Tillage and Residue Management Effects on Soil Physical Properties

D. S. NeSmith, W. L. Hargrove; D. E. Radcliffe, and E. W. Tollner

Agronomy Department. Georgia Station, Experiment. GA 30212: Agronomy Department, University of Georgia, Athens. GA 30602; Agricultural Engineering Department, Georgia Station, Experiment. GA 30212

In 1984, 2.2 million acres of soybeans (Glycine max) were planted in Georgia, approximately 39% of which were dou e-cropped. With double-cropped soybeans, time often becomes an important factor at planting. Efforts to manage the previous crop residue in the least amount of time have led to the development of a variety of approaches, the most popular of which is burning and disking. Other tillage practices used range from conventional tillage with a moldboard plow to the no-tillage system.

Although extensive research has been conducted in the area of tillage practices, it remains unclear how various tillage and residue management practices affect soil physical properties, especially in Ultisols with poor structural development such as found in the Coastal Plain. The objective of this research was to determine the effects of tillage and residue management on soil moisture, temperature, and bulk density under double-cropped soybean production.

Materials and Methods

The study was conducted at the Southwest Georgia Branch Experiment Station near Plains, Georgia. The soil was a Greenville sandy clay loam (clayey, kaolinitic, thermic Rhodic Paleudult). Wheat had been grown on the area the previous fall. A strip-split, randomized block experimental design was used. Individual plot size was 30 ft X 60 ft. and there were four replications. The main blocks were split into burned and nonburned residue and the tillage treatments were then stripped across these blocks. Tillage practices were no-tillage, disk tillage, and conventional tillage. The no-tillage treatment consisted of direct planting of the soybeans with a fluted coulter planter. The disk tillage consisted of four passes with a disk-harrow prior to soybean planting. This resulted in tillage to a depth of about 3 in where residue was left and 4 in where it was burned. Conventional tillage treatments were moldboard plowed to a depth of 12 in and disked tilled before soybeans were planted. Soybeans were planted in early June and were irrigated three times (1" each time) in the first two weeks to ensure a stand. Three additional applications were made in September during a period of moisture shortage.

Bulk density was determined three times during the season from soil core samples (5.4 cm diameter x 5.9 cm length core). The measurements were taken at planting, one month after planting, and after soybean harvest. Most measurements were made in the soil surface (0-10 cm), but post harvest sampling consisted of 0 to 4 in, 8 to 12 in, and 16 to 20 in measurements. At each date, two samples per plot were taken and bulk density was calculated on a dry weight basis.

Soil gravimetric water content was measured periodically during the season, and converted to a volumetric basis using the measured bulk density. The surface was the primary concern, but samples were also taken from other depths.

Soil temperature was measured approximately 3 times per week for the first 8 to 10 weeks. After this time, the soybean canopy had closed and there were no longer differences between treatments. The temperatures were taken at **3:00** p.m. with thermocouple-type thermometers placed 1 in into the soil. There were four measurements per plot and the mean of these was recorded.

An analysis of variance was conducted on the data, and where differences in treatments were found, Fisher's LSD was used to separate the means.

Results and Discussion

Surface (0 to 4 in) bulk density throughout the growing season was significantly greater in the burned no-tillage, nonburned no-tillage, and nonburned disk tillage treatments than in the other treatments (Fig. 1). There was little change within the no-tillage and nonburned disk treatments, so that a compaction problem at the beginning of the growing season persisted throughout the entire season. Visual observations revealed that the high densities had an adverse effect on soybean root growth. The area was disk tilled in the fall prior to wheat planting. This may have compacted the soil and no-tillage or disk tillage in the spring did not eliminate the problem. The burned disk tillage treatment had a lesser density in the surface, but Fig. 2 shows it was similar to the burned no-till, nonburned no-till, and the nonburned disk tillage treatments at the 8 to 12 in depth. This was probably a result of the straw removal allowing the disk to penetrate deeper in the burned treatment.

The post harvest bulk density measurements (Fig. 2) showed that conventional tillage, burned or not, seemed to eliminate the high bulk density in the upper 12 in. There was a trend for the nonburned plow treatment to have a lower density than any of the other treatments in the upper 12 in. This is probably a result of the incorporation of organic material throughout the profile. There was little or no difference between the treatments at 12 to 16 in.

Soil water content in the surface was generally greater under the no-tillage and nonburned disk tillage treatments (Fig. 3). The presence of mulch was probably the most important factor responsible for the greater moisture content of these treatments. Fig. 4 corresponds to the last sampling date in Fig. 3. On this date, soil water content was measured in 6 in increments to a depth of 2 ft. All treatments had a greater water content than the burned conventional and nonburned tillage treatments, especially in the 8 to 16 in zone. This is probably a result of poor soybean rooting at soil depths of 8 to 16 in under the no-tillage and disk tillage treatments. Much better root growth was observed with the conventional tillage soybeans and as a result, moisture was probably taken from the 8 to 16 in depth. Under no-tillage and disk tillage, the roots were primarily confined to the upper 6 in due to compaction problems.

Temperature measurements were made only on the nonburned treatments and were similar to the results of other researchers (Fig. 5). Soil temperature was generally highest under the conventional tillage treatment (bare surface) and lowest under no-tillage which had the greatest amount of residue on the surface. There was little or no difference between treatments near the end of the season, due to canopy closure and shading by soybeans.

Soybean seed yields are shown in Table 1. The burned no-tillage and burned disk tillage treatments resulted in inferior yields relative to the othe treatments. The greater soil densities with disk and no-tillage probably contributed to the reduced yields for the burned treatments. It is interesting to note, however, that the no-tillage treatment with mulch resulted in yields which were not significantly different from the plowed treatment. This is probably a result of moisture conservation and lower surface soil temperatures where the mulch was present.

Although these results are from only one year of data, some preliminary observations have been made. No-tillage and disk tillage treatments had high bulk densities in the upper 6 in. Soil water contents were greatest and soil temperatures were lowest in the nonburned no-tillage treatment. This was probably due to the wheat residue that was present. The burned disk tillage treatment (the most common practice for double-cropped soybean production in the Coastal Plain) resulted in poor yields.

Table 1. Soybean seed yields.

Tillage Treatment	Residue Management		
	Nonburned	Burned	Mean
	Yield, bu/A		
Moldboard plow	30.6	30.4	30.5
Disk	28.8	26.1	27.5
No-Tillage	27.6	22.7	25.2
Mean	29.0	26.4	27.7
LSD .05	NS	4.8	NS

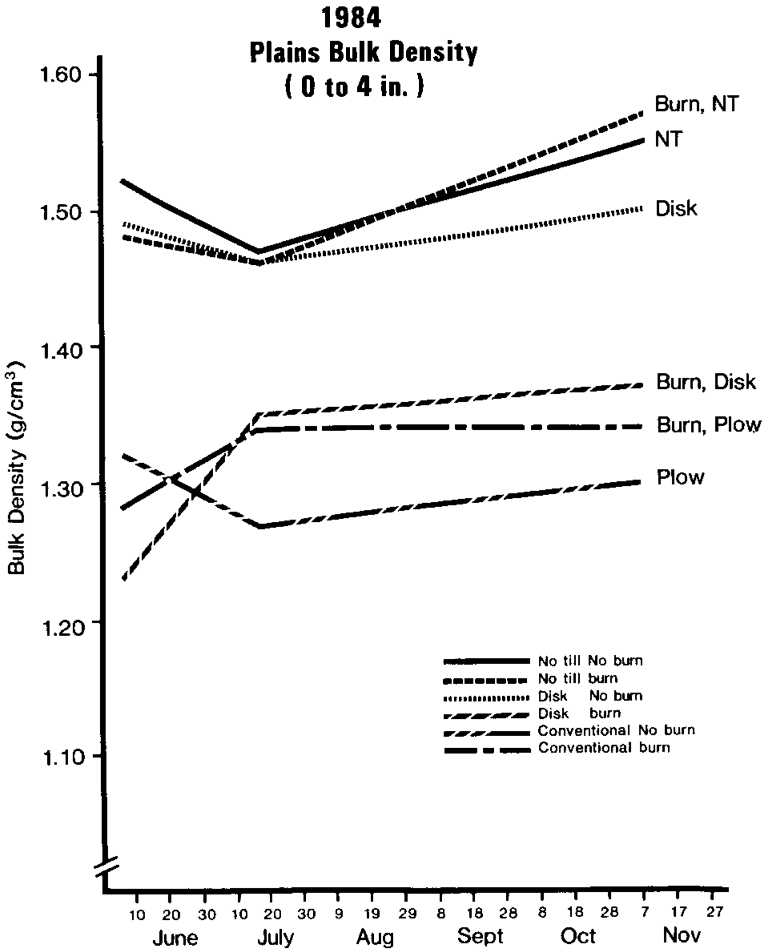

Fig. 1. Surface soil bulk density over time.

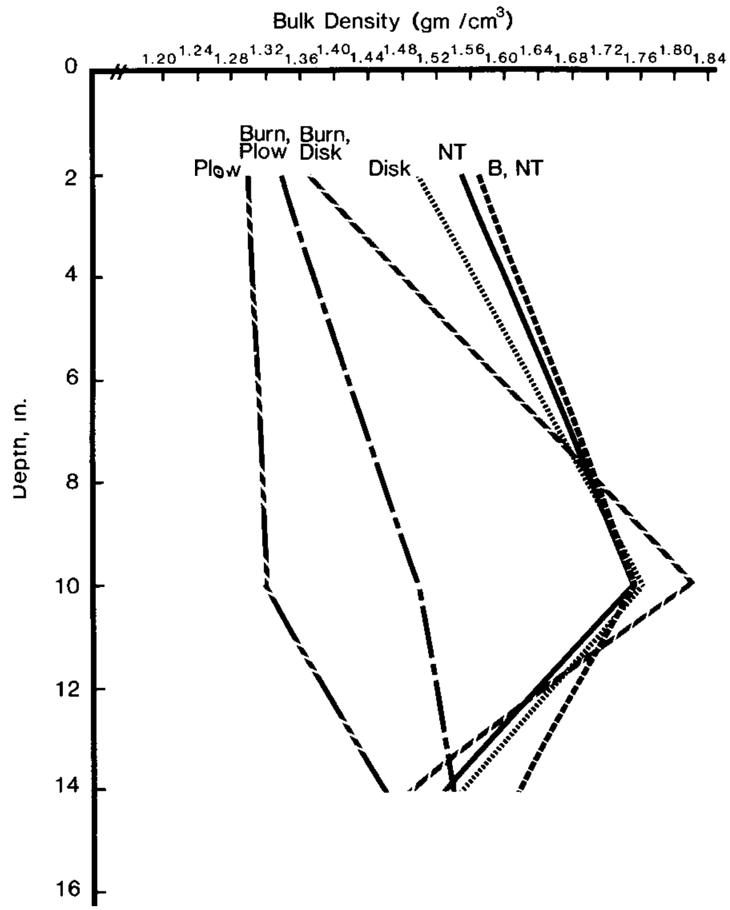

Fig. 2. Bulk density at harvest time.

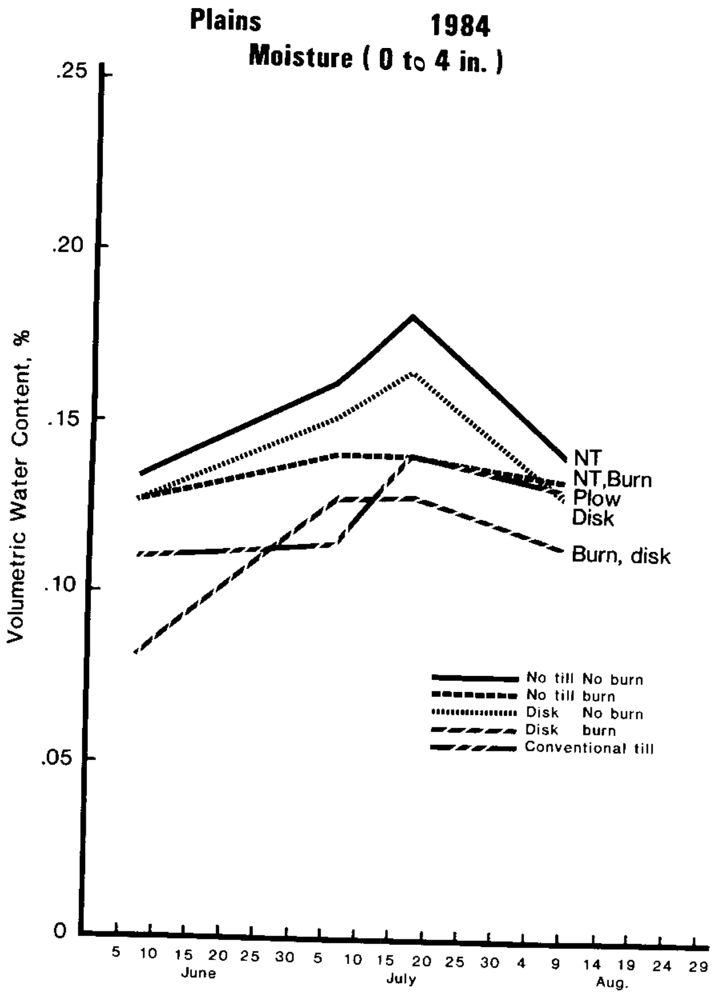

Fig. 3 Surface soil water content over time.

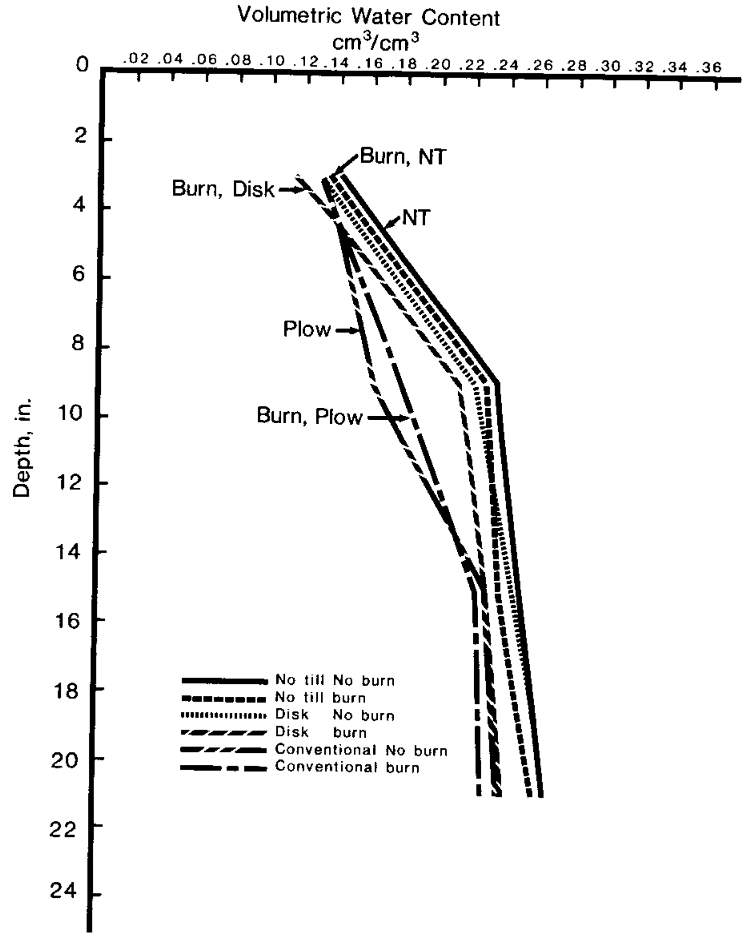

Fig. 4. Soil water content at R-2 soybean growth stage.

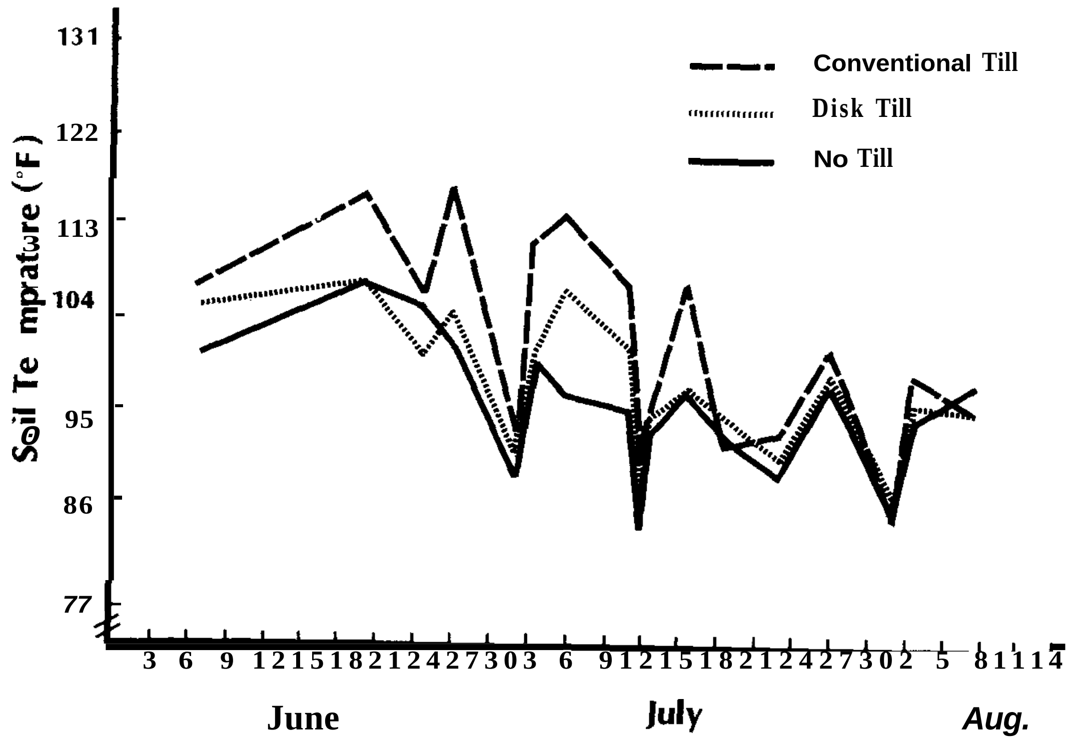

Fig. 5. Surface soil temperature before canopy closure as influenced by tillage.