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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 1 or 2 field cultivation passes for spring seedbed preparation. For the ridge system, ridges were made at cultivation in corn and after harvest in soybeans. Row width for corn is 30-inches. Row width for soybeans was 30-inches for soybeans from 1975 to 1994. Starting in 1995, soybeans were drilled in 7.5-inch rows for plow, chisel and no-till treatments. All 30-inch row treatments except no-till were inter-row cultivated once.

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. Nitrogen source for corn was anhydrous ammonia through 2000 and liquid UAN (28%) starting in 2001, either pre-plant or side-dress. 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.

Five corn hybrids and 10 soybean varieties have been used during the 29 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	16	1990	4/26	5/21
2	1976	4/29	5/10	17	1991	5/10	5/16
3	1977	5/10	5/6	18	1992	5/5	5/8
4	1978	5/3	5/19	19	1993	5/11	5/12
5	1979	5/9	5/17	20	1994	4/26	5/17
6	1980	5/5	5/15	21	1995	5/22	6/1
7	1981	5/22	5/28	22	1996	5/31	6/21
8	1982	4/30	5/11	23	1997	4/29	5/16
9	1983	5/10	5/12	24	1998	5/14	5/18
10	1984	5/2	5/14	25	1999	5/12	5/21
11	1985	4/25	5/16	26	2000	4/26	5/24
12	1986	4/29	5/28	27	2001	5/2	5/10
13	1987	5/5	5/7	28	2002	5/29	5/29
14	1988	4/26	5/12	29	2003	5/23	5/27
15	1989	4/25	5/12	30			

Table 2. Soil test results based on composite samples, Long-term Tillage Study, ACRE, Fall 2003.

Tillage	**Crop**	**Depth**	**OM**	**Phos.**	**K**	**Mg**	**Ca**	**Soil pH**	**Buffer pH**	**CEC**
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Plow	CC	0-8	4.3	38 H	153 M	690 VH	2200 M	6.6	6.9	18.3
No-till	CC	0-4	5.4	72 VH	308 VH	735 VH	2100 L	6.3	6.7	21.0
No-till	CC	4-8	4.0	33 H	120 M	500 H	1800 L	5.4	6.5	19.5
Plow	CB	0-8	4.1	38 H	156 M	760 VH	2550 M	6.9		19.8
No-till	CB	0-4	5.1	70 VH	266 VH	710 VH	2250 M	6.8		18.4
No-till	CB	4-8	4.4	35 H	132 M	580 H	2200 L	5.7	6.5	22.2
Plow	BB	0-8	3.8	39 H	169 H	740 VH	2500 M	7.2		19.1
No-till	BB	0-4	4.9	86 VH	301 VH	760 VH	2600 M	7.2		20.1
No-till	BB	4-8	4.1	23 M	123 M	650 VH	2400 M	6.3	6.7	21.3

2003 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.

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) were equipped to deliver 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.

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. When planting the ridge treatment, row-unit-mounted double vertical disks scraped less than 1-inch of soil off the ridge tops and stabilized the planter on the ridge tops. 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.

Soybeans were planted with a 10-foot John Deere 750 no-till drill in the plow, chisel and no-till treatments. In the ridge treatment, the soybeans were planted with the Case-IH 955 planter in 30-inch rows.

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 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 (and inoperative for “level” cultivating) on the plow and chisel plots. Ridge-till soybean plots were re-ridged after harvest. All corn plots were harvested with a White model 7300 combine equipped with a 4-row corn head. All soybean plots were harvested with a 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 soybeans. This study will continue in 2004. *Dr. Scott Abney*
- Anita Gal, Tony Vyn. Carbon Sequestration 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. These samples were still being analyzed in the laboratory in January of 2004. Once the analyses are complete, they should help us determine the relative effects of tillage and rotation treatments on relative carbon sequestration. 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 29-year history of these long-term plots provides a very valuable background to assess the impacts of management.
- 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.

- Dr. Andreas Westphal, Botany and Plant Pathology, Purdue University. Population dynamics of the soybean cyst nematode (*Heterodera glycines*) under different crop sequences and tillage systems. In this study, population density changes of *H. glycines* under the soybean/corn rotation or continuous corn are compared. In 2003, population densities were determined at planting and at harvest under the susceptible cultivar Williams 82. Comparing the tillage system and crop sequences, soybean in rotation plots had lower cyst numbers under ridge tillage and no-tillage than in other treatments (Fig. 1). Averaged for crop sequence, ridge-tillage and plow tillage had higher numbers of eggs per cyst than no-tillage (Fig. 2). The study will be continued.

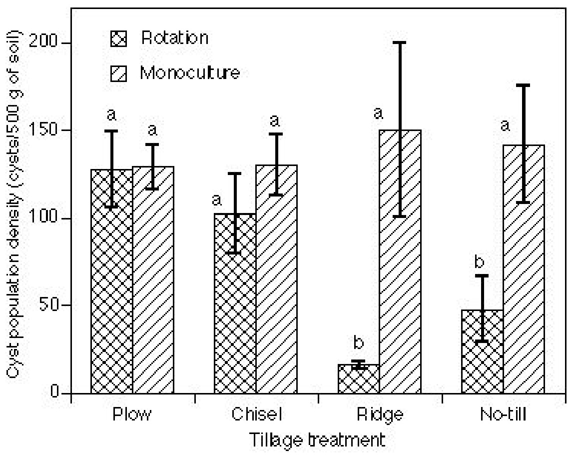


Fig. 1. Cyst population densities of *H. glycines* at 0-30-cm under different crop sequences and tillage systems. Original means and SE were presented. Bars indexed with the same letter were not significantly different when log10-transformed data were compared at $P \leq 0.05$.

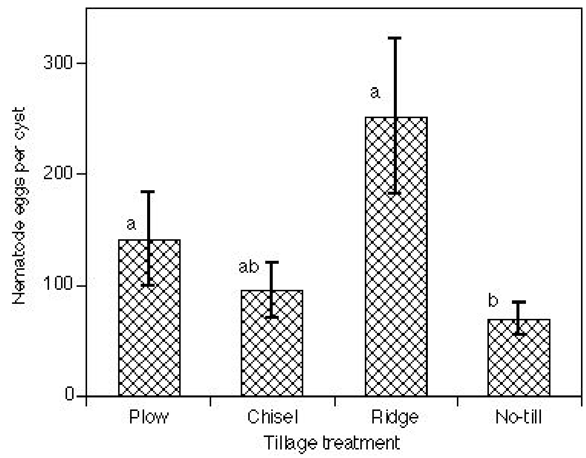


Fig. 2. Number of eggs per cyst determined in soybean plots in 2003. Original means and SE were presented. Bars indexed with the same letter were not significantly different when log10-transformed data were compared at $P \leq 0.05$.

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 93B67 planted in the "sacred" center 10-feet of each plot. Table 6 gives this data based on 4 replications. The Pioneer 93B67 yielded 25% more grain in rotation and 24% more in continuous soybean.

Table 3. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2003. †

		Williams 82		Pioneer 93B67	
Previous Crop	Tillage	Harvest moisture	Yield @13.0%	Harvest moisture	Yield @13.0%
		%	Bu/a.	%	Bu/a.
Corn	Plow	16.4b‡	40.2b	12.3b	52.0
	Chisel	16.4b	36.0b	12.2b	50.8
	Ridge	16.6b	46.8a	12.6b	52.2
	No-till	17.2a	41.3b	13.2a	50.1
Soybean	Plow	16.1	39.5	12.2	48.7ab
	Chisel	16.3	36.4	12.3	49.4ab
	Ridge	16.2	41.2	12.6	47.0b
	No-till	16.2	41.3	12.5	51.6a

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

CULTURAL PRACTICES USED 2003 Long-term Tillage Study, ACRE, Purdue University				
Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/14 5/22	Disk once on plow and chisel plots Field cultivate once on plow and chisel plots	5/14 5/27	Disk once on plow and chisel plots Field cultivate once on plow and chisel plots
Hybrid/Variety planted	5/23	Beck's 5322 (109-Day) Row cleaners on c/b and c/c no-till. Shifted no-till c/c to west. (Shift to east in 2004)	5/27	Pioneer 93B67 Round-up Ready Group 3.5
Seeding rate		30,000 seeds/a., Drum B, 36 pockets (variable rate controller)		Plow, chisel, no-till drilled: 200,000 seeds/a. Ridge 30-inch rows: 140,000 seeds/a. (variable rate controller)
Starter fertilizer/planter		34-0-0 @ 96 LB/a., 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		
Weed control	4/19 5/29	<u>Burndown:</u> Roundup Ultra 1.5 pt/a. on no-till and ridge-till <u>Pre-emergence:</u> Harness Extra 5.6L 5pt/a. Roundup Weather Max 1 pt/a.	4/19 5/29	<u>Burndown:</u> Roundup Ultra 1.5 pt/a. on no-till and ridge-till <u>Pre-emergence:</u> First Rate 0.75 oz/a. Micro-tech (Lasso) 6 pt/a. Roundup Weather Max 1 pt/a.
Nitrogen fertilizer	6/4	200 lbs N as UAN (28%) @ 60 gallons/acre		None
Cultivation	6/25 6/25	Plow and chisel treatments Ridge treatment (re-ridge)	7/1 11/3	Ridge treatment only Ridge treatment (re-ridge)
Harvest	10/23	Center 4 of 12 rows, 150-feet	10/9	Center pass, 10-feet x 150-feet
Phosphorous, Potassium	11/3	0-46-0 @ 300 LB/a. and 0-0-60 @ 300 LB/a. blended	11/3	0-46-0 @ 300 LB/a. and 0-0-60 @ 300 LB/a. blended
Lime		None		None
Primary tillage	11/3 11/3	Fall plow on plow treatment Fall chisel on chisel treatment	11/3 11/3	Fall plow on plow treatment Fall chisel on chisel treatment

Weather and soil conditions in 2003

April rainfall was 2.70-inches compared to a normal rainfall of 3.65-inches (Fig. 3). Due to other planting commitments, we did not plant these plots in April. Rain occurred on 16 of the first 21 days of May totaling 5.53-inches, preventing an early planting in May. As soils approached plantable conditions by May 19th rewetting occurred on May 20th with 0.25 inches of rain. Soils then dried over the next few days and we were able to plant corn on May 23rd and soybeans on May 27th. Weather conditions from date of planting through the middle of June resulted in excellent seed germination and plant emergence for both corn and soybeans. Very little rainfall occurred for the rest of June and the first 4 days of July, however soil moisture was sufficient for good crop growth. Rainy weather from July 5th through July 12th with accumulations of 6.16-inches resulted in standing water in many of the plots. July continued to be wet with a total for the month of 7.90-inches of rain as compared to normal rainfall of 3.79-inches. Another storm on August 3rd dumped another inch of rain that kept the soils very wet. And then we entered a dry period of 25 days with only 0.61 inches of rain. Rainfall on August 29th and 30th provided 1.97-inches of rain to relieve crop stress from the dry soils. August ended with near normal accumulation of rainfall. Heavy rains occurred again on September 1st and 2nd contributing to another period of flooding. Another dry period of 19 days followed and then from September 22nd through September 27th 3.59-inches of rain again caused very wet soil conditions in the plots. October was much drier that normal with an accumulation of only 1.30-inches of rain compared to a normal of 2.96-inches. In summary, this growing season experienced periods of flooding and drought, however most corn yielded very high although soybean yields were less than normal.

Stand, growth, and yield -- Corn.

<u>In no-till continuous corn</u>, establishing a uniform stand can be difficult. The corn residue is thickest on the old row and we had previously 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 9th year of shifting the new rows. We achieved these goals in 8 of the 9 years.

<u>Continuous corn</u>: Tillage and planting went well in all treatments. Excellent seedbeds were established in the plow and chisel treatments with the two secondary tillage passes. After setting the ridge cleaners on the planter to brush residue off the ridge top while removing as little soil as possible, we planted into ideal conditions in the ridges. No-till also planted easily with good seed to soil contact. We achieved similar stands among all treatments with no significant differences (see Table 4). The significantly shorter corn at 4-weeks after planting in the plow treatment is puzzling and we have no

explanation for this. Plant growth continued normally through 8-weeks after planting, although the soil was at times flooded for several 2 to 3 day periods. Pollination was very good with minimal silk clipping from insects. No-till corn grain yields were significantly lower than the other treatments in continuous corn, partly due to lost yield potential from an early fall frost that occurred before most of the no-till plants had matured.

Corn following soybeans: Plant stands were equal in all treatments. As in continuous corn, plant height was shorter in the plow treatment, and again there seem to logical reason for this. There were no significant differences in grain moisture at harvest. The plow treatment yielded the most at 185.1 bushels/acre, but was not significantly different than the other treatments.

Note that when planting late in the season due to wet soils established no-till soils may provide a better seedbed than working plow fields wet. Consistent seed to soil contact is more likely to be achieved in the no-till seedbed than planting in a cloddy tilled seedbed. Cold soil temperatures are not a yield limiting factor for no-till late in the season.

Table 4. Agronomic performance of corn as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ACRE, Purdue Univ., 2003. †

Previous Crop	Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		%	ppa	in	in	%	Bu/a.
Corn	Plow	3d‡	30000	13.1b	68.5ab	17.1	174.1a
	Chisel	26c	28900	14.9a	71.1a	16.9	173.6a
	Ridge	58b	29200	15.6a	68.7ab	16.9	173.1a
	No-till	93a	29500	15.3a	66.4b	17.5	153.7b
Soybean	Plow	3c	29400	13.9b	68.5	17.3	185.1
	Chisel	8c	29200	15.3ab	70.7	17.2	181.5
	Ridge	35b	29400	15.1ab	71.5	17.6	181.5
	No-till	84a	29500	16.7a	71.3	17.6	175.3

†Average of 3 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.

For the tenth consecutive year 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. Seeding rates were set higher for the drilled treatments. 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: Ridge plant populations were significantly lower due to the reduced seeding rate at planting for 30-inch rows (Table 5). Plant growth was not significantly different at 4-weeks after planting, however there were some differences at 8-weeks after planting when soybeans followed corn. The ridge-till and plow treatments were significantly taller than chisel and no-till. We did note some plants infected with Sudden Death Syndrome (SDS). These were more often found in chisel plots. The 30-inch row ridge plots yielded equal to the 7.5-inch drilled treatments. This points out the competitiveness of the ridge-till system to drilling soybeans in a full-width tillage system in this study. Rotation soybeans yielded 3.5% more than continuous soybeans in 2003. Overall yields were slightly below the 28-year average for rotation soybeans following corn and slightly above for continuous soybeans.

Continuous soybean: Plant populations in the ridge treatment were significantly lower due to the reduced seeding rate at planting for 30-inch rows. The ridge treatment, which in the past several years suffered from extremely high populations of SCN in some plots, yielded competitively with full-width tillage systems in 2002. However, in 2003 the ridge treatment again tended to be lower yielding than the other treatments. We suspect that yields in all continuous soybean plots are somewhat affected by SCN. We also observed some plants affected by Sudden Death Syndrome. Overall yields were slightly above the 28-year average for 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., 2003. †

Previous Crop	Tillage	Residue cover After planting	Stand‡ 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		%	ppa	in	in	%	Bu/a.
Corn	Plow	3c§	202800a	4.1	22.8a	12.3	51.4
	Chisel	32b	187200a	3.9	21.0b	12.3	49.9
	Ridge	34b	136700b	4.4	23.3a	12.5	50.6
	No-till	95a	186200a	3.8	18.8c	12.7	49.7
Soybean	Plow	1c	205200a	4.2	21.6	12.2	48.6
	Chisel	6c	186200a	4.3	21.2	12.3	49.1
	Ridge	22b	137200b	4.0	20.2	12.5	46.6
	No-till	73a	207600a	3.8	20.7	12.5	50.4

†Average of 3 replications.
‡Plow, chisel, and no-till are 7.5-inch drilled, ridge is 30-inch rows.
§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., 2003.

Variable	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield Bu/a.
	--Significance Level-------------------------------------					
				Corn		
Tillage	.01	NS	.01	.03	.08	.01
Previous crop	.05	NS	NS	NS	NS	.03
Tillage x previous crop	.01	NS	NS	.01	NS	NS
				Soybean		
Tillage	.01	.01	NS	.01	.04	NS
Previous crop	.01	NS	NS	NS	NS	NS
Tillage x previous crop	.01	NS	NS	.01	NS	NS

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 29-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 7 and 8). 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. 4). 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. 5). Yield reductions with no-till corn are not due to lower populations.
4. No-till soybean yields are likely to be reduced slightly, compared with plowing, but yield differences may be reduced with time (Fig. 6 and 7). No-till soybean yield reductions are likely to be less frequent when grown in narrow rows.

Table 7. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, ACRE, 1975-03.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	176.4	- - -	168.5	- - -	5
Chisel	176.9	100	164.0	97	8
Ridge*	181.5	103	167.1	99	9
No-till	172.5	98	146.2	87	18

*Since 1980

Table 8. Soybean Yield Response to Tillage and Rotation, Long-term Tillage Study, ACRE, 1975-03.

Tillage	Corn/Soybean		Continuous Soybean		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	53.1	- - -	48.4	- - -	10
Chisel	51.5	97	46.1	95	12
Ridge*	51.2	96	45.2	93	13
No-till	50.4	95	46.3	96	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.

Long-term Tillage Study, PPAC

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

In this study we will be investigating crop residue/soil temperature/tillage relationships and their effects on crop growth and yield. In this northern Indiana location, cold soil temperatures limit no-till crop performance. Most farmers in this area use full-width primary tillage with 2 secondary tillage passes to prepare a suitable seedbed. Our plans are to use a wide variety of tillage equipment to determine if there is a level of tillage that will preserve crop residues on the soil surface for erosion control, yet give satisfactory yields. The practices are designed to leave crop residue levels ranging from none to as much as possible with a number of levels in between. We are looking for the most effective mix to insure both soil protection and optimum crop production. This has been a frequently expressed concern in northern Indiana, and one in which farmers have real interest.

This study will be a good start toward addressing questions that area farmers have raised about reduced tillage. We feel this is finally going to provide the comparisons that farmers have been asking for on the soils that are most troublesome. This study was set up in the field in 1996 with proper row direction and cropping sequence.

Crop Rotations	Tillage Treatments	Data to be Collected
Continuous corn	Fall chisel, spring disk and combo-mulch-finisher	Residue cover
Corn/soybean	Fall chisel, spring combo-mulch-finisher	Soil temperatures
Soybean/corn	Fall disk, spring combo-mulch-finisher	Week 4 stand and height
	Fall aerator, spring aerator (1997-2000)	Week 8 height
	Fall strip-till (2001-2003)	% Grain moisture at harvest
	No-till	Yield

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

	Year	Corn	Soybean		Year	Corn	Soybean
1	1997	4/26	5/12	5	2001	5/9	5/9
2	1998	5//12	5/15	6	2002	5/23	5/23
3	1999	5/4	5/15	7	2003	4/28	5/22
4	2000	5/6	5/6	8	2004		

Weather in 2003

April rainfall was near normal which allowed planting into ideal seedbed conditions (Figure 1). May rainfall was nearly double the normal amount. The soil was saturated with water, although no evidence of prolonged ponding was seen. June rainfall was more than 1.5-inches below normal. July rainfall again was nearly double the normal amount and caused saturated soils. August was similar to June in that rainfall was about 1.5-inches less than normal. September rainfall was near normal. Even with the roller-coaster like soil moisture conditions, the corn yielded much better than expected.

Table 2. Soil test results based on composite sampling, Long-term Tillage Study, PPAC, Fall 2003.

Tillage	**Crop**	**Depth**	**OM**	**Phos.**	**K**	**Mg**	**Ca**	**Soil pH**	**Buffer pH**	**CEC**
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CC	0-8	3.2	36 H	131 M	460 VH	1450 M	6.4	6.9	12.6
No-till	CC	0-4	3.8	64 VH	224 H	445 H	1400 L	6.1	6.7	14.9
No-till	CC	4-8	3.2	22 M	92 M	375 H	1350 L	5.7	6.7	13.7
Chisel	CB	0-8	3.7	35 H	118 M	495 VH	1600 M	6.5	6.9	13.6
No-till	CB	0-4	3.5	42 H	204 H	415 VH	1350 L	6.2	6.8	13.1
No-till	CB	4-8	3.3	20 M	97 M	440 H	1500 L	6.0	6.7	15.0

CULTURAL PRACTICES USED 2003

Long-term Tillage Study, Fields B3 & C3, Pinney Purdue Agricultural Center

Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	4/27	Disk	5/21	Disk
	4/28	Field cultivate	5/22	Field cultivate
Hybrid/Variety planted	4/28	Pioneer 34M94	5/22	Pioneer 93B67 Roundup Ready
Seeding rate		32,097 seeds/a.		203,000 seeds/a. in drilled plots 143,000 seed/a. in 30-inch row plots
Starter fertilizer/planter		19-17-0 @ 125 LB/a., 2-inches to the side and 2-inches below the seed.		None.
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.		None
Weed control	4/29	Pre-emerge: Bicep II Magnum 4.2 pt/a. Atrazine 4L 2 pt/a.	4/16	Burndown: Roundup Weather Max 22 oz/a. 2-4DLV 1 pt/a.
	6/3	Post-emerge: Buctril AT 1 pt/a. Atrazine 4L 1 pt/a.	6/23	Post-emerge: Roundup Weather Max 22 oz/a. AMS 17 LB/100 gallons of water
	7/17	Post-emerge: Accent 2/3 oz/a. Buctril 1.5 pt/a. NIS 1 pt/100 gallons water		
Manganese			7/25	Celated Manganese 4 pt/a.
Nitrogen fertilizer	6/2	200 lbs N as UAN (28%) @ 60 gallons/acre (6 row, 5.25 setting)		None.
Cultivation	6/18	Once as required by treatment.		None
Harvest	10/13	All 6 rows, 130-feet.	10/7	Whole plot, 130-feet.
P and K fertilizer		None		None
Lime		None		None
Fall tillage	10/24	Fall chisel with leveling bar.	10/24	Fall chisel with leveling bar.
	11/11	Fall disk, no harrow.	11/11	Fall disk, no harrow.
	11/11	Fall strip-till 8-inch depth.	11/11	Fall strip-till 8-inch depth.

Stand, growth, and yield -- Corn.

Continuous corn: The planter was shifted 6-inches to the side of last year's old row in no-till. We used row cleaners on the planter for the strip-till and no-till treatments. Seed germination and seedling emergence was uniform (Table 3) resulting in no significant differences among treatments. Strip-till and no-till were slower growing than the tilled treatments as shown by measurements at 4 and 8 weeks after planting. Even though they were slower, the plants looked healthy through the year. Pollination was excellent in all treatments. There were no significant differences in grain yield. Yields were very high in all treatments, which is somewhat surprising considering the periods of flood and drought this year.

Rotation corn/soybeans: Soil surface residue cover levels of at least 30% are needed to reduce soil erosion by wind and water. Full-width tillage in the fragile soybean residue reduces levels below 30% (Table 3). Even the least aggressive full-width tillage treatment of disk/field cultivator resulted in 10% residue cover. Both strip-till and no-till left sufficient residue to reduce soil erosion. Less tillage meant greater plant stands at 4 weeks for the no-till and strip-till treatments, although not significantly different from the full-width tillage treatments. Grain yields for all treatments were exceptionally good this year. With the near perfect pollination and late season development, the corn did quite well considering the periods of flood and drought.

Table 3. Agronomic performance of corn as affected by tillage and rotation, Sebewa loam, Long-term Tillage Study, Pinney Purdue Agricultural Center, 2003. †

Previous crop	Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		%	ppa	in	in	%	Bu/a.
Corn	Chisel/disk/field cultivator	20d‡	28000	8.3ab	36.7a	24.2b	210.1a
	Chisel/field cultivator	29d	27500	8.5a	37.5a	23.7b	210.8a
	Disk/field cultivator	62c	27500	8.3ab	35.1a	24.8b	210.3a
	Fall strip-till	76b	28300	7.9ab	33.5a	25.5b	207.6ab
	No-till	94a	28000	7.4b	30.2b	27.0a	201.3b
Soybean	Chisel/disk/field cultivator	4c	28500ab	8.6	38.8ab	25.0	216.6b
	Chisel/field cultivator	6c	27200b	8.4	38.5ab	24.9	221.8ab
	Disk/field cultivator	10c	28200ab	8.7	40.1a	25.1	218.9ab
	Fall strip-till	59b	29200a	8.4	39.0ab	25.4	225.8a
	No-till	83a	29600a	7.9	36.0b	25.6	223.2ab

†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 4. Analysis of variance summary, tillage data, corn, Long-term Tillage Study, PPAC, 2003.

Variable	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield
	--Significance Level---------------------------------					
Tillage	.01	.01	.01	.01	.01	NS
Previous crop	.01	NS	NS	.01	NS	.01
Tillage x previous crop	.01	NS	NS	.05	.07	.01

Stand, growth, and yield -- Soybeans

All treatments except strip-till were drilled at 203,000 seeds/acre while the strip-till treatment was planted at 143,000 seeds per acre in 30-inch rows. There were no significant differences in stands at 4 weeks after planting (Table 4) except for the strip-till. Plant growth was normal through week 4 with no significant differences between treatments. By week 8 after planting, strip-till was significantly taller than the other treatments. A hailstorm in June damaged or broke off the main stem on many of the plants. Subsequent growth of lateral stems developed fewer pods, thus reduced yield potential in all treatments. Strip-till yielded significantly less than all of the other treatments. This is opposite of the previous 2 years when strip-till yielded the highest.

Table 5. Agronomic performance of soybean as affected by tillage, Sebewa loam, rotation soybean/corn, Long-term Tillage Study, Pinney Purdue Agr Center, 2003. †

Tillage	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
	%	ppa	in	in	%	Bu/a.
Chisel/disk/field cultivator	15d‡	186000a	3.3	15.5b	13.4	37.7a
Chisel/field cultivator	26c	215000a	3.3	15.9b	12.6	39.4a
Disk/field cultivator	75b	194000a	3.0	14.4b	13.6	39.8a
Strip-till 30-inch rows	75b	135000b	3.3	17.6a	12.5	34.5b
No-till	97a	205000a	3.3	14.5b	12.5	38.4a
ANOV sig. level	.01	.01	NS	.01	NS	.02

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

Remlinger strip-till tool in cornstalks.

Long-term Yields

Table 6. Yield summary by year, Bu/a., Sebewa loam, Long-term Tillage Study, PPAC.†

Previous Crop	Tillage	1997	1998	1999	2000	2001	2002	2003	97-00 Avg.	97-03 Avg.	01-03 Avg.
						Corn					
Corn	Fall chisel, disk, field cultivate	187.2	188.4	141.5	164.1	204.0	124.9	210.1	170.3	174.3	179.7
	Fall chisel, field cultivate	194.5	187.1	146.8	170.3	206.6	121.4	210.7	174.7	176.8	179.6
	Fall disk, field cultivate	184.3	180.4	133.5	165.9	194.2	123.8	210.3	166.0	170.3	176.1
	Fall aerate, spring aerate	181.4	157.2	123.9	162.0	----	----	----	156.1	----	----
	Fall strip-till	----	----	----	----	201.5	120.1	207.6	---	----	176.4
	No-till	184.9	156.0	124.4	153.4	189.0	117.2	201.3	154.7	160.9	169.2
	CC Average	186.5	173.8	134.0	163.11	199.1	121.5	208.0	164.4	169.4	176.2
Soybeans	Fall chisel, disk, field cultivate	206.9	195.6	166.7	174.8	220.8	135.0	216.6	186.0	188.1	190.8
	Fall chisel, field cultivate	211.3	186.6	171.2	177.8	222.6	135.5	221.8	186.7	189.5	193.3
	Fall disk, field cultivate	205.6	196.1	169.0	177.2	218.9	140.4	218.9	187.0	189.4	192.7
	Fall aerate, spring aerate	207.8	170.7	160.0	172.4	----	----	----	177.7	----	----
	Fall strip-till	----	----	----	----	226.8	134.7	225.8	----	----	195.8
	No-till	204.6	169.9	166.8	173.4	220.2	131.4	223.2	178.7	184.2	191.6
	CB Average	207.2	183.8	166.7	175.1	221.9	135.4	221.3	183.2	187.3	192.8
	Average	196.9	178.8	150.4	169.1	210.5	128.4	214.6	173.8	178.4	184.5
						Soybean					
Corn	Fall chisel, disk, field cultivate	60.4	48.6	46.8	50.0	55.5	30.2	37.7	51.4	47.0	41.1
	Fall chisel, field cultivate	61.9	48.3	49.5	52.8	57.5	33.4	39.4	53.1	49.0	43.4
	Fall disk, field cultivate	60.5	45.1	46.0	56.8	57.6	30.8	39.8	52.1	48.1	42.7
	Fall aerate, spring aerate	61.2	49.9	43.5	49.0	----	----	----	50.9	----	----
	Fall strip-till	----	----	----	----	60.0	39.4	34.5	---	----	44.6
	No-till	60.8	51.0	41.2	47.2	59.8	34.8	38.4	50.1	47.6	44.3
	BC Average	61.0	48.6	45.4	51.2	58.1	33.7	38.0	51.5	48.0	43.3

†Average of 4 replications.

Table 7. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, PPAC, 1997-2003

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of c/d/fc yield	Bu/ac	% of c/d/fc yield	%
Chisel/disk/field cultivator	188.1	- - -	174.3	- - -	8
Chisel/field cultivator	189.5	101	176.8	101	7
Disk/field cultivator	189.4	101	170.3	98	11
No-till	184.2	98	160.9	92	14

Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana

Principal Investigators: Terry D. West, Tony J. Vyn and Gary C. Steinhardt.

Objectives:

1. To expand feasibility studies of various reduced tillage systems for corn and soybean production relative to no-till and conventional tillage systems.
2. To compare crop response to fall strip tillage, deep tillage (Case-IH MRX690 Mulch-till Ripper), single-pass mulch tillage, and no-tillage systems for corn after corn, corn after soybeans, and soybeans after corn.
3. To compare surface residue cover and soil physical properties following various tillage systems and single-pass mulch tillage systems (in either fall or spring) relative to other conservation tillage alternatives.

Duration: October 2001 to December 2004.

Justification and Relevance:

Problem to be addressed:

Reduced tillage has many advantages in terms of efficiency, erosion control and cost savings. These have been documented in numerous studies. There is a continuing problem, however, in cooler climates with the perception that no-till leads to delayed planting, reduced plant stands and yields in corn. These perceptions have resulted in a reduction in no-till corn acreage in Indiana, particularly in the northern part of the state. The recent Purdue University Transect survey estimates that, for Indiana as a whole, only 24% of the corn acreage was planted with no-till in 2003, even though no-till production was used on 60% of the soybean acreage.

Chisel plowing is the most common tillage system prior to corn in Indiana. Since soybeans leave little residue cover to begin with, and because farmers who chisel usually perform two passes of secondary tillage, essentially no residue cover remains after planting. There have been very few investigations of single-pass tillage systems which in fall (stale seedbed) or spring (without any prior primary tillage) might permit sufficient residue cover for erosion control while resulting in yields superior to no-till.

Long-term research (1975-03) at the Agronomy Center for Research and Education has documented significant corn yield reductions with no-till when corn followed corn, but not when corn followed soybeans. Average corn yields were only 2% lower with no-till compared to moldboard plowing after soybeans (Annual Cropping Systems Report 2003). Soil temperatures with no-till were significantly lower than moldboard, chisel and ridge-till systems in the first month after planting. Spring temperatures are even colder at locations farther north. Thus, planting delays and potential yield reductions with no-till corn may be even greater on poorly drained soils in Northern Indiana.

We are continuing a study (initiated in 1997) at the Pinney-Purdue Agricultural Center to look at a range of options from no-till to full-width (chisel) tillage for continuous corn and a rotation of corn and soybeans on a poorly drained Sebawa soil. The two intermediate-intensity tillage systems investigated in this long-term study have not historically included either single-pass mulch tillage or fall strip tillage. In the first six years of this study, corn yields with no-till were 3% lower than with chisel tillage after soybeans and 8% lower than with chisel tillage after corn in rotation. No-till corn yield reductions would have been even higher if we had planted the chiseled plots earlier (because no-till usually takes longer to dry). Furthermore, one of the intermediate-intensity tillage systems (soil aerator) did not yield any more corn than no-till alone. Thus, more reasonable tillage alternatives still need to be explored to provide more viable alternatives to Indiana farmers. They need both comparable yield potential as well as the opportunity to plant earlier.

Current Investigations:

Single-pass concepts that need more investigation are those applied in the fall followed by spring no-till planting (i.e. stale seedbed) or those just before planting in spring. Our current single-pass implement (Case IH 4400 Combo-mulch Finisher) can do single-pass, full-width tillage while maintaining 30% residue cover (the minimum level to be rated as conservation tillage). However, even more residue cover can be left with fall strip tillage. Furthermore, even with chisel shanks, the depth of tillage in fall rarely exceeds 4 to 6 inches. In this study we are investigating another tillage system involving even deeper tillage to break soil pans (using the Case-IH MRX690 Disk-ripper-disk).

This research project is very important if we are to provide farmers with timely and vital information. There are insufficient replicated studies, and too many farmers are not making valid comparisons between full-width tillage, deep tillage, strip tillage and no-till. These plots can help show the possibilities for reduced tillage on the colder soils, and possibly affect the way that farmers think about reduced tillage and no-till planting of corn. This may not solve the problem of no-till planting of corn but it will, with more years of data, show farmers the relative risk and rewards so more informed decisions could be made.

Agronomy Center for Research and Education, Lafayette, IN

Soil Description

The soil types are Drummer silty clay loam and Raub silt loam. These fields are tile drained. "The Drummer series consists of very deep, poorly drained, moderately permeable soils on recessional moraines and till plains. These soils formed in silty sediments and in the underlying glaciofluvial deposits. Slopes range from 0 to 2 percent. The Raub series consists of somewhat poorly drained soils on till plains. These soils are deep over compact glacial till. Permeability is moderate in the upper part of the solum, moderately slow in the lower part of the solum, slow in the underlying material. The soils formed in silty material and in the underlying glacial till. Slopes are 0 to 1 percent," according to the Soil Survey of Tippecanoe County, 1998.

Equipment Description

- Conventional chisel plow: DMI, front disk gang, 7-shank, 4-inch twisted points, soil leveler on rear
- Disk-ripper-disk (DRD): Case-IH MRX690. See photographs.
- Field cultivator: John Deere 22-foot field cultivator with trailing double rolling harrow
- Strip-till: DMI 2500 with mole knives, berming disks and rolling basket
- Planter: 4-row Case-IH Cyclo 950 equipped with row cleaners
- Nitrogen application: DMI NutriPlacr 2800.
- Harvester: John Deere 9400.

Disk-ripper-disk in soybean stubble.

Disk-ripper-disk

Weather and soil conditions in 2003

April rainfall was 2.70-inches compared to a normal rainfall of 3.65-inches (Fig. 1). Soil conditions allowed an early planting date of April 15th and a normal planting date of April 24th. A frost occurred on April 23 that killed above ground tissue of the emerged corn in the early planting date. However, the growing point was below ground and few if any plants were killed. Rain occurred on 16 of the first 21 days of May totaling 5.53 inches. Total rainfall in May equaled 6.80-inches, exceeding the normal by more than 2-inches. Soils were saturated; however no ponding occurred on the plots. Near normal rainfall occurred in June and plant growth was good. Rainy weather from July 5th through July 12th with accumulations of 6.16-inches resulted in saturated soils again. July continued to be wet with a total for the month of 7.90-inches of rain as compared to normal rainfall of 3.79-inches. Another storm on August 3rd dumped another inch of rain that kept the soils very wet. And then we entered a dry period of 25 days with only 0.61 inches of rain. Rainfall on August 29th and 30th provided 1.97-inches of rain to relieve crop stress from the dry soils. August ended with near normal accumulation of rainfall. Heavy rains occurred again on September 1st and 2nd contributing to another period of saturated soils. Another dry period of 19 days followed and then from September 22nd through September 27th 3.59-inches of rain again caused very wet soil conditions in the plots. October was much drier that normal with an accumulation of only 1.30-inches of rain compared to a normal of 2.96-inches. In summary, this growing season experienced periods of flooding and drought, however corn yields were excellent.

Disk ripper-disk shanks

DMI 2500 strip-till.

CULTURAL PRACTICES USED 2003 Corn following Soybeans, Field 116, ACRE		
Item	Date	Application Details
Spring tillage	4/24	22-foot field cultivator with trailing double rolling baskets
Hybrid planted		
First planting date	4/15	Pioneer 34M94 PDR (Precision Designed Rounds) seed
Second planting date	4/24	Pioneer 34M94 PDR seed
Seeding rate		32,000 seeds/ac. Case-IH Cyclo 950 planter equipped with row cleaners.
Starter fertilizer/planter		34-0-0 @ 96 LB/a., 2-inches to the side and 2-inches below the seed (Sprockets driver 36, driven 30)
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.
Rodenticide/planter		Pro-Zap zinc phosphide pellets in furrow for rodent control
Weed control	4/18	Pre-emerge: Degree Extra 7 pt/a. Roundup Weather Max 1.5 pt/a. *All spraying was broadcast with 8004 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gal water/a.*
Nitrogen fertilizer	5/19	200 lbs N as UAN (28%) @ 60 gallons/acre (4-row, 3.5 pump setting)
Harvest	10/6	Center 6 of 12 rows, 150 feet
P and K fertilizer	10/17	0-0-60 @ 300 LB/a. and 0-46-0 @ 300 LB/a.
Field 117 for 2004 study.		
P and K fertilizer	10/17	0-46-0 @ 300 LB/a. and 0-0-60 @ 300 LB/a.
Tillage	10/17	Chisel with ridge leveling sweeps
	10/21	Strip-tilled with Remlinger, JD 4555 tractor, 7th gear, 4.4 mph.
	10/22	Case-IH MRX690 Disk-ripper-disk set at 13-inches deep, 4.5 mph, 8th gear, Case-IH MX240 tractor.

DMI nutri-placr 2800 used for N application.

Soil temperatures:

Soil temperatures were measured from the day after planting through the next 4 weeks in the new row at 2-inches from soil surface in 4 of the 6 replications. Temperatures were recorded with “Watchdog” thermometers made by Spectrum Technologies. The thermometers were set to record temperature hourly. No-till had the lowest average daily maximum soil temperature in both planting dates (Fig. 2). When compared to no-till, strip-tilling warmed the early planting date by 3.0 degrees Fahrenheit and normal planting date by 1.8 degrees Fahrenheit. The full-width DRD with spring field cultivate treatment exhibited the warmest soil temperatures. Average minimum soil temperatures for all treatments were within a 1-degree range per planting date.

Watchdog thermometers.

Corn Following Soybeans

Stand, growth, and yield:

In the no-till plots we set the row cleaners to brush most of the residue aside and leave the soil surface undisturbed. It was noted that in the early planting date the strip-tilled plots provided a drier seedbed than the no-till plots. The plots were quite rough in the DRD stale seedbed treatment as would be expected. The row cleaners on the planter were set to knock off the tops of the humps of soil in hopes of reducing planter row unit bounce. Row cleaners were set shallow to prevent exposing wet soil that would not allow seed slot closure.

Corn yielded surprisingly well in 2003 considering the periods of heavy rain and then extended periods without rain. Plant stands were somewhat less than our goal of 32,000 plants per acre (Table 1). The early planting date suffered from some frost damage to the young plants; however it did not seem to reduce yield potential. Note that the DRD stale seedbed treatment resulted similar plant stands compared to other treatments in spite of the fact that the seedbed was very rough at planting. Plant heights at 4 and 8 weeks after planting were significantly shorter for the early planting date due to cooler soil and air temperatures for the respective periods following planting. No significant yield differences were observed between strip tillage and no-till on either planting date, but it is interesting to note that strip-till corn that was planted early yielded significantly more than all tillage treatments on the normal planting date. Perhaps yield advantages resulting from strip tillage relative to no-till would be more likely when corn planting occurs well before the optimum planting period.

Table 1. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, Corn Following Soybeans, ACRE, 2003.†

Tillage Treatment (Ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
5. Fall strip-till, early planting date	52b‡	30000a	7.1b	35.4d	17.0	225.8a
7. No-till, early planting date	74a	30500a	6.9b	32.4e	17.5	220.0ab
2. Spring field cultivate	27c	29900ab	8.7a	55.9ab	17.3	215.1bc
6. Fall strip-till, normal planting date	46b	29900ab	8.6a	53.4c	17.2	213.8bc
8. No-till, normal planting date	77a	29200b	8.1a	53.0c	17.3	213.6bc
4. Fall DRD, spring field cultivate	13d	30000ab	8.8a	55.8ab	17.2	212.9bc
1. Fall chisel, spring field cultivate	22c	30200a	8.7a	53.9bc	17.1	211.5c
3. Fall DRD, stale seedbed	21cd	29900ab	8.7a	57.1a	17.3	208.2c
LSD (5%)	8	852	0.7	2.0	0.5	8.2

† Average of 6 replications
‡ Means with the same letter are not significantly different.

Late in July we noted plant lodging in all tilled plots, however practically no lodging in the strip-till and no-till plots. The lodging most likely occurred as a result of high winds when soils were near saturation in the first half of July. We counted lodged plants in all treatments (See Table 2). We concluded that due to looser soils plant roots in the tilled plots were not physically able to support the weight of the plants. Soils in the strip-till and no-till plots, though just as saturated, provided firmer rooting and, therefore, very few lodged plants.

Table 2. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, Corn Following Soybeans, ACRE, 2003.†

Tillage Treatment (Ranked by percent lodged)	Plant Lodging July, 2003
	%
2. Spring field cultivate	28a‡
4. Fall DRD, spring field cultivate	28a
3. Fall DRD, stale seedbed	25ab
1. Fall chisel, spring field cultivate	16abc
5. Fall strip-till, early planting date	10bc
6. Fall strip-till, normal planting date	9bc
7. No-till, early planting date	3c
8. No-till, normal planting date	1c
LSD (5%)	16

† Average of 6 replications
‡ Means with the same letter are not significantly different.

Table 3. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage,
and other Single-Pass Tillage Systems in Indiana, Corn Following Soybeans, ACRE, 2002-2003.†

Tillage Treatment (Ranked by average yield)	Grain yield at 15.5%		
	2002	2003	Average
4. Fall DRD, spring field cultivate	187.8a‡	212.9bc	200.3a
6. Fall strip-till, normal planting date	183.7a	213.8bc	198.7a
2. Spring field cultivate	181.6a	215.1bc	198.3a
1. Fall chisel, spring field cultivate	175.5a	211.5c	193.5a
3. Fall DRD, stale seedbed	178.6a	208.2c	193.4a
8. No-till, normal planting date	171.5a	213.6bc	192.5a
5. Fall strip-till, early planting date	102.8b*	225.8a	164.3b
7. No-till, early planting date	101.4b*	220.0ab	160.7b
LSD (5%)	20.1	8.2	11.4

† Average of 6 replications
‡ Means with the same letter are not significantly different.
* Low yields due to silk feeding by insects and poor pollination in 2002.

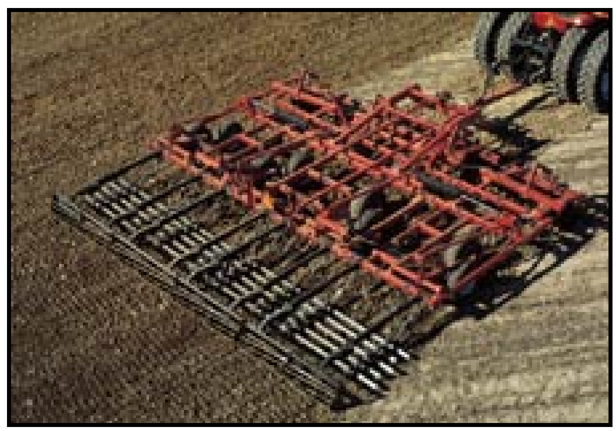
Pinney PAC, Wanatah, IN

Soil Description

The soil type is Sebewa loam. "This nearly level or depressional, deep, very poorly drained soil is on broad flats or in slight depressions where it is intermingled with poorly drained or very poorly drained soils" according to the Soil Survey of Porter County, 1981. It is an interesting soil to do tillage research on because it can be too wet in early spring, and yet be droughty in summer because its moisture holding capacity is far less than the prairie soils at ACRE. So, while farmers in the region are reluctant to no-till for fear of delayed planting and poorer plant stands, the residue cover may well provide later season benefits.

Equipment Description

- Conventional chisel plow: Glenco Soil Saver, front disk gang, 7-shank, 4-inch twisted points, soil leveler on rear
- Disk-ripper-disk (DRD): Case-IH MRX690
- One pass tillage tool (See photo): 18-foot Case-IH Combo-Mulch Finisher 4400 set up per treatment as:
    - VC3BDR (Vibra®Chisel shanks and 3-bar spike-tooth harrow/double rolling baskets)
    - VE3BDR (Vibra®Edge shanks and 3-bar spike-tooth harrow/double rolling baskets)
- Strip-till: Remlinger 6-row Precision Strip-Till unit
- Planter: 6-row John Deere equipped with row cleaners
- Drill: 15-foot John Deere 1560
- Nitrogen application: DMI NutriPlacr 2800
- Harvester: Case-IH 2366



Case-IH Combo-Mulch Finisher, photo by Case-IH

Remlinger strip-till tool in soybean stubble.

Remlinger strip-till tool in soybean stubble.

Weather in 2003

April rainfall was near normal which allowed planting in to ideal seedbed conditions (Figure 3). May rainfall was nearly double the normal amount. The soil was saturated with water, although no evidence of prolonged ponding was seen. June rainfall was more than 1.5-inches below normal. July rainfall again was nearly double the normal amount and caused saturated soils. August was similar to June in that rainfall was about 1.5-inches less than normal. September rainfall was near normal. Even with the roller-coaster like soil moisture conditions, the corn yielded much better than expected.

Soil temperatures:

Soil temperatures were measured from the day after planting through the next 4 weeks in the new row at 2-inches from soil surface in 4 of the 6 replications. Temperatures were recorded with "Watchdog" thermometers made by Spectrum Technologies. The thermometers were set to record temperature hourly.

Continuous corn: No-till had the lowest average daily maximum soil temperature in both planting dates (Fig. 4). When compared to no-till, strip-tilling warmed the early planting date by 1.7 degrees Fahrenheit and normal planting date by 2.5 degrees Fahrenheit. The full-width DRD with spring field cultivate treatment exhibited the warmest soil temperatures. Average minimum soil temperatures for all treatments were within a 1-degree range per planting date.

Corn following soybeans: No-till had the lowest average daily maximum soil temperature in both planting dates (Fig 5). When compared to no-till, strip-tilling warmed the early planting date by 2.1 degrees Fahrenheit and normal planting date by 1.5 degrees Fahrenheit. The full-width DRD with spring field cultivate treatment exhibited the warmest soil temperatures. Average minimum soil temperatures for all treatments were within a 1-degree range per planting date.

Continuous Corn

CULTURAL PRACTICES USED 2003 Continuous Corn, Field D, Pinney PAC		
Item	Date	Application Details
Spring tillage	4/28	Case-IH Combo-mulch-finisher 4400
Hybrid planted		
First planting date	4/15	Pioneer 34M94
Second planting date	4/28	Pioneer 34M94
Seeding rate		32,097 seeds/a.
Starter fertilizer/planter		19-17-0 @ 125 LB/a., 2-inches to the side and 2-inches below the seed
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.
Weed control	4/16	Burndown: Roundup Weather Max 22 oz/a. (All plots)
	4/16	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 4 pt/a. (Early Planting)
	4/29	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 4 pt/a. (Late Planting)
	5/18	Post-emerge: Clarity 8 oz/a.
	6/13	Post-emerge: Clarity 8 oz/a.
Nitrogen fertilizer	6/2	200 lbs N as UAN (28%) @ 60 gallons/acre (6-row, 5.25 pump setting)
Cultivation	6/18	Cultivated tilled plots.
Harvest	10/20	Center 6 of 12 rows, 250-feet.
P and K fertilizer	10/23	0-0-60 @ 350 LB/a. and 0-46-0 @ 300 LB/a.
Lime		None
Tillage	10/17	Chisel plow
	10/23	Case-IH MRX690 Disk-ripper-disk set at 13-inches deep, 5.5 mph, 9th gear, Case-IH MX240 tractor.
	11/11	Case-IH Combo-mulch-finisher equipped with Vibra®Chisel shanks
	11/11	Strip-tilled with Remlinger unit at 8-inches deep

Strip-till in continuous corn. Photo by Terry West

Stand, growth, and yield:

There were significant differences in plant population at 4-weeks after planting, although all were adequate (Table 4). The early strip-till had a much drier and plantable seedbed than early no-till. This allowed for better seed slot closure and more consistent seeding depth than the no-till treatment. The use of row cleaners on the planter helped smooth the way for the row units in fall DRD stale seedbed treatment, which was very rough without secondary tillage. Plant growth through the season was shorter for the early-planted corn. There are some yield trends worth noting. The early strip-till treatment yielded the highest this year, although not significantly different from fall chisel with spring VE3BDR. Strip-till yielded 5 to 11 bushels/acre more than no-till in the heavy residues found in continuous corn. A second tillage pass in full-width tillage systems did not guarantee increased grain yields.

Table 4. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, continuous corn, Pinney PAC, 2003.†

Tillage Treatment (Ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
8. Fall strip-till, early planting	44cde	31200a	5.5d	19.2f	17.4bc	196.5a
1. Fall chisel, spring VE3BDR	29f	29200bc	9.0ab	39.6a	17.4bc	192.6ab
7. Fall DRD, spring VE3BDR	39ef	29600bc	9.8a	39.5a	18.0bc	187.7bc
5. Fall VC3BDR, spring VE3BDR	48bcde	29600bc	8.4bc	38.3ab	18.1bc	187.5bc
6. Fall DRD, stale seedbed	41def	29200bc	8.5bc	35.9d	19.6a	187.5bc
9. Fall strip-till, normal planting	54bcd	28800c	8.3bc	36.8bcd	17.2c	186.3bc
10. No-till, early planting	82a	30500ab	5.3d	19.4f	17.2c	185.6bc
4. Fall VC3BDR, stale seedbed	62b	30100abc	8.0bc	36.3cd	18.6ab	183.7c
2. No-till, normal planting	93a	28900c	8.0c	34.0e	19.8a	181.1c
3. Spring VE3BDR	57bc	30100abc	8.8bc	37.7bc	17.3bc	179.7c
LSD (5%)	15	1400	1.0	1.6	1.3	8.3

† Average of 4 replications
‡ Means with the same letter are not significantly different.

Table 5. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, continuous corn, Pinney PAC, 2002-2003.†

Tillage Treatment (Ranked by average yield)	Grain yield at 15.5%		
	2002	2003	Average
8. Fall strip-till, early planting	95.5ab	196.5a	146.0a
6. Fall DRD, stale seedbed	102.3a	187.5bc	144.9ab
1. Fall chisel, spring VE3BDR	93.8ab	192.6ab	143.2abc
5. Fall VC3BDR, spring VE3BDR	95.5ab	187.5bc	141.5abc
4. Fall VC3BDR, stale seedbed	99.2ab	183.7c	141.4abc
2. No-till, normal planting	98.3ab	181.1c	139.6abc
9. Fall strip-till, normal planting	91.5ab	186.3bc	138.9bc
7. Fall DRD, spring VE3BDR	89.7b	187.7bc	138.7bc
10. No-till, early planting	91.1ab	185.6bc	138.4bc
3. Spring VE3BDR	96.3ab	179.7c	138.0c
LSD (5%)	12.3	8.3	3.7

† Average of 4 replications
‡ Means with the same letter are not significantly different.

Corn Following Soybeans

CULTURAL PRACTICES USED 2003		
Corn following Soybeans, Field D, Pinney PAC		
Item	Date	Application Details
Spring tillage	4/28	Case-IH Combo-mulch-finisher 4400
Hybrid planted		
First planting date	4/15	Pioneer 34M94
Second planting date	4/28	Pioneer 34M94
Seeding rate		32,097 seeds/a.
Starter fertilizer/planter		19-17-0 @ 125 LB/a., 2-inches to the side and 2-inches below the seed
Insecticide/planter		Force 3G, 5.5 oz/1000 row feet.
Weed control	4/16	Burndown: Roundup Weather Max 22 oz/a. (All plots)
	4/16	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 4 pt/a. (Early Planting)
	4/29	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 4 pt/a. (Late Planting)
	5/18	Post-emerge: Clarity 8 oz/a.
	6/13	Post-emerge: Clarity 8 oz/a.
Nitrogen fertilizer	6/2	200 lbs N as UAN (28%) @ 60 gallons/acre (6-row, 5.25 pump setting)
Cultivation	6/18	Cultivated all tilled plots.
Harvest	10/13	Center 6 of 12 rows, 250-feet.
P and K fertilizer	10/23	0-46-0 @ 300 LB/a. and 0-0-60 @ 350 LB/a.
Lime		None
Tillage	10/17	Chisel plow
	10/23	Case-IH MRX690 Disk-ripper-disk set at 13-inches deep, 5.5 mph, 9^{th} gear, Case-IH MX240 tractor.
	11/11	Case-IH Combo-mulch-finisher equipped with Vibra®Chisel shanks
	11/11	Strip-tilled with Remlinger unit at 8-inches deep

No-till corn following soybeans.

Stand, growth, and yield:

Although there are significant differences in plant populations between treatments, all were above 28,000 plants/acre (Table 6). Plant growth through the season was shorter for the early-planted corn as expected. This was a year for early planting as both early planting treatments yielded the most. The rest of the treatments yielded within a 5 to 6 bushels/acre spread. If the goal is to maximize corn production while maintaining sufficient residue cover to reduce soil erosion, then either no-till or strip-till is a viable choice. If the goal is to reduce costs yet do full-width tillage, then our data shows that one tillage pass is sufficient. Furthermore, there were no yield benefits associated with deep disk-ripping for corn after soybeans on this soil.

Table 6. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, corn following soybean, Pinney PAC, 2003.†

Tillage Treatment (Ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 15.5%
	%	Plants/a.	Inches	Inches	%	Bu/a.
10. No-till, early planting	71b	29800ab	5.4e	19.4c	19.2ab	198.4a
8. Fall strip-till, early planting	22ef	30000a	5.7e	17.9c	18.7ab	193.6ab
4. Fall VC3BDR, stale seedbed	38cd	30200a	9.6a	41.5a	17.7b	190.2bc
9. Fall strip-till, normal planting	45c	29600ab	8.3cd	37.6b	19.0ab	188.9bc
3. Spring VE3BDR	30de	29400ab	9.0bc	39.2ab	18.7ab	188.6bc
1. Fall chisel, spring VE3BDR	13g‡	29700ab	8.8bcd	39.3ab	18.4ab	188.3bc
2. No-till, normal planting	84a	28700bc	8.4cd	36.8b	19.0ab	187.9bc
5. Fall VC3BDR, spring VE3BDR	18fg	29200abc	9.3ab	41.3a	18.8ab	186.6c
6. Fall DRD, stale seedbed	22ef	28800bc	8.6cd	37.0b	19.3ab	185.6c
7. Fall DRD, spring VE3BDR	13g	28100c	8.3d	39.2ab	19.5a	184.6c
LSD (5%)	8	1200	0.6	2.5	1.6	6.4

† Average of 4 replications
‡ Means with the same letter are not significantly different.

Table 7. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, corn following soybean, Pinney PAC, 2002-2003.†

Tillage Treatment (Ranked by average yield)	Grain yield at 15.5%		
	2002	2003	Average
3. Spring VE3BDR	119.6a‡	188.6bc	154.1
1. Fall chisel, spring VE3BDR	118.8a	188.3bc	153.6
4. Fall VC3BDR, stale seedbed	111.3abc	190.2bc	150.7
10. No-till, early planting	101.9bc	198.4a	150.1
9. Fall strip-till, normal planting	111.2abc	188.9bc	150.1
5. Fall VC3BDR, spring VE3BDR	112.4abc	186.6c	149.5
7. Fall DRD, spring VE3BDR	114.0ab	184.6c	149.3
2. No-till, normal planting	110.0abc	187.9bc	148.9
6. Fall DRD, stale seedbed	110.8abc	185.6c	148.2
8. Fall strip-till, early planting	101.5c	193.6ab	147.6
LSD (5%)	12.2	6.4	8.3

† Average of 4 replications
‡ Means with the same letter are not significantly different.

Soybean Following Corn

CULTURAL PRACTICES USED 2003 Soybeans following Corn, Field F, Pinney PAC		
Item	Date	Application Details
Spring tillage	5/22	Case-IH Combo-mulch-finisher 4400
Variety planted	5/22	Pioneer 93B67
Seeding rate		203,000 seeds/a. in drilled plots, 143,000 in 30-inch row strip-till treatment
Weed control	5/14	Burndown: Roundup Weather Max 22 oz/a. and 2,4-DLV 1 pt/a.
	6/23	Post-emerge: Roundup Weather Max 2 oz/a. and AMS 17 lb/100 gallons water
Manganese		None
Harvest	10/7	Drilled soybeans: center 15-feet of 30-foot plots, 250-feet 30-inch row soybeans: center 5 rows of 12 row plots, 250-feet
P and K fertilizer	10/21	0-46-0 @ 300 LB/a. and 0-0-60 @ 350 LB/a.
Lime		None
Tillage	10/17	Chisel plow
	10/23	Case-IH MRX690 Disk-ripper-disk set at 13-inches deep, 5.5 mph, 9th gear, Case-IH MX240 tractor.
	11/11	Case-IH Combo-mulch-finisher equipped with Vibra®Chisel shanks
	11/11	Strip-tilled with Remlinger unit at 8-inches deep

Stand, growth, and yield:

Plant populations in the full-width one-pass tillage systems tended to be higher than in two-pass systems. One explanation may be that we lost some plants due to crusting of the finer soil surface of two-pass treatments, although all populations were adequate for maximum yield potential (Table 8). The population in the fall strip-till normal planting date was significantly less than the other treatments due to the planned seed drop of 143,000 per acre. Soybean plant heights wren highest on the fall strip-till treatments, and lowest in no-till. Soybean yields were lower than normal and highly variable due to the extremes of soil moisture from excessive rainfall, long periods of drought, manganese deficiency in some plots, plant diseases, and minor late-season weed pressure. Stale seedbed systems yielded less than those which involved spring tillage. Strip-till yields were much lower than the narrow-row no-till. This was a reversal from 2002, when strip-till yields were significantly higher. One possible explanation for the difference (Table 5) is that the soybean variety in 2002 (Pioneer 93B09) was much more suitable for wide-row soybean production than the one we used in 2003 (Pioneer 93B67).

Table 8. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, soybean following corn, Pinney PAC, 2003.†

Tillage Treatment (Ranked by yield)	Residue cover after planting	Week 4 stand	Week 4 height	Week 8 height	Grain moisture at harvest	Grain yield at 13.0%
	%	Plants/a.	Inches	Inches	%	Bu/a.
3. Spring VE3BDR	46c	217000ab	3.6b	15.9c	12.1a	37.4a
2. No-till	90a	193900b	3.5b	14.5d	12.0ab	35.4ab
1. Fall chisel, spring VE3BDR	21d‡	200000b	3.6b	17.1abc	11.5ab	33.5abc
7. Fall DRD, spring VE3BDR	31cd	203800b	3.6b	16.8abc	11.7ab	32.7abc
5. Fall VC3BDR, spring VE3BDR	36cd	204700b	3.4b	17.5ab	11.6ab	31.5abc
4. Fall VC3BDR, stale seedbed	47c	232700a	3.6b	16.3bc	11.7ab	30.8bc
6. Fall DRD, stale seedbed	42c	232200a	3.5b	17.1abc	11.6ab	28.9bc
9. Fall strip-till	69b	136700c	4.0a	17.6a	11.5b	28.6c
LSD (5%)	21	25285	0.4	1.3	0.5	6.6

† Average of 4 replications
‡ Means with the same letter are not significantly different.

Table 9. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, soybean following corn, Pinney PAC, 2002-2003.†

Tillage Treatment (Ranked by average yield)	Grain yield at 13.0%		
	2002	2003	Average
3. Spring VE3BDR	31.6ab	37.4a	34.5
1. Fall chisel, spring VE3BDR	33.9ab	33.5abc	33.7
2. No-till, normal planting	30.4ab	35.4ab	32.9
9. Fall strip-till, normal planting	37.1a	28.6c	32.9
7. Fall DRD, spring VE3BDR	29.8ab	32.7abc	31.2
6. Fall DRD, stale seedbed	28.9ab	28.9bc	28.9
4. Fall VC3BDR, stale seedbed	26.3abc	30.8bc	28.5
5. Fall VC3BDR, spring VE3BDR	25.3bc	31.5abc	28.4
LSD (5%)	11.3	6.6	7.1

† Average of 4 replications
‡ Means with the same letter are not significantly different.

Table 10. Soil test results based on composite sampling, Field D, PPAC Fall 2003.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CC	0-8	6.2	29 M	162 M	625 H	2400 M	6.2	6.7	21.2
No-till	CC	0-4	5.3	35 H	217 H	510 H	1850 L	5.9	6.7	17.7
No-till	CC	4-8	5.1	13 L	104 M	595 H	2300 L	6.0	6.6	21.5
Chisel	CB	0-8	3.4	20 M	167 H	415 H	1400 L	5.9	6.7	14.5
No-till	CB	0-4	3.8	24 M	239 VH	400 H	1350 L	6.0	6.7	14.3
No-till	CB	4-8	3.2	16 L	131 M	460 VH	1500 M	6.4	6.9	13.1

* This figure seems too high, but is what the soil test stated.

Table 11. Soil test results based on composite sampling, Field F, PPAC, Fall 2003.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	BC	0-8	5.3	32 H	165 H	525 VH	2100 M	6.6	6.9	16.5
No-till	BC	0-4	4.9	43 H	329 VH	595 H	2150 L	6.0	6.6	21.4
No-till	BC	4-8	5.0	14 L	101 M	540 H	2100 M	6.0	6.7	18.9

Table 12. Soil test results based on composite sampling, Field 117, ACRE, Fall 2003.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
No-till	BC	0-4	4.3	27 M	230 H	545 VH	1850 L	6.2	6.7	18.0
No-till	BC	4-8	3.9	22 M	126 M	660 VH	2200 M	6.7	6.9	18.0

Acknowledgements

We are grateful for the in-kind support of tillage and planting equipment from Case-New Holland, the tractor supplied by Case-New Holland, and corn and soybean seed from Pioneer Hi-Bred Ltd. Financial support of Case New Holland and the Mary Rice Fund helped get these projects established. We are also thankful for the help of the farm crews at the Agronomy Center for Research and Education and Pinney PAC.

Vertical Tillage Study

Tony J. Vyn, Terry D. West, and Phil Walker,

Heavy rainfall after planting caused flooding and soil erosion in the plots. Plant stands were greatly reduced in most of the plots irregardless of tillage treatment. The study was replanted on May 27th. Greater detail will be presented in future Cropping Systems Reports. This study will continue at NEPAC in 2004.

CULTURAL PRACTICES USED, NEPAC, 2003		
Field Operation	Date	Application Details
Early fertilization	2/21	0-18-37 @ 825 lb/a.
Tillage		Chisel plow, ToTheMax, field cultivate
Hybrid planted	4/29	Pioneer 34B28
Seeding rate		31,800 seeds per acre
Starter fertilizer/planter		19-17-0 @ 150 lb/a.
Insecticide/planter		Force 3G, 5.4 lb/a.
Weed control	11/7/02	Fall applied:
		Roundup Ultra Max 12 oz/a.
		2,4-D 2 pt/a.
		Request 10 oz/a.
	5/25	Post-emergence:
		2,4-D 10pt/a.
Hybrid replanted	5/27	Pioneer 34B28
Seeding rate		31,800 seeds per acre
Starter fertilizer/planter		16-22-0 @ 150 lb/a.
Insecticide/planter		Force 3G, 5.4 lb/a.
Weed control	6/2	Honcho 2 pt/a.
On replanted corn.		Atrazine 4L 2 pt/a.
		2,4-D 1 pt/a.
		Synurgize 8 oz/a.
		NIS 3.2 oz/a.
	7/1	Accent 0.67 oz/a.
		Distinct 4 oz/a.
		UAN 3 pt/a.
		NIS 3.2 oz/a.
Nitrogen fertilizer	5/19	145 lbs N sidedressed
Harvest	11/7	Machine harvest.

Table 1. Vertical Tillage Study, Corn Following Soybean, NEPAC, 2003.†

Tillage Treatment (Ranked by yield)	Residue cover after planting	Grain moisture at harvest	Grain yield at 15.5%
	%	%	Bu/a.
5. Chisel plus field cultivate	22c	19.9b	131.5a
3. ToTheMax 2 passes	54ab	20.0b	124.2ab
4. Field cultivate once	32bc	20.4ab	123.2ab
1. No-till	63a	21.0a	115.0b
2. ToTheMax 1 pass	57a	20.5ab	113.8b
LSD (5%)	25	0.8	16.3

† Average of 6 replications
‡ Means with the same letter are not significantly different.

Not for publication.

Effect of Temperature-activated Polymer Seed Coatings on the Feasibility of Early Plant Corn

Tony J. Vyn, Martin Gonzalo, Jason Brewer and Terry D. West

Introduction

Recently patented, temperature-activated polymers can be used as seed coatings to enable earlier planting, but delayed emergence, of hybrid corn seed. Relative to uncoated seeds, these polymers could improve emergence uniformity, final population and grain yield when corn is planted early. This benefit could be even more evident as stress increases (whether because of cool soil temperatures, stress-susceptible hybrids, or conservation tillage). The possibility of using seed coatings would allow corn producers to minimize risks associated with early planting, and take more advantage of conservation tillage systems for corn.

Objectives

The objectives of this study are: a) to determine the average corn emergence delay resulting from temperature-sensitive polymers for multiple planting dates and hybrids, b) to determine whether temperature-sensitive polymers applied to the seed coats of selected corn hybrids will improve uniformity of emergence, relative to uncoated seed, when corn is planted early, c) to evaluate if final plant populations and overall grain yields will increase in response to the application of the temperature-activated polymers, relative to uncoated corn seed, and d) to understand the possible interacting effects of polymer treatments, hybrid treatments, and planting date treatments on plant-to-plant variability and final grain yields.

Acknowledgements

We appreciate funding provided by Landec Ag.

CULTURAL PRACTICES USED, ACRE, 2003		
Field Operation	Date	Application Details
Hybrids planted	March 27, April 15 and 23	EX011, EX013, and EX017S
Seeding rate		32,000 seeds per acre
Starter fertilizer/planter		96 LB/ac 34-0-0
Insecticide/planter		Force 3G, 5 oz/1000 row feet, banded over row
Rodenticide/planter		Pro-Zap zinc phosphide pellets in furrow
Weed control	4/2	Burndown: Roundup Ultra 1.5 pt/a.
	4/2	Pre-emergence: Degree Extra 7 pt/a.
	5/18	Post-emergence: Laddock S-12 @ 2.25 pt/a.
Nitrogen fertilizer	5/19	200 lbs N/a as UAN (28%) sidedressed @ 60 gallons/a, 4 row, pump setting = 3.5
Harvest	10/2	4 rows. Machine harvest with John Deere/Almaco 700 combine.

CULTURAL PRACTICES USED, PPAC, 2003		
Field Operation	Date	Application Details
Hybrid planted	April 3, 15, 29	EX011, EX013, and EX017S
Seeding rate		32,000 seeds per acre
Starter fertilizer/planter		96 LB/ac 34-0-0
Insecticide/planter	`	Force 3G, 5 oz/1000 row feet, banded over row
Rodenticide/planter		Pro-Zap zinc phosphide pellets in furrow
Weed control	4/10	Burndown: Roundup Weather Max 22 oz/a.
	4/10	Pre-emergence: Harness Extra 5 pt/a., Atrazine 4L 2 pt/a.
	5/18	Post-emergence: Clarity 8 oz/a.
Nitrogen fertilizer	6/2	200 lbs N/a as UAN (28%) sidedressed @ 60 gallons/a, 4 row, pump setting = 3.5
Harvest	10/21	2 rows. Machine harvest with PPAC's Massey combine.

Effects of Fertility Placement in High Yield Corn Situations

Ann M. Kline, Tony J. Vyn, and Sylvie Brouder

Introduction

Fertilizer rates and placement are important considerations to farmers hoping to raise high yielding corn. Because of the relative immobility of phosphorus (P) and potassium (K) in the soil, different techniques for placing these fertilizers have been studied for average yield corn grown with conservation tillage systems. Although the traditional method of nutrient placement is broadcasting, it may be that a deeper placement of these nutrients would allow corn roots to better utilize the fertilizers applied. Corn yields might also increase if available P and exchangeable K were more uniformly distributed in the corn rooting zone. The purpose of this research is to investigate the effects of the depth of P and K placement on corn response specifically in a high yield environment. Better understanding of processes involved might permit improved fertility recommendations to farmers as yields continue to increase.

Two studies were initiated in 2001 to pursue this research. Both studies are being conducted on dark prairie soils at the Agronomy Center for Research and Education or Animal Sciences Research and Education Center near West Lafayette, Indiana.

The first experiment looks specifically at effects of the depth of placement for P and K together. The treatments include two hybrids (Pioneer 34B24 and 34M95), two populations (32,000 and 42,000 plants per acre), and five fertility treatments. The fertility treatments include a control, broadcast P & K, 6 inch banded P & K, 12 inch banded P & K and a 6 and 12 inch banded P & K. The fertilizer was banded directly beneath the intended row area before planting took place.

CULTURAL PRACTICES USED FOR MAX YIELD CORN, 2003
Animal Sciences Field

Field Operation	Date	Application Details
Tillage	Fall 2002	Strip-till
Fertilizer Application	Fall 2002	192 lbs/a. 0-45-0 and 192 lbs/a. 0-0-60 applied with DMI Nutriplacr 2500
Planting	4/24	34,000 and 44,000 plants per acre seeding rates with JD 1780 planter, hybrids Pioneer 34B24 and Pioneer 34M95
Starter fertilizer/planter		15 gal/ acre 9-18-9 plus zinc
Insecticide/planter		Force 3G, 5 oz/1000 row feet, banded over row
Herbicide Application	4/24	Burndown: Roundup Ultra 1.5 pt/a.
	4/24	Pre-plant: Harness Extra 5.6 @ 3.75 pt/a.
	5/19	Post-emergence: Clarity 0.5 pt/a.
Nitrogen Applications	5/14	150 lbs N/a as UAN (28%) @ 45 gal/a, 6 row, pump setting = 4.0
	5/28	150 lbs N/a as UAN (28%) @ 45 gal/a, 6 row, pump setting = 4.0
Harvest	?	Machine harvest 4 out of 12 rows with John Deere/Almaco model 700 combine

CULTURAL PRACTICES USED FOR MAX YIELD SOYBEAN, 2003
Animal Sciences Field

Field Operation	Date	Application Details
Tillage	None	
Variety		Pioneer 93B67
Planting	5/14	175,000 seeds/a. in 15-inch rows with JD1780 planter.
Herbicide Application	5/19	Roundup Weather Max 2 pt/a.
Harvest	10/15	Machine harvest 5' out of 30' width with Wintersteiger plot combine

The second experiment investigates corn response to placement when either P or K is applied without the other, or in combination. Measurements in this second experiment are also more focused on the effects to the roots. The treatments include two hybrids (Pioneer 31N28 and 34M95) and five fertility applications including a control, broadcast P & K, band P & K, band P alone, and band K alone. Banding depth is 6 inches in the intended row area. The rates of P and K for all treatments except the control are 88 pounds P_2O_5 and 115 pounds K_2O for both studies. P was applied as 0-46-0 and K was applied as muriate of potash (0-0-60).

CULTURAL PRACTICES USED FOR PK CORN, 2003
Field 131, ACRE

Field Operation	Date	Application Details
Tillage	4/21	Strip-till with DMI 2500 (mole knives)
Lime Application		None
Fertilizer Application	4/21	Various treatments
Planting	4/29	
Starter fertilizer/planter		15 gal/ acre 9-18-9 plus zinc
Insecticide/planter		Force 3G, 5 oz/1000 row feet, banded over row
Herbicide Application	4/30	Burndown: Roundup Ultra 1.5 pt/a.
	4/30	Pre-plant: Harness Extra 5.6 @ 5 pt/a.
	5/19	Post-emergence: Laddock S-12 @ 2.25 pt/a..
Nitrogen Applications	5/19	200 lbs N/a as UAN (28%) @ 60 gal/a, 6 row, pump setting = 5.25
	5/28	100 lbs N/a as UAN (28%) @ 30 gal/a, 6 row, pump setting = 2.75

Measurements

Several measurements have been taken throughout the past growing season. Both ear-leaf samples (taken near silk emergence) and grain samples (taken at harvest) were analyzed for nutrient concentrations. Chlorophyll readings were taken on multiple dates during the grain filling period in both studies. The second study looked more intensively at the roots. Measurements included Root:Shoot ratio, root scanning for whole roots at V4 and root scanning for root cores at V10.

Preliminary Conclusions

Further analysis will be done to statistically analyze the fertility treatments as well as hybrid and population responses.

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