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COTTON RESPONSE AND SOIL PROPERTY CHANGES WITH LONG-TERM TILLAGE INTENSITIES

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Abstract

Understanding the effect of long-term soil tillage management on soil physical properties, biochemical transformation and microbiological properties is essential to adjustment of soil test recommendations and improved fertilizer nutrient management. Nutrient stratification in no-till (NT) and minimum till (MT) systems can be of concern in soils with limited hydraulic conductivities. Studies have been conducted on Victoria clay and Orelia sandy clay loam soils that have been variably tilled for 18 and 25 years, respectively, to compare various tillage intensities for effects on soil chemical, physical and microbiological properties and profile distribution of nitrogen (N), and phosphorus (P). Tillage variables included NT, deep moldboard (MLB), chisel and conventional tillage (CT). Additional studies were also conducted on an Orelia sand clay loam soil with emphasis on soil physical properties. The objective of these additional studies was to evaluate effects of long-term variable tillage intensities on certain soil physical properties including soil aggregation, soil bulk densities and soil water retention.

Materials and Methods

Zero-till (NT) and MT were compared with CT and deep [30 cm. (MLB)] tillage. Fertilizer nitrogen (N) and phosphorus (P) were applied at soil test recommended rates of 60-80lbN and 20 lb P_2O_5 per acre in most experiments. Both nutrients were band applied as dry, granular ammonium nitrate and triple superphosphate in preplant applications in the early years while fluid iron (32-0-0) and ammonium polyphosphate was used in later years.

Results and Discussion

Soil Chemical Properties

With zero fertilization, a slight decrease (-0.20 unit) in soil pH was measured with NT while a substantial reduction (-1.1 units) was recorded for fertilized NT Victoria clay soil when comparisons were made with the CT tillage system at the 3-5 inch soil depth. Extractable soil nitrates were some 50 percent higher in surface 3 inches of NT as compared to CT soil. Exchangeable K also varied with tillage intensity with NT showing higher K in surface layers. The plant availability of certain trace elements such as Fe and Zn also appeared to be influenced by NT management of soil as was reflected by laboratory estimations.

Extractable soil P appeared to be affected the most by tillage intensity. Laboratory extractions using the Texas A&M Extraction Method (NH_4OAC+EDTA) showed a 50 percent increase in soil test P in the surface one-inch layer of unfertilized soil when NT was compared with the CT tillage system. However, treatments receiving the soil test recommended fertilizer rate of 60-20-0 over a 18 year period produced more than a 100% increase in extractable soil P in the 0-1” and 1-3” and 3-5” layers of NT soil as compared to the CT system. At the 8” depth, tillage showed no effect on extractable soil P. Surface crop residues increase some 1000 percent as tillage intensity decreased from maximum (MLB) to zero tillage (no-till). Soil organic carbon (SOC), measure of organic matter, decreased from initial 1.0 (CT) to 0.88 for MLB, 1.15 (MT) and 1.39 percent for NT. These SOC values can be converted to soil organic matter (SOM) values of 1.9 initially, 1.67, 2.19, and 2.64 percent for MLB, MT and NT, respectively.
It should be pointed out that SOC or SOM changes very slowly with time in these soils. As these data indicate, the most intense tillage operation (Moldboarding) reduced SOM by 12 percent over 20 years while practicing zero tillage for the same length of time increased SOM 39 percent over the initial level and 58 percent as compared to moldboarding. At the same time the MT system increased SOM by 15 and 31 percent as compared to the initial (base) and MLB system, respectively.

Soil Physical Properties

Degree of soil aggregation and stability of aggregates were significantly higher for NT as compared to MT and CT soils. Also moisture retention at low matric potential (-0.01 M Pa) was higher for NT compared to MT and CT systems. At higher matric potentials no tillage effect was evident. Soil compaction as determined by penetrometer readings and bulk densities were highest for NT soils and generally increased with soil depth. After 20+ years of NT management, soils showed a reduction in clay content in the surface 3 inches as compared to CT, chisel and MLB tillage systems. This could possibly have an influence on cation exchange capacity of the soil.

Soil Microbiological and Biological Properties

The long-term NT system showed significantly higher soil microbial biomass C and N at the preplant and mid-growing season sampling periods as compared to MLB and CT tillage systems. Another measurement of soil quality is mineralizable soil nitrogen, which was substantially higher in NT soil. The tillage effect on both microbial biomass and nitrogen mineralization decreases as soil depth increased. These positive tillage effects by the NT system on soil microbial activity/nitrogen nutrition in addition to the depressive effect on soil pH and increased plant available soil P suggest that increased fertilization may not be necessary in establishment of a viable NT system in crop production on alkaline, calcareous soils in South Texas. Earthworm activity (EA) was measured across the major tillage systems for both corn and cotton. No-till for both crops showed 200-300 percent increase in EA as compared to CT and 400-500 percent increase when compared with MLB tillage. Wheel traffic substantially increased soil compaction but also improved EA.

Crop Yields

Earlier crop yield research with conservation tillage systems including NT, MT and in-row deep chisel (MT+CHL) provided less encouraging evidence that these low input systems would survive South Texas crop production adversities. However, as scientific research data continued to be collected over 5, 10, 15 and 20 plus years, evidence continued to mount that NT and MT systems can be very yield competitive with the CT system. A slow change in soil properties, which can impact crop productivity, did occur as anticipated, and after some 10-15 years became significant. Soil quality parameters such as soil aggregation, organic carbon (organic matter), etc. were strongly influenced by long-term conservation tillage (primarily no-till) and are associated with later improved yield comparisons with CT and deep MLB tillage systems.

On the Orelia sandy clay loam soil cotton yields from NT in the early 1980's fell 10-15 percent short of those for CT. No-till yields improved some over the next 15 years but were quite erratic and fluctuated with rainfall as would be expected. On the finer textured Victoria clay, cotton grown with this same no-till system used on the Orelia soil produced yields equal to or exceeding those from CT over a five-year period from 1998-2003. In 2003, no-till cotton on the Victoria clay yielded a record of 1435 lb lint/ac while MT and CT systems produced 1313 and 1335 lb lint/ac, respectively.

Conclusions

Results of this project thus far indicate that NT and MT systems are viable alternatives to CT with benefits of improved soil quality, comparable crop yields and anticipated reduced production costs.