Penetrometer Measurements in Conventional and Minimum Tillage

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Introduction

In 1984, over 2 million acres of soybean [*Glycine max* (L.) Merr.] were grown in Georgia and nearly 40% of this acreage was double cropped with wheat. Under these conditions, it is important to minimize the time delay between harvest of the winter wheat and planting of soybeans. To this end, many farmers have reduced spring tillage operations to disking or adopted minimum-tillage systems. Fall tillage prior to planting wheat is usually disking. These combinations of tillage systems have led to a number of potential problems, one of which may be compaction. Others have shown that a pan can form just below the depth of disking. In the southeast where the depth of freezing may be shallow, organic matter is low, and non-swelling clays predominate, a pan formed by fall disking may persist through the next growing season if it is not broken up by spring tillage. The purpose of this study was to determine if there was evidence of compaction in the tillage zone of conventional and minimum tillage systems.

Materials and Methods

Two ongoing experiments involving conventional and minimum tillage in double-cropped soybeans were examined. One experiment, located at the Southwest Georgia Branch Experiment Station, Plains, involved different spring tillage systems and residue management, including burning. Only the nonburned portion of the experiment was examined in this study. The three spring tillage treatments were moldboard plow followed by disking, disking alone, and no-tillage. Fall tillage for all treatments was disking. Soybeans were planted in early June and were irrigated three times (1 inch each time) in the first two weeks to ensure a stand. Three additional applications were made in September during a period of moisture stress. The soil was a Greenville sandy clay loam (clayey, kaolinitic, thermic Rhodic Paleudult). Wheel traffic during tillage, spraying, and harvest operations was not confined to designated rows.

The second experiment, located at the Southern Piedmont Conservation Research Center, Watkinsville, involved different spring tillage systems and 3-year combinations of rotations between summer crops of soybean and grain sorghum (Sorghum bicolor (L.) Moench). Only the continuous soybean rotation was examined here. The three spring tillage treatments were disking with an offset disk harrow, no tillage, and chisel tillage in which a chisel was attached to a no-till planter so that in-row subsoiling occurred to a depth of about 7 inches Soybeans were planted in early June and there was no supplemental irrigation. The soil was a Cecil sandy clay loam (clayey, kaolinitic, thermic Typic Hapludult). All spring and summer wheel traffic was confined to alternating rows.

To measure compaction in the tillage zone in each experiment, a tractor-mounted hydraulically driven penetrometer was used. This unit drives a standard ASAE cone (0.8 inch base diameter) into the soil and records the force required, which when divided by the cross sectional area of the base of the cone gives soil mechanical impedance in units of pressure (bars). A micro-computer records mean mechanical impedance for each one-inch depth increment and enters this on a floppy disk. In order to measure soil mechanical impedance in each plot, four transects of readings were made perpendicular to the rows. On each transect, two rows were straddled and a series of five readings were taken at half the row spacing so that measurements alternated, between-row midpoints and in-row, producing two in-row and three between-row readings per transect. In the Watkinsville experiment where wheel traffic was controlled, the transect was centered over the non-traffic area so that the between-row readings could be subdivided into traffic and non-traffic readings. At each point, mechanical impedance was recorded with depth down to 12 inches. After the penetrometer readings were made, each plot was sampled for gravimetric water content.

Results and Discussion

Plains Experiment

Penetrometer measurements were taken at Plains on August 28 and 29. The soybeans were at approximately the bloom stage of growth at this point and the soil moisture levels were similar in the various treatments. Mean mechanical impedance was low near the surface for all treatments, but below 2 inches the readings in the no-till and disk treatments increased more rapidly than in the plow treatment (Figure 1). The no-till and disk means reached a maximum at about 8-9 inches and decreased slowly below this depth. The maximum readings are in the neighborhood of 20 bars which is high enough to reduce root growth rates. The depth of maximum mechanical impedance in these treatments is a little below the depth of disk tillage and indicates that a pan may be formed by this practice. The absence of such a maximum in the plow treatment indicates that spring plowing may destroy the pan. The difference between means was statistically significant at the depths between 5 and 9 inches below the surface. Between-row means showed a similar pattern, but due to the variability introduced by uncontrolled wheel traffic fewer of the differences were statistically significant.

Although the differences in yield were not significant, there was a trend for the plowed treatment to yield slightly higher than the disk and no-till treatments (table 1). This trend could be due to the presence of a pan in the last two treatments that reduced root penetration below the 6-inch depth.

Table 1. Soybean yields

Location	Tillage			
	Plow	Disk	No-till	Chisel
	bu/A			
Plains	30.6	28.8	21.6	
Watkinsville		19.0	18.0	19.3

Watkinsville Experiment

Penetrometer measurements were made at Watkinsville on August 14 which also corresponded to the bloom stage of growth in these earlier planted soybeans. As at Plains, there was little difference in gravimetric soil contents between treatments, but the soil moisture content was less than in the Plains experiment and penetrometer readings were higher at Watkinsville. Mean mechanical impedance in-row was much lower in the chisel treatment than in the no-till and disk treatments, especially between 5 and 9 inches of depth (figure 2). These differences were statistically significant only between the 3 and 6 inch depths due to a strong interaction caused by very high readings in one replication of the no-tillage treatment. However, it appears that the spring chisel treatment, like the plow treatment at Plains, does a good job of breaking up a pan that may be formed during fall tillage.

Due to the lack of irrigation and extremely droughty conditions in the latter part of the 1984 growing season, soybean yields at Watkinsville were very low and there were no significant differences between treatment means.

Since wheel traffic during the three years of the Watkinsville experiment had been confined to designated inter-rows, we were able to contrast between-row traffic and non-traffic readings. The mean mechanical impedance for these two positions are shown in figure 3 for the no-till treatment and in figure 4 for the disk treatment (the between-row patterns for the no-till and no-till chisel were similar). In both treatments, traffic caused higher readings in the top six inches and this effect seemed to be greater in the disk treatment. The differences were statistically significant down to the 5 inch depth. As with the in-row readings, a maximum occurs at about 7 inches indicating that a pan may be present. Below 6 inches, the highest readings occur in the non-traffic positions and these differences are significant statistically between 10 and 12 inches of depth. This may be due to a slight lowering of the surface elevation in the traffic inter-rows. Displacing the traffic curves down one inch causes them to coincide roughly with the non-traffic curves below 6 inches. This also reduces, but does not eliminate, the differences in the top 6 inches.

Conclusions

In both experiments mean mechanical impedance was high in no-tillage and disk tillage systems especially between 5 and 9 inches below the surface. This is interpreted as evidence of a pan formed by fall disk tillage. Use of a moldboard plow or chisel in the spring appears to break up the pan. In the Watkinsville experiment, wheel traffic had a significant effect on mechanical impedance.

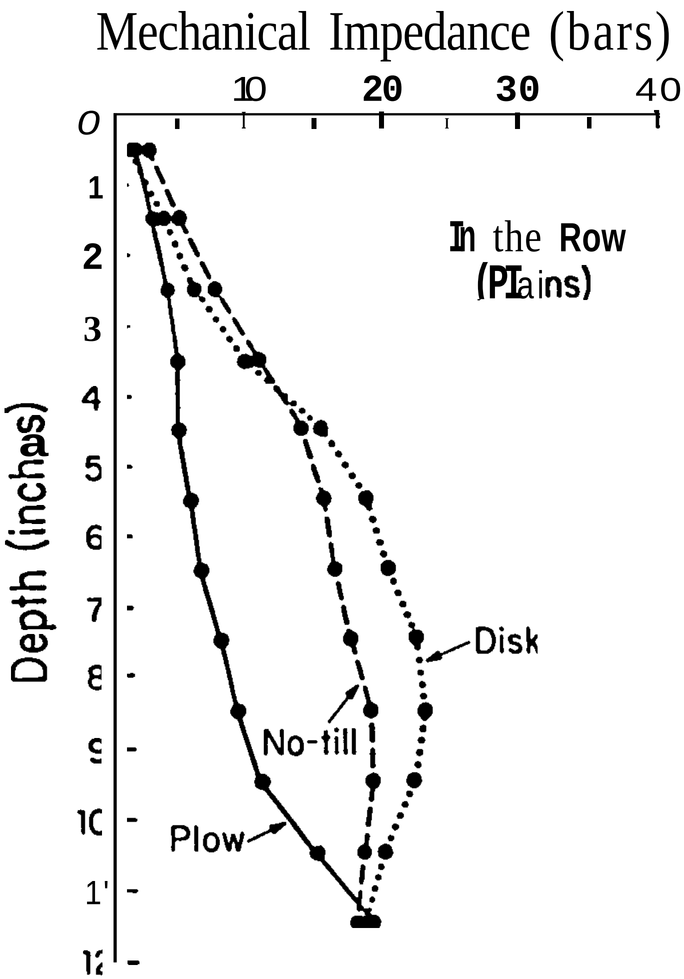

Figure 1. Mean mechanical impedance in-row with depth for three tillage treatments at Plains, Ga.

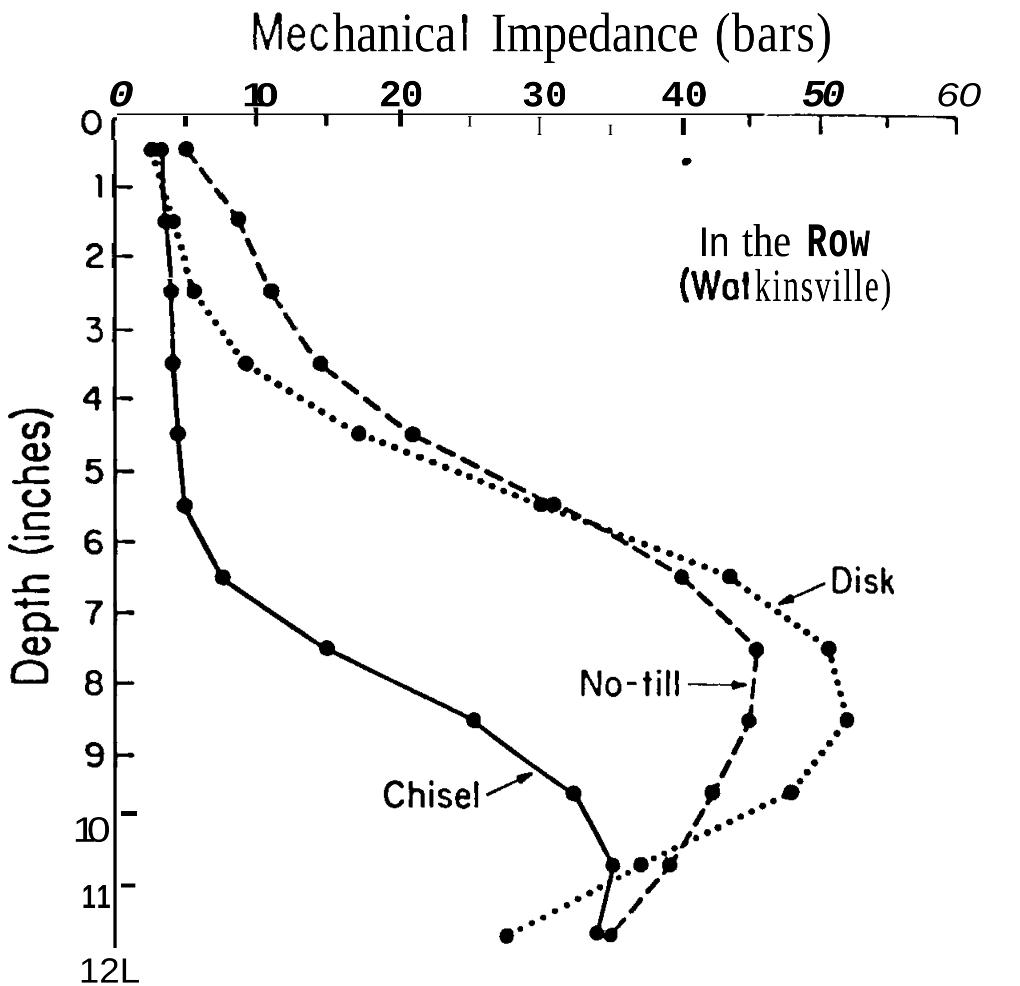

Figure 2. Mean mechanical impedance in-row with depth for three tillage treatments at Watkinsville, Ga.

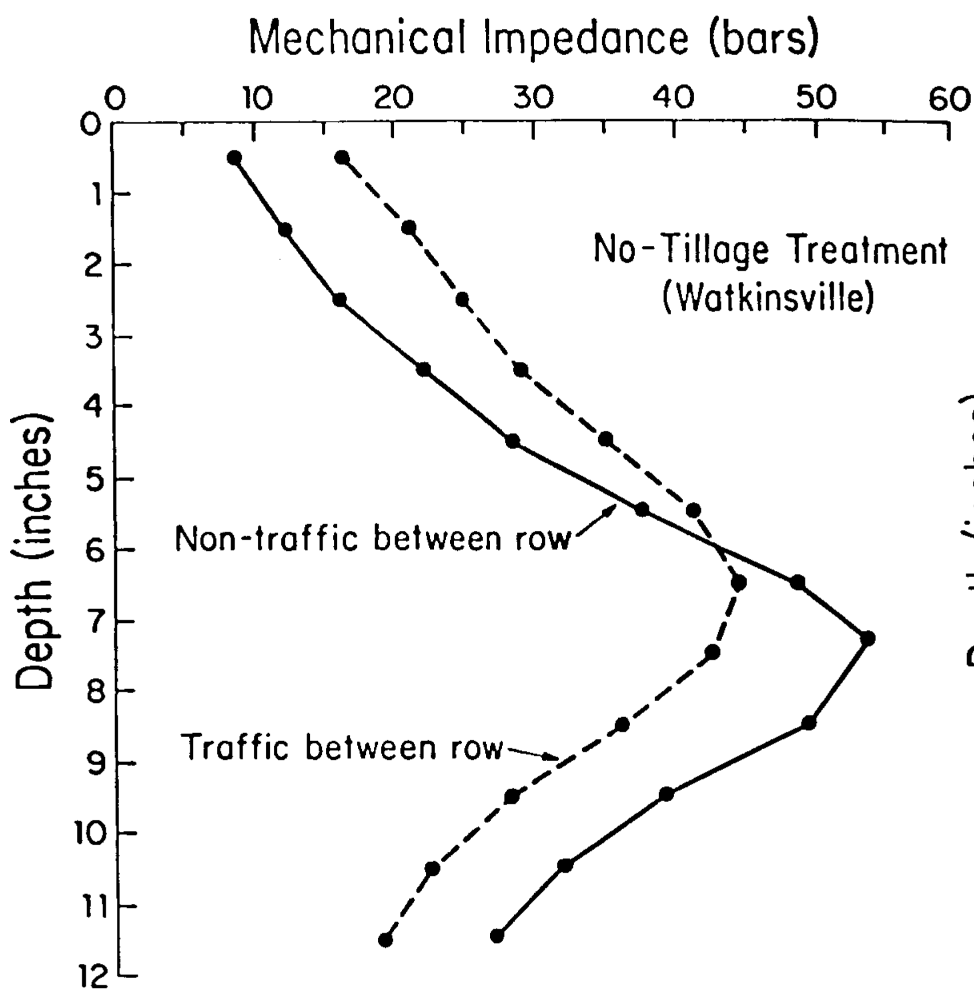

Figure 3. Mean mechanical impedance with depth in the no-till treatment for traffic and non-traffic between-row positions at Watkinsville, Ga.

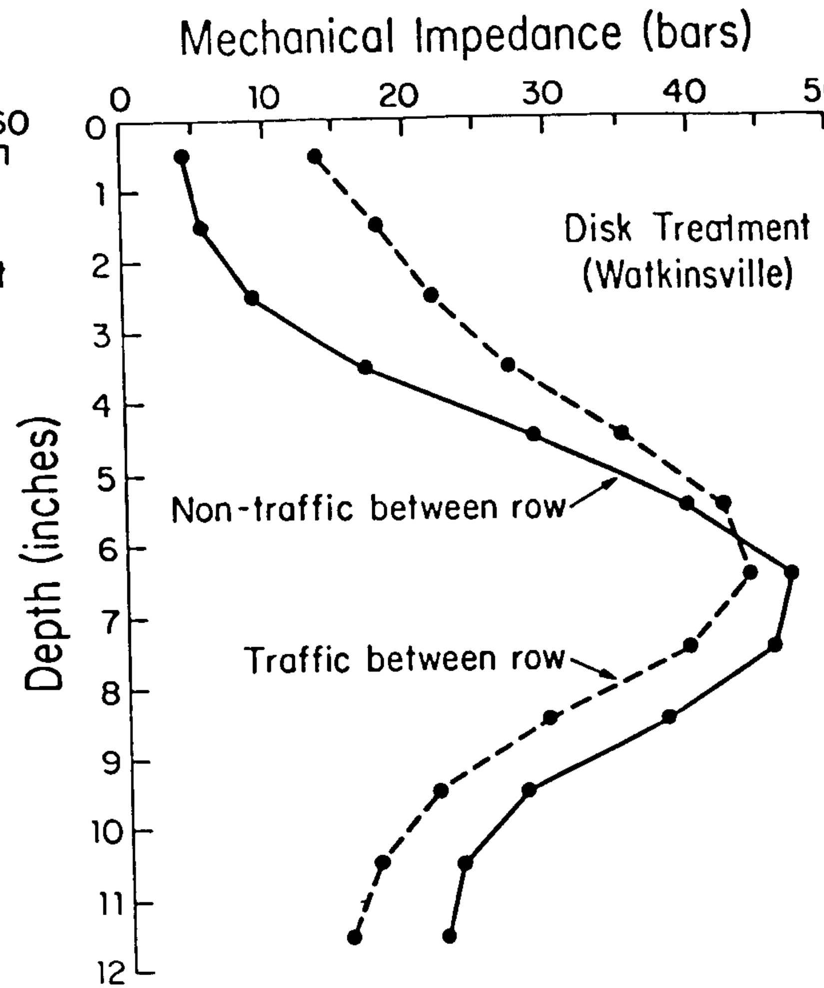

Figure 4. Mean mechanical impedance with depth in the disk treatment for traffic and non-traffic between-row positions at Watkinsville, Ga.