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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 treatments except no-till were cultivated once, except for drilled soybeans.

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 and potassium were surface-applied every other year and lime was 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 four soybean varieties have been used during the 21 years of the project. Average planting date was May 5 for corn and May 11 for soybeans.

1995

Equipment used:

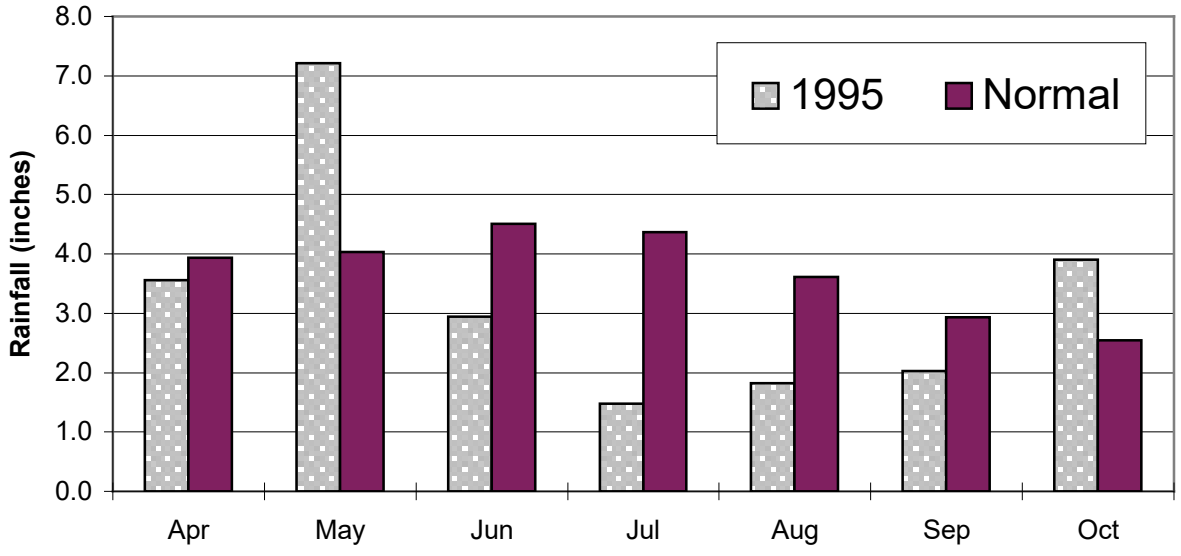
Primary tillage included the use of an International Harvester 5-18 inch bottom semi-mounted moldboard plow on the plow treatments and a DMI 7 shank chisel plow equipped with 4 inch twisted chisel points on 15 inch centers for the chisel treatment. Nitrogen was applied preplant at a depth of 6 to 7 inches 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 a 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 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.
- Don Griffith, Terry D. West, and Dave Gehring, Agronomy.
  D. Griffith and T. West 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. David Mengel, Agronomy.
  Dr. Mengel conducted extensive soil sampling to determine fertility and organic matter levels.
- Dr. Eileen Kladivko, Agronomy.
  Dr. Kladivko measured aggregate stability of surface soil and made earthworm counts.
- Dr. Robert Nielson and Kirby Wuethric, Agronomy.
  Dr. Nielsen and K. Wuethric collected data on corn plant emergence and growth stages.
- Dr. Darrell Norton and Bernie Strnad, USDA.
  Measured soil cracking.

Figure 1. Monthly precipitation, 1995 compared with normal, April through November, Agronomy Research Center.



CULTURAL PRACTICES USED 1995
Long Term Tillage Study, Agronomy Research Center

Item	Corn		Soybean	
	Date	Application	Date	Application
Nitrogen fertilizer	4/7	NH_3 @ 180 lb/ac N in row middles, N-serve, double-disk sealers		None
Secondary tillage	5/22	Disk once on plow and chisel treatments	5/23	Disk once on plow and chisel treatments
	5/22	Field cultivate once on plow and chisel treatments	6/1	Field cultivate once on plow and chisel treatments
Hybrid/Variety planted	5/22	Beck's 6565	6/1	Edison
Seeding rate		29,900 seeds per acre		Plow, chisel, no-till drilled: 59 lb/ac Ridge 30" rows: 47 lb/ac
Starter fertilizer/planter		34-0-0 @ 95 lb/ac, 2 inches to the side and 2 inches below the seed		None
Insecticide/planter		Counter 15G, 9 lb/ac, 8 inch band over row, JD planter setting 22		None
Weed control	5/22	At planting (with planter): Bladex 4L 3 pt/ac Atrazine 4L 3 pt/ac Dual II 3 pt/ac Roundup 3 pt/ac: no-till and ridge. *All broadcast with flat fan nozzles at 40 psi and 40 gallons water/ac*.	6/1	3 point hitch sprayer Lorox Plus 16 oz/ac Dual 8E 2 pt/ac Round up 3 pt/ac: no-till and ridge *All broadcast with flat fan nozzles at 30 psi and 40 gallons water/ac*.
Cultivation	6/19	Plow and chisel treatments	7/6	Ridge treatment
	6/26	Ridge treatment (reridge)	10/12	Ridge treatment (reridge)
Harvest	10/2	Center 4 of 12 rows, 150 ft	9/30	Center 4 of 12 rows, 150 ft
Lime	10/12	2 ton/ac	10/12	2 ton/ac
Primary tillage	10/13	Fall plow on plow treatment	10/13	Fall plow on plow treatment
	10/16	Fall chisel on chisel treatment	10/16	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. Therefore, we decided to shift 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. We did achieve these goals, as there were no significant differences among treatments in plant stands at 4 weeks after planting (Table 1).

Contrary to past years, plant growth at 4 and 8 weeks after planting shows that no-till was equal with plowing and ridge in continuous corn. However, for the yields for no-till continuous corn were still significantly lower than the plow and ridge treatments. The chisel treatment exhibited slower growth at 4 and 8 weeks after planting and yielded significantly lower than plow and ridge in continuous corn.

When corn followed soybeans, plant stands and yields were similar for all systems, with no significant differences. No-till corn was significantly taller at both 4 and 8 weeks after planting than the other treatments.

All corn yields were no doubt affected by gray leaf spot disease. The hybrid used in this study did seem to be less susceptible than many other hybrids. The plants stayed green longer than other fields of corn, however yield potential was reduced.

Stress from hot, dry weather began in June and continued through July, August, and September (Fig 1). Some relief came with rains of 2 inches the last week of June, 1.25 inches in the first week of August, and 1.5 inches in the second week of September. Ears were short in length, but were pollinated from butt to tip.

In the 21 years of this study, only the yields in 1991 are lower. (And we thought we had figured this thing out!) The combination of gray leaf spot disease and the hot and dry weather had a severe impact on yields.

Table 1. 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, 1995.*

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	29750	18.5ab**	71.8a	25.4	135.3a
	Chisel	28750	16.5b	65.1b	24.5	120.4b
	Ridge***	29218	19.8a	70.4a	23.5	129.9a
	No-till	29656	18.2ab	69.2a	24.0	115.7b
Soybean	Plow	29906	19.5b	75.8b	26.4a	147.8
	Chisel	29375	18.5b	71.1c	25.5ab	138.4
	Ridge	29343	19.0b	67.2d	25.0ab	142.4
	No-till	30125	21.5a	80.5a	24.0b	142.4

*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 2 documents that we did achieve uniform stands with standard deviations of less than 3 inches.

Table 2. Plant spacing variability in plow and no-till corn, long term tillage study, Agronomy Research Center, 1995

Tillage	Standard deviation (in)
Continuous corn	
Plow	2.4
No-till	2.5
Corn after soybean	
Plow	2.8
No-till	2.1

Stand, growth, and yield -- Soybeans.

This 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 and resulted in the significant differences found in Table 3.

When soybean followed corn, there were no significant differences in yields. We did not realize a yield advantage for drilling versus the rowed ridge treatment. (Good news for the few remaining ridge tillers in Indiana!) In continuous soybeans, the ridge treatment yields were most likely reduced by infestations of soybean cyst nematodes. Soybean plant soil samples from the affected areas were submitted to the Plant and Pest Diagnostic Laboratory. The lab found SCN females on the roots in all samples. Soil was processed to make egg counts with results of 1,800 to 21,000 eggs per 250 cc of soil, which is categorized as high and extremely high.

Table 3. 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, 1995.*

Previous Crop	Tillage	Stand** 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @13.0%
		ppa	in	in	%	bu/ac
Corn	Plow	189,000b***	7.2b	23.3	9.8	47.3
	Chisel	176,000bc	7.2b	23.6	9.9	51.5
	Ridge	152,000c	8.1a	24.3	10.1	49.4
	No-till	202,000a	6.2c	22.4	10.2	50.4
Soybean	Plow	190,000a	7.4b	23.4	9.4	46.9a
	Chisel	192,000a	7.5b	23.8	9.4	44.2ab
	Ridge	151,000b	8.3a	24.2	9.4	40.8b
	No-till	188,000a	7.0b	24.4	9.5	47.5a

*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, Agronomy Research Center, 1995.

Variable	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield bu/ac
	----------Significance Level----------				
			Corn		
Tillage	NS	.01	.01	.01	.01
Previous crop	NS	NS	.05	NS	.01
Tillage x previous crop	NS	.01	.01	NS	.05
			Soybean		
Tillage	.01	.01	NS	NS	.05
Previous crop	NS	.01	NS	NS	.05
Tillage x previous crop	NS	NS	NS	NS	NS

Long Term Yields (Table 5.)

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%.

Separate page for Table 5.

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 and 1995 is presented in this report. After the 1996 season, a more in-depth discussion of the results will be reported.

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 trash whippers provided removal of residue from the row area.

CULTURAL PRACTICES USED 1995
Strip Preparation Study, Agronomy Research Center

Item	Date	Application
Secondary tillage	4/28	Disk (with drag-type harrow) once on plow treatment
	4/29	Field cultivate (with rolling baskets) once on plow treatment
Hybrid planted	4/29	Pioneer 3394
Seeding rate		26,100 seeds per acre
Starter fertilizer/planter		34-0-0 @ 95 lb/ac, 2 inches to the side and 2 inches below the seed
Insecticide/planter		Counter 15G, 9 lb/ac, 8 inch band over row
Spring strip preparation/planter	4/29	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	4/29	At planting (with planter): Bladex 4L 3 pt/ac Atrazine 4L 3 pt/ac Dual II 3 pt/ac Roundup 3pt/ac: on all treatments except plow *All broadcast with flat fan 8008 nozzles at 40 psi and 40 gallons water/ac.*
Cultivation	6/15	Plow treatment, once
Nitrogen fertilizer	6/6	NH_3 @ 180 lb/ac N in row middles, sidedressed (no covering disks), except fall applied treatments
Harvest	9/29	All 4 rows, 110 ft
Fall strip preparation with toolbar	10/13	3 Coulter treatment in and between old rows: one 1 inch fluted 8 wave center coulter with one 2 inch fluted 8 wave 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 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 row area. No coulters.
Fall strip preparation with NH_3 applicator	11/27	Fertilizer applicator treatment in and between old rows: Applied N-Serve stabilized NH_3 @ 200 lb/ac with 4 knife applicator equipped with 2 covering disks per shank.
Primary tillage	10/13	Fall plow on plow treatment

Table 6. Continuous 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, 1995.*

Treatment	Days to 50% Emergence	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @ 15.5%
		ppa	in	in	%	bu/ac
Fall plow	11	24917	8.3	46.9	14.7	126.5
In old row:						
Fall, row cleaners	16	23417	6.9	37.3	14.3	101.1
Fall, 3 coulters	16	23417	6.4	34.9	15.0	92.7
Fall, row cleaners & 3 coulters	16	23833	6.9	34.8	14.5	98.2
Fall, NH3 band	16	24125	7.1	36.3	14.5	106.3
Spring, row cleaners	16	22875	7.5	36.4	14.9	97.1
Spring, 3 coulters	17	20875	6.2	35.1	14.9	88.8
Spring, row cleaners & 3 coulters	15	24083	7.8	38.8	14.5	113.5
Spring, no-till	16	22208	6.5	34.9	15.2	85.6
Between old rows						
Fall, row cleaners	15	24167	7.5	38.2	14.1	97.2
Fall, 3 coulters	15	25166	7.6	38.4	14.0	97.3
Fall, row cleaners & 3 coulters	14	24917	7.9	39.2	14.1	95.3
Fall, NH3 band	14	25125	7.9	40.8	14.1	106.5
Spring, row cleaners	15	24083	8.0	38.8	14.1	98.6
Spring, 3 coulters	16	23708	6.8	37.5	14.3	97.9
Spring, row cleaners & 3 coulters	15	24417	7.8	38.8	13.9	102.2
Spring, no-till	16	23833	7.0	36.4	13.8	96.0

*Average of 4 replications.

Table 7. Continuous 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, 1994-1995.

Treatment	Days to 50% Emergence	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @ 15.5%
		ppa	in	in	%	bu/ac
Fall plow	13.0	25312	7.8	52.1	17.1	175.0
In old row:						
Fall, row cleaners	17.0	23750	6.5	40.4	17.1	139.9
Fall, 3 coulters	18.5	22625	5.8	36.8	17.6	131.9
Fall, row cleaners & 3 coulters	17.5	24208	6.4	38.0	17.2	139.9
Fall, NH3 band	17.5	23395	6.5	38.4	17.6	145.4
Spring, row cleaners	18.5	22250	6.5	39.5	17.6	135.6
Spring, 3 coulters	19.0	21562	6.0	37.4	17.7	130.2
Spring, row cleaners & 3 coulters	17.0	23020	6.9	41.2	17.3	142.7
Spring, no-till	18.5	21854	5.5	36.7	17.9	124.1
Between old rows						
Fall, row cleaners	17.0	24833	6.9	40.4	16.8	143.5
Fall, 3 coulters	16.5	25270	7.0	40.9	16.8	142.2
Fall, row cleaners & 3 coulters	15.5	25312	7.2	41.0	17.1	142.0
Fall, NH3 band	16.0	24875	6.9	43.1	17.1	150.6
Spring, row cleaners	17.5	23229	6.9	41.1	16.9	138.8
Spring, 3 coulters	17.5	23916	6.3	40.0	17.1	139.7
Spring, row cleaners & 3 coulters	17.0	23687	6.8	41.1	16.9	139.5
Spring, no-till	17.5	24395	6.5	39.0	17.0	139.9

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 on 41 out of 42 days. This year, strip preparation increased the average daily maximum by 2 degrees or less as compared to no-till on the old row (Fig 2).

Manufacturers of strip preparation attachments often claim soil temperatures increase 7 to 10 degrees in the row area when using strip preparation. Our data for 1995 show that the greatest one day soil temperature increase for strip preparation as compared to traditional no-till to be in the range of 0 to 4 degrees (Fig 3).

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.

Challenges with strip preparation.

- Wet soils under heavy residue.
- Use on erodible land.
- Maintaining depth on different soils.
- Removing residue without leaving a depression.

No-till Continuous Corn Row Position Study

We have asked farmers who no-till continuous corn where 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). Each location needs careful attention to seed depth setting in order to establish a uniform stand. Random row placement is the most difficult to achieve correct seed depth due to varying thickness of the residue across 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 the row middles.

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.
- Woods 10 foot mounted mower to chop stalks (used only for row cleaners on old row).
- Case-IH planter model 955 (experimental) 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 cultivator.
- Century mounted sprayer, 32.5 foot boom.
- Case-IH model 5240 tractor.
- White model 3300 combine.

CULTURAL PRACTICES USED 1995
No-till Continuous Corn Row Position Study, Agronomy Research Center

Item	Date	Application
Primary tillage	10/18/94	Fall chisel (4 inch twisted chisel points)
Secondary tillage	5/23	Disk once on chisel treatment
	5/23	Field cultivate once on chisel treatment
Hybrid planted	5/23	Pioneer 3394, medium flats
Seeding rate	5/23	29,946 seeds per acre, drum B
Starter fertilizer/planter	5/23	34-0-0 @ 90 lb./acre, 2 inches to the side and 2 inches below the seed
Insecticide/planter	5/23	Counter 15G, 9 lb./acre, 8 inch band over row
Weed control	5/31	3 pt hitch sprayer, 4 mph, 30 psi, 40 gallon water/acre, 8006 tips
		Atrazine 4L at 3 pt./acre
		Bladex 4L at 3 pt./acre
		Dual II at 3 pt./acre
		Roundup at 3 pt./acre
Cultivation	6/15	Chisel treatment, once
Nitrogen fertilizer	6/23	NH_3 @ 170 lb. N/acre, sidedressed
Harvest	10/2	Center 4 of 12 rows
Lime	10/12	2 ton/ac
Primary tillage	10/16	Fall chisel (4 inch twisted chisel points)

As you will see in Table 8, the corn stand at 4 weeks is reduced up to 9,000 plants per acre from the intended seeding rate. There are several possible reasons for this:

- One is that these plots were planted while a planter clutch problem was developing, which may have caused a jerking movement of the seed drum. This would reduce the number of seeds delivered to the row.
- In the 24 hours after planting, 2.38 inches of rain fell, resulting in severe soil surface crusting in the chisel plots and to a lesser degree in the other treatments. We noted that many plants were curling underground, unable to penetrate the surface crust.
- In the 2 weeks after planting, air temperatures moved into the middle to upper nineties, which added to the crusting problem.
- Due to wet soil conditions, our earliest opportunity to apply herbicides was on the 8th day after planting. The corn started spiking on the 9th and 10th days after planting. Some corn spikes may have been exposed to enough Roundup to be injured or killed.
- Western corn rootworm heavily infested this study. The damage to the corn root systems led to slow early growth and many goosenecked plants later in the season, severely reducing yield potential.

This is a set up year for this study, therefore data collected will not be included in multi-year report.

Table 8. Days to 50% emergence, corn population, height at 4 and 8 weeks after planting, maturity and yield as affected by row cleaners, row location, and tillage, continuous corn, Chalmers silty clay loam, Agronomy Research Center, 1995.*

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/acre
Chisel plow	10	20000	17.3	62.7a	NA	18.1	95.4a
No-till on old row	12	22708	17.3	61.1ab	NA	18.3	64.8a
No-till 6” off old row	12	21084	17.1	62.2a	NA	17.8	87.4a
No-till 15” off old row	12	23167	17.6	59.9ab	NA	18.0	85.8a
No-till on old row/row cleaners**	10	21417	18.9	64.1a	NA	18.6	101.3a
No-till 6” off old row/row cleaners	11	22708	17.6	59.6ab	NA	17.8	94.4a
No-till 15” off old row/row cleaners	12	21625	17.1	57.6b	NA	17.7	72.7b
ANOV significance level	NA	NS	NS	.01	NA	NS	.01

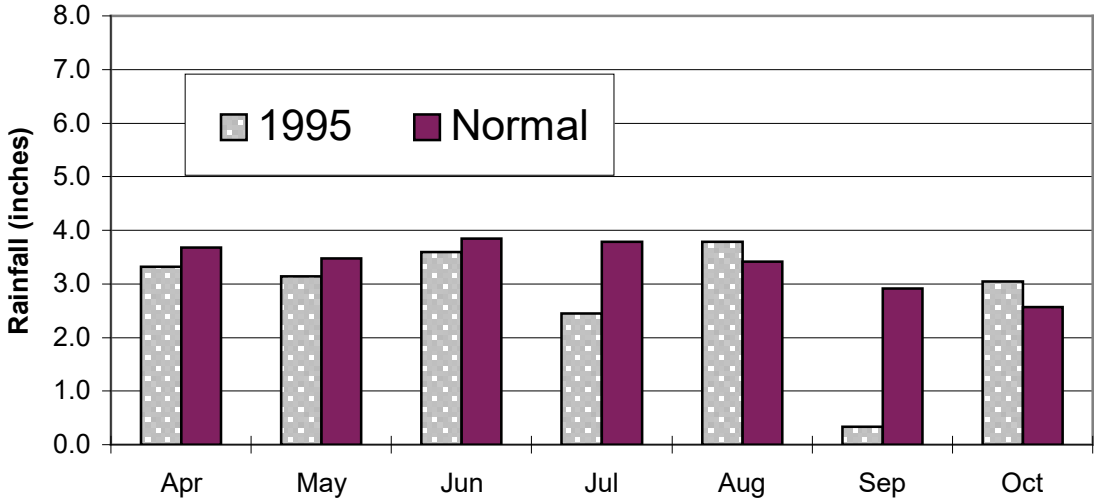
*Average of 4 replications.
**Chopped stalks to eliminate residue plugging under planter.

NORTHEAST PURDUE AGRICULTURAL CENTER

As stated earlier in this report, no-till planting of corn or soybeans 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, which may overcome the early-season problems of no-till fields.

Treatments are evaluated for continuous corn on Boyer and Rawson sandy loams at the Schrader farm and for corn after no-till drilled soybeans on Blount silt loam at the Kyler farm. Treatments include spring chisel plowing, discing, and/or field cultivating as the conventional tillage system, traditional no-till on old row, no-till splitting row middles, row cleaners, multiple coulters and the Purdue "mini-tiller" (loosens soil to 4” depth under the row). Fall and spring timing of strip preparation is another variable at Schrader. All plots were planted with a John Deere Max-Emerge planter equipped with commercially available strip preparation attachments, except for the Purdue mini-tiller. All plots are machine harvested and samples were weighed in a portable electronic weigh buggy.

Figure 4. Monthly precipitation, 1995 compared with normal, April through November, Northeast Purdue Agricultural Center.



Strip Preparation Study, Continuous Corn -- Schrader Farm

CULTURAL PRACTICES USED 1995
Strip Preparation Study, Schrader Farm, Northeast Purdue Agricultural Center

Item	Date	Application
Fall strip preparation	11/17/94	3 Coulters/row cleaners 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.
	3/15/95	Mini-tiller between rows: one 1 inch fluted 8 wave center coulter with one ripple coulter in front of mini-tiller. Mini-tiller operated at a depth of 4 inches.
Primary tillage	4/28	Spring chisel (4 inch twisted points) on chisel treatment
Secondary tillage	4/28	Field cultivate twice on chisel treatment
Strip preparation at planting	5/3	3 Coulters 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. Mini-tiller between old rows: one 1 inch fluted 8 wave center coulter, one 2 inch fluted 8 wave coulter in front of mini-tiller, and one 2 inch 8 wave fluted coulter in front of fertilizer knife. Mini-tiller operated at a depth of 4 inches. Row cleaners between old rows: with one 1 inch fluted 8 wave center coulter, and 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.*
Hybrid planted	5/3	Pioneer 3394
Seeding rate	5/3	26,100 seeds per acre
Starter fertilizer/planter	5/3	18-46-0 @ 95 lb/ac, 2 inches to the side and 2 inches below the seed
Insecticide/planter	5/3	Force 15G, 9 lb/ac, 8 inch band over row
Weed control	4/24	Early preplant (with ATV sprayer at 12 mph): Roundup 2 pt/ac Spreader 2 pt/100 gallons of water (3.2 ounce/ac) Ammonium sulfate 17 lb/100 gallons of water (0.75 lb/ac) *All broadcast with flat fan nozzles spaced at 20", at 30 psi, and 6 gallons water/ac.*
	5/3	At planting (with planter): Extrazine 2.4 lb/ac Dual II 2 pt/ac *All broadcast with flat fan nozzles spaced at 30", at 40 psi and 40 gallons water/ac*.
Nitrogen fertilizer	6/13	NH_3 @ 170 lb/ac N in row middles, sidedressed
Cultivation		None
Harvest	10/10	All 8 rows, 150 ft
Lime	2/10/93	Dolomitic limestone 2 ton/ac

Stand, growth and yield

Plant populations at 4 weeks after planting were adequate in all treatments. Plant growth was slow early in the season due to cool weather with plant heights of only 8 to 10 inches at 4 weeks after planting. By 8 weeks after planting, the chisel treatment measured significantly (P = 0.01) taller than the other treatments (Table 9). By doing some form of strip preparation, we increased corn yields as compared to traditional no-till on the old row. We also increased corn yields by shifting no-till planting off the old row as compared to traditional no-till on the old row. Corn yields were significantly (P =0.01) highest in the chisel plow treatment.

Yield potential in all treatments was reduced by several factors. A combination of low precipitation (Fig 4) and high air temperatures from mid August through September reduced pollination. Gray leaf spot disease lesions were numerous on all leaves by milk to early dough stage and may have reduced yields by 15 to 30% (Don Scott and Jesse Grogan, Pest Management and Crop Production Newsletter, August 18, 1995). Together, these factors lead to severe plant stress during the latter half of the growing season resulting in reduced kernel fill, decreased kernel length, and reduced test weight.

Table 9. Corn population, height at 4 and 8 weeks after planting, maturity, and yield as affected by tillage, continuous corn, Boyer sandy loam and Rawson sandy loam, Schrader Farm, NEPAC, 1995.*

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
	ppa	in	in	%	bu/ac
Chisel, spring	25938a	10.0ab	61.9a	14.2	124.9a
No-till on old row	24156b	8.2c	46.5c	14.8	93.0c
No-till, between old rows	25437a	8.4c	49.1bc	14.7	99.3bc
Row cleaners, between old rows	26000a	9.3b	52.9b	14.3	99.2bc
Coulters, spring, between old rows	24938ab	8.4c	51.7b	14.0	100.2bc
Coulters, fall, between old rows	25250a	9.8ab	54.3b	14.3	113.1ab
Mini-till, spring, between old rows	24906ab	9.4ab	52.3b	14.4	109.2bc
Mini-till, fall, between old rows	25656a	10.3a	53.4b	14.3	106.8bc
ANOV sig. level	.01	.01	.01	NS	.01

*Average of 4 replications

**Within rotations, data followed by the same letter are not significantly different according to Student Newman-Kuels Test (P= 0.05)

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 the 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 one through forty after planting. This year, strip preparation increased the average daily maximum by 2 degrees or less as compared to no-till on the old row (Fig 5).

Manufacturers of strip preparation attachments often claim soil temperatures increase 7 to 10 degrees in the row area when using strip preparation. Our data for 1995 show that the greatest one day soil temperature increase for strip preparation as compared to traditional no-till to be in the range of 0 to 4 degrees (Fig 6).

This year is the third and final year for this continuous corn strip preparation study. Agronomic performance data is presented in Table 10. For 1993, all strip preparation treatments were planted on the previous year's row. We often had problems with residue plugging under the planter when using strip preparation attachments on the old row. Try as we might, we admitted defeat and planted the 1994 and 1995 corn crop 15 inches off the old row to get away from the heaviest of the residue.

We have learned that even though we remove most of the residue when using row cleaners, it doesn't take much wind to blow loose residue back onto the row. Where residue is blown onto the row, the soil is not likely to warm up as compared to the bare soil.

The operating depth of both residue removal and strip tillage attachments can change as soil conditions change across a field. On-the-go adjustment would be desirable.

Summary and conclusions: Where reduced stands or uneven seedling emergence limit traditional no-till yields, either planting between last year's rows (in continuous corn) or using strip preparation should improve yield potential. In the uneven corn residue, row cleaners should provide a more uniform seeding depth. Where previous wheel tracts create a non-uniform soil surface, zone tillage with multiple coulters may also improve seeding depth uniformity.

Table 10. Corn population, height at 4 and 8 weeks after planting, maturity, and yield as affected by tillage, continuous corn, Boyer sandy loam and Rawson sandy loam, Schrader Farm, NEPAC, 1993-1995.*

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
	ppa	in	in	%	bu/ac
Chisel, spring	25563a**	12.0a	66.9a	18.7	146.5a
No-till on old row	23719d	9.4d	56.5b	19.0	125.5b
No-till, between old rows	25541a	10.3bcd	58.3b	18.9	131.8ab
Row cleaners, between old rows	25531a	10.7bc	59.8b	19.1	131.0ab
Coulters, spring, between old rows	24104cd	10.1cd	60.2b	18.0	128.0b
Coulters, fall, between old rows	24031cd	10.3bcd	59.3b	19.0	138.6ab
Mini-till, spring, between old rows	24656bc	10.9bc	59.0b	18.4	134.1ab
Mini-till, fall, between old rows	24917ab	11.2b	59.6b	18.4	129.8b
ANOV sig. level	.01	.01	.01	NS	.05

*Average of 4 replications.

**Within rotations, data followed by the same letter are not significantly different according to Student Newman-Kuels Test (P= 0.05)

Strip Preparation Study, Corn after Soybean -- Kyler Farm

CULTURAL PRACTICES USED 1995
Strip Preparation Study, Kyler Farm, Northeast Purdue Agricultural Center

Item	Date	Application
Primary tillage	5/3	Spring chisel (4 inch twisted points) on chisel treatment
Secondary tillage	5/3	Disk once and field cultivate once on chisel treatment
Hybrid planted	5/3	Pioneer 3394
Strip preparation	5/3	3 Coulters treatment: 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. Mini-tiller treatment: one 1 inch fluted 8 wave center coulter, one 2 inch fluted 8 wave coulter in front of mini-tiller, and one 2 inch 8 wave fluted coulter in front of fertilizer knife. Mini-tiller operated at a depth of 4 inches. Row cleaner treatment: with one 1 inch fluted 8 wave center coulter, and one ripple coulter in front of fertilizer knife. *Note: no-till treatment is with on 1 inch fluted 8 wave center coulter and one ripple coulter in front of fertilizer knife.*
Seeding rate	5/3	26,100 seeds per acre
Starter fertilizer/planter	5/3	18-46-0 @ 95 lb/ac, 2 inches to the side and 2 inches below the seed
Insecticide/planter	5/3	Force 15G, 9 lb/ac, 8 inch band
Weed control	5/3	At planting (with planter): Extrazine 2.4 lb/ac Dual II 2 pt/ac Roundup 4 pt/ac 2,4-D 2 pt/ac *All broadcast with flat fan nozzles spaced at 30", at 40 psi and 40 gallons water/ac*.
Nitrogen fertilizer	6/13	NH_3 @ 170 lb/ac N in row middles, sidedressed
Cultivation		None
Harvest	10/10	All 8 rows, 100 ft
Lime	2/10/93	Dolomitic limestone 2 ton/ac

Stand, growth and yield

Only in plant height at 8 weeks after planting did we find any significant differences (Table 11). Stand at 4 weeks was very uniform. Contributing to the stand uniformity is the fact that the combine was equipped with a chaff spreader which did a good job of spreading the residues at harvest. Yields ranged from 156.5 to 166.6 bu/ac with no statistical differences.

Table 11. Corn population, height at 4 and 8 weeks after planting, maturity, and yield as affected by tillage, rotation corn/soybean, Blount silt loam and Pewamo silty clay loam, Kyler Farm, NEPAC, 1995.*

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
	ppa	in	in	%	bu/ac
Chisel	24208	8.3	43.5b**	18.1	159.9
No-till	24833	8.4	47.6ab	18.3	156.5
Row cleaners	24958	8.8	49.1a	18.3	163.0
3 Coulters	25166	9.0	47.4ab	18.5	164.2
Mini-till	25041	8.9	49.0a	18.4	166.6
ANOV sig. level	NS	NS	.05	NS	NS

*Average of 4 replications.
**Within rotations, data followed by the same letter are not significantly different according to Student Newman-Kuels Test (P= 0.05)

This study points out that where traditional no-till is successful, strip preparation is usually not beneficial. There were no significant differences in plant height at 4 or 8 weeks after planting, harvest moisture, or yields (Table 12). The lowest plant stands are with chisel and row cleaners treatments. This is likely due to soil crusting when residue is removed from the row area. It may be better to leave soybean residue on the soil surface or incorporate it into the row area to reduce surface crusting on low organic matter soils.

Table 12. Corn population, height at 4 and 8 weeks after planting, maturity, and yield as affected by tillage, corn/soybean, Blount silt loam and Pewamo silty clay loam, Kyler Farm, NEPAC, 1992-1995*.

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
	ppa	in	in	%	bu/ac
Chisel	23396b**	10.9	54.3	24.1	156.9
No-till	24708a	11.4	54.8	24.4	154.2
Row cleaners	23469b	11.0	53.6	24.5	154.4
3 Coulters	24813a	11.2	53.8	24.3	157.2
Mini-till	24167ab	11.4	54.9	24.1	159.1
ANOV sig. level	.05	NS	NS	NS	NS

*Average of 4 replications.
**Within rotations, data followed by the same letter are not significantly different according to Student Newman-Kuels Test (P= 0.05)

THROCKMORTON PURDUE AGRICULTURAL CENTER

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 1995
Rainulator - Tillage Study, Throckmorton Purdue Agricultural Center

Item	Corn		Soybean	
	Date	Application	Date	Application
Hybrid/Variety planted	6/5	Pioneer 3394	6/5	Edison
Seeding rate		26,100 seeds per acre		47 lb/ac
Starter fertilizer/planter		34-0-0 @ 95 lb/ac, 2 inches to the side and 2 inches below the seed		None
Insecticide/planter		None		None
Weed control	6/5	At planting (with planter): Atrazine 4L 2 pt/ac Bladex 4L 2 pt/ac Dual II 2 pt/ac Roundup 4 pt/ac *All broadcast with flat fan nozzles at 40 psi and 40 gallons water/ac*.	5/24	At planting (with planter): Broadstrike + Dual 2 pt/ac Roundup 4 pt/ac *All broadcast with flat fan nozzles at 40 psi and 40 gallons water/ac*.
Nitrogen fertilizer	6/26	NH_3 @ 170 lb/ac N		None
Cultivation	7/7	Plow and chisel treatments	6/30	Plow and chisel treatments
		Ridge treatment (reridge)	7/26	Ridge treatment (reridge)
No harvest data taken				

FARM PROGRESS SHOW

Corn was planted for a backdrop for a presentation on strip preparation. No specific treatments were applied.

CULTURAL PRACTICES USED 1995
Farm Progress Show, Vigo County, IN

Item	Date	Application
Hybrid planted	6/7	Crowes
Seeding rate		26,100 seeds per acre
Starter fertilizer/planter		None
Insecticide/planter		None
Weed control	5/3	At planting (hand sprayed): Atrazine 4L 2 pt/ac Bladex 4L 2 pt/ac Dual II 2 pt/ac Roundup 4 pt/ac
Nitrogen fertilizer	6/13	N @ 150 lb/ac as ammonium nitrate, handspread
Cultivation		None
Harvest		No harvest data