DEVELOPING CONSERVATION TILLAGE SYSTEMS FOR THE TENNESSEE VALLEY REGION IN ALABAMA

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Abstract

Cotton (*Gossypium hirsutum* L.) has been grown continuously on many of the silt-loam and silty-clay loam soils of Alabama's Tennessee River Valley for over a hundred years. For many of the farms in the region, conservation tillage is the only practical option available to meet soil conservation compliance guidelines, however, yields with no-tillage have not been competitive to conventional tillage on these soils. In 1995 we began a study to develop a conservation tillage system for these soils that would improve soil quality while maintaining yield levels. The study is located at the Alabama Agricultural Experiment Station's Tennessee Valley substation, Belle Mina, AL on a Decatur silt loam. The experimental design is a randomized complete block of four replications. Treatments are: 1) fall ridging with subsoiling, 2) fall ridging without deep tillage, 3) flat planting with subsoiling, 4) flat planting without deep tillage, 5) fall ridging with paratilling, 6) flat planting with paratilling, 7) spring strip tillage, and 8) conventional tillage. A rye (*Secale cereale* L.) cover crop was used on all plots except the conventional tillage treatment. Fall ridging resulted in greater yields than flat no-tillage (1579 lb/A vs. 1404 lb/A seed cotton) and comparable yields to conventional tillage (1508 lb/A). Although paratilling with ridging reduced soil strengths and increased plant growth and soil water use, it did not result in a yield increase in this drought year. The study will continue in order to test the systems over a wide range of environmental conditions.

Introduction

Soils of the Tennessee River Valley in north-central and northwestern Alabama have been extensively, often continuously, farmed to cotton since before the Civil War. The soils are weathered from limestone and are mainly red clay soils with silt loam or silty clay loam surface textures. Many of the region's farms are classified as highly erodible land (HEL) and must have approved plans for soil conservation. Long term continuous cropping to cotton combined with the silty-clay surface texture and undulating topography has resulted in soil degradation from erosion and loss of organic matter. The undulating topography and use of large equipment restricts the use of parallel terraces and farming on the contour with gradient terraces. Consequently, many farmers are turning to conservation tillage as a means to meet compliance. Few growers use cover crops and the conservation tillage system of choice has been to plant into previous cotton stubble. Cotton yields have not been competitive for no-tillage compared to conventional tillage and development of a conservation tillage system that maintains yield levels while improving soil quality is imperative for economic sustainability of cotton production in the area.

After touring farms in the region and soliciting input from growers and specialists from USDA-NRCS, USDA-ARS and Alabama Agricultural Experiment Station (AAES) scientists initiated experiments to develop practical, economically sustainable conservation tillage systems for the area. One of these experiments was begun in 1995 with the objectives of developing a conservation tillage system for cotton in the region that would: 1) maintain economic yield levels, 2) effectively manage soil compaction, 2) maintain crop residues for compliance and erosion control, and 3) increase soil carbon and improve soil physical properties.

Materials and Methods

The study was initiated in November of 1994 on the AAES Tennessee Valley Substation in Belle Mina, AL. The soil type is a Decatur silt loam (clayey, kaolinitic, thermic Rhodic Paleudult), the major soil type in the region. The experimental area had been in continuous no-tillage cotton without a cover crop for 4 yr prior to beginning the study. Plots are eight 40-inch rows wide by 50 ft. long. The experimental design is a randomized complete block of four replications. Treatments are: 1) fall ridging with subsoiling, 2) fall ridging without deep tillage, 3) flat planting with subsoiling, 4) flat planting without deep tillage, 5) fall ridging with paratilling, 6) flat planting with paratilling, 7) spring strip tillage, and 8) conventional tillage. All treatments were accomplished using four row equipment. Subsoiling was done under-the-row using a KMC® ripper bedder. Paratilling was done with a Tye Paratill®. Ridges were made using KMC bedder disks; the subsoiler shank was removed when ridging except for treatment 1. Conventional tillage consisted of fall disking and chiseling followed by disking and field cultivating in the spring prior to planting. Spring strip tillage was done with an experimental Yetter® implement with an in-row shank set to run 8 to 10 inches deep. The implement had a series of disks, coulters and spiders to disturb a zone approximately 12 inches wide over the row. In order to obtain a smooth seedbed, an implement with 18-inch wide rolling baskets was run over the zone prepared by the Yetter® implement. We also experienced difficulties in aligning rows/ridges over the subsoil channel in treatment 1 and this treatment was converted to a subsoiled chisel plowed treatment the first year of the study (1995). For this reason, treatment 1 is not presented in the results and

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discussion section. The treatment was accomplished as intended in fall of 1996.

Rye was seeded with a grain drill immediately after fall tillage treatments were imposed on all treatments except the conventional tillage treatment check. Cover crops are not planted on conventional tillage cotton in the region. The cover crop was terminated with applications of glyphosate on 11 April and gramoxone on 28 April 1995. A four row John Deere Maxi-Emerge® planter equipped with Acra-Plant® retrofit seed opening discs /V-slice inserts and Martin® row cleaners was used to seed 'DPL 51' cotton on 12 May 1995. At planting a liquid starter fertilizer to supply 15 lb N/A and 6.6 lb P/A was applied as a band over the row.

Plant data reported here include plant stands and heights 33 days after planting (DAP), plant height 95 DAP, nodes above white flower (NAWF), percentage open bolls at harvest, and seed cotton yield from the mechanically harvested four middle rows of each plot. Soil temperature was measured continuously for 11 DAP with an electronic datalogger and thermocouples set at the 4-inch depth under the row and in row middles. Beginning 45 DAP, soil water was determined twice weekly from the 0 to 16 inch depth under the row and in row middles using time-domain reflectometry (TDR). Soil strength was determined with a simultaneous five-position, tractor mounted penetrometer immediately after planting. Penetrations were made over the row and 10 and 20 inches either side of the row. Only row position data is presented here. Data were analyzed using appropriate models for analysis of variance and single degree of freedom comparisons. A predetermined significance level of $P \leq 0.10$ was chosen to separate treatment effects.

Results and Discussion

Soil strength measured immediately after planting varied little with tillage treatment until the 6-inch depth. Below this depth there were significant differences in soil strengths to below 24 inches deep (Fig. 1). Conventional tillage resulted in the greatest soil strengths from the 6 to 18-inch depth. Spring strip tillage reduced soil strength to the 8-inch depth. Both paratilling and subsoiling reduced soil strength below 11 inches but the Paratill® resulted in the lowest soil strengths below this depth.

Plant stands were adequate for all treatments. The only difference in plant stands was a stand increase from ridging compared to planting on the flat (3.4 plants/ft. row vs. 2.4 plants/ft. row $P \leq 0.02$). There was a trend ($P \leq 0.11$) for conventional tillage to have a better stand than no-tillage treatments (3.0 vs. 2.4 plants/ft. row).

Plant heights 33 and 95 DAP were significantly affected by treatments. Heights 33 DAP averaged 12.3 inches for no-tillage, 12.0 inches for ridge tillage, and 7.3 inches for conventional tillage. Single degree of freedom comparisons found conventional tillage plant heights less than no-tillage and ridge-tillage treatments ($P \leq 0.001$). Early season plant height differences were not well related to soil temperatures as the only difference in soil temperatures was an average 7 to 9 °F increase in temperatures with conventional tillage and spring strip tillage compared to all other treatments. The shading effect from the killed rye cover crop, which was left standing at planting, increased internode lengths and plant height in all the no-tillage treatments. The early season plant height differences between ridge and no-tillage compared to conventional tillage were also found at 95 DAP ($P \leq 0.001$). In addition, paratilled treatments were taller than treatments that received no deep tillage (38.3 vs. 35.8 inches, $P \leq 0.05$). Height differences were paralleled by a 0.5 to 1 node decrease in NAWF with conventional tillage compared to any no-tillage treatment.

Differences in earliness were also apparent from percentage of open bolls measured 13 days before harvest. Ridging without deep tillage, spring strip tillage, and conventional tillage treatments had the highest percentage of open bolls (85, 83, and 81%, respectively). Paratilled treatments had the lowest percentage open bolls (74%) and they were significantly less ($P \leq 0.05$) than when no deep tillage was performed (average 82%).

Paratilled plots had lower soil strengths and larger plants than other treatments. This resulted in greater soil water use by plants in this treatment throughout the season. The difference in soil water use was most dramatic in the ridge tillage paratilled treatment. Figure 2 compares soil water maintained under the row by the ridge-tilled paratilled treatment to conventional tillage and the strict no-tillage treatment, i.e., planting on the flat with no deep tillage.

Despite drought and outbreaks of tobacco budworm [*Heliothis virescens* (F.)] seed cotton yields averaged 1480 lb/A. Single degree of freedom contrasts showed significant differences ($P \leq 0.10$) between subsoiling without ridging compared to paratilling without ridging (1564 vs. 1321 lb seed cotton/A). The only other treatment effect was that ridging resulted in greater yields than planting flat (1579 lb/A vs. 1404 lb/A, $P \leq 0.08$).

First years results from this study need to be interpreted carefully. Insect pressure and rainfall deficits may have masked treatment effects. Rainfall in June and July was 31 and 35% below the 30 yr mean, respectively. Tillage studies should be done for five or more years in order to account for environmental variations and to allow time for changes in soil properties to occur as a result of different tillage management schemes. Preliminary conclusions, however, indicate that: fall paratilling and subsoiling may be effective in eliminating compaction deep in the soil profile; spring strip tillage may be effective in eliminating surface compaction but is difficult to do on this silty-clay soil; increased plant growth and soil water depletion following fall paratilling with ridging may have retarded earliness and offset potential yield advantages for this treatment combination in this drier than normal year; and a conservation tillage system with fall ridging may increase plant stands and yields compared to strict no-tillage for soils in this area.

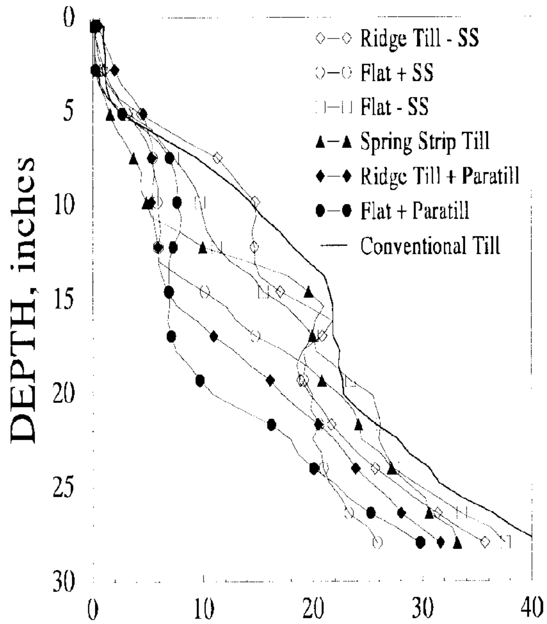

Fig. 1. Soil strength under-the-row at planting on a Decatur silt loam soil in the Tennessee Valley of Alabama as affected by tillage treatments.

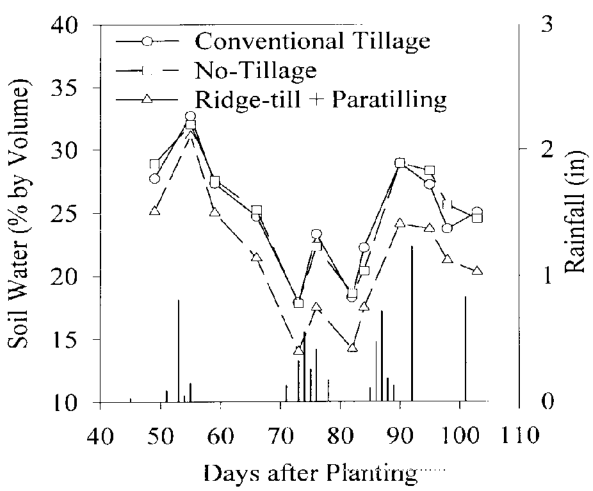

Fig. 2. Volumetric soil water content maintained under-the-row of cotton plants as affected by tillage treatments on a Decatur silt loam in the Tennessee Valley of Alabama.