NEGATING THE EFFECT OF TRAFFIC WITH IN-ROW SUBSOILING

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ABSTRACT

Extensive cone index measurements were used to evaluate the soil condition resulting from five years of a cotton (*Gossypium hirsutum* L.) - wheat (*Triticum aestivum* L.) double cropping experiment. Four cotton tillage systems including a conservation tillage practice of in-row subsoiling and planting into wheat residue stubble and two traffic systems were analyzed. The USDA-ARS Wide-Frame Tractive Vehicle (WFTV) was used to control traffic in the experimental plots. Contour graphs of cone index were used to determine differences in tillage and traffic systems. Traffic was found to reconsolidate soil that was initially completely disrupted to a 0.51-m depth into a soil condition similar to one that had never received a subsoiling treatment. Traffic was also found to decrease the total soil volume estimated for root growth using a 2 MPa limiting cone index value, hut not the maximum rooting depth beneath the row, when an annual in-row subsoiling practice was used.

INTRODUCTION

Soil compaction plagues many parts of the world and affects many different crops. Here in the southeastern part of the United States, cotton has been found to be particularly susceptible to soil compaction [l]. Where soil compaction is a problem, subsoiling has been found to help alleviate it [2]. Subsoiling severely compacted soil provides increased rooting depth to withstand short-term drought conditions prevalent during the growing season in the southeastern United States. Soils in this region are subsoiled to a depth of between 0.3 m and 0.5 m on an annual basis. This is necessary because of wheel traffic and natural forces that cause this soil to reconsolidate. Identifying the major cause of soil compaction is difficult because of the interaction of these two phenomena.

The use of the Wide Frame Tractive Vehicle (WFTV) [3] at the NSDL allows experiments to be conducted to determine exactly how much random wheel traffic contributes to reconsolidation of soil disturbed by a subsoiler. This machine spans a 6-m growing zone that can then be kept completely free of wheel traffic unless a traffic treatment is specified. This vehicle operates on raised traffic paths and facilitates research to determine the effects of traffic and tillage on soil condition without confounding effects from nearby traffic.

MATERIALS AND METHODS

An experiment was conducted between 1987 and 1991 on coastal plains soils at the Alabama Agricultural Experiment Station, Auburn University, Agricultural Engineering Research Farm at Shorter, AL. The soil used was a Cahaba-Wickham-Bassfield sandy loam complex (Typic Hapludults) and contained a well-developed 0.08- to 0.15-m thick hardpan at a 0.2 to 0.3-m depth. Prior to starting the experiment, wheel traffic was run in a moldboard plow furrow incrementally across the field at a 0.2-m depth to reduce the natural variation in the depth and thickness of the hardpan.

A split-plot experiment using cotton and wheat as a double crop was designed with four replications. The main plots were a) conventional traffic and b) no traffic. The subplots contained various common cotton tillage systems[1] including: 1) complete surface tillage (disked and field cultivated) and annual in-row subsoiling to a 0.4-m depth and planting (D, FC, SS+P), 2) initial complete disruption of hardpan in 1987 (but with no annual subsoiling thereafter), complete surface tillage, and planting (CD, D, FC, P), 3) complete surface tillage, and planting (D, FC, P), and 4) in-row subsoiling to a 0.4-m depth (strip-tillage) with no surface tillage (SS+P). The initial complete disruption treatment (CD, D, FC, P) was accomplished by using a V-frame subsoiler on 0.25-m centers operating to a 0.51-m depth. A KMC[2] in-row subsoiler planter was used to plant cotton into the wheat stubble/residue in the strip-tillage treatment (SS+P) and to plant the annual subsoiling treatment. The same planter with the subsoilers removed was used to plant the remaining tillage systems.

The WFTV was used for all tillage treatments, even in plots that received traffic. All traffic treatments were applied with a John Deere 4440 or a high clearance sprayer. These machines would have been used had the WFTV not been available. All plots were eight rows in width and 4-row equipment was assumed to apply the correct traffic treatments. Recommended weed and insect control practices were used throughout the growing season for all plots. Cotton (McNair 220) was planted in 0.76-m rows at 220,000 seeds/hectare.

At the end of the five-year experiment, penetrometer readings were taken with an automatic recording penetrometer to determine changes in soil condition during this time. The penetrometer with base area of 130 mm^2 [4], and mounted on the WFTV was used to sample each subplot at five different locations. At each location, five penetrations were made, starting from the row middle on the untrafficked side of the row and moving in 0.19-m increments across the row and into the trafficked row middle (corresponds to traffic middle in treatments that received traffic). This sampling procedure allowed both tillage and traffic treatments to he analyzed. Four replications x 2 traffic main-plot treatments x 4 tillage subplot treatments x 5 locations within the subplots x 5 positions across each location were sampled to give a total of 800 penetrometer sets of force-

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[1]The tillage operations are defined by the following key: D (disk), FC (field cultivate), SS+P (subsoil and plant beneath row), CD (complete disruption in 1987), and P (plant).

[2]Use of a company name does not imply USDA approval or recommendation of the product or company to the exclusion of others which may be suitable.

distance data. Cone index data were taken at every 0.003 m depth down to an approximate maximum depth of 0.7 m.

The cone index data were averaged in depth increments of 0.05 m for all replications and locations using SAS software [5]. Contour graphs extending from the untrafficked row middle across the row to the trafficked row middle were then created from this data using SURFER contouring software [6]. These contour graphs show the potential root-impeding layers of compaction that are present in the soil profile.

RESULTS AND DISCUSSION

Comparison of contour graphs from the no-traffic plots (Figures 1, 2, 3, and 4) illustrate the beneficial effects of subsoiling. Only Figure 3 has had no subsoiling and the shallowness of the 1 MPa profile differs substantially from the other figures. Figures 1 and 4 also show the presence of the annual in-row subsoiler channel.

The contour graphs from the traffic plots (Figures 5, 6, 7, and 8) differ greatly from the contour graphs from no-traffic plots. In each graph, higher magnitude cone index profiles are much closer to the soil surface. An area of high soil compaction is noted beneath the surface in the trafficked row middle. Also, the in-row subsoiler slot is much easier to detect because of the soil recompaction near the slot.

An interesting comparison can be made between Figures 2 and 6 illustrating the effect of traffic on plots that were initially completely disrupted. A drastic change has occurred in these plots due only to the effect of traffic. The 1 MPa profile moved 0.2 m closer to the soil surface. The soil volume above this 1 MPa profile is near zero. Comparison of Figures 6 and 7 shows that the effect of the initial disruption in 1987 has almost disappeared and the soil condition is very similar to that tillage system that received no subsoiling treatment.

The effect of traffic on subsoiling in a conventional farming system can also be investigated by comparing Figures 1 and 5. The one major difference in these two figures is that the subsoil slot is much narrower in trafficked plots. The total volume of soil that is in a zone of minimal cone index is much greater in Figure 1, but the overall depth of the subsoil slot is almost the same. This result is also echoed by contrasting Figures 4 and 8, the conservation tillage system without and with traffic, respectively. The depth of the subsoil slot is greater in these latter two figures, but the trend is similar.

These contour graphs can also be used to estimate the soil volume available for proper root growth. According to Taylor and Gardner [7], a cone index of greater than 2 MPa can negatively affect crop yields. Figures 1-8 were each analyzed to determine the total soil volume that had a cone index greater than 2 MPa. The results are given in Figure 9. With the exception of the initial complete disruption system (CD, D, FC, P), traffic decreased the soil volume for root growth in each system. In the initial complete disruption tillage system, traffic negatively affected the soil volume between 1 and 2 MPa, but not above this limit. A significant difference is attributed to traffic in the SS+P tillage treatment. In this conservation tillage treatment, only a very small portion of the total soil volume had a cone index greater than 2 MPa in the untrafficked plots.

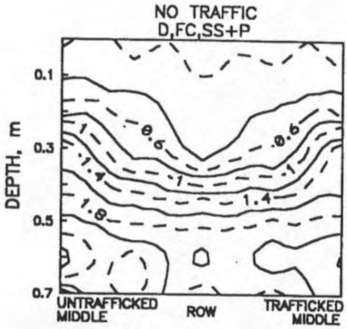

Figure 1. Cone Index Profiles (MPa) across the row for the disk, field cultivate, in-row subsoil and plant tillage treatment with no traffic.

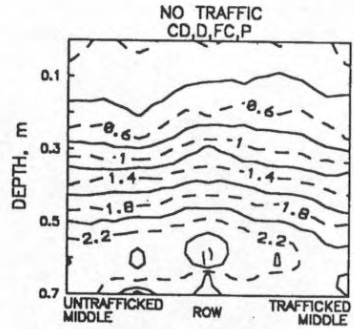

Figure 2. Cone Index Profiles (MPa) across the row for the initial complete disruption, disk, field cultivate and plant tillage treatment with no traffic.

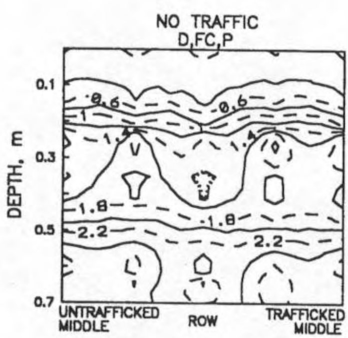

Figure 3. Cone Index Profiles (MPa) across the row for the disk, field cultivate, and plant tillage treatment with no traffic.

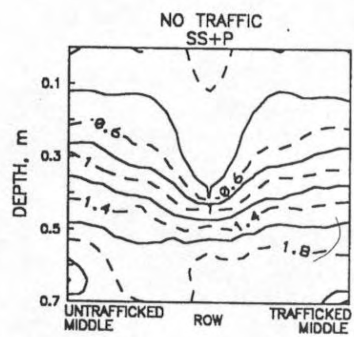

Figure 4. Cone Index Profiles (MPa) across the row for the in-row subsoil and plant tillage system with no traffic.

However, the amount of soil volume available to plant roots may not be as important as the overall soil depth available for rooting. Results reported by Raper et al. [g] showed that the conservation tillage practice of in-row subsoiling and planting (SS+P) had superior cotton yields in plots that received traffic as opposed to plots that received no traffic.

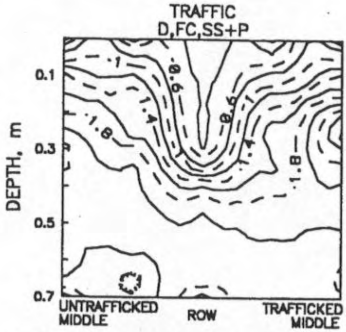

Figure 5. Cone Index Profiles (MPa) across the row for the disk, field cultivate, in-row subsoil and plant tillage system with traffic.

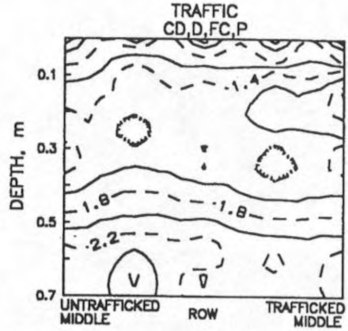

Figure 6. Cone Index Profiles (MPa) across the row for the initial complete disruption, disk, field cultivate and plant tillage system with traffic.

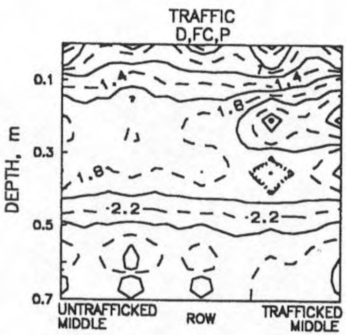

Figure 7. Cone Index Profiles (MPa) across the row for the disk, field cultivate and plant tillage system with traffic.

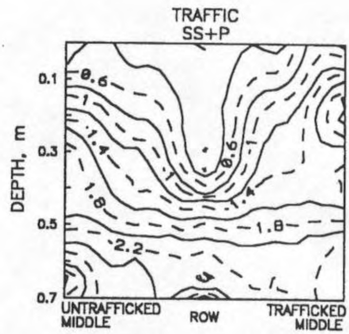

Figure 8. Cone Index Profiles (MPa) across the row for the in-row subsoil and plant tillage system with traffic.

CONCLUSIONS

1) Traffic caused soil in plots initially completely disrupted with a V-frame subsoiler in 1987 to reconsolidate into a state similar to soil in plots that had never been subsoiled.

2) Traffic alongside the row did not significantly change the hardpan depth beneath the row in plots that received subsoiling treatments.

3) The best soil condition resulted from the conservation tillage practice of in-row subsoiling and planting. This practice produced the lowest cone index, and the deepest depth to hardpan of any of the practices studied, even in trafficked plots.

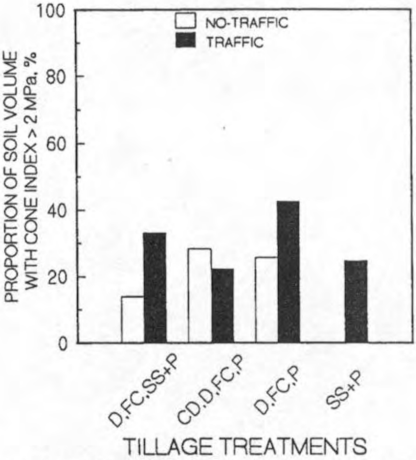

Figure 9. Effect of tillage and traffic treatments on the proportion of soil volume beneath row and wheeltracks with cone index greater than 2MPa.

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