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IRRIGATION SCHEDULES FOR ALLUVIAL SOILS IN LOUISIANA

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Abstract

Irrigation in Northeast Louisiana cotton production is a tool that can enhance production if properly managed. This study was conducted to determine irrigation scheduling methods that optimize lint yield and fiber properties, and to evaluate water use efficiencies of various irrigation schedules. Tests near St. Joseph, La., were conducted in 2000 and 2001 on two alluvial soils, Commerce silt loam and Sharkey clay. Scheduling methods included the Arkansas Irrigation Scheduler at 2-inch and 3-inch soil-moisture deficits, a 1.5-inch water budget with 0.22-in. daily use, and tensiometers set at 10-inches with irrigation triggered at –0.75 bars. In 2000, all irrigation schedules resulted in significantly higher yields than non-irrigated plants, but with no significant yield differences among irrigated treatments. In 2001, one of the experiments on Sharkey clay resulted in significantly higher lint yields with schedules that maintained low soil-moisture deficits in comparison to a schedule with a higher soil-moisture deficit. In other experiments on Sharkey clay and Commerce silt loam, there were no significant lint yield differences among treatments. Total water use efficiency (WUE) was better in 2000 than in 2001. Ineffective storage and utilization of abundant rainfall in 2001 caused the inefficiencies; however, irrigation WUE was similar between years. Schedules with the fewest irrigation applications provided the highest lint yields and the greatest WUE. Timely irrigation, as well as improved engineering and agronomic techniques, provide the best opportunities for conserving water and optimizing yield in Northeast Louisiana cotton production on alluvial soils.

Introduction

On alluvial soils in northeast Louisiana, cotton yield potential is excellent due to high annual rainfall and abundant water holding capacity of soils. Nevertheless, escalating fixed costs such as land, equipment, and planting seed, coupled with low lint prices have made cotton irrigation in this area more attractive to many producers. Irrigation is a tool that reduces risk of cotton production in years when rainfall is sporadic. Unfortunately, irrigation can be a costly endeavor and expenses are exacerbated by poor scheduling (Bosch and Ross, 1990). Poorly timed irrigation can result in sub-optimal yield performance (Orgaz et al., 1992; Radin et al., 1992) and inferior fiber properties (Boquet et al., 2000). Efficient use of irrigation saves energy and water while reducing damage to the environment and enhancing long-term sustainability (Bosch and Ross, 1990; Ragwushundi and Wallender, 1998; Howell, 2001).

Irrigation timing should be based on plant or soil water status rather than days after planting (Steger et al., 1998). Irrigation regimes that quickly replenish soil-moisture after depletion from evapotranspiration generally are superior to less frequent, high volume irrigation (Phillips, 1980; Pringle et al., 1989; Radin et al., 1992; Orgaz et al., 1992; Bordovsky and Lyle, 1999). Delaying initial irrigation can retard lint yield potential (Johnson et al., 1989; Steger et al., 1998). Likewise, premature irrigation termination can limit lint yield (Palomo and Godoy, 1998; McConnell et al., 1999). Nevertheless, cotton has considerable compensatory abilities to recover from both early season and late season drought stress and produce acceptable lint yield (Ball et al., 1994; Pace et al., 1999; Wanjura and Upchurch, 1999). Conditions that confound determination of irrigation scheduling in northeast Louisiana include availability of moisture deep within soil profiles, transpiration rates affected by high relative humidity, and frequent returns to maximum soil-water holding capacity from rainfall events within a growing season.

In its simplest terms, water use efficiency (WUE) can be characterized as crop yield per unit of water use (Howell, 2001). In arid and semi-arid climates, short irrigation intervals are necessary to insure adequate WUE and optimal yield (Wanjura et al., 1996; Husman et al., 1998; Bordovsky and Lyle, 1999); however, in northeast Louisiana, a few well-timed irrigation applications could maximize WUE and yield performance.

More information is needed in northeast Louisiana on irrigation scheduling for production of maximum yield and high quality lint. Objectives of this study were to determine irrigation scheduling methods that optimize lint yield and fiber properties, and to evaluate water use efficiencies of various irrigation schedules.

Materials and Methods

Experimental Design and Harvest Methods

Experiments were established near St. Joseph, LA, on Commerce silt loam and Sharkey clay at Panola Corporation in 2000 and 2001, and on Sharkey clay at the LSU AgCenter-Northeast Research Station in 2001. 'Deltapine NuCOTN 33B' was planted in all tests at the Panola Corp. 'Deltapine 458 B/R' was planted at the LSU AgCenter-Northeast Research Station. At the Panola Corp. the experimental design was a randomized complete block with three replications in 2000 and four replications in 2001. In 2000, plots were 32 rows (38-inch center) X 800-ft. In 2001, plots were 24 rows (38-inch center) X 800-ft. Treatments were furrow irrigated. The four center rows of each plot were harvested with a four-row spindle type picker. Seed cotton was weighed in a boll buggy modified with a weigh cell. At the LSU AgCenter-Northeast Research Station, the experimental design was a randomized complete block with four replications. Plots were 16-rows (40-inch center) X 200-ft. Treatments were furrow irrigated. The two center rows of each plot were harvested with a one-row spindle-type picker. Sub-samples were ginned at the LSU AgCenter-Northeast Research Station's ginning laboratory to determine lint fraction, and fiber was analyzed by the LSU Cotton Fiber Laboratory's HVI classing system.

Scheduling Techniques

Scheduling treatments are listed in Table 1. The Arkansas Irrigation Scheduler (Cahoon et al., 1990) was set at soil moisture deficits of 2-inches (AIS-2) and 3-inches (AIS-3). Temperature and rainfall data was from a weather station located at the LSU AgCenter–Northeast Research Station, which was within 1.5 miles of testing locations. Other climate data required for the Arkansas Irrigation Scheduler was from Calhoun, LA. The treatment, in which irrigation was initiated at the Arkansas Irrigation Scheduler's soil-moisture deficit of 4-inches (AIS-4), was switched to a 2-inch soil-moisture deficit after initial irrigation. The 1.5-inch water budget (WB-1.5) method assumed a 0.22-inch daily use beginning at first bloom and continuing until two weeks past the first open boll (Hutchinson and Sharpe, 1989). This system assumed all precipitation was held in the soil and later available to plants. Tensiometers (Ten) were placed at a depth of 10-inches in each plot and irrigation was triggered when analog gauges were at –0.75 bars. Non-irrigated treatments were included in all tests.

Statistical Analyses and WUE

All data were analyzed using the GLM procedures of SAS (SAS Institute, 2001) and LSD was calculated for mean comparisons. Irrigation water use was determined from input flow rates, which were monitored during each irrigation. WUE for total water was calculated with the formula:

[(precipitation + irrigation) / (lint lb/ac)]

and WUE for irrigation water was calculated with:

[irrigation / (lint lb/ac)]

Results and Discussion

2000

During the growing season, temperatures were higher than normal and precipitation was below the long-term average. Plants developed rapidly and without substantial damage from insect or disease. Irrigation was initiated during the first week of July, about the same time as plants began to bloom.

On Commerce silt loam there were no significant differences among irrigation schedule treatments (Table 2). On average, irrigated treatments produced almost 300-lint lb/ac more than non-irrigated cotton. Fiber from plants irrigated with AIS-2 had significantly less length uniformity than other treatments and a higher short fiber index than non-irrigated cotton and lint produced with the WB-1.5 method. On Sharkey clay, no significant differences for yield or fiber properties were determined among irrigation treatments (Table 3). Plants irrigated with AIS-2 yielded 571 lint lb/ac more than non-irrigated cotton. All irrigation methods produced more lint than the non-irrigated control. In previous research on clay soils in Louisiana using the Arkansas Irrigation Scheduler (Boquet et al., 2000), cotton irrigated with AIS-2 produced significantly more lint lb/ac than with AIS-3.

2001

Climate conditions in 2001 were cooler with more precipitation than in the previous year. These growing conditions had a profound influence on irrigation requirements and crop performance. Seedlings were not vigorous and plant biomass at first bloom was less than in 2000. Soil moisture began to deplete about the same time as plants began to bloom, which was 01 July. Irrigation treatments were initiated at this time. Throughout the growing season, several irrigation applications were soon followed by heavy rainfall, which limited the effectiveness of irrigation.

No statistical lint yield or fiber trait differences among treatments were obtained from the test at Panola Corp. on Commerce silt loam (Table 4). In comparison to the Sharkey clay site, the Commerce silt loam location allowed a deeper rooting volume and had better aeration properties, which enhanced water availability. The experiment on Sharkey clay at Panola Corp. resulted in significant differences among irrigation treatments (Table 5). AIS-2 and WB-1.5 schedules yielded significantly more lint than AIS-3 and non-irrigated plants. Tighter irrigation schedules provided an additional irrigation during peak fruiting. This extra irrigation probably resulted in delayed cut-out and a longer period of profuse flowering which is similar to results of Radin et al. (1992). Fiber micronaire resulting from the AIS-2 schedule was significantly less than other treatments.

The irrigation test conducted at the Northeast Research Station resulted in no yield or fiber property differences among treatments (Table 6). Cultivar selection may have affected results. Deltapine 458 B/R is a late maturing cultivar, and crop earliness can influence efficacy of irrigation scheduling techniques (Orgaz et al., 1992; Steger et al., 1998). Abundant precipitation fell in late August and early September. This provided non-irrigated plants adequate soil moisture to set fruit in the later growing season. Moreover, conditions also subjected fruit that was set early in the growing season to rampant boll rot, which destroyed about a third of all bolls. Findings from this particular experiment underscore the importance of proper irrigation scheduling. If scheduling is not well timed during growing seasons with abundant rainfall, benefits from irrigation may be no better than producing a cotton crop without irrigation.

WUE

Total WUE was much lower in 2001 than in 2000 (Table 7). Almost three times as much precipitation fell during the 2001-growing season than during the previous growing season. Much of this water was inefficiently used or lost to run-off or deep percolation. Irrigation WUE was comparable between years, which suggests similar responses for WUE can be expected among scheduling methods regardless of growing season climate conditions. Irrigating less frequently but still maintaining crucial soil moisture at critical stages of fruit development appears to be a management strategy that maximizes yield and WUE. Schedules with the most irrigation applications did not produce significantly higher lint yield and did not generate greater WUE than more conservative approaches. Besides irrigation scheduling, other methods that can improve WUE in Northeast Louisiana cotton production include conservation tillage, improved pest management, refined irrigation delivery systems, enhanced soil fertility programs, and selection of superior cultivars.

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Table 1. Irrigation scheduling methods at the Panola Corp. and LSU AgCenter-Northeast Research Station at St. Joseph, La., in 2000 and 2001.

Test Site	**Panola 2000**		**Panola 2001**		**NERS 2001**
Soil Method	**silt loam**	**clay**	**silt loam**	**clay**	**clay**
AIS-2	X	X	X	X	X
AIS-3	-	X	X	X	X
AIS-4	X	-	-	-	-
WB-1.5	X	X	X	X	-
Ten.	-	-	-	-	X
Non-irrigated	X	X	X	X	X

Table 2. Lint yield and fiber properties from irrigation schedules at the Panola Corp. on Commerce silt loam in 2000.

			Fiber Properties					
Treatment	**Lint(lb/ac)**	**Lint fraction**	**Lgth UHM**	**Unf**	**SFI**	**Str g/tex**	**Elg**	**Mic**
WB-1.5	1390	34.7	1.10	83.9	2.6	27.7	7.0	5.3
AIS-2	1339	34.5	1.10	82.4	3.4	26.9	7.0	5.3
AIS-4	1360	34.5	1.12	83.1	3.0	26.3	7.2	5.3
NI	1065	34.6	1.11	83.3	2.6	27.2	6.8	5.3
Mean	1289	34.6	1.11	83.2	2.9	27.0	7.0	5.3
L.S.D.$_{(0.05)}$	222	ns	ns	0.6	0.9	ns	ns	ns

Table 3. Lint yield and fiber properties from irrigation schedules at the Panola Corp. on Sharkey clay in 2000.

			Fiber Properties					
			Lgth			Str		
Treatment	Lint (lb/ac)	Lint fraction	UHM	Unf	SFI	g/tex	Elg	Mic
AIS-2	1362	34.3	1.13	82.9	2.8	27.8	6.8	5.0
AIS-3	1211	34.0	1.14	83.7	2.6	28.9	6.9	5.2
WB-1.5	1277	33.8	1.13	83.2	2.3	27.6	6.9	5.1
NI	791	35.0	1.11	82.7	3.1	27.5	7.0	5.1
Mean	1265	34.3	1.13	83.1	2.7	28.0	6.9	5.1
L.S.D.$_{(0.05)}$	156	ns	ns	ns	ns	ns	ns	ns

Table 4. Lint yield and fiber properties from irrigation schedules at the Panola Corp. on Commerce silt loam in 2001.

			Fiber Properties					
			Lgth			Str		
Treatment	Lint (lb/ac)	Lint fraction	UHM	Unf	SFI	g/tex	Elg	Mic
AIS-2	870	39.5	1.11	81.6	7.5	27.8	7.2	4.4
NI	826	36.2	1.09	82.0	6.5	28.4	7.2	4.5
AIS-3	804	35.1	1.13	82.3	5.7	28.6	7.3	4.3
WB-1.5	792	37.4	1.14	82.7	5.5	28.6	7.3	4.4
Mean	823	36.8	1.11	82.1	6.4	28.3	7.2	4.4
L.S.D.$_{(0.05)}$	ns	ns	ns	ns	ns	ns	ns	ns

Table 5. Lint yield and fiber properties from irrigation schedules at the Panola Corp. on Sharkey clay in 2001.

			Fiber Properties					
			Lgth			Str		
Treatment	Lint (lb/ac)	Lint fraction	UHM	Unf	SFI	g/tex	Elg	Mic
AIS-2	830	36.8	1.12	82.0	6.8	29.0	7.2	4.4
WB-1.5	804	37.5	1.12	82.5	6.0	28.8	7.6	4.6
AIS-3	689	36.1	1.11	82.3	5.6	28.6	7.2	4.6
NI	681	37.0	1.10	81.8	5.9	28.5	7.2	4.9
Mean	751	36.7	1.11	82.1	6.1	28.7	7.3	4.6
L.S.D.$_{(0.05)}$	81	ns	ns	ns	ns	ns	ns	0.2

Table 6. Lint yield and fiber properties from irrigation schedules at the LSU AgCenter-Northeast Research Station on Sharkey clay in 2001.

			Fiber Properties					
			Lgth			Str		
Treatment	Lint (lb/ac)	Lint fraction	UHM	Unf	SFI	g/tex	Elg	Mic
AIS-2	997	35.5	1.12	83.0	4.4	30.0	7.0	4.5
Ten.	954	36.3	1.13	83.0	5.5	29.9	6.9	4.5
AIS-3	954	36.4	1.13	82.7	5.6	30.6	7.1	4.5
NI	914	35.2	1.11	82.5	6.1	29.0	7.2	4.1
Mean	955	35.9	1.12	82.8	5.4	29.8	7.0	4.4
L.S.D.$_{(0.05)}$	ns	ns	ns	ns	ns	ns	ns	ns

Table 7. Precipitation, irrigation applications, and water use efficiency for irrigation tests at Panola Corp. and LSU AgCenter-Northeast Research Station, St. Joseph, La.

	Irrigation no.	Total Precip. in./ac	Total Irr. Water in./ac	Total Water in./ac	Lint lb/ac	Total WUE lint lb/in.	Irrigation WUE lint lb/in.
Panola CSL[1]-2000							
WB-1.5	6	8.99	9.60	18.59	1390	74.8	144.8
AIS-2	5	8.99	8.00	16.99	1339	78.8	167.4
AIS-4	4	8.99	6.40	15.39	1360	88.4	212.5
NI	0	8.99	0.00	8.99	1065	118.5	0.00
Panola SC[2]-2000							
AIS-2	5	8.99	12.50	21.49	1362	63.4	109.0
WB-1.5	4	8.99	10.00	18.99	1277	67.2	127.7
AIS-3	3	8.99	7.50	16.49	1211	73.4	161.5
NI	0	8.99	0.00	8.99	791	88.0	0.00
Panola CSL-2001							
AIS-2	3	26.02	4.67	30.69	870	28.3	186.3
WB-1.5	3	26.02	4.58	30.60	792	25.9	172.9
AIS-3	2	26.02	3.04	29.06	804	27.7	264.5
NI	0	26.02	0.00	26.02	826	31.7	0.00
Panola SC-2001							
AIS-2	3	26.02	7.80	33.82	830	24.5	106.4
WB-1.5	2	26.02	5.80	31.82	804	25.3	138.6
AIS-3	2	26.02	5.88	31.90	689	21.6	117.2
NI	0	26.02	0.00	26.02	681	26.2	0.00
NERS[3]-2001							
AIS-2	3	26.02	6.72	32.74	997	30.5	148.4
Ten.	3	26.02	6.93	32.95	954	29.0	137.7
AIS-3	3	26.02	6.90	32.92	954	29.0	138.3
NI	0	26.02	0.00	26.02	914	35.1	0.00

1. Panola Corp. on Commerce silt loam
2. Panola Corp. on Sharkey clay
3. LSU AgCenter – Northeast Research Station on Sharkey clay