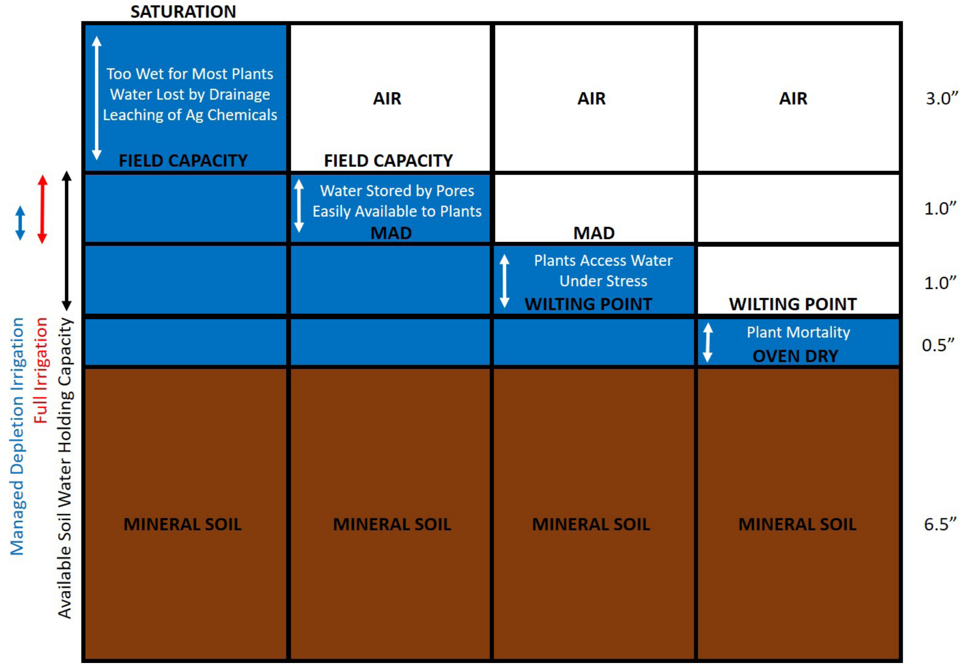


Figure 1: Soil Water Continuum (when air, water and soil are disassociated from pores in a 1-foot column).

Table 1: Available Soil Water Holding Capacity

Soil Texture	**Available Soil Water Holding Capacity (in/ft)**
Clay	1.20 to 1.50
Silty Clay	1.50 to 1.70
Silty Clay Loam	1.80 to 2.00
Silt Loam	2.00 to 2.50
Fine Sandy Loam	1.50 to 2.00 in/ft
Sandy Loam	1.25 to 1.40 in/ft
Loamy Sand	1.10 to 1.20 in/ft
Fine Sand	0.75 to 1.00 in/ft
Course Sand	0.25 to 0.75 in/ft

Table 2: Management Allowable Depletion*

Crop	MAD
Cotton	65%
Corn	55%
Soybean	45%

*Percent of available water that can safely be depleted from the soil before yield loss is expected.

Supplemental Publications

1. The Basics of Cotton Irrigation in Tennessee extension.tennessee.edu/publications/Documents/W809-B.pdf
2. The Basics of Soybean Irrigation in Tennessee extension.tennessee.edu/publications/Documents/W809-C.pdf
3. National Resource Conservation Service – Web Soil Survey websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
4. Moisture Characteristics of Tennessee Soils – (Longwell et al., 1963) trace.tennessee.edu/cgi/viewcontent.cgi?article=1301&context+utk_agbulletin
5. AO Irrigation and Drainage Paper #56 – Chapter 8 – Soil Water Depletion Fraction or MAD fao.org/3/X0490E/x0490e0e.htm

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