PERIODIC DEEP TILLAGE OF NO-TILL CORN AND SOYBEAN SYSTEMS IN SOUTHERN ILLINOIS

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Abstract

Low organic matter and low available moisture supplying soils in southern Illinois lend themselves to no-tillage crop production, but concern about compaction and rooting depth have led some to employ the use of periodic tillage. A field study was conducted at two locations in southern Illinois between 2000 and 2006 to evaluate the effects of periodic deep tillage (ripping 16-18 inches [40-45 cm] with minimum surface disturbance style shanks) prior to corn or soybean production. Deep tillage occurring either every year, every other year or every fourth year was compared to continuous no-tillage and continuous chisel tillage systems. Corn and soybean were grown annually and rotated between two fields at each location. Locations included the University of Illinois Dixon Springs Agricultural Center (DSAC) and Brownstown Agronomy Research Center (BARC). Each tillage treatment listed above was split with two secondary tillage treatments (no-tillage versus disk /field cultivator tillage). Because of the rough surface of the chisel treatment, secondary tillage treatments consisted of minimum tillage (single disking) versus disk/field cultivator tillage. In general, continuous no-tillage produced the highest yields. Tillage such as chisel tillage or disk tillage reduced the surface residue which probably led to reduced soil moisture availability during times of moisture stress. But more importantly, it appears that the continuous no-tillage system has improved internal drainage which increases no-tillage yields over continuous chisel tillage in years with wet springs (as measured by high rainfall in April and May). There is no indication from this study that the periodic tillage of no-tillage systems would justify the additional fuel and equipments costs.

Introduction

Throughout the midwest there are some 80 million acres in conservation tillage (30% residue cover) with some 35 million in no-tillage systems. In Illinois there are about 6 million acres in no-tillage systems, much of which occupy the upland and highly erodible soils in southern Illinois. These include both fragipan and claypan soil types which have root restrictive layers limiting water uptake and nutrient efficiencies. The impacts of no-till on these soils include the beneficial effects of leaving a mulch layer at the surface which aids in soil moisture retention, especially during brief periods of drought. However there are some who believe that periodic tillage of these no-till systems is required to reduce compaction and increase rooting depth. The objective of this study was to determine if the periodic deep ripping of continuous no-tillage production would lead to increase yields in a corn-soybean rotation.

Methods

A field study was established in the fall of 1999 at two locations in southern Illinois, the University of Illinois (UI) Dixon Springs Ag. Center (DSAC) and the UI Brownstown Agronomy research Center (BARC). The soil at DSAC was a Grantsburg sil. fragipan soil and at BARC was a Cisne sil. claypan soil. Fall tillage (primary tillage) treatments consisted of 1) continuous no-tillage, 2) continuous chisel tillage, 3) modified no-tillage employing annually a deep ripper utilizing minimum residue disturbance shanks which ran about 16-18 inches deep in the soil, 4) modified no-tillage using the deep ripper every other year, and 5) modified no-tillage using the deep ripper every fourth year. These treatments were applied to both corn and soybean residues in a corn-soybean rotation in the fall after crop harvest and as soil conditions were favorable. These tillage blocks were split (by secondary tillage) in the spring with half being planted without additional tillage (no-tillage) and half planted after a seedbed was prepared with disking twice or disking following by a field cultivation. In the case of the continuous chisel treatment, the "no-tillage" spring treatment actually consisted of a light disking (once) to level the surface prior to planting. Planting dates for corn and soybean are presented in Table 1. Plant stands (not shown) and grain yields were taken shortly after physiological maturity.

Table 1. Planting dates for corn and soybean at each location.

Year	DSAC Corn	DSAC Soybean	BARC Corn	BARC Soybean
	---------------------------- planting date	-----------------------------		
2000	May 18	May 18	May 17	May 18
2001	April 30	April 30	April 19	April 30
2002	May 30	May 31	May 28	May 29
2003	June 2	June 2	June 1	June 23
2004	May 24	May 25	April 15	June 18
2005	May 11	May 13	April 18	May 5
2006	April 18	May 23	April 24	May 24

Results and Summary

Corn yields varied over years and locations, with more variation occurring at BARC. At DSAC, yields ranged from a low of 107 bu/acre in 2002 to 219 bu/acre in 2006 with an average over the seven-year period of 150 bu/acre (Table 2). Corn yields were much lower at BARC, with a range of 16 bu/acre in 2000 to 207 bu/acre in 2004 and a seven-year average of 109 bu/acre (Table 3). Within most years and overall the continuous no-tillage treatment had equal or higher yields than any of the other primary tillage treatments at both DSAC and BARC (Tables 2 and 3, Figure 1). In 2002 and 2006, the continuous chisel treatments had significantly lower yields than other tillage treatments, and yielded an average of 9 bu/acre lower yields over the seven-year period at DSAC. At BARC, there was not a year where there was a significant difference among the primary tillage treatments. The effects of secondary tillage was significant more often than primary tillage, with overall differences of 5 bu/acre and 4 bu/acre for DSAC and BARC, respectively, for no-tillage over disking. This would indicate that spring tillage to prepare a "better" seedbed is unnecessary and may even hurt corn yields either by reducing soil mulch cover or reducing internal drainage by disrupting flow channels. The reduction of mulch cover could potentially cause less infiltration of rain water and greater evaporation thus reducing available soil moisture, especially during periods of drought during the growing season, which are common in southern Illinois.

Soybean yields are less volatile over the years and locations of this study. The average yields at both DSAC and BARC was 45 bu/acre (Tables 4 and 5). Only in 2004 at BARC, was there a significant reduction in yields with chisel tillage compared to the other tillage treatments. As with corn, the soybean yields associated with continuous no-tillage were equal to or better that the other tillage treatments (Figure 2).

When comparing the impact of periodic tillage, there was no significant difference between 1-yr, 2-yr, and 4-yr treatments, but there was a slight yield advantage with the 4-yr treatment. It appears to support the notion that little or no tillage is better than more frequent tillage. This is also supported when comparisons are made between continuous no-tillage and continuous chisel tillage. High rainfall levels in April and May indicate a wet spring and corn yield differences between no-tillage and chisel tillage are much higher when April + May rainfall is higher (Figures 3 and 4). This is an indication that tillage may be disrupting internal drainage and therefore tilled plots remain wetter during the spring that no-tilled plots. There were no significant differences among tillage treatments for corn stand counts (not shown) in most cases, but wet soil conditions may be lowering yields under chisel tillage in other ways, perhaps due to lower root respiration rates and/or increased N losses associated with denitrification.

Table 2. Effects of primary and secondary tillage on corn grain yields at Dixon Springs, 2000-2006.

Primary Tillage	Secondary Tillage	2000	2001	2002	2003	2004	2005	2006	Ave
		---------------------- *Corn Yields (bu/acre)* -------------------							
No-tillage	No-tillage	132	160	132	133	154	170	219	157
	Disk 2x	127	165	123	132	143	161	196	150
Chisel	Disk 1x	127	164	113	126	136	167	188	146
	Disk 2x	127	162	107	120	141	159	175	142
Rip yearly	No-tillage	127	157	132	133	153	162	206	153
	Disk 2x	128	165	120	122	147	162	193	148
Rip every 2 yr	No-tillage	131	162	133	126	152	164	208	154
	Disk 2x	125	170	125	128	153	162	189	150
Rip every 4 yr	No-tillage	118	160	132	138	152	179	214	156
	Disk 2x	126	166	131	130	146	159	200	151
Average	No-tillage	130	163	128a	133	149	165	208a	153
Primary	Chisel	127	163	110b	123	139	163	181b	144
Tillage	Rip yearly	128	161	126a	128	150	162	199a	151
	Rip every 2 yr	128	166	129a	127	153	163	199a	152
	Rip every 4 yr	122	163	132a	134	149	169	207a	154
Average	No-tillage	127	161b	128a	131	149	168a	207a	153
Secondary	Disk 2x	127	166a	121b	126	146	161b	191b	148
Statistics					Significance				
Primary Tillage (P)		*NS*	*NS*	**	*NS*	*NS*	*NS*	***	
Secondary Tillage (S)		*NS*	**	***	*NS*	*NS*	***	***	
P x S		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	

** = 10%, ** = 5%, *** = 1%, NS = nonsignificant.*

Means within a column followed by the same letter are not significantly different at the 5% level.

Table 3. Effects of primary and secondary tillage on corn grain yields at Brownstown, 2000-2006.

Primary Tillage	Secondary Tillage	2000	2001	2002	2003	2004	2005	2006	Ave
		Corn Yields (bu/acre)							
No-tillage	No-tillage	28	124	85	119	207	101	167	119
	Disk 2x	25	136	74	121	189	74	176	114
Chisel	Disk 1x	35	118	75	115	189	93	154	111
	Disk 2x	42	128	78	100	179	56	181	109
Rip yearly	No-tillage	38	119	73	104	190	74	146	106
	Disk 2x	24	130	71	104	169	64	158	103
Rip every 2 yr	No-tillage	16	115	68	115	167	91	166	105
	Disk 2x	27	123	62	102	169	73	153	101
Rip every 4 yr	No-tillage	34	110	82	108	187	106	171	114
	Disk 2x	31	129	56	111	186	83	159	108
Average	No-tillage	27	130	80	120	198	88	171	116
Primary	Chisel	39	123	77	108	184	75	168	110
Tillage	Rip yearly	31	125	72	104	180	69	152	105
	Rip every 2 yr	22	119	65	109	168	82	159	103
	Rip every 4 yr	33	120	69	110	187	95	165	111
Average	No-tillage	30	117a	77a	112	188	93a	161	111
Secondary	Disk 2x	30	129b	68b	108	178	70b	165	107
Statistics					Significance				
Primary Tillage (P)		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	
Secondary Tillage (S)		*NS*	***	**	*NS*	*NS*	***	*NS*	
P x S		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	

** = 10%, ** = 5%, *** = 1%, NS = nonsignificant.*
Means within a column followed by the same letter are not significantly different at the 5% level.

Table 4. Effects of primary and secondary tillage on soybean grain yields at Dixon Springs, 2000-2005.

Primary Tillage	Secondary Tillage	2000	2001	2002	2003	2004	2005	Ave
		Soybean Yields (bu/acre)						
No-tillage	No-tillage	41	54	39	46	41	58	47
	Disk 2x	42	51	39	42	37	56	44
Chisel	Disk 1x	41	52	38	42	34	56	44
	Disk 2x	39	53	38	41	34	52	43
Rip yearly	No-tillage	40	50	38	47	41	59	46
	Disk 2x	41	52	40	43	39	56	45
Rip every 2 yr	No-tillage	41	55	40	45	40	59	47
	Disk 2x	42	51	40	45	40	59	46
Rip every 4 yr	No-tillage	43	52	39	45	42	57	46
	Disk 2x	39	53	41	43	39	58	46
Average	No-tillage	41	53	39	44	39	57	46
Primary	Chisel	40	53	38	41	34	54	43
Tillage	Rip yearly	41	51	39	45	40	57	45
	Rip every 2 yr	42	53	40	45	40	59	46
	Rip every 4 yr	41	53	40	44	41	57	46
Average	No-tillage	41	53	39	45	40	58	46
Secondary	Disk 2x	41	52	40	43	38	56	45
Statistics					Significance			
Primary Tillage (P)		*NS*	*NS*	*NS*	*NS*	**	*NS*	
Secondary Tillage (S)		*NS*	*NS*	*	***	*NS*	*NS*	
P x S		***	**	*NS*	*NS*	*NS*	*NS*	

** = 10%, ** = 5%, *** = 1%, NS = nonsignificant.*

Means within a column followed by the same letter are not significantly different at the 5% level.

Table 5. Effects of primary and secondary tillage on soybean grain yields at Brownstown, 2000-2005.

Primary Tillage	Secondary Tillage	2000	2001	2002	2003	2004	2005	Ave
		Soybean Yields (bu/acre)						
No-tillage	No-tillage	55	51	24	43	62	51	48
	Disk 2x	54	49	26	42	59	49	47
Chisel	Disk 1x	51	46	22	33	61	48	44
	Disk 2x	53	40	22	43	60	45	44
Rip yearly	No-tillage	46	45	22	36	59	45	42
	Disk 2x	48	46	21	40	56	46	43
Rip every 2 yr	No-tillage	55	48	23	40	56	45	45
	Disk 2x	55	50	24	42	58	46	46
Rip every 4 yr	No-tillage	55	47	25	41	62	47	46
	Disk 2x	48	54	28	47	59	46	47
Average	No-tillage	54	50	25	42	61	50	47
Primary	Chisel	52	43	22	38	61	46	44
Tillage	Rip yearly	47	45	21	38	57	45	42
	Rip every 2 yr	55	49	23	41	57	45	45
	Rip every 4 yr	52	51	27	44	61	47	47
Average	No-tillage	53	48	23	39	60	47	45
Secondary	Disk 2x	51	48	24	43	59	46	45
Statistics		Significance						
Primary Tillage (P)		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	
Secondary Tillage (S)		*NS*	*NS*	*NS*	***	*NS*	*NS*	
P x S		*NS*	*	*NS*	*NS*	*NS*	*NS*	

** = 10%, ** = 5%, *** = 1%, NS = nonsignificant.*
Means within a column followed by the same letter are not significantly different at the 5% level.

Figure 1. Effects of primary tillage on corn yields at Dixon Springs (DSAC) and Brownstown (BARC), averaged over 2000-2006.

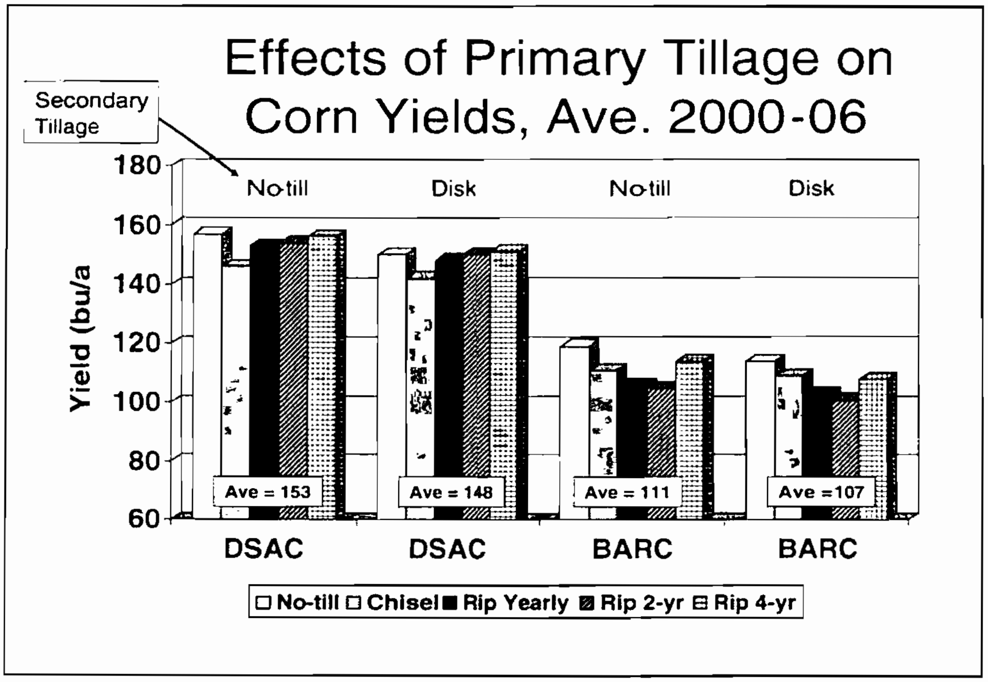


Figure 2. Effects of primary tillage on soybean yields at Dixon Springs (DSAC) and Brownstown (BARC), averaged over 2000-2005.

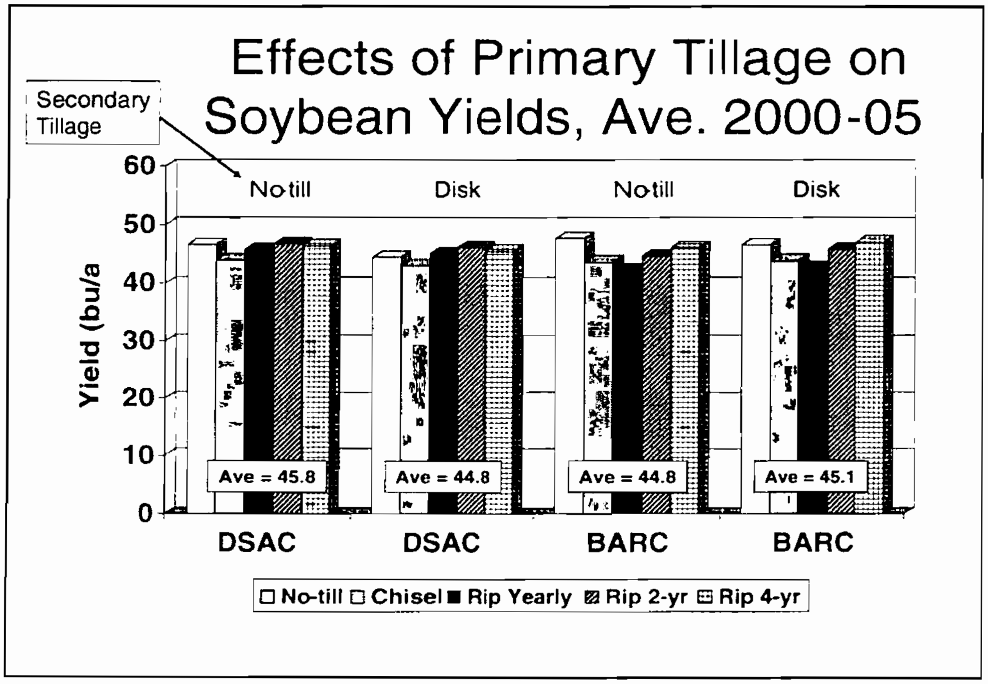


Figure 3. Relationship between rainfall in April and May versus corn yield differential between no-tillage and chisel tillage at Dixon Springs, 2000-2005.

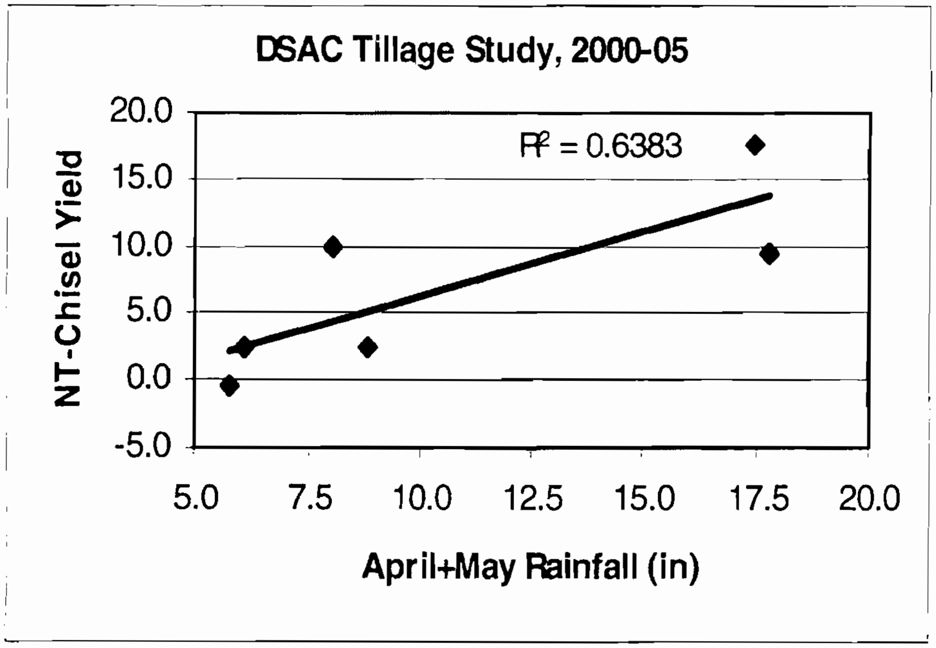
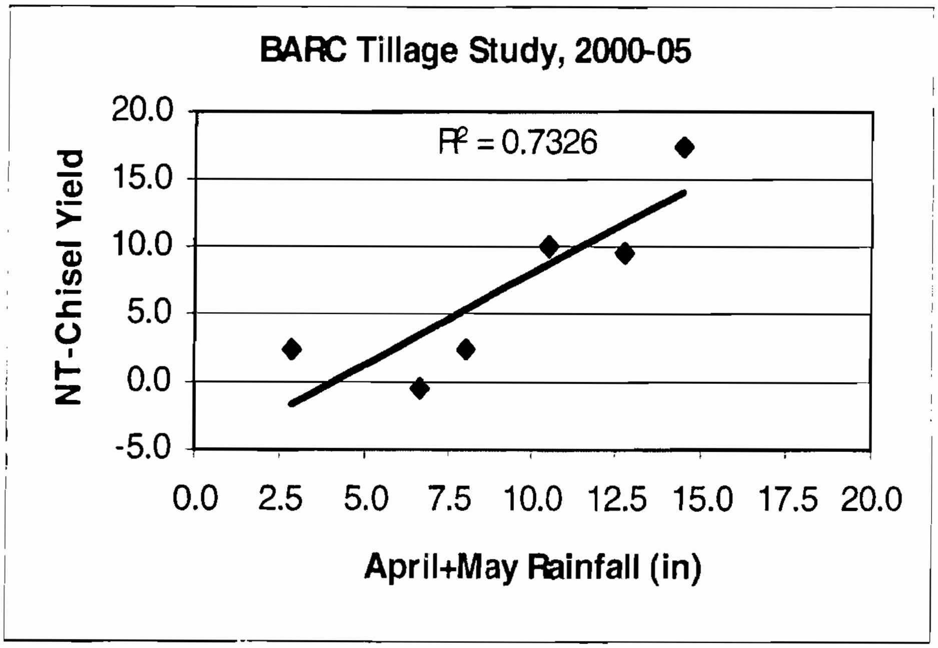


Figure 4. Relationship between rainfall in April and May versus corn yield differential between no-tillage and chisel tillage at Brownstown, 2000-2005



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