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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 discing and one field cultivation for spring seedbed preparation. For the ridge system, ridges were made at cultivation in corn and after harvest in soybeans. A flat disk was used to scrape ridges at planting. For no-till planting, a one-inch fluted or bubble coulter was used ahead of disk openers. 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.

Herbicides were applied at planting. 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. Chemical control for cutworms, stalk borers, bean leaf beetle, and spider mites was used as needed.

Three corn hybrids and five soybean varieties have been used during the 22 years of the project.

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

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

1996

Equipment used:

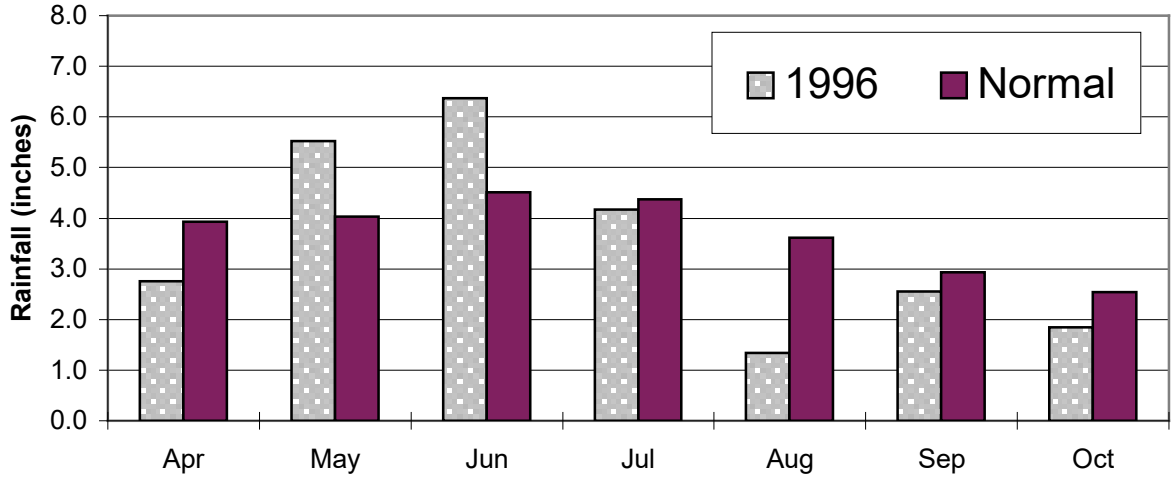
Primary tillage included the use of an International Harvester 5-18 inch bottom semi-mounted moldboard plow on the plow treatments and a DMI 7 shank chisel plow equipped with 4 inch twisted chisel points on 15 inch centers for the chisel treatment. Nitrogen was applied preplant at a depth of 6 to 7 inches with a 5-knife

30-inch anhydrous ammonia applicator equipped with one coulter, one sealing wing, and two covering disks per knife. The 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 15 foot pull type tandem disk and a 10 foot fully mounted field cultivator with rear mounted rolling baskets. Corn was planted with a John Deere Max-Emerge 4-row 30-inch planter equipped with a 1 inch fluted 8-wave coulter per row mounted on a Rawson brand toolbar. Rawson fertilizer openers behind a ripple coulter opened a slot for starter fertilizer placement. When planting the ridge treatment, a Hiniker row cleaner with horizontally mounted disks scraped 1" off the ridge tops and stabilized the planter. 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 John Deere 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.

Following is a summary of studies conducted on the tillage plots by researcher.

- Dr. Scott Abney, Botany and Plant Pathology.
  Dr. Abney conducted a study to evaluate late season foliage diseases and root rots on soybeans.
- 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 on all plots. Corn plant spacing was also measured.
- 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 attractivness 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. Traps catches are being processed (Jan 97).

Figure 1. Monthly precipitation, 1996 compared with normal, April through October, Agronomy Research Center.



CULTURAL PRACTICES USED 1996
Long Term Tillage Study, Agronomy Research Center

Item	Corn		Soybean	
	Date	Application	Date	Application
Nitrogen fertilizer	4/11	NH_3 @ 200 lb/a. N in row middles, N-serve, double-disk sealers		None
Secondary tillage	5/22	Disk once on plow and chisel treatments	6/16	Disk once on plow and chisel treatments
	5/23	Field cultivate once on plow and chisel treatments	6/20	Field cultivate once on plow and chisel treatments
Hybrid/Variety planted	5/31	Beck's 6565 (114 day)	6/21	Ag Alumni 3351
Seeding rate		29,900 seeds/a.		Plow, chisel, no-till drilled: 230,000 seeds/a. Ridge 30" rows: 150,000 seeds/a.
Starter fertilizer/planter		34-0-0 @ 95 lb/a., 2 inches to the side and 2 inches below the seed		None
Insecticide/planter		Counter 15G, 8.7 lb/a., 8 inch band over row, JD planter setting 30		None
Weed control	5/31	At planting (with planter): Bladex 4L 3 pt/a. Atrazine 4L 3 pt/a. Dual II 3 pt/a. Roundup 3 pt/a.: no-till and ridge. *All broadcast with flat fan nozzles at 40 psi and 40 gallons water/a.*	7/8	3 point hitch sprayer Ridge and no-till: Basagran 2 pt/a. Blazer 0.75 pt/a. Poast 2 pt/a. Crop oil 1 pt/a. *All broadcast with flat fan nozzles at 40 psi and 40 gallons water/a.* Plow and chisel: no herbicides, hand weeded.
			7/1	Rotary hoe plow and chisel treatments
Cultivation	7/1	Plow and chisel treatments		None
	7/1	Ridge treatment (reridge)	11/4	Ridge treatment (reridge)
Harvest	10/21	Center 4 of 12 rows, 150 ft	10/28	Center 4 of 12 rows
Primary tillage	11/6	Fall plow on plow treatment	11/6	Fall plow on plow treatment
	11/6	Fall chisel on chisel treatment	11/6	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 lead 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. This is the second year of shifting the new rows. By shifting the new rows, we wanted to gain more uniform seeding depth, improved seed to soil contact, and more uniform seedling emergence. We did achieve these goals, as there were no significant differences among treatments in plant stands at 4 weeks after planting (Table 2).

Plant growth at 4 weeks after planting shows that no-till was equal with plow, chisel and ridge in continuous corn. By 8 weeks after planting, plant height was statistically different for each of the treatments (no explanation). Yields for no-till continuous corn were significantly lower than the plow, chisel and ridge treatments.

When corn followed soybeans, plant stands were excellent in all treatments. Yields were similar for all systems, with no significant differences.

Plant stress from hot, dry weather began in late July and continued through August (Fig 1). Coupled with the late planting, yields were the 2nd lowest in the 22 years of this study.

Table 2. Corn population, height at 4 and 8 weeks after planting, maturity, and yield as affected by tillage and rotation, Chalmers silty clay loam, long term tillage study, Agronomy Research Center, 1996.†

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/a.
Corn	Plow	26531	23.3	73.5a	28.2b	129.5a
	Chisel	26718	24.4	70.1b	29.1b	123.1a
	Ridge§	27031	25.3	65.1d	28.5b	118.4a
	No-till	26937	23.6	67.0c	32.3a	105.4b
Soybean	Plow	26250b	23.3b	74.5a	28.5	136.7
	Chisel	26812ab	24.7ab	74.4a	28.3	138.7
	Ridge	27375ab	25.8ab	68.8c	28.1	131.8
	No-till	27875a	25.1a	72.2b	28.7	131.4

†Average of 4 replications.
‡Within rotations, data followed by the same letter are not significantly different according to Student-Newman-Kuels Test (P= .05).
§Height at 8 weeks measured after ridging. Ridge height was 4 to 5 inches.

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, Dave Gehring measured plant spacing and calculated standard deviation for corn in plow and no-till continuous corn and rotation corn soybean. The data presented in Table 3 documents that we did achieve uniform stands with standard deviations of less than 3 inches.

Table 3. Plant spacing variability in plow and no-till corn, long term tillage study, Agronomy Research Center, 1996

Tillage	Standard deviation (in)
Continuous corn	
Plow	2.6
No-till	3.0
Corn after soybean	
Plow	2.6
No-till	2.9

Stand, growth, and yield -- Soybeans.

For the second 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. The plots received 2.5 inches of rain on the day after planting. Severe soil crusting in the plow and chisel plots reduced plant emergence significantly (Table 4). When soils were dry enough, we rotary hoed the plow and chisel plot but even this did not seem to help plants that could not emerge through the crust. The plant residues on the no-till soybeans after corn treatment helped to prevent the crusting effects of the heavy rains and allowed acceptable stands. Soil crusting also reduced stands in the no-till continuous soybean treatment, but not as severe as the tilled continuous soybean treatments.

When soybean followed corn, ridge yielded significantly lower than the other treatments.

Table 4. Soybean population, height at 4 and 8 weeks after planting, maturity, and yield as affected by tillage and rotation, Chalmers silty clay loam, long term tillage study, Agronomy Research Center, 1996.†

Previous Crop	Tillage	Stand‡ 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @13.0%
		ppa	in	in	%	bu/a.

Corn	Plow	131000b	6.6	21.4	14.9	39.9a
	Chisel	146000b	6.2	21.0	14.9	38.3a
	Ridge	144000b	6.9	21.1	15.1	34.3b
	No-till	200000a	6.4	19.8	14.9	38.3a
Soybean	Plow	106000b	6.2b	20.0a	14.9	37.3
	Chisel	116000b	6.7ab	20.5a	14.8	35.5
	Ridge	136000ab	7.4a	21.0a	15.0	31.6
	No-till	162000a	5.9b	18.1b	14.9	33.6

†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 5. Analysis of variance summary, tillage data, long term tillage study, Agronomy Research Center, 1996.

Variable	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield bu/a.
	----------Significance Level----------				
			Corn		
Tillage	.02	.01	.01	.01	.01
Previous crop	NS	NS	.01	.04	.04
Tillage x previous crop	NS	NS	.01	.01	.07
			Soybean		
Tillage	.01	.01	.01	NS	.01
Previous crop	.01	NS	NS	NS	.01
Tillage x previous crop	NS	NS	NS	NS	NS

Long Term Yields (Table 6.)

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 14% less in continuous corn and 3% 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 5% with plowing, 7-8% with chisel and ridge, and by 15% 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 7-10%.

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.

Separate page for Table 6.

Strip Preparation Study

What is strip preparation?

- The concept of preparing a residue free and/or tilled strip for each row in soil that is not tilled before planting.

Why strip preparation?

- To provide a warmer, drier and less dense soil in the row area, more uniform seed depth, improved seed-soil contact and reduced allelopathy.
- More favorable in-row soil may provide more vigorous early rooting, speed crop maturity, and increase yield compared to standard no-till planting.
- To provide improved control of soil erosion compared to full width tillage.
- To increase net profits.

Objective of this study.

- To determine the affect of strip preparation on corn and soybean emergence, growth, maturity and yield in central and northern Indiana.
- To determine the effect of residue removal and zone tillage on soil temperature.

No-till planting of corn or soybean into heavy residue sometimes reduces yield potential in northern Indiana and on poorly drained soils in central and southern Indiana. The combination of cool soil temperature and dense soil tends to slow growth and maturity, compared to a conventional seedbed.

Studies in Ontario, Iowa and Minnesota indicate that some form of residue removal or strip tillage for each row may overcome the early-season problems of no-till fields. This would allow for competitive yield potential while maintaining soil conservation, improved water quality and cost reduction benefits of no-till. This study will evaluate currently available strip preparation attachments such as "trash whippers" and multiple fluted coulters under Indiana conditions and allow development of new strip preparation techniques. Field activities conducted in 1993 were to establish plot location and cropping sequence. The data from 1994 through 1996 is presented in this report.

Treatments include plow, standard no-till, and multiple coulters, all with and without removal of residue from the row area. Fall application of NH3 using covering discs to create a small ridge to plant on in the spring is another treatment. Fall versus spring application of treatments and on row versus between rows are other variables. Rawson brand coulters tilled an eight inch wide band approximately 2-4 inches deep with a one inch waffle coulter in front followed by two 2 inch fluted coulters. Standard no-till treatment included a ripple coulter ahead of seeding units. Dawn brand trash whippers provided removal of residue from the row area.

CULTURAL PRACTICES USED 1996
Strip Preparation Study, Agronomy Research Center

Item	Date	Application
Secondary tillage	5/19	Disk (with spike tooth harrow) once on plow treatment
	5/20	Field cultivate (with rolling baskets) once on plow treatment
Hybrid planted	5/20	Pioneer 3335 (113 day)
Seeding rate		26,100 seeds/a.
Starter fertilizer/planter		34-0-0 @ 95 lb/a., 2 inches to the side and 2 inches below the seed
Insecticide/planter		Counter 15G, 8.7 lb/a., 8 inch band over row
Spring strip preparation/planter	5/20	3 Coulter treatment in and between old rows: one 1 inch fluted 8 wave center coulter with one 2 inch fluted 8 wave coulter 4 inches to each side of the center coulter. 3 Coulter with row cleaners treatment in and between old rows: one 1 inch fluted 8 wave center coulter with one 2 inch fluted 8 wave coulter 4 inches to each side of the center coulter. Row cleaners used ahead of coulters to remove residue from row area. Row cleaners treatment in and between old rows: Row cleaners used to remove residue from new row area. One 1 inch fluted 8 wave center coulter and one ripple coulter used ahead of fertilizer knife. *Note: no-till treatment is with one 1 inch fluted 8 wave center coulter and one ripple coulter in front of fertilizer knife.*
Weed control	5/20	At planting (with planter): Bladex 4L 3 pt/a. Atrazine 4L 3 pt/a. Dual II 3 pt/a. Roundup 3pt/a.: on all treatments except plow *All broadcast with flat fan 8008 nozzles at 40 psi and 40 gallons water/a.*
Cultivation		None
Nitrogen fertilizer	7/1	NH_3 @ 180 lb/a. N in row middles, sidedressed (no covering disks), except fall applied treatments
Harvest	10/16	All 4 rows, 110 ft

Table 7. Corn population, days to 50% emergence, height at 4 and 8 weeks after planting, maturity, and yield as affected by strip preparation, row location, and timing of strip preparation, Agronomy Research Center, 1996.†

Treatment	Days to 50% emergence	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @ 15.5%
		ppa	in	in	%	bu/a.
			CONTINUOUS CORN			
Fall plow	8	26208	11.3	65.6	20.7	150.5
In old row:						
Fall, row cleaners	10	24208	11.5	58.4	20.2	140.5
Fall, 3 coulters	12	21917	7.8	58.6	22.2	141.2
Fall, row cleaners & 3 coulters	10	24750	11.0	57.8	21.1	149.7
Fall, NH3 band	10	23333	10.7	57.8	20.4	145.5
Spring, row cleaners	10	23708	12.7	61.5	20.6	152.4
Spring, 3 coulters	11	21333	11.3	58.9	21.2	149.4
Spring, row cleaners & 3 coulters	10	23667	11.0	61.9	19.8	148.8
Spring, no-till	12	21083	10.5	57.7	23.0	138.1
Between old rows						
Fall, row cleaners	11	25667	11.7	61.5	19.4	142.9
Fall, 3 coulters	10	24958	11.0	60.3	19.4	131.6
Fall, row cleaners & 3 coulters	9	25000	12.0	61.3	19.3	132.7
Fall, NH3 band	10	24666	11.6	60.3	19.4	141.3
Spring, row cleaners	10	23541	12.2	62.3	19.0	143.7
Spring, 3 coulters	10	23416	11.6	61.3	19.1	138.4
Spring, row cleaners & 3 coulters	10	24083	12.3	62.0	19.6	146.4
Spring, no-till	12	23916	10.4	58.6	21.0	141.3
			CORN AFTER SOYBEANS			
Fall plow	8	26708	11.9	66.1	20.9	165.7
Fall, row cleaners	8	26167	11.8	67.2	21.2	167.6
Fall, 3 coulters	8	26583	12.4	66.0	21.8	164.3
Fall, row cleaners & 3 coulters	8	26500	12.5	66.5	22.0	164.9
Fall, NH3 band	8	26250	12.5	64.8	21.5	160.7
Spring, row cleaners	9	26208	12.1	66.0	21.2	168.6
Spring, 3 coulters	9	24875	11.7	64.9	22.4	162.8
Spring, row cleaners & 3 coulters	9	25833	11.5	65.3	22.1	161.0
Spring, no-till	10	25667	11.8	64.3	21.9	165.3

†Average of 4 replications.

Table 8. Corn population, days to 50% emergence, height at 4 and 8 weeks after planting, maturity, and yield as affected by strip preparation, row location, and timing of strip preparation, Agronomy Research Center, 1994-1996.†

Treatment	Days to 50% Emergence	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @ 15.5%
		ppa	in	in	%	bu/a.
		CONTINUOUS CORN (1994, 1995, 1996)				
Fall plow	11	25611	9.0	56.6	18.3	166.8
In old row:						
Fall, row cleaners	15	23902	8.2	46.4	18.1	140.1
Fall, 3 coulters	16	22389	7.1	44.0	19.1	135.0
Fall, row cleaners & 3 coulters	15	24389	7.9	44.6	18.5	143.2
Fall, NH3 band	15	23375	7.9	44.8	18.5	145.4
Spring, row cleaners	16	22736	8.5	46.8	18.6	141.2
Spring, 3 coulters	16	21486	7.8	44.5	18.9	136.6
Spring, row cleaners & 3 coulters	15	23236	8.3	48.1	18.1	144.7
Spring, no-till	16	21597	7.2	43.7	19.6	128.8
Between old rows						
Fall, row cleaners	15	25111	8.5	47.4	17.7	143.3
Fall, 3 coulters	14	25167	8.3	47.3	17.7	138.7
Fall, row cleaners & 3 coulters	13	25208	8.8	47.8	17.8	138.9
Fall, NH3 band	14	24805	8.5	48.8	17.9	147.5
Spring, row cleaners	15	23333	8.7	48.2	17.6	140.4
Spring, 3 coulters	15	23750	8.1	47.1	17.8	139.2
Spring, row cleaners & 3 coulters	15	23819	8.6	48.1	17.8	141.8
Spring, no-till	16	24236	7.8	45.6	18.4	140.3
		CORN AFTER SOYBEANS (1994, 1996)				
Fall plow	11	26417	9.9	62.2	20.1	194.3
Fall, row cleaners	11	26479	9.7	61.4	20.4	196.5
Fall, 3 coulters	12	26479	9.6	57.6	21.0	193.3
Fall, row cleaners & 3 coulters	12	26479	10.0	59.4	20.9	197.0
Fall, NH3 band	12	26458	9.8	59.0	20.6	195.6
Spring, row cleaners	13	25583	9.6	59.8	20.6	191.3
Spring, 3 coulters	13	25104	9.1	56.7	21.5	185.7
Spring, row cleaners & 3 coulters	13	24875	9.1	57.1	21.2	184.5
Spring, no-till	13	25667	9.4	56.8	21.2	189.6

†Average of 4 replications.

Soil Temperatures: To document the effect of strip preparation on soil temperatures, we used electronic thermometers to record daily maximum and minimum temperatures. The sensor part of each thermometer was buried (being careful not to disturb the soil structure or residue cover) at 4 inches below the soil surface, directly in the new seed row. Data was recorded from day after planting through 5 weeks. This data was averaged for the 5 week period and is presented in Fig. 2. Strip preparation increased the average daily maximum by 1 to 3 degrees as compared to no-till on the old row.

Soil temperatures were recorded in 1994 and 1996 when corn followed soybeans. The 2 year averages are presented in Fig 3. The relatively light residue cover following soybeans allows soil temperature to warm within 1 to 2 degrees of the plow treatment. Using strip preparation did not significantly warm no-till soil temperatures.

Conclusions from Midwest strip preparation research.

- Not likely to be beneficial where traditional no-till planting is successful.
- May not improve yields consistently in corn/soybean rotation, even on poorly drained soil.

- Moving residue should improve no-till continuous corn yields on dark poorly drained soil, but not likely to equal yields with full width tillage.
- Where needed, it may be more beneficial when done in the fall than when done at planting.
- May provide more uniform seedling emergence in uneven residue or uneven soil surface.

Trouble Shooting

- Set operating depth of row cleaners deep enough to move residue with little soil disturbance. Moving too much soil can create shallow valleys that hold water after heavy rains and keep soil cool.
- In heavy corn after corn residues, row cleaners can cause trash plugging problems under the planter. Chop stalks, move off old row or raise row cleaners to move less residue.
- Strip preparation on sloping soils can lead to severe soil erosion in the row area after heavy rains. Leave enough residue to slow water runoff.
- The use of multiple coulters in wet, sticky soils can leave a rough seedbed resulting in inconsistent seed depth. Wait until soils dry adequately for planting. Do not run coulters to deep.
- When using fall applied strip preparation, match toolbar width to planter width. Use guide markers on toolbar and follow same pass when planting.

No-till Continuous Corn Row Position Study

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.

In this study we are researching how row position affects corn emergence, populations, growth, maturity and yield in continuous corn. We will also be looking at soil compaction in from wheel traffic.

Treatments include positioning the new row on the old row, beside the old row, and in between the old rows (middles). Treatments are repeated with the addition of row cleaners on the planter. A chisel plow treatment represents full width tillage.

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.

CULTURAL PRACTICES USED 1996
No-till Continuous Corn Row Position Study, Agronomy Research Center

Item	Date	Application
Primary tillage	10/16/95	Fall chisel (4 inch twisted chisel points)
Secondary tillage	5/21	Disk once on chisel treatment
	5/22	Field cultivate once on chisel treatment
Hybrid planted	5/22	Pioneer 3335 (113 day)
Seeding rate	5/23	29,101 seeds/a., drum A (24 pocket, sprockets: D1=20, D2=32, D3=34, D4=20)
Starter fertilizer/planter	5/22	34-0-0 @ 90 lb./a., 2 inches to the side and 2 inches below the seed
Insecticide/planter	5/22	Counter 15G, 8.7 lb./a., 8 inch band over row
Weed control	5/19	3 point hitch sprayer, 4 mph, 30 psi, 40 gallon water/a., 8006 tips Gramoxone Extra at 3 pt/a. Spreader 4 pt/100 gallons of water
	5/22	3 point hitch sprayer, 4 mph, 30 psi, 40 gallon water/a., 8006 tips 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	6/21	NH_3 @ 180 lb. N/a., sidedressed, no covering disks
Cultivation	7/1	Chisel treatment, once
Harvest	10/15	Center 4 of 12 rows
Primary tillage	11/6	Fall chisel (4 inch twisted chisel points) with ridge leveling sweeps

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.

Excellent stands were achieved in all treatments. The chisel plow treatment achieved 50% emergence in 10 days, no-till off the old row with and without row cleaners in 11 days, and no-till on the old row in 12 days. Corn yields were greater off the old row, with and without row cleaners, than on the old row. This difference is not statistically significant, however it could indicate a concern for planting on the old row. Chisel plow yielded the highest on this poorly drained soil (Table 9).

This is the first data year for this study. We plan to conduct this study for 3 more years. We will be measuring soil compaction and agronomic performance.

Table 9. Agronomic performance of corn as affected by row cleaners, row location, and tillage, continuous corn, Chalmers silty clay loam, Agronomy Research Center, 1996.†

Treatment	Days to 50% Emergence	Stand 4 weeks	Height 4 weeks	Height 8 weeks	50 % Tassel	Harvest moisture	Yield @ 15.5%
	days	ppa	in	in	days	%	bu/a.
Chisel plow	10	30291	15.0	61.0a‡	68	23.4bc	158.1a
No-till on old row	12	29875	13.9	58.2b	70	25.6a	140.7b
No-till 6” off old row	11	29458	14.8	60.7a	70	24.7ab	153.3ab
No-till 15” off old row	11	29916	15.3	61.6a	70	22.9c	152.5ab
No-till on old row/row cleaners	11	29958	15.2	62.0a	70	23.3bc	146.0ab
No-till 6” off old row/row cleaners	11	29875	14.6	62.0a	70	24.1bc	148.5ab
No-till 15” off old row/row cleaners	11	29541	15.7	63.1a	70	22.9c	151.1ab
ANOV significance level		NS	NS	.01		.01	.05

†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 10. Plant spacing variability, row position study, Agronomy Research Center, 1996

Treatment	Standard deviation (in)
Chisel	2.4
No-till on old row	2.9
No-till 6" off old row	2.9
No-till 15" off old row	3.1
No-till on old row with row cleaners	3.0
No-till 6" off old row with row cleaners	3.0
No-till 15" off old row with row cleaners	3.5

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. We also compared a "Space Kadet" plant counting device to hand sampling. Cultural practices and results are as follows.

CULTURAL PRACTICES USED 1996
Case-IH Planter Speed Trials, Agronomy Research Center

Item	Date	Application
Previous crop		Soybeans
Nitrogen fertilizer	4/11	NH_3 @ 180 lb. N/a.
Secondary tillage	6/5	Field cultivate w/rolling baskets (Fox-Brady)
		Field cultivate w/rolling baskets (Glenco)
Hybrid planted	6/5	Pioneer 3489 (108 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 = 8.1mph, (seed drive sprockets 20-30 22-20)
Starter fertilizer/planter		None Removed all coulters.
Insecticide/planter	6/17	Counter 15G, 8.7 lb./a., 8 inch band over row
Weed control	5/13	Early preplant;
		2,4-D 0.75 pt/a.
		Roundup 2 pt/a.
		Ammonium sulfate 17 lb/100 gallons of water
		At planting:
		Atrex Nine-O 0.8 lb/a.
		Bladex 90DF 1.8 lb/a.
		Frontier 22 oz/a.
Cultivation		None
Harvest	11/5	4 rows by 260 ft.

1. 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 equipped with one coulter per row for fertilizer placement. 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 1996).

The 24 hole drum performed well at speeds of 4 to 6 mph. As speed increased above 6 mph, plant populations decreased up to 50% with 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 speeds of 4 to 8 mph. At 9 mph the plant population began to decrease with greater variability in seed spacing as indicated by the standard deviations. There appears to be no advantage for the 72 drum as compared to the 36 drum.

Figs 4 and 5

2. "Space Kadet" plant population and spacing wheel.

This measuring wheel looks like most hand propelled distance measuring wheels except it has a "cat whisker" device mounted near the wheel axle. This whisker protrudes out from the wheel and "clicks" on corn stalks. The computer on board then keeps a tally of plants and can give a total population and standard deviation of plant spacing. Population at 4 weeks are given for the Space Kadet and for counting by hand in Table 11.

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†, Agronomy Research Center, 1996.

		Stand at 4 weeks		Standard	Weigh Buggy		Yield Monitor	
Drum	Speed	Space Cadet	hand count	deviation: Space Kadet	Harvest moisture	Yield @15.5%	Harvest moisture	Yield @15.5%
	mph	ppa	ppa		%	bu/a.	%	bu/a.
A (24)	4	27700a‡	28500a	3.2c	19.5	123.5a	18.9	128.7
A (24)	5	28200a	29300a	2.9c	19.2	116.2a	18.6	120.7
A (24)	6	25100ab	24900a	3.9b	18.9	118.1a	18.6	118.4
A (24)	7	21300b	20300b	6.3ab	19.0	112.7ab	18.7	117.5
A (24)	8	16000c	14800c	9.7a	19.1	98.0b	18.5	108.0
A (24)	9	15500c	14500c	10.3a	19.1	96.9b	18.6	105.7
B (36)	4	29300	29800	2.8	18.9	131.8	18.9	130.1
B (36)	5	29900	29300	2.8	19.2	119.1	18.5	125.3
B (36)	6	29000	28800	2.8	19.0	130.4	18.6	129.2
B (36)	7	28200	29200	3.3	19.2	124.0	18.6	128.2
B (36)	8	26900	28500	3.8	18.9	122.0	18.4	124.3
B (36)	9	24900	25500	4.6	18.8	121.3	18.5	121.5
C (72)	4	30200	30300a	2.6	19.0	124.7	18.4	127.9
C (72)	5	28700	29300a	3.1	18.9	123.9	18.6	128.1
C (72)	6	29000	29300a	2.9	19.0	120.7	18.6	127.4
C (72)	7	28700	28800ab	3.3	19.0	122.8	18.7	127.7
C (72)	8	27100	27300ab	3.7	19.1	117.5	18.5	119.5
C (72)	9	24800	23900b	4.9	18.8	124.2	18.5	126.8
ANOV sig. level		.01	.01	.01	NS	.01	no statistics run	

†Average of 3 replications.
‡Within drum, data followed by the same letter are not significantly different according to Student- Newman-Kuels Test (P= .05).

3. 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 260 feet long with significant differences in treatment yields. 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. Weight of grain was recorded from the weigh buggy scale with moisture taken with a hand held Dickey-john moisture meter. Yield calculations from the weight recorded was corrected for grain moisture and is presented in Table 11 and Figure 6. Yields calculated from yield monitor data tended to be on average 3 to 4% higher than the weigh buggy data. Greatest differences tended to be at lower yields.

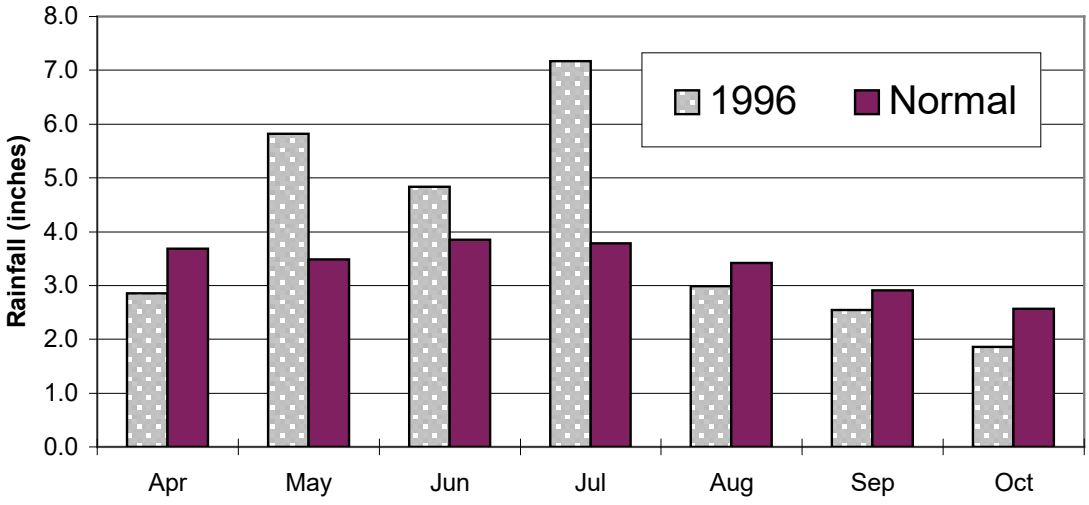
NORTHEAST PURDUE AGRICULTURAL CENTER

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. Our first data year will be 1997, and the study will continue for at least 4 years.

Figure 4. Monthly precipitation, 1996 compared with normal, April through October, Northeast Purdue Agricultural Center.



CULTURAL PRACTICES USED 1996

Strip Preparation Study, Field S6, Schrader Farm, Northeast Purdue Agricultural Center

Item	Date	Application
Primary tillage	??	Spring chisel (4 inch twisted points) on chisel treatment
Secondary tillage	6/16	Field cultivate twice on chisel treatment
Strip preparation at planting	6/17	3 Coulters: one 1 inch fluted 8 wave center coulter with one 2 inch fluted 8 wave coulter 4 inches to each side of the center coulter. 3 Coulters/row cleaners: one 1 inch fluted 8 wave center coulter with one 2 inch fluted 8 wave coulter 4 inches to each side of the center coulter. Row cleaners mounted on row unit. Row cleaners: mounted on row unit. One ripple coulter in front of fertilizer knife. *Note: no-till treatment is with one 1 inch fluted 8 wave center coulter and one ripple coulter in front of fertilizer knife. Chisel treatment is with one ripple coulter in front of fertilizer knife.*
Hybrid planted	6/17	Pioneer 3563 (105 day)
Seeding rate	6/17	27,000 seeds/a., Case-IH 955 planter, Drum A (24 pocket)
Starter fertilizer/planter	6/17	18-46-0 @ 96 lb/a., 2 inches to the side and 2 inches below the seed
Insecticide/planter	6/17	Force 15G, 4.4 lb/a., 8 inch band over row
Weed control	5/13	Early preplant (with ATV sprayer at 12 mph): 2,4-D 1 pt/a. Roundup Ultra 32 oz/a. Ammonium sulfate 17 lb/100 gallons of water (0.75 lb/a.) *All broadcast with flat fan nozzles spaced at 20", at 30 psi, and 6 gallons water/a.*
	6/21	After planting, before emergence: Atrazine 4L 2 pt/a. 2,4-D 1.75 pt/a. Dual II 1.5 pt/a. Roundup Ultra 32 oz/a.
	7/16	Post application for shattercane and broadleaves: Accent 2/3 oz/a. Clarity 1 pt/a. Activate Plus 2 pt/a. UAN 4 pt/a.
Nitrogen fertilizer	7/19	28% @ 120 lb/a. N in row middles, sidedressed (Phil's rig and tractor)
Cultivation		None
Harvest	10/31	All 12 rows, 128 ft
Fall chisel	11/4	Chisel treatment only

Stand, growth and yield

Table 12. Corn yield as affected by strip tillage, row location, and tillage, continuous corn, Morley loam and Glynwood loam, Schrader Farm, NEPAC, 1996. SET UP YEAR†

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
	ppa	in	in	%	bu/a.
Chisel plow	----	----	----	26.0	103.8
No-till on old row	----	----	----	26.2	99.5
No-till 6” off old row	----	----	----	28.0	85.7
No-till 15” off old row	----	----	----	27.4	88.4
No-till 6” off old row/row cleaners	----	----	----	24.5	97.4
No-till 15” off old row/row cleaners	----	----	----	25.1	93.8
No-till 6” off old row/3 coulters	----	----	----	24.2	99.3
No-till 15” off old row/3 coulters	----	----	----	26.4	93.9
No-till 6” off old row/3 coulters/row cleaners	----	----	----	27.1	88.5
No-till 15” off old row/3 coulters/row cleaners	----	----	----	26.2	87.1
ANOV sig. level				NS	NS

†Average of 4 replications

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. Our first data year will be 1997, and the study will continue for at least 4 years.

CULTURAL PRACTICES USED 1996, SET UP YEAR
Long Term Tillage Study, Fields B3 & C3, Pinney Purdue Agricultural Center

Item	Corn		Soybean	
	Date	Application	Date	Application
Nitrogen fertilizer	5/1	NH_3 @ 150 lb/a. N, 7 knife applicator w/nursetank, 5 mph, double-disk sealers		None
Secondary tillage	5/3	Field cultivate with rolling baskets	6/9	Field cultivate with rolling baskets
Hybrid/Variety planted	5/3	Pioneer 3489 (108 day)	6/10	Pioneer 9301
Seeding rate		26,100 seeds/a.		80 lbs/a.
Starter fertilizer/planter		10-34-0 @ 125 lb/a., 2 inches to the side and 2 inches below the seed		None
Insecticide/planter		None		None
Weed control	5/31	Pre-emergence with field cultivator: Atrazine 0.5 lb/a. Extrazine 1.5 lb/a. Dual 2 pt/a. *Broadcast with 8008 flat fan nozzles on 30" centers at 5.5 mph, 20 gallons water/a.*	??	Pre-emergence with field cultivator: Treflan 1 pt/a. Command 0.5 pt/a. Lexone 0.25 lb/a. *Broadcast with 8008 flat fan nozzles on 30" centers at 5.5 mph, 20 gallons water/a.* Post-emergence with trailer sprayer: Cobra 4 oz/a. Pursuit 4 oz/a. 28% 2 qt/a. Surfactant 1 qt/100 gallons water *Broadcast with 8008 flat fan nozzles on 20" centers at 5.5 mph, 20 gallons water/a.*
Cultivation		None		None
Harvest	10/25	All 6 rows, 130 ft	10/14	Whole plot, 130 ft
Fertilizer	11/15	Broadcast P & K at 400 lbs/a. of 0-23-30	11/15	Broadcast P & K at 400 lbs/a. of 0-23-30
Lime	11-15	Broadcast lime at 2.4 tons/a.	11-15	Broadcast lime at 2.4 tons/a.
Primary tillage	11/16	Fall chisel on chisel treatment	11/6	Fall chisel on chisel treatment
	????	Fall Aer-way	????	Fall Aer-way

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

Table 13. Corn maturity and yield as affected by tillage and rotation, Sebewa loam, long term tillage study, Pinney Purdue Agricultural Center, 1996.† SET UP YEAR

Previous crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
		ppa	in	in	%	bu/a.
Corn	Chisel/disk/field cultivate	----	----	----	25.4	191.9
	Chisel, field cultivate	----	----	----	25.0	192.6
	Aer-way	----	----	----	25.4	195.7
	Disk/field cultivate	----	----	----	25.3	195.6
	No-till	----	----	----	25.2	191.1
Soybean	Chisel/disk/field cultivate	----	----	----	24.3	187.7
	Chisel, field cultivate	----	----	----	24.9	175.2
	Aer-way	----	----	----	24.4	192.3
	Disk/field cultivate	----	----	----	25.3	190.7
	No-till	----	----	----	24.5	188.2

†Average of 4 replications.

Table 14. Analysis of variance summary, tillage data, long term tillage study, PPAC, 1996.

Variable	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield bu/a.
	----------Significance Level----------				
	Corn				
Tillage				NS	NS
Previous crop				NS	NS
Tillage x previous crop				NS	NS

Table 15. Soybean maturity and yield as affected by tillage, Sebewa loam, rotation soybean/corn, long term tillage study, Pinney Purdue Agricultural Center, 1996.† SET UP YEAR

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest moisture	Yield @15.5%
	ppa	in	in	%	bu/a.
Chisel/disk/field cultivate	----	----	----	17.1	46.4
Chisel, finishing tool	----	----	----	17.4	42.2
Aer-way	----	----	----	17.5	43.7
Disk/finishing tool	----	----	----	17.3	40.6
No-till	----	----	----	17.6	43.0
ANOV sig. level				NS	NS

†Average of 4 replications.

THROCKMORTON PURDUE AGRICULTURAL CENTER

Rainulator/Tillage Study

These plots, now in their 10+ year, are used by the National Soil Erosion Laboratory to study the long term effect of reduced tillage on soil physical properties and soil erosion. Treatments include plow, chisel, ridge and no-till planting for continuous corn, corn after soybeans, soybeans after corn, and continuous soybeans. There is no replication.

CULTURAL PRACTICES USED 1996
Rainulator - Tillage Study, Throckmorton Purdue Agricultural Center

Item	Corn		Soybean	
	Date	Application	Date	Application
Hybrid/Variety planted	6/28	Miscellaneous	6/28	Ag Alumni 3351
Seeding rate		20,000 seeds/a.		150,000 seeds/a.
Starter fertilizer/planter		none		None
Insecticide/planter		None		None
Weed control		Farm applied		Farm applied
Nitrogen fertilizer	??	NH_3 @ 180 lb/a. N		None
Cultivation	8/5	Plow and chisel treatments	8/5	Plow and chisel treatments
	8/5	Ridge treatment (reridge)	8/5	Ridge treatment (reridge)
No harvest data taken				