COTTON IRRIGATION WITH THE CROP WATER USE PROGRAM ON THREE SOILS

G. Stevens
J. Travlos
S. Martin
A. Jones
P. Guinan
J. Henggeler
M. Rhine
R. Massey
J. Heiser
University of Missouri-Delta Center
Portageville, MO

Abstract

A study was conducted in 2013 to validate Crop Water Use program for scheduling irrigation on cotton in fields with sandy loam, silt loam, and loamy fine sand soils. Two fields were furrow irrigated and one field was irrigated with a lateral move irrigation system. Each site had three irrigation scenarios: a well watered and two delayed irrigation treatments. The Crop Water Use Calculator showed that the sandy soil at Clarkton needed more frequent irrigations than the loam soils. Output was sensitive to rooting depth, soil texture, and allowable depletion settings. The field tests helped us identify new features that will be added to make CWU more user friendly.

Introduction

Water is one of the biggest factors affecting cotton yield. For the last three years we have been developing a mobile program called Crop Water Use Calculator (CWU) which is available free to farmers at http://agebb.missouri.edu/weather/reports/cwu/.

The program uses reference evapotranspiration (ET_o) from a network of 30 electronic weather stations located across Missouri. ET_o is the total amount of water lost from a reference crop (grass) and soil evaporation. Users enter the closest weather station, crop type, planting date, weather date, and weather station. ET_o is multiplied by a crop coefficient, which is specific for the growth stage and type of crop providing the crop water use (ET_c) on that day. The current online CWU program has limitations which made it difficult for farmers to use. It does not have a soil component and users must reenter crop information each time the program is used (Figure 1).

The objective of this study is to evaluate irrigation on three soil textures using an updated CWU which tracks water deficit based on available water holding capacity and rooting depth.

Methods

In 2013, cotton was grown in irrigated fields at Hayward, Portageville, and Clarkton, Missouri. Soils were a Tiptonville sandy loam (fine-loamy, mixed, superactive, thermic Oxylaquic Argiudoll) at Hayward, a Reelfoot silt loam (fine-silty, mixed, superactive, thermic aquic Argiudoll) at Portageville, and Malden loamy fine sand (mixed, thermic typic Udipsamment) at Clarkton. The Hayward and Portageville sites were furrow irrigated. The Clarkton site was sprinkler irrigated with a lateral move system. Campbell Scientific weather stations were used to calculate daily reference evapotranspiration (ET_o). New logic for CWU was tested in a spreadsheet. An electronic "checkbook" in Excel tallied rainfall and irrigation as deposits and ET_c as withdrawals to estimate soil water deficits. Cotton coefficients and growth stages were predicted by cumulative crop Heat Units (60^o base). The rooting depth for each soil was assumed to be 24 inches and the allowable soil water depletion to trigger irrigation was 50% of the total available water holding capacity (AWHC), equivalent to 0.50 *[Field Capacity – Permanent Wilting Point] for each soil.

Each site had three irrigation scenarios: a well watered and two delayed irrigation treatments. The first delay represents a situation where a producer chooses to wait to begin irrigating until most of field operations such as pinhead square insecticide applications were completed. The second delayed treatment represents a situation where

a pump was broken and the farmer could not water or he expected an early season rain that did not occur and then irrigated correctly the rest of the season.

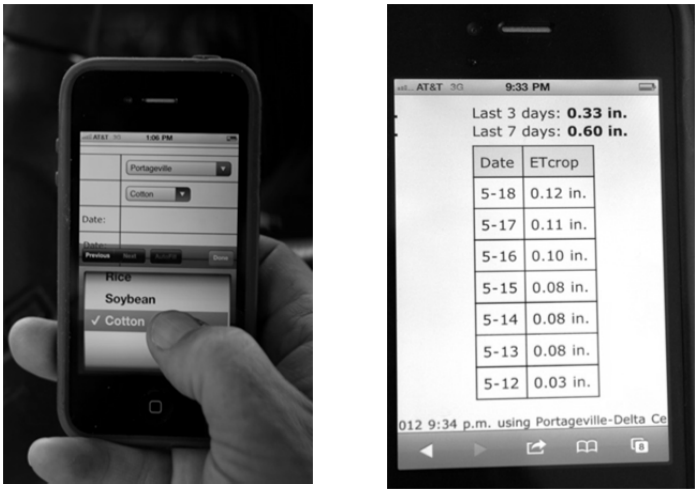

Figure 1. The new version of CWU will not require farmers to reenter planting date and nearest weather station each time it is used.

Figure 2. Soil samples were weighed, and oven dried to determine volumetric soil moisture content. Plant height, leaf temperature, and NDVI were collected to ascertain water stress in cotton plots

Results

Daily soil water deficits were monitored (Tables 1 and 2). The irrigation trigger was AWHC*Root Depth* Allowable Depletion. Example: 0.125 inch/inch *24 inch *50% = 1.50 inch (Table 2). A low rainfall period occurred in late June and early July. But most of the 2013 growing season had adequate rainfall and did not need irrigation. Soil water depletions in delayed treatments were not allowed to exceed total available soil water. Cotton plants responded to water stress by producing smaller leaves and closing stomata to conserve water.

Table 1. A furrow irrigation application was made at Hayward, Missouri on July 10 when the deficit exceeded -1.5 inches on the previous day.

Crop: Cotton					Allow Depletion	Root	AWHC in/in	Total H2O	Deficit
Location: Hayward		sandy loam			50%	24 inch	0.125	3.00	-1.5
Date		ETo	DD60	K	ETcot	Irrig	Rain	H2O Def	Warning
Sun	30-Jun	0.12	640	0.51	0.06		0.14	-0.89	
Mon	1-Jul	0.11	659	0.52	0.06		0.07	-0.87	
Tue	2-Jul	0.12	672	0.53	0.06			-0.94	
Wed	3-Jul	0.16	684	0.54	0.09			-1.02	
Thu	4-Jul	0.22	693	0.55	0.12			-1.15	*
Fri	5-Jul	0.19	704	0.55	0.10			-1.12	*
Sat	6-Jul	0.16	719	0.56	0.09			-1.19	*
Sun	7-Jul	0.19	736	0.58	0.11			-1.3	**
Mon	8-Jul	0.2	755	0.59	0.12			-1.42	***
Tue	9-Jul	0.22	774	0.6	0.13			-1.55	XXX
Wed	10-Jul	0.16	797	1	0.16	2.5		0	
Thu	11-Jul	0.26	823	0.64	0.17			-0.17	
Fri	12-Jul	0.26	848	0.66	0.17			-0.33	
Sat	13-Jul	0.22	868	0.67	0.15			-0.48	
Sun	14-Jul	0.16	883	0.68	0.11		0.03	-0.56	
Mon	15-Jul	0.15	897	0.69	0.10		0.12	-0.54	

Depletion Warning Scale: *= 70%, **=80%, ***=90%, XXX > 100%.

Table 2. A sprinkler irrigation application was made at Clarkton on Friday, June 27 when the deficit was predicted to exceed -1.25 inches over the weekend.

Crop: Cotton					Allow Depletion	Root	AWHC in/in	Total H2O	Deficit
Location: Clarkton		|loamy fine sand|			50%	24 inch	0.104	2.50	-1.25
Date		ETo	DD60	K	ETcot	Irrig	Rain	H2O Def		Warning
Sun	16-Jun	0.14	439	0.39	0.05			-0.60		
Mon	17-Jun	0.12	457	1.00	0.12		0.58	-0.14		
Tue	18-Jun	0.20	473	0.41	0.08		0.10	-0.12		
Wed	19-Jun	0.16	491	0.42	0.07		0.09	-0.10		
Thu	20-Jun	0.21	511	0.43	0.09			-0.19		
Fri	21-Jun	0.24	533	0.44	0.11			-0.30		
Sat	22-Jun	0.25	554	0.46	0.12			-0.41		
Sun	23-Jun	0.21	575	0.47	0.10			-0.51		
Mon	24-Jun	0.24	598	0.48	0.12			-0.63		
Tue	25-Jun	0.23	622	0.50	0.11			-0.74		
Wed	26-Jun	0.23	646	0.51	0.12			-0.82		
Thu	27-Jun	0.26	674	0.53	0.14			-0.96		*
Fri	28-Jun	0.22	696	1.00	0.22	1.0	0.03	-0.25		
Sat	29-Jun	0.26	713	0.56	0.14			-0.39		
Sun	30-Jun	0.10	726	0.57	0.06		0.14	-0.30		
Mon	1-July	0.09	737	0.58	0.05		0.08	-0.28		

Depletion Warning Scale: *= 70%, **=80%, ***=90%, XXX > 100%.

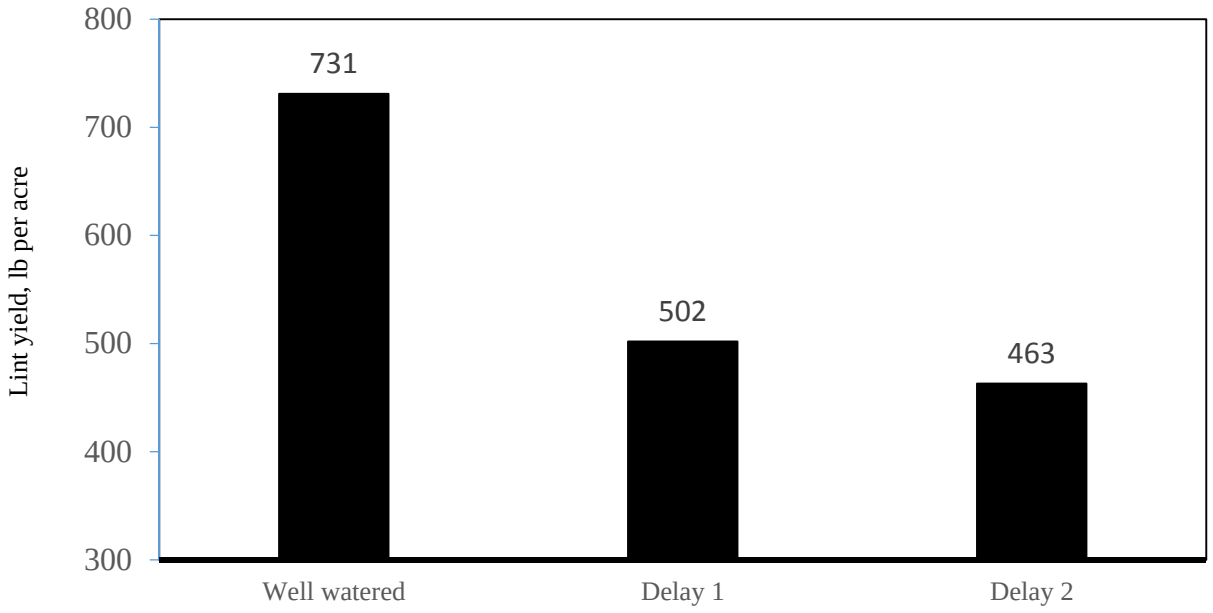

Figure 3. Cotton yields from irrigation treatments at Clarkton, MO on a loamy fine sand soil.

NDVI readings and cotton yields at Clarkton showed that the Crop Water Use appeared to predict when irrigation was needed (Figure 3). No significant yield increase was found from irrigation treatments at Portageville and Hayward in 2013.

Summary

The Crop Water Use Calculator showed that the sandy soil at Clarkton needed more frequent irrigations than the loam soils. Output was sensitive to rooting depth, soil texture, and allowable depletion settings. Our field tests in 2013 helped us identify new features that will be added to make CWU more user friendly.

We found it helpful to include days of the week (Monday, Tuesday …) and "Today" on output reports. In the new program, we plan to also project ET_c and soil water deficit for the next 5 days. This will help farmers plan around weekends and holidays.

Warning symbols (*, **, ***, XXX) will be shown because a soil deficit value can be satisfactory for a loam but cause severe stress in a sand. The program will include a master screen showing soil water deficits from all fields to prioritize work schedule.

The Natural Resource Conservation Service has financial incentives for farmers to use irrigation scheduling technology based on weather. See http://www.nrcs.gov/wps/portal/nrcs/main/national/financial/csp (Activity list section, page 11, WQT07). University of Missouri plans to launch Part 2 of Crop Water Use program before the 2014 planting season.

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