

IMPACT OF REDUCED TILLAGE ON SOIL PHOSPHORUS AND COTTON YIELDS

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Abstract

Tillage and crop residue management practices have been shown to alter soil properties, which influence soil quality and ultimately crop production. This long-term study was performed to determine the effect of various long-term tillage practices on a selected soil property, extractable soil P, and crop yields. An Orelia sandy clay loam soil (hyperthermic Typic Ochraqualf), which received the same cultural practices for the past 27 years, was the test soil. Soil was sampled at 0-6 inches and 6-12 inches following harvest. Tillage treatments studied were: conventional (CT-6 inch depth), moldboard (MB-12 inch depth), minimum till (MT- 3 inch depth), and no-till (NT-zero tillage). Phosphorus fertilizer was band applied at two rates, 20 and 40 lbs. P₂O₅/acre. CT showed the least soil P at both rates in both years sampled. Both conservation tillage systems (MT, NT) produced the highest soil P at the 6-12 inch depth. Cotton yield responses to P fertilizer rates varied within the three years studied, with the greatest tillage effect on yield responses for CT and MB treatments. Environmental factors, specifically precipitation and timing of precipitation, affected yields between years more than tillage and P combined.

Introduction

As the price of N and P continue to be affected by the increasing price of energy for the production of fertilizer, knowing the fate of nutrients in agricultural production operations becomes more imperative. Although phosphorus is highly immobile in the soil, it is still both expensive, and a major plant macronutrient necessary for producing a crop. Tillage and crop residue management practices have been shown to alter soil properties, which influence soil quality and ultimately crop production (Havlin, et al 1990, Matocha and Vasek, 2001). Many studies on tillage, in particular, reduced tillage, have been performed in the eastern United States and Midwest farming regions, yet the effect of reduced tillage on the calcareous soils of the western United States has been sparse. Research on conservation tillage has been less ubiquitous in the warmer southwest USA environment (Potter and Chichester, 1993). This study was performed at the Texas AgriLife research farm at Corpus Christi, Texas on a typical south Texas calcareous sandy clay loam to determine the effect of four long-term tillage practices on extractable soil P and cotton yields.

Materials and Methods

The study was conducted at the Texas AgriLife Research Center farm at Corpus Christi, Texas on an Orelia sandy clay loam soil (hyperthermic Typic Ochraqualf). Some of the characteristics of the surface horizon of this soil are as follows: sand content-60.2%; silt content-14.1%; clay content-25.7%, moisture retention at 0.1 bar-24.7%, and at 0.33 bar-18.2%. Initial soil test showed medium levels of nitrogen and extractable soil P. The study was conducted under dry-land conditions with a mean annual precipitation at the research farm of 32.26 inches, and a mean growing season (Feb.-July) precipitation of 12.64 inches. Growing season precipitation levels for the three years studied are for 2005-10.58 inches, 2007-20.98 inches, and 2008 13.33 inches. It should be noted that no crops were planted in 2006 due to severe drought and all plots remained fallow throughout the year. In 2008, 6.56 inches of precipitation was received in the last week of July. Prior to that precipitation event the cotton plants were moisture stressed for most of the growing season.

Tillage treatments (Table 1) used in this study were conventional till (CT), 12-inch moldboard (MB), minimum till (MT), and no till (NT). Primary tillage practices in CT were performed to a depth of 6 inches using a bed; rebed system with 22 inch sweeps. Middles were run as needed for weed control with the same sweeps. After primary tillage with a moldboard plow to a depth of 12 inches, the bedder plow was used to form beds in the MB treatment. In the MT tillage treatment there is no tillage deeper than 3 inches, and the only cultivation was at lay-by, or the last cultivation prior to excessive crop growth for fieldwork. The blade plow utilized in MT was a McElroy root plow

that severs the roots of the harvested crop. The NT treatment involved zero tillage. All plots were planted with a John Deere maxi-merge planter with row cleaners in front of the disk openers on the planter at a seeding rate of 55,000 plants per acre.

Table1. Description of tillage treatments

Conventional (CT)	Moldboard (MT)	Minimum Till (MT)	No Till (NT)
Shred stalks	Shred stalks	Shred stalks	Shred stalks
Disk	Disk	Root plow and bed (1X)	Spray (2-3X)
Bed out stalks	Moldboard 12 inches	Run middles	Plant/JD MM planter
Re bed	Bed	Pre-emerge herbicide	Spray post emerge herb.
Run middles (2X)	Run middles (2X)	Plant/JD MM planter	
Plant/ JD MM planter	Plant/JD MM planter	Cultivate (1X)	
Cultivate (3X)	Cultivate (3X)		

All soil samples were taken after harvest in both 2005 and 2008. The soil was sampled from 0-6 inches and 6-12 inches depth. The extractable P was extracted by the sodium bicarbonate method. Total extractable P was determined by the molybdophosphoric blue color method in a hydrochloric acid system. Soil test N and P were medium and low, respectively at the start of the study.

To achieve minimal disturbance of the soil surface during fertilization activities, all fertilizer was pre-plant applied by spoke applicator in MT and NT tillage systems, and knife applicator in CT and MB systems. Spoke application of fertilizer was pre-plant at 2-3 inch depth and placed directly in the row. Knifed fertilizer was placed 5 inches beside the row, and 3 inches below planting depth. Nitrogen rate for all tillage variables was blanketed as 60 lbs/ac as uran (32-0-0). Phosphorus was applied at two rates in 20 and 40 lbs/ac P_2O_5 in 2005 and 2007, and 0 and 20 lbs/ac P_2O_5 in 2008. Ammonium polyphosphate (11-37-0) was used as P source in all years.

Treatments were arranged in a randomized complete block design. Tillage systems were compared as main plots. Phosphorus rates were compared within main plots in a split plot design. Main plots consisted of 8 rows with 80 feet plot lengths while split plots (P rates) were compared in 40 feet lengths. All plots were planted to cotton for at least five years (except for 2004 and 2006 when all plots were fallow due to severe drought). The original rotation when the study was implemented 25 years earlier involved 4 years of cotton followed by 4 years of corn.

In 2005, two different genotypes were planted in four row subplots side by side. DP&L 444RR (broadleaf type) was compared with FM 832RR (okra leaf type) across all tillage systems and P rates. In 2007, ST4554B2RF was planted in all plots across all tillage systems and P rates, while ST5527 B2RF was planted in 2008.

Results and Discussion

Extractable soil P, 0-6 inches depth, in CT system was significantly lower for both rates of applied P for both years (Fig 1), as well as significantly lower for the high rate in 2008 (Fig. 2). Other tillage systems were not significantly different except MT in 2008 (Fig. 2). Extractable soil phosphorus, 6-12 inches depth was significantly lower for both rates and both years for CT and MB systems as compared to MT and NT. Extractable soil P in this study may be mostly inorganic. It is possible that tillage practices will have a greater impact on soil organic P as compared to inorganic fractions, especially in MT and NT tillage systems where soil organic carbon and total soil organic matter tend to be much higher.

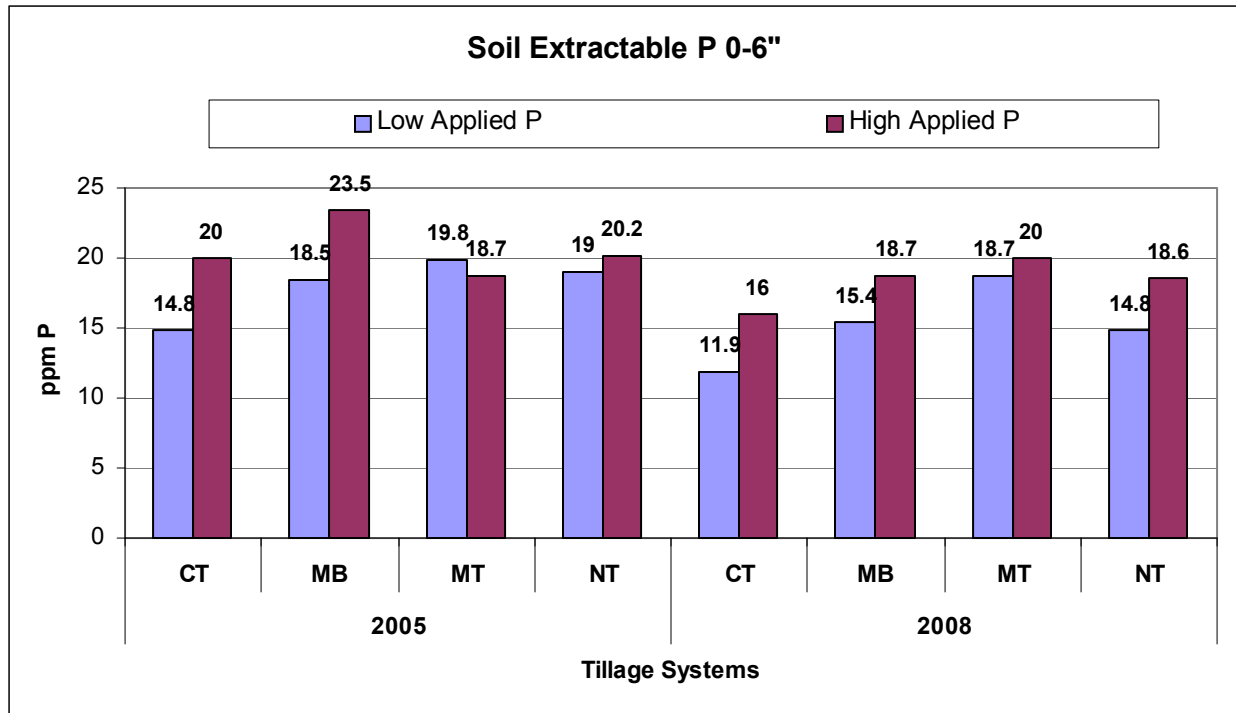


Figure 1. Effects of tillage systems on extractable soil P in surface 6 inches at two rates of P application for each of two years.

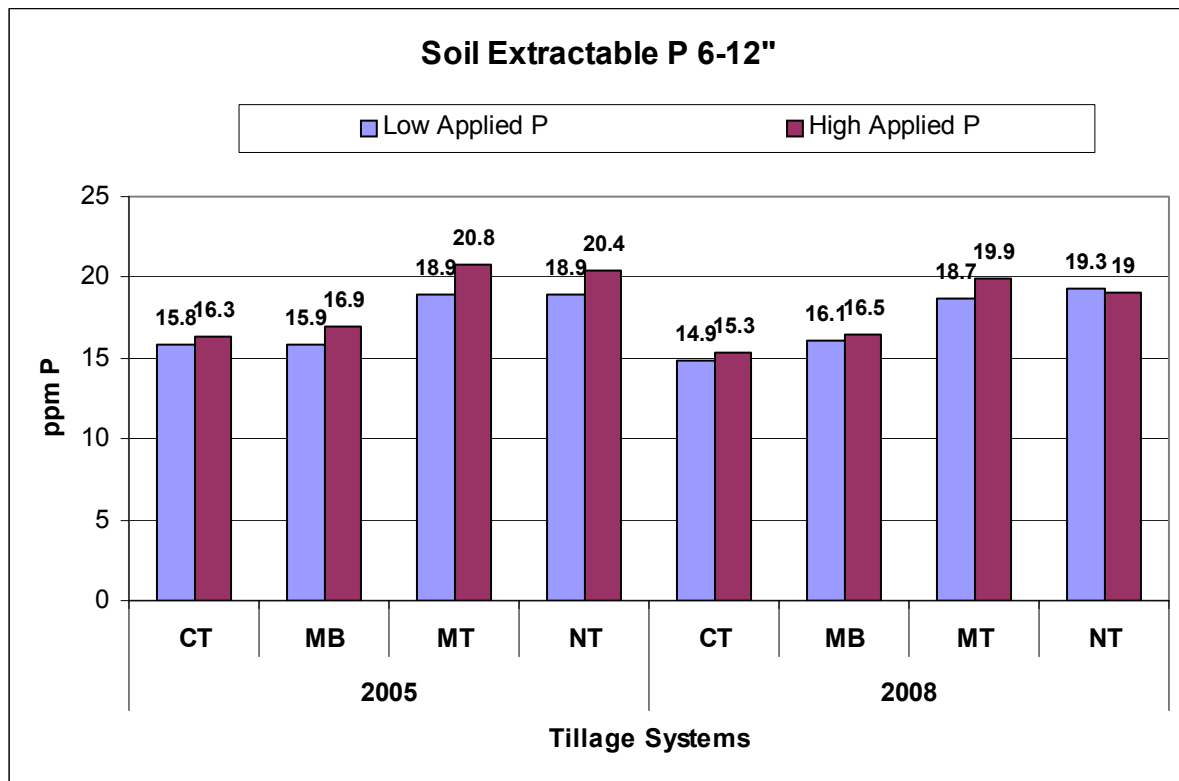


Figure 2. Effects of tillage systems on extractable soil P, at 6-12 inch depth, at two rates of application for each of two years.

Yield Results

Yield results from 2005 indicate extremely good lint production with above average yields (Fig. 3). These yields reflect the near optimum seasonal rainfall and soil moisture conditions as compared to the last year of this study. The data show a significant response to tillage systems.

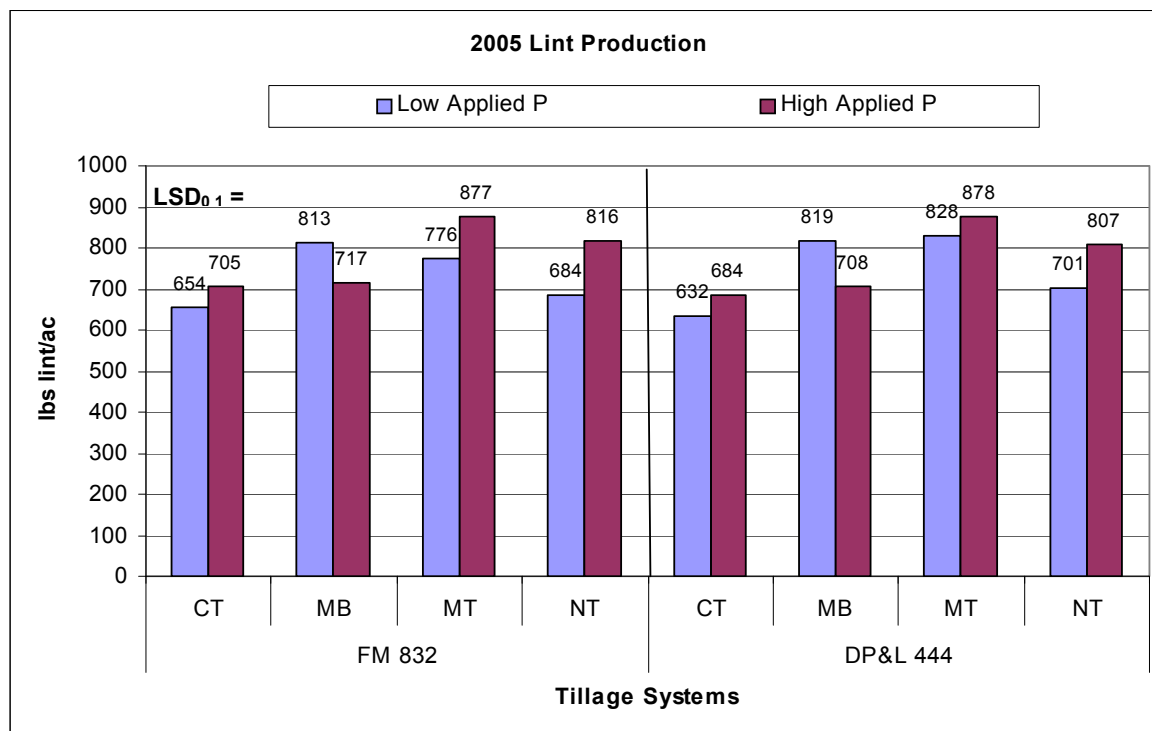


Figure 3. Cotton lint yields from 2005 comparing two cultivars across four tillage treatments and two P rates.

Both cotton cultivars responded significantly to P in the NT system, while in MT, only the okra leaf (FM 832) showed a significant P response. Cultivars did not respond differently to tillage systems. However, within cultivar, lint yields were significantly higher for MT cotton than CT at both levels of applied P while the NT was higher only at the high rate. With the broad leaf DP&L 444 cultivar yields, with the MT system were 196 and 194 lbs/ac higher than with CT at the low and high P rates, respectively. Although NT yields were slightly lower than MT, they were still significantly higher than CT in most cases. The MB tillage system produced a significant yield increase over the CT system only in the low P treatment. Yields with MB tillage were decreased by increasing P from 20 to 40 lb P₂O₅/ac. Since this decrease only occurred in 2005, no plausible explanation is offered at this time.

Due to severe drought, no yields are available for 2006. Lint yields in 2007 showed record yields and comparable to those for 2005. A significant response to applied P occurred in the CT system (Fig. 4). The 2007 crop year was a particularly wet year with almost twice the normal precipitation that is received during the growing season, and subsequently, all tillage systems produced above average yields. Yield differences due to tillage were highly variable and generally non significant with the exception of CT with the high P rate.

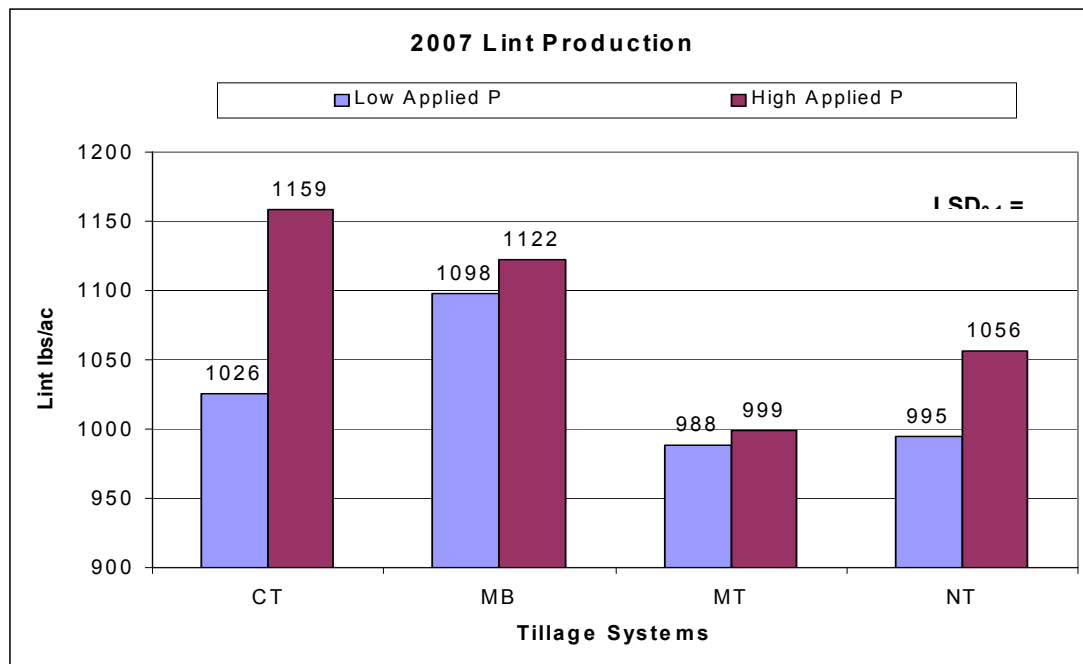


Figure 4. Cotton lint yields from 2007 comparing two rates of P across four tillage treatments.

Lint yields in 2008 were much lower than the previous two years due to lack of appreciable precipitation until the end of the growing season. When the large precipitation event happened the last week of July, the cotton had already reached cutout, and the rain did not boost yields. Lint yields averaged across all treatments showed only 32% of yields from the previous year. A significant difference due to applied P was measured only in the MB system in 2008 (Fig. 5). A slight response to P rate was suggested by data in the MT and NT systems. Cotton yields in the MT system almost equaled those from CT tillage and were significantly higher at the high P rate than yields in the NT system.

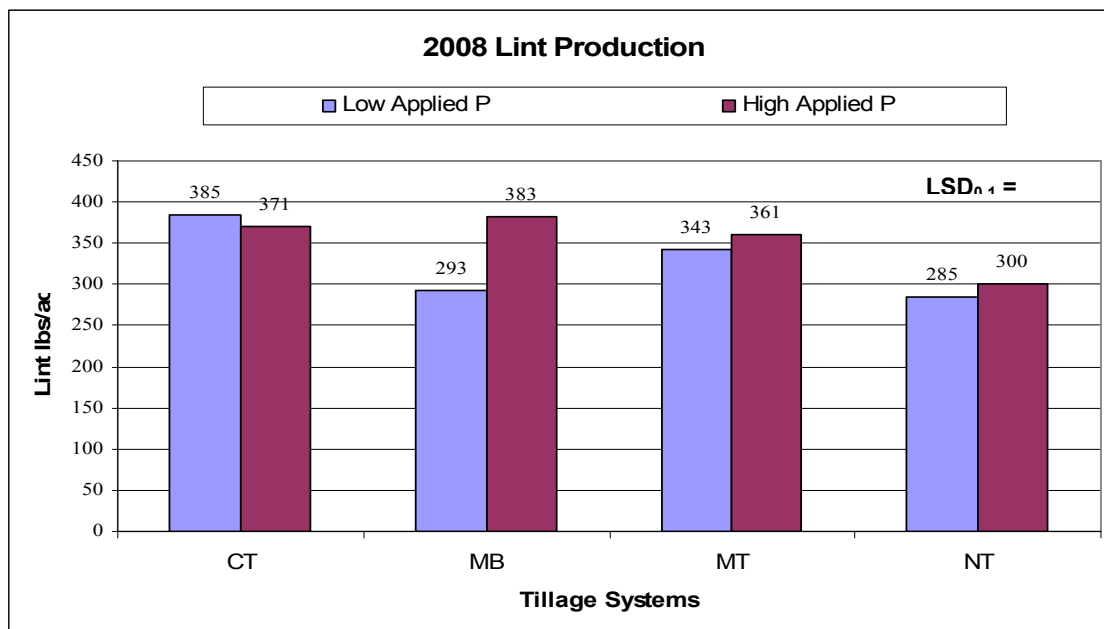


Figure 5. Cotton lint yields from 2008 comparing two rates of P across four tillage treatments.

Summary

The impact of reduced tillage (MT and NT) on lint yields on a calcareous sandy clay loam was significantly greater than with CT and MB when an average precipitation season occurred. Average lint yields for the MT system were 30% higher than those for the CT system when seasonal precipitation was adequate. Three-year average yields were 8% higher with MT production of cotton while deep tillage with moldboard plow increased yield 6% over the CT system. In general, lint yield responses to tillage systems were inconsistent during the three years, in most part due to variable precipitation across the growing seasons. Although there were significant lint yield responses to soil applied P, they were not consistent throughout the 3 years. Reducing the rate of applied P in a MB system during a droughty season appeared to significantly reduce lint yields. Generally, the largest response to P was measured in the CT and MB systems. Although not always significant, response to P appeared most consistent in NT and MB plow systems. Cultivar type appeared to have no influence on response to tillage but significant response to high rate of applied P was measured for both cultivars in the NT system. Precipitation amounts and timing affected the lint yields more than both applied soil P and tillage systems. Yield data for a different soil type (Victoria clay) on the same research farm and the same time period have shown greater response to limited tillage systems (both MT and NT), but that data was not included in this study.

Acknowledgements

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References

- Havlin, J.L, Kissel, D.E., Maddux, L.D., Classen, M.M., Long, J.H., 1990. Crop rotation and tillage effects on soil organic carbon and nitrogen. *Soil Sci. J.* 54, 448-452.
- Potter, K.N., and Chichester, F.W., 1993. Physical and chemical properties of a vertisol with continuous controlled traffic, no-till management. *Trans. ASAE* 36, 95-99.
- Matocha, J.E., Vacek, S. G., 2001. Changes in soil properties as influenced by long-term no-till. *Proceedings Beltwide Cotton Conferences*, p. 589.