CONSERVATION TILLAGE METHODS FOR COTTON GROWN WITH SUBSURFACE DRIP IRRIGATION ON COMPACTED SOIL

P. J. Bauer, C. R. Camp, W. J. Busscher

ABSTRACT. *Subsurface drip irrigation and conservation tillage are tools for improving water management for cotton (*Gossypium hirsutum *L.). In previous research with cotton grown with no tillage over subsurface drip laterals, excessive soil compaction near the soil surface occurred. We hypothesized that loosening this compacted surface soil would improve cotton productivity. We tested this hypothesis by conducting a 2–year field experiment to determine the effect of three levels of soil loosening (no tillage, shallow in–row tillage with a rigid shank, and shallow tillage with a stubble mulch plow to loosen the entire surface layer of soil) and two drip lateral spacings (under every row and in every other row middle; 1–m and 2–m spacings, respectively) on early–season physiological parameters and productivity of cotton. The subsurface drip irrigation system had been used for 7 years before initiating this experiment. Early–season cotton leaf gas exchange, leaf nutrient concentrations, yield, and fiber quality were measured. The tillage implements loosened the soil as expected (as determined with a cone penetrometer), but the level of soil loosening had almost no effect on leaf gas exchange and leaf nutrient status. Similarly, tillage and lateral spacing did not affect cotton yield and quality. Yields were not high (mean yield of 1215 kg/hain 1998 and 700 kg/hain 1999) but were not atypical for irrigated yields in this region during those years. Conservation tillage methods that include shallow tillage over drip laterals on compacted SE coastal plain soils did not improve cotton productivity.*

Keywords. *Soil strength, Trickle irrigation, Cotton yield, Cotton fiber quality.*

Interest in irrigation of cotton in the southeastern U.S. has increased as drought periods over much of the region caused low yields over the last several years. Although farmers normally use overhead sprinkler irrigation systems, subsurface drip has been demonstrated as a possible alternative to sprinkler irrigation for cotton in the southeast (Camp et al., 1996, 1999). Subsurface drip systems are flexible in design so that they can be used on many fields that are small or of irregular shape, and these systems are more efficient than overhead sprinkler systems. Thus, they are a possibly important tool to lessen the competition for water between agricultural and urban/industrial entities, and to utilize low–capacity water supplies. Subsurface drip irrigation has been used extensively for cotton production in the western U.S. cotton belt (Tollefson, 1985a, 1985b; Henngeler, 1995).

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Southeastern U.S. coastal plain soils often contain a tillage pan, a naturally forming hardpan (an eluviated E horizon), or both (NeSmith et al., 1987). Although the depth of the pan is variable, it is generally 20 to 40 cm below the soil surface, and annual subsoiling to disrupt the pans is often used for cotton in the region. The soil in the pans becomes more root–restricting when dry (Busscher et al., 1997). Camp et al. (1999) tested the hypothesis that using drip laterals buried just below the pan layers may keep the soil layers wet enough so that tillage is not necessary. They conducted a 2–yr study growing cotton with no–tillage culture over drip laterals that were 30–cm deep (just under the naturally occurring E horizon in that soil). They did not find a difference in yield between cotton grown with subsurface drip irrigation and cotton grown under rainfed conditions that included in–row subsoiling, but yields for the rainfed were high and averaged over 1000 kg/ha. Instead, they found high levels of soil compaction within 5 cm of the soil surface in the irrigated plots when soil strength measurements were taken shortly after planting. Excavated roots from the rainfed treatment (that had been subsoiled) at the end of the season appeared normal, but taproots dug from the irrigated plots (no tillage) were short and deformed. These results suggested that some shallow tillage to reduce soil strength in the A horizon may improve productivity with subsurface drip irrigation on these soils. Taylor and Gardner (1963) found cotton root penetration decreased linearly with increasing soil strength in an Amarillo fine sandy loam soil, and that root elongation stopped when soil penetrometer values reached 2.96 MPa (296 N cm^{-2}). Raper et al. (2000) found that shallow in–row tillage increased cotton yield when grown with conservation tillage on a compacted Decatur silt loam soil in the Tennessee Valley of Alabama.

Soil compaction limits the volume of soil from which roots can extract water and nutrients. Even if subsurface drip irrigation is able to supply enough water to a crop with stunted roots when roots are near the irrigation lateral, soil loosening may still be required to overcome possible nutrient deficiencies, especially for nutrients that are susceptible to leaching such as N, K, S, and B. We hypothesized that yield potential would be improved by disrupting the surface compaction with tillage implements. In this study, we used two implements to loosen soil in the surface horizon with minimal disruption of surface residues and compared them to no–tillage culture. The implements used were a stubble mulch plow to loosen the entire soil surface layer, and a prototype Beasley strip tillage unit (Naderman, 1993) to loosen the soil directly under the row. Our objective was to determine the effect of three levels of soil loosening and two drip lateral spacings on early–season nutrient concentration, early–season leaf gas exchange, cotton lint yield, and fiber properties.

Materials and Methods

The experiment was conducted at Clemson University's Pee Dee Research and Education Center near Florence, South Carolina, on a Eunola loamy sand (Aquic Hapludults) soil in 1998 and 1999. The subsurface drip system used in the experiment was described previously (Camp et al., 1999). Experiments have been conducted on the site since 1991. From 1991 through 1995, the soil surface was disked twice in the spring before planting crops. In 1996 and 1997, crops were grown with no–tillage culture. Experimental design for this experiment was randomized complete block with treatments in a factorial arrangement with four replicates. Treatments were spacing of the buried drip laterals (1–m and 2–m) and tillage (no tillage, shallow in–row tillage with a Beasley strip tillage implement, and complete surface loosening by stubble mulch plowing). Plots were eight rows wide and 15 m long.

Drip irrigation laterals were 0.30 m below the soil surface. They were placed either under every plant row (1–m spacing; one lateral per row) or in the non–traffic middle of two rows (2–m spacing; one lateral per two rows). The stubble mulch plow consisted of five overlapping sweeps each 1.1 m wide. These sweeps disturbed the soil across the entire plot area to a depth of 10 to 15 cm but left most of the residues from the previous crop on the surface. The Beasley strip tillage implement was a shank that operated to a 20–cm depth, disturbing a narrow soil band directly under the plant row. Pneumatic wheels firmed the soil surface in that narrow band behind the shanks.

Soil pH and P, K, and Mn levels were maintained by making pre–plant surface applications of lime and fertilizers at recommended rates, based on soil test values. Each year, 11.2 kg/ha of S and 0.45 kg/ha of B were applied in the fertilizer. Approximately 2 weeks before planting cotton each year, winter weeds were killed with glyphosate. In 1998, cotton cultivar DPL Acala 90 was planted on 13 May. In 1999, DPL 33B was planted on 10 May. Cotton was planted with a four–row planter equipped with wavy coulters. Aldicarb (0.34 kg a.i. ha^{-1}) was applied in–furrow at planting. Throughout both seasons, plots were scouted regularly and insect pests were controlled with insecticides. Weeds were controlled with a combination of herbicides and hand weeding. Nitrogen was applied through the drip system in four applications each year. In 1998, 45 kg N ha^{-1} was applied on 20 May. Then, applications of 22.5 kg N ha^{-1} each were made on 16 June, 23 June, and 30 June. In 1999, a 45 kg N ha^{-1} application was made on 19 May, with 22.5 kg N ha^{-1} applications being made on 17 June, 24 June, and 1 July.

Soil strength in the surface 60 cm of each plot was measured just after cotton emergence each year, as described earlier (Camp et al., 1999). Cone index data were taken with a 12.5–mm diameter cone–tipped penetrometer. Cone indices were measured by pushing the penetrometer into the soil to a depth of 60 cm at three positions: a non–traffic midrow, in the row, and a traffic midrow. Cone index data at 5–cm depth intervals were digitized and stored in a computer file. Because soil strength is dependent on moisture content, soil samples were collected for determination of gravimetric water content at the same time cone index data were being collected. Soil samples (2.5 cm cores) were collected from depths of 0–10, 10–20, 20–30, 30–40, 40–50, and 50–60 cm in the row and in the non–traffic midrow in all plots. Samples were weighed, dried at 105°C, and weighed again to determine water content.

Soil water potential measurements were made using gauge–type tensiometers installed at depths of 20 cm and 60 cm in the row area in two replicates of all treatments. Tensiometer measurements were recorded three times each week, and irrigation was initiated when soil water potential values at the 20–cm depth in any two plots reached –30 kPa. The irrigation application depths were usually 9 mm, but 18 mm was applied occasionally.

During June of each year, we began making measurements of plant responses to the tillage systems. Midday leaf gas exchange (photosynthesis, transpiration, stomatal resistance) of uppermost fully expanded leaves was measured on 17 June, 29 June, and 13 July in 1998 and on 9 June and 24 June in 1999 with a CI–301PS Photosynthesis System (CID, Inc., Vancouver, Wash.). Uppermost fully expanded leaf blades were collected from interior rows of the plots for nutrient analysis five times at 2–week intervals (beginning on 16 June each year). The first leaf collection occurred just prior to the second N application each year. Leaf blade N, P, K, Ca, Mg, S, Zn, Cu, Mn, Fe, B, and Al were determined for the samples collected on the first two sampling dates each year. Only N concentration in the leaf samples was measured on the last three sampling dates. On each sampling date, approximately 20 leaf blades were collected. The leaves were dried at 65°C for at least 3 days and then ground. Samples were then sent to the Clemson University Agricultural Service Laboratory for analysis.

The four center rows of each plot were harvested with a two–row spindle picker on 29 September 1998 and 22 October 1999, and all plants in the harvest rows were counted shortly after that. Samples of seed cotton were collected from the harvest bag and ginned. Lint yields were calculated from the lint percentages. Fiber samples were sent to Star–Lab, Inc (Knoxville, Tenn.) for high–volume instrumentation analysis of physical properties of the lint.

Means and standard deviations of the cone index values were calculated and plotted against soil depth (*ASAE Standards*, 1999). Means and standard deviations for soil water content at the time that cone index measurements were made were also calculated. All other data were subjected to analysis of variance, and means were separated with an LSD when main effect or interaction terms were significant ($P \leq 0.05$). The data sets from each year were analyzed separately.

Results and Discussion

The total amount of irrigation water applied was about the same each year (figs. 1 and 2). In 1998, 248 mm of water was applied, while 237 mm of water was applied in 1999. Total seasonal rainfall was lower in 1998 (306 mm) than in 1999 (399 mm). Up until 120 days after planting, total rainfall plus irrigation was similar for the two years. Though 1999 had higher total rainfall, it was better distributed in 1998. In 1999, almost 40% (about 150 mm) of the total rainfall occurred during mid–late September (beyond the 120 days after planting in fig. 2) and thus was of limited benefit to the crop.

Temperature regimes were quite different between the two years (fig. 3). The spring and early summer of 1999 was much cooler than the early season of 1998. By 30 days after planting, heat unit [((maximum daily temperature + minimum daily temperature)/2) –15] accumulation in 1998 was 34% higher than it was in 1999 (309 in 1998 and 231 in 1999). Heat unit accumulations in 1999 lagged behind those of 1998 throughout the season (fig. 3). The higher early season temperatures in 1998 resulted in more water use by the crop early in the season. Up to about 80 days after planting, total irrigation applied in 1998 was about 200 mm and total irrigation plus rainfall was about 400 mm (fig. 1), while in 1999 (fig. 2), irrigation applied was about 1/2 of the amount applied by this time in 1998, and total irrigation plus rainfall was also about 1/2 of the amount in 1998.

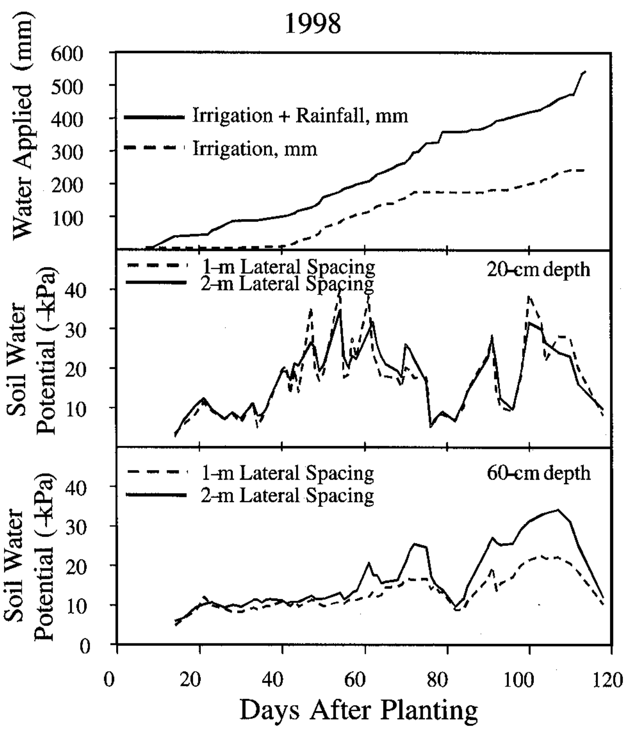


Figure 1. Cumulative water applied to cotton through irrigation and irrigation plus rainfall (top) and in–row soil water potential at the 20–cm depth (middle) and 60–cm depth (bottom) for the 1–m and 2–m lateral spacings in 1998 near Florence, South Carolina.

The tillage implements loosened the soil as expected (fig. 4). The Beasley strip tillage implement loosened the soil under the row to a depth of between 20 and 25 cm each year, but high soil strength remained in both midrows. The stubble mulch plow was operated at a slightly deeper depth in 1999 than in 1998. In 1998, it loosened the entire surface to a depth of 5 to 10 cm, while in 1999 soil was loosened to a depth of 10 to 15 cm. With the stubble mulch plow, re–compaction of the trafficked midrows occurred during planting. For the no–tillage treatment, there was high soil strength at depths within 5 cm of the surface across the entire row width (fig. 4).

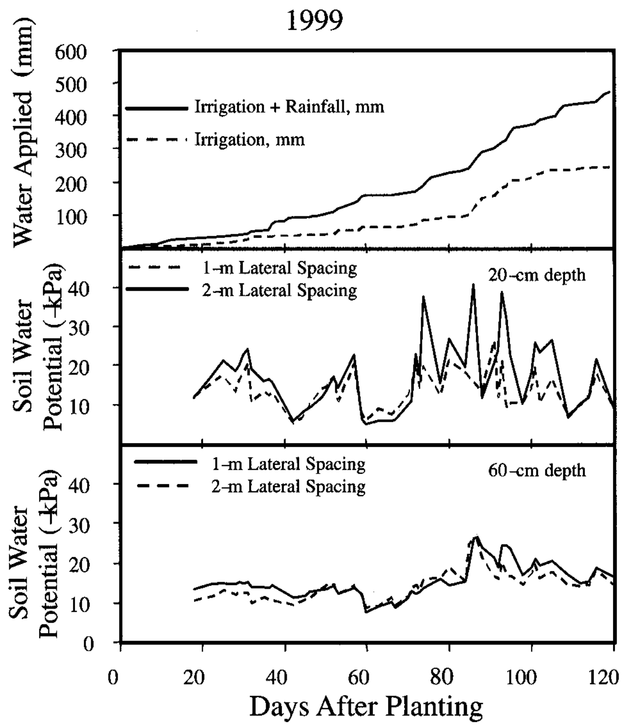


Figure 2. Cumulative water applied to cotton through irrigation and irrigation plus rainfall (top) and in–row soil water potential at the 20–cm depth (middle) and the 60–cm depth (bottom) for the 1–m and 2–m lateral spacings in 1999 near Florence, South Carolina.

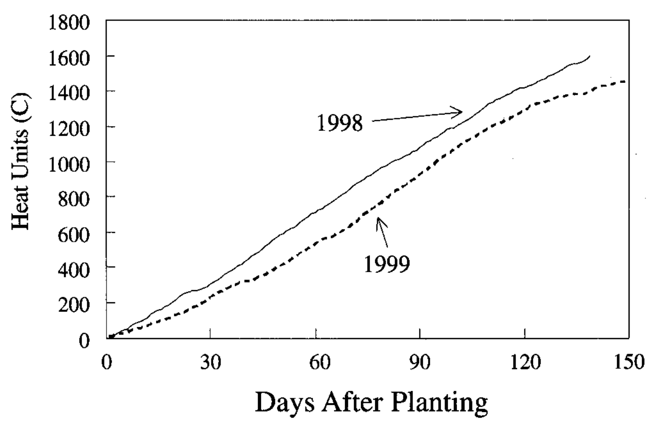


Figure 3. Accumulated heat units (with a base temperature of 15°C) from planting to harvest in 1998 and 1999 near Florence, South Carolina.

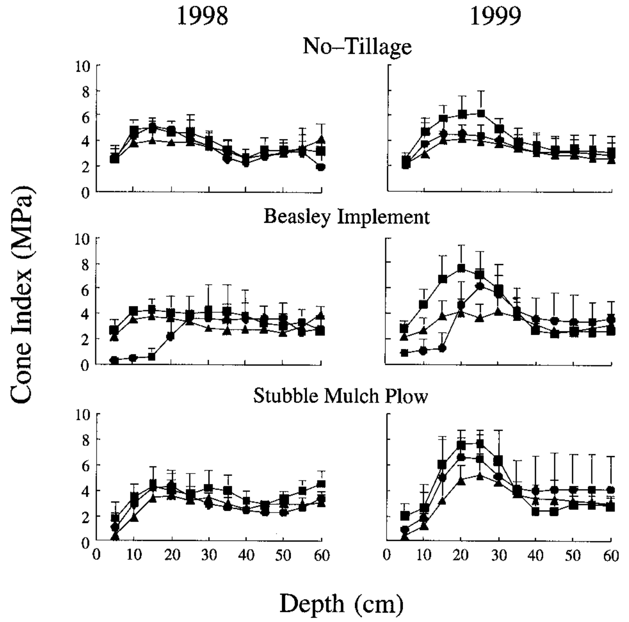


Figure 4. Mean cone index for the three tillage treatments and three row positions in 1998 and 1999. Triangles are data for the non–traffic midrow, circles are data for the in–row position, and squares are data for the traffic midrow. Error bars are the standard deviation of each mean (n = 4).

Soil strength between the 15–cm and 30–cm depths tended to be higher in 1999 than in 1998, but differences were dependent on tillage and row position (fig. 4). For the no–tillage treatment, differences between years only occurred in the traffic midrow. For the Beasley treatment, soil strength was higher at the 15– to 30–cm depths in 1999 than in 1998 for the traffic midrow, and at the in–row position at depths immediately below the area that was tilled (at the 20–cm to 30–cm depths). All three row positions were higher in soil strength in 1999 than in 1998 at the 15–cm to 30–cm depths for the stubble mulch tillage treatment. It is not clear why differences in soil strength occurred between years at these depths. Soil water contents at those depths were slightly lower in 1999 than in 1998 (table 1), which may have contributed to the higher soil strength that year, but the differences in soil water content do not appear to be enough to cause all of the differences between years. Perhaps the differences were due to soil water conditions at the time of tillage and at planting. This appears logical, since most of the differences between years occurred in the traffic midrow or in the areas where tillage was done. Soil strength at this depth for the no–tillage treatment was similar both in the row and in the non–wheel traffic row middle. Beyond the 30–cm depth, there was little difference in soil strength between years, row positions, or tillage treatments (fig. 4).

Tillage had only a small effect on in–row soil water potential (data not shown). In both years, differences between the tillage treatments for soil water potential occurred on only a few days. When differences did occur at the 20–cm depth, the soil water potential of plots where the Beasley implement was used was lower (greater tension) than where the stubble mulch plow or no–tillage was used. Since the tensiometers at that depth were placed near the bottom of the area loosened by the Beasley implement, it is likely that these differences were caused by more of the roots of the cotton plants being near the tensiometers. Soil water potential under the row at the 20–cm depth was very similar for 1–m and 2–m lateral spacing in 1998 (fig. 1). In 1999, soil water potential at that depth under the row of the plots with the 2–m lateral spacing was lower than with the 1–m spacing on a few days (fig. 2). This is not unexpected, as the tensiometers in the 1–m spacing were 10 cm directly above the drip lateral, while in the 2–m spacing, the tensiometers were 10 cm above and 50 cm to the side of the drip lateral. Camp et al. (1999) previously reported lower in–row soil water potential at the 20–cm depth for the 2–m spacing compared to the 1–m spacing.

Only relatively small changes occurred through the season in soil water potential at the 60–cm depth for the 1–m lateral spacing in 1998 (fig. 1). Larger changes occurred for soil water potential at that depth for the 2–m lateral spacing in that year. Differences between the lateral spacings at that depth are again likely due to tube placement, with the tensiometer in the 1–m lateral spacing being 30 cm directly below the drip line, while in the 2–m spacing, the tensiometer was 30 cm below and 50 cm to the side of the lateral. There was little change throughout the season in soil water potential at the 60–cm depth for both lateral spacings in 1999 (fig. 2), the year when spring temperatures were cooler (fig. 3) and early season irrigation need was less.

Neither the differences in soil compaction caused by the tillage treatments nor the differences in water placement by lateral drip spacing had much effect on early season leaf gas exchange (data not shown). Treatments had no effect on leaf photosynthesis at any of the dates that gas exchange measurements were made in either year. Average photosynthetic rates were generally about 20 μmol CO_2 m^{-2} s^{-1}. No differences occurred among treatment combinations for stomatal resistance in either sampling date in 1999. In 1998, the lateral spacing by tillage interaction was significant for stomatal resistance on 13 July. On that date, there were no differences among tillage treatments in the 2–m lateral spacing treatment (mean resistance for the three tillage treat–

Table 1. Gravimetric soil water contents at several depths corresponding to cone index measurements in cotton for different tillage treatments near Florence, South Carolina, in 1998 and 1999. Values are averages (in g/g) of samples collected in the non–traffic midrow and in the row. Values in parentheses are standard deviation of means (n = 8).

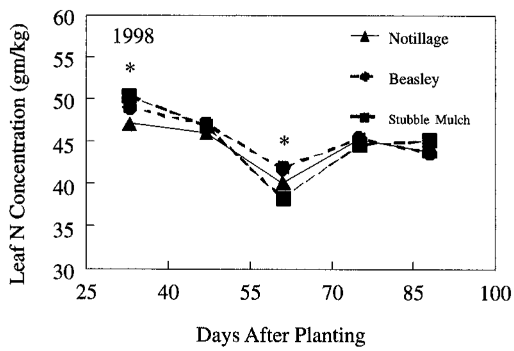
Depth	1998			1999		
(cm)	No tillage	Beasley	Stubble mulch	No tillage	Beasley	Stubble mulch
0–10	0.12 (0.02)	0.12 (0.02)	0.11 (0.02)	0.10 (0.01)	0.09 (0.01)	0.10 (0.01)
10–20	0.10 (0.01)	0.10 (0.02)	0.09 (0.01)	0.09 (0.01)	0.08 (0.01)	0.08 (0.01)
20–30	0.11 (0.02)	0.10 (0.01)	0.10 (0.01)	0.09 (0.02)	0.08 (0.01)	0.09 (0.01)
30–40	0.12 (0.03)	0.11 (0.01)	0.11 (0.02)	0.11 (0.03)	0.09 (0.01)	0.11 (0.00)
40–50	0.14 (0.03)	0.12 (0.02)	0.13 (0.02)	0.13 (0.02)	0.11 (0.02)	0.13 (0.03)
50–60	0.15 (0.02)	0.14 (0.03)	0.15 (0.02)	0.14 (0.02)	0.12 (0.02)	0.14 (0.03)

ments was 7.4 s m^{-1}). In the 1–m lateral spacing treatment, however, stomatal resistance for cotton grown with the Beasley implement was lower than for cotton grown with no tillage. Mean stomatal resistance for the three tillage treatments on 13 July with 1–m lateral spacing was 7.1 s/m, 7.9 s/m, and 7.5 s/m for the Beasley strip tillage, no tillage, and the stubble mulch plow treatments, respectively, and the least significant difference (P = 0.05) was 0.6 s/m. Statistically significant differences also occurred between lateral spacings for leaf resistance on 17 June 1998 (8.1 s/m for the 1–m and 7.4 s/m for the 2–m lateral spacing). Though statistically significant, these small differences between treatment means appear to be of little practical consequence.

At about the same time as the gas exchange measurements were made, uppermost fully expanded leaves were collected for nutrient analysis. Because 45 kg/ha N was applied through the buried laterals about 1 wk after planting, with this sampling scheme we were able to determine if the soil loosening by the tillage implements allowed greater N uptake by the young cotton plants, presumably by allowing less impeded growth of roots to the drip laterals. Leaf N concentrations at 33 days after planting in each year are shown in table 2. In 1998, leaf N concentration increased with increasing soil disturbance at this early sampling date. Leaf N concentration was lowest for no tillage and highest for the stubble mulch treatment. In that year, cotton grown in the 1–m lateral spacing treatment had higher leaf N than cotton grown in the 2–m lateral spacing treatment. In 1999, variation among samples was higher in the experiment compared to 1998 (coefficient of variation was 1.8% in 1998 and 12.8% in 1999), and no significant differences occurred among treatments. However, trends in 1999 for the 1–m lateral spacing were similar to the response in 1998 in that leaf N increased with increased soil disruption. For the 2–m lateral spacing in 1999, although means were not significantly different, cotton from the no–tillage treatment had the highest leaf N, while the cotton grown following tillage with the Beasley implement had the lowest leaf N.

For all later sampling dates (>33 days), the tillage and lateral spacing treatments had little effect on leaf N concentration. At about 60 days after planting in both years, leaf N concentration was greater for the cotton grown following tillage with the Beasley implement than for cotton grown in the other two tillage treatments (fig. 5). Otherwise, there was little impact of tillage or lateral spacing on leaf N concentrations.

Average concentrations of the other plant nutrients for the three tillage treatments at 33 days after planting are shown in table 3. Tillage effects on leaf concentrations of Ca, Mg, and Fe were similar to those for concentrations of N. In 1998,



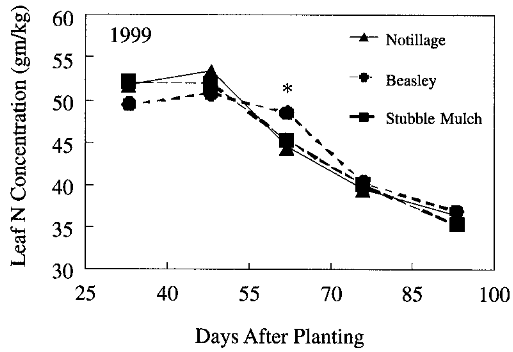


Figure 5. Leaf N concentration in uppermost fully expanded cotton leaves throughout the 1998 and 1999 growing seasons as affected by tillage method. Asterisks indicate dates when significant differences (P < 0.05) occurred among treatments. In 1998, the LSD (0.05) at 33 days after planting (DAP) is 0.9 gm/kg and the LSD at 60 DAP is 1.5 gm/kg. In 1999, the LSD at 61 DAP is 3.0 gm/kg.

concentrations of these nutrients increased with more soil disturbance, while in 1999 there was no difference among treatments. At the second sampling date (47 days after planting in 1998, and 48 days after planting in 1999), there was no difference among tillage treatments for nutrient concentration (data not shown). For nutrients other than N, lateral spacing of the drip tubes had no effect on leaf nutrient concentrations in 1998 at either sampling date. At 33 days after planting in 1999, cotton leaves from the 2–m lateral spacing treatment had significantly higher levels of K (23.6 vs. 18.9 g/kg), S (4.6 vs. 3.4 g/kg) and Fe (85 mg/kg vs. 74 mg/kg) than did the 1–m spacing. By 48 days after planting in that year, S was the only nutrient that remained higher in the 2–m lateral spacing treatment (8.1 g/kg for the 2–m spacing vs. 6.6 g/kg for the 1–m spacing). Even though there were

Table 2. Effect of tillage and spacing of subsurface drip laterals on cotton uppermost fully expanded leaf blade N concentration (in g N kg^{-1}) at 33 days after planting in 1998 and 1999 near Florence, South Carolina.

Tillage	1998			1999		
	1–m spacing	2–m spacing	Mean	1–m spacing	2–m spacing	Mean
No tillage	47.6	46.7	47.1[b]	52.0[c]	51.5	51.7
Beasley	49.7	48.3	49.0	52.7	46.3	49.5
Stubble mulch	50.7	50.1	50.4	55.5	48.8	52.2
Mean	49.3[a]	48.3		53.4	48.9	

[a] Indicates lateral spacing means differed at P ≤ 0.05.
[b] LSD (0.05) for comparing tillage means averaged over irrigation lateral treatments is 0.9 g N kg^{-1}.
[c] No sources of variation from ANOVA (lateral spacing, tillage, or interaction) were significant (P ≤ 0.05) in 1999.

Table 3. Effect of tillage on uppermost fully expanded leaf blade nutrient concentrations, averaged over lateral spacing treatments, at 33 days after planting in 1998 and 1999 near Florence, South Carolina.

Year	Tillage	P	K	Ca	Mg	S	Mn	Fe	B	Cu	Zn
		(Values in g/kg)					(Values in mg/kg)				
1998	No tillage	3.6	22.9	23.5	5.4	4.9	56.8	78.9	53.1	8.9	30.5
	Beasley	3.6	21.4	25.5	5.9	4.9	55.6	88.6	49.6	8.8	31.6
	Stubble mulch	3.4	21.4	27.2	6.3	5.0	53.3	103.9	49	8.6	29.9
	LSD (0.05)	ns	ns	1.9	0.4	ns	ns	13.3	ns	ns	ns
1999	No tillage	4.5	21.7	34.8	6.7	4.3	101	76	61.4	8.3	34.3
	Beasley	4.1	20.8	32.2	6.0	3.9	102	80	68.9	7.4	34.0
	Stubble mulch	4.2	21.4	36.6	6.6	4.0	88	83	58.9	7.7	34.1
	LSD (0.05)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

differences among treatments for nutrient concentrations, all concentrations were above deficiency levels at all sampling times each year (Roof et al., 1994). Similarly, Arvidsson (1999) studied the effect of surface compaction on barley (*Hordeum vulgare* L.) and found that severe compaction reduced the concentration of some nutrients in plant tissues, but amounts in the tissues were rarely low enough to be considered deficient.

The two different years produced substantially different yields and physical properties of the crop (table 4). The cooler season (fig. 3) was probably the most important reason that average yield in 1999 (700 kg/ha) was only about 60% of the yield of 1998 (1215 kg/ha). Overall, cotton fiber in 1998 was longer, stronger, and finer than the fiber in 1999. There were two check plots in each replicate that did not receive irrigation, but since the objective of this work was to evaluate tillage methods for subsurface drip systems, they were not included in the analysis of data. Unlike the previous conservation tillage study at this site (Camp et al., 1999), irrigation increased lint yield in both years, with rainfed yield being 855 kg/ha in 1998 and 385 kg/ha in 1999.

Like the majority of the early season physiological data in this study, there was no difference among tillage or lateral spacing treatments for lint yield in either year (table 3). Similarly, fiber length and micronaire were not influenced by the treatments. A lateral spacing × tillage interaction occurred for fiber strength both years, but the nature of the interaction in 1998 was different from that of 1999. In 1998, fiber strength of cotton grown following tillage with the stubble mulch plow was lower than that of cotton grown following tillage with the Beasley implement, but only in the 2–m lateral drip spacing. On the other hand, in 1999, differences among tillage treatments occurred only in the 1–m lateral spacing, as cotton grown with no tillage had higher fiber strength than cotton grown following in–row tillage with the Beasley implement (table 4). Even though they are statistically significant, the practical significance of these fiber strength differences is small.

Conclusions

The practicability of conservation tillage production of crops, especially no tillage, has been questioned in recent years because of suspected yield limitations caused by compaction. Our results suggest that when using subsurface drip irrigation with laterals buried 30 cm below the surface, lowering soil strength by shallow tillage, either directly in the row or across the entire surface horizon, does not improve the early–season physiological status, yield, or fiber properties of cotton. Early–season leaf gas exchange, plant nutrient status, and yield and quality were not improved by limited surface tillage that reduced soil strength. Yield levels in this and in the previous conservation tillage study (Camp et al., 1999) at this site were representative of irrigated cotton yields in this region, but were not high. The results from this study indicate that neither water nor nutrient–deficit stress are the cause for the moderate yields. Thus, it appears that other management or environmental limitations need to be identified and overcome to improve irrigated cotton yield potential in the humid southeast.

Table 4. Effect of lateral spacing and tillage on cotton lint yield and selected fiber properties in 1998 and 1999 near Florence, South Carolina.

Lateral Spacing	Tillage	Lint Yield (kg/ha)		Fiber Length (mm)		Fiber Strength (kN m kg^{-1})		Micronaire units	
		1998	1999	1998	1999	1998	1999	1998	1999
1–m	No tillage	1173	801	28.1	27.2	295	282	3.7	4.4
	Beasley	1296	636	28.9	27.1	292	271	3.7	4.3
	Stubble mulch	1217	638	29.1	27.3	298	275	3.7	4.7
2–m	None	1208	670	28.6	27.4	305	276	3.8	4.4
	Beasley	1283	698	28.8	27.4	319	279	3.8	4.2
	Stubble mulch	1117	759	28.4	27.0	292	281	3.7	4.3
LSD (0.05)		ns	ns	ns	ns	16	8	ns	ns

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