

Crop Water Use Program for Irrigation

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and Soil, Environmental, and Atmospheric Sciences

Water is an important factor affecting crop yields. The University of Missouri Extension Service developed an on-line application to help farmers produce higher crop yields by improving irrigation management. The Crop Water Use (CWU) application can be run on a desktop or smart phone. This bulletin gives information about the app and explains how to track soil moisture in fields for optimum yields and water conservation.

Farmers with irrigation are usually able to harvest consistent yields in spite of the droughts. Irrigation also helps in periods of short-term crop water stress which are common many summers, usually in July or August. To prevent yield losses and conserve water resources, farmers need information on daily crop water use and a better understanding of how much soil water can be stored for root uptake between rainfall and irrigation events in specific fields on their farms. This bulletin is divided into two sections: (1.) Irrigating Fields on Your Farm and (2.) Navigating Functions in the App.

How Does The Application Work?

The application estimates crop water use from weather data. An equation for calculating evaporation from soil and plants (called evapotranspiration, ET) is used. The application also calculates daily soil water balances for each field. Reports include indexes to help farmers determine when to irrigate.

Crop Water Use. The University of MO Extension automatically downloads data each day from a network of agricultural weather stations located across Missouri. ET is calculated from solar radiation, temperature, humidity, and wind. CWU uses the Standardized short crop Penman-Monteith Evapotranspiration (ET_o) equation which was developed by a task committee of the American Society of Civil Engineers. ET_o is the amount of combined water lost from a reference crop (grass) and soil evaporation.

ET_o is multiplied by a crop coefficient, which is specific for the crop and growth stage. The crop coefficients, except for rice, are derived from UN Food and Ag Organization publication FAO-56. Beginning at planting, growth stages are predicted from heat units for corn, rice, and cotton. Calendar days are used for soybean. This information is used to estimate daily crop water use (ET_c).

Section 1. Irrigating Fields on Your Farm

Irrigation is a management tool to protect against yield loss from crop water stress in years with low rainfall. The cost of installing irrigation depends on the water source and whether applications are made by flood, furrow or sprinkler. To be profitable, the average crop yield increase from watering should exceed the cost of the irrigations. Irrigation can be viewed as an

insurance policy. Applying irrigations when the crop does not need it is a waste of water, energy, and money. But in a drought, it can save the farm from financial ruin. Most of the cost of irrigation is the equipment which is a multiple year investment. Wells, pumps, pipes, valves, and sprinklers are fixed costs that are an expense even in years when they are not used. Variable costs for irrigation include fuel and repairs and change depending on how many inches of water are applied in a given growing season.

Field Verification. The Crop Water Use app is a model which can estimate soil water conditions in your fields. It is a helpful tool to help you make decisions. But before deciding whether to irrigate or not irrigate, always go to the field and check the soil dryness with a shovel or soil probe and look at the crop leaves for signs of water stress. Soil moisture sensors installed in fields are also useful for evaluating the accuracy of the app in your field.

Weather. Watching El Nino and La Nina patterns are helpful for long range planning, but less useful in day-to-day irrigation scheduling. Five day rainfall predictions for a region are an improvement but isolated storms are common in the summer. Irrigation decisions are difficult on days when the local weather forecast predicts an 80% or greater chance of rain for the region. Generally, it is best to assume no rain or only a small amount of rain will occur unless radar shows a large, continuous band of rain is moving towards your fields.

The two most common mistakes that farmers make are waiting too late to start irrigation applications and not applying enough water to keep up with crop water use. The highest crop water use occurs on days with bright sun, low humidity and strong winds. The crop growth and leaf canopy cover are also important. When a farmer fails to make a needed irrigation application, it is often difficult to adequately recharge soil water in the profile with later irrigations. The economic savings of delaying or skipping an irrigation application is small compared to the potential yield loss from crop stress. Farmers should irrigate when the Crop Water app shows the soil water balance is at the trigger point rather than delay watering just because of a high probability of rainfall in the local forecast.

Daily crop water use from evapotranspiration (ET) is mainly effected by sunlight intensity, humidity, and wind. Using actual weather to estimate ET is more accurate than long-term historical averages. It is not critical that the University of Missouri have a weather station located very near to your farm because sunlight, humidity, and wind do not vary significantly across a region. Year to year differences in ET for a calendar date are usually greater than location to location ET differences within a year. For example, ET differences were usually small in 2014 between Columbia and Portageville, Missouri weather stations for a specific summer day. But, ET value differences were large between years at each location on the same date.

Evapotranspiration is more uniform over a region than rainfall. The program accesses the network of University of Missouri weather stations and automatically enters daily evapotranspiration estimates of crops. To access historical and real-time data from the extension weather stations in Missouri go to <http://agebb.missouri.edu/weather/stations/>.

Every station records rainfall but it is not used in the app. Latitude and longitude of fields are used to input rainfall amounts from the National Weather Station rainfall grid. It would be difficult to have enough University of Missouri weathers station estimate rainfall in all farmer fields because isolated storms can occur on one field and miss another field a short distance away.

Soil Water Balance

Daily soil water balance is the most important value estimated in the Crop Water Use app for managing irrigation timing. When the soil profile is full (field capacity), the balance is 0. Field capacity is characterized as water that exists in the upper limit of available water. As water is extracted, the balance becomes negative. Most of the graphics and tables, which will be discussed in the next section, are based on the soil water balance. For each field, rainfall and irrigation are tallied as deposits and crop water use and soil evaporation as withdrawals. The soil water balance can become negative quickly in periods of high crop water use and low rainfall. As soils get drier, crop roots have more difficulty extracting water. This causes crop leaves to wilt and results in yield loss. When a soil becomes very, dry plants will die. The goal for farmers is to keep the soil water balance high enough (less negative) throughout the growing season to prevent significant crop water stress. When the soil profile is full or near field capacity, the soil water balance is 0 and as water is extracted, the balance becomes more negative.

Irrigation Trigger. In the app, soil available water holding capacity, crop rooting depth, and allowable depletion are used to determine the irrigation trigger point. The trigger is the readily available water in the root zone multiplied by percent allowable depletion. Generally, sandy soils hold less available water than loams and clays and have smaller (faster) triggers.

Rooting depth, a component of the trigger calculation, is one of the inputs in the field setup. Extension and USDA Natural Resource Conservation Service agents in your county can help you decide what rooting depth to input. Typical rooting depths for many fields in the Mid-South are 18 or 24 inches. In fields with compacted layers or clay pans which limit root growth in the subsoil enter shallower depths such as 6 or 9 inches should be used.

When setting up new fields in the app, farmers have a choice of entering soil texture or a five digit mapping unit assigned to soil zones of fields by the USDA Natural Resource Conservation Service (NRCS). This information is used to estimate the available water holding capacity of the soil in the field. Generally, the five digit NRCS mapping unit should be more specific for your field situation than soil texture alone. Available water is measured between Field Capacity and Permanent Wilting Point representing the upper and lower limits of plant available water.

Allowable depletion is the final input needed to set the irrigation trigger for a field. For most crops, the best setting for allowable depletion is 50% but for water stress sensitive crops such as rice 30% should be used. It helps to think of soils as different size fuel tanks in a car. Tank size does not affect fuel efficiency (miles per gallon) but does determine how long you can go

between fill ups. As a soil dries, the last 50% of the available water in soil is tightly bound to soil particles. So, you probably want set the allowable depletion to trigger before the “soil water tank” goes past one-half empty.

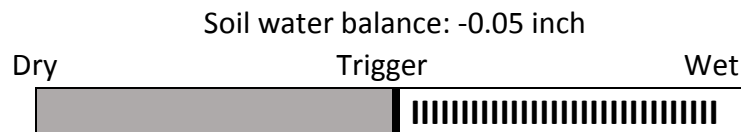
Scheduling Irrigation on Fields

The Crop Water Use app is designed to allow users to monitor the soil water balance by two methods. Each way has its pros and cons for making management decisions. Farmers who like to plan several days in advance usually like Farm Summary. If you prefer to just take one day at a time you may like Field Status best.

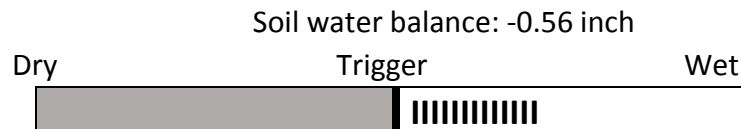
Field Status. The Field Status button is on the main menu of the app. Farmers can scroll between fields each day to determine which needs to be irrigated. Fields are sorted driest to wettest based on their current estimated soil water balances. Use an index finger to swipe across a smart phone screen left to right to advance to the next field.

Each field has two graphs in Field Status. The first is a horizon bar graph which shows the relative soil water balance to Field Capacity (wet) and Permanent Wilting Point (dry) with the irrigation trigger in the center. It is designed to resemble an electronic fuel gauge. It stops when the soil water balance declines past to the trigger point in the center. Below are three examples of different soil water conditions. In Scenario 1 and 2, irrigation is not needed. In Scenario 3, a farmer should check the soil and crops in the field to determine whether irrigation is needed.

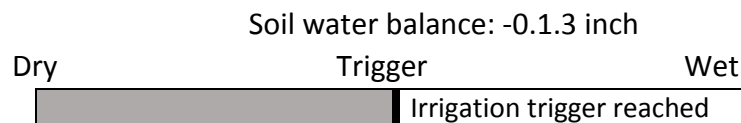
Scenario 1. Soil Water is near Field Capacity.



Scenario 2. Field is drying but irrigation may not be needed.



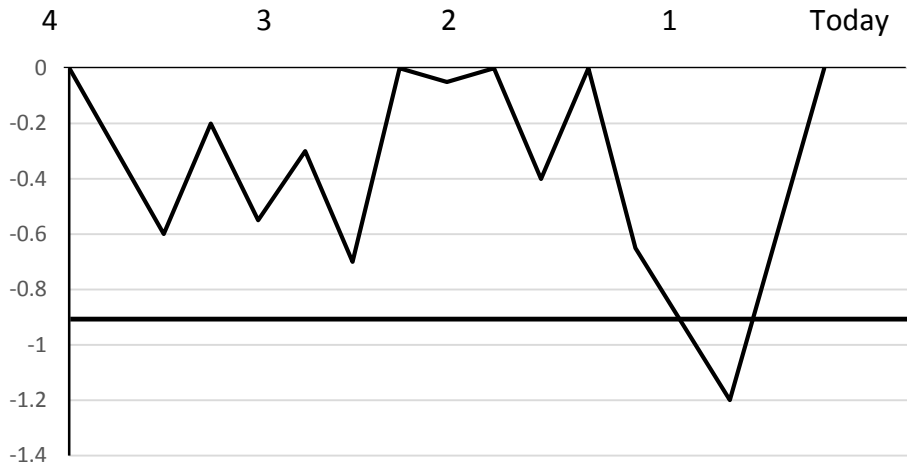
Scenario 3. Check soil and crop in field to verify that irrigation is needed.



The tick marks in the bar graph disappear from right to left as a field gets drier. The goal is to irrigate before the trigger line in the center is reached.

Also in Field Status, located below the bar graph, a line graph tracks how the Soil Water Balance has done over the last four weeks relative to the irrigation trigger. This is a good way to see how well you have been keeping up with irrigations over the last month. If the field soil water balance is consistently below the trigger line more frequent irrigations may be needed.

Past 4 Weeks



Irrigation trigger: -0.90 inch Soil Water Balance

Farm Summary is the second monitoring option in the Crop Water Use app which can help a farmer make plans in his or her fields for the next week assuming no rainfall occurs. It can help farmer look ahead for labor needs. It also helps to anticipate future irrigations which might interfere with family activities over a weekend.

The Soil Dryness Index in the Farm Summary is derived from the soil water balance and the Irrigation Trigger. This index can simplify irrigation management and save farmers time. For growers with 100 or more fields keeping up with which irrigation trigger value to use on each field is difficult. For example, two fields of a crop planted on the same day can be different even when Soil Water Balances are the same. Triggers may be different because the soils are not the same. A field with silt loam soil may last one or two days longer without water stress compared to a field with sandy loam soil which may need to be irrigated sooner.

To make the process easier for farmers to interpret, a dryness index with four levels was developed which is based on a critical soil water balance for each field calculated from rooting depth, available water holding capacity, and management allowed depletion. The table below is an example from research fields irrigated at University of Missouri. Field 4 Pivot E and Lee Farm 12-a needed irrigation that day. The others could wait until later in the week. A warning was given based on the soil water balance trigger for each field. When a field shows an "OK"

dryness index, the balance was greater than 70% of the critical level. One, two, and three asterisks were shown when the balance exceeds 70, 80, and 90% of the critical level, respectively. Three X's are shown when the balance exceeds the critical level and irrigation is needed.

An example of a daily Farm Summary report from irrigated fields managed by the University of Missouri-Fisher Delta Research Cropping Systems Project.

Farm Summary		Tuesday, July 14, 2015							
Name	Soil Water Today	Projected Dryness Index With No Rain							
		Tues	Wed	Thu	Fri	Sat	Sun	Mon	
Field 4 Pivot E 1/2 Rice	-1.09	XXX	XXX	XXX	XXX	XXX	XXX	XXX	
Marsh Field 4 Pivot W 1/2 Soybean	-0.84	OK	OK	*	***	XXX	XXX	XXX	
Marsh Field 5 Pivot Corn	-1.15	***	XXX	XXX	XXX	XXX	XXX	XXX	
Rhodes Field 1 Cotton	-0.17	OK	OK	**	***	XXX	XXX	XXX	
Rhodes Fields 14 & 15 Cotton	0	OK	OK	OK	***	XXX	XXX	XXX	
Lee Field 12-1a Soybean	-1.27	XXX	XXX	XXX	XXX	XXX	XXX	XXX	
Lee Field 12-1b Corn	-1.16	**	***	XXX	XXX	XXX	XXX	XXX	

The dryness indexes for each field assumed historical ET for the projected days and no rainfall will occur in the next week. Fields are can be printed out to distribute to farm workers.

Reports

Farmers using the Crop Water Use app may eligible to receive federal funds from Environmental Quality Incentives Program (EQIP). Beginning in 2015, the CWU irrigation app meet the criteria for the Missouri 2015 General Conservation Stewardship Program, Enhancement Activity NRCS Code WQT07 (Regional weather networks for irrigation scheduling). The app has a Report option which allows users to print season long results for each field which can be used as documentation at the end of the year for NRCS. This report could also be used to calculate the amount of water pumped per field or well for a field.