Irrigation Water Management (IWM) — A Simple Analogy

Brian Leib, Associate Professor, Irrigation Systems and Management

Tim Grant, Extension Assistant, Soil and Water Resources

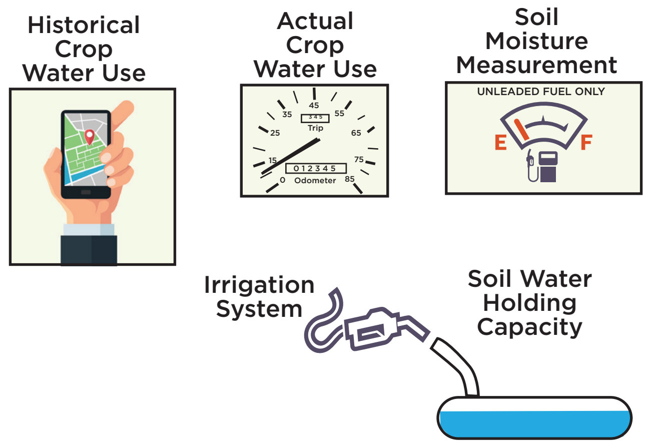
Department of Biosystems Engineering and Soil Science

Irrigation water management (IWM) can seem complicated and much of the equipment used is of a technical nature; however in reality, the concepts that govern IWM are simple. For example, why do most of us keep track of the gasoline in our cars? The self-evident answer is that most of us do not want to run out of gas and be stranded. Similarly, we irrigate so our crops do not run out of water and strand us with less than desirable yields. Let's take the analogy of irrigation management and fuel management a little further.

Just as gas tanks are limited in the amount of fuel they can store (12, 16, 20 gallons etc. depending on the vehicle), soils are likewise limited (0.5 to 2.3 inches of water per foot of soil depending on texture, sand to clay, respectively). The rooting depth also limits water storage. A crop with 4-foot roots in a silt loam soil that has a water holding capacity of 2 inches per foot will be able to store 8 inches of water for the plant to use (2 inches per foot x 4 feet = 8 inches). It is not advisable to allow the crop to use all the available moisture (8 inches in this example) before irrigating because the crop would be severely stressed. A rule of thumb value is that yield reduction starts when about 50 percent of the total available water (in this case 4 inches of water) is depleted. A better understanding of how soils store water and specific water holding capacities for Tennessee soils are available. [1]

If we overfill a tank during refueling, gas shoots out of the tank, onto the ground, and possibly onto ourselves. No one likes wasting gas that has been paid for, contaminating the environment, and reeking with the smell of gasoline. The effects of over-irrigation are similar, if not as dramatic. Full irrigation (replenishing soil water to field capacity) followed by an unexpected rainfall event can result in runoff with soil erosion from the soil surface and/or deep percolation with leaching through the crop-root zone. Both are a waste of water that create the potential to wash ag chemicals into streams and groundwater.

Water and Fuel Management



In a humid region like Tennessee, managed depletion irrigation (MDI: not totally refilling the soil to field capacity) can leave storage capacity in the soil to capture rainfall.

The uncertainty of rainfall amount and timing in a humid region like Tennessee would be like having a generous neighbor who liked to put free gas in vehicles at unknown times and in unknown amounts without any regard for the level of gas already in a tank. Even though this is an unrealistic situation for refueling, it is the reality of irrigating in the humid Southeast. If this were a realistic situation, the logical response would be to keep your fuel tank partially full: perhaps 1/3 full. This would leave room to store any free gas (i.e., rainfall) that the generous neighbor might put in your tank yet still maintain a buffer against running empty if no free gas (or rainfall) arrived. This principle of maintaining a managed depletion of water from the soil profile can be applied to most crops, and has been applied specifically to cotton [2] and soybean crops [3] in Tennessee.

We have several tools to assist us with MDI similar to those used in fuel management. A smartphone and navigation app can be used to plan a trip. If we wanted to drive to Miami from Memphis, we would look up the mileage and find out it is approximately 1,000 miles. If the vehicle gets 20 mpg, we could calculate how much gas we would need, and knowing there may not always be a gas station available, we may decide to refill the tank after 10 gallons are used from the 16-gallon tank. With this approach, we would expect to refuel five times during our trip (10 gal x 20 mpg x 5 refills = 1,000 miles). Similarly, historical crop-water use and rainfall can help us plan how to irrigate a crop. Historically, for West Tennessee, corn is expected to use 20 inches of water. The average effective rainfall during the same period is 14 inches (17.5 inches total — 3.5 excess early rainfall), and 3 inches of soil water can safely be depleted in a silt loam soil. Therefore, the irrigation requirement would be 3 inches. If an irrigation system applies 0.5 inches per application, then on average the field will need to be irrigated six times during the growing season to maximize yield. Historic crop-water use and rainfall can be found in the MOIST (**M**anagement **o**f **I**rrigation **S**ystems in **T**ennessee) Tables for **"Corn," "Cotton" and "Soybean."** In a humid region like Tennessee, not all rainfall is effectively stored for plant use and rain rarely falls according to yearly averages. Therefore, irrigation will need to be adjusted accordingly.

Another tool used in fuel management is the trip odometer. Many of us zero the trip odometer after refueling to estimate gas mileage and gas usage. If the trip odometer reads 120 miles since refueling and the vehicle gets 20 mpg, then 6 gallons of gas have been used and up to 6 gallons could be added at the pump without overfilling or more gas could be utilized before refueling. In this scenario, we are keeping track of actual usage because real trips do not always turn out the way they are planned. In the same way, actual crop-water use can be calculated from **weather stations** maintained by UT's Department of Biosystems Engineering and Soil Science. [4] For example, a crop has used 1.5 inches of water in a week based on the growth stage and weather conditions. If 1 inch of rain occurred during this week, only 0.5 inches of irrigation are required to keep soil moisture at the same level. Programs like the MOIST Spreadsheet can help calculate actual crop-water use and balance water use with rainfall and irrigation to maintain an appropriate MDI level of soil moisture. [5]

Of course, the most popular method of tracking fuel supply is measuring the tank level with a fuel gauge. Similarly, soil moisture levels can be measured by a variety of sensors. Without going into the details of how different soil water sensors work, it is important to remember your own experience with fuel gauges in different vehicles. One vehicle may read E for empty and mean it is safe to drive for another 75 miles, while another vehicle at E means it is time to refuel immediately. Likewise, soil moisture sensors vary in calibration and also have different characteristics and costs. Spending some time understanding a sensor's characteristics and hands-on experience with MDI levels for triggering irrigation are required to get the most out of any soil water sensor. The University of Tennessee has tested many types of sensors and can provide guidance on how to use different types. [6] The MOIST+ APP (**M**anagement of **I**rrigation **plus S**oil **T**ension **APP**lication) incorporates the use of sensors that measure soil tension. [7]

Finally, gas pumps can be compared with irrigation systems. A gas pump meters fuel into the tank as an irrigation system delivers water to the soil at a known rate. However, gas pumps are fairly universal and there are many distinct types of irrigation systems with a wide range of application rates and characteristics requiring different operation times to apply the same amount of water. For example, drip irrigation forces the effective soil moisture storage tank to be small because it can't supply water to the entire soil profile, leading to frequent smaller irrigations. Center pivot irrigation can supply water to the entire soil profile, but its high potential for runoff forces light and frequent irrigation similar to buying a few gallons worth of gas every couple of days. Very few irrigation systems have been successfully engineered to turn off automatically when soil moisture has reached the desired level, as a gas pump does when the tank is full or the dollar amount is reached. Therefore, irrigators need to understand how their systems apply water to effectively implement a managed depletion of soil water. [8]

Supplemental Articles

1. How Soils Hold Water, a Home Experiment.
2. The Basics of Cotton Irrigation in Tennessee.
3. The Basics of Soybean Irrigation in Tennessee.
4. How Much Water Is Your Crop Using?
5. Using a Water Balance to Make Irrigation Decisions: MOIST.
6. Using Soil Moisture Sensors for Irrigation Management in Tennessee.
7. The MOIST+ APP
8. Understanding Application Characteristics of Center Pivot Irrigation.

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