TILLAGE RESEARCH REPORT

1993

Terry D. West
Donald R. Griffith
Peter R. Hill

Agronomy Department
Purdue University
West Lafayette, In

Tillage Research Report -- 1993

Table of contents

AGRONOMY RESEARCH CENTER

Long Term Tillage Study

Corn was planted on May 11 and soybeans on May 12 with a John Deere Max-Emerge 4 row planter. For the 7th year, a Hiniker horizontally mounted disk row cleaner scraped the ridge tops and stabilized the planter. Plow and chisel plots were tilled with a 15 foot tandem disk and a 15 foot field cultivator. Nitrogen was applied sidedress with an anhydrous ammonia applicator equipped with one coulter and one wing per knife. All tilled plots were cultivated with a Hiniker ridging cultivator. Corn and soybean were harvested with a White 7300 combine and a John Deere 3300 combine, respectively, and samples weighed with a portable electronic scale. After harvest, chisel plots were chiseled with a DMI 7-shank coulter-chisel equipped with three inch twisted shanks. Plowing was accomplished with a 5 bottom moldboard plow.

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

- S. Abney, Botany and Plant Pathology
  Dr. Abney conducted a study to evaluate late season foliage diseases and root rots on plow and no-till soybean plots.

- D. Griffith and T. West, Agronomy
  D. Griffith and T. West studied long term affects of tillage and rotation by measuring plant population, growth and yield on all plots.

CULTURAL PRACTICES USED 1993

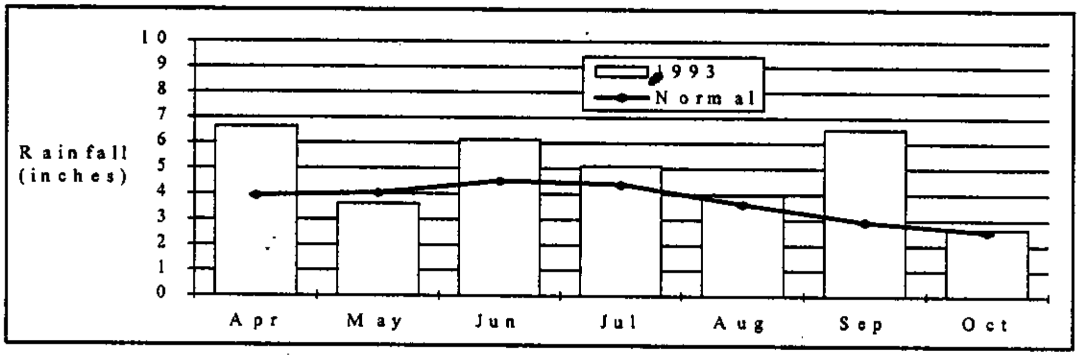
Agronomy Research Center Long Term Tillage Study

	Corn	Soybean
Hybrid/Variety	Beck's 65X	Edison
Date planted	May 11	May 12
Seeding rate	26,100 ppa	49 lb/ac
Seedbed preparation	Disk once and field cultivate once on plow and chisel plots	Same
Fertilizer	95 lb/ac 34-0-0 starter 180 lb/ac N as NH3 sidedress	No starter No N
Insecticide	Counter 15G, band, 9 lb/ac	No insecticide
Weed control	Preplant: Roundup 1.5 pt/ac and 2,4-D 1 pt/ac on no-till, mini-till and coulters At planting: Bladex 4L 3 pt/ac Atrazine 4L 3 pt/ac Dual II 3 pt/ac	Preplant: Roundup 1.5 pt/ac and 2,4-D 1 pt/ac on no-till, mini-till and coulters At planting Lorox 2.4 pt/ac Dual 3 pt/ac Post plant: 2,4-DB 3 pt/ac directed spray on no-till continuous soybeans
Cultivation	Plow, chisel, and ridge once	Plow, chisel, and ridge once
Harvest area	4 rows x 150 ft	4 rows x 150 ft

Stand, growth and yield

Above normal rainfall in April (see Figure 1) kept soils very wet and prevented preplant applications of anhydrous ammonia and an April planting. Soils dried enough by the second week of May to allow planting. Moisture continued to be plentiful through the growing season with normal or above normal rainfall in June, July, August and September. For the months of April through October, rainfall totaled 34.7 inches, which was well above the normal of 25.9 inches.

Figure 1. Monthly precipitation, April through October, Agronomy Research Center, 1993.



Corn populations at 4 weeks after planting were within 1000 plants per acre of planter setting for seed drop with no significant differences between tillages within previous crop (see Table 1). When comparing population means for previous crop, continuous corn was lower by 970 plants per acre, which was significant at the .01 level.

Continuous corn: Plant height at 4 and 8 weeks after planting and grain moisture at harvest shows that on this poorly drained soil no-till lagged significantly behind in plant growth and maturity. No-till also yielded 25.9 to 32.4 bushels per acre less than the other tillages. In this year of above normal rain, no-till plant growth and yields on this poorly drained soil were significantly different at the .01 level.

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, Agronomy Research Center, 1993.*

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
		ppa	in	in	%	bu/ac
Corn	Plow	26440	12.9a	69.5a	25.5b	180.3a
	Chisel	25660	13.7a	67.6a	26.4b	173.8a
	Ridge***	26030	13.9a	64.9a	25.6b	176.2a
	No-till	25310	10.7b	61.1b	27.6a	147.9b
Average		25860	12.8	65.8	26.3	170.0
Soybean	Plow	26880	13.3b	70.8b	25.6	183.9ab
	Chisel	27090	15.4a	76.7a	24.2	190.8a
	Ridge***	26190	14.6ab	73.2ab	24.7	182.0ab
	No-till	27160	14.9ab	73.4ab	24.9	175.4b
Average		26830	14.6	73.5	24.9	183.0

*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.

Soybean: With the plentiful soil moisture at planting, soybeans emerged well with no significant differences among tillages or crop rotations (See Table 2). The soybeans' growth appeared to be normal with a significant difference only in 8 week height due to previous crop. The ridge tilled soybeans grew 1.5 to 3 inches taller than the other tillages. However, this height difference did not translate into higher yields compared to the other tillages. The 4 bushel per acre plus yield drop is surprising since ridge-till has yielded as well as chiseling in the past.

Yields were up as compared to the long term averages by nearly six bushels per acre. The yields were quite variable and no significant differences occurred. In rotation soybeans, no-till yielded the highest, although long-term average shows no-till 4 bushels per acre less than plowing. Considering the wet year and potential for diseases, the soybeans yielded better than expected.

Table 2. Soybean population, height at 4 and 8 weeks after planting, maturity and yield as affected by tillage and rotation, Chalmers silty clay loam, Agronomy Research Center, 1993.*

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @13.0%
		ppf	in	in	%	bu/ac
Corn	Plow	9.7	5.1	18.8b	11.7	60.4
	Chisel	10.2	5.2	17.8b	11.9	59.3
	Ridge	10.3	5.4	20.3a	11.6	55.3
	No-till	9.1	5.0	17.5b	11.8	62.1
Soybean	Plow	9.7	5.2	17.9	11.7	55.1
	Chisel	9.8	5.4	18.4	11.6	47.3
	Ridge	10.0	4.9	17.8	11.8	50.7
	No-till	10.6	5.4	19.9	11.7	51.7

*Average of 4 replications.

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

Table 3. Analysis of variance summary, Agronomy Research Center, tillage data, 1993.

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

Table 4. Yield summary, bu/ac, Chalmers si.c.l., Agronomy Farm, 1975-1993.

Previous Crop	Tillage	1975	1976	1977	1978	1979	1980	1981a	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	75-93 Avg.	80-93 Avg.
											Corn											
Corn	Fall Plow	176.1	140.4	137.8	146.8	205.1	149.3	169.0	209.2	144.2	181.8	195.4	169.5	174.4	128.5	186.3	184.8	122.6	194.3	180.3	168.2	170.7
	Fall Chisel	165.0	147.4	135.5	144.7	190.8	136.0	170.9	190.4	139.3	182.3	185.5	167.6	172.3	141.2	182.8	180.9	125.7	192.6	173.8	164.5	167.2
	Ridge	—	—	—	—	—	142.6	166.6	203.2	148.6	176.2	187.2	161.7	172.8	137.7	180.8	187.4	133.0	189.6	176.2	—	168.8
	No-Till	165.4	153.7	136.3	146.1	176.6	134.4	164.6	188.8	83.7	159.0	173.7	149.1	162.6	121.1	140.1	175.3	104.4	126.0	147.9	147.8	145.1
Soybeans	Fall Plow	167.4	145.1	146.1	145.4	209.5	166.0	176.4	212.4	166.4	205.6	204.2	190.3	186.1	149.1	181.9	192.9	138.2	202.6	183.9	177.3	182.6
	Fall Chisel	177.1	140.8	149.5	140.2	206.7	159.4	170.3	209.1	170.7	198.2	197.5	190.0	177.8	140.4	195.5	195.2	140.8	205.2	190.8	176.6	181.5
	Ridge	—	—	—	—	—	164.2	173.6	216.6	176.8	200.2	207.5	190.5	180.4	151.6	192.5	198.7	149.4	199.1	182.0	—	184.5
	No-Till	175.2	143.4	144.4	142.8	187.6	155.8	174.6	208.9	163.4	193.3	195.6	178.5	182.0	135.9	184.6	195.2	131.8	190.7	175.4	171.5	176.1
	Yearly Average	171.0	145.1	141.6	144.3	196.1	151.0	170.8	204.8	149.1	187.1	193.3	174.7	176.1	138.2	180.6	188.8	130.7	187.5	176.3		

a Planted May 22, all other years planted prior to May 13.

Previous Crop	Tillage	1975	1976	1977	1978	1979	1980	1981a	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	75-93 Avg.	80-93 Avg.
											Soybeans											
Corn	Fall plow	56.4	54.4	55.4	39.3	48.6	54.4	49.2	62.5	60.3	57.6	56.7	48.3	53.3	46.5	45.9	52.6	52.4	48.5	60.4	52.8	53.5
	Fall Chisel	57.6	50.7	54.1	45.0	49.5	54.6	46.2	56.8	59.0	54.2	54.6	47.5	50.2	39.9	45.3	49.3	56.6	44.3	59.3	51.3	51.3
	Ridge	—	—	—	—	—	55.0	47.6	61.4	57.0	48.1	54.9	47.0	51.5	40.6	45.3	49.2	56.7	40.1	55.3	—	50.7
	No-Till	56.0	48.3	52.1	36.2	43.5	51.8	48.4	58.1	50.9	42.9	54.5	45.7	50.9	34.3	43.9	52.2	59.3	40.9	62.1	49.1	49.7
Soybeans	Fall Plow	52.7	48.0	50.3	38.2	47.9	54.3	49.7	55.4	57.7	54.6	49.8	43.7	46.1	36.5	37.5	51.5	47.3	44.4	55.1	48.5	48.8
	Fall Chisel	52.2	45.5	48.8	37.8	49.2	50.7	42.8	53.1	54.8	49.8	50.0	42.1	43.7	35.9	36.6	48.2	49.7	40.3	47.3	46.2	46.1
	Ridge	—	—	—	—	—	48.1	45.6	53.1	56.8	50.0	44.3	42.6	47.1	35.4	42.1	50.5	51.2	37.6	50.7	—	46.8
	No-Till	47.8	41.4	44.6	34.1	45.0	49.5	46.8	47.7	51.4	45.2	46.2	40.7	46.2	37.2	47.0	50.5	57.5	39.9	51.7	45.8	47.0
	Yearly Average	53.8	48.1	50.9	38.4	47.3	52.3	47.0	56.0	56.0	50.3	51.4	44.7	48.6	38.3	43.0	50.5	53.8	42.0	55.2		

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 1990 were to establish plot location and cropping sequence. The data from 1993 is presented in this report. The long term table includes data from 1991 - 1993.

Treatments include plow, standard no-till, multiple coulters and Purdue "mini-tiller," all with and without removal of residue from the row area. 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 3 inch waffle coulters. The mini-tiller is a 5 inch blade attached behind a rippled coulter and set 4 - 5 inches deep to lift and loosen soil in the row area. 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 1993

Agronomy Research Center Strip Preparation Study

	Corn	Soybean
Hybrid/Variety	Beck's 65X	Edison
Date planted	May 10	May 14
Seeding rate	26,100 ppa	49 lb/ac
Seedbed preparation	Disk once and field cultivate once on plow plots	Same
Fertilizer	95 lb/ac 34-0-0 starter 180 lb/ac N as NH3 sidedress	No starter No N
Insecticide	Counter 15G, band, 9 lb/ac	No insecticide
Weed control	Preplant: Roundup 1.5 pt/ac and 2,4-D 1 pt/ac on no-till, mini-till and coulters At planting: Bladex 4L 3 pt/ac Atrazine 4L 3 pt/ac Dual II 3 pt/ac	Preplant: Roundup 1.5 pt/ac and 2,4-D 1 pt/ac on no-till, mini-till and coulters At planting Lorox L 2.4 pt/ac Dual 8E 3 pt/ac Post plant: 2,4-DB 3 pt/ac directed spray on no-till, mini-till and coulters
Cultivation	Plow once	Plow once
Harvest area	4 rows x 115 ft	4 rows x 115 ft

Soil Temperatures:

Starting on May 8 and continuing until June 6, soil temperatures were measured at 7-8 AM and 4-5 PM daily. This data is summarized in Table 5. We measured soil temperatures at four points in each treatment at a depth of 4 inches. We used electronic thermistor type thermometers that are rated at ± one tenth of a degree.

This year's data from continuous corn plots indicates that removing residue and/or strip prepping a no-till environment increased 4:00 PM soil temperatures by 1 to 3 degrees at a depth of 4 inches (see Table 6). In rotation corn/soybeans or soybeans/corn, the difference was less.

Table 6. Soil temperature as affected by previous crop, tillage and residue removal, Chalmers silty clay loam, Agronomy Research Center, 1993.

Previous Crop	Tillage	AM Temperature	PM Temperature	Daily Mean
		°F	°F	°F
			Corn	
Corn	Plow	59.8	69.8	64.8
	No-till RR*	58.0	66.7	62.4
	No-till	57.4	63.5	60.5
	Coulters RR	58.1	67.0	62.6
	Coulters	58.1	65.0	61.6
	Mini-tiller RR	58.2	66.4	62.3
	Mini-tiller	57.9	64.1	61.0
Soybean	Plow	60.0	70.0	65.0
	No-till RR	59.1	68.5	63.8
	No-till	58.6	66.5	62.6
	Coulters RR	59.2	68.2	63.7
	Coulters	59.1	68.1	63.6
	Mini-tiller RR	59.3	68.5	63.9
	Mini-tiller	58.9	68.2	63.6
			Soybean	
Corn	Plow	59.8	69.2	64.5
	No-till RR	58.1	65.8	62.0
	No-till	57.5	63.0	60.3
	Coulters RR	58.2	65.1	61.7
	Coulters	58.1	64.3	61.2
	Mini-tiller RR	58.3	65.3	61.8
	Mini-tiller	58.0	64.5	61.3

*RR = residues removed.

Figures 2 through 7 show the 3 year average soil temperatures. Soil temperatures for 5 weeks after planting were 1/2 to 2 1/2 degrees warmer at the 4 inch depth with strip preparation and/or residue removal as compared to no-till in heavy corn residues. Temperatures in fall plowed soil were significantly higher than with strip preparation. Soils with strip preparation were only 1/2 degree warmer than in no-till soil in soybean residues.

Figure 2. Strip preparation average PM soil temperatures from day of planting to 5 weeks, corn/corn, Chalmers si.c.l., 1991-1993.

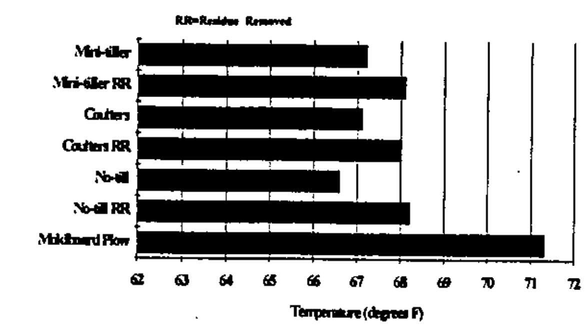


Figure 3. Strip preparation average PM soil temperatures from day of planting to 5 weeks, corn/soybean, Chalmers si.c.l., 1991-1993.

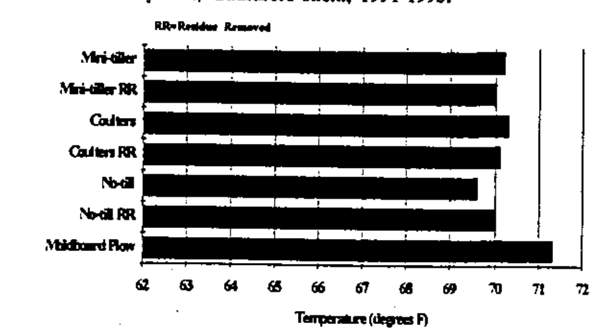


Figure 4. Strip preparation average PM soil temperatures from day of planting to 5 weeks, soybean/corn, Chalmers si.c.l., 1991-1993.

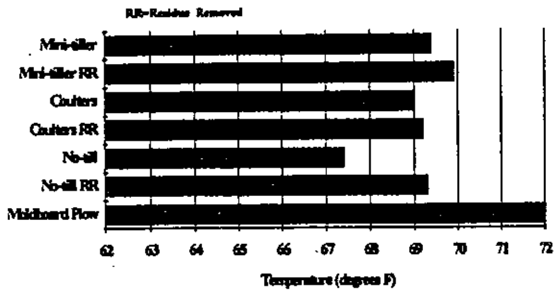


Figure 5. Strip preparation average AM soil temperatures from day of planting to 5 weeks, corn/corn, Chalmers si.c.l., 1991-1993.

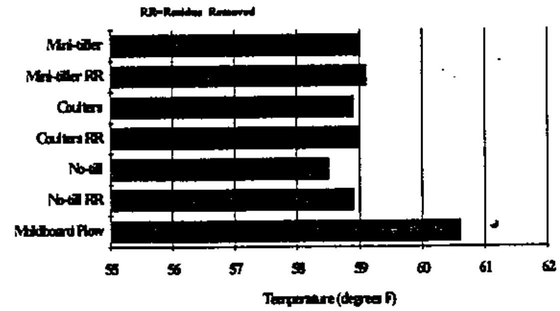


Figure 6. Strip preparation average AM soil temperatures from day of planting to 5 weeks, corn/soybean, Chalmers si.c.l., 1991-1993.

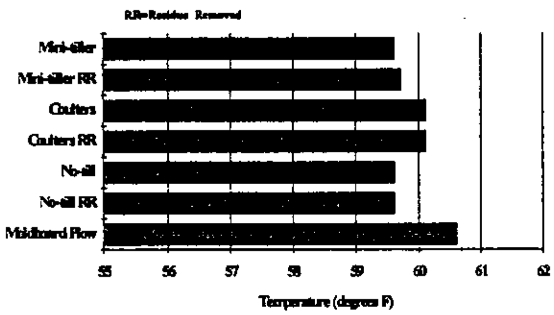
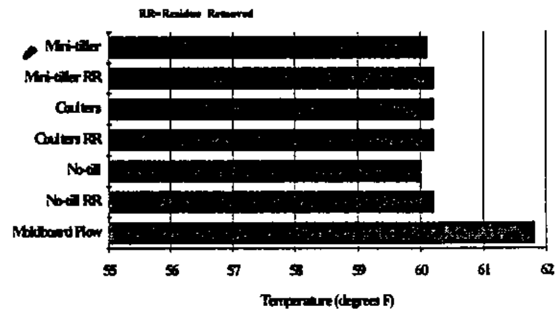


Figure 7. Strip preparation average AM soil temperatures from day of planting to 5 weeks, soybean/corn, Chalmers si.c.l., 1991-1993.



It has been suggested that temperatures taken at 2 inches would correlate better with germination and early maturity since seed placement is at about 2 inches. Previous attempts to do this have shown much variability in readings within treatment. For 12 days during the first 5 weeks we were able to record temperatures at both 2 and 4 inches. This comparison is summarized in Table 7. Two -inch readings were about 2° F warmer for all tillage systems. Based on this limited sampling, 4-inch readings should be well correlated with shoot and root growth.

Table 7. Comparison of 2-inch and 4-inch soil temperatures, °F, ARC, 1993.

Crop	Tillage	2" AM	4" AM	2" PM	4" PM	2" PM - 4" PM	
C/C	Moldboard plow	59.3	59.2	71.7	68.4	3.3	
C/C	No-till RR*	58.2	58.0	67.8	65.5	2.3	
C/C	No-till	57.4	57.7	64.8	63.1	1.7	
C/C	Coulters RR	58.6	58.3	69.2	66.3	2.9	2.3
C/C	Coulters	58.1	58.1	66.6	64.4	2.2	
C/C	Mini-tiller RR	58.4	58.2	67.3	65.3	2.1	
C/C	Mini-tiller	58.2	58.1	65.2	63.5	1.7	
C/B	Moldboard plow	59.9	59.7	70.6	68.6	2.0	
C/B	No-till RR	59.7	59.1	69.3	67.3	2.0	
C/B	No-till	58.7	58.4	67.2	65.5	1.8	
C/B	Coulters RR	59.6	59.2	68.8	67.0	1.9	2.2
C/B	Coulters	59.2	58.8	69.2	66.9	2.3	
C/B	Mini-tiller RR	59.8	59.2	69.7	67.4	2.3	
C/B	Mini-tiller	58.8	58.5	69.7	66.9	2.8	
B/C	Moldboard plow	61.7	60.8	70.1	67.6	2.5	
B/C	No-till RR	60.4	59.8	67.1	65.2	1.9	
B/C	No-till	59.4	59.1	64.5	62.8	1.7	
B/C	Coulters RR	60.6	60.1	66.2	64.4	1.8	2.0
B/C	Coulters	60.1	59.8	65.2	63.7	1.6	
B/C	Mini-tiller RR	60.4	59.9	66.7	64.4	2.3	
B/C	Mini-tiller	60.2	59.6	66.3	63.8	2.5	

*RR = residue removed.

Stand, Growth and Yield

Corn: In corn after corn, there were no significant differences in plant populations at 4 weeks after planting within rotation (See Table 8). No-till plant growth was slowest and plow the fastest with the strip preparation techniques in between. Full width tillage with plowing gave the highest yields. The mini-tiller was redesigned to be less aggressive (less lift on the soil), hopefully leaving a finer seed zone. We accomplished this objective but still have our lowest yields with this treatment. In the residue of continuous corn, there was a yield increase for removing residue in no-till, coulters and mini-till, although it was not significant at the 0.05 level. Three-year average yields (Table 11) also show a trend response to moving residue, but not to zone tillage. Plowed yields were significantly higher than other treatments for the 3 years.

When corn followed soybean, there were no significant differences in stands, growth, and maturity for any of the treatments. All treatments yielded from 174 to 180 bushels per acre with no significant differences. Table 8 also shows that there may be little effect on plant growth to maturity as measured by days to 50% tassle by strip preparation. Note that in rotation, all treatments reached 50% tassling on the same number of days. This data supports the conclusion that strip preparation may not improve yields consistantly in corn/soybean rotation.

Table 8. Corn population, height at 4 and 8 weeks after planting, number of leaves at 4 weeks, maturity and yield as affected by strip tillage, residue management and rotation, Chalmers silty clay loam, Agronomy Research Center, 1993.*

Previous Crop	Tillage	Stand 4 weeks	Height 4 weeks	# Leaves 8 weeks	Height 8 weeks	Harvest Moisture	Yield @ 15.5%
		ppa	in		in	%	bu/ac
Corn	Plow	26500	12.2a	6.7a	70.1a	24.7b	170.8a
	No-till RR**	25000	10.3ab	5.3b	58.7c	26.4a	160.2ab
	No-till	26000	9.2b	4.8b	55.0c	26.6a	157.9ab
	Coulters RR	25330	11.1ab	5.7b	65.3ab	26.3a	164.6ab
	Coulters	25500	10.8ab	5.3b	60.6bc	26.9a	161.7ab
	Mini-tiller RR	24500	11.1ab	5.5b	59.7c	26.2a	156.6ab
	Mini-tiller	25000	11.2ab	5.3b	59.7c	27.5a	155.2b
Soybean	Plow	26000	12.3	6.7	70.8	24.4	175.7
	No-till RR	27080	12.5	7.0	74.2	24.4	179.6
	No-till	26330	11.6	6.7	72.8	24.4	176.6
	Coulters RR	27330	12.8	6.5	72.0	23.9	175.9
	Coulters	26920	12.0	7.1	73.6	24.3	178.6
	Mini-tiller RR	26660	12.0	7.1	69.4	24.9	174.2
	Mini-tiller	27000	12.6	6.8	72.3	25.0	177.4

*Average of 3 replications.
**RR = residues removed.

Table 9. Days to 50% tassle as affected by previous crop, tillage and residue removal, Chalmers silty clay loam, Agronomy Research Center, 1993.

Previous Crop	Tillage	Days
Corn	Plow	72.3
	No-till RR*	76.3
	No-till	78.0
	Coulters RR	75.0
	Coulters	76.0
	Mini-tiller RR	76.3
	Mini-tiller	77.7
Soybean	Plow	72.0
	No-till RR	72.0
	No-till	72.7
	Coulters RR	72.0
	Coulters	72.3
	Mini-tiller RR	72.3
	Mini-tiller	72.7

*RR = residues removed.

Soybean: Plant populations at 4 weeks after planting, plant height at 4 and 8 weeks exhibited many significant differences, however by harvest time yields were statistically equal, just as with the 3 year averages (Table 11).

Table 10. Soybean population, height at 4 and 8 weeks after planting, maturity and yield as affected by strip tillage and residue management, Chalmers silty clay loam, Agronomy Research Center, 1993.*

Tillage	Stand 4 weeks	Height 4 weeks	Tri-foliates 4 weeks	Height 8 weeks	Harvest Moisture	Yield @ 15½ %
	ppf	in		in	%	bu/ac
Plow	9.9ab**	5.4a	2.0	20.2a	10.9	54.3
No-till RR***	10.4ab	4.7ab	1.6	14.3b	11.3	52.0
No-till	10.1ab	4.4ab	1.3	15.0b	11.5	54.0
Coulters RR	11.1a	4.7ab	1.2	16.6b	11.3	53.5
Coulters	10.9ab	4.2b	1.3	17.2b	11.2	53.0
Mini-tiller RR	9.2b	4.3ab	1.3	15.8b	11.3	51.6
Mini-tiller	9.6b	4.1b	1.4	14.5b	11.2	55.0

*Average of 3 replications

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

***RR = residue removed.

Table 11. Yield summary, Chalmers silty clay loam, Agronomy Research Center, 1991-1993.

Previous Crop	Tillage	1991	1992	1993	Avg.
			bu/ac		
		Corn			
Corn	Plow	136.7a	205.9a	170.8a	171.1a
	No-till RR*	116.0b	200.7ab	160.2ab	158.9bc
	No-till	104.6b	193.5bc	157.9ab	152.0bc
	Coulters RR	119.3b	199.4ab	164.6ab	161.1b
	Coulters	105.0b	193.9bc	161.7ab	153.6bc
	Mini-tiller RR	115.4b	188.8bc	156.6ab	153.6bc
	Mini-tiller	113.6b	182.8c	155.2b	150.5c
Soybean	Plow	137.1	206.4	175.7	173.1
	No-till RR	146.5	204.0	179.6	176.7
	No-till	147.8	199.0	176.6	174.5
	Coulters RR	138.4	201.3	175.9	171.9
	Coulters	137.6	201.1	178.6	172.4
	Mini-tiller RR	141.9	197.3	174.2	171.1
	Mini-tiller	149.8	200.0	177.4	175.7
		Soybean			
Corn	Plow	46.9	52.4	54.3	51.2
	No-till RR	48.7	50.2	52.0	50.3
	No-till	47.2	49.7	54.0	50.3
	Coulters RR	52.6	49.4	53.5	51.8
	Coulters	50.7	49.8	53.0	51.1
	Mini-tiller RR	51.4	48.2	51.6	50.4
	Mini-tiller	50.9	49.4	55.0	51.8

* RR = residue removed.

Residue cover with strip preparation.

The photographic method was used for estimating residue cover after planting. Slides (35-mm) were taken of five randomly selected areas using a 30 by 20 inch frame that was placed over the center of the row. The slides were then projected on 2 separate gridded screens to measure residue cover for the planting system and in-row area (8 inch). Each screen contained 100 equally spaced dots; one covered the entire area of the frame while the second covered only the in-row area. Residue cover was the percentage of the intersections on the grid with residue (no residue particle size differentiation).

Table 12. Strip preparation effects on system and in-row residue cover, 3 -yr means, Chalmers silty clay loam, Agronomy Research Center, 1991 - 1993.

		System			In-Row (8" wide band)		
Rotation	Tillage System	Standard	Residue Removed	Difference	Standard	Residue Removed	Difference
		% Residue cover after planting*					
C / B	Plow	3	2	1	3	2	1
	No-till	59	45	14	41	23	18
	Coulters	45	39	6	31	23	8
	Mini-tiller	46	36	10	26	13	13
C / C	Plow	6	5	1	7	6	1
	No-till	77	62	15	66	37	29
	Coulters	71	63	8	59	39	20
	Mini-tiller	69	56	13	58	37	21

- Initial residue cover (spring, pre-plant, 3-yr average): Corn residue – 93%, soybean stubble – 82%.
- Standard no-till systems consistently left the highest amount of residue cover after planting.
- Residue removal in the multi-coulter system (Rawson, 3-fluted coulters) affected system and in-row residue cover the least, regardless of previous crop. This is likely due to the partial incorporation of residue by the coulters ahead of residue removal.
- The effects of residue removal in soybean stubble were less pronounced than in corn residue. This was expected as there was significantly less residue before planting.
- With the exception of fall plow, residue removal significantly reduced in-row residue cover for all systems by an average of 18%. In-row residue cover was highest for continuous corn and lowest for corn following soybeans. With strip preparation, it is not possible to remove all of the residue without removing a significant amount of soil (trenching). Some residue should be left in the row to control soil erosion and to help prevent crusting.
- As expected, in-row residue cover, after residue removal, is nearly independent of tillage system within each crop rotation. This demonstrates the effectiveness of the strip preparation methods (Dawn Trashwheels in 1993 and 1992, flat disks in 1991).

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.

Strip Preparation Demonstration (with R. Neilsen)

Non- replicated demonstration plots comparing traditional no-till (1 coulter) with 3 coulters and with spiked wheels for removing residues were planted on May 6 in field #3. These 3 treatments were compared at planting speeds of 5 and 7 mph and all plots were duplicated in the old rows and between the old rows for continuous corn. Similar demonstrations were planted into drilled soybean residue in field #4. The hybrid used was Becks 60X. Other cultural practices were similar to those in the replicated strip preparation study. Soil types are moderately well drained in these fields. Plots were used for diagnostic training and for the fall ARC Field Day.

Stand, growth and maturity measurements showed no difference among treatments wen planting into soybean stubble. Continuous corn data is summarized in Table 13. Since planting speed had little affect on data collected, the 2 speeds were combined in these comparisons.

When planting in the old row, moving residue form the row improved stand, growth, maturity and yield compared to traditional no-till. (There was no tilled comparison.) The 3-coulter system reduce stand and did not help growth, maturity or yield. Planting between rows provided better yields than in-row planting, but removing residues and using 3 coulters did not improve yields.

Table 13 Tillage demonstrations, continuous corn, Agronomy Research Center, 1993.

Treatment	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Tassel	Harvest Moisture	Yield @ 15.5%
	ppa	in	in	days	%	bu/ac
		IN OLD ROW				
No-till	23708	8.7	58.1	76	24.2	164
Residue Removed	24436	10.2	63.4	74	23.8	177
3 Coulters	21759	9.5	56.3	75	24.5	167
		BETWEEN ROWS				
No-till	25076	10.7	63.6	74	23.1	184
Residue Removed	24843	10.7	64.5	74	23.6	185
3 Coulters	24901	10.5	65.5	74	23.7	179

Strip Intercropping Study

This study is designed to evaluate corn and soybean response to eight row alternating strips with two levels of management for corn. Corn and soybean strips are compared to the middle eight rows of a sixteen row "non-stripped" plot. To represent a high level of management for corn we increased seeding rate on rows one and eight by 29% and rows two and seven by 12%. With the increased population, we also increased nitrogen for the outside rows by doubling the rate (from 60 to 120 pounds/acre) on the NH3 knife between rows 1-2 and 7-8 during side-dress application. This raised the average rate per acre by 15 pounds. For the non-stripped comparison under high management, the eight harvested rows were treated the same as eight row strips with regard to seeding rate and N.

We planted this study using a Hiniker horizontal disc row cleaner and a John Deere 7000 Max-Emerge planter in a ridge tillage system. Until this year all harvesting was done by hand to get yield checks. In 1992 and 1993,we harvested all plots with full size combines and weighed samples in a portable electronic scale, therefore there is no row by row yield data as in the past.

CULTURAL PRACTICES USED 1993

Agronomy Research Center Strip Intercropping Study

	Corn	Soybean
Hybrid/Variety	Beck's 65X	Edison
Date planted	May 11	May 12
Seeding rate	High population:	49 lb/ac
	Rows 1 & 8 = 33150 ppa	
	Rows 2 & 7 = 29230 ppa	
	Rows 3,4,5 & 6 = 26100 ppa	
	Standard population	
	All rows = 26100 ppa	
Fertilizer	0-115-210 (N-P_2O_5-K_2O)	No starter
	broadcast in fall of 1990	
	Starter: 113 lb/ac 18-46-0	
	High input N (as NH3)	No N
	Rows 1,2,7,8 -- 215 lb/ac	
	Rows 3,4,5,6 -- 200 lb/ac	
	Standard input N (as NH3)	
	All rows 200 lb/ac	
Insecticide	Counter 15G, band, 9 lb/ac	No insecticide
Weed control	Preplant:	Preplant:
	Roundup 1.5 pt/ac	Roundup 1.5 pt/ac
	2,4-D 1 pt/ac	2,4-D 1 pt/ac
	At planting:	At planting
	Bladex 4L 3 pt/ac	Lorox L 2.4 pt/ac
	Atrazine 4L 3 pt/ac	Dual 8E 3 pt/ac
	Dual II 3 pt/ac	
Cultivation	Once	Once
Harvest area	8 rows x 90 ft	8 rows x 90 ft

Stand, growth and yield

Corn: Excellent seedling emergence resulted in the 4 week stands found in Table 14. The advantage for high management stripping as compared to non-strip regular management was 24.3 bushels per acre.

Soybean: As in the past, stripped soybean yields suffered from the shading by the adjacent tall crop of corn (See Table 14). This year's yield reduction of 7.1 bushels per acre is more than we have come to expect on these plots. In past years we have experienced yield reductions of 4 to 6 bushels per acre.

Table 14. Corn population, height at 4 and 8 weeks after planting, maturity and yield as affected by strip and management, Chalmers silty clay loam, Agronomy Research Center, 1993.*

Strip	Management	Stand 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
		ppa	in	%	bu/ac
Strip	High	28063	75.3	25.1	202.6
Strip	Regular	25390	74.8	24.7	198.5
Non-strip	High	28250	76.9	24.2	183.3
Non-strip	Regular	26250	76.5	24.3	178.3

*Average of 4 replications.

Table 15. Soybean maturity and yield as affected by strip, Chalmers silty clay loam, Agronomy Research Center, 1993.*

Strip	Harvest Moisture	Yield @13.0%
	%	bu/ac
Strip	11.3	47.2
Non-strip	11.0	54.3

*Average of 8 replications.

Using average yields obtained in this year and prices of $6.50/bu for soybean and $2.50/bu for corn (a 10 year average soybean/corn price ratio), the value of corn and soybean grown in strips was greater than the value of the crops grown separately (Table 16). In years of high corn yields and low soybean yields this should be expected at these prices. The addition of extra population and N increased profit both in strips and in the crops grown separately. For more detailed information on this study for the years 1986 to 1990 see the Journal of Production Agriculture, Volume 5, no. 1, January-March 1992. This project has been terminated after the 1993 season.

Table 16. Economic returns to stripping and management, Agronomy Research Center, 1993.

	Not Stripped		Stripped	
	Regular mgt.	High mgt.	Regular mgt.	High mgt.
	$			
Returns from 0.5 acre corn @ $2.50/bu	222.88	229.13	248.13	253.25
Returns from 0.5 acre soybean @ $6.50/bu	176.48	176.48	153.40	153.40
Gross returns/acre	339.36	405.61	401.53	406.65
Costs for additional seed and N		2.17		2.17
Net returns	399.36	403.44	401.53	404.48
Return to stripping and management		4.08	2.17	5.12

Table 17. Strip Intercropping yield summary, Agronomy Research Center, 1986-1993.

Strip	Management	1986	1987	1988	1989	1990	1991	1992	1993	Average
		Year								
					Corn					
Strip	High	210.3	183.7	153.0	199.9	214.6	136.1	216.2	202.6	189.6
Strip	Regular	198.4	180.8	157.0	201.5	206.0	143.3	210.1	198.5	187.0
Non-strip	High	187.6	176.8	149.6	188.7	184.3	129.7	199.8	183.3	175.0
Non-strip	Regular	182.5	169.5	140.8	186.2	182.6	130.5	195.3	178.3	170.7
	Average	194.7	177.7	150.1	194.1	196.9	134.9	205.4	190.7	180.5
					Soybeans					
Strip		43.2	47.1	36.3	37.2	44.7	45.1	37.9	47.2	42.3
Non-strip		50.0	55.1	40.0	39.9	53.0	48.2	41.5	54.3	47.8
	Average	46.6	51.1	38.2	38.6	48.9	46.7	39.7	50.8	45.0

Table 18. Long term economic returns to stripping and management, Agronomy Research Center, 1986-1993. Soybeans valued at $6.50/bushel and corn at $2.50/bushel.

	Not Stripped		Stripped	
	Regular mgt.	High mgt.	Regular mgt.	High mgt.
	$			
Returns from 0.5 acre corn @ $2.50/bu	213.38	218.75	233.75	237.00
Returns from 0.5 acre soybean @ $6.50/bu	155.35	155.35	137.48	137.48
Gross returns/acre	368.73	374.10	371.23	374.48
Costs for additional seed and N		2.17		2.17
Net returns	368.73	371.93	371.23	372.31
Return to stripping and management		3.20	2.50	3.58

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 will investigate 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 soybeans on Blount silt loam at the Kyler farm. Treatments include spring chisel plowing as the conventional soil tillage system, standard no-till, splitting no-till middles, spider wheels, multiple coulters and the Purdue "mini-tiller". 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. Disking provides the secondary tillage in conventional plots. All plots are machine harvested and samples weighed in a portable electronic weigh buggy.

Strip Preparation Study -- Schrader Farm

CULTURAL PRACTICES USED 1993

	Corn
Hybrid	Pioneer 3394
Date planted	May 18
Seeding Rate	26,100 ppa
Seedbed preparation	Chisel plots (3 inch twisted chisel): disked twice Mini-till plots: one center coulter Spider wheels plots: one center coulter Coulter plots: 1" coulter in front followed by 2 2" coulters
Fertilizer	113 lb/ac 18-46-0 170 lb/ac N as NH3 sidedress
Insecticide	Force 15G 9 lb/ac
Weed control	Early Preplant: Roundup 4 pt/ac At planting: Extrazine 2.4 lb/ac Dual II 2 pt/ac
Cultivation	Chisel plots: once
Harvest area	8 rows x 150 ft

Stand, growth and yield

There are some interesting differences in the plant populations at 4 weeks after planting this year. Chisel, no-till split middles and spider wheels (residue removed) had significantly higher stands than the other treatments. Splitting no-till middles increased plant populations by more than 2000 plants per acre over no-till on the old row. The coulter treatment stands may be reduced because of some planter malfunctions. In the mini-till treatments we continue to have difficulties with residue flow which results in erratic seed placement.

Chiseling gave the highest yield (Table 19) on this soil during this year of normal or above normal rainfall (see Figure 8). Splitting no-till middles yielded nearly 6 bushels per acre more than no-till in old row.

Figure 8. Monthly precipitation, April through October, NEPAC,1993.

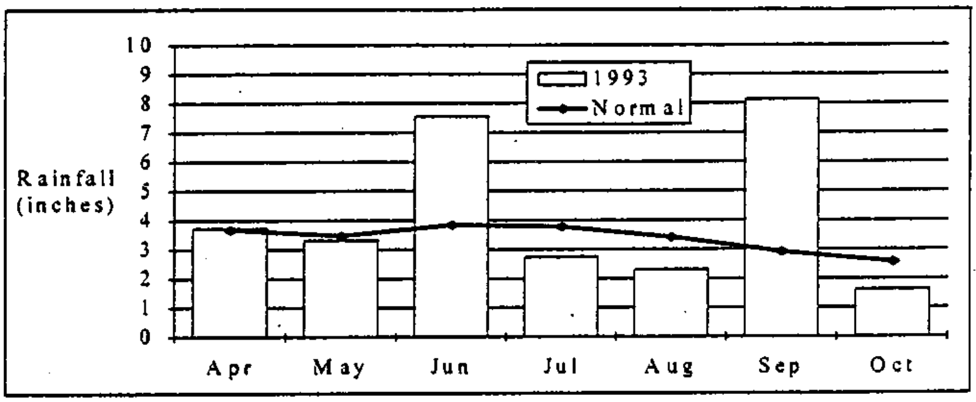


Table 19. Corn population, height at 4 and 8 weeks after planting, maturity and yield as affected by tillage, continuous corn, Boyer sandy loam and Rawson sandy loam, Schrader Farm, NEPAC, 1993.*

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
	ppa	in	in	%	bu/ac
Chisel	24940ab**	13.3	71.1	24.5	171.2a
No-till	23590b	11.5	71.4	22.9	152.8b
No-till (split middles)	25840a	13.5	71.5	23.4	158.6b
Spider wheels	24780ab	13.0	72.9	24.5	156.5b
Coulters, spring	21940c	12.0	70.7	22.8	149.2b
Coulters, (fall)***	21560c	11.8	69.7	24.0	163.5ab
Mini-till, spring	23380b	13.0	68.1	23.3	154.0b
Mini-till, (fall)***	23810b	13.0	69.1	23.4	151.5b
ANOV sig. level	.05	NS	NS	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)
*** Shaded areas indicate set up year treatments. These plots were duplicates of the spring treatments in 1993.

Strip Preparation Study -- Kyler Farm

CULTURAL PRACTICES USED 1993

	Corn
Hybrid	Pioneer 3394
Date planted	May 19
Seeding Rate	26,100 ppa
Seedbed preparation	Chisel plots (3 inch twisted chisel): disked twice Mini-till plots: with 1 center coulter Spider wheels plots: with 1 center coulter Coulter plots: 1" coulter in front followed by two 2" coulters
Fertilizer	113 lb/ac 18-46-0 170 lb/ac N as NH3 sidedress
Insecticide	Force 15G 9 lb/ac
Weed control	At planting: Extrazine 2.5 lb/ac Dual II 2 pt/ac Roundup 4 pt/ac
Cultivation	Chisel plots: once
Harvest area	8 rows x 100 ft

Stand, growth and yield

There being no significant differences in corn plant populations, growth, maturity and yield when planted into soybean residue illustrates that strip preparation did not improve crop performance this year (see Table 20).

Table 20. Corn population, height at 4 and 8 weeks after planting, maturity and yield as affected by tillage, rotation corn/soybean, Blount silt loam, Kyler Farm, NEPAC, 1993.*

Tillage	Stand 4 weeks	Height 4 weeks	Height 8 weeks	Harvest Moisture	Yield @15.5%
	ppa	in	in	%	bu/ac
Chisel	25250	13.3	65.5	26.7	185.8
No-till	25800	13.4	63.2	27.0	175.4
Spider wheels	26200	12.6	60.5	27.4	182.7
Coulters	26000	12.1	60.8	27.4	185.5
Mini-till	25800	12.8	60.8	27.4	185.3
ANOV sig. level	NS	NS	NS	NS	NS

*Average of 4 replications.

THROCKMORTON AGRICULTURAL CENTER

Rainulator -- Tillage Study

CULTURAL PRACTICES USED 1993

	Corn	Soybean
Hybrid/Variety	Beck's 54 XA	Edison
Date planted	July 16	July 16
Seedbed preparation	Field cultivate twice on plow and chisel plots	Same
Fertilizer	95 lb/ac 34-0-0 starter 100 lb/ac N as NH3 sidedress	No starter No N
Insecticide	No insecticide	No insecticide
Weed control	At planting: Bladex 4L 2 pt/ac Atrazine 4L 2 pt/ac Dual 8E 2 pt/ac Roundup 3 pt/ac on no-till and ridge	At planting Lorox L 2 pt/ac Dual 8E 2 pt/ac Roundup 3 pt/ac on no-till and ridge
Cultivation	Plow, chisel, and ridge once	Plow, chisel, and ridge once
Harvest area	No harvest	No harvest

These plots are maintained for D. Norton and associates at the National Soil Erosion Lab. Soil erodibility and other soil physical properties are measured periodically. Planting was delayed in 1993 to allow extensive infiltration measurements, and due to heavy June rainfall.

LOG OF FIELD ACTIVITIES -- 1993

January	26	NEPAC	Spread 92 lbs P_2O_5/ac and 120 lbs K_2O/ac with Gandy set at 55 (400 lbs/ac of 50% 0-46-0 and 50% 0-0-60)
April	23	NEPAC	Flag plots
	30	ARC	Flag plots
May	6	ARC	Spray Roundup and 2,4-D on diagnostic, long term, strip preparation and strip intercrop no-till and ridge plots as knockdown herbicides
	7	ARC	Plant corn on strip preparation demonstration, diagnostic center
	10	ARC	Plant corn on strip preparation study
	11	ARC	Plant long term tillage corn, strip intercrop corn, diagnostic ridge corn and no-till corn
	12	ARC	Plant diagnostic ridge soybeans, strip intercrop soybeans and long term tillage plow, chisel and no-till soybeans
	13	ARC	Plant long term tillage ridge soybeans
	14	ARC	Plant strip preparation soybeans
	18	NEPAC	Plant corn on Schrader Farm strip preparation study
	19	NEPAC	Plant corn on Kyler Farm strip preparation study
	20	ARC	Plant corn on Steinhardt's compaction study
	25	ARC	Residue pictures on strip preparation study
	27	ARC	Plant corn on diagnostic center starter fertilizer placement demo
June	4	ARC	Measure strip preparation demonstration corn week 4 height
	10	ARC	Measure strip preparation study corn week 4 stand and height
	11	ARC	Measure long term tillage corn week 4 stand and height Measure strip intercrop corn week 4 stand
	14	ARC	Measure long term tillage soybeans week 4 stand and height Measure strip preparation study soybean week 4 stand and height
	16	NEPAC	Measure Schrader Farm strip preparation corn week 4 stand and height Measure Kyler Farm strip preparation corn week 4 stand and height
	16	ARC	Apply NH3 on strip preparation, long term tillage, strip preparation demonstration, strip intercrop and T. Bauman's corn
	17	ARC	Plant corn on diagnostic center starter fertilizer placement demo
	18	ARC	Cultivate and/or ridge corn in long term tillage, strip preparation, diagnostic center, and strip intercrop.
	24	NEPAC	Apply NH3 on Schrader Farm and Kyler Farm strip preparation studies
July	6	ARC	Measure strip preparation demonstration corn week 8 height
	7	ARC	Measure strip preparation study corn week 8 height Measure long term tillage corn week 8 height Measure strip intercrop corn week 8 height
	8	ARC	Measure long term tillage soybean week 8 height
	9	ARC	Cultivate Steinhardt's compaction corn, strip preparation study soybeans and strip intercrop soybeans
	9	ARC	Measure strip preparation study week 8 height
	12	ARC	Spray 2,4DB in strip preparation study soybeans, long term tillage no-till soybean/soybean plots
	15	NEPAC	Measure Schrader and Kyler Farms strip preparation corn week 8 height

	16	TPAC	Plant corn and soybean on rainulator study
	23	NEPAC	Spot spray weeds, end trim and hoe
	28	TPAC	Apply NH3 on rainulator study
August	18	TPAC	Cultivate and/or ridge corn and soybeans
	26	NEPAC	Prepare for field day
September	30	ARC	Soil sample in long term tillage
October	4	ARC	Harvest long term tillage, strip intercrop, and strip preparation soybeans
	7	ARC	Harvest long term tillage and strip intercrop corn
	8	ARC	Harvest strip preparation study and strip preparation demonstration corn
	11	ARC	Setup for strip preparation NH3 covering discs
	15	ARC	Fall strip preparation tillage on Field 3
	25	NEPAC	Harvest Schrader and Kyler strip preparation corn
	26	NEPAC	Fall strip preparation tillage on Schrader Farm
	27	ARC	Harvest Steinhardt's compaction corn
	28	ARC	Fall tillage in long term tillage, plow, chisel plow Fall plow in strip preparation Fall plow in Water Quality Station Disc and chisel strip intercrop study
November	2	ARC	Ridge soybean ground in long term tillage