Irrigation Strategies for Corn-Cotton Systems in Southwest Kansas

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INTRODUCTION

Cotton is a relatively new crop to producers of Southwest Kansas. Irrigation practices designed to maximize corn yields have evolved with a long history of corn production. Typically, good conditions after emergence lead to the formation of an adequate number of squares to obtain maximum yield potentials for the available thermal units. However, as the season progresses and corn water demands increase, producers have been reluctant to divert irrigation water to cotton, typically resulting in the abortion of squares, and thus yield potential. This study was designed to evaluate crop response to applied irrigation, and the partitioning and timing of water in corn-cotton systems under simulated irrigation capacity constraints.

MATERIALS AND METHODS

The study was conducted from 2011 to 2015 on a producer field near Moscow in Stevens County, Kansas. The soil was mapped as a Zella loam with 0 to 1 percent slopes. This is a well drained soil formed from silty and clayey loess and is capable of holding 2 inches of plant available water per foot of depth.

An advisory committee of producers and crop consultants assisted in developing the irrigation strategies. Three irrigation capacities were simulated for full season irrigation of corn and cotton: 1.9, 2.7, and 3.8 gpm ac^{-1}. Additional paired treatments constrained the use of water to either the corn or cotton during any given time period. This was to simulate fields split in half, or multiple irrigation systems sharing a common water supply. Two capacities, 3 and 4.5 gpm ac^{-1}, were simulated to provide full season irrigation of the corn except for targeted applications to cotton at match-head square (MHS), bloom, or both. All irrigation applications were targeted to a depth of 1 inch. Pre-season irrigation applications were made as needed to mimic producer actions with a general target of 50-60% ASW in the profile at planting. All treatments (including the dryland cotton treatment) received a minimum of 1 inch after planting to ensure uniform germination and emergence.

The study was conducted using spring strip-tillage in the context of a corn-cotton rotation. Treatments were arranged in a split-plot design with four replications. Rotation phase (corn or cotton) was the whole-plot treatment with irrigation strategy assigned to the split-plots. Plots measured 10 by 40 ft. Irrigation was applied using pressure compensated drip tape placed on the soil surface approximately 4-6 inches to the side of the planted row. The drip tape was designed with an emitter flow rate of 1.32 gallons hr^{-1} and an emitter spacing of 7.6 inches. This configuration simulates the area-weighted mean application rate under a standard 132 ac center-pivot nozzled at 500 GPM.

Corn (Pioneer 35F40, 2011-2012; Pioneer P1151AMX, 2013-2015) and Cotton (NexGen NG1551RF, 2011-2014; NG1572, 2015) were typically seeded the third or fourth week of May at average rates of 29,500 and 64,000 seeds ac^{-1} respectively. Fertilizer was applied during the spring strip-till operation to ensure non-limiting levels for crop growth and yield formation. The center two rows were machine harvested for grain and lint yield. Corn yield components were calculated and cotton fiber quality was analyzed with HVI.

RESULTS AND DISCUSSION

A wide range of climatic conditions were experienced during the course of the study. In-season precipitation (Figure 1) set record lows during the 2011 and 2012 seasons, and was well above average in 2015. Cumulative heat units were above normal in all years of the study (Figure 2), playing an important role in maximizing cotton yield potential and maintaining fiber quality in a traditionally thermally limited environment. The duration of the irrigation season, and thus applied irrigation amounts, remained fairly consistent throughout the study duration (Table 1).

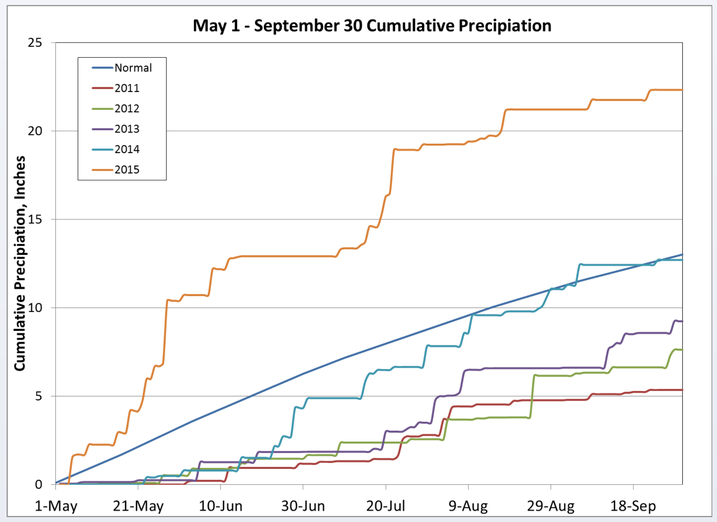

Figure 1. In-season (May 1 through September 30) cumulative precipitation for the study years 2011-2015 and long-term normal near Moscow, Kansas.

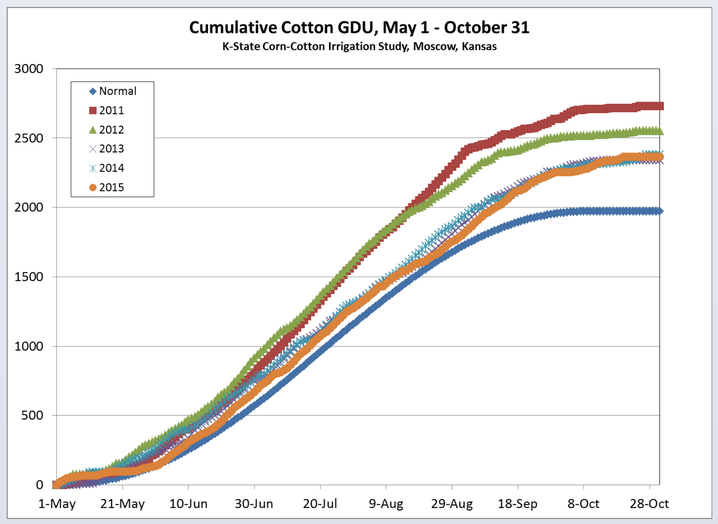

Figure 2. In-season (May 1 through October 31) cumulative cotton GDUs for the study years 2011-2015 and long-term normal near Moscow, Kansas.

Table 1. Annual irrigation application totals and average across years for irrigation strategies at Moscow, KS, 2011-2015.

Crop	Irrigation Strategy	Irrigation Applied, Inches					
		2011	2012	2013	2014	2015	Average
Cotton							
	1" at Seeding, then Dryland	1	1	2	2	1	1.4
	1.9 gpm ac^{-1}, Fully Irrigate (1" every 10 days)	6.5	9	7	9	6	7.5
	2.7 gpm ac^{-1}, Fully Irrigate (1" every 7 days)	9.5	11	10	11	8	9.9
	3.8 gpm ac^{-1}, Fully Irrigate (1" every 5 days)	12.5	14	14	15	12	13.5
	1" Seeding + 1" MHS	2	2	3	3	2	2.4
	1" Seeding + 1" MHS + 1" Bloom	3	3	4	4	3	3.4
	1" Seeding + 1" MHS	2	2	3	3	2	2.4
	1" Seeding + 1" MHS + 1" Bloom	3	3	4	4	3	3.4
	1" Seeding + 1" 2wks before MHS + 1" Bloom	3	5	3	4	3	3.6
Corn							
	Supplimented Dryland Corn - Limited to 5"	4	5	5	5	5	4.8
	1.9 gpm ac^{-1}, Fully Irrigate (1" every 10 days)	6	8	8	9	6	7.4
	2.7 gpm ac^{-1}, Fully Irrigate (1" every 7 days)	9	11	12	11	8	10.2
	3.8 gpm ac^{-1}, Fully Irrigate (1" every 5 days)	12	14	15	15	12	13.6
	Corn @ 4.5 gpm ac^{-1} until 1" MHS	13.5	15	16	18	14	15.3
	Corn @ 4.5 gpm ac^{-1} until 1" MHS + 1" Bloom	12.5	14	15	17	13	14.3
	Corn @ 3 gpm ac^{-1} until 1" MHS	9.5	10	10	12	9	10.1
	Corn @ 3 gpm ac-1 until 1" MHS + 1" Bloom	8.5	9	9	11	8	9.1
	Corn @ 3 gpm ac^{-1} until 1" Bloom	9.5	10	9	11	10	9.9

The dry conditions greatly affected corn grain yields, with several of the treatments failing to produce grain in 2012 (Table 2). In general, corn grain yields increased with increasing irrigation level. Of the paired treatments, corn irrigated at 3 gpm ac^{-1} produced the lowest grain yields regardless if 1 or 2 inches was removed for cotton irrigation. Corn irrigated at 4.5 gpm ac^{-1} performed similarly and generally produced the highest yields in the study, regardless if 1 or 2 inches of irrigation was removed for targeted application to the cotton.

Table 2. Corn grain yields as affected by irrigation strategy, 2011-2015, Moscow, KS.

Irrigation Strategy	Corn Grain Yields, bu ac^{-1}					
	2011	2012	2013	2014	2015	Across-Years
Supplimented Dryland Corn - Limited to 5"	17.3 c	0.0 d	38.3 d	99.6 d	185.8 c	68.2 d
1.9 gpm ac^{-1}, Fully Irrigate (1" every 10 days)	18.0 c	0.0 d	131.1 a	100.5 d	200.1 bc	89.9 c
2.7 gpm ac^{-1}, Fully Irrigate (1" every 7 days)	56.3 ab	10.3 bc	162.9 bc	132.6 b	226.8 a	117.8 b
3.8 gpm ac^{-1}, Fully Irrigate (1" every 5 days)	70.3 a	19.3 bc	185.7 c	157.4 a	220.7 ab	130.7 ab
Corn @ 4.5 gpm ac^{-1} until 1" MHS	66.5 a	36.5 a	182.2 a	163.6 a	229.5 a	135.7 a
Corn @ 4.5 gpm ac^{-1} until 1" MHS + 1" Bloom	68.9 a	20.0 b	179.6 c	178.1 a	219.3 ab	133.2 a
Corn @ 3 gpm ac^{-1} until 1" MHS	31.0 bc	10.0 bc	133.5 a	124.0 bc	209.0 ab	101.5 c
Corn @ 3 gpm ac-1 until 1" MHS + 1" Bloom	24.0 c	0.0 d	126.7 ab	100.1 d	195.8 bc	89.3 c
Corn @ 3 gpm ac^{-1} until 1" Bloom	26.4 bc	3.5 cd	141.2 c	107.6 cd	189.2 c	93.6 c
ANOVA P>F	0.0012	0.001	<0.0001	<0.0001	0.0077	<0.0001

Letters within a column represent differences at LSD (0.05)

Lint yields in 2014 were greatly reduced by 2,4-D injury. In general, large differences were not observed in lint yield among the three levels of full season irrigation (Table 3). As a group, the full season irrigation treatments yielded more than the targeted irrigations or the dryland treatment. The largest marginal return to irrigation resulted from applying 1 inch at MHS. The increase ranged from 34 (2015) to 443 lbs. ac^{-1} (2013), averaging 252 lbs. ac^{-1}. Only in one year (2012) did an additional 1 inch at bloom increase yields over the MHS only treatment.

Table 3. Cotton lint yields as affected by irrigation strategy, 2011-2015, Moscow, KS.

Irrigation Strategy	Cotton Lint Yields, lb ac^{-1}				
	2011	2012	2013	2014	2015
1" at seeding, then dryland	344 c	303 e	590 c	287	1446 ab
1.9 gpm ac^{-1}, Fully Irrigate (1" every 10 days)	723 a	892 b	1059 ab	452	1647 a
2.7 gpm ac^{-1}, Fully Irrigate (1" every 7 days)	817 a	1374 a	1106 ab	340	1332 b
3.8 gpm ac^{-1}, Fully Irrigate (1" every 5 days)	723 a	1405 a	1184 a	389	1472 ab
1" seeding + 1" MHS	500 b	574 d	1129 ab	371	1638 a
1" seeding + 1" MHS + 1" bloom	455 bc	722 c	870 bc	449	1384 b
1" seeding + 1" MHS	519 b	670 cd	1101 ab	421	1418 ab
1" seeding + 1" MHS + 1" bloom	467 bc	593 cd	1012 ab	316	1514 ab
1" seeding + 1" 2wks before MHS + 1" bloom	411 bc	668 cd	1032 ab	312	1298 b
ANOVA P>F	<0.0001	<0.0001	0.0165	0.3021	0.0603

Letters within a column represent differences at LSD (0.05)

Across years, improvements in lint yield were driven by a greater number of harvestable bolls (Figure 3), implying less square abortion under stress. In a regression analysis (data not shown), bolls plant^{-1} explained over 52% of lint yield variability in 2011-2013.

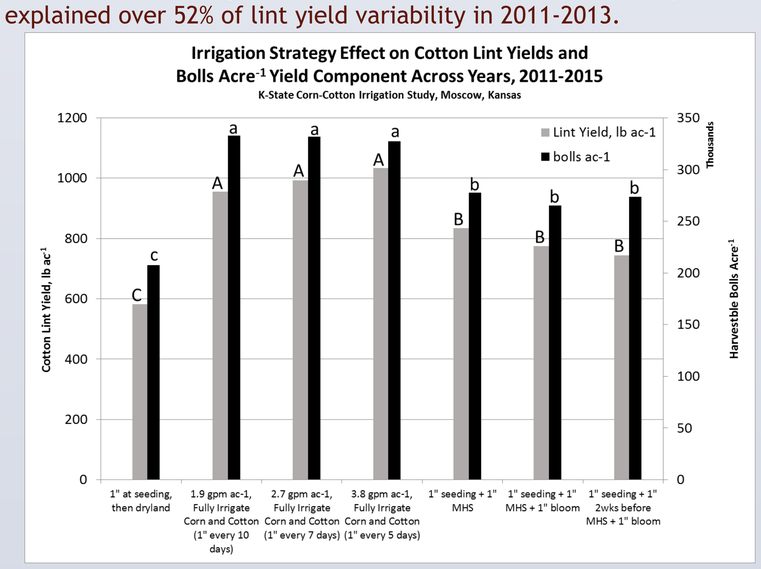

Figure 3. Irrigation strategy effect on cotton lint yields and bolls acre^{-1} across years, Moscow, KS 2011-2015.

CONCLUSIONS

- Across years, application of 1" of water at MHS increased cotton lint yields 252 lb ac^{-1} compared to dryland.
- An additional 1" of irrigation at bloom did not further improve yields.
- Other than in a record drought year (2012), no yield advantage was observed for full season irrigation of cotton at 3.8 or 2.7 gpm ac^{-1} compared to 1.9 gpm ac^{-1}.
- Corn irrigated at 4.5 gpm ac^{-1} with water removed for targeted cotton irrigation yielded similarly to corn irrigated at 3.8 gpm ac^{-1}.

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