

Long-term Tillage Study, ACRE

T.D. West, T.J. Vyn and G.C. Steinhardt

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 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. Row width for corn is 30-inches. Both moldboard and chisel plowed corn plots were also inter-row cultivated, 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 were not inter-row cultivated in 2005 or 2006.

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-till 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.

Seven corn hybrids and 11 soybean varieties have been used during the 33 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, Kladvko 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.

	<u>Year</u>	<u>Corn</u>	<u>Soybean</u>		<u>Year</u>	<u>Corn</u>	<u>Soybean</u>
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				

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

Rotation	Tillage	Soil pH			Soil P Concentrations			Soil K Concentrations		
		0-4"	4-8"	Mean	0-4"	4-8"	Mean	0-4"	4-8"	Mean
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)

2007 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 included the use of an International 22-foot pull type tandem disk with spring tooth harrow and a Glencoe 10-foot field cultivator with rear-mounted, double-rolling baskets.

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.

All 30-inch row corn plots, except no-till, were cultivated with a 4-row Hiniker ridging cultivator to control weeds and aerate the soil. The ridging wings were raised on the plow and chisel plots so that these plots were left as level as possible with inter-row cultivation. Ridge-till soybean plots were re-ridged after harvest. 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 2008. *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:

Gál, A., T.J. Vyn, E. Michéli, E.J. Kladvko, 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. Hegyemegi, and A. Gál. 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.

Drs. Andreas Westphal (Botany and Plant Pathology) and Tony Vyn (Agronomy)

Population densities of Soybean Cyst Nematode under different tillage systems in different crop sequences

The role of tillage intensity on population density development of *H. glycines* was investigated in long-term tillage plots, established in 1975 at the Agricultural Center for Research and Education, Purdue University. In this long-term experiment, main plots were crop sequence treatments: (1) continuous corn, (2) corn-soybean, (3) soybean-corn, and (4) continuous soybean. Subplots in a split-plot arrangement, were tillage treatments: (A) moldboard plow and secondary tillage, (B) chisel and secondary tillage, (C) ridge tillage, and (D) no tillage. In earlier years, the soybean cultivars used in the experiment had some resistance to *H. glycines*. Starting in 2003, a strip (comprised of 1/3 of the original plot area) in each soybean subplot was planted to the *H. glycines*-susceptible cultivar Williams 82 to allow nematodes to reproduce. In spring and fall of 2003 and 2004, soil samples were collected to a depth of 30 cm to monitor nematode population densities. In the combined analysis of rotational and soybean monoculture plots of both years, fall population densities of *H. glycines* decreased with decreasing intensity of tillage in the corn-soybean rotational soils, whereas population densities were not significantly different among tillage treatments in the monoculture soybean soils (Fig. 1). Tillage has fundamental effects on the soil environment that warrant further study on how these affect population densities of *H. glycines*.

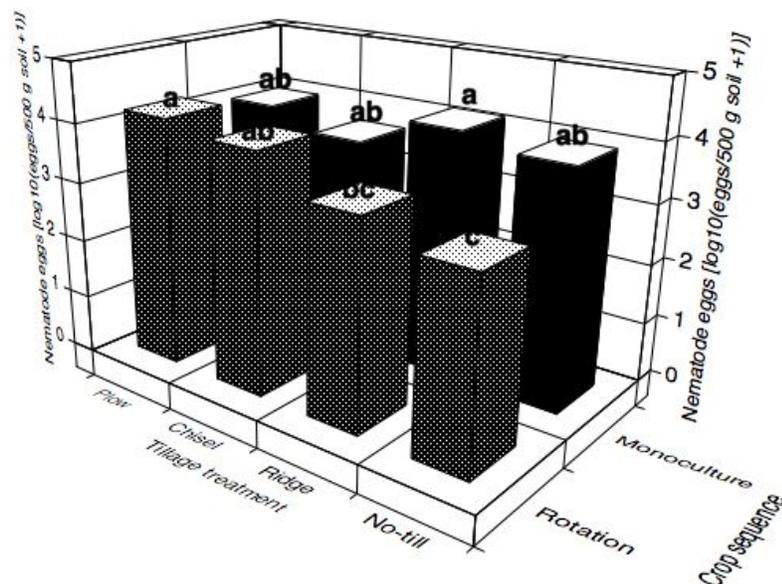


Fig. 1. Population densities of *H. glycines* at harvest of soybean in "rotation" (crop sequence of corn and soybean) or "monoculture" (continuous soybean). Nematode egg population densities were log-transformed before the combined analysis for 2003 and 2004 harvest data. Bars indexed with the same letter were not significantly different at $P \leq 0.05$.

The west 10-feet of each soybean plot was planted with Williams 82 as a part of Dr. Westphal's study of SCN and Sudden Death Syndrome. Grain samples were taken to compare with the Pioneer 93M82 planted in the "sacred" center 10-feet of each plot. See Table 3. The Pioneer 93M82 variety yielded 43% more grain in rotation soybean, and 45% more in continuous soybean, than Williams 82 variety. Both varieties suffered from SDS symptoms in 2007, and the symptoms appeared worst in the chisel treatment.

Table 3. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2007.†

Previous Crop	Tillage	Williams 82		Pioneer 93M82	
		Harvest moisture %	Yield @13.0% bu/ac	Harvest moisture %	Yield @13.0% bu/ac
Corn	Plow	15.1	38.0	14.8	58.7
	Chisel	15.0	36.9	14.6	54.9
	Ridge	15.0	47.0	14.5	62.1
	No-till	15.1	43.3	15.0	59.7
Soybean	Plow	14.8	40.1	14.8	56.0
	Chisel	15.0	37.2	14.9	54.4
	Ridge	14.5	39.5	14.5	57.4
	No-till	14.9	37.5	14.8	55.3

†Average of 4 replications



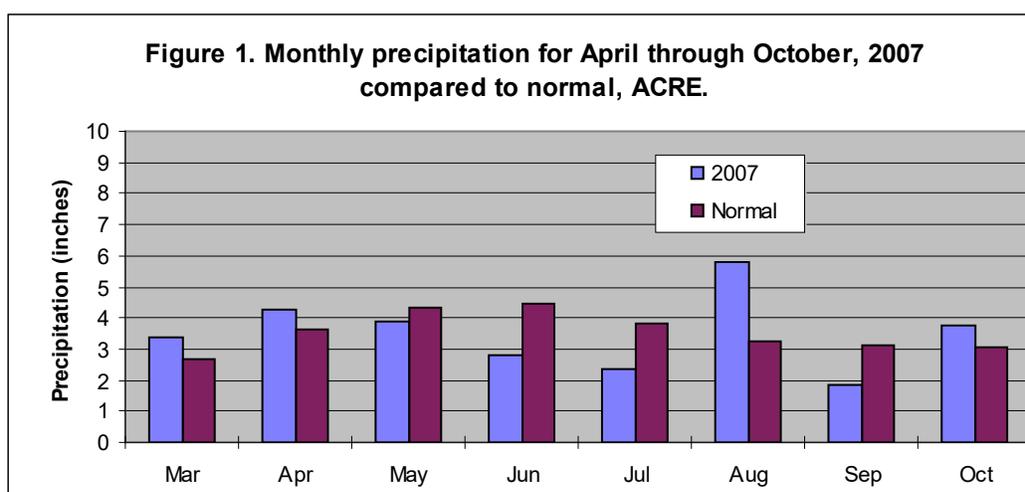
Long-term Tillage Plots, ACRE.

CULTURAL PRACTICES USED 2007				
Long-term Tillage Study, ACRE, Purdue University				
Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/2	Disk once on plow and chisel plots	5/2	Disk once on plow and chisel plots
	5/3	Field cultivate twice on plow and chisel plots	5/3	Field cultivate twice on plow and chisel plots
Hybrid/Variety planted	5/5	Pioneer 333T59 (113-day) Row cleaners on c/b and c/c no-till. Shifted no-till c/c to west. (Shift to east in 2008)	5/5	Pioneer 93M82 Round-up Ready Group 3.8
Seeding rate	5/5	32,000 seeds/ac, Drum B, 36 pockets	5/7	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		Force 3G, 5 oz/1000 row feet, banded over row (Insecticide setting 1-7)		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	5/7	<u>Burndown plus pre-emergence:</u> Roundup Original Max 24 oz/ac Harness Extra 5.6L 5pt/ac Ammonium sulfate 17 lbs/100 gallons water.	5/8	<u>Pre-emergence:</u> First Rate 0.75 oz/ac Micro-tech (Lasso) 6 pt/ac Roundup Original Max 24 oz/ac
Nitrogen fertilizer	5/23	200 lbs N as UAN (28%) @ 60 gallons/acre		None
Cultivation	6/11	Plow and chisel treatments	6/11	Plow, chisel, and ridge treatments
	6/11	Ridge treatment (re-ridge)	11/5	Ridge treatment (re-ridge)
Harvest	10/4	Center 4 of 12 rows, 150-feet	10/9	Center pass, 10-feet x 150-feet
Fall fertilizers:				
Phosphorous		None		None
Potassium	10/22	0-0-60 @ 300 lbs/ac	10/22	0-0-60 @ 300 lbs/ac
Lime	11/2	2 ton/ac	11/2	2 ton/ac
Primary tillage	11/5	Fall plow on plow treatment	11/5	Fall plow on plow treatment
	11/7	Fall chisel on chisel treatment	11/7	Fall chisel on chisel treatment

Weather and soil conditions in 2007

March and April rainfall was slightly wetter than normal (Fig. 1). Rainfall of 1.87-inches in the last week of April prevented a late April planting. The plow and chisel plots were disked on May 3rd and due to wet soil conditions the seedbed was very cloddy. It would have been better to have waited a few more days for the soil to dry. Two passes of the field cultivator did little more than roll the clods around. Corn was planted on May 5th in cloddy soil conditions in the plow and especially the chisel plots. The no-till and ridge-till soil conditions were very good for planting. Soybeans were planted on May 7th also in cloddy soil conditions. Rainfall of 3.5-inches in the last week of May replenished soil moisture and helped germinate seeds lying in dry soil in the plow and chisel treatments. June and July rainfall was approximately 1.6-inches less than normal each month. August had over 5-inches of rainfall in the last 10 days of the month that seemed to revive the drought stressed corn and soybeans. September was less than normal with 1.83-inches of rain.

In summary there less than adequate soil moisture for most of July and the first 3 weeks of August. Late August rains helped tremendously followed by a dry September. The crops matured normally and yields were good.



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 12 of the 13 years.

Continuous corn: Tillage and planting went well in the no-till and ridge 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. The cloddy conditions in the plow and especially the chisel plots left seeds in a dry seedbed. Rainfall was needed to get these seeds germinated. Plant populations at 4-weeks after planting in the chisel treatment were significantly lower than the plow treatment (Table 4). Although the chisel populations were 1,000 or more plants lower than the no-till and ridge populations this difference was not significant. No-till plant growth was slower than the other tillage systems at 4 and 8 weeks after planting. This difference was significant at 8 weeks. Pollination was satisfactory with little silk clipping.

This year's corn yields were lower than the past 2-years. This could be partly due to drier soil conditions in late June, most of July, and the first 3-weeks of August. Yields in the plowed treatment were equal for continuous corn and those for corn grown in rotation with soybean. The trend over the 33-years of this study is for continuous corn in the plow treatment to yield an average of 8 bushels per acre less than the corn in rotation with soybean. This was also our first year for this hybrid (Pioneer 33T59, 113 CRM). The chisel yields were not significantly different than plow yields despite the reduced population in the chisel treatment. Harvest grain moisture with no-till was not significantly higher than after the other treatments. Although there was a 15.1 bushel/acre spread from highest to lowest yields there were no significant differences.

Corn following soybeans: Plant stands, plant height at 4- and 8-weeks after planting were equal in all treatments. There were significant differences in grain moisture at harvest with chisel treatment being the driest and no-till treatment the wettest. There were significant yield differences among the tillage systems. The plow treatment was surprisingly low this year as compared to the other treatments and was significantly lower than the chisel treatment. The chisel, ridge and no-till treatments were statistically equal.

Table 4. Agronomic performance of corn as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2007. †

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	32218a‡	22.7a	72.6a	19.4	186.4
	Chisel	30968b	20.5b	70.1a	19.8	184.6
	Ridge	31406ab	20.1ab	69.5a	21.5	186.0
	No-till	31187ab	19.2ab	64.9b	21.7	171.3
Soybean	Plow	32218	22.4	72.2	20.7a	185.2b
	Chisel	31715	21.1	73.3	18.5b	206.6a
	Ridge	32000	24.0	75.0	19.0ab	198.4ab
	No-till	31875	23.1	75.5	21.1ab	200.5ab

†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 two 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.

Rotation soybean/corn: Plant populations at 4-weeks after planting were satisfactory for all treatments (Table 5). Slight differences in plant height at 4-weeks after planting were noted with the plow treatment tallest and the chisel treatment shortest. By 8-weeks after planting the chisel treatment had fallen further behind and was statistically the shortest of all treatments. The ridge treatment yielded highest with 62.1 bushels per acre but not significantly different from plow and no-till. The chisel treatment yielded 54.9 bushels per acre which was significantly lower

than the other treatments. We did note the chisel treatment had the most plants infected with Sudden Death Syndrome (SDS), and that might explain the yield response following chisel.

Continuous soybean: Plant populations were satisfactory although there were significant differences among treatments (Table 5). Again, all treatments were planted in 30-inch rows. We suspect that yields in all soybean plots were affected by soybean cyst nematode (SCN). We also observed many plants affected by SDS. 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 5. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2007. †

Previous Crop	Tillage	Stand‡ 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		ppa	in	in	%	bu/ac
Corn	Plow	123700a‡	8.0a	24.5a	14.8	58.7a
	Chisel	101100bc	5.7b	20.0b	14.6	54.9b
	Ridge	107800c	7.0b	23.6a	14.5	62.1a
	No-till	114300ab	6.9b	22.4a	15.0	59.7a
Soybean	Plow	117400a	7.3bc	24.3	14.8	56.0
	Chisel	107300b	6.9c	24.0	14.9	54.4
	Ridge	121400a	9.4a	25.1	14.5	57.4
	No-till	122300a	8.5ab	24.1	14.8	55.3

†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 6. Analysis of variance summary, tillage data, Long-term Tillage Study, ACRE, Purdue Univ., 2007.

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

Soybean analysis for 2005-2007, 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 treatment being shortest along with the ridge and no-till treatments. 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 ridge treatment yielded highest with 59.6 bushels per acre and was significantly different from the other treatments. The chisel treatment yielded 50.0 bushels per acre which was significantly lower than the other treatments. We did note 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 no significant differences among treatments (Table 7). We suspect that yields in all soybean plots were affected by SCN. We also observed many plants affected by SDS. 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., 2005-2007. †

Previous Crop	Tillage	Stand 4 weeks ppa	Height 4 weeks in	Height 8 weeks in	Harvest moisture %	Yield @13.0% bu/ac
Corn	Plow	123200a‡	6.5a	24.2a	13.6	55.7b
	Chisel	113400bc	5.8b	22.1c	13.6	50.0c
	Ridge	120000ab	6.1ab	23.3b	13.6	59.6a
	No-till	116900c	5.9b	21.8c	13.7	56.7b
Soybean	Plow	120200	6.2b	23.2	13.6	48.2b
	Chisel	117600	6.0b	23.0	13.7	49.5ab
	Ridge	119500	6.8a	23.1	13.5	51.9a
	No-till	122200	6.5ab	23.2	13.6	49.6ab

†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., 2005-2007.

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

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 2005-06). 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, 1975-07.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation	
	Bu/ac	% of plow yield	Bu/ac	% of plow yield		%
Plow	179.7	---	172.7	---		4
Chisel	180.9	101	168.2	97		8
Ridge*	184.9	103	169.7	98		9
No-till	176.0	98	149.1	86		18

*Since 1980

Table 10. Soybean Yield Response to Tillage and Rotation, Long-term Tillage Study, ACRE, 1975-07.

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation	
	Bu/ac	% of plow yield	Bu/ac	% of plow yield		%
Plow	53.5	---	48.2	---		11
Chisel	51.4	96	46.5	96		11
Ridge*	52.1	97	46.2	95		13
No-till	51.3	96	47.0	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.

