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AGRONOMY RESEARCH CENTER

Long Term Tillage Study

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 residue covered often increased yield potential on these soils. These findings could not be generalized, however, to the dark silty clay loam soils of the Central 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 was 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 were compared for continuous corn, corn following soybeans, soybeans following corn, and continuous soybeans. Plots were 12 rows wide and 150 feet long. Row width was 30 inches for both corn and soybeans from 1975 to 1994. Starting in 1995, plow, chisel and no-till soybeans were drilled in 7.5 inch rows.

The following cultural practices have been used since the study began. Plowing and chiseling were done in the fall with one disking and one field cultivation for spring seedbed preparation. For the ridge system, ridges were made at cultivation in corn and after harvest in soybeans. All 30" row treatments except no-till were cultivated once.

Starter fertilizer was used for all corn plots, but not for soybeans. Placement was two inches to the side and 2 inches below the seed. Nitrogen source for corn was anhydrous ammonia, either pre-plant or side-dress. Phosphorus, potassium and lime were surface-applied as needed.

Several planting practices were changed in 1997. A flat disk was used to scrape ridges at planting from 1980 to 1996. Starting in 1997, planter mounted, double vertical disks were used to clear ridge tops of residue. For no-till planting, a one inch fluted or bubble coulter was used ahead of disk openers from 1975 to 1996. Starting in 1997, no coulters were used ahead of disk openers as per planter manufacturer recommendation.

Herbicides were applied at planting from 1975 through 1996. In 1997, herbicides were applied pre-emergence after planting with a 3-point hitch sprayer. They included atrazine, Bladex, and Dual for all corn, plus either Roundup or Gramoxone Extra for burndown on ridge and no-till plots. Lorox L, Lorox Plus and Dual were used for all soybeans, with burndown the same as for corn. Where needed, plots were hand weeded to be sure that weed control did not limit yield. Counter was band-applied at planting for corn rootworm control from 1975 through 1996. Starting in 1997, Force 1.5G was used. Chemical control for cutworms, stalk borers, bean leaf beetle, and spider mites was used as needed.

Three corn hybrids and six soybean varieties have been used during the 23 years of the project.

Table 1. Planting dates for corn and soybean, Chalmers silty clay loam, Agronomy Research Center,

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

1997

Equipment used:

Primary tillage included the use of an International Harvester 5-18 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 5-danish-tine sweep leveling bar was used for the chisel treatment. Nitrogen was applied preplant at a depth of 6 to 7 inches with a 5-knife 30-inch anhydrous ammonia applicator equipped with one coulter, one sealing wing, and two covering disks per knife. The covering disks were removed for no-till continuous corn due to residue plugging. The disks were also removed for all ridge plots to prevent “shaving” of the ridge shoulders. The outside knives (#1 and #5) were reduced to 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. Secondary tillage for plow and chisel included the use of a International 15 foot pull type tandem disk and a Glenco 10 foot fully mounted field cultivator with rear mounted rolling baskets.

Corn was planted with a Case-IH model 955 4-row planter. Rawson brand fertilizer openers behind a ripple coulter 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. In addition to planting the no-till continuous corn beside rather than on the old row, we used row unit mounted row cleaners to clear the row area of 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 4-row 30-inch planter. All rowed plots, except no-till, were cultivated with a 4-row 30-inch 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 30-inch cornhead. All soybean plots were harvested with a John Deere model 3300 combine equipped with a 10-foot grain platform with pickup reel.

Summary of studies conducted on the tillage plots by researcher.

- Dr. James Wilcox, Agronomy.
Conventional Tillage v. No-till Effects on Seed Composition. “My objective was to determine if tillage method affected seed protein of genotypes that varied widely in seed protein concentration. Tillage method affected maturity and plant height, but had no effect on lodging, seed yield, and either protein or oil (both on a dry basis). Tillage method did not affect chemical composition of the seed, and the lack of a significant interaction between tillage method and entries for all traits indicates that all entries responded similarly to the tillage treatments.” This study will continue in 1998.
- 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 soybeans with Phytophthora root rot and sudden death syndrome symptoms, respectively. This research is important to Indiana and the northcentral 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 northcentral 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 1998.
- Dave Gehring and Dr. Gary Steinhardt.
“Dave Gehring and Gary Steinhardt used the automated penetrometer and took readings to a depth of 40 cm for all plow and no-till plots. Readings were taken in the wheel track, row middle (non-tracked), and in the west two rows for the corn plots. Data collected in soybeans was only wheel track and row middle (non-tracked). Initial results have not yet been determined, but more data will be needed to confirm whatever the results may be.” Dave Gehring
“Dave Gehring used two Amoozemeter to measure the soil's saturated hydraulic conductivity for the C/C and

C/B no-till and plow plots. He took measurements in four locations in the plot; wheel track, in the row, row middle (non-tracked) and the skip row (area between the plots). Initial results show the wheel track as having the lowest conductivity while the row middle as having the highest. Further data will be collected to confirm the initial results.” Dave Gehring

- Dr. Larry Bledsoe, Entomology.
“Western corn rootworm is adapting to crop rotation in east central Illinois and northwest Indiana by laying eggs in soybean. This behavior can result in economic injury to corn in the following season. Tillage methods and resulting crop residues in the plots were used to assess the attraction of different crop habitats to western corn rootworm. Three types of traps were used to measure the relative attractiveness of the combinations of tillage type, crop residue type and amount, and current crop to the adult beetles over time. This study is part of a series of experiments to investigate possible mechanisms that would explain the behavioral shift. In brief, we found no strong connections (in our experiment) between tillage and/or residue types that explain the behavioral shift seen in rootworms. This was an important finding. Further testing is being done on larger plots in several counties. The behavioral shift was evident in the ARC residue plots as elsewhere on the farm. The tillage/residue plots provided an important monitoring environment that, when coupled with meteorological data in the future, may allow different types of correlation to be made.”
- J.E. Wells, S.M. Brouder and C.H. Nakatsu, Agronomy.
Soil Microbial Community Analysis in Agricultural Soils. “Soil microbial communities in agricultural fields are complex and diverse. Information on whole microbial communities in agricultural soils is limited because only about one percent of the microorganisms can be cultured using standard methods. In this study we determine if changes in soil microbial communities associated with plant growth can be detected by 16S rDNA (ribosomal DNA) analysis. Samples were collected from no-till and conventional plowed plots with corn or soybeans grown in monoculture or annual rotation. Corn and soybean root samples were collected to evaluate microbial communities in the rhizosphere. Six cylinders (4” dia. PVC pipe, 6” deep) were placed in the center rows of each corn and soybean plot of interest. The pipe was used as a barrier to exclude roots from interacting with the soil inside the cylinder. Soil collected from the cylinders was considered +bulk- soil. Differences in the community structure of rhizosphere and bulk soil microbial populations were observed and related to changes in crop development.” Jason Wells
- Terry West, Gary Steinhardt, and Dave Gehring, Agronomy.
T. West and G. Steinhardt studied long term affects of tillage and rotation by measuring plant population, growth, and yield of corn and soybeans.

<u>CULTURAL PRACTICES USED 1997</u>				
Long Term Tillage Study, ARC, Purdue Univ.				
Item	<u>Corn</u>		<u>Soybean</u>	
	Date	Application	Date	Application
Nitrogen fertilizer	4/15	NH ₃ @ 200 LB/a. N in row middles, N-serve, double-disk sealers on all plow and chisel, no-till corn after soybean		None
Secondary tillage	4/23	Disk once on plow and chisel treatments	5/15	Disk once on plow and chisel treatments
	4/28	Field cultivate once on plow and chisel treatments	5/16	Field cultivate once on plow and chisel treatments
Hybrid/Variety planted	4/29	Beck's 6565 (114 day)	5/16	Asgrow 3244 (3050 seeds/lb.)
Seeding rate		29879 seeds/a. (sprockets 20-22-24-34)		Plow, chisel, no-till drilled: 210,000 seeds/a. Ridge 30" rows: 140,608 seeds/a. (sprockets 32-22-20-34)
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 1.5G, 10 oz/1000 row feet, banded over row.		None
Weed control	4/29	(Insecticide setting 2-0) <u>3 point hitch sprayer:</u> Pre-emergence: Bladex 4L 3 pt/a. Atrazine 4L 3 pt/a. Dual II 3 pt/a. Roundup 3 pt/a.: no-till and ridge. <i>All broadcast with flat fan 8006 nozzles at 30 psi and 40 gallons water/a., 4 mph.</i>	5/16	<u>3 point hitch sprayer:</u> Pre-emergence: Dual II 2.5 pt/a. Lorox Plus 18 oz/a. Roundup 3 pt/a.: no-till and ridge <i>All broadcast with flat fan 8006 nozzles at 30 psi and 40 gallons water/a., 4 mph</i>
Cultivation	6/19	Plow and chisel treatments	7/14	Ridge treatment only
	6/21	Ridge treatment (reridge)	10/24	Ridge treatment (reridge)
Harvest	10/10	Center 4 of 12 rows, 150 ft	10/03	Center pass, 150 ft.
Primary tillage	10/23	Fall plow on plow treatment	10/23	Fall plow on plow treatment
	10/23	Fall chisel on chisel treatment	10/23	Fall chisel on chisel treatment

Stand, growth, and yield -- Corn.

In no-till continuous corn, establishing a uniform stand can be difficult. As hybrids become more stalk rot resistant, the residue can still be very tough come spring planting. We have found that these tough stalks do not decay enough to be easily broken and smashed down by the planter. This has led to uneven seed depth as the planter units bounce over the old corn stubs. Often root balls "bulldoze over" leaving a rough soil surface, also resulting in uneven seed depth. The corn residue is thickest on the old row and we have noted 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, improved seed to soil contact, and more uniform seedling emergence. This is the third year of shifting the new rows. In contrast to years 1 and 2 of shifting the rows, we did not achieve these goals. The no-till corn suffered significant decreases in plant stands at 4 weeks after planting (Table 2).

The no-till corn was slower maturing through the year when compared to the other tillage systems. Plant growth at 4 and 8 weeks after planting shows that no-till was significantly (.01 level) shorter than plow, chisel and ridge in continuous corn.

Pollination occurred during dry conditions. Plow, chisel and ridge treatments had ears with 1 to 2 inches of bare cob after pollination. No-till corn pollinated 5 to 10 days later than the other treatments, when conditions were even dryer. Completely barren cobs could be found in the no-till treatment. Yields for no-till continuous corn were significantly (.01 level) lower than the plow, chisel and ridge treatments.

When corn followed soybeans, plant stands were excellent in all treatments. Corn in rotation reached pollination earlier than continuous corn, before the dry weather had an affect. Nearly all ears of corn had filled to the tip. Although there was a 12.7 bushel/acre spread among the tillages, no significant differences existed.

Table 2. Agronomic performance of corn as affected by tillage and rotation, Chalmers silty clay loam, Long Term Tillage Study, ARC, Purdue Univ., 1997.†

Previous Crop	Tillage	Residue cover after planting %	Stand 4 weeks ppa	Height 4 weeks in	Height 8 weeks in	Harvest moisture %	Yield @15.5% bu/a.
Corn	Plow	4d‡	28219a	5.6a	26.8a	30.4b	147.2a
	Chisel	26c	26969a	5.0a	27.0a	31.0b	139.7a
	Ridge	62b	27281a	5.1a	27.7a	30.5b	143.3a
	No-till	85a	22031b	3.6b	23.3b	33.5a	95.4b
Soybean	Plow	1c	28875	6.5a	32.7ab	27.7	174.6
	Chisel	3c	28188	6.1a	34.9a	26.7	173.1
	Ridge	22b	27563	5.3b	31.2b	27.1	165.7
	No-till	47a	28750	5.5b	33.2ab	28.3	161.9

†Average of 4 replications, except for residue cover after planting which is 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 third 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.

Rotation soybean/corn: Plant emergence was very uniform in all treatments (See Table 3). Early growth was slow at 4 and 8 weeks after planting. This slow growth was particularly noticeable in the no-till treatments. The cold and wet conditions following planting appeared to have a greater affect on the no-till treatment, where the 90% residue cover kept the soil cool and wet. By plant maturity, no-till was still shorter than the other treatments. There were no significant differences in yield among tillages. The 30" row ridge plots yielded 4-6% less than the 7.5" drilled treatments.

Continuous soybean: Plant emergence was very uniform in all treatments. Plant growth was slow, however, no-till was not shorter than the other tillages as was the case in rotation. Plow, chisel and no-till yields were equal statistically. The ridge treatment continues to suffer from soybean cyst nematodes which affected yield significantly. The warmer and drier soil found in the ridges favors cyst nematode development. Without tillage or the use of a resistant soybean variety, it is likely that yields will continue to suffer, especially with periods of unusually dry weather.

Table 3. Agronomic performance of soybean as affected by tillage and rotation, Chalmers silty clay loam, Long Term Tillage Study, ARC, Purdue Univ., 1997.†

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	8	241320a§	3.7a	11.9a	9.5b	59.3
	Chisel	53	227460a	3.7a	10.8b	9.6b	58.5
	Ridge	60	141570b	3.9a	11.5ab	9.8b	55.8
	No-till	90	221773a	3.4b	8.5c	10.5a	58.7
Soybean	Plow	2	238833a	3.7ab	12.8	9.6	56.2a
	Chisel	5	240965a	3.8a	11.2	9.6	52.3a
	Ridge	32	143567b	3.9a	11.2	9.5	41.1b
	No-till	60	271175a	3.5b	10.8	9.6	52.8a

†Average of 4 replications.

‡Plow, chisel, and no-till are 7.5" drilled, ridge is 30" rows.

§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, Long Term Tillage Study, ARC, Purdue Univ., 1997.

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	.01	.01
Previous crop	.01	.01	.01	.01	.01	.01
Tillage x previous crop	.01	.01	.01	.01	.10	.01
Soybean						
Tillage	.01	.01	.01	.01	.03	.01
Previous crop	.01	NS	NS	NS	.01	.01
Tillage x previous crop	.01	.10	NS	.01	.05	.01

Grain Composition Analysis

Grain samples were taken from all treatments for grain composition analysis. No explanations for results are offered here. Samples were tested by the Grain Composition Analysis Service. The following quote is from the Service's internet homepage found at <http://pasture.ecn.purdue.edu/~grainlab/comp.html>.

Grain Composition Analysis Service
 Grain Quality Laboratory
 1146 ABE Building
 Purdue University
 West Lafayette, IN 47907-1146

“The significance of end-user oriented quality factors is growing. Differentiating grains based on quality traits and testing for composition of corn and soybeans should be of importance to:

- Crop producers interested in taking advantage of premiums for quality grains
- Livestock feeders aiming at optimizing ration formulations, and utilizing higher protein and oil hybrids for their feeds
- Elevators merchandising grain based on desired quality traits
- Processors in need of grain qualities that optimize milling and end product yield
- Plant breeders striving to develop value-added corn and soybean varieties

Economically, maximizing end-user oriented intrinsic quality traits such as protein, oil, starch, and fiber content can increase value by 10-40 cents per bushel. If during the 1994-1995 marketing year only 10 percent of Indiana's corn and soybean crops had been sold based on such premiums, an additional \$10.8-43.1 million could have been generated in income for Indiana producers.”

Table 5. Corn grain content as affected by tillage and rotation, Chalmers si.c.l., Long Term Tillage Study, ARC, Purdue Univ., 1997.†

Previous Crop	Tillage	Grain				
		Moisture	Protein	Oil	Starch	Density
		%	%	%	%	%
Corn	Plow	20.6	8.2b‡	4.1	56.3	1.260
	Chisel	20.6	8.1b	4.2	56.0	1.249
	Ridge	19.9	8.2b	3.9	56.5	1.263
	No-till	18.6	8.7a	4.2	56.0	1.257
Soybean	Plow	20.1	8.3	3.9	56.3	1.275
	Chisel	19.7	8.2	4.1	56.8	1.277
	Ridge	19.6	8.3	4.1	56.5	1.274
	No-till	20.4	8.4	4.2	56.5	1.265

†Average of 4 replications.

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

Table 6. Soybean grain content as affected by tillage and rotation, Chalmers si.c.l., Long Term Tillage Study, ARC, Purdue Univ., 1997.†

Previous Crop	Tillage	Grain			
		Moisture	Protein	Oil	Fiber
		%	%	%	%
Corn	Plow	8.8b‡	36.3	17.1	5.0
	Chisel	8.7b	36.3	16.7	5.1
	Ridge	8.7b	36.1	16.8	5.1
	No-till	9.4a	36.1	16.9	5.0
Soybean	Plow	8.6	37.0	16.6	5.0
	Chisel	8.6	36.8	16.6	5.0
	Ridge	8.7	37.3	16.4	4.9
	No-till	8.8	37.1	16.4	5.0

†Average of 4 replications.

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

Long Term Yields (Table 7.)

Average corn yields for chisel and ridge systems are reduced only 3% or less, compared to plowing, in continuous corn and these systems are equal to plowing for corn after soybeans. No-till average yield is 18% less in continuous corn and 4% less for corn after soybeans, compared to plowing. In continuous corn, there is a tendency

for greater reduction in no-till yields with time. Rotation corn yields were better than continuous corn yields by 6% with plowing, 8-9% with chisel and ridge, and by 20% with no-till.

Soybean response to tillage shows long-term average yield with plowing about 5% better than yields with chisel, ridge, and no-till systems. There appears to be tendency for no-till soybean yields to be more competitive with time. Rotation soybean yields have consistently been better than continuous soybean yields by 5-10%.

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, 1996 issue. A reprint can be obtained by contacting Terry D. West, Agronomy Department.

No-till Continuous Corn Row Position Study

Farmer experience and long-term tillage plots have demonstrated the difficulty of planting no-till corn after corn in the row from the previous crop. Stand and yield have been substantially reduced. Corn planted into soybean residue is less likely to have reduced stands and has smaller or no yield reductions. We have asked farmers who no-till continuous corn “Where do they plant the new crop row in relation to last year’s row?”. Some say on the old row, some say beside the old row, some say in the middle, and some say they are not concerned with row placement (random). The residue thickness can vary greatly as you move across the row. Each row location needs careful attention to planter seed depth setting in order to achieve uniform seed depth with seed to soil contact. Random row placement, with one planter setting, is the most difficult to achieve correct seed depth due to varying thickness of the residue across the row.

The goal in no-till planting row is to achieve consistent seed depth and seed to soil contact. Several factors are important in selecting a position for the new crop row. When planting into the heavy residues directly on the row, seed depth is variable as the planter gauge wheels roll over corn stalk stubs and mats of stalk and leaf residue. Moving off the old row enough to clear the gauge wheels eliminates the stubs, but still has considerable residue from leaves and upper stalks. Planting in the row middles involves the compaction from wheel traffic.

Our objectives in this study include:

- Determine if row cleaners are effective in improving stand, growth and yield.
- Determine if location of new crop row has any impact on stand, growth and yield.
- How soil penetration is distributed.

Factors associated with reduced no-till corn yields:

- Heavy residue cover.
- Uneven soil surface.
- Soil compaction.
- Poorly drained soils.
- Slow plant emergence and growth.
- Variable soil types within a field.
- Cool soil temperatures in northern half of Corn Belt.

Factors associated with reduced stands in no-till continuous corn:

- Non-uniform seed depth.
- Non-uniform seed to soil contact.
- “Hairpinning” of residue.
- Allelopathy.
- Cool soil temperatures under heavy residues.

With no-till when planting in heavy corn residues:

- Should row cleaners be used for a residue free strip on each row?
- Should the new row be placed on, beside, or between previous rows?
- Will soil compaction limit yield potential when planting in tire tracks?

Treatments include positioning the new row on the old row, beside the old row, and in between the old rows (middles). These treatments are repeated with the addition of row cleaners on the planter. A chisel plow treatment represents full width tillage. For those plots that were planted beside the old row, a shift was made to the west on odd years and back to the east on even years.

Evaluation of Stand, Emergence and Yield: The following data were determined on each of the plots:

- Emergence both by day and total.
- Plant populations at 4 weeks after planting.
- Plant growth at 4 and 8 weeks after planting.
- Grain moisture at harvest.
- Grain yield.

Evaluation of Soil Compaction:

A recording penetrometer was used to evaluate penetration resistance 3 weeks after planting in the second row from the east in each of the plots. Observations were also made in the east most row of the no-till plant 15 inches off the row. This row did not have a spring wheel track. Three observations were made in each plot and then combined to compare between replications.

Field equipment used:

- DMI 7 shank coulter chisel plow equipped with 4 inch twisted points on the chisel treatments.
- International Harvester 15 foot tandem disk.
- Glenco 10 foot mounted field cultivator with rolling baskets.
- Case-IH planter model 955 4 row, 30 inch planter equipped with detachable unit mounted row cleaners, no-till fertilizer coulters/openers, heavy duty down pressure springs on row units.
- Hiniker row crop cultivator.
- Century mounted sprayer, 32.5 foot boom.
- Case-IH model 5240 tractor.
- White model 3300 combine.

<u>CULTURAL PRACTICES USED 1997</u>		
No-till Continuous Corn Row Position Study, ARC, Purdue Univ.		
Item	Date	Application
Secondary tillage	4/23	Disk once on chisel treatment
	4/28	Field cultivate once on chisel treatment
Hybrid planted	4/29	Pioneer 3335 (113 day)
Seeding rate		29,215 seeds/a., drum A (24 pocket, sprockets: 32-30-34-34)
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 1.5G, 10 oz/1000 row feet, banded over row. (Insecticide setting 2-0)
Weed control	4/29	<u>3 point hitch sprayer, 4 mph, 30 psi, 40 gallon water/a., 8006 tips</u> Gramoxone Extra at 3 pt/a. Spreader 4 pt/100 gallons of water
	5/22	<u>3 point hitch sprayer, 4 mph, 30 psi, 40 gallon water/a., 8006 tips</u> Atrazine 4L at 3 pt./a. Bladex 4L at 3 pt./a. Dual II at 3 pt./a. Roundup at 3 pt./a.
Nitrogen fertilizer	6/20	NH ₃ @ 180 lb. N/a., sidedressed, no covering disks
Cultivation	6/19	Chisel treatment, once
Harvest	10/16	Center 4 of 12 rows
Primary tillage	10/23	Fall chisel (4 inch twisted chisel points) with ridge leveling sweeps

Results and discussion 1997.

Excellent stands were achieved in all treatments except the no-till on the old row. The chisel plow treatment achieved 50% emergence in 19 days, no-till off the old row with and without row cleaners in 24-25 days, and no-till on the old row in 26 days (Fig. 2 and 3). When row cleaners were used on each row position, corn emerged 1 to 2 days sooner. Corn yields were greater off the old row, with and without row cleaners, than on the old row. Chisel plow yielded the highest on this poorly drained soil (Table 8).

Table 8. Agronomic performance of corn as affected by row cleaners, row location, and tillage, continuous corn, Chalmers silty clay loam, Row Position Study, ARC, Purdue Univ., 1997.†

Treatment	Days to 50% Emergence days	Stand 4 weeks ppa	Height 4 weeks in	Height 8 weeks in	Harvest moisture %	Yield @ 15.5% bu/a.
Chisel plow	19	29458a‡	6.7a	29.3a	22.0	158.5a
No-till on old row	26	26458b	4.8b	22.0d	23.6	128.9c
No-till 6" off old row	24	29333a	4.9b	24.5c	22.5	135.7bc
No-till 15" off old row	25	28500a	4.9b	26.3bc	22.7	134.0bc
No-till on old row/row cleaners	24	28500a	5.3b	26.1bc	22.2	141.6b
No-till 6" off old row/row cleaners	22	29291a	5.4b	26.8bc	21.5	139.6bc
No-till 15" off old row/row cleaners	24	29000a	5.1b	27.9ab	21.8	142.2b
ANOVA significance level		.01	.01	.01	NS	.01

†Average of 4 replications.

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

Results and discussion, 1997-1998.

Uneven stand establishment in corn can reduce yield potential. According to Bob Nielsen, rate of yield loss due to corn plant spacing variability is 2.5 bushels for each inch of standard deviation. The planter needs to be properly adjusted for uniform seed placement in tilled and no-till fields. Using Bob's publication AGRY-91-01 "Stand Establishment Variability in Corn" as a guide, we measured plant spacing and calculated standard deviation for corn. A moderately variable stand of corn would be in the 3-5 inch range. The data presented in Table 9 documents that we did achieve uniform stands with standard deviations of less than 3.5 inches.

Table 9. Plant spacing variability, Row Position Study, ARC, Purdue Univ..

Treatment	1996	1997	1998	1999	Average
Chisel	2.40	2.63			2.5
No-till on old row	2.90	3.33			3.1
No-till 6" off old row	2.93	2.83			2.9
No-till 15" off old row	3.10	3.25			3.2
No-till on old row with row cleaners	3.00	3.08			3.0
No-till 6" off old row with row cleaners	2.95	3.05			3.0
No-till 15" off old row with row cleaners	3.45	3.35			3.4

The total crop emergence was very different due to weather variation in the two growing seasons however the trends are similar although much longer in 1997. The chisel plowed plots were faster to emerge, the no-till plots on the old row were slowest to emerge and the various off row and row cleaned plots intermediate. Row cleaners appear beneficial when planting on the old row. When considering the emergence day by day a similar result is observed.

Total stand measured at 4 weeks again showed chisel plots with greater stand than no-till on the old row with other treatments intermediate (Table 10). The differences between the chisel and no-till on the row is statistically significant at the .01 level. The no-till planted off the row and/or with row cleaners was not statistically different from the chisel plots.

Yields reflect similar results to the emergence and stand studies. The chisel plow plots were the highest yielding and the no-till on the old row the lowest. The plots planted off row and/or row cleaned were intermediate. Statistical analyses showed a statistical difference at the .01 level for each of these 3 conditions.

Table 10. Agronomic performance of corn as affected by row cleaners, row location, and tillage, continuous corn, Chalmers silty clay loam, Row Position Study, ARC, Purdue Univ., 1997-1998.†

Treatment	Days to 50% Emergence days	Stand 4 weeks ppa	Height 4 weeks in	Height 8 weeks in	Harvest moisture %	Yield @ 15.5% bu/a.
Chisel plow	14.5	29875a	10.8a	45.2a	22.7b	158.3a
No-till on old row	19.0	28167b	9.3b	40.1c	24.6a	134.8c
No-till 6" off old row	17.5	29396a	9.8ab	42.6b	23.6b	144.5b
No-till 15" off old row	18.0	29208ab	10.1ab	43.9ab	22.8b	143.5b
No-till on old row/row cleaners	17.5	29299ab	10.3ab	44.0ab	22.8b	143.8b
No-till 6" off old row/row cleaners	16.5	29583a	10.0ab	44.4a	22.8b	144.0b
No-till 15" off old row/row cleaners	17.5	29271ab	10.4ab	45.5a	22.4b	146.7b
ANOVA significance level		.01	.05	.01	.01	.01

†Average of 4 replications.

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

Soil penetration resistance was quite variable across the range of conditions. Lowest penetration resistance was found for the non-tracked row, 15 inches from the old row. This has been influenced by the application of NH₃ with a knife applicator. Much higher penetration resistance was found in the wheel track at 15 inches from the old row. Directly on the old row the penetration resistance was higher than that with chisel plowing and secondary tillage. The penetration resistance at 6 inches from the old row was similar to the wheel track because the row selected was included in the tire track of the previous season.

One interesting aspect of these results is the higher penetration resistance observed when row cleaners are used. There is no clear reason why this should occur. Moisture amounts are very similar and the cleaners were set to very lightly engage the soil surface. More work will be needed to resolve this issue.

Conclusions

1. In no-till continuous corn, stands can be improved by either planting off the row or using row cleaners.
2. In no-till continuous corn, yields can be improved by planting off the row or using row cleaners but yields are still less than those of full width tillage on this poorly drained soil.
3. Non-tracked rows had much less penetration resistance than tracked rows. Use of row cleaners in each of the 3 no-till row locations resulted in higher penetration resistance. The cause for this is not clear from the results.

Case-IH Planter Speed Trials

In this study we looked at several agronomic and machinery practices including planter speed effects on seed spacing variability and yield.

CULTURAL PRACTICES USED 1997 Case-IH Planter Speed Trials, ARC, Purdue Univ.		
Item	Date	Application
Previous crop		Soybeans
Nitrogen fertilizer	4/15	NH ₃ @ 180 lb. N/a.
Secondary tillage	4/25	Field cultivate w/rolling baskets (Fox-Brady)
	5/9	Field cultivate w/rolling baskets (Fox-Brady)
Hybrid planted	5/9	Pioneer 3335 (113 day)
Seeding rate	6/5	Drum A (24 hole) 29101 seeds/a., maximum recommended speed = 5.7 mph, (seed drive sprockets 20-32 34-20)
		Drum B (36 hole) 30128 seeds/a., maximum recommended speed = 8.1 mph, (seed drive sprockets 20-30 22-20)
		Drum C (36 hole, 72 dimple) 30128 seeds/a., max. recommended speed = 8.1 mph, (seed drive sprockets 20-30 22-20)
Starter fertilizer/planter		None. Removed all coulters.
Insecticide/planter		Force 1.5G, 10 oz/1000 row feet, banded over row. (Insecticide setting 2-0)
Weed control	5/6	<u>Early preplant, spot spray:</u> 2,4-D 1.0 pt/a. Roundup 2 pt/a.
		<u>Pre-emergence:</u> Broadstrike-Dual 2.5 pt/a.
Cultivation	6/19	All plots.
Harvest	10/16	4 rows by 300 ft.

Plant spacing in relation to planter speed with various seed drums.

According to Bob Nielsen in his paper AGRY-91-01 (re 11/93) "Stand Establishment Variability in Corn", 3 to 5 inch standard deviation of plant spacing is considered moderately variable. His research indicates that approximately 2.5 bushels per acre are lost for every 1 inch increase in the standard deviation of the plant-to-plant spacing. In this study we wanted to document the effects of speed and planter drum performance on seed spacing and populations. For this study we used a Case-IH model 955 Cyclo Air 4 row trailing planter. We used 3 seed drums at speeds of 4 to 9 mph. Maximum speed as per planter owners manual was exceeded for all 3 drums (see Cultural Practices Used 1997).

The 24 hole drum performed well at speeds of 4 to 6 mph (See Figs 4 and 5). As speed increased above 6 mph, plant populations decreased and showed greater variability in spacing. In other words, the seeds that were dropped were more likely to be in doubles or triples.

The 36 and 72 drums performed well at all speeds. Plant populations and spacing were acceptable even at 9 mph, contrary to last year where we noted a deterioration in populations and spacing above 8 mph. The difference from last year to this could be the seedbed preparation. This year's seedbed was very smooth and fine. At these higher speeds, it is very important that the seedbed be smooth as possible, to prevent bouncing of the planter units, resulting in uneven seed placement. There appears to be no advantage for the 72 drum as compared to the 36 drum.

This is the last year for this study. I have included graphs that summarize the planter performance data collected over the 2 years of this study. (See Figs. 5 and 6). In a tilled seedbed, corn can be planted at speeds up to 8 mph if that seedbed is consistently smooth and uniformly tilled. The planter must be set up properly according to the manufacturer's recommendations.

Table 11. Corn stand, plant spacing standard deviation, maturity and yield as affected by planter drum and speed Corn after soybean. Case-IH Planter Speed Trials[†], ARC, Purdue Univ., 1997.

Drum	Speed	Stand at 4 weeks	Standard deviation	Weigh Buggy		Yield Monitor	
				Harvest moisture	Yield @15.5%	Harvest moisture	Yield @15.5%
	mph	ppa		%	bu/a.	%	bu/a.
A (24)	4	29300a [‡]	3.0a	21.4	151.0	22.0	154.4
A (24)	5	29700a	2.3a	20.8	153.4	21.2	155.9
A (24)	6	30100a	2.8a	21.1	150.7	21.8	152.1
A (24)	7	27700a	3.8b	21.5	156.7	22.0	160.5
A (24)	8	26200b	4.0b	21.0	151.5	21.8	152.6
A (24)	9	23100c	5.8c	21.2	155.5	22.1	158.2
B (36)	4	30600	2.8	21.2	162.5	21.9	165.2
B (36)	5	30700	2.6	20.7	153.5	21.5	155.3
B (36)	6	31200	2.4	21.0	152.8	21.5	156.5
B (36)	7	30800	2.9	21.4	159.5	22.0	162.8
B (36)	8	30600	2.8	21.2	159.9	21.6	164.5
B (36)	9	30200	3.0	21.3	164.8	22.5	166.8
C (72)	4	31800	2.4	21.9	160.3	22.6	162.7
C (72)	5	31600	2.5	21.6	161.2	22.3	162.6
C (72)	6	30800	2.5	21.3	160.3	21.9	163.9
C (72)	7	30900	2.6	21.5	161.3	22.5	163.7
C (72)	8	30300	3.0	21.8	163.9	22.4	167.7
C (72)	9	30000	3.6	21.8	164.1	22.3	167.7
ANOVA sig. level		.01	.01	NS	NS	NS	NS

[†]Average of 3 replications.

[‡]Within drum, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).

Corn: Weigh buggy versus Yield Monitor for grain moisture and yield.

These plots were ideally suited for a comparison of data collection methods of using a stationary electronic weigh buggy versus a combine mounted yield monitor. The plots were 10 feet wide (4 30" rows) and 300 feet long. Each plot was harvested with the combine and yield monitor data for total weight of grain harvested and grain moisture recorded before dumping into the weigh buggy. Other data recorded from the monitor included load number, plot length and grain yield. Weight of grain was recorded from the weigh buggy scale with moisture taken with a hand held Dickey-john moisture meter. Yields were corrected for grain moisture and are presented in Table 11 and Figures 8 and 9. Monitor yields tended to be on average 5.5% lower than the weigh buggy data. Monitor yields were 1.8% higher than weigh buggy data when corrected for actual plot length.

Case-IH Variable Seed Rate “Sheets” Drill Demonstration

This demonstration was set up to evaluate the variable seeding rate mechanism on an experimental drill belonging to Case-IH. This 15 foot drill has 2 toolbars and 2 drill type seed hoppers. “Early Riser” row units are mounted on the toolbars giving a 7.5” row spacing. Hydraulic motors, one for each seed hopper, are controlled from in-cab mounted electro-hydraulic flow controllers. A population monitor then gives a seeding rate count.

Fifteen passes were planted at various speeds and rate settings. Since we did not calibrate seeding rates for various controller settings, plant populations were the result of “educated guesses”. We admit that soybean populations of 300,000 to 400,000 plants per acre may be a bit high! However, even these extremely high populations did not lodge as one would expect. With these high populations, canopy closure occurred shortly after the cotyledon stage (just joking!). Plant populations, harvest grain moisture, and grain yield are presented in Table 12.

This demonstration presented another opportunity to compare data from weigh buggy and combine yield monitor harvest.

CULTURAL PRACTICES USED 1997		
Case-IH “Sheets” Drill Demonstration, ARC, Purdue Univ.		
Item	Date	Application
Previous crop		Soybeans
Nitrogen fertilizer	4/15	NH ₃ @ 180 lb. N/a. (This field was fertilized for a corn crop.)
Secondary tillage	4/25	Field cultivate w/rolling baskets (Fox-Brady)
	5/9	Field cultivate w/rolling baskets (Fox-Brady)
Variety planted	5/23	Asgrow 3244
Weed control	5/25	Broadstrike-Dual

Table 12. Case-IH drill demonstration, soybean populations and yield, Agronomy Research Center, Purdue University, 1997.

Plot #	Controller		Speed mph	Population ppa	Weigh Buggy			Yield Monitor		
	Top	Bottom			Sample Wt. lb.	Moisture %	Yield bu/ac @ 13%	Sample Wt. lb.	Moisture %	Yield bu/ac @ 13%
<i>North Block</i>										
0	Borders				4160			4411		
1	75	93	9.3	299000	404	11.5	66.3	441	10.3	74.1
2	65	83	6.3	375000	406	11.4	66.7	443	10.3	74.2
3	75	93	7.5	361000	385	11.3	63.5	428	10.2	72.8
4	55	73	6.3	250000	385	11.1	63.5	416	10.2	70.7
5	75	93	6.3	404000	388	11.3	63.8	425	10.2	71.2
6	55	73	6.3	323000	368	11.6	60.3	399	10.3	66.7
<i>South Block</i>										
1	40	58	6.3	186000	413	11.4	67.9	444	10.3	75.5
2	45	63	6.3	220000	425	11.5	69.7	459	10.4	77.7
3	35	49	6.3	219000	437	11.4	71.8	455	10.3	77.3
4	45	63	6.3	239000	452	11.7	74.0	500	10.6	85.4
5	35	49	6.3	183000	443	11.6	72.6	486	10.5	83.5
6	40	58	6.3	260000	441	12.0	72.0	489	10.7	83.5
7	26	40	6.3	176000	439	12.8	71.0	465	11.2	78.9
8	26	40	6.3	162000	431	12.0	70.3	463	10.8	78.3
9	26	40	6.3	154000	442	11.9	72.2	461	10.8	77.6

Conclusions:

- Variable seeding rate mechanism: Adjustments need to be made so that the controllers read out the same number for each hopper. This may eliminate confusion as to seed rate delivered by each hopper. It may be better to have one controller that would drive both hoppers. This would also reduce the mass of wires and monitors in the cab.
- Seed monitor: The seed monitor needs to cycle through all rows quicker so that changes made in seeding rate is more quickly displayed.
- Seed placement, plant growth and yield: The row units did an excellent job of seed placement. Plant growth was satisfactory with surprisingly high grain yields. This yield may be attributed to uniform seedling emergence and growth, and adequate soil moisture in this “wet” field.

Soybean: Weigh buggy versus Yield Monitor for grain moisture and yield.

Yield monitor versus weigh buggy (Figs. 10 and 11). The unexpectedly great difference between the two harvest calculation methods may be due to inadequate monitor flow rate calibrations. The differences, however, were consistent.

NORTHEAST PURDUE AGRICULTURAL CENTER

Strip Preparation Study, Continuous Corn -- Schrader Farm

As stated earlier in this report, no-till planting of corn into heavy residue sometimes reduces yield potential in northern Indiana. The combination of cool soil temperature and dense soil tends to slow growth and maturity, compared to a conventional seedbed. In these studies we are investigating forms of shallow strip preparation for each row and positioning of the new rows, which may overcome the early-season problems of no-till fields.

Treatments are evaluated for continuous corn on Morley and Glynwood loams at the Schrader farm. Treatments include spring chisel plowing, discing, and/or field cultivating as the conventional tillage system, traditional no-till on old row, beside the old row, and between the old rows (middles). No-till treatments beside and between the rows are repeated with the addition of row cleaners and/or multiple coulters on the planter. All plots were planted with a Case-IH planter equipped with commercially available strip preparation attachments. All plots are machine harvested and samples were weighed in a portable electronic weigh buggy. This study was set up in the field in 1996 with proper row direction and plot size.

<u>CULTURAL PRACTICES USED 1997</u>		
Strip Preparation Study, Field S6, Schrader Farm, Northeast Purdue Agricultural Center		
Item	Date	Application
Secondary tillage	5/14	Field cultivate twice on chisel treatment
Strip preparation at planting	5/14	<u>3 Coulters</u> : one 1 inch fluted 8 wave center coulters with one 2 inch fluted 8 wave coulters 4 inches to each side of the center coulters. <u>3 Coulters/row cleaners</u> : one 1 inch fluted 8 wave center coulters with one 2 inch fluted 8 wave coulters 4 inches to each side of the center coulters. Row cleaners mounted on row unit. <u>Row cleaners</u> : mounted on row unit. One ripple coulters in front of fertilizer knife.

CULTURAL PRACTICES USED 1997, NEPAC, continued		
Hybrid planted (4.8mph)	5/14	<i>Note: no-till treatment is with one ripple coulter in front of fertilizer knife.</i> <i>Chisel treatment is with one ripple coulter in front of fertilizer knife.</i>
Seeding rate		Pioneer 3335 (113 day)
Starter fertilizer/planter		29,101 seeds/a., Case-IH 955 planter, Drum A (24 pocket) 20-32-34-20 18-46-0 @ 96 LB/a., 2 inches to the side and 2 inches below the seed (sprockets: driver 36, driven 30)
Insecticide/planter	5/22	Force 1.5G, 10 oz/1000 row feet, 8 inch band over row. Setting = 1-9.
Weed control		<u>After planting, before emergence:</u> 2,4-D 2 pt/a. Dual II 1.5 pt/a. Extrazine II DF 3.6 LB/a. Roundup Ultra 24 oz/a. Ammonium sulfate 17 LB/100 gallons of water (0.75 LB/a.)
Nitrogen fertilizer		28% @ 140 LB/a. N in row middles, sidedressed (Phil's rig and tractor)
Cultivation		None
Harvest	10/30	All 12 rows, 128 ft
Fall chisel		Chisel treatment only

Stand, growth and yield

Planting occurred in ideal soil conditions. Row cleaners cleaned "as advertised" and multiple coulters tilled "as advertised". When row cleaners and multiple coulters were used together, a mellow residue free seedbed was created. In no-till planting, the seed slot was closed consistently. Planting on and off the rows presented no problems. And then it rained and turned cold. Plant emergence was slow in all treatments. Several plots showed signs of slug feeding and cutworm damage. Yield was variable for all treatments with no significant differences (See Table 13).

Table 13. Corn yield as affected by strip tillage, row location, and tillage, continuous corn, Morley loam and Glynwood loam, Schrader Farm, NEPAC, Purdue Univ., 1997.†

Tillage	Stand	Height	Height	Harvest	Yield
	4 weeks	4 weeks	8 weeks	moisture	@15.5%
	ppa	in	in	%	bu/a.
Chisel plow	28277	5.5	52.7	33.9	157.2
No-till on old row	24277	4.7	49.7	33.6	152.1
No-till 6" off old row	25250	4.2	46.7	34.1	146.0
No-till 15" off old row	25750	4.4	48.6	33.7	149.4
No-till 6" off old row/row cleaners	28055	6.1	55.2	32.5	164.6
No-till 15" off old row/row cleaners	28277	6.1	55.8	32.6	165.5
No-till 6" off old row/3 coulters	27666	5.6	58.3	32.3	163.7
No-till 15" off old row/3 coulters	27833	5.6	50.8	33.3	156.5
No-till 6" off old row/3 coulters/row cleaners	27611	4.9	50.8	34.1	148.5
No-till 15" off old row/3 coulters/row cleaners	27222	5.5	52.8	32.9	154.9
ANOVA sig. level	NS	NS	NS	NS	NS

†Average of 4 replications

Soil temperatures:

Soil temperatures were measured using maximum-minimum thermometers placed in the new row at 2 inches from soil surface. Temperatures were recorded daily (except weekends) and thermometers reset to capture the maximum-minimum temperatures for the period until next reading. No-till planting on the old row had the lowest average daily maximum soil temperature. Moving the new row beside or between the old rows, the addition of row cleaners, and the addition of row cleaners and/or multiple coulters resulted in a 2 to 6 degree increase in soil temperature (See Fig. 13). Minimum soil temperatures for all treatments measured within a 2 degree range (See Fig. 14).

PINNEY PURDUE AGRICULTURAL CENTER

Long Term Tillage Study

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 proper row direction and cropping sequence. The study will continue for at least 4 years.

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 Aer-way, spring Aer-way	Soil temperatures
	Fall disk, spring combo-mulch-finisher	Week 4 stand and height
	No-till	Week 8 height
		% grain moisture at harvest
		Yield

<u>CULTURAL PRACTICES USED 1997</u>				
Long Term Tillage Study, Fields B3 & C3, Pinney Purdue Agricultural Center				
Item	<u>Corn</u>		<u>Soybean</u>	
	Date	Application	Date	Application
Spring tillage	3/27	Spring Aer-way: Case-IH 7220 tractor w/duals, 7 mph, 2.5 degree angle on aerator gangs.	3/27	Spring Aer-way: Case-IH 7220 tractor w/duals, 7 mph, 2.5 degree angle on aerator gangs.
Nitrogen fertilizer	4/22	NH ₃ @ 150 LB/a. N, 5 knife applicator w/double rate on outside knives, 4.7 mph		None
Secondary tillage	4/26	Disk and/or field cultivate as required by treatment	5/12	Disk and/or field cultivate as required by treatment
Hybrid/Variety planted	4/26	Pioneer 3489 (108 day)	5/12	Pioneer 9306
Seeding rate		27,700 seeds/a.		200,000 seeds/a.
Starter fertilizer/planter		10-34-0 @ 125 LB/a., 2 inches to the side and 2 inches below the seed		None
Insecticide/planter		Force 1.5G, 10 oz/1000 row feet		None
Weed control	4/26	<u>Pre-emergence with field cultivator:</u> Atrazine 0.5 LB/a. Extrazine 1.5 LB/a. Dual 2 pt/a. <i>Broadcast with 8008 flat fan nozzles on 20" centers at 5.5 mph, 20 gallons water/a.</i>	5/14	<u>Pre-emergence with field cultivator:</u> Prowl 2 pt/a. Roundup Ultra 1 pt/a. <i>Broadcast with XR 8008 flat fan nozzles on 20" centers at 5.5 mph, 20 gallons water/a.</i> <u>Post-emergence with trailer sprayer:</u> Cobra 4 oz/a. Pursuit 4 oz/a. 28% 2 qt/a. Surfactant 1 qt/100 gallons water
Cultivation	6/23	Once as required by treatment		None
Harvest	10/21	All 6 rows, 130 ft	9/30	Whole plot, 130 ft
Primary tillage	10/21	Fall chisel on chisel treatment Fall disk on disk treatment	10/21	Fall chisel on chisel treatment Fall disk on disk treatment

Stand, growth, and yield -- Corn.

Plant emergence and growth through 8 weeks was very slow due to cool weather (See Table 14). This location received plentiful rainfall through the growing season. According to Jon Leuck, farm superintendent, there was never more than a 10 day period without rainfall, and there were no flooding rains. Along with no disease or insect problems, this crop of corn yielded very well for all treatments. (We may have experienced our best year to come for this study!)

Continuous corn. One of our goals for the tillage treatments is to achieve various levels of residue cover. Our one spring pass of the Aer-way aerator at the least aggressive setting of the machine did not reduce residue cover as compared to no-till. We plan to have a late fall (1997) pass of this tillage tool in addition to the spring pass that should reduce percent residue cover to approximately 50%. Surprisingly, the disk/field cultivator treatment did not reduce residue cover compared to no-till.

Rotation corn/soybeans. Again, our use of the Aer-way aerator did not reduce residue cover levels, however, the 29% cover may be sufficient for erosion control. The one spring pass at the least aggressive setting may be adequate for aerating the soil surface when operated in soybean stubble. Yields were equal for all treatments.

Table 14. Agronomic performance of corn as affected by tillage and rotation, Sebewa loam, Long Term Tillage Study, Pinney Purdue Agricultural Center, 1997.†

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	22c‡	25500	5.0a	24.9	23.2b	187.2ab
	Chisel/field cultivator	39b	25833	4.8a	26.5	23.2b	194.5a
	Aer-way	73a	23958	3.5c	25.0	23.5ab	181.4b
	Disk/field cultivator	70a	25417	4.2b	23.3	24.1a	184.3b
	No-till	70a	24208	3.1c	23.0	24.1a	184.9ab
Soybean	Chisel/disk/field cultivator	4b	26250	5.3	31.2ab	22.9	206.9
	Chisel/field cultivator	8b	26833	5.2	31.9a	22.7	211.3
	Aer-way	29a	26292	4.8	29.4ab	22.2	207.8
	Disk/field cultivator	9b	26458	4.9	27.7b	23.1	205.6
	No-till	29a	26875	4.7	28.5ab	22.8	204.6

†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 15. Analysis of variance summary, tillage data, long term tillage study, PPAC, 1997.

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	.01	.01	.03
Previous crop	.01	.02	.02	.01	.06	.01
Tillage x previous crop	.01	NS	.01	NS	.05	NS

Stand, growth, and yield -- Soybean.

The tillage treatments did result in the various levels of residue cover that we wanted (See Table 16). We will operate the equipment in 1998 as we did in 1997. The cool weather after planting may be responsible for the low populations achieved, considering the drill was set for 200,000 seeds per acre, or the drill was not delivering the desired rate. Further calibration of the drill is needed for the 1998 crop year. Yields were equal for all treatments.

Table 16. Agronomic performance of soybean as affected by tillage, Sebewa loam, rotation soybean/corn, Long Term Tillage Study, Pinney Purdue Ag Center, 1997.†

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	21c‡	180000	2.3	10.5ab	12.1	60.4
Chisel/field cultivator	26c	164000	2.4	10.7a	12.1	61.9
Aer-way	66a	191000	2.5	9.5bc	12.6	61.2
Disk/field cultivator	53b	172000	2.3	9.6abc	12.2	60.5
No-till	75a	171000	2.4	8.9c	12.3	60.8
ANOV sig. level	.01	NS	NS	.05	NS	NS

†Average of 4 replications.

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

Soil temperatures:

Soil temperatures were measured using maximum-minimum thermometers placed in the new row at 2 inches from soil surface. Temperatures were recorded daily and thermometers reset to capture the maximum-minimum

temperatures for the period until next reading. No-till planting on the old row had the lowest average daily maximum soil temperature in rotation and monoculture (See Fig. 15). All levels of tillage increased the daily maximum soil temperature. Minimum soil temperatures for all treatments measured within a 2 degree range (See Fig. 16).

Grain Composition Analysis

Grain samples were taken from all treatments for grain composition analysis. No explanations for results are offered here. Samples were tested by the Grain Composition Analysis Service. See quote on page 7-8 of this report.

Table 17. Corn grain content as affected by tillage and rotation, Sebewa loam, Long Term Tillage Study, Pinney Purdue Agricultural Center, 1997.†

Previous Crop	Tillage	Grain				
		Moisture %	Protein %	Oil %	Starch %	Density %
Corn	Chisel/disk/field cultivator	21.1	7.3	4.1	57.1	1.261
	Chisel/field cultivator	21.3	7.4	4.1	59.2	1.258
	Aer-way	21.6	7.3	4.1	57.1	1.260
	Disk/field cultivator	22.0	7.2	4.1	27.2	1.260
	No-till	21.6	7.3	4.1	56.6	1.257
Soybean	Chisel/disk/field cultivator	21.2	8.0	4.3	56.3	1.267
	Chisel/field cultivator	21.0	7.8	4.1	56.8	1.265
	Aer-way	21.0	7.6	4.1	57.0	1.260
	Disk/field cultivator	21.1	7.9	4.2	56.5	1.259
	No-till	20.6	7.6	4.3	56.9	1.264

No statistical differences.

†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 18. Soybean grain content as affected by tillage and rotation, Sebewa loam., Long Term Tillage Study, Pinney Purdue Agricultural Center, 1997.†

Tillage	Grain			
	Moisture %	Protein %	Oil %	Fiber %
Chisel/disk/field cultivator	10.9	36.3	18.3	5.0
Chisel/field cultivator	11.0	36.2	18.4	5.0
Aer-way	11.3	36.3	18.4	4.9
Disk/field cultivator	10.9	36.1	18.4	5.0
No-till	11.1	36.2	18.3	5.0

No significant differences.

†Average of 4 replications.