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RECOMPACTION BY TRAFFIC OF A COMPLETELY DISRUPTED COASTAL PLAIN SOIL

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Introduction

Soil compaction is an acute problem in the southeastern United States (Cooper et al., 1969). This root-limiting condition is alleviated by subsoiling (Campbell et al., 1974). Subsoiling densely compacted soil allows deeper rooting to withstand short-term droughts prevalent during the growing season in the Southeast. Typically. soils in this region are subsoiled every year to depths of 0.3-0.5m. Annual subsoiling is recommended because soils recompact quickly due to natural consolidation processes and random wheel traffic (Tupper et al., 1989; Busscher *et al.,* 1986). In a few cases, researchers have recommended subsoiling on a less frequent basis. (Colwick et al., 1981; Smith. 1985; Reeder *et al.,* 1993).

The ability to control traffic in a field situation over a broad area allows compaction experiments to be conducted without the interference of random traffic effects. At the USDA-ARS National Soil Dynamics Laboratory (NSDL). the Wide Frame Tractive Vehicle (WFTV) (Monroe and Burt, 1989) allows experiments to be conducted using a 6.l-m wide growing zone that can be kept completely free of traffic. Targeted research can then be carried out to determine how much random wheel traffic contributes to recompaction of soil disrupted by a subsoiler,

The objective of this study was to determine how much soil recompaction occurred over a multi-year experiment using the WFTV to eliminate wheel traffic on half of the plots.

Methods

A long-term corn-soybean *(Zea mays* L. *-Glycine max* (L.) Merr.) rotation experiment was conducted from 1988-l993 to analyze the effects of traffic and its interaction with surface and deep tillage practices on a Norfolk loamy sand soil (tine-loamy. siliceous. thermic Typic Kandiudults) at Alabama Agricultural Experiment Station's E.V. Smith Research Center near Shorter, AL. USA. This soil is highly compactable and has a welldeveloped hardpan at the 18-30 cm depth.

The experimental design was a strip-split plot design of four replications. Vertical factors were deep tillage: (i) no deep tillage: (ii) annual in-row subsoiling, and (iii) initial complete disruption. Subsoiling treatments were conducted to a depth of 40-44 cm. The initial complete disruption treatment was applied before the study was initiated by subsoiling on 25-cm centers. For this paper, only data from the initially completely disrupted treatment is presented due to space limitations. Horizontal factors were traffic: (i) no traffic; (ii) trafficked. Intersection or subplot treatments were surface tillage: (i) no surface tillage; and (ii) disk-field cultivate.

All operations were done with the WFTV. A 4.6 t two-wheel drive tractor with 18.4 R38 tires inflated to 125 kPa was driven through the trafficked plots immediately after operations were conducted with the WFTV. This process simulated traffic that would have been applied had the WFTV not been used. In the spring and summer, traffic was kept on appropriate row middles to simulate planting operations with 4-row equipment. In the fall, traffic was randomly applied to the whole plot to simulate land preparation/planting operations necessary for establishing a winter cover crop of crimson clover *(Trifolium incarnatum* L.).

Extensive soil sampling was conducted in the spring of the year after five years to determine whether significant changes in soil condition were induced by management practices. Corn was grown in the previous year on the portion of the plots sampled. Soil bulk density samples were taken in each plot at two different locations. Three positions across a middle row were sampled; (i) the untrafficked row middle, (ii) the trafficked row middle, and (in) the row. Samples were also taken at three depths: (i) near the surface at a depth of 3-8 cm, (ii) in the hardpan at a depth of 20-25 cm, and (iii) below the hardpan at a depth of 45-50 cm. Gravimetric water content and dry bulk density were determined from these samples.

Cone index measurements (ASAE, 1996) were taken during the same period in a fashion similar to the bulk density samples. Five sets of force-depth measurements were made about row 3: (i) in the trafficked row middle, (ii) halfway between the trafficked row middle and the row, (iii) in the row, (iv) halfway between the untrafficked row middle and the row, and (v) in the untrafficked row middle. These sets of readings were taken at four locations within each plot. Cone index forces were recorded at approximately every 3 mm of depth.

Results and Discussion

Statistically significant differences were found in buIk density near the surface (3-8 cm depth) due to the effects of traffic (P ≤ O.O09), surface tillage (P ≤ O.OOOl), and location across the row (P ≤ O.OOOl). Because of the expected differences found across the row, these data were analyzed individually for each row location. The location directly under the row is of particular interest as this is the soil condition that would most affect plant response. Analysis of this location showed that traffic (P ≤ 0.015) and surface tillage (P ≤ O.OOOl) were again statistically significant. The interaction of subsoiling and surface tillage was also found to be significant (P ≤ O.O203).

Analyzing the bulk density measurements taken at the hardpan depth (20-25 cm) showed subsoiling (P ≤ O.O3) and trafficking (P ≤ O.O04) effects. When the location directly under the row was analyzed individually, subsoiling was found to be the major statistically significant factor (P ≤ 0.0015). Surface tillage was also found to be significant (P ≤ 0.0526). No significant interactions were found at this depth.

Bulk density measurements taken below the hardpan at depths of 45-50 cm were not significantly affected by any of the investigated variables. All tillage and traffic effects were confined to shallower depths.

Plots that were completely disrupted at the beginning of the experiment showed increased bulk density as a result of surface tillage and traffic (Figure 1).Initially completely disrupted plots that had surface tillage showed decreased bulk density near the surface when compared to plots prepared with no tillage. Differences due to traffic occurring over the 5-year period following complete disruption are illustrated in all three locations across the row. The largest change occurred directly under the trafficked region beside the row, but the area beneath the row as well as the untrafficked row middle all showed increased bulk density due to traffic (Figure 1).

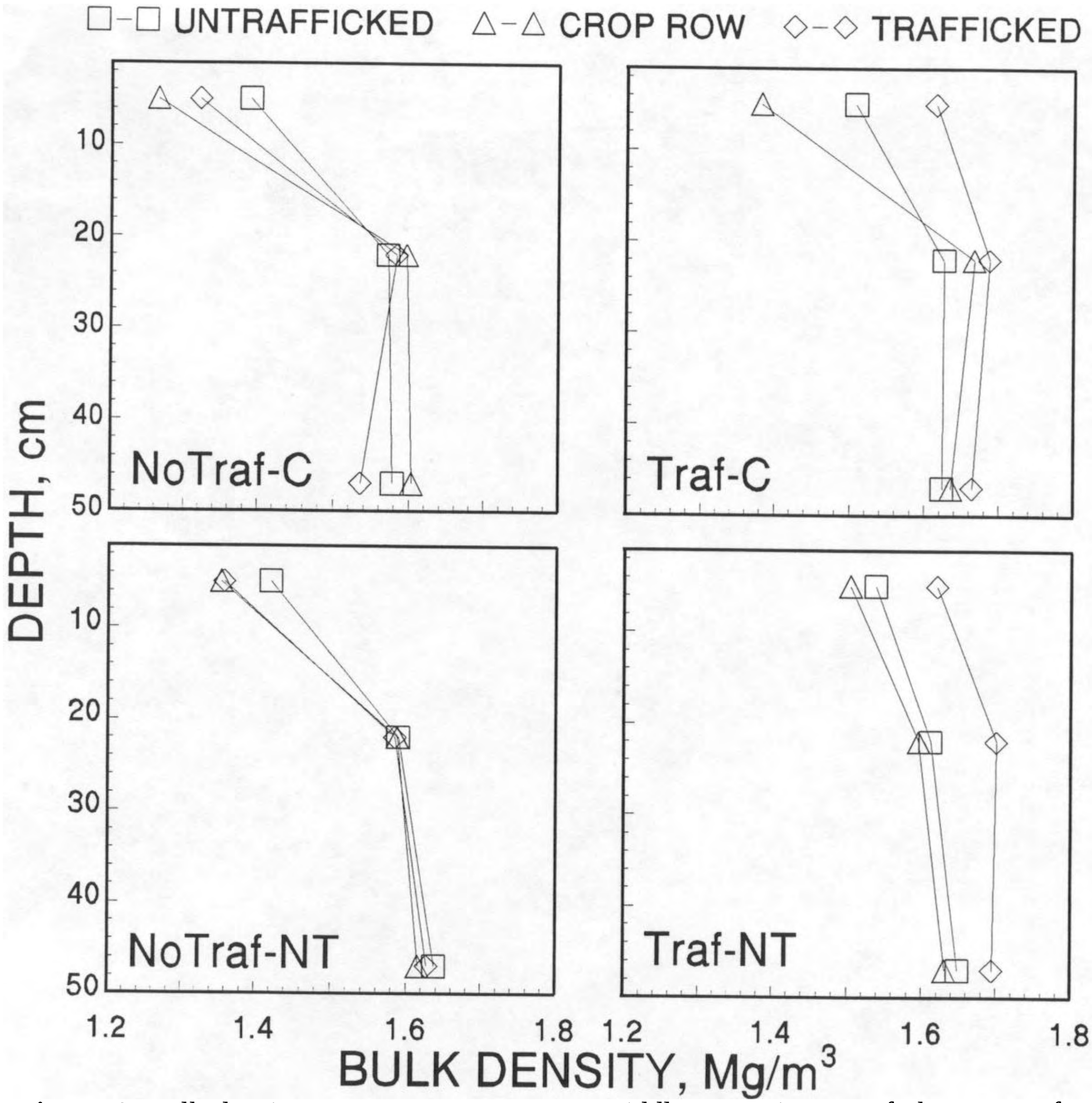

Figure 1. Bulk density measurements across a middle row. First set of characters of legend indicates traffic (Traf) or no-traffic (NoTraf); second set of characters indicate (C) conventional or (NT) no-tillage.

Cone index measurements (MPa) are summarized as isolines in vertical profiles across the crop row (Figure 2). These graphs show average cone index values across all locations and replications in these plots. The graphs are arranged as in Figure 1 for ease of comparison. Darker areas indicate areas of extreme compaction while lighter areas indicate less compaction.

The detrimental effects of traffic are easily noticed in the graphs in the right half of Figure 2. Both of these graphs in Figure 2 show significant recompaction, particularly in the area beneath the trafficked middle which lies on the positive side of the row. Conventional tillage also intensified the effects of traffic resulting in higher cone index values in the hardpan zone (top right).

Conclusions

Significant recompaction was detected by means of bulk density and cone index readings in trafficked plots 5 years after complete disruption. Other plots that were not trafficked showed significantly reduced values of bulk density. Cone index profiles revealed that compacted zones

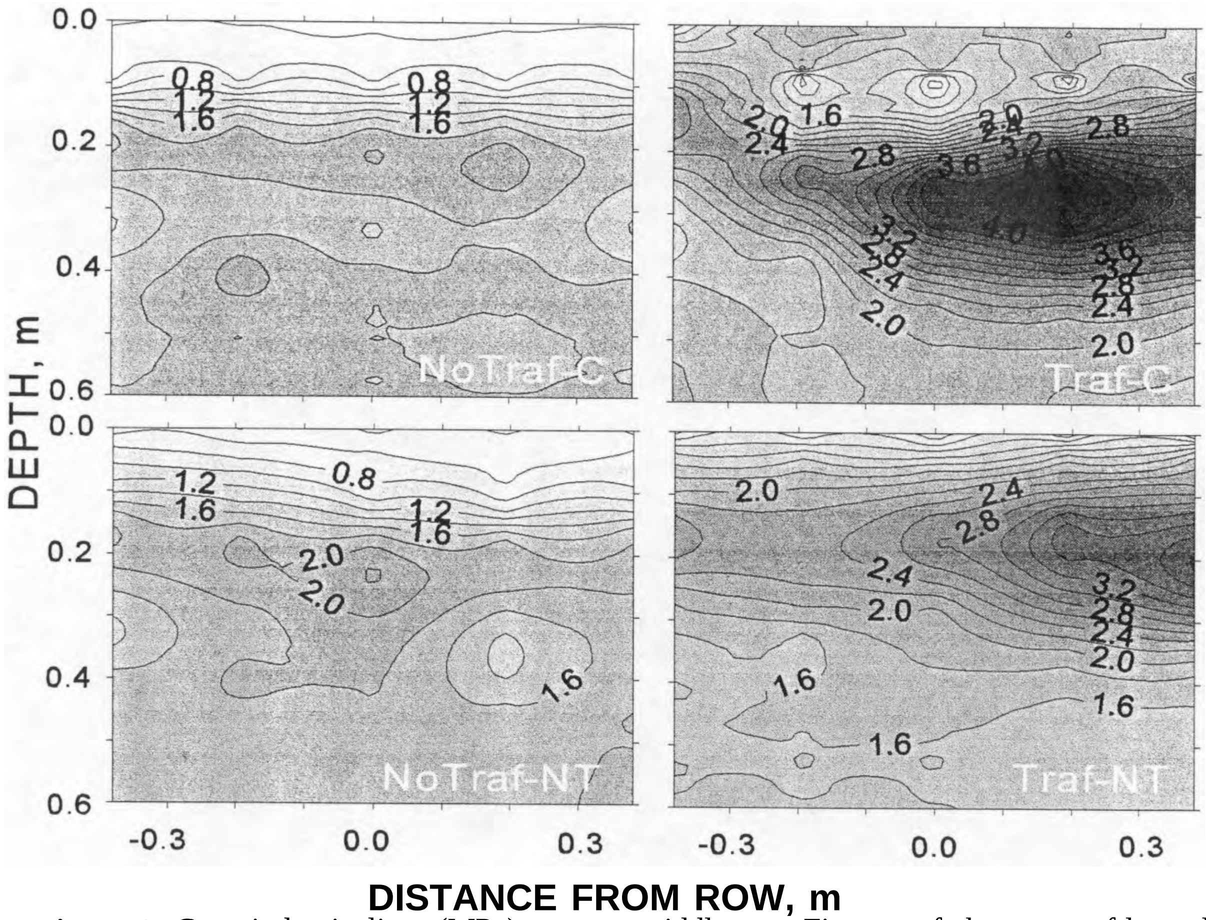

Figure 2. Cone index isolines (MPa) across a middle row. First set of characters of legend indicates traffic (Traf) or no-traffic (NoTraf); second set of characters indicate (C) conventional or (NT) no-tillage. Traffic was applied on the positive side of the row in plots where it was a treatment.

were caused by traffic, compared to non-trafficked plots. These profiles also showed that conventional tillage intensified hardpan reformation compared to no-tillage.

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