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Tillage and Subsoiling Effects on Soil Compaction and Yield of Burley Tobacco

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Introduction

Historically, tobacco producers have relied heavily on surface tillage to prepare fields for transplanting. This typically involved moldboard plowing, followed by several secondary tillage operations, such as discing then leveling with a soil finisher. Transplanter developments and modifications in the late 1990's, coupled with new chemicals for weed control, made no-till (NT) tobacco a viable option for tobacco producers in Kentucky (KY).

No-till production is beneficial for several reasons. It allows for production on sloping lands that are prone to erosion with conventional tillage. This increases the available acreage a producer can utilize for tobacco production and allows for greater flexibility of rotation, which is critical for disease and pest management. Other benefits that make NT tobacco production a favorable option include conservation of soil moisture, a wider time span for field operation because of better trafficability, reduced fuel and labor expenditures for field preparation, less wear on equipment, and cleaner cured leaf at stripping. These benefits associated with NT crop production are known to help maintain the productivity of the soil and reduce surface runoff of applied nutrients and agro-chemicals into surrounding surface waters.

Many benefits to subsurface tillage have been documented, as well as some negative impacts. Subsoiling has been shown to decrease soil bulk density (BD) and penetrometer resistance (PR) and increase yields when compaction was present prior to tillage (Varsa et al., 1997; Busscher et al., 1995). Subsoiling has been shown to significantly reduce PR values and significantly increase tobacco root growth (Vepraskas and Miner, 1986) and in-row subsoiling below the depth of compaction has shown to increase tobacco yields (Murdock et al., 1986). The benefits of subsurface tillage have been well promoted; however many of the negative impacts are not as well known. A loss of the soil bearing capacity because loosening the subsoil may make it prone for recompaction (Reeves et al., 1992). Two passes of a tractor following subsoiling can recompact soil to initial values, thus offsetting any benefit of deep tillage (Reeder et al., 1993). Wheel traffic from tillage, planting, and spraying can increase soil BD twice as much as subsoiling reduces it (Evans et al., 1996).

Since production costs have increased and tobacco leaf prices have decreased over the years, transplanting methods that don't rely on tillage might now be more acceptable. This study was established to determine how soil PR and burley tobacco yields were influenced by surface and subsurface tillage (subsoiling) on soils with no known compaction present.

Materials and Methods

The study was conducted at Spindletop Research Farm in Fayette County, KY from 2004 to 2007 on a Maury silt loam soil (Typic Paleudalf). Each year a "new" field was used that had been in tall fescue

(*Festuca arundinacea*) sod for a minimum of three years prior to plot establishment. The experimental design was a split plot with main plot treatments of NT and conventional tillage (CT) arranged in a randomized complete block and sub-plot treatments of subsoiled or not subsoiled within the main treatments.

Vegetation covering the no-tillage plots was chemically killed approximately one month prior to transplanting with Roundup (glyphosphate) at one qt. product/A. Tilled plots were moldboard plowed two to three months prior to transplanting, followed by discing twice and leveling. Subsoiling was performed prior to chemically killing the sod for the NT plots. The tilled plots were subsoiled prior to moldboard plowing in 2004 and 2005 and after moldboard plowing in 2006 and 2007. Nitrogen was surface applied to all plots as ammonium nitrate at a rate of 250 pounds of N per acre without incorporation for the NT treatments. Nitrogen was incorporated for the tilled treatments. Pre-plant herbicides were surface applied approximately three days prior to transplanting and consisted of Spartan 4F (sulfentrazone) at 10 fl. oz product/A and Command (clomazone) at 2.67 pints product per acre without incorporation. Roundup was applied with the pre-plant herbicides at 1 qt. product/A to burn down any new weed growth that might have occurred subsequent to the initial “burn down” treatment.

Tobacco was transplanted in the NT plots using a modified Mechanical ™ carousel transplanter at a plant density of approximately 7,500 plants acre^{-1}. Modifications to the transplanter included added fluted coulters in front of individual setter units. A v-shaped shank was added directly in front of the transplanter shoe to pull the transplanter unit into the ground and to disrupt a narrow band of soil in which the transplant was placed. The width of the press wheels was reduced in order to place additional pressure on the soil to adequately close soil around the transplant. The CT plots were transplanted using a similar transplanter without the modifications. Float tobacco plants were used. In 2004 to 2006 the tobacco variety was TN 90 and in 2007, the tobacco variety was KT 204.

At transplanting, Admire (imidacloprid) at 8 fl. oz product per acre and Acephate 90SP at 0.90 pounds product per acre were added to the setter water and dispensed to the plants in approximately 200 gallon solution per acre. Tobacco was managed according to The University of Kentucky Cooperative Extension recommendations. The plots were stalk-cut and cured normally. At stripping, tobacco was separated into four farm grades and cured leaf yield was determined.

Soil samples were collected following the harvest of tobacco. Undisturbed soil cores were collected for BD determination using a 1.97 inch by 1.97 inch ring for a total volume of 5.99 cubic inches. One sample at each depth of 0-2.5, 3-5.5, 6-8.5, 9-11.5, and 13-15.5 inches was collected at the inter-row position (row middles) in each plot, and BD was determined. Penetrometer resistance was determined in 2.5 inch (6.35 cm) increments in 2005 to 2007 to a depth of 18 inches along a transect, perpendicular to the plant row. The BD samples were reported as treatment means within a particular depth increment. The PR samples were analyzed as distance from the row and across all depths, so that distances and depths could be compared.

Results and Discussion

Soil BD gave little insight into differences due to tillage for the experiment. In 2004, soil bulk density measurements tended to be lower in the CT plots at the upper soil depths than in the NT plots if a difference was observed. However, in 2006 the opposite was true, with the NT resulting in lower BD than the CT treatments at the 3 to 5.5 inch depth and below. There was a significant interaction that occurred between tillage and subsoiling in 2006 indicating that BD was lowest in the NT subsoiled plots at the 3 to 5.5 inch depth and below and the same tendency was present in 2007 starting at the 6 to 8.5 inch depth.

Penetrometer resistance was measured in 2004, 2006, and 2007. All data showed the same results, in that subsoiling increased PR in the CT systems below 6 inches and decreased PR in the NT below the 6 inch depth compared to the respective non-subsoiled treatments. In both systems the difference in PR was observed to a depth of 18 inches. This difference in response is thought to be a result of disruption of the soil structure leading to reduced bearing capacity of the soil, and a greater susceptibility to compaction (Reeves et al., 1992). An example is given in table 1.

The same was true for compaction resulting from specific wheel traffic. The transplanter wheel spacing was 85 inches and a spike in PR was detected to a depth of 12 inches in some plots by the use of spectral analysis. This spike in compaction was more prominent in the CT treatments than NT treatments and also more pronounced in the subsoiled as compared to the non-subsoiled treatments. Another observation from the spectral analysis was that wheel traffic from the tractor traffic was detected to a depth of 8 inches in several plots and almost always to 6 inches in the CT plots. This reaffirms the suggestion that the disruption of soil structure in the CT plots led to a greater susceptibility to compaction.

Table 1. Penetrometer resistance in pounds per square inch (PSI) for 2006 averaged across the plot for the 0-6, 6-12, and 12-18 inch depth.

Depth	NT not subsoiled	NT subsoiled	CT not subsoiled	CT subsoiled
0-6	215	190	190	202
6-12	290	239	278	280
12-18	322	286	305	326

Yield results were mixed for the main effect of tillage, with two of the four years producing significantly higher yields for the CT plots than for the NT plots (Table 2). Even though tillage appeared to be detrimental to soil physical properties, no yield loss resulted in the tilled system. The slight yield benefit to tillage might be due to better initial plant establishment, allowing the plants to grow more vigorously early in the season. However, little difference in initial plant growth was observed most years.

Subsoiling the plots never significantly increased leaf yield during the timeframe of this experiment. No differences in cured leaf quality were observed for the experiment.

Table 2. Burley tobacco yields in pounds per acre for the main effects of tillage (NT and CT) and subsoiling versus no subsoiling.

	Year			
Treatment	2004	2005	2006	2007
NT	2172	2791	2632	3255
CT	2297	2968*	2399	3671*
Subsoiled	2197	2942	2558	3499
Not Subsoiled	2272	2817	2473	3426

* Significantly different at a 90% confidence interval for the main effect of tillage. All other treatments were not significantly different.

Summary

No-tillage crop production has been successful and widely used for many crops. Advances have been made in NT tobacco production, but acceptance has been limited due to problems associated with weed control and transplant establishment. The relative yields for the two tillage systems were variable from year to year and more years of data would be needed for a true estimate of the difference.

Previous studies have shown both benefits and detriments relating to subsoiling tobacco, depending on the soil type and amount of compaction present. Other than quality, cured leaf yield is the measure of success used in tobacco production. Although PR in CT plots tended to be adversely affected by subsoiling, no loss of yield was observed for this experiment. Bulk density and PR were generally improved when NT soils were subsoiled, but no statistical differences were observed for yield. As the amount of soil disturbance increased, the likelihood of compaction increased, particularly with increasing depth. The overall results are that there is no yield advantage from subsoiling and the effects of surface tillage are variable for this silt loam soil.

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