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Long-term Tillage Study, ARC

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 Research Center in West-central Indiana. Our goal is 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 soybean, soybean following corn, and continuous soybean. 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 soybean. Row width for corn is 30-inches. Row width for soybean was 30-inches for soybean from 1975 to 1994. Starting in 1995, soybean 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 soybean. Placement was two inches to the side and two inches below the seed. Nitrogen source for corn was anhydrous ammonia (either pre-plant or side-dress) through 2000 and liquid UAN (28%) 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.

Five corn hybrids and ten soybean varieties have been used during the 28 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 (Dr. Abney), 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, ARC.

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

2002 Field Practices

Primary tillage included the use of an International Harvester five 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, a Glencoe 10-foot field cultivator with rear-mounted, double-rolling baskets, and a 10-foot Lely rotovator. The rotovator was necessary in 2002 due to extremely cloddy soil conditions.

Nitrogen was sidedressed at a depth of 3 to 4 inches with a DMI NutriPlacr 2800 five-knife liquid nitrogen applicator equipped with one 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.

Soybean 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 soybean 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 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 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 soybean 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 soybean. This study will continue in 2003. *Dr. Scott Abney*

- Akilah Martin and Dr. C. J. Johannsen, Agronomy: Crop Residue Delineation
  Akilah collected data in support of her research. This information can be found in her thesis: Martin, A.R., "Detection of Residues and Tillage Systems by Remote Sensing Techniques" MS dissertation, 106 pp. Department of Agronomy, Purdue University, December 2002
- Anita Gal, Tony Vyn. Carbon Sequestration Study.
  A new study was initiated in 2002 to study carbon sequestration in these plots. Some soil samples were taken in the fall with more to be taken in the spring of 2003.
- Dr. Andreas Westphal, Botany and Plant Pathology, Purdue University. Population Dynamics of Soybean Cyst Nematodes (*H. glycines*)
  This study will describe the population dynamics of *H. glycines* in rotation soybean/corn and continuous soybean. This monitoring will be continued for two years to get one full sequence for the soybean-corn treatment. Soil will also be collected in fall from plots of the various tillage systems for greenhouse and growth chamber experiments involving *H. glycines*.

Table 1. Test population densities of *Heterodera glycines* under soybean monoculture in different tillage systems in fall 2002*

Tillage Treatment	Number of eggs/500 g of soil.
Plow	329 c
Chisel	608 bc
No-tillage	833 ab
Ridge-tillage	1204 a

* The soybean cultivar Pioneer 93B67 had some resistance to *H. glycines*.
Numbers followed by the same letter are not significantly different at P=0.05.

- 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 soybean.

Table 2. Soil test results based on composite samples, Long-term Tillage Study, ARC, Fall 2002.

Tillage	**Crop**	**Depth**	**OM**	**Phos.**	**K**	**Mg**	**Ca**	**Soil pH**	**Buffer pH**	**CEC**
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Plow	CC	0-8	4.7	45 H	161 M	735 VH	2300 M	6.5	6.8	20.4
No-till	CC	0-4	5.1	86 VH	329 VH	795 VH	2250 M	6.7	6.9	19.9
No-till	CC	4-8	4.1	51 VH	131 M	560 H	1950 VL	5.3	6.4	22.0
Plow	CB	0-8	4.2	36 H	143 M	810 VH	2550 M	7.0		19.9
No-till	CB	0-4	5.1	77 VH	296 VH	795 VH	2400 M	7.0		19.4
No-till	CB	4-8	4.0	36 H	125 M	625 H	2150 L	5.6	6.5	22.3
Plow	BB	0-8	3.8	38 H	152 M	765 VH	2550 M	7.2		19.5
No-till	BB	0-4	4.8	69 VH	224 H	740 VH	2600 M	7.1		19.7
No-till	BB	4-8	4.1	22 M	128 M	715 VH	2650 M	6.6	6.8	21.9

CULTURAL PRACTICES USED 2002 Long-term Tillage Study, ARC, Purdue Univ.				
Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/27	Disk once on plow and chisel plots	5/27	Disk once on plow and chisel plots
	5/28	Field cultivate once on plow and chisel plots	5/28	Field cultivate once on plow and chisel plots
	5/28	Lely rotovator once on plow and chisel plots	5/28	Lely rotovator once on plow and chisel plots
Hybrid/Variety planted	5/29	Beck's 5322 (109-Day) Row cleaners on c/b and c/c no-till. Shifted no-till c/c to east. (Shift to west in 2003)	5/29	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	Burndown: Gramoxone Extra 1.5 pt/a. with 1 pt/100 gallons water spreader on no-till and ridge-till	5/2	Burndown: Gramoxone Extra 1.5 pt/a. with 1 pt/100 gallons water spreader on no-till and ridge-till
	5/29	Pre-emergence: Harness Extra 5.6L 5pt/a. Roundup Ultra 2 pt/a.	5/29	Pre-emergence: First Rate 0.75 oz/a. Dual II Magnum 1.67 pt/a. Roundup Ultra 2 pt/a.
Nitrogen fertilizer	6/4	200 lbs N as UAN (28%) @ 60 gallons/acre		None
Cultivation	6/25	Plow and chisel treatments	7/1	Ridge treatment only
	6/25	Ridge treatment (re-ridge)	11/20	Ridge treatment (re-ridge)
Harvest	10/14	Center 4 of 12 rows, 150-feet	10/8	Center pass, 150-feet
Phosphorous, Potassium	11/14	0-46-0 @ 200 LB/a and 0-0-60 @ 300 LB/a. blended	11/14	0-46-0 @ 200 LB/a and 0-0-60 @ 300 LB/a. blended
Primary tillage	11/18	Fall plow on plow treatment	11/18	Fall plow on plow treatment
	11/14	Fall chisel on chisel treatment	11/14	Fall chisel on chisel treatment
Lime	11/18	2 ton/a. Bulk spread	11/18	2 ton/a. Bulk spread

Weather and soil conditions in 2002

April was a very wet month with 5.39-inches of rain compared to a normal rainfall of 3.65-inches (Fig. 1). Rainfall on April 28th totaled 1.60-inches which prevented an early planting of corn. As soils approached plantable conditions by May 5th we entered a wet period of eight days that totaled 3.05-inches of rain. Over the next 13 days soils dried marginally with rewetting occurring during two periods of rain totaling 0.97-inches.

On May 27th we proceeded with secondary tillage in the plow and chisel treatments even though soil conditions were not ideal. The disking done on May 27th left the seedbed very cloddy and the field cultivating on May 28th marginally improved the seedbed. We then made an additional pass with the Lely rotovator to break the clods and provide more fines in the seedbed. Still, the seedbed condition was less than desirable with too many clods. In the ridge treatment we set the ridge cleaners to brush the residue aside and leave the soil surface undisturbed. However, the wet soil conditions made it difficult to consistently close the seed slot and led to some sidewall compaction. In the no-till plots we also set the row cleaners to brush most of the residue aside and leave the soil surface undisturbed. We were able to close the seed slot satisfactorily.

Corn and soybean yielded surprisingly well in 2002 considering the wet spring and late planting dates. Extended periods of dry and sunny weather provided the necessary growing degree-days to speed plant growth and maturity. The occasional rains we did get provided 1 to 2-inches of rain per event, which supplied sufficient moisture for continued growth and development.

Stand, growth, and yield -- Corn.

In no-till continuous corn, 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 8th year of shifting the new rows. We achieved these goals in 7 of the 8 years.

Continuous corn. Plant emergence was erratic in the plow and chisel treatments due to the cloddy seedbed. Although most seeds germinated shortly after planting, there were lengths of some rows that did not germinate until some rain occurred 1 week later. Plow, chisel and no-till plant stands were equal at four weeks after planting (Table 3). Plant stands in the ridge treatment were significantly lower likely due to open seed slots. The plow treatment had significantly shorter plant heights at 4 and 8 weeks after planting than the other treatments. This was due to late emergence of some plants where seeds were planted into cloddy conditions and restricted root growth in compacted soil. Soil compaction was evident as rows of corn planted in the wheeltracks were stunted compared to non-wheeltrack rows. There were no significant differences in grain yield. No-till yielded 177.9 bushels/acre, which is the third highest no-till corn yield in the history of this study (highest was 188.8 bushels/acre in 1982 and second highest was 187.4 in 2001).

Corn following soybean. Plant stands were equal in all treatments. Soil conditions in the plow and chisel treatments were not as cloddy as those in continuous corn and did not delay emergence. We also did not experience the slot closure problems in the ridges. As in continuous corn, the plow treatment showed signs of wheeltrack soil compaction. The plow treatment corn was significantly shorter at 4 and 8 weeks. There were no significant differences in grain moisture at harvest. The ridge treatment yielded the most at 207.9 bushels/acre, but was not significantly different than the other treatments. Overall rotation system effects were non-significant for all corn response parameters in 2002. There were yield advantages for crop rotation in 2002 in chisel, ridge-till, and no-till systems.

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

Table 3. Agronomic performance of corn as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ARC, Purdue Univ., 2002. †

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	3c‡	30500a	20.4b	89.3b	20.2	189.0
	Chisel	12b	29958a	26.8a	97.9a	19.7	190.9
	Ridge	76a	28292b	28.3a	98.4a	19.9	190.6
	No-till	82a	29750a	26.0a	97.3a	19.8	177.9
Soybean	Plow	1c	30000	21.1b	87.8b	21.4	187.9
	Chisel	6c	30167	26.3a	98.3a	20.9	202.5
	Ridge	23b	28875	29.3a	98.0a	20.2	207.9
	No-till	85a	28958	29.5a	98.1a	20.5	202.5

†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 -- Soybean.

For the ninth 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 4). Plant growth was significantly taller in the ridge treatment at 4 weeks and 8 weeks after planting. We did note some plants infected with Sudden Death Syndrome (SDS). These were more often found in chisel plots. This may have led to the slightly reduced yields in the chisel treatment as compared to the other treatments. The 30-inch row ridge plots yielded essentially equal to the 7.5-inch drilled treatments. This points out the competitiveness of the ridge-till system to drilling soybean in a full-width tillage system in this study. Rotation soybean yielded about 11% more than continuous soybean in 2002.

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. We suspect that yields in all continuous soybean plots are somewhat affected by SCN. We also observed some plants affected by Sudden Death Syndrome.

Table 4. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long-term Tillage Study, ARC, Purdue Univ., 2002. †

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	3d§	176300a	5.4b	23.8b	11.5	67.8
	Chisel	17c	171500a	5.8b	24.3b	11.5	63.5
	Ridge	55b	115000b	7.4a	27.4a	11.5	62.9
	No-till	86a	184300a	5.5b	23.9b	11.9	65.9
Soybean	Plow	2c	182400a	5.5b	23.9b	11.3	58.4
	Chisel	4c	172500a	5.8b	25.9ab	11.2	57.3
	Ridge	13b	107000b	7.0a	27.3a	11.1	58.3
	No-till	81a	178700a	5.9b	24.7b	11.4	60.1

†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 5. Analysis of variance summary, tillage data, Long-term Tillage Study, ARC, Purdue Univ., 2002.

Variable	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield Bu/a.
	Significance Level					
				Corn		
Tillage	.01	.01	.01	.01	NS	NS
Previous crop	.02	NS	NS	NS	NS	.03
Tillage x previous crop	.01	NS	NS	NS	NS	NS
				Soybean		
Tillage	.01	.01	.01	.01	.03	NS
Previous crop	.01	NS	NS	NS	.04	.02
Tillage x previous crop	.01	NS	NS	NS	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 28 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 6 and 7). The positive response to rotation is greatest for no-till corn and least with moldboard plowed 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 with yield 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 have been 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 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. Whenever soybean follow soybean, no-till has consistently resulted in yields equal to those after chisel plowing.

Table 6. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, ARC, 1975-02.

Tillage	Corn/Soybean		Continuous Corn		Yield Gain for Rotation
	Bu/ac	% of plow yield	Bu/ac	% of plow yield	%
Plow	176.1	- - -	168.3	- - -	5
Chisel	176.8	100	163.7	97	8
Ridge*	181.5	103	166.9	99	9
No-till	172.4	98	145.9	87	18

*Since 1980

Table 7. Soybean Yield Response to Tillage and Rotation, Long-term Tillage Study, ARC, 1975-02.

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	46.0	95	12
Ridge*	51.2	96	45.1	93	14
No-till	50.5	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.

Fall Strip-till Depth/Equipment Study, ARC

Tony J. Vyn, Terry D. West, and M. Gonzalo, Dept. of Agronomy, Purdue University.

Introduction

Fall zone tillage can be considered as an alternative to intensive tillage systems when farmers are reluctant to initiate or continue with a pure no-till system. Fall zone tillage is a type of in-row loosening where only the intended row area for the subsequent crop is disturbed, leaving the interrow area covered with residue. Fall zone tillage allows for the option of planting row crops directly into the loosened area in the spring. Ideally, the fall zone-tilled strips will leave a mound in the fall approximately three to four inches high, which will mellow down to about one to two inches in spring. This slight ridge, plus the loosening and residue disturbance associated with the fall zone tillage may improve soil drying and warming in spring compared to regular no-till rows. Earlier planting could be another advantage. Fall zone tillage may result in corn yields, which are comparable to those with moldboard plow and disk systems, but superior to that after no-till alone. Biggest benefits are expected on poorly drained soils with high clay content. Ultimately, the adoption of fall zone-till would help to over come the challenges of planting corn in early spring on poorly drained fine-textured soils while still maintaining erosion control benefits, productivity, and profitability.

Objective

The objective of this research project was to evaluate the effects of fall zone tillage systems with varying depths and subsequent secondary tillage on (a) spring soil dry down, (b) soil physical properties in the seedbed, and (c) the response of corn compared to full-width and no-till systems. Seven different tillage treatments were evaluated to determine the optimum fall zone tillage depth. The purpose of this study was to introduce fall zone tillage as an alternative system to intensive tillage and pure no-till where needed.

Site Information

In the fall of 1999 the field experiment was established at the Agronomy Research Center (ARC). The soil type is a Drummer and Raub-Brenton Complex, which is somewhat poorly to poorly drained, silty clay loam to clay loam with 3-4.5% organic matter. The field had been in continuous no-till production for at least five years. The experiment was initiated after soybean in a corn-soybean rotation for corn planted in 30-inch rows.

Treatments

1) Fall chisel plow plus secondary tillage
2) DMI w/mole knife 8-inches deep
3) DMI w/mole knife 4-inches deep
4) DMI w/no-till point 8-inches deep
5) Yetter strip-till 8-inches deep
6) DMI w/no-till point 13-inches deep
7) No-till with Row Cleaners

CULTURAL PRACTICES USED 2002

Fall Strip-till Depth/Equipment Study, ARC, Purdue Univ.		
Field Operation	Date	Application Details
Secondary tillage		None (planted stale seedbed in chisel plots)
Hybrid planted	5/24	Pioneer 33A14 (113 day). John Deere 1780 planter.
Seeding rate		30,000 seeds/a.
Starter fertilizer/planter		None
Insecticide/planter		Force 3G, 5 oz/1000 row feet.
Weed control	5/16	Burndown
		Roundup Ultra 2.5 pt/a.
		Pre-emergence
	5/27	Harness Extra 5.6 5 pt/a.
		Roundup Ultra 1.5 pt/a.
		All broadcast with flat fan 8006 nozzles at
		30 psi and 30 gallons water/a., 5.0 mph.
Nitrogen fertilizer	6/4	200 lbs N as UAN (28%) @ 60 gallons/acre
Harvest	11/02	Machine harvest center 4 rows of 12 row plots
Phosphorous, Potassium	11/14	0-46-0 @ 200 LB/a and 0-0-60 @ 300 LB/a. blended
Lime	11/18	2 ton/a. Bulk spread

Preliminary Results for 2002

Numerous emergence, plant height and v-stage measurements were recorded to better understand the degree of uniformity in plant-to-plant development as affected by tillage systems. These measurements have not been analyzed yet.

Table 1. Corn grain yields, Fall Strip-till Depth/Equipment Study, corn following soybean, ARC, 2002. †

Tillage	Harvest moisture	Yield @15.5%
	%	Bu/a.
Fall chisel plow plus secondary tillage	17.8‡	220.4
DMI w/mole knife 8-inches deep	19.5	217.1
DMI w/mole knife 4-inches deep	18.9	222.8
DMI w/no-till point 8-inches deep	19.0	219.4
Yetter strip-till 8-inches deep	19.2	222.6
DMI w/no-till point 13-inches deep	19.0	211.8
No-till with Row Cleaners	19.0	218.9

†Average of 4 replications.
‡No statistics run.

Acknowledgements:

We are grateful for the in-kind support of (a) zone tillage equipment from Case-DMI (Goodfield, Illinois) and John Deere Ltd. (Des Moines, Iowa) and (b) corn seed from Pioneer Hi-Bred Ltd. (Tipton, Indiana).

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 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 five tillage systems in two cropping sequences.

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

Table 1. Soil test results based on composite sampling, Long-term Tillage Study, PPAC, Fall 2002.

Tillage	**Crop**	**Depth**	**OM**	**Phos.**	**K**	**Mg**	**Ca**	**Soil pH**	**Buffer pH**	**CEC**
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CC	0-8	3.3	44 H	174 H	510 VH	1600 L	6.0	6.7	16.3
No-till	CC	0-4	3.6	52 VH	220 H	460 VH	1400 L	6.0	6.7	15.0
No-till	CC	4-8	3.2	37 H	95 M	385 H	1300 L	5.7	6.7	13.6
Chisel	CB	0-8	3.2	34 H	123 M	495 VH	1550 L	6.1	6.7	15.8
No-till	CB	0-4	3.5	64 VH	256 VH	500 VH	1550 L	6.0	6.7	16.2
No-till	CB	4-8	3.1	29 M	91 M	450 H	1500 L	5.7	6.6	16.3

CULTURAL PRACTICES USED 2002

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

Item	Corn		Soybean	
	Date	Application Details	Date	Application Details
Secondary tillage	5/21 5/22	Disk Field cultivate	5/21 5/22	Disk Field cultivate
Hybrid/Variety planted	5/23	Pioneer 34M94	5/23	Pioneer 93B09 Roundup Ready
Seeding rate		30,800 seeds/a.		200,000 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	5/1	<u>Burndown:</u> Roundup Ultra 2 pt/a. on entire plot area	4/16	<u>Burndown:</u> Roundup Ultra 2 pt/a. on entire plot area
	5/27	<u>Pre-emerge:</u> Bicep II Magnum 4.2 pt/a.	6/23	<u>Post-emerge:</u> Roundup Ultra2 pt/a. AMS 17 LB/100 gallons of water *Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gallons water/a.*
	6/7	<u>Post-emerge:</u> Buctril AT 2pt/a. *Broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gallons water/a.*		
Nitrogen fertilizer	6/6	200 lbs N as UAN (28%) @ 60 gallons/acre (6 row, 5.25 setting)		None.
Cultivation	6/28	Once as required by treatment.		None
Harvest	10/10	All 6 rows, 130-feet.	9/25	Whole plot, 130-feet.
P and K fertilizer	10/18 10/21	0-0-60 @ 250 LB/a. 0-46-0 @ 200 LB/a.	10/18 10/21	0-0-60 @ 250 LB/a. 0-46-0 @ 200 LB/a.
Lime	10/18	3.8 ton/a. Steadman lime bulk spread	10/18	3.8 ton/a. Steadman lime bulk spread
Fall tillage	10/23	Fall chisel with leveling bar. Fall disk, no harrow. Fall strip-till 8-inch depth.	10/23	Fall chisel with leveling bar. Fall disk, no harrow. Fall strip-till 8-inch depth.

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 1 of the 4 replications. Temperatures were recorded with maximum-minimum thermometers that were read daily. No-till had the lowest average daily maximum soil temperature in both continuous corn and in rotation (Fig. 2). All levels of tillage increased the daily maximum soil temperature. Maximum temperatures wee highest with fall chisel plowing for both continuous corn and corn after soybean. Strip-tilling raised maximum soil temperatures 2 to 4 degrees compared to no-till. Average minimum soil temperatures for all treatments were within a 2-degree range (Fig. 3).

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, however the strip-till did have a significantly higher stand at 4 weeks after planting than the other treatments (Table 2). Strip-till also had significantly taller plants at 4 weeks after planting. By 8 weeks after planting the tilled treatments were not significantly different, however no-till was significantly shorter. There were no significant differences in grain yield, but no-till corn was at least 4% wetter at harvest than any other treatment. Overall corn yields were about 11% higher in rotation; the rotation advantage was normal in this drought-stressed year.

Rotation corn/soybean. 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 2). Even the least aggressive full-width tillage treatment of disk/field cultivator resulted in 8% residue cover. Both strip-till and no-till left sufficient residue to reduce soil erosion. There were no significant differences in plant stand at 4 weeks, plant height at 4 weeks, grain moisture at harvest and grain yield.

Table 2. Agronomic performance of corn as affected by tillage and rotation, Sebewa loam, Long-term Tillage Study, Pinney Purdue Agricultural Center, 2002. †

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	19d‡	28833b	15.3b	66.5a	20.2b	124.9
	Chisel/field cultivator	22c	28167b	15.1b	67.1a	20.2b	121.4
	Disk/field cultivator	33b	29250b	14.8b	66.4a	22.2b	123.8
	Fall strip-till	71a	30208a	16.3a	65.7a	22.5b	120.1
	No-till	86a	29250b	13.1b	61.0b	26.5a	117.2
Soybean	Chisel/disk/field cultivator	4c	28916	16.5	73.6a	18.1	135.0
	Chisel/field cultivator	5c	28916	16.4	70.2ab	17.9	135.5
	Disk/field cultivator	8c	29541	15.3	68.6b	19.3	140.4
	Fall strip-till	61b	30042	17.2	72.6ab	18.2	134.7
	No-till	74a	29333	15.3	69.3ab	19.5	131.4

†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 3. Analysis of variance summary, tillage data, corn, Long-term Tillage Study, PPAC, 2002.

Variable	Residue cover after planting	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield Bu/a.
	--Significance Level---------------------------------					
Tillage	.01	.01	.01	.01	.01	NS
Previous crop	.01	NS	.09	.05	.05	.04
Tillage x previous crop	NS	NS	NS	.05	.02	NS

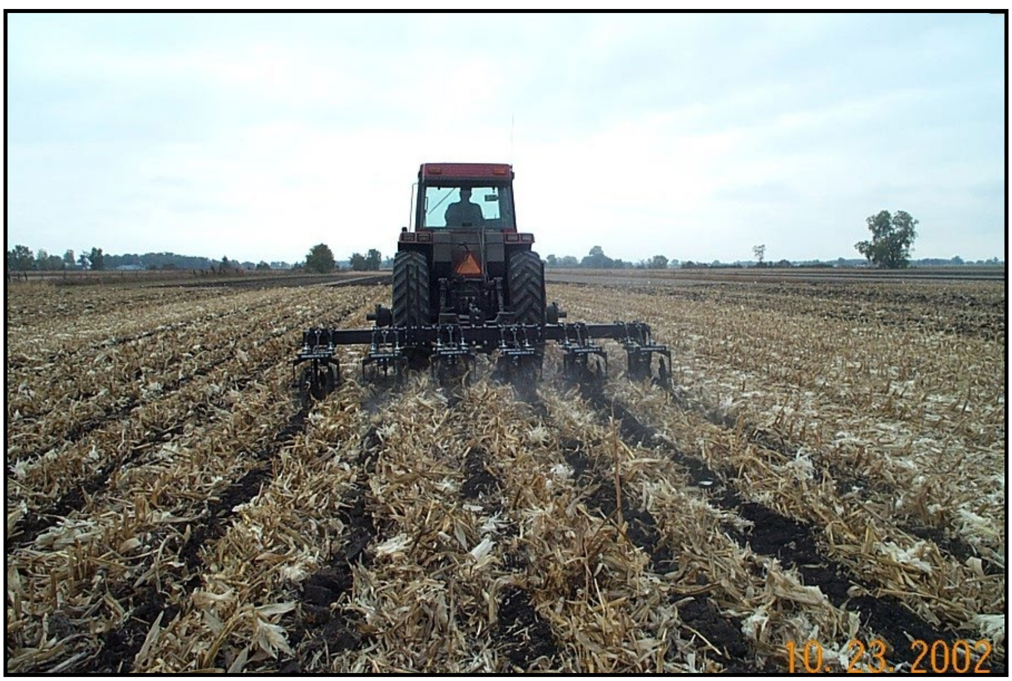
Stand, growth, and yield -- Soybean

All treatments except strip-till were drilled at 200,000 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). Our drilled soybean plant population was well below our seed drop. The low plant stands in the drilled plots may be from not having the drill set deep enough, insufficient soil moisture at seed depth, and poor quality seed. In the drilled treatments we achieved only 62% stand of what we had the drill set for. Seed depth was more consistent in the strip-till plots resulting in 80% of our intended plant population. Plant growth was normal through week 4 with no-till being significantly shorter than the other treatments. By week 8 after planting, strip-till was significantly taller than the other treatments. No-till was significantly shorter than all other treatments. Strip-till significantly yielded more than any of the other treatments despite the 30-inch row width. The fact that this occurred in such a dry year suggests that this system enhanced soil moisture availability. The Remlinger strip-till tool that we used has a shank that tilled to a depth of 8-inches. This may have allowed the soybean roots to penetrate deeper and more quickly into the soil, thus supplying the plant with needed moisture in this dry year.

Table 4. Agronomic performance of soybean as affected by tillage, Sebewa loam, rotation soybean/corn, Long-term Tillage Study, Pinney Purdue Agr Center, 2002. †

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	17d	122300	5.4a	18.0b	12.3	30.2b
Chisel/field cultivator	25cd	117000	6.0a	18.4b	12.6	33.4b
Disk/field cultivator	33c	132200	5.3a	17.0b	12.2	30.8b
Strip-till 30-inch rows	57b	113500	6.0a	21.2a	12.5	39.4a
No-till	89a	123200	4.5b	15.5c	12.9	34.8b
ANOV sig. level	.01	NS	.01	.01	NS	.01

†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 5. Yield summary by year, Bu/a., Sebewa loam, Long-term Tillage Study, PAC.†

Previous Crop	Tillage	1997	1998	1999	2000	2001	2002	97-02 Avg.	01-02 Avg.
				Corn					
Corn	Fall chisel, disk, field cultivate	187.2	188.4	141.5	164.1	204.0	124.9	168.4	164.5
	Fall chisel, field cultivate	194.5	187.1	146.8	170.3	206.6	121.4	171.1	164.0
	Fall disk, field cultivate	184.3	180.4	133.5	165.9	194.2	123.8	163.7	159.0
	Fall aerate, spring aerate	181.4	157.2	123.9	162.0	----	----	----	----
	Fall strip-till	----	----	----	----	201.5	120.1	----	160.8
	No-till	184.9	156.0	124.4	153.4	189.0	117.2	154.2	153.1
	CC Average	186.5	173.8	134.0	163.11	199.1	121.5	164.4	163.0
Soybean	Fall chisel, disk, field cultivate	206.9	195.6	166.7	174.8	220.8	135.0	183.3	177.9
	Fall chisel, field cultivate	211.3	186.6	171.2	177.8	222.6	135.5	184.2	179.0
	Fall disk, field cultivate	205.6	196.1	169.0	177.2	218.9	140.4	184.5	179.6
	Fall aerate, spring aerate	207.8	170.7	160.0	172.4	----		----	----
	Fall strip-till	----	----	----	----	226.8	134.7	----	180.7
	No-till	204.6	169.9	166.8	173.4	220.2	131.4	177.7	175.8
	CB Average	207.2	183.8	166.7	175.1	221.9	135.4	182.4	181.7
	Average	196.9	178.8	150.4	169.1	210.5	128.4	173.4	172.4
				Soybean					
Corn	Fall chisel, disk, field cultivate	60.4	48.6	46.8	50.0	55.5	30.2	48.6	42.8
	Fall chisel, field cultivate	61.9	48.3	49.5	52.8	57.5	33.4	50.5	45.4
	Fall disk, field cultivate	60.5	45.1	46.0	56.8	57.6	30.8	49.5	44.2
	Fall aerate, spring aerate	61.2	49.9	43.5	49.0	----	----	----	----
	Fall strip-till	----	----	----	----	60.0	39.4	----	49.7
	No-till	60.8	51.0	41.2	47.2	59.8	34.8	49.2	47.3
	BC Average	61.0	48.6	45.4	51.2	58.1	33.7	49.5	52.9

†Average of 4 replications.

Table 6. Corn Yield Response to Tillage and Rotation, Long-term Tillage Study, PPAC, 1997-2002

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	183.3	- - -	168.4	- - -	9
Chisel/field cultivator	184.2	100	171.1	102	8
Disk/field cultivator	184.5	100	163.7	97	13
No-till	177.7	97	154.2	92	15

Not for publication.

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 soybean, and soybean 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 21% of the corn acreage was planted with no-till in 2002, even though no-till production was used on 56% 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 (1975-02) at the Agronomy Research Center has documented significant corn yield reductions with no-till when corn followed corn, but not when corn followed soybean. Average corn yields were only 3% lower with no-till compared to moldboard plowing after soybean (Annual Cropping Systems Report 2002). 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 soybean 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 soybean 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.

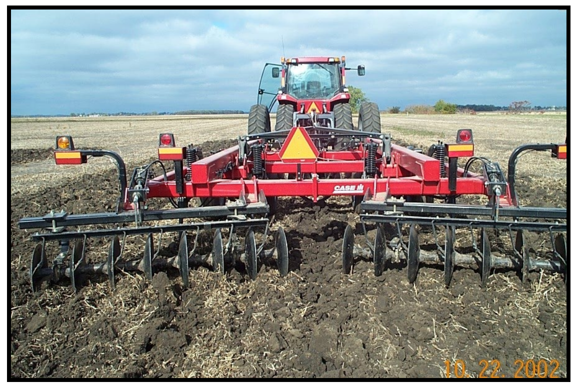
Agronomy Research Center, Lafayette, IN

Soil Description

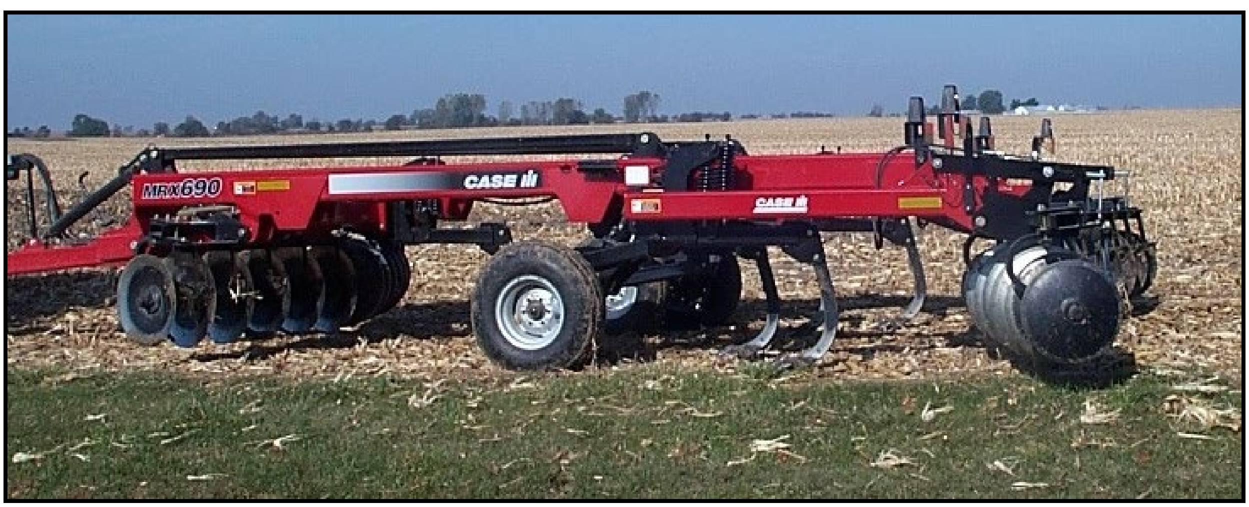
The soil types are Drummer silty clay loam and Raub silt loam. These fields were tiled in recent years. "The Drummer series consists of very deep, poorly drained, moderately permeable soils on recessional moraines and till plains. These soils formed in silty sediments and in the underlying glaciofluvial 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 2002

April was a very wet month with 5.4-inches of rain compared to a normal rainfall of 3.7-inches (Fig. 1). We planted the early date of corn on April 18th. The no-till soil was somewhat wet but still plantable and the strip-till was ideal. The weather turned cold and wet for the next two weeks. As soils approached plantable conditions by May 5th we entered a wet period of eight days that totaled 3.05-inches of rain. Over the next thirteen days soils dried marginally with rewetting occurring during two periods of rain totaling another one inch.

On May 23rd we decided to proceed with the normal planting date treatments even though soil conditions were not ideal. The field cultivating on the morning of May 23rd left the seedbed in the tilled plots cloddy. In the no-till plots we set the row cleaners to brush most of the residue aside and leave the soil surface undisturbed. As in the early planting date the strip-tilled plots provided a drier seedbed than the no-till plots. The plots were quite undulating 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 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 2002 considering the wet spring and delayed planting. Extended periods of dry and sunny weather provided the necessary growing degree-days to speed plant growth and maturity. The occasional rains we did get provided one to two inches of rain per event, which supplied sufficient moisture for continued growth and development.

Disk ripper-disk shanks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Disk-ripper-disk shank in soybean stubble.

CULTURAL PRACTICES USED 2002 Corn following Soybean, Field 117, ARC		
Item	Date	Application Details
Spring tillage	5/23	22-foot field cultivator with trailing double rolling baskets
Hybrid planted		
First planting date	4/18	Pioneer 34M94 seed
Second planting date	5/23	Pioneer 34M94 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		
All plots	4/19	Pre-emerge: Degree Extra 7 pt/a. Roundup 1.5 pt/a.
Second planting date	6/12	Post-emerge: Clarity ½ pt/a. Accent 1/3 ounce/a. *All spraying was broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gal water/a.*
Nitrogen fertilizer	6/3	200 lbs N as UAN (28%) @ 60 gallons/acre (4-row, 3.5 pump setting)
Harvest	10/24	Center 6 of 12 rows, 150 feet
P and K fertilizer	11/4	0-0-60 @ 200 LB/a. and 0-46-0 @ 200 LB/a.
Field 116 for 2003 study.		
P and K fertilizer	10/2	0-0-60 @ 250 LB/a. and 0-46-0 @ 200 LB/a.
Tillage	10/15 10/18 11/14	Case-IH MRX690 Disk-ripper-disk set at 13-inches deep, 4.5 mph, 8th gear, Case-IH MX240 tractor. Chisel with ridge leveling sweeps Strip-tilled with DMI 2500 equipped with mole knives and baskets

DMI 2500 strip-till.

Corn Following Soybean

Stand, growth, and yield:

Plant stands were significantly less than our goal of 32,000 plants per acre (Table 1). The early planting date suffered from an extended period of wet and cold soils with some frost damage to the young plants. The corn in the normal planting date, planted 5-weeks later, fared better except for the no-till treatment. Note that the DRD stale seedbed treatment resulted in taller week 4 plant heights and similar plant stands compared to other normal date treatments in spite of the fact that the plots were rough at planting. Plant heights at 4 and 8 weeks after planting were significantly shorter for the early planting date due to cold soil and air temperatures and the shorter day length. Grain yields for the early planting date suffered from poor pollination caused by increased silk clipping as compared to the normal date corn. A tendency for higher yields in the fall DRD spring field cultivate and the fall strip-till treatments that provided a deep tilled (12-inches and 8-inches respectively) soil with satisfactory seedbed conditions was observed. Spring field cultivation alone did not provide the deeper tillage, and the fall DRD stale seedbed may still have been too rough. The low no-till corn yields in this study are surprising in that in other experiments this year at the Agronomy Research Center no-till corn yields were very good.

Table 1. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, Corn Following Soybean, ARC, 2002.†

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.
4. Fall DRD, spring field cultivate	10d‡	28700a	16.7b	65.3b	16.6ab	187.8a
6. Fall strip-till, normal planting date	75b	28300ab	17.6ab	69.2a	16.6ab	183.7a
2. Spring field cultivate	27c	28100ab	17.1b	66.6ab	16.6ab	181.6a
3. Fall DRD, stale seedbed	13d	28600ab	18.2a	67.9ab	16.5bc	178.6a
1. Fall chisel, spring field cultivate	12d	28700ab	16.7b	66.7ab	16.5bc	175.5a
8. No-till, normal planting date	75b	25300d	16.8b	66.0ab	16.9a	171.5a
5. Fall strip-till, early planting date	73b	27600b	4.7c	29.4c	16.3cd	102.8b
7. No-till, early planting date	84a	26400c	4.6c	27.0c	16.1cd	101.4b
LSD (5%)	7	1115	1.0	3.8	0.3	20.1

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

Table 2. Soil test results based on composite sampling, Field 117, ARC, Fall 2002.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CB	0-8	3.7	15 L	134 M	660 VH	2000 L	6.4	6.8	18.2
No-till	CB	0-4	3.8	19 L	225 H	625 VH	1900 L	6.4	6.8	17.7
No-till	CB	4-8	3.9	18 L	104 M	680 VH	2050 M	6.6	6.9	17.4

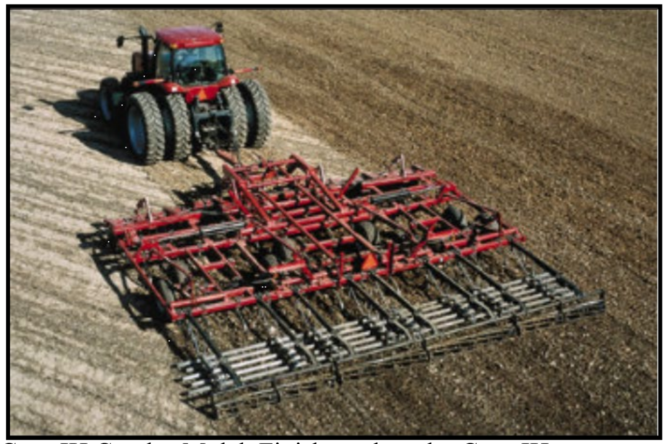
Pinney PAC, Wanatah, IN

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.

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 1640



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 2002

All of April and the first half of May were very wet with above normal rainfall (Fig 2). Air temperatures in April allowed frost to develop which injured the early planted crops. From June 1st through October rainfall was far below normal. The largest rainfall recorded from June 1st to the end of October was 0.51-inches. June rainfall was less than one inch. July had a total of 2.61-inches of rain but this represents the accumulation of brief rains of which the largest was 0.51-inches. In other words, after June 1st the soil moisture was insufficient for good crop development. Air temperatures for the summer were near normal and GDD accumulation was above normal.

Continuous Corn

CULTURAL PRACTICES USED 2002 Continuous Corn, Field D, Pinney PAC		
Item	Date	Application Details
Spring tillage	5/22	Case-IH Combo-mulch-finisher 4400
Hybrid planted		
First planting date	4/16	Pioneer 34M94
Second planting date	5/23	Pioneer 34M94
Seeding rate		32,000 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		
All plots	4/17	Burndown: Roundup Ultra 2 pt/a.
First planting date	4/17	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 2.5 lb/a.
	6/7	Post-emerge: Buctril AT 2pt/a., Accent SP 2/3 oz/a.
Second planting date	5/28	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 2.5 lb/a.
	6/7	Post-emerge: Buctril AT 2pt/a., Accent SP 2/3 oz/a.
		All spraying was broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gal water/a.
CULTURAL PRACTICES USED 2002, Continued Continuous Corn, Field D, Pinney PAC		
Nitrogen fertilizer	6/6	200 lbs N as UAN (28%) @ 60 gallons/acre (6-row, 5.25 pump setting)

Insecticide/sprayer	7/19	Co-op Hi-boy sprayed Warrior at 3 oz/a. for silk feeding by Japanese beetles and corn rootworm beetles.
Harvest	10/10	Center 6 of 12 rows, 250-feet.
P and K fertilizer	10/18	0-0-60 @ 250 LB/a.
	10/21	0-46-0 @ 200 LB/a.
Lime	10/18	3.8 ton/a. Steadman lime bulk spread
Tillage	10/23	Case-IH MRX690 Disk-ripper-disk set at 11-inches deep, 5.5 mph, 9th gear, Case-IH MX240 tractor. Case-IH Combo-mulch-finisher equipped with Vibra®Chisel shanks Chisel plow Strip-tilled with Remlinger unit at 8-inches deep

Stand, growth, and yield:

Plant populations in the two early planting treatments were reduced compared to normal planting dates by frost damage and continued cold and wet soil for 3-weeks after planting (Table 3). Although the early strip-till had a much drier seedbed than early no-till this did not translate into increased plant stands or taller plants. The fall DRD stale seedbed treatment had a lower population than other normal planting date treatments likely caused by less uniform seed depth placement. Plant growth through the season was shorter for the early-planted corn. Corn yields were approximately 42% less than the previous 5-year corn yields from the Long-term Tillage Study at Pinney. This can be attributed to the dry summer. There are some yield trends worth noting. The top three yields are from tillage treatments that do the least soil disturbance in the spring. This may have preserved soil moisture compared to other treatments and eliminated any chances of soil compaction (by wheel tracks or tillage tools) at the time of secondary tillage. It is also interesting that the same three treatments had the highest grain moisture content at harvest; perhaps drought hastened plant maturity occurred sooner in the other treatments. The most aggressive treatment, fall DRD with spring VE3BDR, had the lowest yield. This treatment would likely have had the least soil moisture available for plant growth.

Table 3. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, continuous corn, Pinney PAC, 2002.†

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.
6. Fall DRD, stale seedbed	67bc‡	29700cd	15.9a	55.3b	20.9a	102.3a
4. Fall VC3BDR, stale seedbed	75ab	32400a	15.5a	55.3b	19.9abc	99.2ab
2. No-till, normal planting	86a	31900ab	13.8b	56.4b	20.3ab	98.3ab
3. Spring VE3BDR	79ab	31000bc	15.8a	59.0ab	17.0d	96.3ab
5. Fall VC3BDR, spring VE3BDR	68bc	31700ab	16.4a	57.1b	18.7abcd	95.5ab
8. Fall strip-till, early planting	61cd	29000d	3.2c	14.1d	17.0d	95.5ab
1. Fall chisel, spring VE3BDR	48d	32000ab	16.3a	61.1a	17.9cd	93.8ab
9. Fall strip-till, normal planting	70bc	31900ab	14.4b	51.3c	20.4ab	91.5ab
10. No-till, early planting	86a	29100d	3.0c	13.0d	18.4bcd	91.1ab
7. Fall DRD, spring VE3BDR	60cd	32100ab	15.5a	57.8ab	17.3d	89.7b
LSD (5%)	13	1362	1.0	3.9	2.4	12.3

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

Corn Following Soybean

CULTURAL PRACTICES USED 2002

Corn following Soybean, Field F, Pinney PAC		
Item	Date	Application Details
Spring tillage	5/21	Case-IH Combo-mulch-finisher 4400
Hybrid planted		
First planting date	4/16	Pioneer 34M94
Second planting date	5/22	Pioneer 34M94
Seeding rate		32,000 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		
All plots	4/17	Burndown: Roundup Ultra 2 pt/a.
First planting date	4/17	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 2.5 lb/a.
	6/7	Post-emerge: Buctril AT 2pt/a., Accent SP 2/3 oz/a.
Second planting date	5/28	Pre-emerge: Bicep II Magnum 4.2 pt/a., Atrazine 2.5 lb/a.
	6/7	Post-emerge: Buctril AT 2pt/a., Accent SP 2/3 oz/a.
		All spraying was broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gal water/a.
Nitrogen fertilizer	6/6	200 lbs N as UAN (28%) @ 60 gallons/acre (6-row, 5.25 pump setting)
Insecticide/sprayer	7/19	Co-op Hi-boy sprayed Warrior at 3 oz/a. for silk feeding by Japanese beetles and corn rootworm beetles.
Harvest	10/10	Center 6 of 12 rows, 250-feet.
P and K fertilizer	10/18	0-0-60 @ 250 LB/a.
	10/21	0-46-0 @ 200 LB/a.
Lime	10/18	3.8 ton/a. Steadman lime bulk spread
Tillage	10/23	Case-IH MRX690 Disk-ripper-disk set at 11-inches deep, 5.5 mph, 9th gear, Case-IH MX240 tractor.
		Case-IH Combo-mulch-finisher equipped with Vibra®Chisel shanks
		Chisel plow
		Strip-tilled with Remlinger unit at 8-inches deep

Stand, growth, and yield:

Plant populations in the two early planting treatments were reduced somewhat compared to normal planting dates by frost damage and continued cold and wet soil for three weeks after planting (Table 4). Plant growth through the season was shorter for the early-planted corn. Corn yields were approximately 45% less than the previous 5-year corn yields from the Long-term Tillage Study at Pinney. This can be attributed to the dry summer. The reduced yields in the early-planted treatments were associated with wet and cold soil conditions after planting. No tillage treatment differences in yield were apparent for the later planting date.

Table 4. Feasibility of Disk-ripper-disk Tillage, Fall Strip Tillage, and other Single-Pass Tillage Systems in Indiana, corn following soybean, Pinney PAC, 2002.†

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.
3. Spring VE3BDR	48b	32200ab	17.4ab	66.2abc	16.6a	119.6a
1. Fall chisel, spring VE3BDR	6d	31100bc	17.6ab	69.6a	16.3bcd	118.8a
7. Fall DRD, spring VE3BDR	8d	32000abc	16.0b	68.8ab	16.4abc	114.0ab
5. Fall VC3BDR, spring VE3BDR	25cd	32400ab	16.1b	67.5abc	16.2bcd	112.4abc
4. Fall VC3BDR, stale seedbed	38bc	33000a	17.8a	64.9bc	16.4ab	111.3abc
9. Fall strip-till, normal planting	48b	32100abc	16.0b	64.8bc	16.4abc	111.2abc
6. Fall DRD, stale seedbed	13d	31200bc	16.8ab	68.5ab	16.3bcd	110.8abc
2. No-till, normal planting	87a	32400ab	17.3ab	64.2c	16.2bcd	110.0abc
10. No-till, early planting	73a	30500c	3.9c	18.8d	16.0d	101.9bc
8. Fall strip-till, early planting	48bc	32000abc	4.2c	19.6d	16.1cd	101.5c
LSD (5%)	22	1669	1.7	4.0	0.3	12.2

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

Soybean Following Corn

CULTURAL PRACTICES USED 2002
Soybean following Corn, Field D, Pinney PAC

Item	Date	Application Details
Spring tillage	5/22	Case-IH Combo-mulch-finisher 4400
Variety planted	4/16 and 5/23	Pioneer 93B09
Seeding rate		200,000 seeds/a. in drilled plots, 143,000 in 30-inch row strip-till treatment
Weed control	4/17	Burndown: Roundup Ultra 2 pt/a.
	6/23	Post-emerge: Roundup Ultra 2 pt/a., AMS 17 lb/100 gallons water *All spraying was broadcast with 8008 flat fan nozzles on 20-inch centers at 5.5 mph, 20 gal water/a.*
Manganese	6/23	4 pt/a. chelated manganese
Harvest	9/30	Drilled soybean: center 15-feet of 30-foot plots, 250-feet 30-inch row soybean: center 5 rows of 12 row plots, 250-feet
P and K fertilizer	10/18	0-0-60 @ 250 LB/a.
	10/21	0-46-0 @ 200 LB/a.
Lime	10/18	3.8 ton/a. Steadman lime bulk spread
Tillage	10/23	Case-IH MRX690 Disk-ripper-disk set at 11-inches deep, 5.5 mph, 9th gear, Case-IH MX240 tractor. Case-IH Combo-mulch-finisher equipped with Vibra®Chisel shanks Chisel plow Strip-tilled with Remlinger unit at 8-inches deep

Stand, growth, and yield:

Plant populations in the drilled treatments fell far short of our 200,000 seed drop (Table 5). The fall strip-till normal planting date was also far below the seed drop of 143,000. Reasons include poor seed germination and shallow seed depth. The no-till early planting treatment had to be replanted due to frost damage. The fall strip-till early planting date also suffered from frost, however we did not replant this treatment. Tallest soybean plants at four and eight weeks after planting were consistently observed in the treatments with deeper fall tillage (whether strip-till, DRD, or chisel). Soybean yields were highly variable due to drought and approximately 44% less than the previous 5-year soybean yields from the Long-term Tillage Study at Pinney. Within treatments with normal planting dates, strip-till yielded at least 3.2 bushels/acre higher than any other treatment. Strip-till soybean also yielded more in the Long-term Tillage Study at Pinney (2002) despite the disadvantage that is normally associated with wide-row production systems compared to narrow-row systems.

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

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.
9. Fall strip-till, normal planting	67b‡	108900bc	6.3a	18.8a	11.0	37.1a
10. No-till, early planting (replanted)	89a	103800*c	1.0d	14.8d	11.2	35.7ab
1. Fall chisel, spring VE3BDR	39d	152600a	6.1a	16.7bc	11.2	33.9ab
3. Spring VE3BDR	69b	141700ab	5.4bc	15.7cd	11.3	31.6ab
2. No-till, normal planting	83a	125100abc	4.8c	14.6d	11.3	30.4ab
7. Fall DRD, spring VE3BDR	57bc	133600abc	6.0ab	17.4abc	11.0	29.8ab
6. Fall DRD, stale seedbed	48cd	117500bc	5.7ab	17.4ab	11.2	28.9ab
4. Fall VC3BDR, stale seedbed	68b	140700ab	5.4bc	14.9d	11.4	26.3abc
5. Fall VC3BDR, spring VE3BDR	67b	133600abc	5.7ab	16.7bc	11.2	25.3bc
8. Fall strip-till, early planting	69b	137700ab	1.0d	4.2e	11.0	16.7**c
LSD (5%)	13	33607	0.6	1.7	0.9	11.3

† Average of 4 replications
‡ Means with the same letter are not significantly different.
* Population before replanting. Week 4 height is original stand height and week 8 height is that of replanted soybean. Grain moisture and yield is of replant.
** Reps 2 and 4 were severely frosted due to location next to grass alley. A more representative treatment yield from reps 1 and 3 would be 23.1 bu/a.

Table 6. Soil test results based on composite sampling, Field D, PPAC Fall 2002.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CC	0-8	6.1	35 H	215 H	615 H	2350 L	5.9	6.6	22.2
No-till	CC	0-4	5.8	24 M	252 H	595 H	2200 L	5.8	6.6	21.4
No-till	CC	4-8	5.4	12 L	108 M	515 H	2150 L	5.7	6.6	20.1
Chisel	BC	0-8	7.0*	23 M	155 M	525 H	2200 L	5.9	6.6	20.6
No-till	BC	0-4	4.7	28 M	219 H	580 VH	2050 L	6.3	6.7	19.2
No-till	BC	4-8	4.7	13 L	98 M	530 H	2050 L	5.9	6.6	19.7

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

Table 7. Soil test results based on composite sampling, Field F, PPAC, Fall 2002.

Tillage	Crop	Depth	OM	Phos.	K	Mg	Ca	Soil pH	Buffer pH	CEC
		Inches	%	ppm	ppm	ppm	ppm			meq/100g
Chisel	CB	0-8	2.7	21 M	147 M	440 H	1500 L	5.6	6.6	16.3
No-till	CB	0-4	3.6	17 L	178 H	460 H	1500 L	5.7	6.6	16.6
No-till	CB	4-8	3.6	16 L	109 M	470 VH	1500 L	6.0	6.7	15.3

Table 8. Soil test results based on composite sampling, Field 116, ARC, Fall 2002.

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	3.1	29 M	186 H	590 VH	1750 M	6.5	6.9	15.3
No-till	BC	4-8	3.1	15 L	103 M	620 VH	1850 L	6.5	6.8	17.1

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

Mercedes Murua, Tony J. Vyn, 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.

Site Information and Treatments

The study was conducted at the Agronomy Research Center (ARC), IN, on Drummers silty clay loam soil in 2000 and 2001. Two corn hybrids (Fielder's Choice 9307 and 8509, 107 to 109 day RM) were no-till planted on three dates representing early (28 March 2000, 2 April 2001), intermediate (14 April 2000, 19 April 2001) and late (16 May 2000, 11 May 2001) planting times. Each hybrid had the following coating treatments in Year 2000: the control (UTC), coating A (2 % of seed weight), coating B (3 % of seed weight), and in 2001: the control (UTC), coating C (slightly different polymer than in 2000, 2 % of seed weight), coating D (same polymer as in 2000, 2.5 % of seed weight).

CULTURAL PRACTICES USED AT 5 LOCATIONS IN 2000-01

Field Operation	Date	Application Details
Seeding rate	April-May	30,000 seed/a.
Starter fertilizer		95 LB/ac 34-0-0
Nitrogen fertilizer	May	180 N LB/ac as NH_3 sidedress
Weed control	April	Harness Extra 5 pt/a.
(Pre-emergence)		Roundup Ultra 1.5 pt/a.
		Gramoxone Extra 3 pt/a.
		All broadcast with flat fan 8006 nozzles at 30 psi and 30 gallons of water/a., 5.0 mph
Harvest	Sept.-Dec.	Hand harvest 15-20 meters of row per plot

Preliminary Results

Preliminary results for days from planting to 50 % emergence, days from 10 to 90 % emergence and plant populations are summarize in Tables 1 & 2.

Table 1. Coating treatment effects on days to 50 % emergence, days from 10 to 90 % emergence for different planting dates, and hybrids in years 2000 and 2001.

Treatment	Mean Days to 50 % Emergence			Days from 10-90 % Emergence		
	Planting Date			Planting Date		
Year 2000	**3/28**	**4/14**	**5/16**	**3/28**	**4/14**	**5/16**
9307/UTC	28.2 c	16.4 b	10.2	5.5	4.3	4.6
9307/A	31.1 b	18.5 a	11.2	6.4	4.0	4.0
9307/B	33.3 a	19.2 a	11.1	6.9	4.4	4.4
8509/UTC	29.7 b	16.3 b	9.8	9.3 a	2.8	4.0
8509/A	30.3 b	18.4 a	10.8	5.0 b	4.1	3.4
8509/B	31.5 a	18.7 a	10.9	5.6 b	3.4	2.8
Year 2001	**4/2**	**4/19**	**5/11**	**4/2**	**4/19**	**5/11**
9307/UTC	10.94 b	10.19 b	8 c	4.0 b	2.5	3.4 b
9307/C	15.81 a	13.56 a	12.44 a	8.1 a	4.4	8.9 a
9307/D	16.31 a	13.06 a	10.25 b	8.8 a	3.3	4.1 b
8509/UTC	10.75 b	10.69 b	8.06 b	3.5 b	2.9	2.9
8509/D	15.13 a	13.19 a	10.13 a	6.8 a	3.4	2.6

Means separation within planting date and hybrid by Duncan range test, 5% level.
Treatment code: UTC, control, A, coating A, B, coting B, C, coatging C, D, coating D.

Table 2. Coating treatment effects on final plant populations in 2000 and 2001.

Plant Population (Plants/acre)							
Treatment	Planting Date			**Treatment**	Planting Date		
Year 2000	**3/28**	**4/14**	**5/16**	**Year 2001**	**4/2**	**4/19**	**5/11**
9307/UTC	27200	28700	26600	**9307/UTC**	17400 b	28500 a	30500 a
9307/A	28700	28700	27400	**9307/C**	24300 a	26000 b	28400 b
9307/B	29000	28200	26900	**9307/D**	23300 a	28200 a	30600 a
8509/UTC	31300	31600	30500	**8509/UTC**	25000 b	25700	30000
8509/A	30900	31900	29600	**8509/D**	29100 a	27400	30400
8509/B	30400	31700	30400				

Means separation within planting date and hybrid by Duncan range test, 5% level.
Treatment code: UTC, control, A, coating A, B, coting B, C, coatging C, D, coating D.

Preliminary conclusions

Polymer coatings resulted in emergence delays for early, intermediate and late planting dates for both hybrids and in both years. Uncoated seeds generally emerged 1 to 4 days before the coated seeds (coating treatments A, B, C or D), and the emergence period from initial to final emergence was longer for coated treatments than for uncoated seeds. In terms of emergence uniformity, coated treatments resulted in additional days from 10 to 90 % emergence for the early planting date in 2001, but not in 2000. Final plant populations were never lower with polymer-coated seeds than uncoated seeds in FC-8509. In 2001, coated seeds resulted in significantly higher plant populations of both hybrids for the early planting date. Potential treatment differences in developmental stages, height, silking, plant spacing as well as grain yield are not certain because all data are yet to be statistically analyzed.

The potential for utilization of these polymers on hybrid corn production is obvious if producers can be assured that yields associated with early planting would be at least equal to those planted uncoated hybrid corn seed during the optimum period. Analysis of this research data will further contribute to the assessment of whether temperature-sensitive polymers will reduce the traditional risks associated with early planting.

Acknowledgements

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Publications

Vyn, T. J. and M. Murua. 2002. Polymer seed coatings: sufficient reduction for early plant corn? Proceedings of the 56 annual corn & sorghum research conference. In press.

Effects of Fertility Placement in High Yield Corn Situations

Ann M. Kline, Tony J. Vyn, and Sylvie M. 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. The studies are being conducted on dark prairie soils at the Agronomy and Animal Science Centers for Research and Education near West Lafayette, Indiana. The soils are deep, and are characterized as silt loams or silty clay loams. Both investigations are for first year corn after soybean in rotation.

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 plus 12 inch banded P & K. The fertilizer was banded directly beneath the intended row area before planting took place.

CULTURAL PRACTICES USED FOR STUDY 1 IN 2001-2002

Field Operation	Date	Application Details
Tillage	Spring 2002	JD 980 Field Cultivator with trailing Unverferth rolling harrow
Fertilizer Application	06/04/02	192 lbs 0-45-0 and 0-0-60 with DMI Nutriplacr 2500
	06/10/02	
Planting	06/11/02 34B24	34,000 and 44,000 plants per acre seeding rates with JD 1780 planter,
	06/17/02 34M95	hybrids Pioneer 34B24 and Pioneer 34M95
Starter fertilizer	06/11/02	12 gal/ acre 9-18-9 plus zinc
Nitrogen Applications	06/21/02	135 lbs/acre N applied as UAN with DMI Nutriplacr 2800
	07/01/02	115 lbs/acre N applied as UAN with DMI Nutriplacr 2800
Weed Control	05/22/02	Roundup
	06/17/02	Dual II Magnum (2 pt/acre) and Atrazine (2.5 pt/acre)
	06/24/02	Beacon (0.76 oz/acre)
	07/05/02	Row-crop cultivated
Harvest	11/19/02	Hand harvest 16 m row length per plot

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 34B24 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 STUDY 2 IN 2001-2002

Field Operation	Date	Application Details

Primary Tillage	Fall 2001	Chiseled wheat and soybean stubble
Secondary Tillage	05/29/02 06/04/02	JD 980 Field Cultivator with trailing Unverferth rolling harrow
Fertilizer Application	06/10/02	192 lbs 0-45-0 and/or 0-0-60 with DMI Nutriplacr 2500
Planting	06/11/02 34B24 06/17/02 34M95	34,000 plants per acre seeding rate with JD 1780 planter, hybrids Pioneer 34B24 and Pioneer 34M95
Starter fertilizer	06/11/02	12 gal/ acre 9-18-9 plus zinc
Nitrogen Applications	06/21/02	135 lbs/acre N applied as UAN with DMI Nutriplacr 2800
	07/01/02	115 lbs/acre N applied as UAN with DMI Nutriplacr 2800
Weed Control	05/22/02	Roundup
	06/17/02	Dual II Magnum (2 pt/acre) and Atrazine (2.5 pt/acre)
	06/24/02	Beacon (0.76 oz/acre)
Harvest	11/21/02	Hand harvest 16 m row length per plot

Measurements

Several measurements were taken throughout the past growing season. The first measurements for both experiments were soil fertility samples taken at 3 depths: 0-4, 4-8, and 8-16 inch. In the first study, shoot samples were taken as well as leaf area measurements at both V6 and R1 growth stages. Early height measurements and chlorophyll readings were taken for both studies. The second study looked more intensively at the roots. Measurements included the shoot to root ratio, root scanning for whole roots at V4, and root scanning for root cores from in-row and between-row samples at V10.

Preliminary Results & Discussion

Excessive rain and delayed soil drying in April and May of 2002 made the second year of this study much more challenging, but some interesting data has been collected nevertheless. Although statistics must still be completed, there are some noteworthy trends. Overall grain yields in 2002 were still in the 200 bushel/acre range despite the delay in planting until near mid-June (data not shown). Corn in the higher plant populations (42,000 plants/acre) had increased leaf area at R1 with both hybrids, yet lower plant populations (32,000 plants/acre) resulted in higher grain yields.

Root analyses are incomplete, but high variability in root morphological responses to fertilizer treatments made it difficult to show treatment differences. In 2001, the broadcast treatment had a higher weight per shoot at V4 (Table 1), which reinforces the higher V5 shoot weights observed after broadcasting in the main placement/depth study (data not shown). Deep banding of P alone, K alone, or P and K together did not enhance shoot weights, root weights, or root proliferation at this early stage. After results of root responses in 2002, and shoot nutrient concentrations in both years, are known, we may want to investigate alternate concentrations of P and K fertilizers in the 6” bands.

Hybrid impacts on root characteristics were generally greater than the impact of fertility placements. For example, 34B24 always had higher shoot weights, root weights, shoot to root ratios, and V4 root characteristics than 34M95 (see Tables 1-4). Shoot weight data confirmed that the broadcast treatment resulted in higher shoot weights than other treatments (see Table 1). The V10 root core data (Table 5) illustrates a higher root diameter and root volume for either broadcast P and K or banded K treatments relative to the control and banded treatments with P. This, however, did not translate into a yield advantage at the end of the season.

Although conclusions about high-yield corn responses to fertility treatment differences are premature, it appears that banding of P and K (at these rates) does not provide an early corn-growth advantage relative to broadcasting; however, there may be a later-season advantage associated with deep banding. For instance, chlorophyll meter readings during the grain fill period suggest delayed leaf senescence with deep banding (data not shown). Also, banding of P alone appears to have no advantages with respect to broadcast application or banding of P and K together.

Table 1. Hybrid and Fertility Effects on Shoot Weights at V4 in 2001

	Fertility Treatments					
Hybrid	Control	BC P&K	Band P&K	Band P	Band K	Mean
	g/plant					
Pioneer 34B24	2.20	2.56	2.39	2.15	2.10	2.28a
Pioneer 34M95	1.63	1.90	1.27	1.68	1.51	1.60b

Mean	1.91b	2.22a	1.83b	1.92b	1.81b	

Table 2. Hybrid and Fertility Effects on Root Weights at V4 in 2001

	Fertility Treatments					
Hybrid	Control	BC P&K	Band P&K	Band P	Band K	Mean
	g/plant					
Pioneer 34B24	0.40	0.43	0.41	0.37	0.38	0.40a
Pioneer 34M95	0.32	0.42	0.31	0.36	0.35	0.35b

Table 3. Hybrid and Fertility Effects on Shoot:Root Ratio in 2001

	Fertility Treatments					
Hybrid	Control	BC P&K	Band P&K	Band P	Band K	Mean
Pioneer 34B24	5.45	5.98	5.86	5.89	5.55	5.74a
Pioneer 34M95	5.05	4.47	4.12	4.62	4.33	4.52b

Table 4. Hybrid Effects on V4 Root Characteristics in 2001.

Hybrid	Length	Area	Surface Area	Avg. Diameter	Volume
	cm	cm^2	cm^2	cm^2	cm^3
Pioneer 34B24	325.0a	37.13a	116.6a	1.153a	3.391a
Pioneer 34M95	295.4b	32.30b	102.4b	1.113b	2.874b

Table 5. Fertility Effects on V10 Root Characteristics in 2001.

	Avg. Diameter	Volume
	mm	cm^3
Control	0.823b	0.489c
Broadcast P&K	0.892a	0.616ab
Band P&K	0.829b	0.520bc
Band P	0.816b	0.499c
Band K	0.887a	0.640a

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Related Posters and Presentations

Kline, A., T. Vyn, and S. Brouder. 2002. Effects of Fertility Placement on Early Corn Growth. Presented at the American Society of Agronomy Meetings, Indianapolis, IN, Nov. 10-14. Also presented at the North Central Industry-Extension Soil Fertility Conference, Des Moines, IA, Nov. 20-21.

Vyn, T. J. 2002. Tillage selection for management of soil compaction and fertility: Strip tillage and the alternatives. Presented at 2002 Indiana CCA Convention, Dec. 18, Indianapolis, IN.

Vyn, T.J., X. Yin and S.M. Brouder. 2002. What are the preferred K placement options for conservation-till soybean? Invited presentation to A-9 Symposium at the Annual Meetings of the American Society of Agronomy Meetings. Indianapolis, IN. Nov. 10-14.