How Soils Hold Water, A Home Experiment
University of Tennessee, Extension Fact-Sheet

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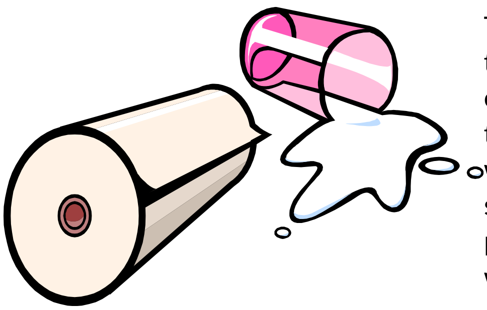


The short answer to how soils hold water is pores and the tension or suction that pores exert to retain water. The pores or openings between the soil particles provide space for water to reside and surface area on which water can adhere. The soil-water interactions can be complex, but it is possible 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 is safe for children to try at home.

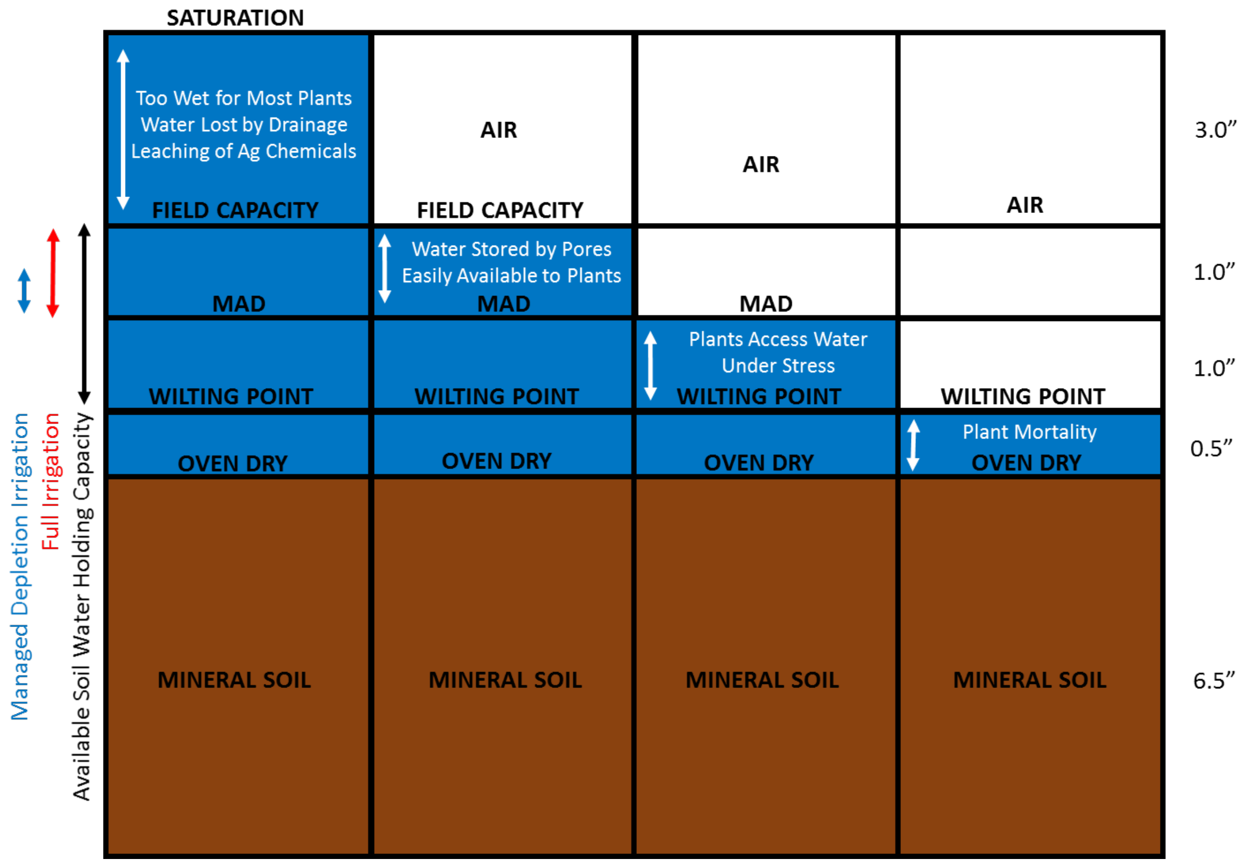
The porous media to be studied is the common but extraordinary paper towel (or a piece of dish sponge). First, submerge the paper towel in a bowl of water. *Participants should agree that all pores are now filled with water*. In the same way, a soil can have all its pore space filled with water, a status 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 two minutes. *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 will percolate through the bottom of root zone and leach agricultural fertilizer and chemicals toward groundwater.

After the paper towel has finished draining, proceed to squeeze the paper towel firmly and then squeeze a second time with all of your might. *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 and as a surface film on soil particles, 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 capture of rainfall, an approach being describes as Managed Depletion Irrigation (MDI). The MDI approach has been specifically applied to cotton[1] and soybean[2] in Tennessee. The soil water continuum is illustrated in Figure 1.

Soil Water Continuum

(when air, water, and soil are disassociated from pores in a 12" or 1 foot column)



General values for available soil water holding capacity by texture are in shown in Table 1 and MAD values for row crops are in Table 2. 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 (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 will 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 over 2 inches per foot. If lettuce with a 1.5-foot root zone and a MAD of 35% are grown on loamy sand, the effective storage of soil water will only be around 0.5 inches. In contrast, cotton (4 foot root zone and 65% MAD) grown in silt loam could effectively store over 5 inches of water. The combination of soils and crops 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, soil is an integral part of every irrigation decision.

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 1: Available Soil Water Holding Capacity

Crop	MAD
Cotton	65%
Corn	55%
Soybean	45%

Table 2: Management Allowable Depletion

(percent of plant available water safely depleted from the soil before crop experiences stress)

1. The Basics of Cotton Irrigation in Tennessee.
2. The Basics of Soybean Irrigation in Tennessee.
3. National Resource Conservation Service – Soil Survey.
4. Moisture Characteristics of Tennessee Soils – Longwell et al., 1963).
5. FAO Irrigation and Drainage Paper #56 – Chapter 8 – Soil Water Depletion Fraction or MAD.