SUBSURFACE DRIP IRRIGATION AND CONSERVATION TILLAGE METHODS FOR COTTON ON A SOIL WITH COMPACTED LAYERS

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Abstract

Subsurface drip irrigation offers many advantages for management of water and nutrients, but its effectiveness may be limited by weather or soil conditions. Solving soil problems, such as compaction, in subsurface drip irrigation systems is understandably difficult using deep tillage. In a previous experiment with cotton under no-tillage culture and subsurface drip irrigation, there was no yield difference in either of two years for two irrigation drip line spacings (38 and 76 in.), three irrigation amounts (1/4, 3/8, and 1/2 in. per application), or between irrigated and rainfed treatments. Cotton root observations and soil strength measurements during that experiment indicated that considerable soil compaction occurred at very shallow soil depths (< 2 in.), which restricted root growth, and probably limited the efficacy of subsurface drip irrigation (12 in. deep).

With the objectives of developing strategies to reduce soil strength and obtaining optimum no-tillage crop production, an experiment was conducted during 1998-99 to determine the effectiveness of shallow minimum tillage in reducing shallow soil compaction and increasing cotton lint yield with subsurface drip irrigation at two lateral spacings (38 and 76 in.). Three tillage treatments included two shallow (6 in.) tillage methods, an in-row subsoiler (Beasley) and a stubble mulch plow, and the standard no-tillage, which had no tillage, surface or subsurface. There were no differences in cotton lint yield among the three tillage methods or between the two subsurface drip lateral spacings. Mean lint yield for the irrigated treatments across the two years was greater than that for the rainfed treatments. Lint yields in 1999 were much less for all treatments than in 1998, probably because of cool spring temperatures. Soil strength measurements in both years reflected only slight differences among the tillage treatments and were similar for the two years. These results indicate that these two shallow tillage methods were not effective in improving irrigation water distribution to the shallow root zone or in increasing cotton lint yield. Consequently, it appears that strategies to reduce soil strength must be developed before optimum no-tillage crop production can be obtained on these soils with subsurface drip irrigation.

REDUCING SOIL COMPACTION OF TENNESSEE VALLEY SOILS IN CONSERVATION TILLAGE SYSTEMS

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Abstract

Inadequate rooting systems from excessive soil compaction have prevented farmers in the Tennessee Valley Region of North Alabama from adopting conservation tillage systems. Cotton (*Gossypium hirsutum* L.) yields declined on many farms when conventional tillage systems were not used and strict no-till systems were adopted. Experiments were initiated in 1994 to develop conservation tillage systems that incorporated in-row tillage and rye (*Secale cereale* L.) cover crops as methods of maintaining surface cover and alleviating extreme soil compaction conditions. Depth of in-row tillage (7" or 13") and timing of tillage (fall or spring) were factors also investigated for this experiment. Cone index measurements taken in the spring and fall of 1997 prior to tillage and bulk density measurements taken in fall of 1998 immediately after harvest were used to examine changes in soil condition resulting from several years of experimentation. The results showed reduced cone index and bulk density from either shallow or deep in-row tillage performed in the spring or fall of the year. Although fall measurements in no-till plots showed no effect of cover crops, spring measurements of cone index were found to be reduced substantially by the use of cover crops, most likely due to increased soil moisture. Therefore, reduced soil compaction beneath the row to depths adequate to sustain proper root growth was achieved by either shallow in-row tillage and/or cover crops.

Introduction

Switching from conventional tillage systems to conservation tillage systems is not always easy nor profitable in the short-term. This transition can be especially difficult when the soils are extremely degraded from more than 100 years of annual moldboard plowing and the resulting soil erosion. Reports of producers in the Tennessee Valley Region of North Alabama having reduced cotton yields when they adopted conservation tillage systems prompted USDA-NRCS (Natural Resource Conservation Service) to request that USDA-ARS (Agricultural Research Service) perform research to assist farmers with this transition. The traditional methods of tillage which did not promote surface residue retention included moldboard plowing, chisel plowing, and disking. Increasing adoption of conservation tillage systems were an important component of reducing soil erosion through reducing soil disturbance and maintaining adequate amounts of surface residue.

Upon preliminary investigations, it was found that the soil which had recently been converted to strict no-till systems exhibited considerable soil strength at relatively shallow depths. Many cotton tap roots were found in these no-till fields which were in the shape of a 'J' at depths of less than 6 inches. We hypothesized that extreme soil compaction was responsible for this rooting problem as a result of being degraded and compacted by long-term moldboard plowing and erosion. We determined that a systems approach including factors of tillage timing, tillage depth, and cover crops would be the most logical research to solve the problem.

The objectives of the research reported in this paper were to assess if reductions in soil strength, as measured by cone index and bulk density over an extended period, occurred due to the use of conservation tillage systems.

Materials and Methods

The experiment was begun in the fall of 1994 with fall tillage being applied at the Alabama Agricultural Experiment Station's Tennessee Valley Substation in Belle Mina, AL. The soil type in this region is predominantly a Decatur silt loam (clayey, kaolinitic, thermic Rhodic Paleudult). Prior to this tillage, the field had been conventionally tilled for cotton production for many years.

The plots are four 40-inch rows wide by 30 ft. long. The experimental design was a randomized complete block with a 2x2x2 factorial arrangement of treatments augmented with three additional control treatments of 1) no-tillage with no cover crop, 2) no-tillage with a cover crop, and 3) conventional tillage with no cover crop. The three factors are: 1) cover crop (none or rye), 2) tillage timing (fall or spring), and 3) tillage depth (shallow or deep). To determine the depth of tillage, multiple cone-index profiles were obtained in plots that had been used to grow conventionally tilled cotton and that were going to be used for our experiment. These measurements showed that the depth of the compacted soil layer began at approximately 6 inches. The shallow depth of tillage was therefore chosen as 7 inches and the deep depth of tillage was set to be at 13 inches. An experimental Yetter™ implement with in-row subsoilers that could be adjusted to operate at both shallow and deep depths was used for all tillage treatments. Fingered wheels and fluted coulters were used to move residue away from the shanks. A small bedded region approximately 12 inches wide and 4 inches high was created by closing disks mounted on the rear of the shank. The conventional tillage treatment consisted of fall disking and chiseling followed by disking and field cultivating in the spring prior to planting.

Soil strength and soil moisture measurements were taken both spring and fall immediately before and after tillage treatments were applied. Soil strength was determined by using a tractor-mounted multiple-cone penetrometer (Raper et al., 1999) and then calculating the cone index (ASAE, 1999a; ASAE, 1999b). Five penetrometer probes were inserted 1) in the row, 2) midway between the row and the untrafficked row middle (10 inches from the row), 3) in the untrafficked row middle (20 inches from the row), 4) midway between the row and the trafficked row middle (10 inches from the row), and 5) in the trafficked row middle (20 inches from the row). Soil moisture was determined gravimetrically at shallow (0-6 inches) and deep (6-12 inches) depths. The same soil sampling unit was used to obtain measurements of bulk density at 2-inch depth increments in the row following harvest of the 1998 crop.

The factorial arrangement of eight treatments within the randomized complete block was analyzed with an appropriate ANOVA model using SAS. The augmented control treatments effects were also separated using single degree of freedom contrasts. A predetermined significance level of $P \leq 0.10$ was chosen to separate treatment effects.

Results and Discussion

Contour plots (Figures 1, 2, 3, 4, and 5) were constructed from the cone index profiles obtained with the multiple-probe soil cone penetrometer. Profiles measured in spring of 1997 in the no-till plots without cover crops (Figure 1A) showed somewhat increased values of cone index as compared the profiles measured in the fall of 1997 (Figure 1B). This was most likely due to differences in soil moisture with values of 17.0% and 20.4 % being measured in the spring of 1997 at 0-6" and 6-12", respectively, and 20.3 % and 19.7% at 0-6" and 6-12" being measured in the fall of 1997.

More similar values of moisture content were measured in the no-till plots with a cover crop with values of 19.4% and 20.5% being measured at 0-6" and 6-12", respectively, in the spring of 1997 and 20.5% and 20.0% being measured in the fall of 1997. Comparing these graphs from the no-till with a cover crop (Figure 2) showed a lack of a compacted zone extending across the row in the spring of the year. Also, comparing Figures 1A with 2A and Figures 1B with 2B showed that a cover crop tended to reduce cone index values in the spring, particularly, but had little positive effect by fall. This result was found even stronger in crop yield data which showed significant benefits of cover crops in three of four years (Raper et al., 1998).

The benefits of shallow tillage conducted in fall of 1996 is illustrated in cone index profiles measured in spring of 1997 (Figure 3A) and fall of 1997 (Figure 3B). Note that the compacted zone directly beneath the row has been reduced by the tillage process. Any increased consolidation that may have taken place over the summer months is probably not visible due to the increased soil moisture contents in these plots in the fall of 1997 (17.0% and 19.5% for 0-6" and 6-12" depths in spring of 1997 vs. 21.2% and 21.2% for 0-6" and 6-12" depths in fall of 1997).

Deep tillage conducted in fall of 1996 showed similar trends as shallow tillage in cone index profiles measured in spring of 1997 (Figure 4A) and fall of 1997 (Figure 4B). The moisture contents for these plots were also reduced in the spring of the year with 17.2% and 19.2% at 0-6" and 6-12" depths being measured as compared with 21.7% and 21.3% being measured in fall of 1997.

When shallow tillage was conducted in spring 1997, cone index profiles taken immediately after (Figure 5A) and those taken in fall of 1997 showed significant consolidation (Figure 5B) having taken place over the summer months. These results were somewhat contrary to the soil moisture measurements, which showed 16.8% and 19.2% at 0-6" and 6-12" depths in spring of 1997 and 21.3% and 20.4% at 0-6" and 6-12" depths in fall of 1997. Also, some improvements in cone index values were visible with spring 1997 shallow tillage (Figure 5B) having reduced values as compared to fall 1996 shallow tillage (Figure 4B). These results are reasonable with the most recent tillage event having the least opportunity to consolidate.

A factorial analysis of bulk density measurements showed some significant main effects within the tillage depth range (Table 1). Timing of tillage treatments was found to be significant at the 0-2, 4-6, and 8-10" ranges, with spring tillage having reduced values of bulk density (Figure 6). This result was reasonable, because the most recent tillage event would have been spring tillage and the soil could have consolidated from the previous fall's tillage. Significant depth of tillage effects were also found in the 4-6, 6-8, and 8-10" depth ranges due to the different depths of tillage applied. Also, small differences in bulk density could be attributed to cover crops, with only one depth (10-12") indicating significant treatment effects.

The highest values of bulk density near the surface were found in the no-till plots, with the effect of the cover crop increasing bulk density in these plots (Figure 6). As mentioned previously from the statistical comparison, clear benefits of spring tillage were seen in this figure, with significant consolidation resulting from the previous fall's tillage practice. Differences were also seen in the depth range of 6-12" between shallow and deep tillage conducted either in spring or fall.

These results illustrate the shortcomings of using bulk density solely as a method of determining optimum growing conditions for plants. Obvious differences due to tillage timing or tillage depths were found, but no significant benefits of cover crops were found using bulk density measurements. Measurements of cone index also did not show improved soil condition for cover crops in fall of 1997, however improvements were were seen in spring of 1997. These results were contrary to a large cover crop effect found almost every year of the experiment, with its presence improving cotton yields significantly (Raper et al., 1998). One explanation may be that cover crops increase infiltration and reduce evaporation during winter months. The resulting soil condition has increased soil moisture, decreased soil strength, and leads to increased yields.

Summary

Investigations were conducted to determine optimum procedures for creating a seedbed to enhance rooting with conservation tillage components. Soil strength was found to be reduced by in-row tillage performed either in fall or spring, at either shallow (7") or deep (13") depths. Reduced values of cone index and bulk density were found from the more recent spring tillage as compared to fall tillage performed almost 12 months prior. Cover crops were found to be effective in reducing soil strength in spring due to increased soil moisture. By fall, however, no differences could be seen in cone index profiles or bulk density measurements from no-till plots with or without a cover crop.

Disclaimer

The use of companies, tradenames, or company names does not imply endorsement by USDA-ARS or Auburn University.

References

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Table 1. Significance levels of treatments for bulk density measurements. (Shaded areas indicate statistical significance at the 0.10 level.)

Depth (in.)	C*	T	D	CxT	CxD	DxT	CxTxD
0-2	0.58	**0.08**	0.54	0.31	0.88	0.60	0.22
2-4	0.37	0.31	0.99	**0.09**	0.75	0.16	0.80
4-6	0.36	**0.00**	**0.10**	0.32	**0.03**	**0.01**	0.68
6-8	0.46	0.43	**0.00**	0.58	0.63	0.25	0.76
8-10	0.56	**0.03**	**0.00**	0.86	0.78	0.12	0.96
10-12	**0.09**	0.65	0.26	0.88	0.15	**0.08**	0.45
12-14	0.87	0.59	0.87	0.99	0.61	0.73	0.60

*C - cover crop effect
T - tillage timing effect
D - tillage depth effect

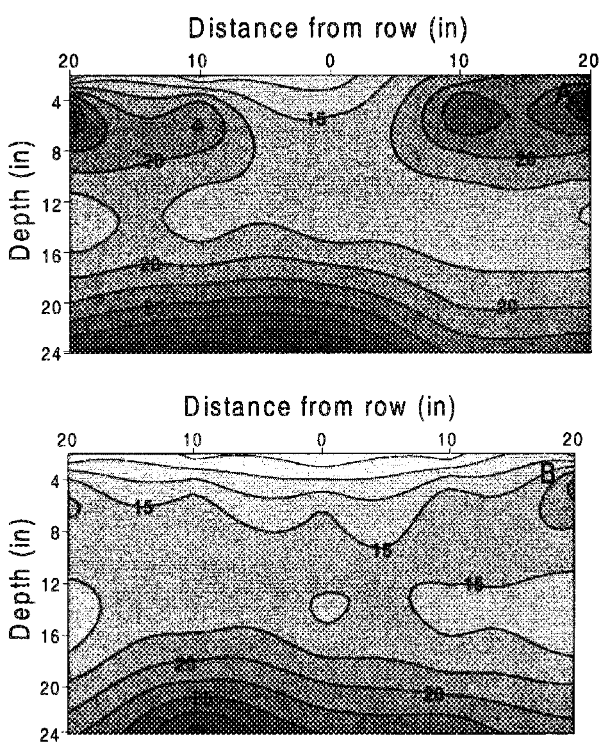

Figure 1. Cone index iso-lines(bars) for no-till plots with no cover crops with the top figure(A) obtained in spring 1997 and the bottom figure(B) obtained in fall 1997.

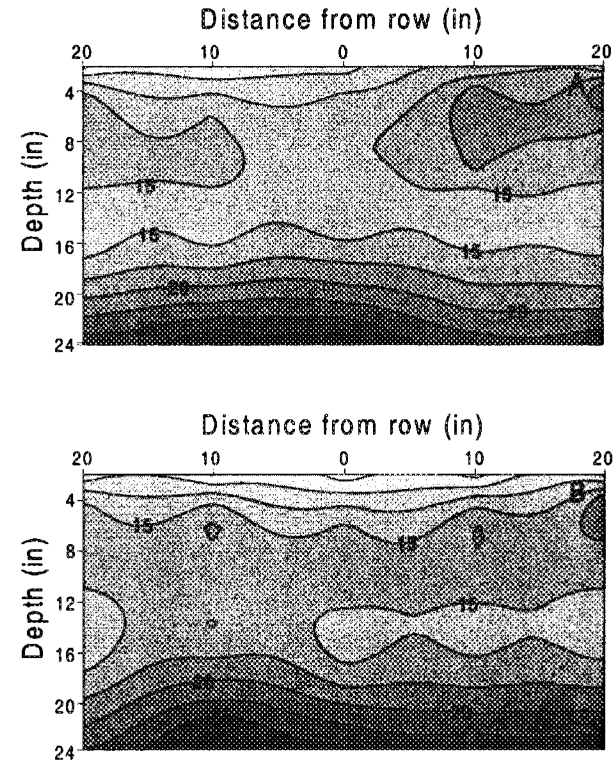

Figure 2. Cone index iso-lines(bars) for no-till plots with cover crops with top figure(A) obtaines in spring 1997 and the bottom figure(B) obtained in fall 1997.

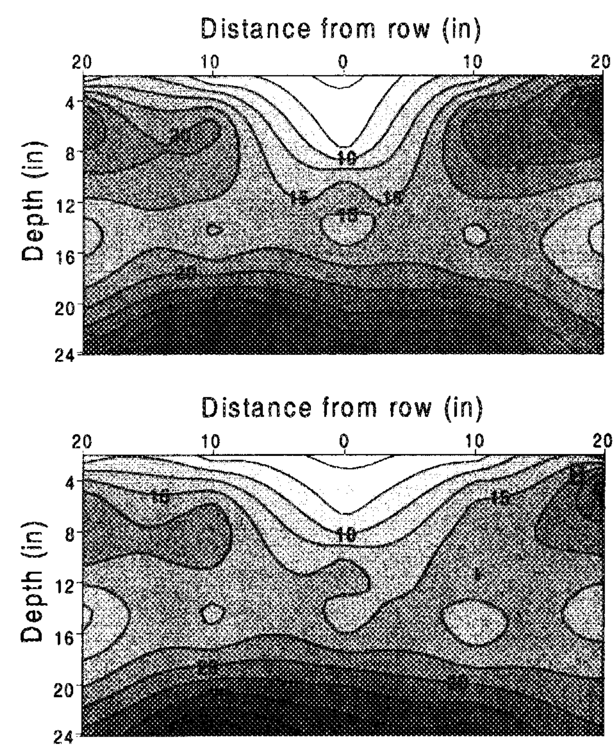

Figure 3. Cone index iso-lines(bars) for plots with shallow in-row tillage in fall 1996 without cover crops with the top figure(A) obtained in spring 1997 and the bottom figure(B) obtained in fall 1997.

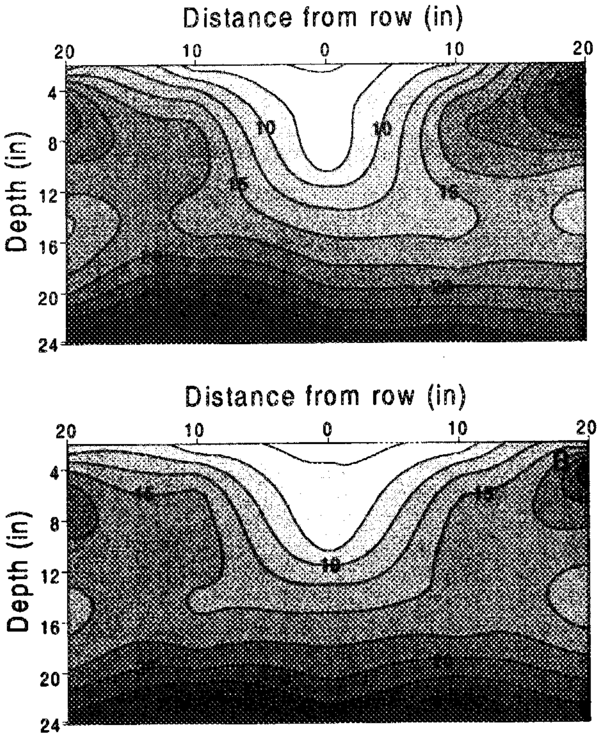

Figure 4. Cone index iso-lines(bars) for plots with deep in-row tillage in fall1996 without cover crops with the top figure(A) obtained in spring 1997 and the bottom figure(B) obtained in fall 1997.

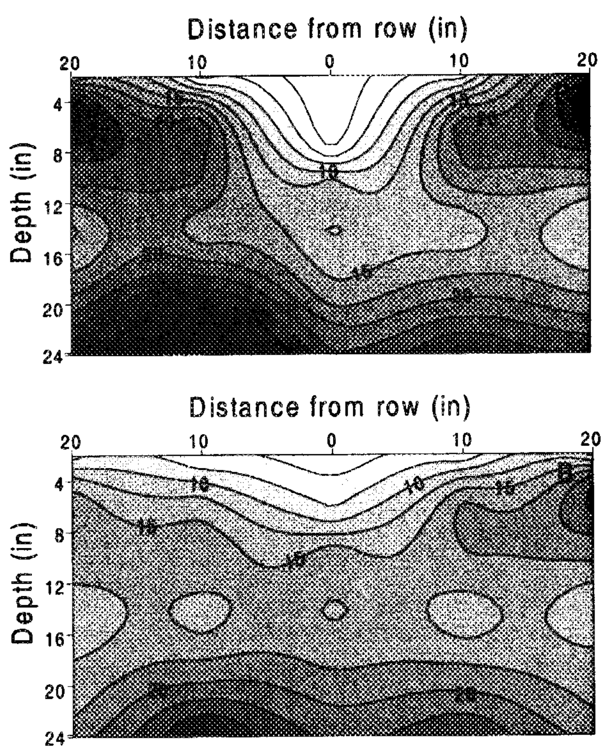

Figure 5. Cone index iso-lines(bars) for plots with shallow in-row tillage in spring 1997 without cover crops with the top figure(A) obtained in spring 1997 and the bottom figure(B) obtained in fall 1997.

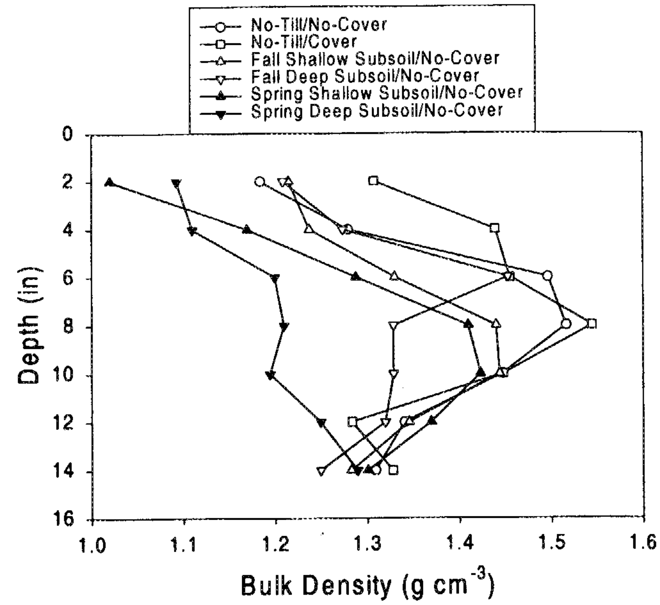

Figure 6. Bulk density values obtained in fall of 1998 beneath the row.

COMPARSION OF FINGER STRIPPERS, BRUSH ROLL STRIPPERS AND SPINDLE PICKERS ON THE TEXAS HIGH PLAINS

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Abstract

A comparison was conducted in 1998 on narrow row cotton harvested with a finger stripper to cotton grown in 40-inch row spacing and harvested with a brush roll stripper and a spindle picker. The brush roll stripper and finger stripper were equipped with a field cleaner. Two cotton varieties D&PL 1220 and PM 2200 were grown under both row patterns and irrigated with a LEPA irrigation system. The plots were 4 rows wide and the harvested area varied from ½ to 3/4 acre. The cotton was harvested on Oct. 16-19, 1998 and ginned the following day at the USDA-ARS Cotton Ginning Research Laboratory, Lubbock, TX.

Data from this study indicated that total foreign matter in seed cotton was highest for the D&PL 1220 variety when harvested with the finger stripper and brush roll stripper. No significant difference was found in total foreign matter between the varieties when harvested with the spindle picker. Stick content was significantly higher for D&PL 1220 for all three harvest methods. This was apparently due to the composition of the cotton plant for the D&PL variety which was taller and had longer fruiting branches. Harvest method had a significant effect on stick content of the seed cotton samples collected at the trailer. The spindle picker had significantly less sticks than the finger stripper or the brush roll stripper, while the brush roll stripper had significantly less sticks than the finger stripper. The fine trash content was significantly less for both varieties when harvested with the spindle picker.

Leaf grades for the PM 2200 were not significantly different for the 3 harvest methods but were significantly lower when harvested with the picker and harvesting the D&PL 1220 cotton. No leaf grades were higher than a 3 for any of the treatments. HVI trash and visible foreign matter as