NO-TILLAGE ON SWELLING HEAVY CLAY SOILS: A PROGRESS REPORT

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Introduction

Reported increases in soil bulk density, soil strength, and lower root densities under no-tillage demonstrate the need for tillage under some conditions (1,5,6). However, long-term cropping systems using no-tillage management have potential for reducing erosion, fuel and labor costs, and enhancing water use efficiency. Previous studies from locations on heavy clay soils with poor drainage have not favored no-tillage (4). The Blackland Prairie of Texas is comprised of self-mulching, montmorillonitic clay and silty-clay soils that have good surface drainage, but poor internal drainage when wet. The soils are very sticky and highly erodible when wet. Because yield of crops grown with no-tillage have varied with respect to location, environment, and soil type, our objectives were to determine the long-term effects of no-tillage on soil properties, crop development, and yield for the heavy clay soils of the Texas Blacklands.

Methods

A long-term study (four years) was established in October, 1980 to determine the effects of conventional tillage and no-tillage on soil physical properties, crop development and yield of wheat, grain sorghum, and cotton. The experimental site was on an Austin silty clay soil with a 1 to 3% slope. The conventional tillage treatment was comprised of repeated disk and chisel operations (to depths of 10-12 cm) following harvest to control weeds and completely incorporate the existing crop residue. A rotary-tine harrow was used to provide a uniformly flat surface and weed free seedbed prior to conventional planting. No-tillage treatments were maintained free of weeds using combinations of pre-emergence, post-emergence directed spray, and post-harvest herbicide applications. Both conventional and no-tillage systems received identical quantities of nitrogen and phosphorous to maximize crop yields. Fertilizer was applied in solution fomulation at 10 cm depth prior to planting of cotton and grain sorghum. Urea-ammonium nitrate was dribbled on the surface during the tillering stage for wheat. Crops were planted with commercially available equipment fitted with double-disk furrow openers and smooth rolling coulters. Soil bulk density, cone penetration resistance, available water, and crop yield and yield components were measured.

Results

No-tillage management did not alter the physical properties of our expanding silty-clay soil after three crop years. Both soil strength (as measured by cone penetration resistance) and wet soil bulk densities were similar between conventional tillage and no-tillage (Tables 1 and 2). Plant available soil water increased by 25 mm/year for crops growing under no-tillage (2). Root densities (cm/cm^3) in the top 30 cm of soil profile were significantly higher for no-tillage grain sorghum and cotton, but were not affected by tillage at depths greater than 30 cm (Table 3). However, rooting density of wheat was not altered by tillage treatments. Each crop produced thicker (larger diameter) roots in the upper 30 cm of the no-tillage treatment (Table 4).

Grain yields of wheat and sorghum and lint yields of cotton were equivalent under no-tillage and conventional tillage during the 1981-1983 crop years. One exception was the low grain yield of 1982 no-tillage wheat. In this instance, a severe drought, coupled with high levels of leaf rust at the tillering and jointing development stages reduced the no-tillage wheat capacity to produce tillers.

Discussion

The results of our study, thus far, suggest that no-tillage is a viable management alternative to conventional tillage of expansive clay soils. Crop yields are equivalent under no-tillage with no adverse effects on soil properties. No-tillage increases rooting of the crop in the upper 30 cm of the soil profile permitting better crop utilization of water and nutrients. Residue and soil movement occurred during the study as evidenced by rill formation, demonstrating that no-tillage alone will not eliminate erosion. Modification of the system by the use of permanent raised beds with discrete furrow to control the flow of excess water may solve this problem and provide other benefits (3) to extend no-tillage technology to high clay soils in more humid regions. In addition, no-tillage may reduce the risk associated with alternative management practices such as double cropping of grain sorghum, soybeans, and cotton following small grains and ratoon cropping grain sorghum, thereby increasing crop productivity by more efficiently utilizing available growing season and water resources.

References

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Table 1. Cone penetration resistance comparisons of conventional tillage (CT) and no-tillage (NT) on a swelling clay soil near the upper limit of plant available soil water after three crop years.

Depth	Penetration Resistance CT	NT
(cm)	------ -kg/cm² --------	
0-15	3.04	3.26
15-30	16.51	18.59
30-60	35.0	38.0
60-90	40.0	50.0
LSD 0.05 (tillage x depth)	NS	

Table 2. Wet bulk densities of conventional tillage (CT) and no-tillage (NT) on a swelling clay soil near the upper limit of plant available soil water after three crop years.

Depth	Bulk Density CT	NT
(cm)	------- g/cm³ --------	
0-2	0.99	0.99
2-4	1.23	1.18
4-6	1.32	1.29
8-15	1.51	1.57
30-38	1.61	1.62
50-58	1.64	1.64
LSD 0.05 (tillage x depth)	NS	

Table 3. Root length density (RLD) and specific root weights (SRW) at flowering of wheat, sorghum and cotton as affected by conventional tillage (CT) and no-tillage (NT) in 1983.

Crop	Depth	RLD CT	RLD NT	SRW (1×10^{-5}) CT	SRW (1×10^{-5}) NT
	- cm -	--- cm/cm^3 ---		---- g/cm ----	
Wheat	0-15	16.11	13.38	4.0	4.8
	15-30	2.93	3.01	4.8	5.7
	30-60	1.38	1.40	5.5	6.0
	60-90	1.32	1.13	6.1	7.7
LSD 0.05 (tillage x depth)		NS		0.4	
Sorghum	0-15	2.01	2.42	12.5	16.3
	15-30	1.32	1.86	7.4	9.2
	30-60	0.89	1.04	5.9	9.5
	60-90	0.89	0.81	5.8	9.4
LSD 0.05 (tillage x depth)		0.15		2.1	
Cotton	0-15	1.28	2.01	14.8	19.9
	15-30	1.69	1.82	10.2	9.4
	30-60	1.10	1.01	12.1	9.8
	60-90	0.88	0.84	11.3	11.1
LSD 0.05 (tillage x depth)		0.11		2.9	

Table 4. Grain yields of wheat and sorghum and lint yield of cotton growth under conventional tillage (CT) and no-tillage (NT) for 1981-1983 crop years.

Year	Wheat CT	Wheat NT	Sorghum CT	Sorghum NT	Cotton CT	Cotton NT
	------------ kg grain/ha			--------	- kg lint/ha -	
1981	3170	2630	6320	6200	*	*
1982	1940	1250	4960	4530	254	216
1983	3410	3270	3665	3637	568	565
LSD 0.05 (tillage x year)	610		560		39	

* Data not available.