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COMPARISON OF STRIP TILLAGE SYSTEMS IN COASTAL PLAIN SOILS FOR COTTON PRODUCTION

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Abstract

Soil compaction management in the southeastern U.S. relies heavily on the use of annual deep tillage. The conventional cotton production systems in this area require a minimum of three and often five field operations at a cost of approximately $31 per acre. Strip tillage systems have shown considerable promise for reducing the energy and labor requirement, equipment cost, soil erosion and cotton plant damage from blowing sand. Cost savings of approximately $20 per acre could be achieved by strip tillage compared to conventional methods. This research was conducted to evaluate the performance of three different strip tillage systems compared to conventional and no-till methods in terms of effects on soil parameters, crop responses, and energy requirements; and to investigate the feasibility of eliminating the need for annual deep tillage by planting cotton directly into the previous years subsoiler furrow and controlling traffic. Replicated field experiments were conducted during the 2002 and 2003 growing seasons at Clemson University's Edisto and Pee Dee Research & Education Centers. Tillage treatments included: conventional tillage, straight shank strip-till, bent-leg shank strip-till (Paratill), bent-leg shank strip till (Terra Max), and no-till. At Blackville, the treatments were compared side by side with and without irrigation. In 2003, the test plots from previous year were split in half to determine the residual effects of different tillage systems. No deep tillage was applied to one-half of the plot while the other half received the same tillage treatment as in 2002.

At Edisto, deep tillage significantly reduced soil compaction in crop rows compared to no-till. Strip till systems utilizing Paratill and Terra Max shanks reduced soil compaction in the non-traffic row-middles. Taproots were significantly longer in deep tillage plots than those in no-till plots in both irrigated and dry land locations. No differences in plant stand occurred among the tillage treatments. There was no difference in cotton yield between the strip-till systems and conventional tillage in either dry land or irrigated plots. Deep tillage significantly increased lint yields compared to no-till. In 2002, the yield increases from deep tillage were 15% and 26% for irrigated and dry land plots respectively. Irrigation significantly increased cotton yields compared to dry land in 2002. Averaged over all treatments, irrigated plots yielded 77% more than those on dry land. There was no difference in cotton yield between dry land and irrigated plots in 2003. There was no difference in lint yield between plots which had deep tillage operation in 2002 & 2003 and those which had tillage operation only in 2002. On average deep tillage (either in 2002 or 2003) increased lint yield by 41.5% compared to no-till system.

At the Pee Dee location, dry matter partitioning data collected at first bloom showed a significant reduction in the growth and development of plants grown in strip-till and no-till production systems compared to the conventional system. Reproductive development was also affected by tillage systems, with conventional plants developing significantly more squares and partitioning more of their dry weight into squares compared to plants grown in strip-till or no-till systems. However, these differences in early-season growth and development were not apparent near the end of boll development, with no differences in any vegetative or reproductive growth measurements found. Tillage systems had no affect on flower development or nutrient uptake throughout the growing season or on lint yield and fiber quality at the end of the season.

Introduction

Soil compaction management in the southeastern U.S. relies heavily on the use of annual deep tillage. This practice improves yields in soils of the coastal plain, which are subject to the formation of hardpans (Garner et al., 1989; Khalilian et al. 1991). The conventional cotton production systems in this area require a minimum of three and often five field operations at a cost of approximately $31 per acre. Typically the field is disked two times to bury previous crop residue and incorporate pre-emergence herbicides, subsoiled/bedded to break soil compaction and prepare seedbed, and then cotton is planted. The costs associated with conventional systems plus the advent of better herbicides and equipment have stimulated interest in conservation tillage especially strip tillage among many South Carolina cotton growers. Strip tillage systems have shown considerable promise for reducing the energy and labor requirement, equipment cost, soil erosion and cotton plant damage from blowing sand. Cost savings of approximately $20 per acre could be achieved by strip tillage compared to conventional methods.

Recently strip tillage systems with bent-leg shanks (such as Paratill and Terra Max) have become commercially available for cotton production. The bent-leg shanks loosen up a greater volume of the compacted layer without disturbing the topsoil and have potential to enhance crop performance. Averaged over three years, non-irrigated soybeans planted behind a Paratill yielded 11% more than those planted with a straight shank subsoiler (Khalilian et al. 1991). The average yield increase from irrigated locations was 8.6%.

There is a great interest in avoiding annual deep tillage to reduce costs. Research in some sandy soils in South Carolina has shown reconsolidation of the hardpan layer from one season to another. However, with controlled traffic and planting directly into the previous years subsoiler furrow, the residual effect of deep tillage operations could extend for one or two additional years. There is a need to evaluate performance of bent-leg strip tillage systems compared to straight shank strip tillage, conventional tillage, and no tillage systems on different coastal plain soils. The residual effects of these tillage methods under a controlled traffic scenario on cotton production need to be determined.

The objectives of this study were: A) To evaluate the performance of three different strip tillage systems compared to conventional and no-till methods in terms of effects on soil parameters, seed placement, crop responses, and energy requirements; and B) To investigate the feasibility of eliminating the need for annual deep tillage by planting cotton directly into the previous years subsoiler furrow and controlling traffic.

Materials and Methods

Replicated field studies were conducted on typical coastal plain soils in a randomized complete block design at the Edisto Research & Education Center and Pee Dee Research & Education Center located in Blackville and Florence, SC, respectively. Four units of rip/strip attachments (Unverferth Mfg. Co.) were installed on a special toolbar, which could be mounted behind a 4-row tillage tool such as a Terra Max (Figure 1). Combining the rip/strip system with straight and bent-leg tillage equipment five tillage treatments were performed in both locations in early May, 2002. Four replications of the following treatments were planted and carried to cotton yield using recommended practices for seeding, fertilization, insect, and weed control. Cotton variety DP 458 BR was planted on May 7th at Edisto and May 16th at Pee Dee. At Edisto, the treatments were compared side by side with and without irrigation to determine the effects of irrigation on reformation of the hardpan layer. At Florence, no supplemental irrigation was applied to the study. The treatments included:

1. Conventional tillage (2 x disk + subsoil-bed + Plant)
2. Straight shank strip-till system
3. Bent-leg shank strip-till system (Tye Paratill)
4. Bent-leg shank strip-till system (Worksaver's Terra Max)
5. No surface or deep tillage.

To determine the effects of different tillage systems on soil compaction, a microcomputer-based, tractor-mounted recording penetrometer was used to quantify soil penetration resistance during the growing season. Soil compaction data were collected before tillage operations and 6-weeks after planting. Soil and plant data was collected during the growing season. Cotton was harvested on October 10 at Edisto and October 15 at Pee Dee with plot pickers equipped with sacking attachment and weighing system. An instrumented John Deere tractor was used to make in field measurements of tractor fuel consumption, ground speed, wheel slip, and draft requirements of different tillage treatments.

In 2003, the test plots from previous year were split in half to determine the residual effects of different tillage systems. No deep tillage was applied to one-half of the plot while the other half received the same tillage treatment as in 2002. Cotton variety DP 555BR was planted on May 7th at Edisto and May 14th at Pee Dee. All plots were planted with a case international no-till planter at Pee Dee and with a John Deere MaxEmerge2 planter at Edisto. Soil compaction data were collected before tillage operations and on July 8th at both test sites. Also, the penetrometer readings were repeated at Edisto on July 30th. Cotton was harvested on October 27th at Pee Dee and on November 3rd at Edisto.

Results and Discussion

Cone index values before initiation of tillage test, indicated that the test field at Edisto REC had a hardpan in the E horizon at a depth of 5 to 12 inches. Figure 2 shows profiles of cone index versus depth from crop rows for different tillage treatments in 2002. Deep tillage (conventional and strip-till systems) significantly reduced soil compaction in crop rows compared to no-till method. The biggest difference in soil compaction was found in the E horizon. Strip till systems utilizing Paratill and Terra Max shanks reduced soil compaction in the non-traffic row-middles (Figure 3). This is due to the fact that a bent-leg shank disturbs a wider section of the soil profile than a straight shank.

Taproots measured six weeks after planting were significantly longer in deep tillage plots than those in no-till plot in both irrigated and dry land locations (Table 1). Similar results were obtained with total dry root weight. Irrigation increased plant height and root weight by18% and 22% respectively compared to dry land.

No differences in plant stand occurred among the tillage treatments at Florence, with all plots ranging between 12 and 16 plants/m^2. Dry matter partitioning data collected at first bloom (July 11th) showed a significant reduction in the growth and development of plants grown in strip-till and no-till production systems compared to the conventional system. Total plant dry weight was reduced 19 to 43%, stem dry weight was reduced 21 to 47%, leaf dry weight was reduced 18 to 38%, and leaf area index was reduced 19 to 37% at first bloom. Reproductive development was also affected by tillage system, with conventional plants developing significantly more squares (17 to 38%) and partitioning more of their dry weight into squares compared to plants grown in strip-till or no-till systems. However, these differences in early-season growth and development were not apparent near the end of boll development on Aug. 9th, with no differences in any vegetative or reproductive growth measurements found. Tillage systems had no effect on flower development or nutrient uptake throughout the growing season or on lint yield and fiber quality at the end of the season (Table 2 and Figure 4).

There was no difference in cotton yield between the strip-till systems and conventional tillage in either dry land or irrigated plots at Edisto in 2002 (Figure 5). However, deep tillage systems (conventional and strip-till) significantly increased lint yields compared to no-till production system. The yield increase averaged 15% and 26% for irrigated and dry land plots respectively. Also, irrigation significantly increased cotton yields compared to dry land. Averaged over all treatments, irrigated plots yielded 77% more than those on dry land.

Figure 6 shows penetrometer data from crop rows two months after tillage in 2003. There was no difference in soil compaction between the plots which had deep tillage operation only in 2002 and those which hade deep tillage operations in 2002 & 2003. Therefore, with controlled traffic and planting directly into the previous years subsoiler furrow, the residual effect of deep tillage operations could extend at least for one additional year. Similar results were observed in non-trafficked row middles.

In 2003, we had 30 in. of rain during growing season compared to average rainfall of 20 in. for the same period. Therefore irrigation was not applied to "irrigated" plots at Edisto. Since there was no difference in lint yield between dry land and irrigated plots the yield data were averaged over 8 replications. There was no difference in lint yield between cotton planted back into the previous year's subsoil furrows compared to an annual deep tillage operation (Figure 7). Also statistically there were no differences in yield among the deep tillage plots. However, deep tillage significantly increased lint yield compared to no-till plots. The average yield increase was 41.5%.

Figure 8 shows number of fire ant mounds for different tillage treatments. Fire ants are major predators in controlling cotton insects. There were 93% more fire ants in plots which did not have tillage in 2003. In tillage plots, number of fire ant mounds was inversely correlated to the severity of tillage operation. Conventional tillage plots had the least fire ants while the terra Max plots had the highest numbers.

Conclusion

- Deep tillage significantly reduced soil compaction in crop rows compared to no-till method.
- Strip till systems utilizing Paratill and Terra Max shanks reduced soil compaction in the non-traffic row-middles.
- Taproots were significantly longer in deep tillage plots than those in no-till plots in both irrigated and dry land locations
- No differences in plant stand occurred among the tillage treatments
- There was no difference in cotton yield between the strip-till systems and conventional tillage in either dry land or irrigated plots.
- Deep tillage significantly increased lint yields compared to no-till. In 2002, the yield increases were 15% and 26% for irrigated and dry land plots respectively.
- Irrigation significantly increased cotton yields compared to dry land. Averaged over all treatments, irrigated plots yielded 77% more than those on dry land.
- There was no difference in cotton yield between dry land and irrigated plots in 2003.
- There was no difference in lint yield between plots which had deep tillage operation in 2002 & 2003 with those which had tillage operation only in 2002.
- On average deep tillage (either in 2002 or 2003) increased lint yield by 41.5% compared to no-till system.

Acknowledgments

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Disclaimer

Mention of a trade name does not imply endorsement of the product by Clemson University to the exclusion of others that may be available.

References

Garner, T.H., A. Khalilian, and M.J. Sullivan. 1989. Deep tillage for cotton in Coastal Plain soils-costs/returns. 1989 Proceedings, Beltwide Cotton Production Research Conferences, pp.168-171, January 1989, Nashville, TN.

Khalilian, A., C. E. Hood, J. H. Palmer, T. H. Garner, and G. R. Bathke. 1991. Soil compaction and crop response to wheat/soybean interseeding. Transactions of the ASAE, Vol. 34: 2299-2303.

Table 1. Effects of tillage and irrigation on plant height, taproot length and root weight six week after planting, Edisto REC, 2002.

Irrigation	Tillage Treatments	Plant Height (in)	Taproot length (in)	Root Dry weight (g)
Irrigated	Conventional Tillage	39 a	15.9 a	32.8 a
	Straight Shank Strip-till	43 a	15.6 a	35.5 a
	Tye Paratill, Bent-leg Shank Strip-till	41 a	15.7 a	33.9 a
	Worksaver's Terra Max, Bent-leg Strip-till	39 a	15.3 a	32.8 a
	No-Till	28 b	6.9 b	25.4 b
Dry Land	Conventional Tillage	34.5 a	13.2 a	30.1 a
	Straight Shank Strip-till	33.6 a	13.4 a	28.6 a
	Tye Paratill, Bent-leg Shank Strip-till	32.5 a	13.7 a	28.3 a
	Worksaver's Terra Max, Bent-leg Strip-till	33.5 a	13.9 a	28.1 a
	No-Till	28.0 b	5.7 b	14.8 b

Table 2. Lint yield, gin turnout, and fiber quality parameters in response to various tillage systems, Florence, 2002.

Treatments	Lint Yield (lbs/A)	Gin Turnout (%)	Micronaire	Length (in)	Strength (g/tex)	Uniformity	Elongation
Conventional	445	39.8	5.1	1.06	29.6	81.3	8.3
Straight Shank Strip-till	458	39.8	5.0	1.08	30.1	81.9	8.6
Paratill Strip-till	456	39.6	5.2	1.04	28.9	81.6	8.4
Terra Max Strip-till	456	39.0	5.2	1.04	28.7	81.4	8.2
No-Till	499	40.9	5.1	1.07	30.6	82.8	8.5
LSD (0.05)	**ns**	**ns**	**ns**	**ns**	**ns**	**1.0**	**ns**

DPL 458 BR planted on 5/16/02; Dry land.

Figure 1. Bent-leg shank strip-till system (Worksaver's Terra Max).

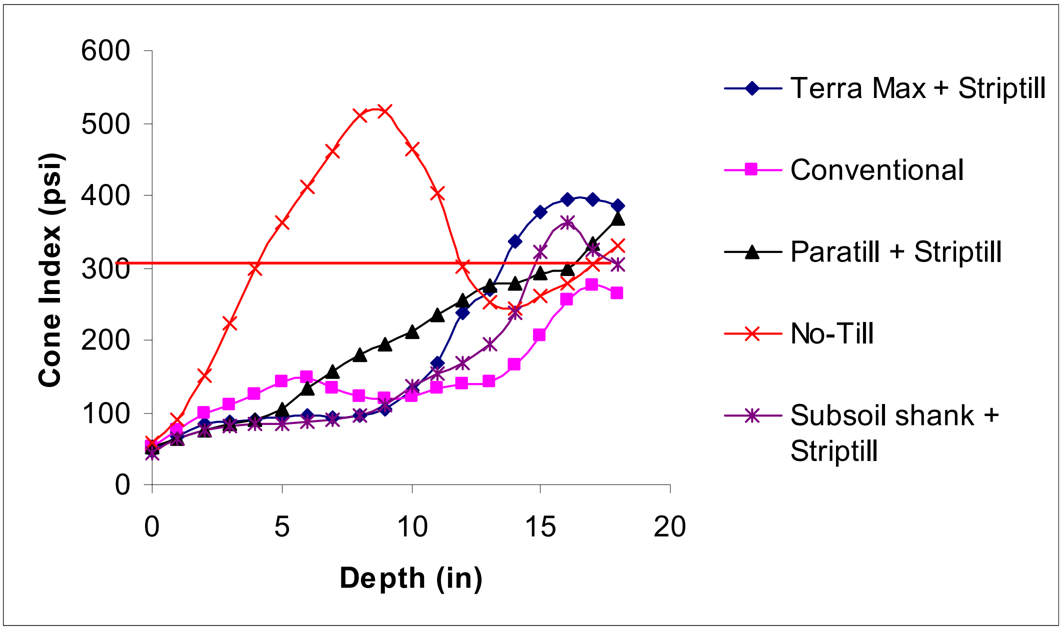

Figure 2. Effects of tillage on soil compaction from crop rows six week after tillage, Edisto REC, 2002.

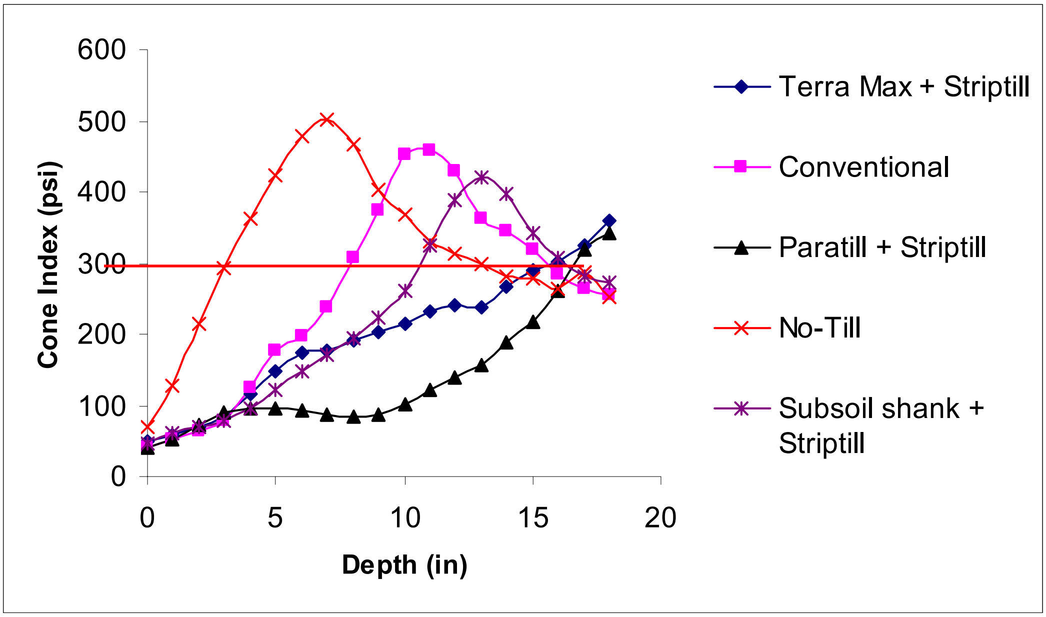

Figure 3. Effects of tillage on soil compaction from non-traffic row-middles (9 inches from crop rows) six week after tillage, Edisto REC, 2002.

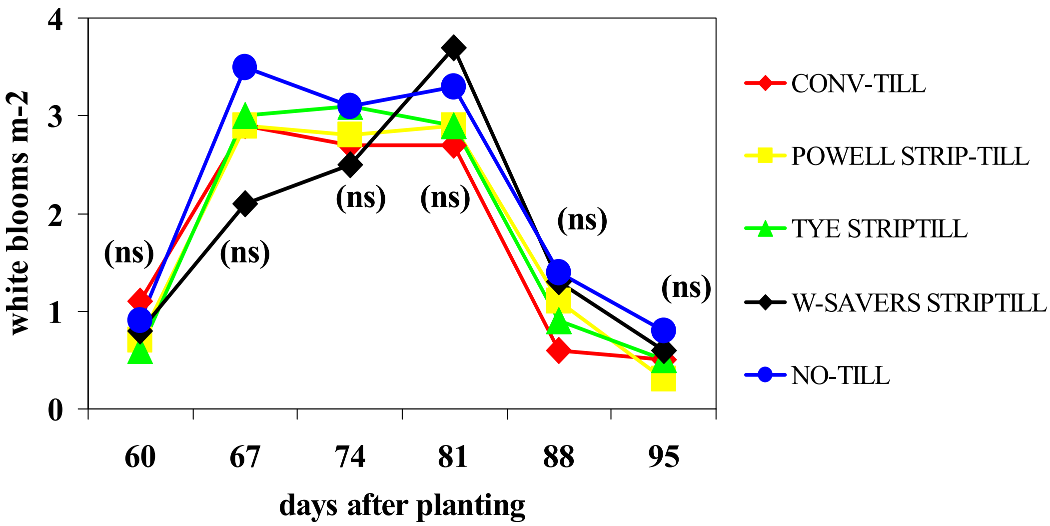

Figure 4. Flowers per meter/day as a function of days after planting for cotton in response to various tillage systems in 2002 at Florence, SC.

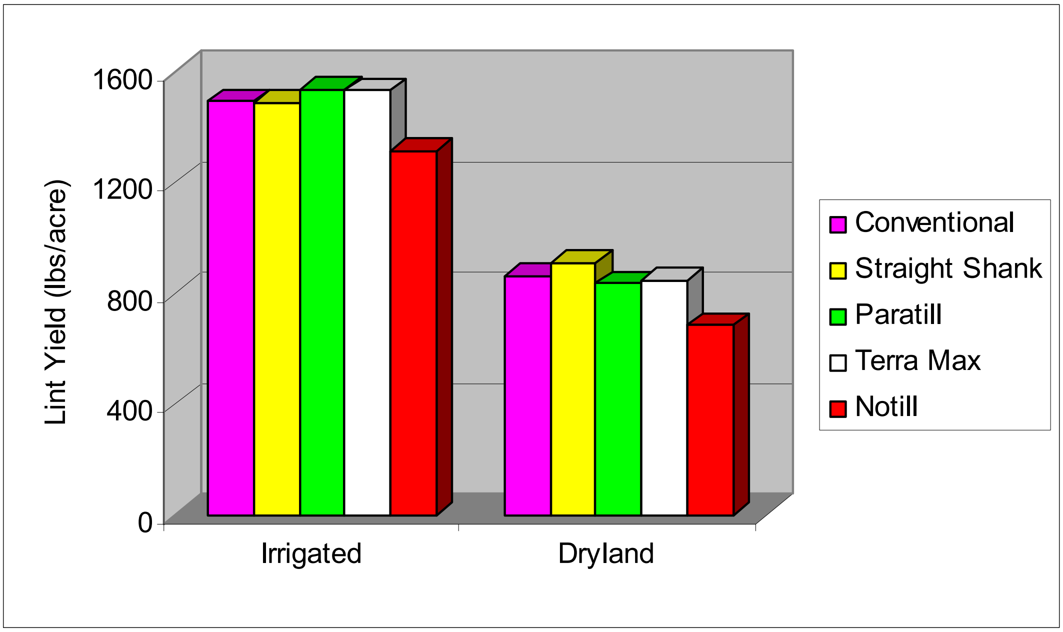

Figure 5. Effects of tillage and irrigation on lint yield, Edisto REC, 2002.

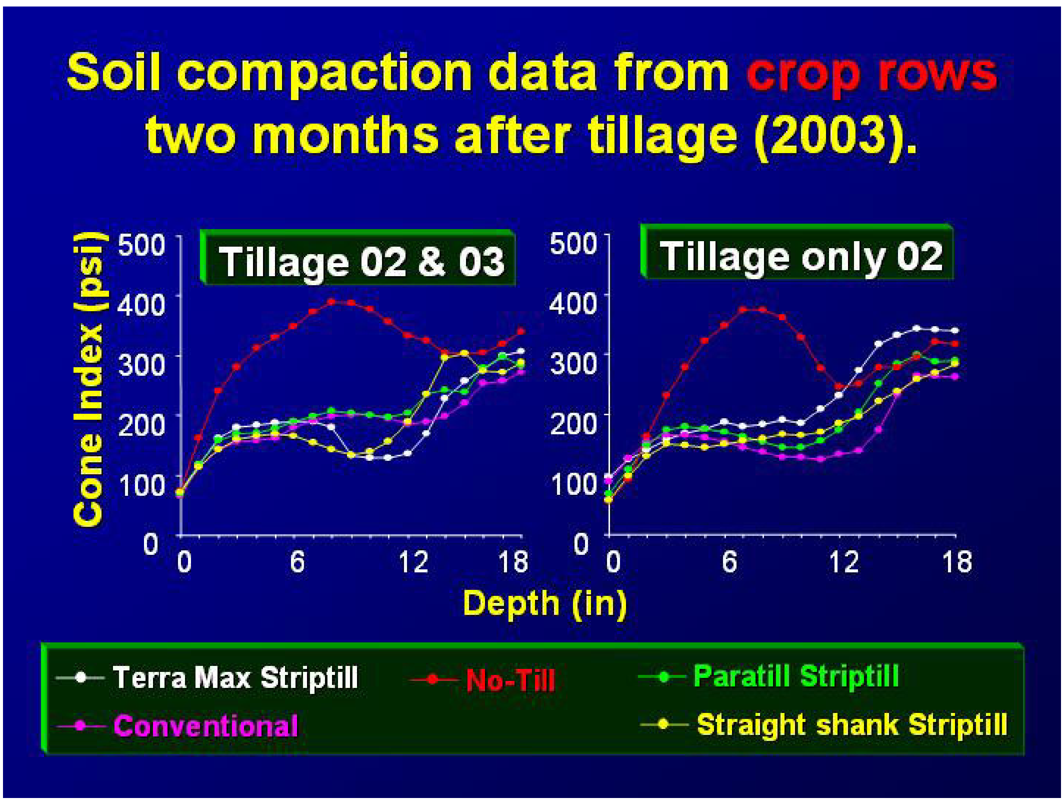

Figure 6. Soil compaction data from crop rows two months after tillage, Edisto, 2003.

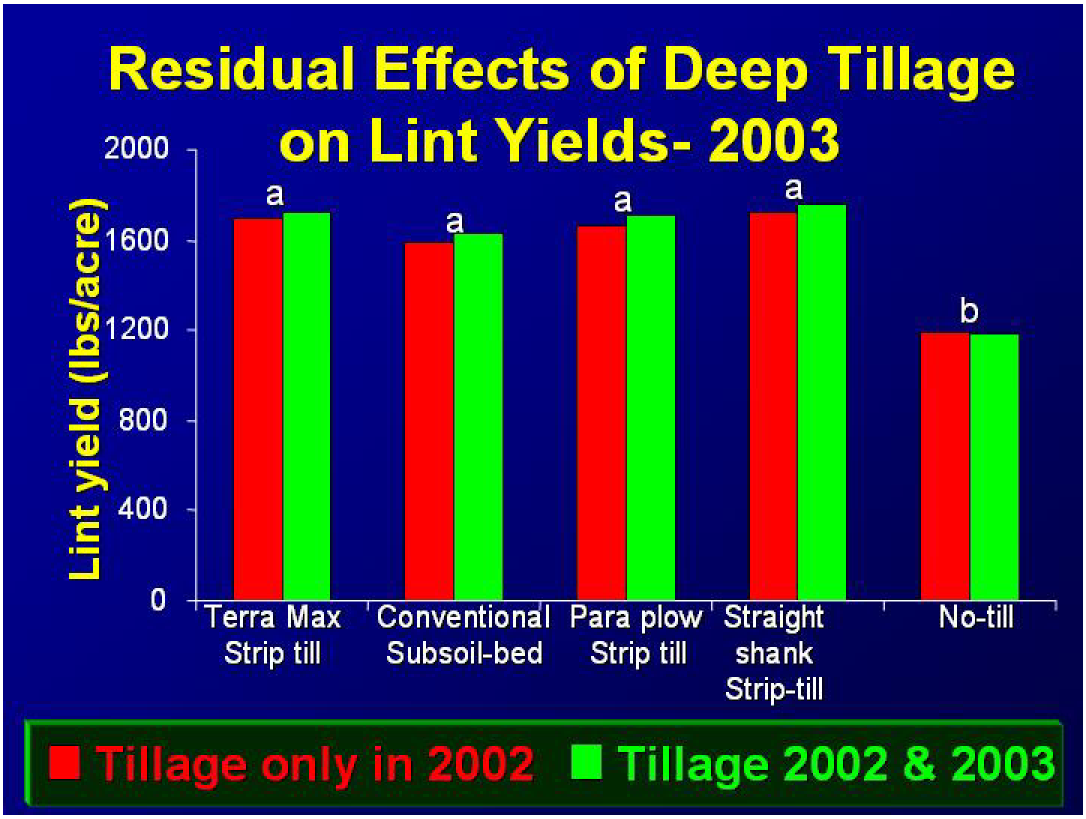

Figure 7. Residual effects of deep tillage on lint yields, Edisto, 2003. Data averaged over 8 replications.

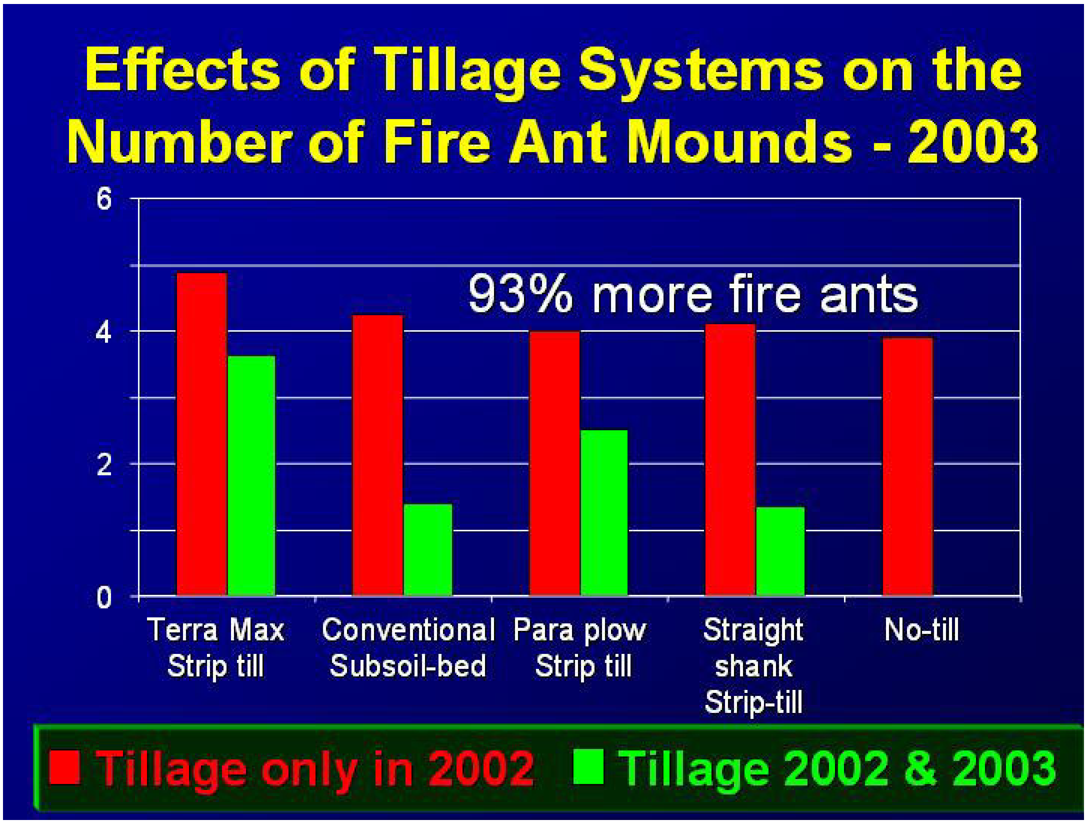

Figure 8. Effects of deep tillage on the number of fire ant mounds, Edisto, 2003. Data averaged over 8 replications.