DEEP SUBSURFACE DRIP IRRIGATION FOR COTTON IN THE SOUTHEAST

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Abstract

Long-term cotton (*Gossypium hirsutum* L) yield with various irrigation rates and crop rotations irrigated with subsurface drip irrigation (SSDI) is not known for the US Southeast. A SSDI system was installed in Southwest GA (1998) and maintained for 10 years. The soil was a Tifton loamy sand (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults) and consisted of three crop rotations, two drip tube lateral spacings, and three irrigation levels. Crop rotations were alternate year cotton (cotton-peanut; *Arachis hypogeae* L), two years (cotton-maize (*Zea mays* L.) - peanut), and three years between cotton (cotton-maize-maize-peanut). Drip tube laterals were installed underneath each crop row and alternate crop row furrows. Cotton was not grown in 1999 and 2006. Crops were irrigated daily at 100, 75 and 50% of estimated crop water use. There was no lint yield difference due to crop rotation. Lint yield differences were attributed to irrigation treatments in 4 out of 8 years. Lint yields were greatest when irrigated at the 75% irrigation level compared with 50% and in 3 out of 4 years when compared with 100% irrigation treatment. Higher lint yield with irrigation also coincided with lower seasonal rainfall totals. Drip tube lateral spacing affected lint yield 4 out of 8 years. Across all years, yield data indicates that alternate row furrow lateral spacing is as effective as every-row lateral spacing. Some fiber qualities were affected by irrigation, lateral, and rotation treatments but these effects were small and inconsistent. For SSDI use in the Southeast, the recommendation would be to irrigate cotton using 75% irrigation level and with tubing in alternate row furrows.

Introduction

Cotton production in Georgia has been stable for the last 10 years with an average of over 570,000 ha (Georgia Dept. of Ag, 2009), with about one-third of these cotton hectares being irrigated. Of the total irrigated hectares in Georgia about 10% was irrigated using drip, trickle, or micro-sprinkler irrigation (Census of Agriculture, 2007). Due to the expense of installing drip systems, it is assumed that most drip systems are limited to use on high value vegetable crops. Total area used for drip or trickle systems in cotton or other commodity row crops such as maize or peanut is unknown.

Economic calculations showed that SSDI would be more profitable in fields under a 30 ha threshold because it requires a lower initial investment per unit land area and has lower pumping costs compared to fixed or towable center-pivot systems. As emphasized by Bosch et al. (1992) and O'Brien et al. (1998), SSDI systems have a near-static cost per hectare compared with overhead sprinkler systems (center pivots), where per hectare cost decreases as the length of the system increases. Overhead sprinkler irrigation systems are the most common in the tri-state area (Alabama, Florida, and Georgia) because they are easy to assemble, durable, do not require elaborate filtering systems, and have owner familiarity with operation and maintenance.

One major concern with overhead sprinkler systems is the loss of water not reaching the intended target due to drift and evaporation and not being available for crop use. In contrast, SSDI is not affected by these environmental conditions. Benefits of SSDI include precise placement of water and chemicals, low labor requirements, and reduced runoff and erosion compared with overhead sprinkler systems. A SSDI system has the capability of frequently supplying water to the root zone thereby reducing the risk of cyclic water stress typical of other irrigation systems. Various researchers have shown that crop yield and quality can be improved using SSDI on tomato (*Lycopersicon esculentum* L), (Bogle et al., 1989; Camp et al., 1989), cotton (Bucks et al., 1988; Henggeler, 1988), and maize (Mitchell, 1981; Mitchell and Sparks, 1982; Powell and Wright, 1993). Thus, SSDI has the potential to provide consistently high yields while conserving soil, water, and energy.

These SSDI systems are adaptable to various field sizes and shapes which is an important economic consideration, especially in the Southeast. This economic advantage is apparent when considering the option to design a SSDI

system to effectively cover an irregularly shaped field that would not be totally covered with an overhead sprinkler system (Bosch et al., 1992). With proper SSDI designs, these systems can provide sufficient water to different field areas according to the area, soils, and crop species.

Drip tube laterals have been tested at 0.2- and 0.3-m soil depths (Bucks et al., 1988; Tollefson, 1985; Phene et al., 1987; Camp et al., 1989) on cotton, maize, fruits, and vegetables. Drip lateral spacing has been tested at 1, 2, and 3 m apart with yields decreasing as lateral spacing increased to greater than 2 m (French et al., 1985; Lamm et al., 1992; Powell and Wright, 1993; Camp et al., 1997). Comparisons of drip tubing placement have been made at various lateral spacings, i.e., every row or alternate row furrows, in continuous cotton or cotton-maize-peanut rotations (Camp et al., 1993; Camp et al., 1997; Dougherty et al., 2009; Sorensen and Lamb, 2008). In continuous cotton with alternate row furrow lateral spacing, there was year-to-year variability due to climatic patterns, but irrigated cotton yields were greater than nonirrigated yields especially in dry years (Dougherty et al., 2009). A comparison of alternate row furrow and lateral spacing under every crop row showed no yield difference in either continuous cotton or a cotton-peanut rotation (Camp et al., 1993; Camp et al., 1997; Sorensen and Lamb, 2008).

With increasing concern for water conservation in the tri-state region, the use of SSDI due to the greater irrigation efficiency of these systems may be of great interest to individual growers, water and environmental conservancy agencies, and policy making agencies. There is little long-term cotton yield or quality response data with SSDI to make management recommendations. Therefore, the objectives of this research were to determine the long-term yield and quality response of cotton to: 1) three irrigation rates, 2) two lateral spacings, and 3) three crop rotations using SSDI over a 10 year period.

Materials and Methods

The research site was located in Terrell County near Sasser, GA on a Tifton sandy loam soil (Fine-loamy, kaolinitic, thermic Plinthic Kandiudults) with 2-5% slope. A SSDI system was installed in 1998 on non-irrigated farmland that consisted of three irrigation levels, five crop rotations, two drip tube lateral spacings, and three replications for a total of 90 individual plots. Cotton had been planted two years prior to installing the SSDI system. A 6.8 ha rectangle was split into three equal areas referred to as tiers. There were alley-ways (12.2 m minimum) between tiers, at the sides, and crop row ends for equipment turn areas. Each SSDI tier (38 m by 274 m) was randomly assigned an irrigation level. The irrigation levels were 100%, 75% and 50% of estimated crop water use (Sorensen et al., 2001).

Each SSDI tier consisted of five crop rotations split into three blocks (replications) and each rotation was split using two thin-wall drip lateral spacings. Drip tube lateral were installed underneath each crop row (narrow, 0.91-m) and in alternate crop row furrows (wide, 1.83-m). Sorensen et al. (2001) describes in detail the treatments, irrigation system design criteria, and irrigation control. There were a total of 30 plots arranged in a randomized block design within each irrigation tier.

Table 1. Illustration of crop rotation by year.

Crop rotation[z]	Year									
	98	99	00	01	02	03	04	05	06	07
cp	p	c	p	c	p	c	p	c	p	c
cmp	m	c	m	p	c	m	p	c	m	p
cmmp	m	p	c	m	m	p	c	m	m	p

[z]p= peanut, c= cotton, m= maize.

The five crop rotations included continuous peanut (PPP), cotton-peanut (CP), maize-peanut (MP), cotton-maize-peanut (CMP), and a cotton-maize-maize-peanut (CMMP) (Table 1). Only the rotations that include cotton will be discussed here. All crops were planted on a 0.91 m row spacing in a single row orientation.

The thin-wall drip tube (Super Typhoon, Netafim Irrigation, Inc., Fresno, CA; www.netafim-usa.com) had a wall thickness of 0.254 mm (10 mil) and emitters spaced every 46 cm with a flow rate of 1.5 L h^{-1} per emitter. All thin-wall drip tubing was buried a minimum 31 cm deep using a modified ripper shank. Drip tubing cost \$0.082/m or \$897 ha^{-1} for the 0.91-m lateral spacing and half this cost for the 1.83-m lateral spacing.

Irrigation water was applied daily based on replacement of estimated crop water use for cotton. Air temperature (maximum, minimum and average), relative humidity, total solar radiation, and precipitation were recorded daily. From 1998 to 2003, meteorological data were collected using programmable logic control (PLC) modules (DirectLogic, AutomationDirect, Inc., Cumming, GA). This system worked well but was vulnerable to lightning. The result was inconsistent runtimes to the irrigation treatments. Therefore, in spring 2004, the PLC system was replaced with a more reliable datalogger system (Campbell Sci., Inc, Logan, UT; CR23X). Daily potential evapotranspiration (ET_o) was estimated using the modified Jensen-Haise equation adjusted for local conditions (Jensen and Haise, 1963). Crop coefficients, Kc, were determined by dividing the estimated daily water use of Harrison and Tyson (1993) by archived daily ET_o data for the same day and time period. This Kc by time function was then programmed into the datalogger used to control the irrigation system. The estimated daily Kc was then multiplied by the daily estimated ET_o from the weather data to calculate the depth of water to apply (ET_a) for the 100% irrigation treatment. The other two irrigation levels were determined by multiplying the 100% irrigation level by 75% and 50%. Precipitation totals were subtracted from the estimated daily ET. Irrigation events were scheduled daily except when precipitation exceeded estimated ET.

Fertilizer and lime were applied at the same time and rate as determined by university recommendations following a soil test (Collins et al, 2010). Seed-bed preparation for all crops consisted of one to two passes (once in the fall and once in the spring) with experimental tillage equipment (USDA-ARS-National Peanut Research Laboratory) that would essentially till the top 10 to 15 cm of soil. This equipment would reshape the soil into one single planting bed that was about 1.4 m wide with crop rows spaced 0.91-m apart on these beds. This equipment also provided controlled-traffic such that no wheeled equipment ran over the buried lateral drip-tube positions. A small field cultivator was used to break any soil crust, incorporate herbicides, and provide weed control prior to planting any crop. After harvest, crop residue was mowed, lightly tilled with a disc harrow, and then re-bedded as described previously. A tractor guidance system was not available so all row patterns were measured directly from a beginning point and checked periodically across the field by digging and finding specific drip tubing rows/patterns.

Cotton was planted at a density of 106,300 seeds ha^{-1}. Yearly plant and harvest dates, total rainfall, total irrigation amount, and cotton cultivar are shown in Table 2. Each year prior to sowing, 22 kg N ha^{-1} of dry fertilizer was applied along with other recommended fertilizer (phosphorus and potassium) as determined by soil test (custom blended to match recommendation). A total of 80 kg N ha^{-1} was applied through the drip system using injector pumps (32-0-0). Each year was managed independently such that pesticides and growth regulators were applied as recommended by field scouting (Roberts, 1997). Cotton was harvested using a 2-row spindle picker modified to collect cotton in a large mesh bag. The sample was weighed and ginned. A 0.2 kg sub-sample was collected from each ginned sample to determine lint quality. Gross revenue was determined using the average price received for lint cotton for the 2008 growing season at \$1.40 kg^{-1} (Georgia Dept. of Ag, 2009).

Due to restricted amount of land area, all phases of each crop rotation were not planted every year. Consequently, not every cotton rotation combination could be analyzed by rotation. Yield and lint quality data were analyzed using a split or split-split-randomized block design using linear general analysis of variance procedures (Statistix9, 2008). The main plot was irrigation rate (tiers), the subplot was crop rotation, and the sub-sub plot was lateral spacing. Crop yield and lint quality data were analyzed by individual years, irrigation treatment, crop rotation (when possible), and lateral spacing within and across years if applicable. Differences between crop yield and lint quality means were determined using Tukey's multiple comparison when *ANOVA F*-test showed significance ($P \leq 0.05$).

Results and Discussion

Rainfall and irrigation

Cotton was planted near the end of April and first part of May which is considered the optimal planting time for cotton in this region. Rainfall was least in 2000 (335 mm) and greatest in 2005 (756 mm) with an average rainfall of 515 mm in the remaining years (Table 2).

Table 2. Cotton planting and harvest dates, rainfall, irrigation amount and cultivar selected by year. Rainfall is from day of year 120 to 275 (30 April to 02 October).

Year	Plant date	Harvest date	Rainfall	Irrigation			Cultivar[z]
				100%	75%	50%	
			---------- mm----------				
1999	12 May	26 Oct	493	299	225	158	DP655RR
2000	11 May	30 Oct	335	208	164	na[y]	DP655RR
2001	11 May	11 Oct	433	249	212	168	DP458RR
2002	08 May	22 Oct	441	120	103	62	DP458RR
2003	28 Apr	21 Oct	682	207	162	117	DP458RR
2004	26 Apr	04 Oct	623	148	111	74	DP458RR
2005	03 May	06 Oct	756	190	133	96	DP458RR
2007	23 Apr	02 Nov	418	297	222	148	DP555RR

[z]DP = Delta Pineland; RR = Roundup Ready

[y] Not applicable. Only two irrigation rates were used this year

Figure 1 shows the cumulative ET_a, irrigation applied and rainfall plus irrigation received during 2000. Cumulative irrigation plus rainfall match estimated ET_a quite well until later in the season when rainfall increased. Contrast Figure 1 with Figure 2 where rainfall during the growing season was much higher. Cumulative irrigation was much lower while irrigation plus rainfall was much higher than the estimated ET_a. In 2007, rainfall was about midway between that received during 2000 and 2005 (Figure 3). The irrigation plus rainfall curve tracked close to the ET_a curve until about 80 DAP when rainfall increased and the curves diverge. These three figures show that each crop year has a unique yet similar rainfall pattern during various parts of the growing season with periods of convergence and divergence to the ET_a curve. These yearly rainfall patterns increase the difficulty of irrigation scheduling and may have affected the final cotton yield.

The greatest irrigation depth was applied in 1999 and 2007 (299 and 297 mm, respectively) while the least irrigation was applied in 2002 (120 mm). The average irrigation applied was 200 mm over the remaining years. Total irrigation amounts fluctuated yearly depending on amount and timing of the rainfall events. Three cotton cultivars were used during this long-term project. Cultivar selection was made on recommendations provided by local university variety yield trial data and seed availability.

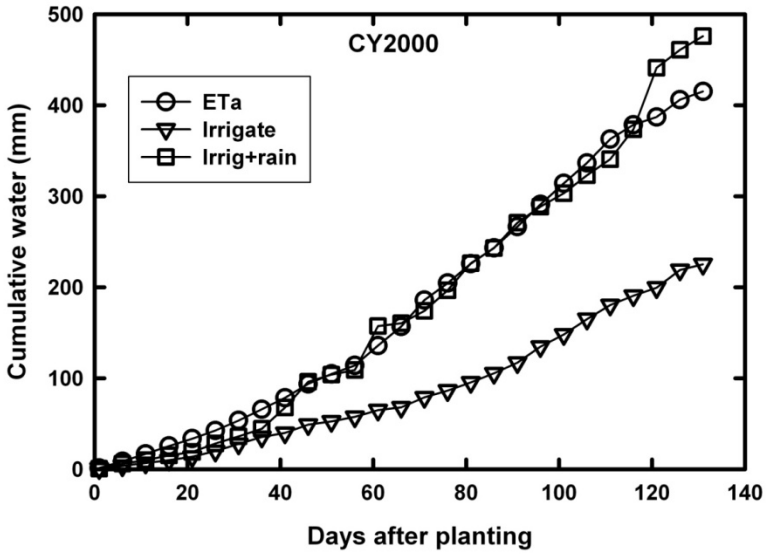

Figure 1. Cumulative ET_a, irrigation, and irrigation plus rainfall depths measured from 0 to 130 days after planting for CY2000, a low rainfall year. Only every 5th day is shown.

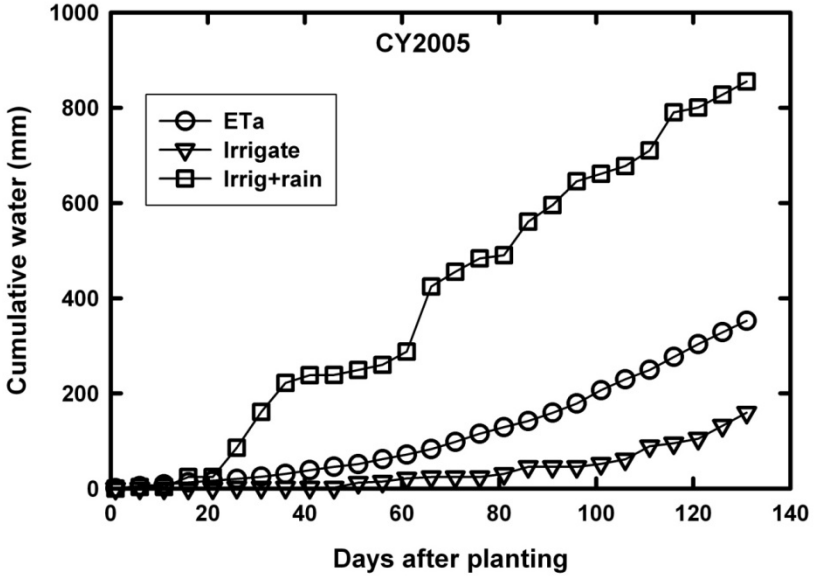

Figure 2. Cumulative ET_a, irrigation, and irrigation plus rainfall depths measured from 0 to 130 days after planting for CY2005, a high rainfall year. Only every 5th day is shown.

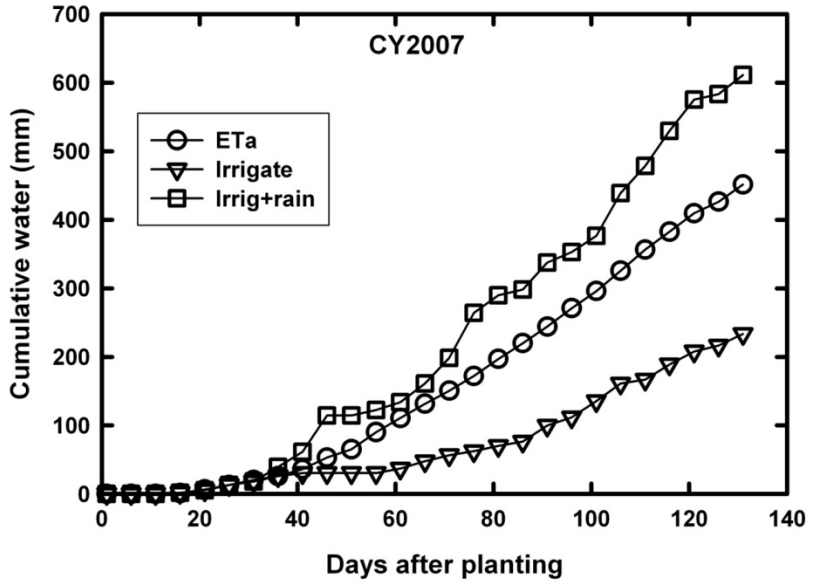

Figure 3. Cumulative ET_a, irrigation, and irrigation plus rainfall depths measured from 0 to 130 days after planting for CY2007, a medium rainfall year. Only every 5th day is shown.

Irrigation treatment

In 2003 the cotton crop was damaged due to herbicide drift from an adjacent farm. The average crop yield in 2003 was only 853 kg ha^{-1} compared with 1349 kg ha^{-1} for the rest of the years where irrigation treatments had no significant response to an irrigation treatment (1999, 2005, and 2007). Therefore, yield data from 2003 was not used in any of the averages across years.

The ANOVA data (Table 3) indicate there was significant crop yield difference attributed to irrigation treatment (Water) in 4 out of 8 years (2000, 2001, 2002, and 2004). However, the years in which lint yield was different due to irrigation treatment coincided with only two of the years (2000 and 2002) where lint yield was different due to drip tube lateral spacing.

Table 3. Analysis of variance table of lint yield probability values for treatment of water applied (W), crop rotation (R), and drip lateral spacing (L) and associated interactions.

Source	99	00	01	02	03	04	05	07
	---------- p-values ----------							
Water (W)	0.070	0.047	0.013	0.000	0.596	0.045	0.536	0.084
Rotation (R)	0.056	- -	- -	- -	- -	- -	0.228	- -
Lateral (L)	0.019	0.019	0.556	0.001	0.767	0.312	0.002	0.342
W x R	0.404	- -	- -	- -	- -	- -	0.876	- -
W x L	0.612	0.304	0.667	0.665	0.701	0.626	0.275	0.949
R x L	0.000	- -	- -	- -	- -	- -	0.033	- -
W x R x L	0.561	- -	- -	- -	- -	- -	0.221	- -

Cotton lint yield for the four years where the irrigation treatment showed significant differences (2000, 2001, 2002, and 2004) is shown in Table 4. Analyzed within each year, lint yields were greatest when the crop was irrigated at 75% irrigation treatment compared with 50% irrigation level and 3 out of 4 years when compared with 100% irrigation treatment. Lint yield at the 75% irrigation level averaged 1401 kg ha^{-1} with a high of 1665 and low of 1259 kg ha^{-1}. Cotton lint yield averaged 1238 kg ha^{-1} at the 50% irrigation level. Three out of the four years where lint yield differed due to irrigation treatments coincided with the three lowest years for total cumulative rainfall. Lint yields from this research are similar to other SSDI research yields. Camp et al. (1997) showed lint yields ranging from 706 to 1518 kg ha^{-1} for two years (1992 and 1994, respectively) averaged across two lateral spacings and three nitrogen rates. Nuti et al. (2006) showed SSDI cotton lint yields ranging from 900 to 1900 kg ha^{-1} depending on yearly rainfall and irrigation amounts. Yearly yield fluctuation can be attributed to climatic/rainfall differences as well as crop genetics and management. Rainfall patterns and total amount per event may have more of an impact on final yield compared with total rainfall received during the growing season. Camp et al (1993) also showed that showed that less irrigation was needed to obtain the same yield during three growing seasons with different rainfall patterns no matter the irrigation schedule technique employed, i.e., either cotton growth models or with soil based sensors.

Table 4. Lint yield values for various irrigation levels (Water) which showed significant yield differences within year.

Water	2000	2001	2002	2003	2004
			---------- kg ha^{-1} ---------		
50	na[z]	1205b[y]	1303c	793a	1205b
75	1259a	1376a	1665a	892a	1302a
100	1136b	1332a	1511b	873a	1196b

[z]Not applicable.
[y]Means in the same column followed by different lower case letters are significantly different at the p=0.05 level.

Overall, these irrigation treatments indicate that irrigating at 75% of existing recommended crop water use values had greater yields 50% of the time. During the remainder of the time, the 75% irrigation level had the same yield as the 50% and 100% irrigation levels with somewhat adequate rainfall patterns. This implies a possible 25% water savings for cotton for the same yield during most years and higher during drought or poor rainfall pattern years.

Lateral spacing

Lint yield was significantly affected by drip tube lateral spacing (Lateral) in 4 out of 8 years (1999, 2000, 2002, and 2005; Table 3). The four years where significant cotton lint yield differences were attributed to drip tube lateral spacing are shown in Table 5. These data show that narrow drip tube spacing (0.91-m) had higher yields in 3 out of 4 years compared with wide drip tube lateral spacing (1.83-m). The average yield for the narrow lateral spacing was 1443 kg ha^{-1} compared with the wide lateral spacing average yield of 1235 kg ha^{-1}. Over the 10-year period, lateral

spacing had an effect on cotton yield only 50% of the time. The narrow lateral spacing increased yield slightly more than 200 kg ha^{-1} of cotton lint representing additional gross revenue of \$280 ha^{-1}. The cost of drip tubing is about \$0.082 m^{-1} and would cost about \$897 ha^{-1} just for the tubing at the 0.91-m lateral spacing. It would take almost four "yield-increase events" to equal the cost of the additional tubing for drip tubing installed under every crop row. Even though cotton yields increase 50% of the time with the 0.91-m lateral spacing, the additional revenue generated may not be sufficient to cover the cost of laterals placed in every row compared with laterals spaced in alternate row furrows.

Table 5. Cotton lint yield values for drip tube lateral spacing which showed significant yield differences within year.

Lateral	1999	2000	2002	2005
	---------- kg ha^{-1} ----------			
0.91 m	1415b[z]	1380a	1586a	1364a
1.83 m	1465a	1114b	1400b	1191b

[z]Means in the same column followed by different lower case letters are significantly different at the p=0.05 level.

These yield data coincide with Camp et al. (1993, 1997) which evaluated both SSDI and surface drip irrigation with laterals placed in every row or in alternate row furrows. They concluded that alternate mid-row placement was as effective as in-row placement when drip laterals are placed on the soil surface. Bucks et al. (1988) and French et al. (1985) reported that wider spacing of drip laterals than in-row placement was adequate for cotton production in Arizona. Enciso et al. (2005) showed that laterals spaced 2-m apart (alternate row furrows) were more economical than those spaced at 1-m spacing. This was especially after the 3rd year of the project. They also showed that various treatments of lateral spacing or lateral depth had very little effect on cotton quality.

Overall, this research showed no clear evidence indicating one specific lateral spacing (narrow or wide) is better than another at increasing yield. However, economically it would be advantageous to select the alternate row furrow lateral spacing to reduce tubing expense by 50%.

Crop rotation

There was no significant yield difference due to crop rotation (Table 3). In all instances, cotton always following peanut because the rotations were designed for testing disease pressure in peanut, which would have little bearing on cotton response. There was no lint yield increase between alternate year and two years between cotton. Crop rotation sequence would be determined by crop market values for best economic returns.

There was a rotation by lateral (R x L) interaction in 1999 and 2005 when both rotations were grown in the same year. Table 6 shows cotton lint yield data for the two crop rotations by lateral spacing interactions. In 1999, the lowest yield was for the CMP rotation with a narrow lateral spacing which was only 152 kg ha^{-1} less than the average of the other rotations and lateral spacing treatments. In 2005, the lowest yield was for the cotton-peanut rotation using the wide drip tube lateral spacing which had over 200 kg ha^{-1} less cotton lint compared with other crop rotations and lateral spacing treatments. There was not a consistent "highest yield response" to crop rotation or lateral spacing thus no recommendation can be assessed.

Table 6. Cotton lint yield values for two crop rotations by lateral spacing interaction which showed significant yield difference within year.

Crop rotation	Lateral spacing	1999	2005
	-- m --	------- kg ha^{-1} ------	
cp	0.91	1503a[y]	1321a
cp	1.83	1467a	1108b
cmp	0.91	1325b	1338a
cmp	1.83	1463a	1274a

[z] p= peanut, c= cotton, m= maize.

[y]Means in the same column followed by different lower case letters are significantly different at p=0.05 level.

A comparison of lint yield across all years (excluding 2003), irrigation levels, and lateral spacings for the three crop rotations of cotton-peanut (CP; n=5), cotton-maze-peanut (CMP; n=3), and cotton-maze-maze-peanut (CMMP; n=2) were similar at 1342, 1398, and 1260 kg ha^{-1} respectively. Using the best recommendation of 75% irrigation level and alternate row lateral spacing, the average cotton lint yield across all years at the various crop rotations had 1349 (CP), 1402 (CMP), and 1286 (CMMP) kg ha^{-1}, respectively. Though not statistically valid to compare across years and treatments in this fashion, these values show little cotton yield difference by rotation when irrigated with SSDI at various irrigation levels or lateral spacings.

Lint quality

No lint quality data was recorded for 2002. Table 7 shows the ANOVA probability values for cotton lint quality factors of micronaire, fiber length, strength, and uniformity. Probability values indicate differences in micronaire with water treatment in 2000, 2001 and 2004. For these three years, micronaire values ranged from 3.78 to 4.63 (Table 8). There was a trend for the 50% water treatment to have higher micronaire values (4.61) compared with the 100% irrigation (4.1). For the years where micronaire showed no difference to the various water treatments (1999, 2003, 2005, and 2007), values ranged from 4.22 to 4.76 with an average value of 4.44. Across all years, these irrigation treatments did not result in micronaire values outside the base or premium range.

For 2 out of 7 years (2000 and 2005) there was a significant difference for micronaire with lateral spacing. Comparisons within these two years show that micronaire was greater for the narrow lateral spacing (4.2) compared with the wide lateral spacing (4.0). There were no micronaire values outside of the base or premium values with respect to lateral spacing.

Table 7. Analysis of variance table of lint quality probability values for treatment of water applied, crop rotation, and drip lateral spacing and associated interactions.

Source	1999	2000	2001	2003	2004	2005	2007
	---------- p-values ----------						
				Micronaire			
Water (W)	0.106	0.001	0.027	0.739	0.001	0.304	0.902
Rotation(R)	0.169	- -	- -	- -	- -	0.519	- -
W x R	0.952	- -	- -	- -	- -	0.209	- -
Lateral (L)	0.863	0.019	0.318	0.579	0.082	0.021	0.660
W x L	0.480	0.748	0.311	0.603	0.175	0.626	0.902
R x L	0.240	- -	- -	- -	- -	0.015	- -
W x R x L	0.098	- -	- -	- -	- -	0.075	- -
				Length			
Water (W)	0.009	0.010	0.077	0.773	0.098	0.532	0.362
Rotation(R)	0.405	- -	- -	- -	- -	0.500	- -
W x R	0.818	- -	- -	- -	- -	0.752	- -
Lateral (L)	0.899	0.005	0.153	0.735	0.197	0.108	0.732
W x L	0.984	0.685	0.866	0.501	0.333	0.245	0.812
R x L	0.705	- -	- -	- -	- -	0.012	- -
W x R x L	0.540	- -	- -	- -	- -	0.565	- -
				Strength			
Water (W)	0.062	0.277	0.424	0.693	0.339	0.136	0.177
Rotation(R)	1.000	- -	- -	- -	- -	0.387	- -
W x R	0.727	- -	- -	- -	- -	0.597	- -
Lateral (L)	0.499	0.186	0.373	0.947	0.449	0.462	0.043
W x L	0.401	0.436	0.901	0.428	0.496	0.630	0.692
R x L	0.126	- -	- -	- -	- -	0.302	- -
W x R x L	0.131	- -	- -	- -	- -	0.838	- -
				Uniformity			
Water (W)	0.038	0.533	0.452	0.435	0.075	0.443	0.377
Rotation(R)	0.082	- -	- -	- -	- -	0.062	- -
W x R	0.413	- -	- -	- -	- -	0.518	- -
Lateral (L)	0.856	0.079	0.712	0.615	0.160	0.349	0.783
W x L	0.420	0.718	0.825	0.393	0.493	0.064	0.771
R x L	0.108	- -	- -	- -	- -	0.105	- -
W x R x L	0.624	- -	- -	- -	- -	0.575	- -

Table 7 also shows fiber length was different 2 out of 7 years (1999 and 2000) with respect to water treatment. Comparisons of these two years show that 50% irrigation had shorter fiber length (27.7 mm) compared with 75 or 100% irrigation level (28.2 mm). Fiber length for the other 5 years averaged 27.9 mm (Table 8).

Fiber strength and uniformity had little variation within or across years (Table 7). There was one incidence where fiber strength was different with lateral spacing (2007) and another incidence where fiber uniformity was different with water treatment (1999). With only one incidence in seven years, there is not enough evidence to suggest that fiber strength or uniformity would be influenced by water amount, lateral spacing, or crop rotation when using SSDI. However, irrigation amount, lateral spacing, and crop rotation did influence lint quality, but, these differences did not affect the economic value of the cotton.

Table 8. Irrigation level (Water) and lateral spacing (Lateral) treatment effects on fiber quality of micronaire and length by year.

Treatment	1999	2000	2001	2002	2003	2004	2005	2007
Water				micronaire				
50	4.76a[z]	na[y]	4.6a	na	4.34a	4.63a	4.22a	4.33a
75	4.57a	4.13a	4.33ab	na	4.46a	4.22b	4.22a	4.33a
100	4.65a	3.78b	4.3b	na	4.52a	4.25b	4.37a	4.25a
Lateral								
0.91-m	4.66a	4.07a	4.45a	na	4.49a	4.43a	4.36a	4.34a
1.83-m	4.66a	3.84b	4.37a	na	4.39a	4.31a	4.18b	4.3a
Water				length (mm)				
50	27.7a	na	26.7a	na	28.2a	28.4a	28.2a	27.4a
75	28.2a	28.2b	27.2a	na	28.2a	28.7a	28.2a	28.2a
100	28.2a	28.7a	27.2a	na	28.2a	28.2a	28.2a	28.2a
Lateral								
0.91-m	27.9a	28.2b	26.9a	na	28.2a	28.2a	28.2a	27.7a
1.83-m	28.2a	28.7a	27.2a	na	28.2a	28.4a	28.4a	27.7a

[z]Means in the same column by treatment, and quality parameter followed by different lower case letters are significantly different at the p=0.05 level.
[y]Not applicable.

Conclusions

Cotton lint yield data indicate a significant improvement when irrigating at 75% of existing recommended crop water use values in half of the years studied. During the other half of the time, the 75% irrigation level was just as good as the 50% and 100% irrigation levels. This implies a possible 25% water savings in cotton without sacrificing yield potential.

In three out of the four years when lint yield was significant due to irrigation treatment, these higher yields occurred in the years with the lowest total cumulative rainfall. This may indicate that rainfall patterns and total amount per event may have a greater impact on final yield than total rainfall received.

There was lint yield difference attributed to drip tube lateral spacing 50% of the time. However, the years in which lint yield was affected by irrigation coincided with only two of the years where lint yield was affected by lateral spacing. There was no apparent strong relationship between lateral spacing and irrigation level on lint yield. These data also show that in years where yields were higher due to drip tube spacing, laterals spaced at 0.91-m had higher lint yields 75% of the time compared with laterals spaced at 1.86-m. The average yield for the 0.91-m lateral spacing was 1443 kg/ha compared with 1235 kg ha^{-1} for cotton irrigated using 1.86-m lateral spacing.

Crop rotation had no effect on lint yield. In all instances cotton always followed peanut. There was no lint yield increase due to rotation between alternate year and two years between cotton crops.

Based on this research, when SSDI is used to irrigate cotton in the Southeast, drip tube laterals should be installed in alternate row furrows and irrigation scheduled to supply 75% of ET_o. Further research may be necessary to identify lint yield response to mono-cropped cotton, nitrogen rates, and tillage treatments with SSDI.

Disclaimer

Mention of proprietary product or company is included for the reader's convenience and does not imply any endorsement or preferential treatment by the USDA-ARS.

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