# ALLEVIATION OF COMPACTION IN A MICROIRRIGATED COASTAL SOIL

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## ABSTRACT

**Compaction became so severe in a microirrigated loamy sand Aquic Hapludult soil that root limiting values of soil cone index occurred in both the A horizon and the genetic hardpan below it. Surface and deep tillage systems were evaluated for their ability to alleviate compaction. Surface tillage included disking, chiseling plus disking, or none; deep tillage included subsoiling or none. Chiseling and subsoiling were located in row or between rows to avoid laterals that were buried under every other mid-row or every row. Cotton (*Gossypium hirsutum*) was planted in 38-in wide rows. Irrigation improved yield because both 2001 and 2002 were dry years. Tillage tools loosened the soil but compacted zones remained between subsoiled and chiseled areas. Subsoiling improved yield when it was performed in row where laterals were placed in the mid rows; but it did not improve yield when it was performed in mid rows where laterals were placed in the rows. Under this management system, it was just as productive and less expensive to install laterals in every other mid row than every row.**

## INTRODUCTION

In the southeastern Coastal Plains, three factors combine to cause severe water stress and limit yield: sandy soils with low water holding capacity, short periods of drought, and shallow subsurface hard, structureless root-restricting layers. The shallow subsurface hard layer can restrict roots to the surface Ap horizon (Busscher *et al.,* 1986). Sandy soil above the layer may hold only 1 in of water per foot. At peak bloom, cotton can use up to 0.4 in per day. Crops that are not able to root into the subsoil often do not have enough water to sustain plant growth for the frequent 5 to 20 day droughts that occur seasonally (Sadler and Camp, 1986).

Producers commonly increase access to the soil water supply for plants by subsoiling. Subsoiling loosens the soil down to horizons that have structure and a greater water holding capacity, both of which can encourage root growth. However, subsoiling is expensive because it requires large tractors (18-27 hp per deep tillage shank), 2 to 3 gal of fuel per acre, and 10 to 20 minutes of labor per acre (Karlen *et al.* 1991). Less expensive and more permanent, alternative solutions are desirable.

Irrigation from buried microirrigation laterals have been studied for a number of crops in the southeastern Coastal Plains (Camp *et al*., 1998). However, soils above the laterals have consolidated into hard soils when no tillage was used, probably as a result of settling and traffic when laterals remain buried for several years (Camp *et al.,* 1999).

We hypothesized that disruption of the soil by subsoiling between buried microirrigation tubes or disking above the tubes would loosen soil and permit better root growth and increase yield.

## MATERIALS AND METHODS

This study was conducted in 2001 and 2002 on Eunola sandy loam (fine-loamy siliceous, thermic Aeric Hapludult) at the Pee Dee Research Center near Florence, SC. The experimental design was randomized complete block of sixteen 25 by 50 ft plots in each of four replicates. Twelve of the sixteen plots were irrigated with buried microirrigation laterals (Geoflow Rootguard[1]). Laterals had in-line labyrinth emitters 2 ft apart that delivered 0.45 gal $hr^{-1}$ of water. Six plots had laterals buried under each of eight rows at 38-in spacings (IR). Six plots had laterals buried under alternate mid rows at 76-in spacings (MR). Laterals were buried at one-foot depths. Four plots had no irrigation.

Treatments imposed on each plot were subsoiling to a depth of about 1 ft and not subsoiling. Irrigated subsoiled and not-subsoiled treatments were also disked to a depth of about 6 in, chiseled to a depth of 8 in, or not tilled. Non-irrigated subsoiled and not-subsoiled treatments were also chiseled or not tilled. Non-irrigated treatments were not disked. The experiment had been set up in 1991 with a set number of plots and could not be modified.

The recommended practice for this soil includes in-row subsoiling each year. Because of the buried laterals, in-row subsoiling was not feasible in all plots. In 1991, prior to installation of the laterals, all plots had been cross-subsoiled in the direction of the rows and perpendicular to the rows (Camp *et al.,* 1999). In 2001 and 2002, plots with laterals buried below each row were subsoiled in the mid-rows and plots with laterals buried in every other mid-row were subsoiled in every row.

The tillage equipment included: a 15-ft wide John Deere disk (Deere Inc., Moline, IL, USA) in 2001 or Case-IH disk (Case-IH, Racine, WI, USA) in 2002; a KMC (Kelley Manufacturing Co., Tifton, GA, USA) straight 45 degree forward angled subsoiler; and a 7-ft wide seven shank chisel.

Plots were planted to cotton (var DP 458BRR) in summer and flax (*Linum usitatissium* var Laura) in winter. Cotton was planted in 38-in wide rows at 4 plants per foot on 4 June 2001 and 15 May 2002 using a four-row Case-IH 900 series planter equipped with Yetter wavy coulters. Flax was drilled as a winter cover at 100 lbs $a^{-1}$ using a John Deere 750 no-till grain drill. Flax fiber was removed from the plots.

Soil strength measurements were taken in the cotton plots after tillage. Because of the buried irrigation laterals, soil strength data could not be collected at positions in the row for some plots and in the mid row for others. Soil strength, cone index, data were taken with a 0.5-in-diameter cone-tipped penetrometer on 6 June 2001 and 20, 21 May 2002. Cone index data were digitized into the computer at 2-in depth intervals and log transformed before analysis according to the recommendation of Cassel and Nelson (1979).

Gravimetric soil water content samples were taken along with cone indices. They were taken at the first and fifth positions of cone index readings. Since tubes were buried at the first and fifth positions for the MR and IR treatments respectively, samples were taken at either the second or fourth positions respectively in these treatments. Water contents were measured at 4-in depth intervals to the 24-in depth. These water contents were taken as representative of the water contents of the plot.

In mid to late October, cotton was chemically defoliated. On 7 November 2001 and 28 October 2002, seed cotton yield was harvested from the two interior rows using a two-row spindle picker and bagged. Each harvest bag was subsampled; the subsample was saw-ginned to determine lint percent. Lint percentage was multiplied by seed cotton yield to calculate lint yield.

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[2]Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

Cone index, water content, and yield data were analyzed using the ANOVA and the least square mean separation procedures (SAS Institute, 1990). Cone index and water content data were analyzed using a split-split plot randomized complete block design where the first split was position across the row and the second depth. Data were tested for significance at the 5%.

## RESULTS AND DISCUSSION

### Soil Water Content

Differences in water contents can significantly affect cone index readings, masking strength differences in treatments. To avoid this, we took cone index measurements before irrigation began.

### Soil Strength

Cone indices were analyzed separately for irrigated and non-irrigated treatments because non-irrigated did not have a disked treatment, which had been studied previously (Busscher et al., 2001). Additionally, since the non-irrigated treatment had no buried tube, the treatment lent itself to a more traditional annual-subsoiling management system over the years.

For the irrigated treatments: Since mean soil strengths for the two years (23.1 ATM in 2001 and 22.3 ATM in 2002) were not significantly different and no interactions with years were significant, data for both years were analyzed together.

Cone indices for irrigation tube placements were not significantly different because the two had the same treatments. Cone indices differed by depth and position across the row because different tillage treatments disrupted soil to different depths and at different positions across the row to avoid buried laterals. Cone indices also differed with position as a result of higher values caused by wheel traffic seen at the right side of the contour plots (e.g. positions 28 and 38 in as seen in Fig. 1).

Cone indices differed among surface tillage treatments, subsoiling treatments, and their interaction (Table 1). Cone indices were significantly reduced by subsoiling in the disked and no surface tillage treatments, but not in the chiseled treatments. Subsoiling the disked and no surface tillage treatments reduced high soil strength caused by the tillage pan or the genetic pan (Fig. 1). Cone indices of the chiseled treatments that were also subsoiled were lower than the chiseled only treatments; however, these differences were not statistically significant probably because chiseling and subsoiling were performed at the same position in each plot and at depths that differed by only 4 in. This was also observed in the non-irrigated treatments (Fig. 2).

For the non-irrigated treatments: Cone indices differed significantly by year at 24.8 MPa for 2001 and 29.0 MPa for 2002. Though cone indices differed in magnitude between years, there were no significant interactions between year and any treatment; so data for the two years were analyzed together.

Cone indices (Table 1) differed for the subsoiled treatments, the chiseled treatments, and for the interaction of the two. Cone indices were lower for treatments that were chiseled or subsoiled vs. those that were not. Chiseled treatments had a shallower, wider zone of disruption (Fig. 2) compared to subsoiling. The non-tilled treatment still had remnants of previous deep tillage (Fig. 2) that may have been enough to provide adequate root growth (Busscher et al., 2003) unlike the irrigated treatments where the laterals prevented deep tillage on a regular basis (Fig. 1).

**Yield**

Irrigated treatments: For the MR lateral placement, yield improved with subsoiling regardless of surface tillage; for the IR lateral placement, yield of subsoiled treatments did not differ (Table 2, Fig. 3).

Non-irrigated treatments: Rainfall affected yield; it was lower than normal (47 in $y^{-1}$) both years but especially low in 2002 (Fig. 4). As a result, yields were lower for non-irrigated than for irrigated treatments with irrigated cotton lint yield averaging 911 lbs $a^{-1}$ and non-irrigated yield averaging 433 lbs $a^{-1}$. Yields for the non-irrigated treatments averaged 543 lbs $a^{-1}$ for 2001 and 314 lbs $a^{-1}$ for 2002. Non-irrigated yields were unaffected by subsoiling or chiseling. Since non-irrigated plots did not have buried tubes, the were more suited to conventional management; even the plots that were not subsoiled for this study had been subsoiled within the past 2 to 3 years for a previous experiment in these plots. The lack of difference among treatments supports the conclusions of Busscher et al. (2003) that subsoiling is not needed every year for in-row subsoiled cotton grown in conventional row widths and using controlled traffic.

## CONCLUSIONS

For the non-irrigated treatments, subsoiling was not effective because even the non-subsoiled treatments had lower strengths from in-row deep tillage in previous years.

For the irrigated treatments, when micro irrigation tubes were buried under the rows, tillage decreased soil strengths in the mid rows; and when tubes were buried under every other mid row, tillage decreased strength in the rows.

When laterals were buried under mid rows, subsoiling improved yield because it softened the soil where roots have to grow to get to the water source. When laterals were buried under rows, subsoiling did not affect yield because roots did not have to grow through it to get to the water.

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Table 1. Mean profile cone indices in atmospheres for irrigated and non-irrigated treatments (treatments with and without buried laterals) averaged over years 2001 and 2002 before irrigation started.

| | Irrigated | | | Non-irrigated | | |
|---|---|---|---|---|---|---|
| Tillage | Subsoiled | Non-subsoiled | Mean | Subsoiled | Non-subsoiled | Mean |
| | ---------------------------------- ATM ---------------------------------- | | | | | |
| Chisel | 19.5c* | 21.5c | 20.5c** | 21.0c* | 22.0c | 21.5b** |
| Disk | 20.4c | 25.5b | 22.8b | -- | -- | -- |
| None | 20.9c | 30.8a | 25.2a | 27.4b | 34.5a | 30.8a |
| Mean | 20.2b** | 25.6a | | 24.0b** | 28.0a | |

* Means for the interaction of surface tillage with subsoiling with the same letter are not significantly different for lsd mean separation procedure at 5%.
** Means within columns or rows with the same letter are not significantly different for lsd mean separation procedure at 5%.

Table 2. Lint yield of different lateral spacings and subsoiling.

| Spacing | Subsoiling | Yield |
|---|---|---|
| | | lbs $a^{-1}$ |
| Alternate mid row | Yes | 967a* |
| Alternate mid row | No | 850b |
| In row | Yes | 881ab |
| In row | No | 948ab |

* Means within the column with the same letter are not significantly different for lsd mean separation procedure at 5%.

Figure 1. Profile cone indices for irrigated treatments averaged over both years and four replicates. Data were adjusted to center the zone of deepest tillage in the contour plots because it was performed in the row or mid-row to avoid buried irrigation tubes.

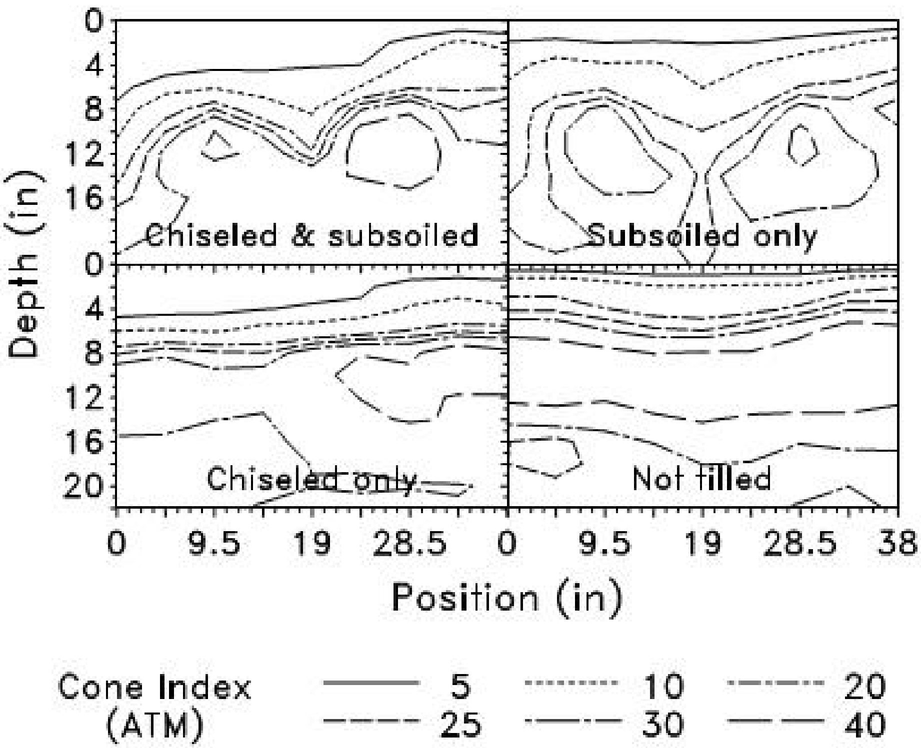

Figure 2. Profile cone indices for non-irrigated treatments averaged over both years and four replicates.

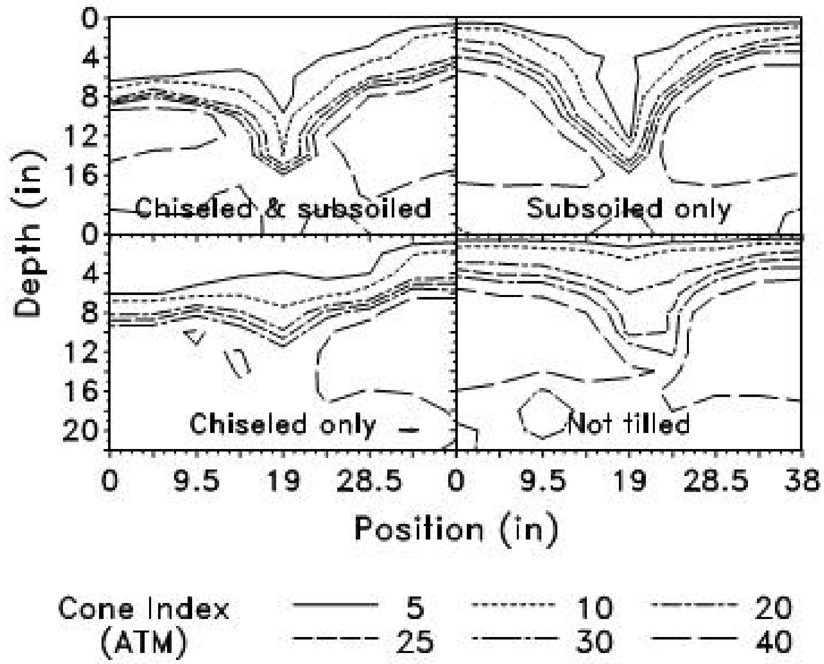

Figure 3. Profile cone indices for subsoiled or non-subsoiled treatments where laterals are placed in alternate mid rows (MR) or in every row (IR).

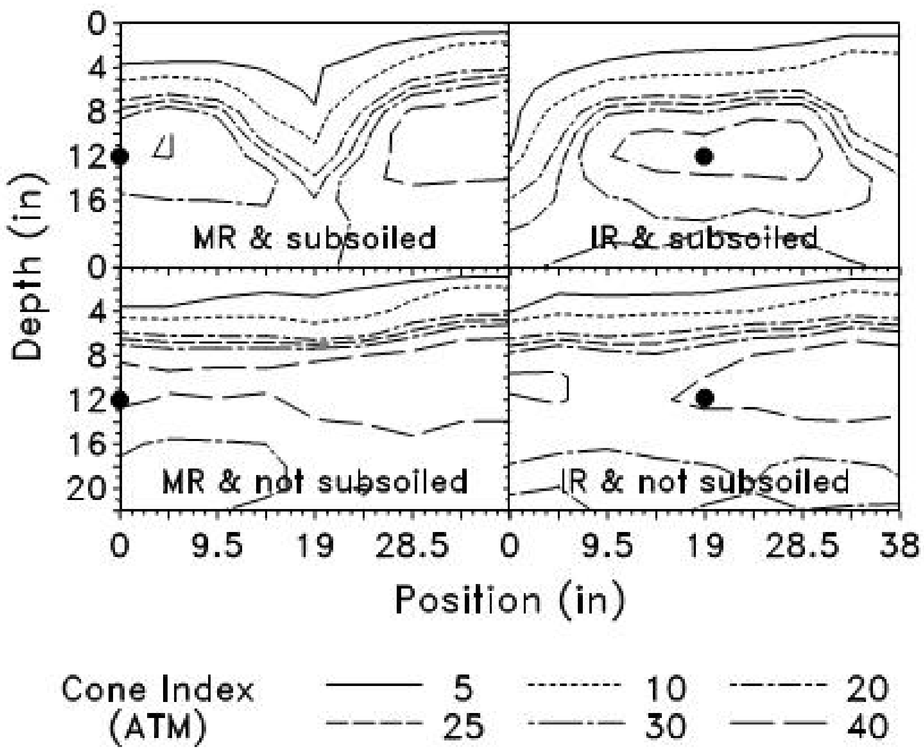

Figure 4. Cumulative rainfall for 2001 and 2002. Both years were dryer than the mean 30 year umulative annual rainfall of 47 in http://www.weather.com/weather/climatology/monthly/29501)