Long-term Tillage Study, ACRE

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Introduction

Early evaluation of reduced tillage systems in the Midwest centered on well-drained and/or erosive soils. Due to reduced water erosion and savings in soil moisture, systems leaving 70% or more of the soil surface covered with residue often increased yield potential on these soils. These findings could not be generalized, however, to the dark silty clay loam soils of the Eastern Corn Belt where soil moisture and erosion were less severe problems.

Beginning in 1975, a range of tillage systems have been compared annually on Chalmers silty clay loam soil (4% OM) at the Purdue Agronomy Center for Research and Education (ACRE) in West-central Indiana. Our goals are to determine long-term yield potential of the different systems and to determine changes in soil characteristics and crop growth that could be associated with yield differences. Plow, chisel, ridge, and no-till systems are compared for continuous corn, corn following soybeans, soybeans following corn, and continuous soybeans. There are 4 replications; individual plots are 30-feet wide and 150-feet long.

Soil and Crop Management

Cultural practices have been relatively consistent since the study began. Plowing and chiseling were done in the fall with 1 disking and/or 1 or 2 field cultivation passes for spring seedbed preparation. For the ridge system, ridges were made at the time of inter-row cultivation in corn and after harvest in soybeans. (The ridge system was replaced with strip-till for the 2009 and beyond crops.) Row width for corn is 30-inches. Both moldboard and chisel plowed corn plots were also inter-row cultivated in most years, but not no-till. Row width for soybeans was 30-inches for soybeans in all treatments from 1975 to 1994. Starting in 1995, soybeans were drilled in 7.5-inch rows for plow, chisel and no-till treatments, but the ridge treatment remained at 30-inches. Due to the threat of soybean rust disease, all soybean treatments were switched back to 30-inch rows starting in 2005. We concluded that the mechanical damage to plants during possible fungicide application(s) most likely would have greatly reduced yield in the harvest area of drilled soybeans. Soybean plots have not been inter-row cultivated since 2004.

Starter fertilizer was used for all corn plots, but not for soybeans. Placement was 2-inches to the side and 2-inches below the seed. The nitrogen source for corn was anhydrous ammonia through 2000 (either pre-plant or side-dress) and liquid UAN (28%) (always side-dress applied) starting in 2001. Total nitrogen applied generally exceeded 180 lbs/acre of actual N. Phosphorus, potassium and lime were surface-applied as needed.

Corn planting dates ranged from April 25 to May 31 and soybean dates from May 3 to June 21; however, all tillage treatments were planted on the same day each year. One-inch fluted, 2-inch fluted or bubble coulters were used ahead of planter disk openers from 1975 to 1996. Starting in 1997, no coulters were used ahead of disk openers as per planter manufacturer recommendation; however, tined row cleaners were used in no-till corn treatments. For ridge planting, horizontal disks were used to scrape ridges at planting from 1980 to 1996 and then we switched to planter-mounted, double-vertical disks in 1997.

Burndown herbicides were applied to control existing vegetation when needed. Pre-emergence herbicides were applied with the planter pass from 1975 through 1996. Starting in 1997, pre-emergence herbicides were applied after planting in a separate operation. Post-applied herbicides were used for weed escapes. Where needed, plots were hand weeded to ensure that weed control did not limit yield. Insecticides were applied at planting for corn rootworm control. Chemical control for cutworms, stalk borers, bean leaf beetle, rodents, and spider mites was applied as needed.

The ridge-till treatment was discontinued after harvest in the fall of 2008. These plots were chisel plowed and disked to destroy the ridges. The new treatment is strip-till. All plots were strip-tilled in March of 2009.

Eight corn hybrids and 12 soybean varieties have been used during the 34 years of this project.

Researchers Involved

Dr. Jerry V. Mannering, Harry Galloway and Donald R. Griffith initiated the experiment in 1975 and continued to direct it until their respective retirements in 1989, 1980, and 1995. Terry D. West has managed the experiment from 1979 until present. Dr. Tony J. Vyn became involved in 1998, after moving from Canada where he had been involved in tillage research for 20 years.

Numerous faculty and graduate students have conducted research on this experiment over the years. Most of the efforts were directed towards soil physical properties (Drs. Mannering, Kladivko and Steinhardt), soybean diseases (Drs. Abney and Westphal), corn and soybean production (Griffith and Dr. Swearingin), agricultural engineering (Dr. Parsons), soil microbiology (Drs. Nakatsu, Turco and Brouder), soil fertility (Dr. Mengel) and entomology (Bledsoe).

Table 1. Planting dates for corn and soybean, Long-term Tillage Study, ACRE.

	Year	Corn	Soybean		Year	Corn	Soybean
1	1975	5/2	5/6	18	1992	5/5	5/8
2	1976	4/29	5/10	19	1993	5/11	5/12
3	1977	5/10	5/6	20	1994	4/26	5/17
4	1978	5/3	5/19	21	1995	5/22	6/1
5	1979	5/9	5/17	22	1996	5/31	6/21
6	1980	5/5	5/15	23	1997	4/29	5/16
7	1981	5/22	5/28	24	1998	5/14	5/18
8	1982	4/30	5/11	25	1999	5/12	5/21
9	1983	5/10	5/12	26	2000	4/26	5/24
10	1984	5/2	5/14	27	2001	5/2	5/10
11	1985	4/25	5/16	28	2002	5/29	5/29
12	1986	4/29	5/28	29	2003	5/23	5/27
13	1987	5/5	5/7	30	2004	4/29	6/4
14	1988	4/26	5/12	31	2005	4/19	5/5
15	1989	4/25	5/12	32	2006	4/29	5/31
16	1990	4/26	5/21	33	2007	5/5	5/7
17	1991	5/10	5/16	34	2008	5/1	5/28

Table 2. Soil test results based on composite samples, Long-term Tillage Study, ACRE, Fall 2004.

		Soil pH			Soil P Concentrations			Soil K Concentrations		
Rotation	Tillage	0-4”	4-8”	Mean	0-4”	4-8”	Mean	0-4”	4-8”	Mean
					ppm	ppm	ppm	ppm	ppm	ppm
Con’t soybean	Plow	7.1	7.1a*	7.1a	60b	66	63b	175b	191	183b
	Chisel	7.4	7.1a	7.3a	96a	48	72ab	245a	168	206ab
	Ridge	7.3	6.5b	6.9b	111a	42	76ab	253a	149	201ab
	No-till	7.1	6.4b	6.8b	119a	52	85a	293a	171	232a
	Average			7.0			74			206
Corn/soybean	Plow	6.8	6.9a	6.8a	47c	48	48c	148c	152	150c
	Chisel	7.1	6.6a	6.9a	84b	49	66bc	202bc	141	171bc
	Ridge	6.9	5.9b	6.4b	111ab	50	80ab	269b	141	205ab
	No-till	6.7	5.5b	6.1b	124a	54	89a	344a	157	251a
	Average			6.5			71			194
Con’t corn	Plow	6.8ab	6.7a	6.7a	49b	55	52c	152c	171	161c
	Chisel	7.0a	6.2b	6.6a	94a	54	74b	236b	150	193bc
	Ridge	6.4b	5.6c	6.0b	107a	64	85ab	293ab	153	223ab
	No-till	6.5ab	5.4c	5.9b	117a	74	95a	328a	175	251a
	Average			6.3			77			207

*Means with the same letter are not significantly different.
Within rotations, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P = .05)

2008 Field Practices

Primary tillage included the use of an International Harvester 5-furrow 18-inch bottom semi-mounted moldboard plow on the plow treatments. A DMI 7-shank coulter-chisel plow equipped with 4-inch twisted chisel points on 15-inch centers and a Danish-tine sweep leveling bar was used for the chisel treatment. Secondary tillage for plow and chisel was accomplished with a Glencoe 10-foot field cultivator with rear-mounted, double-rolling baskets. Chisel plots were field cultivated once and plow plots twice.

Corn was planted in 30-inch rows with a Case-IH model 955 4-row planter. Ripple coulters opened a slot for starter fertilizer placement.

We used row-unit-mounted vertical disks to scrape the ridge tops when planting the ridge treatment. We removed 1-inch or less of soil and residue to take advantage of the ridge's warmer and dryer soil conditions.

We planted the no-till continuous corn 6-inches beside the old row rather than on the old row. We also used unit-mounted row cleaners to clear the row area of residue when no-till planting into corn and soybean residue.

Nitrogen was sidedressed at a depth of 3 to 4 inches with a DMI NutriPlacr 2800 5-knife liquid nitrogen applicator equipped with 1 coulter per knife. The outside knives (#1 and #5) delivered 1/2 rate and, after the first pass through the plots, an outside knife was placed back in the previous outside knife track to give a full rate. This method of knife placement gives us a marker for guiding the equipment for uniform application.

Soybeans were planted with the Case-IH 955 planter in 30-inch rows in all treatments.

Herbicides were applied with a tractor mounted Century 30-foot sprayer. All herbicides were broadcast with flat fan 8004 nozzles at 30-psi and 20-gallons water/acre at 5-miles per hour.

Row crop cultivating was not done this year and the ridge plots were not re-ridged. A decision was made to eliminate the ridge treatment and replace it with a strip-till treatment. The ridge plots were chiseled and disked to level the ridges. If weather and soil conditions allow we will strip-till the plots in early spring.

All corn plots were harvested with a John-Deere/Almaco model 700 combine equipped with a 4-row corn head. All soybean plots were harvested the same John-Deere/Almaco model 700 combine equipped with a 10-foot grain platform with pickup reel and a straw chopper.

Summary of studies conducted on the tillage plots by researcher.

Dr. Scott Abney, USDA-ARS, Botany and Plant Pathology.
The overall objectives of the soybean pathology research in the Long-Term tillage plots are: 1) identify and describe incidence and severity of Sudden Death Syndrome and Phytophthora root rot in conventional vs. reduced-tillage soybean production systems; 2) characterize the role of selected fungicide and post-herbicide treatments associated with conventional and no-till systems on developmental progress of soybean diseases that will facilitate improved plant health; and, 3) continue identifying pathogenicity and virulence of *Phytophthora sojae* races and *Fusarium solani* strains isolated from soybeans with Phytophthora root rot and sudden death syndrome symptoms, respectively. This research is important to Indiana and the North Central region agriculture and is an integral part of Abney's on-going soybean pathology research project which emphasizes maintaining improved plant health as a means of reducing yield losses caused by Phytophthora root rot, sudden death syndrome and late season diseases. During the 1990s, diseases caused by *P. sojae* and *F. solani* have increased throughout the North Central region. Research data from field sites with a history of disease caused by these important soybean pathogens are critical to the success of the above objectives. Diseases caused by both pathogens occur in the Long-Term tillage plots and this test site is one of the best locations at the Purdue Agriculture Research Center to evaluate Phytophthora damage on early planted soybeans. This study will continue in 2009. *Dr. Scott Abney*.

Anita Gal, Rex Omonode, Tony Vyn. Carbon Sequestration and Greenhouse Gas Emission Study.
A study was initiated in 2002 to study carbon sequestration. Six probes per plot to a depth of 1-meter were collected from the no-till and moldboard plow plots in continuous corn and in the corn-soybean rotation. The soil cores were divided into 0-5, 5-15, 15-30, 30-50, 50-75 and 75-100 cm intervals for the determination of soil carbon, soil nitrogen and soil bulk density. Greenhouse gas emissions from the soil surface of selected plots have been measured during the growing seasons of 2004 to 2006. These results will be combined with other efforts at Purdue University

and 8 other universities in the United States of America that are part of the Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS). Our overall goal is to develop better recommendations on best management practices for greenhouse gas sequestration. The 33-year history of these long-term plots provides a very valuable background to assess the impacts of management.

Further information about our results are available from 2 published papers:

Gàl, A., T.J. Vyn, E. Michéli, E.J. Kladivko, and W.W. McFee. 2007. Soil carbon and nitrogen accumulation with long-term no-till versus moldboard plowing overestimated with tilled-zone sampling depths. Soil Tillage Research. In Press, Corrected Proof. Available on-line March 27, 2007.

Omonode, R.A., T.J. Vyn, D.R. Smith, P. Hegymegi, and A. Gàl. 2007. Soil carbon dioxide and methane fluxes from long-term tillage systems in continuous corn and corn-soybean rotations. Soil and Tillage Research, In Press. Corrected Proof. Available on-line Feb. 20, 2007.

Terry D. West, Tony Vyn, and Gary Steinhardt, Agronomy.
T. West, T. Vyn and G. Steinhardt studied long-term affects of tillage and rotation by measuring plant population, growth, and yield of corn and soybeans.

Long-term Tillage Plots, ACRE.

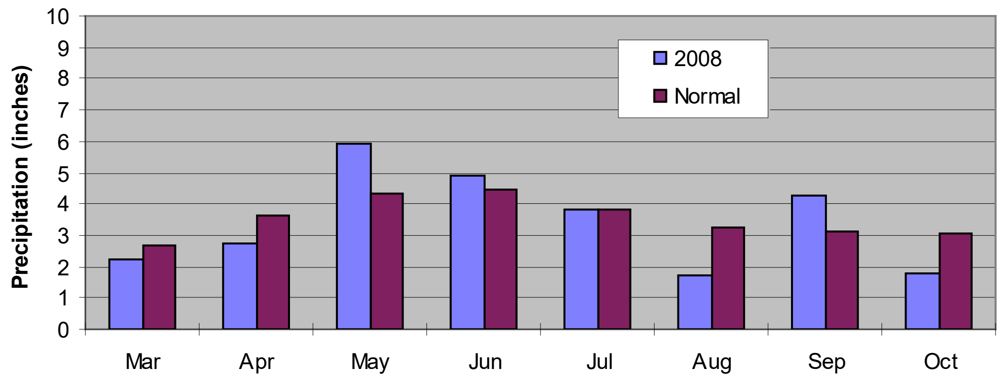
CULTURAL PRACTICES USED 2008 Long-term Tillage Study, ACRE, Purdue University				
Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/1	Field cultivate once on chisel and twice on plow plots.	5/27	Field cultivate once on chisel and twice on plow plots.
Hybrid/Variety planted	5/1	Pioneer 33T85 (HXX, LL, RR2) (115-day) Row cleaners on c/b and c/c no-till. Shifted no-till c/c to east. (Shift to west in 2009)	5/28	Pioneer 93M42 Round-up Ready Group 3.4. West and center passes.
Seeding rate		34,000 seeds/ac, Drum B, 36 pockets, 72 dimples.		140,000 seeds/ac
Starter fertilizer/planter		34-0-0 @ 96 LB/ac, 2-inches to the side and 2-inches below the seed (sprockets driver 36, driven 30)		None
Insecticide/planter		None		None
Rodenticide/planter		Pro-Zap zinc phosphide pellets in furrow for rodent control		Pro-Zap zinc phosphide pellets in furrow for rodent control
Weed control	5/5	<u>Burndown plus pre-emergence:</u> Harness Extra 5.6L 5pt/ac Atrazine ½ lbs/ac Roundup Original Max 24 oz/ac Ammonium sulfate 8 lbs/100 gallons water	5/5	<u>Burndown plus pre-emergence:</u> Ridge and No-till only: Roundup Original Max 32 oz/ac AMS 8 lbs/100 gallons water
	6/?	<u>Post-emergence:</u> Roundup Original Max 24 oz/ac AMS 8 lbs/100 gallons water	5/29	<u>Pre-emergence:</u> First Rate 0.75 oz/ac Micro-tech (Lasso) 5 pt/ac Roundup Original Max 22 oz/ac AMS 8 lbs/100 gallons water
Nitrogen fertilizer	6/11	200 lbs N as UAN (28%) @ 60 gallons/acre		None
Cultivation	None	Plow and chisel treatments	None	Plow, chisel, and ridge treatments
	None	Ridge treatment (re-ridge)	None	Ridge treatment (re-ridge)
Harvest	10/30	Center 4 of 12 rows, 150-feet	10/22	Center pass, 10-feet x 150-feet
Fall fertilizers:				
Phosphorous		None		None
Potassium		None		None
Lime		None		None
Primary tillage	11/06	Fall plow on plow treatment	11/06	Fall plow on plow treatment
	11/06	Fall chisel on chisel treatment	11/06	Fall chisel on chisel treatment
Destruction of ridge plots. These plots will be strip-tilled from now on.	11/06	Fall chisel plus one pass of tandem disk.	11/06	Fall chisel plus one pass of tandem disk.

Weather and soil conditions in 2008

March and April rainfall was slightly drier than normal (Fig. 1). With most of April's rainfall in the first half of the month soil conditions were good for a May 1st planting of corn. As usual in continuous corn chisel plots the seedbed was less than ideal with many clods. The plow, no-till and ridge soil conditions were very good for planting. The first half of May was wet with 4.0-inches of rain. The plots never had standing water on them. Soybeans were planted on May 28th as the 2nd half of May was relatively dry with only 0.33-inches of rain until May 31st when 1.53-inches of rain fell. June and July rainfall was normal each month. August had 1.3-inches of rainfall on August 5th and then was very dry the rest of the month with only 0.4-inches of rain. The 4.24-inches of rain in the first 2 weeks of September relieved any crop stress from the dry second half of August. No rain fell the rest of September and October was very dry with 1.79-inches of rain for the entire month.

In summary there was adequate soil moisture during most of the growing season. The crops matured normally and yields were excellent.

Figure 1. Monthly precipitation for March through October, 2008 compared to normal, ACRE.



Stand, growth, and yield -- Corn.

Establishing a uniform stand can be difficult in no-till continuous corn. The corn residue is thickest on the old row and we have observed seeds planted in contact with residue, not in contact with soil. Variable seed depth and inconsistent contact with the soil can result in non-uniform germination, reducing yield potential. We have shifted no-till corn after corn rows 6-inches (enough to clear the planter gauge wheels) to the side of last year's rows. By shifting the new rows, we wanted to gain more uniform seeding depth, improve seed to soil contact, and achieve more uniform seedling emergence. This is the 13th year of shifting the new rows. We achieved these goals in 13 of the 14 years.

Continuous corn: Tillage and planting went well in all treatments. We used row-unit-mounted vertical disks to scrape the ridge tops when planting the ridge treatment. The disks were set to remove 1-inch or less of soil and residue to take advantage of the ridge's warmer and dryer soil conditions. There were no problems this year with root balls popping up and leaving holes in the row area. Plant populations at 4-weeks were equal in all treatments

(Table 4). We planted 34,000 seeds per acre; however plant stands at 4-weeks after planting averaged only 31,400 seeds per acre. Some of this 9% stand loss may be attributed to the cool and wet first half of May. No-till plant growth was slower than the other tillage systems at 4 and 8 weeks after planting. This difference was significant at both 4 and 8 weeks. Pollination was satisfactory with little or no silk clipping.

This was our first year for Pioneer 33T85 (HXX, LL, RR2), a triple stacked hybrid. Yields in the plowed treatment were equal with those from chisel, but significantly higher than the ridge and no-till treatments. Harvest grain moisture with no-till was significantly higher than after the other treatments even at these late harvest date.

This year's corn yields were highest in the 34 years of this study for all treatments. A combination of plentiful soil moisture yet never flooded, sufficient growing degree days, excellent plant health, practically no silk clipping, and little or no root feeding contributed to these fantastic yields. The plow treatment yielded 37.1 bushels/acre higher than the previous best plow yield set in 2006. The no-till treatment yielded a whopping 46.3 bushels/acre higher than the previous best no-till yield set in 1982.

<u>Corn following soybeans</u>: Plant stands, plant heights at 4- and 8-weeks after planting, and grain moisture at harvest were equal in all treatments. We planted 34,000 seeds per acre; however plant stands at 4-weeks after planting averaged only 32,400 seeds per acre. Some of this 5% stand loss may be attributed to the cool and wet first half of May.

As in continuous corn, this year's rotation corn yields were the highest in the 34 years of this study. All treatments set record yields. Plow, chisel, ridge, and no-till were 42.0, 34.9, 36.4, and 44.2 bushels per acre higher that previous highs respectively. The combined yield for all treatments beat the old record set in 1994 by 41.4 bushels per acre. Excellent weather and soil moisture, little crop disease, and practically no silk feeding lead to fantastic yields in 2008. Do note that there were no significant differences in grain yield among treatments.

Table 4. Agronomic performance of corn as affected by tillage and rotation,
Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2008. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	32000	13.0a‡	48.8a	18.5b	251.4a
	Chisel	30875	12.4a	48.3a	18.6b	242.7ab
	Ridge	31781	11.8a	44.9a	18.9b	236.2b
	No-till	31031	10.0b	39.8b	19.8a	231.1b
Soybean	Plow	32938	12.8	50.9	18.6	260.6
	Chisel	32656	13.4	54.1	18.6	261.9
	Ridge	32250	14.3	52.8	19.0	255.8
	No-till	31844	13.4	51.1	19.1	255.8

†Average of 4 replications.
‡Within rotations, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Stand, growth, and yield -- Soybeans.

From 1995 through 2004 we drilled the plow, chisel, and no-till treatments at 7.5-inch row spacing, while the ridge treatment was planted at 30-inch row spacing. In 2005, we went back to 30-inch rows for all treatments. This was due to the threat of soybean rust disease. In order to spray fungicides if an outbreak occurred, the mechanical damage to drilled rows of the "sacred" harvest area would have severely impacted the yields. Any damage to 30-inch rows would be minimal, so we switched to the 30-inch rows. Also, we have continued 30-inch rows to facilitate other research projects.

Soil samples taken in 1999 and 2002 confirmed the presence of Soybean Cyst Nematodes (SCN) in many of the plots. To reduce the negative impact of SCN on yield potential we have planted SCN resistant varieties since 2000.

<u>Rotation soybean/corn</u>: Plant populations at 4-weeks after planting were satisfactory for all treatments (Table 5). The reduced population in the ridge system is likely due to an operator error. Slight differences in plant height at 4-

weeks after planting were noted with the ridge treatment tallest and the no-till treatment shortest. By 8-weeks after planting the no-till treatment had fallen further behind and was statistically the shortest of all treatments. The plow treatment yielded highest with 66.2 bushels per acre but not significantly different from the other treatments. Sudden Death Syndrome (SDS) was not a significant problem this year. The 4 treatment average grain yield was the 2nd best of the 34 years of this study.

Continuous soybean: Plant populations were satisfactory for the plow, chisel and no-till treatments with ridge significantly lower (Table 5). The lower ridge stand was a result of an operator error. Again, all treatments were planted in 30-inch rows. Plow and chisel yielded 65.9 and 64.0 bushels per acre respectively and were significantly higher that the ridge and no-till systems. The ridge treatment grain yield may have been adversely affected by the low stand count. The no-till plants were significantly shortest at 4 and 8 weeks after planting compared to the other treatments and may have set fewer pods.

Table 5. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2008. †

Previous Crop	Tillage	Stand‡ 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		ppa	in	in	%	bu/ac
Corn	Plow	130100a‡	7.1b	34.8a	13.1	66.2
	Chisel	128100a	7.0b	34.1a	13.6	63.9
	Ridge	110900b	8.0a	35.0a	13.5	62.8
	No-till	120900ab	6.8b	31.5b	13.2	62.6
Soybean	Plow	130700a	7.6b	34.9a	13.0	65.9a
	Chisel	127800a	7.5b	34.4a	13.1	64.0a
	Ridge	94700b	8.3a	34.1a	13.2	56.8c
	No-till	127400a	6.7c	30.5b	13.3	60.3b

†Average of 4 replications.
‡Within rotation, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Table 6. Analysis of variance summary, tillage data, Long-term Tillage Study, ACRE, Purdue Univ., 2008.

Variable	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield bu/ac
	-----------------------------Significance Level--------------------------------				
			Corn		
Tillage	NS	.05	.01	.01	.03
Previous crop	.03	.02	.01	NS	.01
Tillage x previous crop	NS	.01	.04	NS	NS
			Soybean		
Tillage	.01	.01	.01	NS	.01
Previous crop	NS	NS	NS	NS	NS
Tillage x previous crop	.08	NS	NS	.06	.04

Soybean analysis for 2005-2008, all 30-inch rows, Long-term Tillage Study, ACRE

Rotation soybean/corn: Plant populations at 4-weeks after planting were satisfactory for all treatments (Table 7). Slight differences in plant height at 4-weeks after planting were noted with the chisel and no-till treatments being shortest. By 8-weeks after planting the chisel and no-till treatments had fallen further behind and was statistically different than plow or ridge treatments. The plow, ridge and no-till grain yields were not significantly different and on average was 59.0 bushels per acre. The chisel treatment yielded 53.5 bushels per acre which was significantly lower than the other treatments. In 2005, 2006 and 2007 we noted that the chisel treatment had the most plants infected with SDS, and that might explain the yield response following chisel.

Continuous soybean: Plant populations were satisfactory with the ridge treatment significantly lower than the other treatments (Table 7). We suspect that yields in all soybean plots were affected by SCN in 3 of the 4 years of this comparison. We also observed many plants affected by SDS in that same 3 year period (2005, 2006, and 2007). Plow, ridge and no-till all yielded better in rotation compared to continuous soybean. The chisel treatment in rotation was within 1 bushel per acre of continuous soybeans.

Table 7. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2005-2008. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		ppa	in	in	%	bu/ac
Corn	Plow	125000a‡	6.6	26.8a	13.5	58.3a
	Chisel	117100b	6.1	25.1b	13.6	53.5b
	Ridge	117700b	6.6	26.2a	13.6	60.4a
	No-till	117900b	6.1	24.2c	13.6	58.2a
Soybean	Plow	122800a	6.5b	26.1a	13.5	52.6
	Chisel	120100a	6.4b	25.9ab	13.5	53.1
	Ridge	113300b	7.2a	25.9ab	13.4	53.1
	No-till	123500a	6.5b	25.0b	13.6	52.3

†Average of 4 replications.
‡Within rotation, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Table 8. Analysis of variance summary, tillage data, Long-term Tillage Study, ACRE, Purdue Univ., 2005-2008.

Variable	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield bu/ac
	Significance Level				
Tillage	.01	.01	.01	NS	.03
Previous crop	NS	.10	NS	NS	.01
Tillage x previous crop	.01	.08	.02	NS	.02

Long-term Yields

Results from this study provide insight into long-term yield potential of corn and soybean with different tillage systems on dark prairie soils of the Central and Northern Corn Belt. While equipment, cultivars, and seeding rates were changed periodically, tillage treatments were not altered during the 33-years of this continuing experiment.

Both tillage system and rotation influenced stand, growth and yield of corn and soybean in these studies. In continuous corn, tillage system also influenced grain moisture. With planting conditions similar to those in this study, the following conclusions appear to be justified:

1. Both corn and soybean yields are greater in rotation than in continuous cropping for all tillage systems (Tables 9 and 10). The positive response to rotation is greatest for no-till corn. However, within the 3 tilled treatments (plow, chisel, and ridge) soybean yields increased more (percent basis) with rotation than did corn yields.
2. When corn follows corn, yields with chiseling and ridging may be reduced slightly (3% or less) compared with plowing. No-till continuous corn yield on dark, poorly drained soil is likely to be reduced, compared to yields with other systems, and the yield reduction may increase with time when planted on the old row (Fig. 2). Part, but not all, of the yield loss prior to 1995 may be due to reduced stand or non-uniform plant emergence. Since planting beside old row starting in 1995, the yield gap has been reduced.
3. When corn follows soybean, yields with plow and chisel are likely to be about the same. Yields from the ridge system may be slightly better (3%) than plow and chisel. No-till corn yields may be slightly reduced (2%) compared to plow and chisel, but the relative yields of no-till change little with time (Fig. 3). Yield reductions with no-till corn are not due to lower plant populations.
4. No-till soybean yields are likely to be reduced slightly, compared with plowing, but yield differences may be reduced with time (Fig. 4 and 5). No-till soybean yield reductions are likely to be less frequent when grown in narrow rows (note the yield responses from 1995 to 2004), but no-till yields can be similar to those after plowing even in 30-inch row widths (note the yield responses in 1990-94, and again in 2005-08). We acknowledge that variety selection plays a large role in the relative yield responses of soybean to wide row widths and to no-till systems. However, soil-borne disease incidence was not the highest in long-term no-till for the pathogens evaluated (see earlier sections).

Table 9. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, ACRE, 1975-08.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	182.0	- - -	175.1	- - -	4
Chisel	183.2	101	170.2	97	8
Ridge*	187.3	103	172.2	98	9
No-till	178.3	98	151.6	87	18

*Since 1980

Table 10. Soybean Yield Response to Tillage and Rotation, Long-term Tillage Study, ACRE, 1975-08.

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	53.9	- - -	48.9	- - -	10
Chisel	51.8	96	47.0	96	10
Ridge*	52.4	97	46.5	95	13
No-till	51.6	96	47.4	97	9

*Since 1980

The Journal of Production Agriculture article titled “Effect of Tillage and Rotation on Agronomic Performance of Corn and Soybean: Twenty-Year Study on Dark Silty Clay Loam Soil” gives a detailed report of this research project. This article can be found in volume 9, no. 2, page 241 to 248, 1996. A reprint can be obtained by contacting Terry D. West, Agronomy Department.