Ogallala Aquifer
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Project Plan from FY2016
(Fiscal Years 2017-2018)

Title: Maturity Related Response of Cotton Cultivars to Irrigation Timing, Capacity, and Termination Dates

Investigators:

PIs:

James Bordovsky, Irrigation Engineer, Texas A&M AgriLife Research, Plainview, Texas

Glen Ritchie, Plant Physiologist, Texas Tech and Texas A&M AgriLife, Lubbock, Texas

Cooperators:

Dana Porter, Irrigation Engineer, Texas A&M AgriLife Extension and Research, Lubbock, Texas

Ryan Williams, Agricultural Economist, Texas Tech and Texas A&M AgriLife, Lubbock, Texas

Research Location: Texas A&M AgriLife Research, Halfway, Texas

Summary-Abstract:

Recent experiments at the Texas A&M AgriLife Research Center at Halfway indicated treatments with no irrigation during the period from germination to degree-day = $550_{15.6C}$ (mid-July) used 20% less seasonal irrigation with ≤ 2% yield loss compared to corresponding treatments that were irrigated at 3.2 and 6.4 mm d^{-1} throughout the typical irrigation period. However, the protocol for this experiment resulted in irrigation termination that did not appear to be the optimal for all treatments, providing a possible opportunity for further improvement in water productivity. Also, seed company representatives who viewed this project inquired about possible differences in optimum deficit irrigation management of cotton varieties having a different (shorter) maturity classification than that used in this experiment. The proposed study will document the effects of in-season irrigation capacity changes during multiple cotton growth periods, particularly the effect on different irrigation management and termination dates of both short and medium maturity cotton varieties. Documenting the economic significance of reduced irrigation capacity at specific cotton growth periods will give producers additional information on how to manage water as irrigation supplies are reduced or as opportunities for alternative water uses present themselves.

Project Narrative

Objectives:

The OAP sub-objective being addressed is the development and evaluation of water management strategies and technologies that could reduce water withdrawals for irrigation by 20%. The goal of this project is to develop strategies and methods to improve irrigation water value by focusing on the end of the cotton irrigation period (the strategy may be different depending on irrigation capacity, irrigation system type, cultivar, etc.) and to quantify differences in irrigation water use of “more determinate” or short season cultivars compared to the "less determinate" or medium maturity cotton cultivars. Specific objectives are:

1) Conduct a replicated field experiment having 26 irrigation schemes composed of combinations of irrigation capacity (3 levels) and irrigation timing (4 periods) to determine water value (lint per unit of irrigation) of late season irrigation under a range of irrigation induced seasonal conditions.
2) Document yield and water use of both short and medium maturity cotton varieties resulting from the 26 treatments of objective 1.

Rationale/Literature Review/ Conceptual Framework:

Comprehensive irrigation timing experiments at deficit capacities on cotton from 2010-2013 indicated early season irrigations that attempted to fill the soil profile reduced seasonal irrigation water use efficiency and, in some cases, yield, compared to limited or no early irrigations. Treatments with no irrigation during the period from germination to degree-day (15.6^{o}C) = 550 (mid-July) used 20% less seasonal irrigation with ≤ 2% yield loss compared to corresponding treatments that were irrigated at 3.2 and 6.4 mm d^{-1} rate throughout the typical irrigation period. (Bordovsky et al., 2015).

This initial irrigation timing experiment raised other significant questions related to achieving the highest irrigation water value through cotton on the Texas High Plains. Because cotton plant development through the entire season was greatly affected by differences in early applied water, the question of irrigation termination became more uncertain than normal. Cotton irrigation termination in the area is generally based on either calendar date or, if plants are being monitored, the plant development stage called "cutout". Kelley and Keeling (2011) noted that research studies showed few benefits of extending irrigation beyond 275 $HU_{15.6}$ past cutout, but also pointed out that most published research lacked information on soil profile moisture status in the trials at the time of irrigation termination. The protocol of the original deficit irrigated timing experiments called for irrigation termination of all treatments on the same date in each year. This did not appear to be the optimal timing for certain treatments. A more robust irrigation termination strategy would relate timing of past irrigations and rainfall, seasonal plant development through August, soil water status at the end of August, irrigation system type, and near term weather forecasts to more accurately assess water requirements and late season irrigation water value.

Also, commercial cotton varieties are typically classified by maturity designations with "short season" having more determinate and "full season" more indeterminate growth characteristics. Cotton varieties planted in the Texas High Plains are typically short to medium maturity due to the relatively short cotton growing season. The more determinate varieties tend to be are more sensitive to water stress. The cotton cultivar evaluated in the timing study at Halfway (Bordovsky et al., 2015) was classified as a medium maturity. Throughout the previous experimental period, seed company representatives who viewed the project inquired about possible differences in optimum deficit irrigation management of cotton varieties having a different (shorter) maturity classification.

A potentially significant outcome of the 2010-2013 irrigation timing experiment was the development of the irrigation scheduling software called "DIEM" or the Dashboard for Irrigation Efficiency Management, to help explain and facilitate the use of relevant irrigation research findings (Wythe, 2016). Using a simple interface, DIEM integrates localized farm and environmental data, leverages a computational model based on available irrigation timing and other field experiments, and optimizes irrigation prescriptions for the remainder of the season to support producer understanding and decision making. Multi-factor experimental data such as that described in this project are needed to improve total water use efficiencies through irrigation decision aids such as DIEM.

How the objectives will be met:

Irrigated cotton will be evaluated at the Texas A&M AgriLife Research Center at Halfway. The treatment factors will include irrigation capacity (maximums of 0 mm d^{-1} – **Low**, 2.5 mm d^{-1} – **Medium**, and 5.1 mm d^{-1} – **High**) and irrigation application within a specific growth stage window (pre-bloom, peak bloom, post peak bloom, and termination period). Each treatment combination (similar to those from the 2010-2013 experiment having the ***highest*** yield and water use efficiencies) will have both early and late irrigation termination (Table 1). Four additional low irrigation treatments will provide treatment checks. Combinations of these factors will result in 26 different irrigation schemes, each to be replicated up to four times. The extreme treatments will be 0 mm d^{-1} in all growth periods (dryland production) and 5.1 mm d^{-1} during all growth periods (approaching 80% ET with reasonable rainfall). Within each treatment area, water will be applied at specified irrigation capacities during specific growth periods in an attempt to increase plant available soil water to approximately 80% of field capacity subject to a protocol described by Bordovsky and Lyle (1996). Soil water content for each treatment will be estimated using soil water balance (Bordovsky et al., 2015) with representative treatment plots monitored by neutron moisture measurement. Within each irrigation treatment plot, both short and medium maturity cotton varieties (tentatively FM2011GT and FM2484B2F, respectively) will be planted.

Table 1. Proposed irrigation treatments for cultivar-irrigation capacity-timing study and related 2010-2013 yields and seasonal irrigation water use efficiencies at Texas A&M AgriLife, Halfway, Texas.

		Maximum Irr. Capacity During Period (mm d^{-1})					
Treat No	Treat Name	Pre-bloom	Bloom	Post-Bloom	Irr. Termination	2010-2013 Yield (kg ha^{-1})	2010-2013 SIWUE (kg m^{-3})
1	HHH+	5.1	5.1	5.1	5.1		
2	HHH	5.1	5.1	5.1	0	1407	0.29
3	MHH+	2.5	5.1	5.1	5.1		
4	MHH	2.5	5.1	5.1	0	1478	0.32
5	LHH+	0	5.1	5.1	5.1		
6	LHH	0	5.1	5.1	0	1397	0.35
7	MMH+	2.5	2.5	5.1	5.1		
8	MMH	2.5	2.5	5.1	0	1282	0.29
9	LMH+	0	2.5	5.1	5.1		
10	LMH	0	2.5	5.1	0	1197	0.34
11	MHM+	2.5	5.1	2.5	2.5		
12	MHM	2.5	5.1	2.5	0	1173	0.27
13	LHM+	0	5.1	2.5	2.5		
14	LHM	0	5.1	2.5	0	1049	0.29
15	HMM+	2.5	2.5	2.5	2.5		
16	HMM	5.1	2.5	2.5	0	1070	0.24
17	MMM+	2.5	2.5	2.5	2.5		
18	MMM	2.5	2.5	2.5	0	977	0.25
19	LMM+	0	2.5	2.5	2.5		
20	LMM	0	2.5	2.5	0	964	0.35
21	LLM+	0	0	2.5	2.5		
22	LLM	0	0	2.5	0	625	0.25
23	LHL	0	5.1	0	0	594	0.14
24	MML	2.5	2.5	0	0	587	0.12
25	LML	0	2.5	0	0	573	0.24
26	LLL	0	0	0	0	410	

A 3-span, site-specific LEPA pivot (Zimmatic 9500P with VRI system) will provide irrigation to treatment plots 12-rows wide (1-m rows) and ≥ 30 m long in a 6-ha area. Rows will be arranged in circular pattern to accommodate LEPA applicators dispensing water in alternate diked furrows (Figure 1). Prior to each seasonal application, irrigation quantities for each treatment will be determined from local meteorological measurements, irrigation quantity from the previous irrigation sequence, and a locally derived water use function. An irrigation application map file will then be created using available software (FieldMAP™, Lindsay Int. (ANZ) Pty Limited, New Zealand); uploaded; and executed by in the pivot's VRI control system.

Sufficient pre-plant irrigation will be uniformly applied for plant establishment. Seasonal irrigations will begin as early as practical. Initial irrigation termination will be on or near 1 Sept with the second termination no later than 25 Sept with irrigation amounts subject to a planned decrease in soil water content (Bordovsky and Lyle, 1996) and weather forecasts. Irrigation frequency will be up to 3 times per week depending on irrigation capacity and irrigation quantity required for a particular plot.

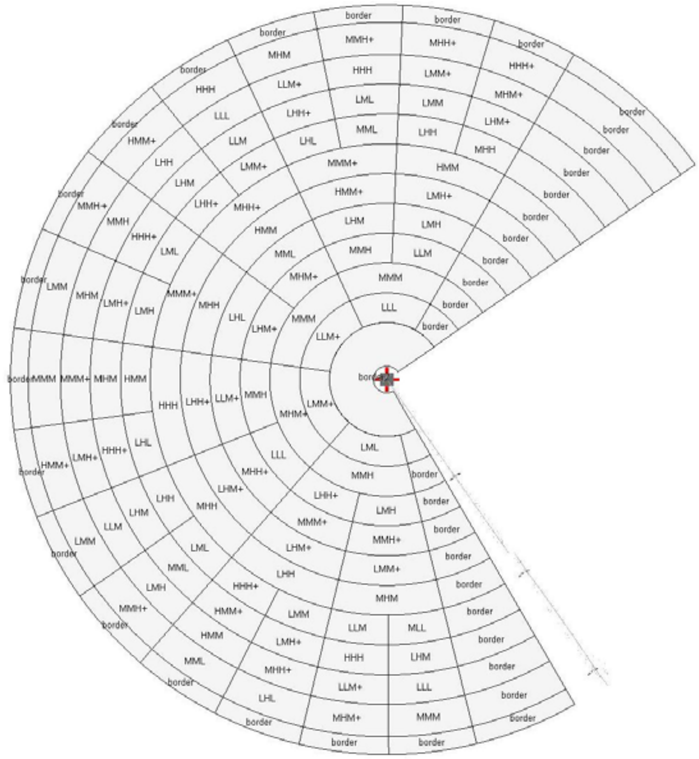

Figure 1. Proposed layout of cultivar-irrigation capacity-timing research plots at the Texas A&M AgriLife Research Center at Halfway, 2016-2018.

Prior to irrigation termination and concurrent with the baseline soil moisture measurements, plant mapping will be performed on a 2-m subplot within each field plot. Cotton bolls will be counted by fruiting site (mainstem node and fruiting position) and will include all viable bolls on all plants within the subsample. After defoliation, but prior to harvest, the subplots will be mapped a second time to determine fruit retention over the course of irrigation termination and to discriminate between the effects of boll retention and boll development on the final yield and fiber quality.

Cotton yield, fiber quality and water use efficiency will be determined for each treatment. Data analysis will be with standard AOV and means separation. A proposed activity timeline is in Figure 2.

Figure 2. Timeline of activities for proposed cotton cultivar irrigation timing research project.

	2016	2017				2018				2019
Activity	Oct-Dec	Jan-Apr	May-Jun	Jun-Sept	Oct-Dec	Jan-Apr	May-Jun	Jun-Sept	Oct-Dec	Jan-Apr
Prepare field sites and acquire materials and supplies.	■	■			■	■				
Establish field plots, plant crops, install neutron access tubes, etc.			■				■			
Read initial soil water.			■				■			
Irrigate plots according to procedures.				■				■		
Measure crop phenology, soil water and etc.				■	■			■		
Measure soil water to aid in determination of seasonal water use.					■				■	
Harvest crop samples for yield determination.					■				■	
Analyze and summarize first year's field results.					■	■				
Analyze combine 2 yr results and prepare reports.									■	■
Make presentations at regional or national meetings.										■
Develop initial publications										■

Expected Outcomes:

This study will document the effects of in-season irrigation capacity changes during multiple cotton growth periods, particularly the effect on different irrigation termination dates of both short and medium maturity cotton varieties. Information concerning total water use, water use efficiency, and effects on fiber quality and lint value will be determined. Documenting and communicating the economic significance of reduced irrigation capacity at specific cotton growth periods will give producers additional information on how to manage water as irrigation supplies are reduced or as opportunities for alternative water uses present themselves.

Results from these experiments will be incorporated into the DIEM software. It will also be made available at field days, at local and regional cotton conferences, and for appropriate targeted mass media (i.e. agricultural trade journals and similar outlets). Economic evaluations will be performed following acquisition of appropriate data. Papers will be published in suitable journals at the conclusion of these experiments.

Relevant publications:

Bordovsky, J.P., J.T. Mustian, A.M. Cranmer, C.L. Emerson. 2011. Cotton-grain sorghum rotation under extreme deficit irrigation conditions. *Applied Engineering in Agriculture* Vol. 27(3): 359-371.

Bordovsky, J.P., J.T. Mustian, G.L. Ritchie and K.L. Lewis. 2015. Cotton irrigation timing with variable seasonal irrigation capacities in the Texas South Plains. *Applied Engineering in Agriculture*. 31(6): 883-897. (doi: 10.13031/aea.31.10953).

Simao, F., G. Ritchie and C. Bednarz. 2013. Cotton physiological parameters affected by episodic irrigation interruption. *J. Agric. Sci. Tech, A(3)*, 443-454.

Snowden, M.C., G.L. Ritchie, F.R. Simao, and J.P. Bordovsky. 2014. Timing of episodic drought can be critical in cotton. *Agron. J*. 106:452-458.

References:

Bordovsky, J.P. and W.M. Lyle. 1996. Protocol for planned soil water depletion of irrigated cotton. In: *Proceedings of the International Conference on Evapotranspiration and Irrigation Scheduling*. Nov. 3-6. San Antonio, TX. ASAE. Pp. 201-206.

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Kelley, M. and W. Keeling. 2011. Texas High Plains cotton irrigation termination. Texas A&M AgriLife Extension and Research.

Wythe, K. 2016. Innovative information. TX:H2O. Texas Water Resources Institute. Texas A&M University. 11(1)16-20. http://twri.tamu.edu/publications/txh2o/spring-2016/innovative-information/