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Effect of Timing of In-Row Subsoiling on Soil Properties, Cover Crop Production, and Cotton Production

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Abstract. *Soil compaction is often treated in the Southeastern United States by using the conservation practice of annual in-row subsoiling. It is common to in-row subsoil immediately prior to planting, however, lack of adequate rainfall in the spring of the year can prevent timely tillage and planting events. It may be helpful to conduct in-row subsoiling during winter months when rainfall is plentiful. An experiment was conducted to determine the effects of elapsed time between in-row subsoiling and planting on a highly compactable Coastal Plain soil. In-row subsoiling was conducted by two different subsoilers, a KMC and a Paratill™, during winter months when time and rainfall was more readily available. Results from this 2 year study (which is continuing) indicated that reduced bulk density, reduced cone index, and slightly increased cash crop and cover crop yields resulted from in-row subsoiling immediately prior to planting.*

Keywords. Soil compaction, strip-tillage, biomass

Introduction

Soils in the southeastern U.S. are prone to severe soil compaction caused by natural soil conditions and vehicle traffic (Craul, 1994; Raper, 2005a). Vehicle traffic can be controlled but is limited in its ability to reduce soil compaction below levels acceptable for crop production (Reeves et al., 1992; Raper et al., 1994; Raper et al., 1998). Even though conservation tillage systems have been found to reduce the effects of soil compaction in this region, they have not been able to completely eliminate the need for annual in-row subsoiling (Raper et al., 2000; Schwab et al., 2002). Coastal Plain soils have been especially problematic, with naturally occurring soil compaction requiring annual tillage.

In-row subsoiling is a conservation tillage practice that leaves significant amounts of residue on the soil surface while adequately disturbing compacted soil profiles (Raper, 2005b). This tillage practice is mostly conducted on an annual basis (Busscher et al., 1986; Tupper et al., 1989; Barber, 1994). One significant disadvantage of not conducting an in-row subsoiling operation every year is that in a drought year, yields are generally higher when subsoiling has been recently completed. The previous studies also indicated that significant reconsolidation was possible when in-row subsoiling was not applied on an annual basis. However, the effect of smaller amounts of time that would elapse between the tillage operation and the planting event is largely unknown, particularly for these highly compactable southeastern U.S. soils. For problematic southeastern soils where compaction must be annually eliminated, it is normally thought that subsoiling must be conducted relatively closely to the time when roots are actively growing where they can fully utilize the loosened soil condition. However, in some spring months, due to unpredictable rainfall and weather patterns, an abundance of time for an in-row subsoiling operation may not be plentiful. In-row subsoiling conducted during the winter months may offer adequate crop and soil benefits.

Therefore the objectives of this study were to determine the effect of time elapsed since in-row subsoiling on:

1) Cotton productivity,

2) soil strength, and

3) cover crop productivity.

Methods and Materials

An experiment was conducted at the E.V. Smith Research Center near Shorter, AL to determine when the optimum benefits would occur with the timing of in-row subsoiling for eradication of severely compacted soils. The soil selected for this experiment was a Compass loamy sand soil (*coarse-loamy, siliceous, subactive, thermic Plintic Paleudults*) which is a Coastal Plain soil commonly found in the southeastern U.S. and along the Atlantic Coast of the US. The soil is easily compacted and a hardpan condition is often found at depths of 20-30 cm. The experiment began in the fall of 2004 and will be concluded in 2007.

The first factor to be considered was the shank type; angled or bentleg. The shanks used for the experiment were from two different manufacturers and were mounted on 4-row toolbars. The straight shank was an angled in-row subsoiler shank which was manufactured by Kelley Manufacturing Company[1] (KMC; Tifton, GA). The shank design had an angle of 45° with the horizontal. This shank had a width of 25-mm and used a wear tip of 44-mm width. Wear plates

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[1] The use of company names or tradenames does not indicate endorsement by USDA-ARS.

were used with the shanks to simulate conditions of actual use. A bentleg shank was also included in the study. Bigham Brothers Inc. (Lubbock, TX) manufactured the Paratill™ shank which was formerly manufactured by Howard Rotovator and ICI (Harrison et al., 1991). This shank is bent to one side by 45° and with the leading edge rotated forward by 25°. As the shank travels forward, it contacts the soil over a 216 mm width. The Paratill™ has a 57-mm wide point.

The second factor to be considered was the period of time that had elapsed between the time of subsoiling and planting; 0, 6, 12, or 18 weeks. In-row subsoiling was conducted at each of the four elapsed times to assess how quickly the soil reconsolidated and what effect this in-row subsoiling operation had on crop productivity, cover crop productivity, and soil condition.

A 2 x 4 randomized block experiment with an additional treatment of no-in-row subsoiling (no-till) with four replications was conducted on 4-row plots (0.76-m row spacing) which were 6.1-m long by 3.0-m wide. The two factors were subsoiler shank (KMC subsoiler and Paratill™ subsoiler) and timing elapsed between in-row subsoiling and planting (0, 6, 12, or 18 weeks).

A rye (*Secale cereale* L.) cover crop was established in the fall immediately after harvest on all plots by drilling. In the spring prior to planting, three random 0.25 m^2 measurements were obtained from each plot to obtain the amount of biomass present.

As a cash crop, cotton (*Gossypium hirsutum* L.) was planted on all plots in April of each year. Measurements of cotton yield were obtained from the middle two rows of each plot.

After harvest in 2006, a set of five cone index measurements was acquired with a multiple-probe soil measurement system (MPSMS) (Raper et al., 1999). This set of measurements was taken with all five-cone index measurements being equally spaced at a 0.19-m distance across the soil with the middle measurement being directly in the path of the shank. Using the frame of the MPSMS, bulk density measurements were also taken in the row. Cores obtained with the MPSMS were sliced into 5-cm depth increments. Three cores were taken to quantify the disturbed soil profile.

Preplanned single degree of freedom contrasts and Fisher's protected least significant difference (LSD) were used for mean comparison. A probability level of 0.1 was assumed to test the null hypothesis that no differences existed between shanks or tillage timing treatments.

Results and Discussion

Soil Effects

Differences in average bulk density measurements were found between depths (p ≤ 0.01), tillage timing treatments (p ≤ 0.08), and with a significant tillage timing treatment by depth interaction (p ≤ 0.01). The most obvious differences occurred with depth with the smallest values occurring near the soil surface, gradually increasing with depth to approximately 20 cm where the soil hardpan was located, and then declining with depth (fig. 1). Another obvious difference was that the no-till treatment had the greatest bulk density values at almost every depth at which measurements were taken. Few significant differences in bulk density were found between the various subsoiling treatments.

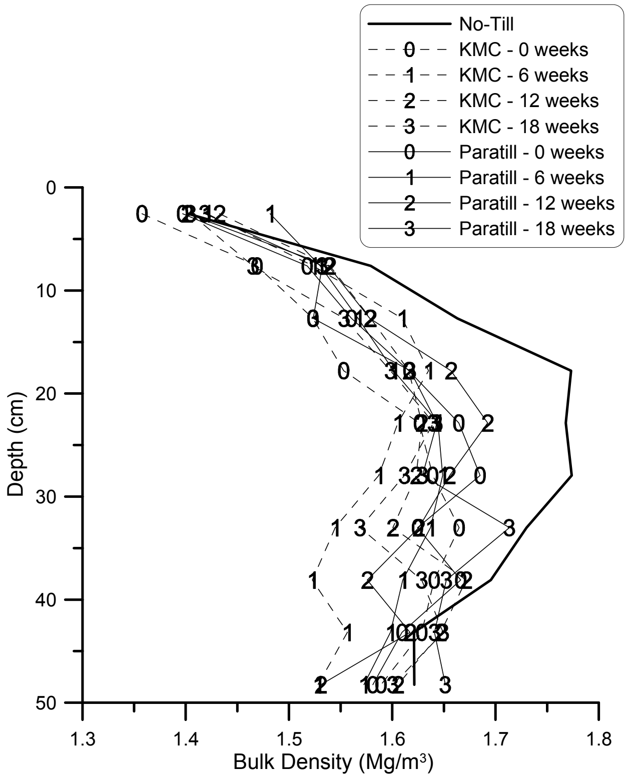

Figure 1. Bulk density measurements taken in the row in fall of 2006 showing differences in tillage timing treatments.

Differences in cone index measurements were found between depth (p ≤ 0.01), tillage timing treatments (p ≤ 0.03), and sampling positions across the row (p ≤ 0.01) with significant interactions occurring between tillage timing treatment by depth (p ≤ 0.01), sampling position by depth (p ≤ 0.01), and tillage timing treatment by sampling position (p ≤ 0.01). Obvious differences occurred between the positions at which the measurements were taken, with the greatest values occurring in the trafficked region, median values occurring in the non-trafficked region, and minimum values occurring in the in-row position which received the maximum benefit from in-row subsoiling (fig. 2). It is important to note that only with the in-row subsoiling position do cone index values fall below the threshold value of 2 MPa which is normally recognized to limit root growth (Taylor and Gardner, 1963).

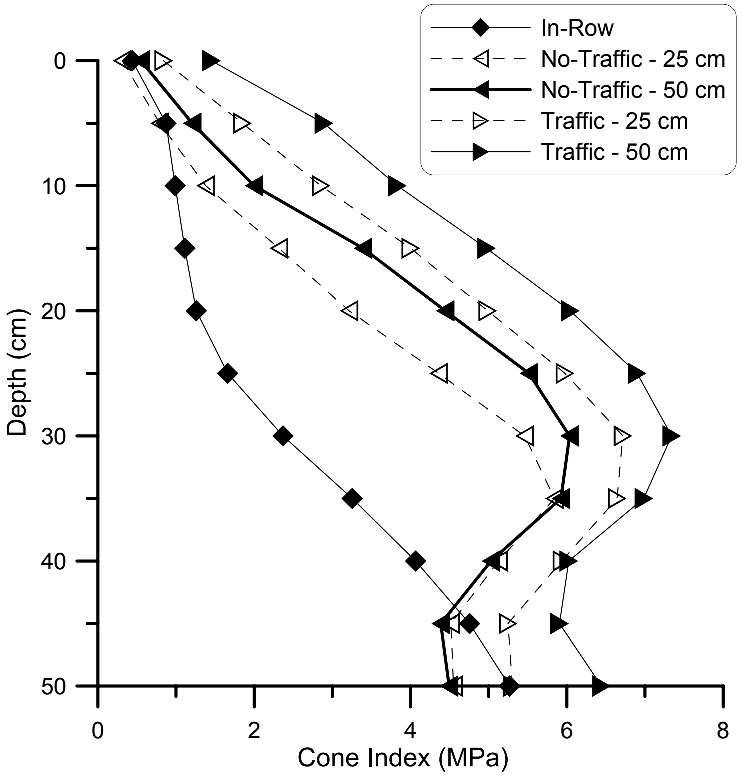

Figure 2. Cone index measurements averaged across all tillage timing treatments shown in the different row positions where they were obtained.

Considering only the in-row position where cone index was most affected by in-row subsoiling, significant differences were found in depth ($p \leq 0.01$) and tillage timing treatment ($p \leq 0.01$) with a significant interaction occurring between tillage timing treatment by depth ($p \leq 0.01$). The no-till treatment had excessive values in cone index that would limit root growth occurring as shallow as 10 cm (fig. 3). Few significant differences occurred between any of the other treatments with the only notable trend being that the most recently in-row subsoiled area had the minimum values of cone index. The Paratill™ tended to adequately disturb soil down to 30 cm for all tillage timing treatments while the KMC only adequately disturbed down to 20 cm.

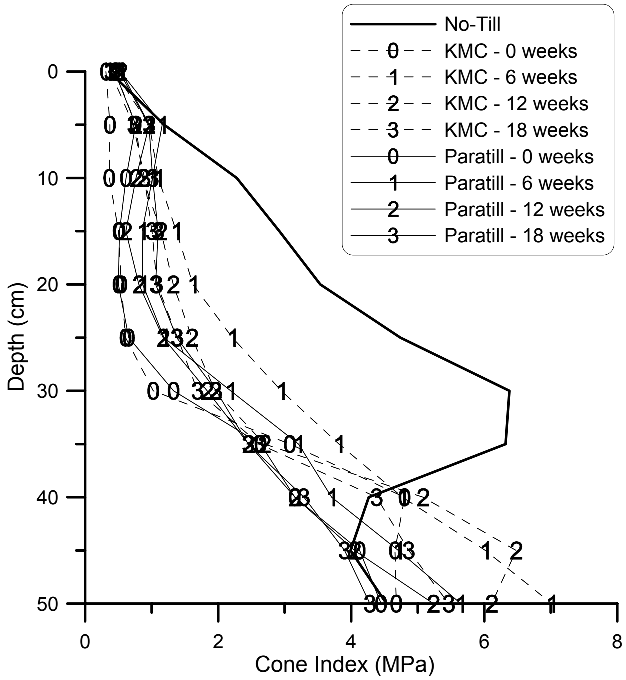

Figure 3. Cone index measurements from the in-row position for all tillage timing treatments.

Crop Effects

No significant differences occurred between the seed cotton yields measured based on the time of in-row subsoiling for either year of the study. However, a trend existed that indicated that all treatments that received in-row subsoiling had greater yields than the no-till treatment (fig. 4). A slight trend was also noted that indicated larger yields were mostly found with the minimum time elapsed between in-row subsoiling and planting.

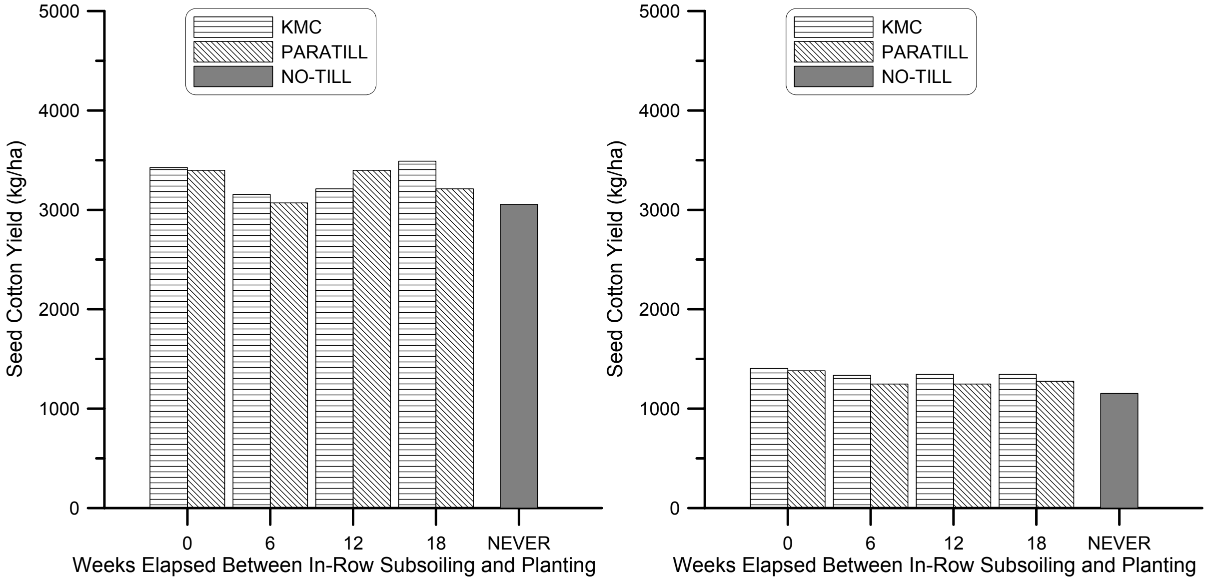

Figure 4. Seed cotton yield produced by the tillage timing treatments for 2005 (left) and 2006 (right). Letters indicate $LSD_{0.1}$ while absence of letters indicates no significant differences were found.

Cover Crop Effects

During the first year of the study (2005), large variations in cover crop production were found which may have negated any significant treatment effects (fig. 5). One important consideration is that in-row subsoiling conducted during the winter months could have a negative effect on cover crop biomass production due to root disturbance when the cover crop is actively growing. However, most treatments produced more biomass than the no-till treatment which did not receive any subsoiling. Even those treatments that had the minimum amount of time occurring between in-row subsoiling and planting had some positive benefits associated with the tillage practice.

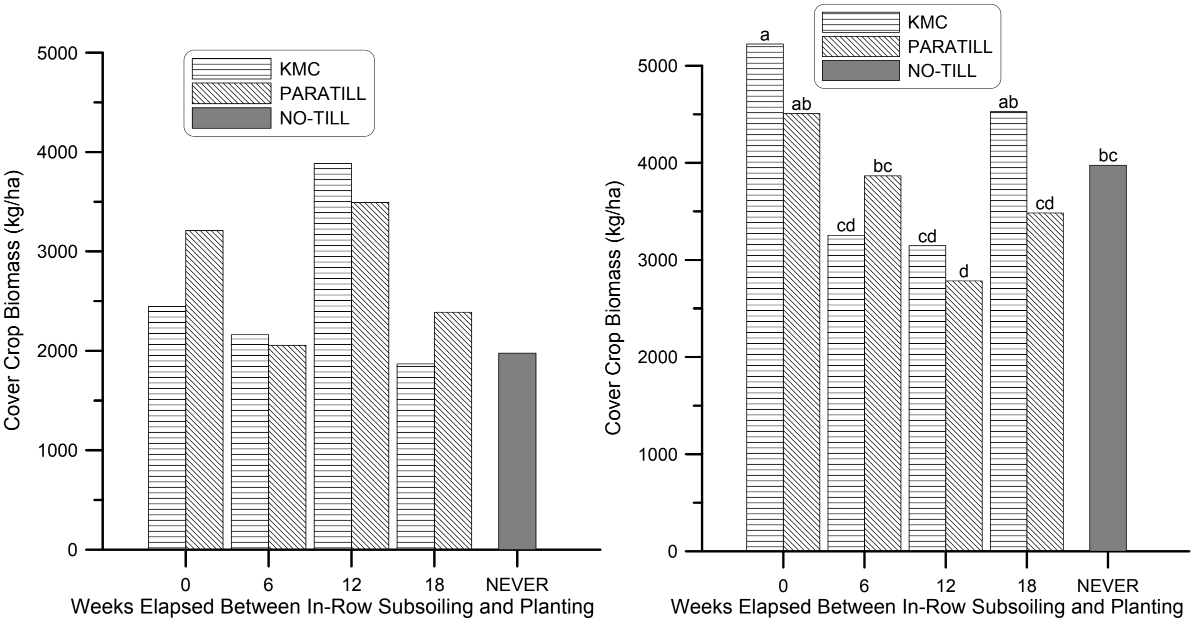

Figure 5. Cover crop biomass produced by the tillage timing treatments for 2005 (left) and 2006 (right). Letters indicate $LSD_{0.1}$ while absence of letters indicates no significant differences were found.

In 2006, the biomass produced by the cover crop was greatest owing to the least amount of time that had elapsed between subsoiling and planting of the cover crop (fig. 5). Even though this in-row subsoiling practice occurred several months before the cover crop was planted, the plants were able to utilize this disturbed area more effectively than the previous in-row subsoiled treatments. Also, in 2006, the plots that had never been subsoiled produced greater cover crop biomass than several of the tillage timing treatments. Disturbance of the roots while the crop was actively growing could have been the cause of this phenomenon.

Conclusions

1. Bulk density and cone index measurements indicated that no-tillage had significantly greater soil strength in the row than any of the treatments that received in-row subsoiling. Increased elapsed time between subsoiling and planting also tended to increase soil strength.

2. No significant differences in cash crop yield were found between the treatments in either year, but a trend existed that all in-row subsoiling treatments had greater seed cotton yields than the no-in-row subsoiling treatment. A slight increase in seed cotton yield was also noted as the time elapsed between in-row subsoiling and planting declined.

3. Increased cover crop biomass was found in 2006 with the most recently occurring in-row subsoiling (0 weeks prior to planting) resulting in the greatest amount of biomass.

References

Barber, R.G. 1994. Persistence of loosened horizons and soybean yield increases in Bolivia. *Soil Sci. Soc. Am. J.* 58(3):943-950.

Busscher, W.J., R.E. Sojka, and C.W. Doty. 1986. Residual effects of tillage on Coastal Plain soil strength. *Soil Sci.* 141(2):144-148.

Craul, P.J. 1994. Soil compaction on heavily used sites. *Journal of Arboriculture* 20(2):69-74.

Harrison, H. P., D. S. Chanasyk, and J. C. Kienholtz. Deep tillage with a bentleg plow. *ASAE Paper* No. 91-1554, 1-10. 1991. St. Joseph, MI, ASAE.

Raper, R.L. 2005a. Agricultural traffic impacts on soil. *J. Terra.* 42:259-280.

Raper, R.L. 2005b. Subsoiling. In *Encyclopedia of Soils in the Environment,* pp. 69-75. D. Hillel, D. Rosenzweig, K. Powlson, M. Scow, M. Singer, and D. Sparks, ed. Oxford, U.K.: Elsevier Ltd.

Raper, R.L., D.W. Reeves, and E. Burt. 1998. Using in-row subsoiling to minimize soil compaction caused by traffic. *J. Cotton Sci.* 2(3):130-135.

Raper, R.L., D.W. Reeves, E. Burt, and H.A. Torbert. 1994. Conservation tillage and traffic effects on soil condition. *Trans. ASAE* 37(3):763-768.

Raper, R.L., D.W. Reeves, E.B. Schwab, and C.H. Burmester. 2000. Reducing soil compaction of Tennessee Valley soils in conservation tillage systems. *J. Cotton Sci.* 4(2):84-90.

Reeves, D.W., H.H. Rogers, J.A. Droppers, S.A. Prior, and J.B. Powell. 1992. Wheel-traffic effects on corn as influenced by tillage system. *Soil Till. Res.* 23(1-2):177-192.

Schwab, E.B., D.W. Reeves, C.H. Burmester, and R.L. Raper. 2002. Conservation tillage systems for cotton grown on a silt loam soil in the Tennessee Valley. *Soil Sci. Soc. Am. J.* 66(2):569-577.

Taylor, H.M., and H.R. Gardner. 1963. Penetration of cotton seedling taproots as influenced by bulk density, moisture content, and strength of soil. *Soil Sci.* 96(3):153-156.

Tupper, G.R., J.G. Hamill, and H.C. Pringle, III. 1989. Cotton response to subsoiling frequency. In *Proc. Beltwide Cotton Prod. Res. Conf.,* 10. Nashville, TN: National Cotton Council.