TILLAGE RESEARCH STUDIES

ANNUAL REPORT

1988

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THE 1988 SEASON -- A SPECIAL NOTE

The 1988 season was unusual in several ways and caused some unusual responses to reduced tillage. The early-season drouth was broken in mid-July at all of our test sites, but rainfall for the first 10 weeks after planting totalled only 1.33" at the Agronomy Farm, 2.73" at SEPAC and 2.62" at Davis PAC (Table 17). Although it was very hot during mid-summer, air temperatures averaged 3-4°F cooler than normal at planting and for the next 2 weeks. In addition, Agronomy Farm no-till corn and beans suffered severe frost damage on May 26, with little damage to crops with other forms of tillage. This not only delayed growth in no-till plots, but reduced stands by about 10% in corn and 30% in beans.

The combination of early drouth, cool temperatures and slow root growth caused no-till crops to be stressed earlier and more severely than plowed and chiselled crop. Ridged corn and beans showed slightly more stress than crops with full width tillage, but much less than no-till. In 22 years of tillage research, this is the third time we have seen early season stress on no-till corn after corn, but the first time for no-till corn after beans -- an indication of the severity of the 1988 drouth.

With near normal rainfall after mid-July, all crops, but especially no-till planting, made an amazing recovery. While no-till yields didn't always catch up to those with plowing, they were usually equal or better to yields with plowing on well drained soils. In the final analysis, tillage system relation to soil type was not much different in 1988 than we would expect based on past performance.

TILLAGE RESEARCH RESULTS - 1988

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AGRONOMY FARM - LONG TIME STUDY

Corn was planted on April 26 and soybeans on May 12 with a John Deere Max-Emerge 4 row planter. For the 3rd year, a Hiniker flat disk row cleaner was used to scrape the ridge tops and stabilize the planter. Plow and chisel plots were tilled with a 15' tandem disk and a 15' field cultivator. Nitrogen was applied 1 week preplant with an anhydrous ammonia applicator equipped with coulters and 1 wing per knife. A standard shovel row crop cultivator was used in the plow and chisel plots and a Hiniker ridging cultivator served in the ridge plots. Corn and soybeans were harvested with a John Deere 4420 combine and samples were weighed with a portable electronic scale. After harvest, chisel plots were chiseled with a DMI 7-shank coulter-chisel equipped with 3" twisted shanks. Plowing was accomplished with a 5 bottom moldboard plow.

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

S. Abney, Botany and Plant Pathology - evaluate late season foliage diseases and root rots on all soybeans plots. Used fungicides with a susceptible Gr 2 variety.

D. Griffith and T. West, Agronomy - measure plant population, growth and yield, all plots.

J. Kovar, Agronomy - study corn root growth in relation to soil moisture in moldboard and ridge treatments after soybeans.

J. V. Mannering, Agronomy - determine % surface residue cover, all plots.

R. Turco, Agronomy - study buildup of deleterious microoganisms with continuous corn cropping, especially in no-till. Also evaluating pesticide absorption through the soil profile.

CULTURAL PRACTICES USED 1988
Agronomy Farm Tillage Study

	Corn	Soybeans
Hybrid/Variety	Beck's 65X	Century 84
Date planted	April 26	May 12
Seeding Rate	26,100 ppa	49 lbs/ac
Seedbed Preparation	Disk once and field cultivate once on plow & chisel plots	Same
Fertilizer	113#/ac 18-46-0 starter 250#/ac N as NH_3 0-115-210 ($N-P_2O_5-K_2O$) broadcast in fall of 1986.	No starter No N Same
Insecticide	Counter 15G, band, 9 lbs/ac	No insecticide at planting Dimethoate 4EC 1 pt/ac for spider mites
Weed Control	<u>At planting:</u> Gramoxone 2 pt/ac on no-till X-77 2 pt/100 gal. water Bladex 4L 3pt/ac Atrazine 4L 3pt/ac Dual 8E 3 pt/ac <u>Post-directed</u>: Basagran 1.5 pt/ac with 2 pt/ac COC	<u>At planting</u>: Round-Up 4 pt/ac no-till and ridge plots Dual 8E 3 pt/ac Lorox 4L 2.4 pt/ac <u>Post-directed</u>: 2,4-DB 1.5 pt/ac
Cultivation	Plow, chisel and ridge once	No cultivation
Harvest area	4 rows x 150'	4 rows x 150' or less depending on plot condition

Stand, growth and yield.

Corn - When corn followed corn, growth was severely retarded and moisture stress much more severe for no-till planting until the rains came in mid-July. Ridge planting was intermediate between no-till and plowing in growth response to the drouth. Apparently, cooler soil temperature and more dense soil in no-till, compared to other systems, did not allow corn roots to keep pace with receding soil moisture as the drouth continued.

No-till yield was significantly (.01) lower than chisel and ridge, but not different from plow. The plow treatment may have suffered yield potential due to uneven and late germination. However, the stand for plowing was not significantly lower than the other treatment populations. While no-till continuous corn made an amazing late season recovery, maturity was greatly delayed. Harvest moisture was 11% greater than with plowing.

When corn followed soybeans, drouth effect on no-till corn growth was less severe than in continuous corn, but no-till was under more stress than other systems in late May and June. Although there was a 15.7 bushel yield difference between high and low treatments, it was not found to be significant (.05). The increased variability within treatment is common in a dry year. Treatment yields, except for chisel, were higher in rotation than in continuous corn.

Table 1. Corn response to tillage and previous crop, Chalmers si.c.l., 1988.*

Prev. Crop	Tillage	Stand 4 wks	Height 4 wks	Height 8 wks	Harv. Moist.	Yield @ 15 1/2%
		ppa	in	in	%	bu/ac
Corn	Plow	20,531	9.8a***	47.6a	24.2a	128.5ab
	Chisel	21,500	9.9a	42.3a	25.7a	141.2a
	Ridge	21,531	8.6ab	39.4a**	28.4b	137.7a
	No-till	21,062	6.9b	29.3b	35.2c	121.1b
Soybeans	Plow	21,718	9.8	50.5	23.1a	149.1
	Chisel	20,000	9.3	50.5	24.3a	140.0
	Ridge	23,625	10.7	42.1**	25.0a	151.6
	No-till	22,687	8.9	45.3	28.2b	135.9

*Average of 4 replications.

**Height measured from top of ridge.

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

Soybeans - On May 26, two weeks after planting, freezing temperatures occurred and the no-till plots suffered 30-50% loss of population. The residue cover prevented ground heat from rising, thus frost formed causing the significant (.01 level) reduction in stand noted in Table 2. No-till soybean plant height lagged significantly (.01 level) behind the other treatments through the year. When following corn, plow yielded significantly highest and no-till lowest (.01 level) with no difference between chisel and ridge. In continuous soybeans, there was no significant differences among treatment yields.

Table 2. Soybean response to tillage and previous crop, Chalmers si.c.l., 1988.*

Prev. Crop	Tillage	Stand 4 wks.	Height 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 13%
		ppf	in	in	%	bu/ac
Corn	Plow	8.7a**	5.8a	17.8a	12.4	46.5a
	Chisel	7.3a	4.7a	13.9b	12.5	39.9b
	Ridge	9.2a	5.2a	14.3b	12.5	40.6b
	No-till	4.5b	3.7b	9.8c	12.5	34.3c
Soybeans	Plow	8.8a	5.8a	15.4a	12.3	36.5
	Chisel	8.5a	5.5a	16.5a	12.1	35.9
	Ridge	9.4a	5.5a	14.8a	12.4	35.4
	No-till	5.7b	3.3b	10.7b	12.6	37.2

*Average of 4 replications.

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

Table 3. ANOV summary, Agronomy Farm tillage data, 1988.

Variable	Stand 4 wks	Height 4 wks	Height 8 wks	Harv. Moist.	Yield bu/ac
	-------- Significance Level --------				
	Corn				
Tillage	NS	.05	.01	.01	.01
Previous Crop	NS	.05	.01	.05	.05
Tillage x Previous Crop	NS	NS	NS	.01	NS
	Soybeans				
Tillage	.01	.01	.01	NS	.01
Previous Crop	NS	NS	NS	NS	.01
Tillage x Previous Crop	NS	NS	.01	NS	NS

Table 4. Corn yield summary, bu/ac, Chalmers si.c.l., Agronomy Farm, 1975-1988.

Previous Crop	Tillage	1975	1976	1977	1978	1979	1980	1981[a]	1982	1983	1984	1985	1986	1987	1988	75-88 Avg.	80-88 Avg.
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	166.4	169.0
	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	161.7	165.0
	Ridge	-	-	-	-	-	142.6	166.6	203.2	148.6	176.2	187.2	161.7	172.8	137.7	--	166.2
	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	151.1	148.6
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	176.4	184.2
	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	173.5	179.5
	Ridge	-	-	-	-	-	164.2	173.6	216.6	176.8	200.2	207.5	190.5	180.4	151.6	--	184.6
	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	170.2	176.4
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		

[a]Planted May 22, all other years planted prior to May 10.

Soybean yield summary, Chalmers si.c.l., Agronomy Farm, 1975-1988.

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	53.1	54.3
	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	51.4	51.4
	Ridge	-	-	-	-	-	55.0	47.6	61.4	57.0	48.1	54.9	47.0	51.5	40.6	--	51.4
	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	48.0	46.5
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	48.9	49.7
	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	47.0	46.9
	Ridge	-	-	-	-	-[a]	48.1	45.6	53.1	56.8	50.0	44.3	42.6	47.1	35.4	--	47.0
	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	44.5	45.6
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		

AGRONOMY FARM -- PARAPLOW STUDY

Equipment used in this experiment was the same as for the Long Time Tillage Study, except for the paraplow. A 4 leg paratill set on 30" centers was delivered in the summer and was used after harvest for the '89 crop. This new machine will allow us to better control traffic patterns and seed placement at planting.

One objective of this study is to determine how often paraplowing needs to be done. We chose to evaluate this need on a two year basis. Half of the paraplow treatments are paraplowed annually with the other half biennially.

Date	Crop Year	Treatment
Fall 1985	1986	Annual & biennial plots
Fall 1986	1987	Annuals only
Fall 1987	1988	Annual & biennial plots
Fall 1988	1989	Annuals only
Fall 1989	1990	Annual & biennial plots

CULTURAL PRACTICES USED -- 1988
Agronomy Farm Paraplow Study

Hybrid	Beck's 65X
Date planted	April 26
Seeding rate	26,100 ppa
Seedbed preparation	Disk once and field cultivate once on moldboard-plow and paraplow-moldboard plots
Fertilizer	113 #/ac 18-46-0 starter 250 #/ac preplant N as NH_3 0-115-210 (N-P_2O_5 - K_2O) broadcast in fall of 1986.
Insecticide	Counter 15 G, band, 9 lbs/ac
Weed control	At planting: Bladex 4L 3 pt/ac Atrazine 4L 3 pt/ac Dual 8E 3 pt/ac 4 weeks after planting: Direct-spray Basagran 1 1/2 pt/ac with 2 pt/ac COC
Cultivation	Moldboard-plow and paraplow-moldboard
Harvest area	4 rows x 116'

Due to drouth induced variation in the experiment, there were no significant differences among yields. However, annual paraplowing tended to improve no-till yield and provided yield about equal to the moldboard treatments. Biennial paraplowing had some residual effect. It is interesting that at 8 weeks plant height, annual paraplow-no-till exhibited a significantly (.01 level) taller plant height than straight no-till. All paraplow treatments at 8 weeks were taller than corresponding treatments without paraplow. Harvest moisture of the annual paraplow-no-till treatment was significantly (.01 level) 3.5 points lower than no-till.

In the 1988 drought conditions, did paraplowing of no-till allow the corn roots to develop earlier in the season and deeper into the soil to the available moisture? The more normal plant height, drier grain moisture content at harvest and increased yield indicate that paraplowing was beneficial to no-tilling in this drought year.

Table 5. Corn response to paraplowing, continuous corn, Agronomy Farm, 1988.

Tillage	Stand 4 wks.	Height 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 15%
	ppf	in	in	%	bu/ac
Annual Paraplow, No-till	21,438	8.3b*	35.5b	28.3b	113.0
Biennial Paraplow, No-till	21,688	8.3b	32.1bc	31.1a	107.9
No-till	20,563	8.6b	30.1c	31.8a	103.2
Annual Paraplow, Moldboard	21,875	12.1ab	47.9a	26.0bc	114.5
Biennual Paraplow, Moldboard	22,250	11.1ab	50.5a	25.4bc	115.7
Moldboard	22,250	13.2a	46.0a	24.3c	110.3
ANOV sig. level	NS	.01	.01	.01	NS

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

AGRONOMY FARM -- STRIP CROPPING ON RIDGES STUDY

This study is designed to evaluate corn and soybean response to 8 row alternating strips with 2 levels of management for corn. Corn and bean strips are compared to the middle 8 rows of a 16-row "non-stripped" plot. To represent a high level of management for corn we increased seeding rate on rows 1 and 8 by 29% and on rows 2 and 7 by 12%. With the increased population, we also increased N for the outside rows by doubling the rate (from 60 to 120 #/A) on the NH_3 knife between rows 1-2 and 7-8 during side-dress application. This raised the average rate/ac by 15 lbs of N. For the "non-strip" comparison under high management, the 8 harvested rows were treated the same as 8-row strips with regard to seeding rate and N.

CULTURAL PRACTICES USED -- 1988
Agronomy Farm Strip Crop on Ridges

	Corn	Soybeans
Hybrid/Variety	Beck's 65X	Century 84
Date planted	April 20	May 13
Seeding rate	High population: Rows 1 & 8 = 33,150 ppa Rows 2 & 7 = 29,230 ppa Rows 3,4,5, & 6 = 26,100 ppa Standard population All rows = 26,100 ppa	49 lbs/ac
Fertilizer	High input N (as NH_3): All rows 140 lbs/ac preplant Rows 1,2,7,8--90 lbs/ac sidedress Rows 3,4,5,6--60 lbs/ac sidedress 100#/ac 18-46-0 as starter 0-115-210 (N-P_2O_5-K_2O) broadcast in fall of 1986 Standard input N: All rows 140 lb/ac preplant All rows sidedressed 60 lbs N/ac 113 #/ac 18-46-0 as starter 0-115-210 (N-P_2O_5 - K_2O) broadcast in fall of 1986	No N No starter Same No starter Same
Insecticide	Counter 15 G, band, 9 lbs/ac	No insecticide at planting Dimethoate 4EC 1 pt/ac
Weed control	Gramoxone 2 pt/ac X-77 2 pt/100 gal. water Bladex 4L 3 pt/ac Atrazine 4L 3 pt/ac Dual 8E 3 pt/ac	Dual 8E 3 pt/ac Lorox 4L 2.4 pt/ac for spider mites
Cultivation	No	No
Ridging	At cultivation	After harvest
Harvest area	Individual rows, 50 ft.	Individual rows 80' & 100'

Corn - Growth and yield data are given in Table 6. Response to stripping was 16.2 bu/ac with regular management, but only 3.5 bu/ac with high management (increased population and N). With the limited soil moisture in 1988, the increased populations in rows 1, 2, 7 and 8 were stressed more and did not boost yields as much as in previous years (See Fig. 1). In the non-strip plots it appears that high management techniques improved yields by 8.8 bu/ac, but this is not so. The increased population and N did not increase yields of outside rows. The 8.8 bu/ac increase came from the middle 4 rows which were treated identically in both management levels. There seems to be no reasonable explanation why this occurred.

Fig. 2 is a comparison of strip and non-strip corn yields with high and average management, by row, over the 3 years of this experiment. Response to stripping was 19.1 bu/ac with high management and 15.5 with average management. A more detailed discussion of this experiment will be submitted to the Journal of Production Agriculture, hopefully, in 1989.

Table 6. Corn response to strip cropping on ridges, Agronomy Farm, 1988.

	Strip				Non-Strip			
	Average Management				Average Management			
Row	Stand 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 15½%	Stand 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 15½%
	ppa	in.	%	bu/ac	ppa	in.	%	bu/ac
1(west)	23,500	31.9	26.0	165.4	25,750	35.0	25.3	141.1
2	24,625	33.3	26.0	149.6	23,250	30.1	24.9	146.5
3	25,000	36.5	24.5	154.3	23,375	35.8	26.4	138.9
4	24,250	37.6	24.7	139.7	24,125	38.0	26.0	135.9
5	24,250	37.3	25.6	143.8	25,000	36.0	25.9	135.1
6	23,000	36.1	24.9	162.7	22,125	34.4	26.6	136.8
7	23,875	31.1	25.1	154.3	23,375	34.3	26.1	145.5
8(east)	22,375	31.8	24.6	186.2	23,500	34.8	24.7	147.0
Avg.	23,859	34.4	25.2	157.0	23,812	34.8	25.7	140.8
	High Management				High Management			
1(west)	32,125	31.5	24.9	161.5	30,500	32.5	26.3	137.1
2	27,000	32.9	26.0	134.8	26,375	35.0	25.7	147.1
3	25,000	34.1	26.0	151.4	23,625	33.4	25.1	151.0
4	24,250	37.9	25.4	145.6	24,875	34.8	25.1	158.2
5	23,750	35.5	24.3	147.0	23,125	34.5	25.1	155.6
6	25,125	34.4	25.2	152.9	24,375	35.0	25.5	160.3
7	25,500	33.4	25.3	149.6	26,375	34.4	26.4	146.9
8(east)	31,750	33.0	25.3	181.4	32,375	33.6	26.8	140.9
Avg.	26,813	34.1	25.3	153.1	26,453	34.1	25.8	149.6

FIG 1. Comparison of strip and non-strip corn yields, by row, Agronomy Farm, 1988.

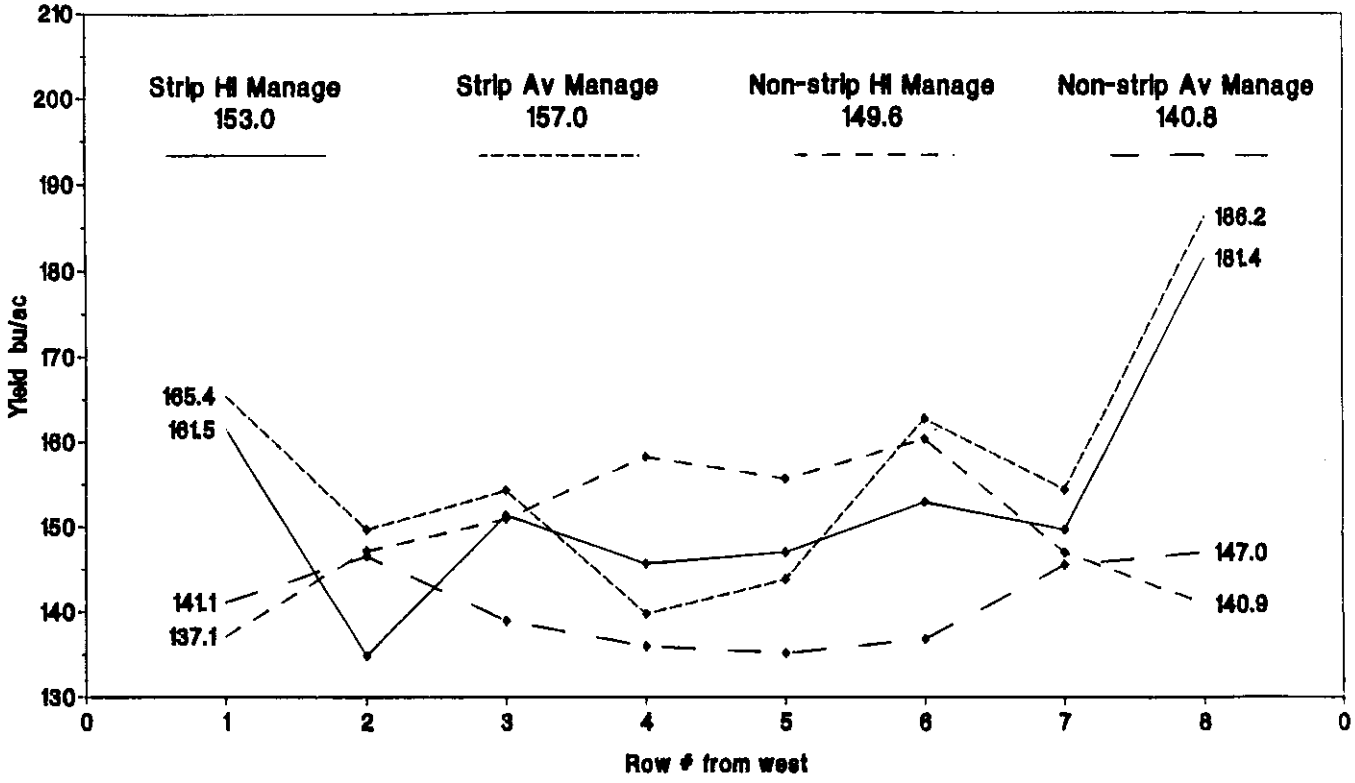
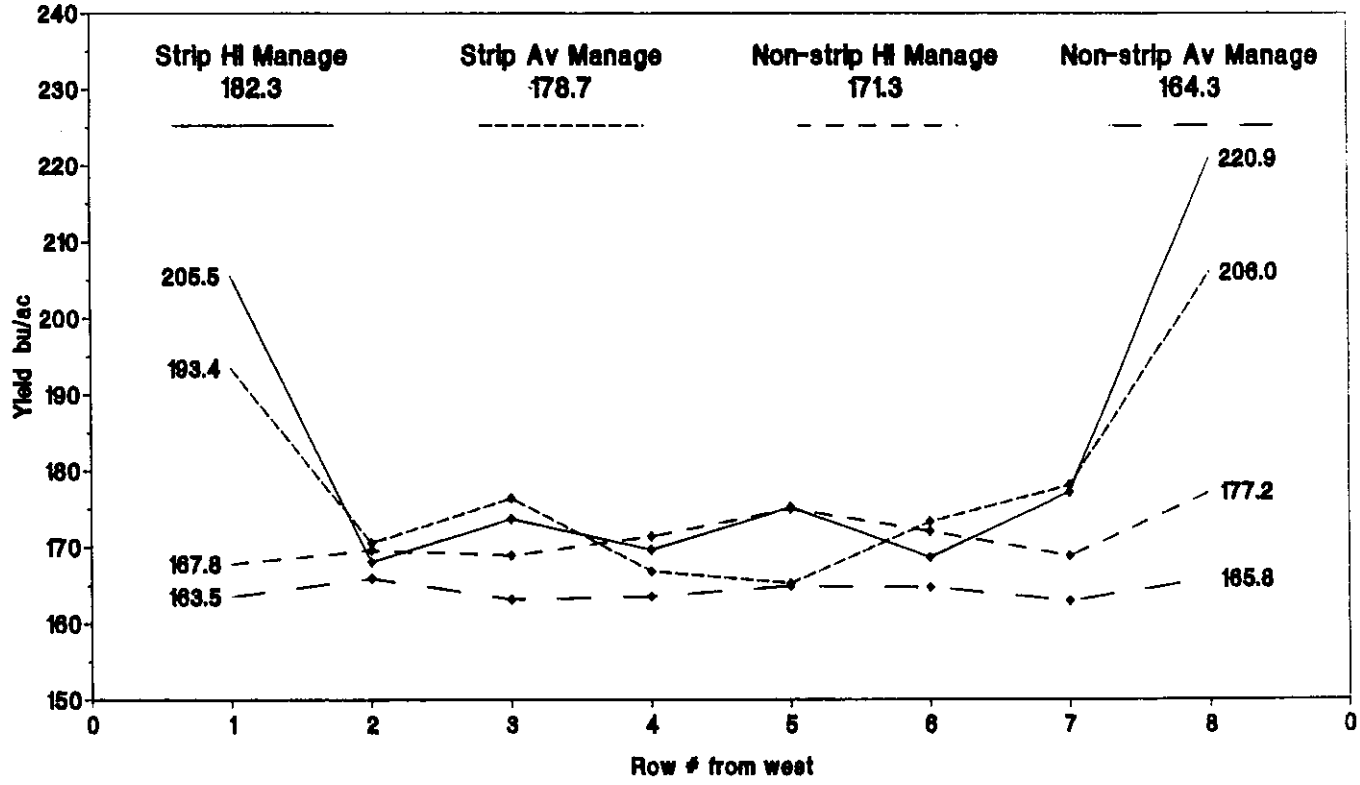


FIG 2. Comparison of strip and non-strip corn yields, by row, Agronomy Farm, 1986-1988.



Soybean - Data given in Table 7. Non-strip soybeans out yielded strip soybeans by 3.7 bu/ac, significant at the .05 level. It is interesting to note that for the third year, each non-strip row (except row 2 in 1988) yielded higher than its counterpart strip row, even for the rows in the middle of the strip. It appears that the shading effect extends across all 8 rows of soybeans. See Figs. 3 and 4. The major yield loss in strips was found in rows 1 and 8. Only 1 management level was used.

Table 7. Soybean response to strip cropping on ridges, Agronomy Farm, 1988.

	Strip		Non-Strip	
Row	Moisture	Yield @ 13%	Moisture	Yield @ 13%
	%	bu/ac	%	bu/ac
1(west)	10.4	31.7c*	10.2	40.4
2	10.4	41.5a	10.2	40.6
3	10.1	37.4ab	10.1	40.2
4	10.2	38.6ab	10.2	40.3
5	10.2	38.2ab	10.2	40.5
6	10.0	36.8b	10.3	40.2
7	10.3	37.6ab	10.5	39.0
8(east)	10.1	29.0c	10.3	38.5
Avg.	10.2	36.4	10.3	40.0

*Data followed by the same letter are not statistically different according to Student-Newman-Kuels test (P = .05).

FIG 3. Comparison of strip and non-strip soybean yields, by row, Agronomy Farm, 1988.

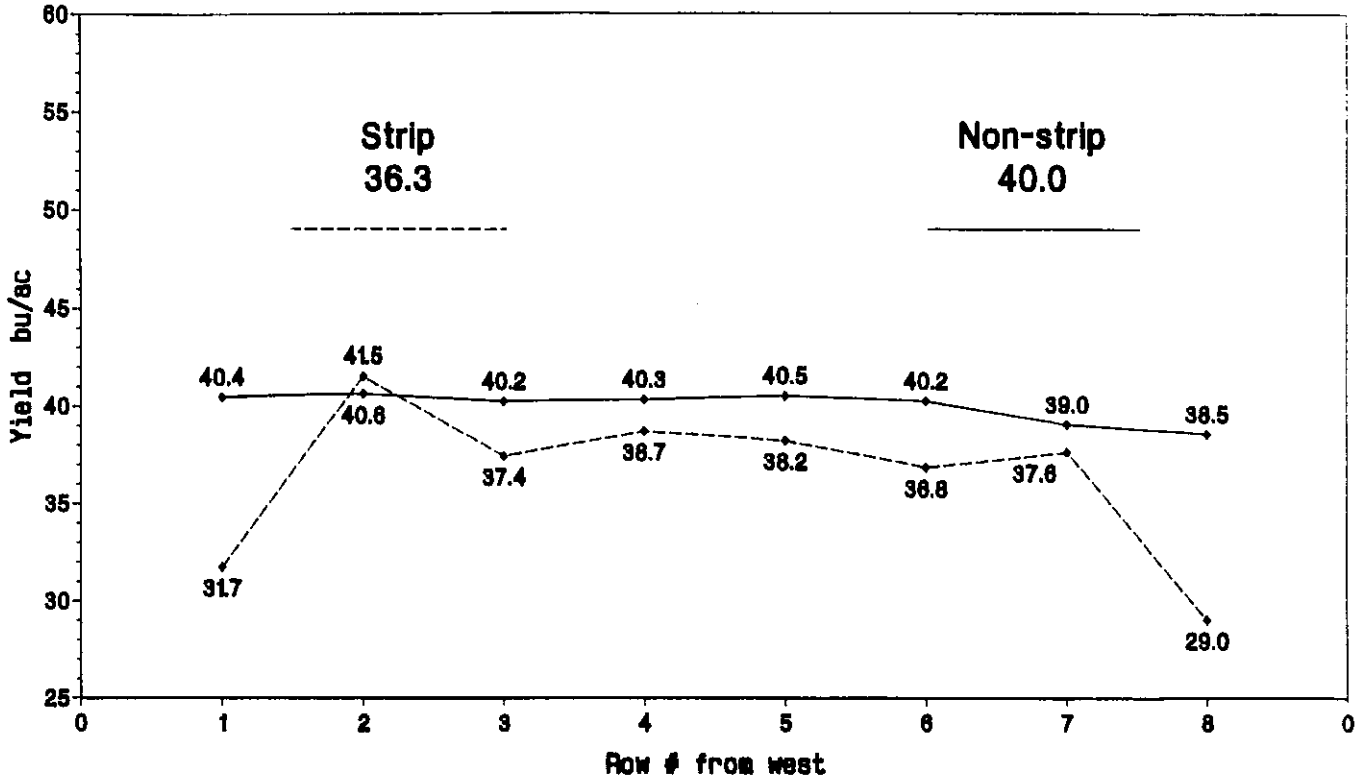


FIG 4. Comparison of strip and non-strip soybean yields, by row, Agronomy Farm, 1986-1988.

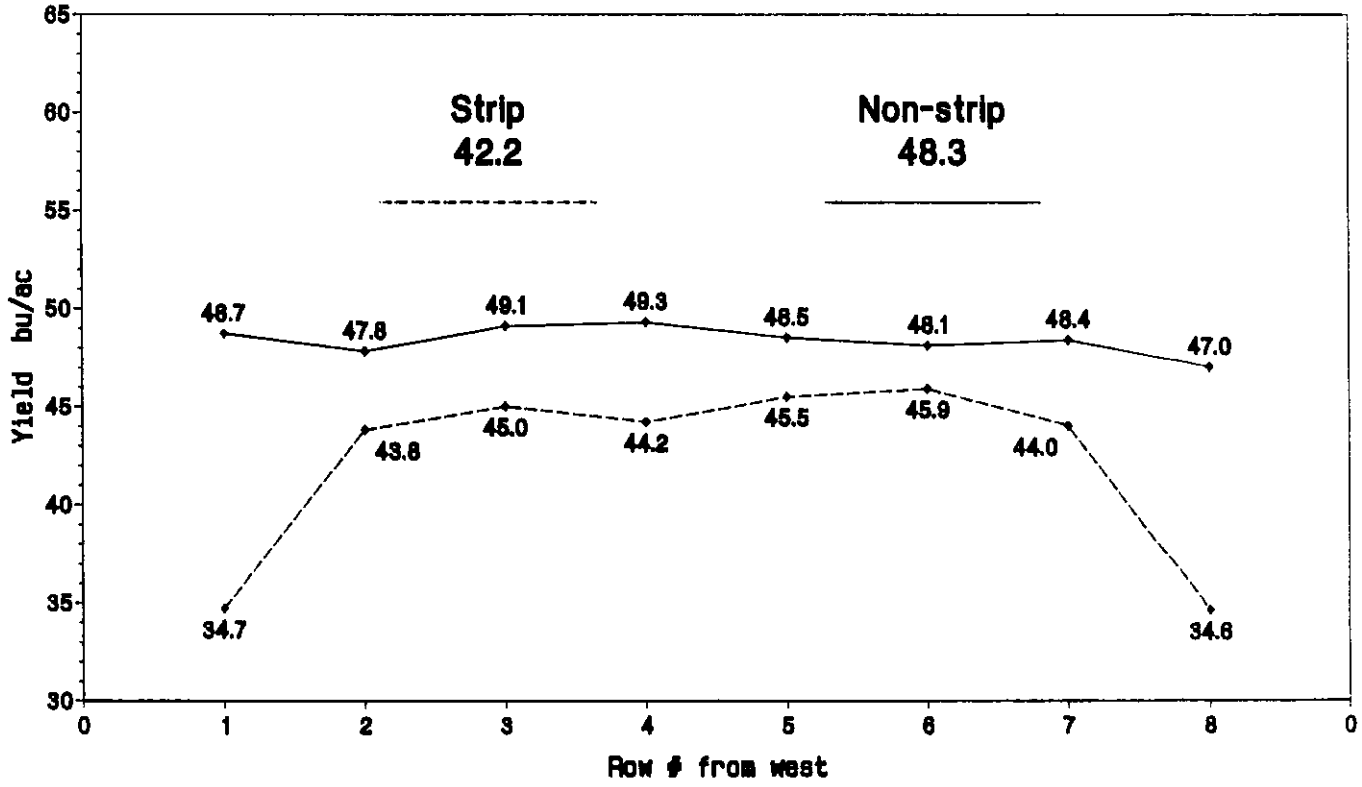


Table 8. ANOV summary, strip cropping on ridges data, Agronomy Farm, 1988.

Variable	Stand 4 wks.	Height 8 wks.	Harv. Moist.	Yield bu/ac
	---- significance level -----			
	Corn			
Strip	NS	NS	NS	.05
Management	.01	NS	NS	NS
Row #	.01	.01	NS	.01
	Soybeans			
Strip	--	--	NS	.05
Row #	--	--	NS	.01
Strip x Row	--	--	NS	.01

SEPAC

LONG TIME TILLAGE STUDY

Corn was planted on May 3. Soybeans were planted on May 4. Primary tillage included the use of a 5-bottom plow and a Glenco coulter chisel on appropriate treatments. Plow and chisel plots received 2 passes with a 15' Glenco soil finisher as secondary tillage. The same tool was used (2 passes) for the shallow tillage disk treatment. Plots were cultivated with a standard shovel type and a Hiniker ridging cultivator. Ridge soybean plots were not reridged for the 1989 corn crop due to sufficient ridge height left after the 1988 crop year. All NH_3 was applied pre-plant. Corn and soybeans were harvested with a John Deere 4425 combine and samples were weighed with a portable electronic scale.

In corn, pre-emergence and knockdown herbicides gave adequate control of weeds except for fall panicum in the no-till plots. In soybeans, pre-emergence herbicides did not give lasting control of fall panicum, smartweed, cocklebur or vines. A post-applied spray of Blazer-Basagran also failed to clean up the weeds, especially in drilled beans.

CULTURAL PRACTICES USED - 1988
SEPAC Tillage Study

	Corn	Soybeans
Hybrid/Variety	Pioneer 3184	Pella '86
Date planted	May 3	May 4
Seeding rate	26,100 ppa	49 lbs/ac
Seedbed preparation	For plow, chisel - 2 passes with soil finisher For disk - 2 passes with finisher	Same
Fertilizer	200 lb N/ac as NH_3 113# 18-46-0 starter 0-115-210 (N-P_2O_5-K_2O) broadcast in fall of 1985	No N No starter Same
Insecticide	Counter 15 G 9 lbs/ac	None

Weed control	At planting: Bladex 4L 1.5 pts/ac Atrazine 4L 1.5 pts/ac Dual 8E 2 pts/ac Round-Up 4 pts/ac	At planting: Lorox 4L 1 1/4 pts/ac Dual 8E 2 pts/ac Round-Up 4 pts/ac Post-plant: Blazer 1.5 pt/ac Basagran 1.5 pt/ac Crop oil conc. 1 pt/ac
Cultivation	Once (except no-till)	Once (except no-till)
Harvest area	4-30" rows x 200' (Reps I, II) 4-30" rows x 270' (Reps III, IV)	2-30" rows x 30' 4-8" drill rows x 20'

Stand, growth and yield.

Corn - When corn followed corn, the ridge treatment was significantly shorter and yielded the lowest with no-till second lowest (significant at .01 level). There was no differences among the tilled plots. In rotation there were no significant differences in yield among tillage systems. No-till yielded as high as plow in this stress year. Ridge and no-till had significantly (.01 level) lower plant populations. Ridge showed more stress through the growing season with significantly (.01 level) shorter plant height at 4 and 8 weeks and a delayed maturity with the highest grain moisture content at harvest (Table 9).

Soybean - In 30-inch rows, no-till and plowed yields were about equal, with ridge yields significantly lower than either. As in the past, when beans were drilled, no-till had highest yield. As in corn, the ridge system exhibited shorter plant height through the season and reduced yields. Some data from E. Kladivko shows that there may be a soil density problem in the ridges. A study by E. Kladivko and F. Larney measured penetration resistance with a constant-rate cone penetrometer in the tillage systems at SEPAC. The data reflected a less permeable soil in the ridge system, which may have limited root development into the subsoil moisture, thus resulting in the stress symptoms and poor yield. In 1989 an effort will be made to further identify any soil conditions that may be limiting yield potential in the ridge system, what is causing it and what can be done to correct the problem.

Table 9. Response to tillage and previous crop, Clermont si.l., SEPAC, 1988.

Prev. Crop	Tillage	Stand 4 wks.	Height 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 15½%
		ppa	in.	in.	%	bu/ac
				Corn		
Corn	Plow	24,188a*	14.1a	55.8a	25.2ab	122.4a
	Chisel	24,500a	15.1a	52.1ab	24.5b	114.5ab
	Disk	24,812a	14.8a	51.0ab	24.3b	112.0ab
	Ridge	23,843a	10.8b	40.8c	26.2a	95.2c
	No-till	22,656b	11.3b	47.9b	26.3a	102.8bc
Soybean	Plow	24,718ab	14.1ab	52.2a	26.2a	120.0
	Chisel	25,312a	12.8bc	47.3a	26.8a	108.4
	Disk	24,031b	14.6a	50.9a	26.0a	116.9
	Ridge	22,625c	11.4c	40.3b	29.9c	113.9
	No-till	22,781c	12.3c	50.3a	28.4b	118.8

		Soybean 30" rows					Drill strip	
		ppf	in.	in.	%	bu/ac-13%	%	bu/ac-13%
Corn	Plow	7.5	3.9b	16.3a	15.5a	46.9a	15.8	46.4
	Chisel	6.7	3.6b	15.2ab	15.2ab	40.7b	15.1	43.2
	Disk	6.6	3.7b	15.3ab	15.6a	43.1ab	15.2	44.8
	Ridge	7.5	3.6b	13.7b	15.0b	38.8b	--	--
	No-till	7.5	4.6a	15.0ab	15.2ab	47.9a	15.0	50.9

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

Table 10. ANOV summary, tillage data, SEPAC, 1988.

Variable	Stand 4 wks.	Height 4 wks.	Height 8 wks.	Harv. Moist.	Yield
	-------- significance level ---------				
			Corn		
Tillage	.01	.01	.01	.01	.01
Previous Crop	NS	NS	NS	.05	NS
Tillage x Prev. Crop	.05	.05	NS	NS	.01
			Soybeans		
Tillage	.05	.01	.05	.05	.01

Table 11. 1980-88 yield summary, bu/ac, SEPAC tillage.

Previous Crop	Tillage	Corn 1980	1981	1982	1983	1984	1985	1986	1987	1988	1980-88 Avg.	1983-88 Avg.
Corn	Plow, spring	113.5	123.3	186.8	53.3	145.3	180.5	146.6	150.7	122.3	135.8	133.2
	Chisel, fall	121.8	131.4	194.4	58.0	154.6	185.8	150.7	165.7	114.5	141.9	138.2
	Disk, spring	117.0	125.21	181.4	50.7	145.8	176.8	155.5	148.8	112.0	134.8	131.6
	Ridge	---	---	---	52.1	150.8	179.7	142.5	139.9	95.2	---	126.7
	No-Till	104.9	104.6	159.9	66.2	155.5	178.1	162.4	130.1	102.8	129.4	132.6
Soybeans	Plow, spring	116.2	122.0	196.6	48.5	149.4	185.5	139.4	157.8	120.0	137.2	133.4
	Chisel, fall	112.0	118.9	187.3	64.5	141.6	183.1	129.0	156.7	108.4	133.6	130.5
	Disk, spring	119.5	120.0	195.8	70.9	150.8	182.2	144.2	160.6	116.9	140.1	137.6
	Ridge	---	---	---	64.3	155.5	185.1	153.6	158.1	113.9	---	138.5
	No-Till	119.6	115.5	197.2	75.8	165.0	181.4	172.4	153.2	118.8	144.3	144.4
	Yearly Average	115.6	120.1	187.4	60.4	151.4	181.8	149.6	152.2	112.5		

Previous Crop	Tillage	Soybeans 1980	1981	1982	1983	1984	1985	1986	1987	1988	1980-88 Avg.	1981-88 Avg.	1983-88 Avg.
Corn	Plow, spring	38.9	43.1	52.0	23.0	36.5	53.6	48.8	39.0	46.9	42.5	42.9	41.3
	Chisel, fall	39.6	41.4	51.1	30.1	39.0	53.0	48.5	37.7	40.7	42.4	42.6	41.5
	Disk, spring	40.0	38.6	51.9	37.2	37.4	51.4	49.8	41.4	43.1	43.5	43.9	44.1
	Ridge	--	--	--	35.6	40.6	54.0	47.1	41.0	38.8	--	--	42.8
	No-Till	18.7[a]	42.2	49.4	39.6	40.1	54.0	48.3	48.1	47.9	43.2	46.2	46.3
	Yearly Average	34.3	41.3	51.1	33.1	38.7	53.2	48.5	41.4	43.5			

[a]Phytophthora root rot reduced yield.

Table 12. Drilled (10") bean yield summary, Clermont si.l., SEPAC, 1988.

Tillage	1981	1982	1983	1984	1985	1986	1987	1988	81-87 Avg
					bu/ac				
Plow	42.9	57.8	25.0	37.0	61.8	50.6	45.3	46.4	45.9
Chisel	38.5	65.2	26.8	43.0	59.5	54.1	49.3	43.2	47.5
Disk	40.8	62.7	38.0	46.0	59.9	54.6	51.3	44.8	49.7
No-till	56.7	72.9	50.4	48.0	73.1	53.8	54.0	50.9	57.6

SEPAC

PARAPLOW STUDY - 1988

Prior to planting corn on May 4, the tilled plots were worked with a Glenco soil finisher. Cultivation was with a conventional cultivator. All plots were harvested with a J.D. 4425 combine and samples were weighed in a weigh buggy.

As at the Agronomy Farm, one objective of this study is to determine how often paraplowing needs to be done. We chose to evaluate this need on a two year basis. Half of the paraplow treatments are paraplowed annually with the other half biennially.

Date	Crop Year	Treatments
Spring 86	1986	Annual & biennial plots
Spring 87	1987	Annual only
Fall 87	1988	Annual & biennial plots
Fall 88	1989	Annual only
Fall 89	1990	Annual & biennial plots

CULTURAL PRACTICES USED - 1988

SEPAC PARAPLOW STUDY

Hybrid	Pioneer 3184
Date planted	May 4
Seeding rate	26,100 ppa
Seedbed preparation	For chisel, paraplow + chisel and paraplow: 2 passes with soil finisher
Fertilizer	180# N/ac as NH_3 (sidedress) 113# 18-46-0 starter
Insecticide	Counter 15 G 9#/ac
Weed control	Gramoxone 2 pt/ac on no-till X-77 2 pt/100 gal. water Bladex 4L 1.5 pt/ac Atrazine 4L 1.5 pt/ac Dual 8E 2 pt/ac
Cultivation	Once on tilled plots
Harvest area	4-30" rows x 204'

Considering the drought experienced this year, one would have expected paraplowing to increase yields by allowing earlier root development into the subsoil moisture. This did not appear to have happened in no-till or chisel situations. Annual paraplowing yielded 5.6 bu/ac less than no-till but this was not significant. All chisel systems yielded within 2 bu/ac of each other.

Table 13. Corn response to paraplowing, continuous corn, SEPAC, 1988.

Tillage	Stand 4 wks.	Height 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 15½%
	ppf	in	in	%	bu/ac
Annual Paraplow, No-till	22,875b*	11.4ab	51.6	30.9a	124.6
Biennial Paraplow, No-till	23,875ab	11.1b	49.6	31.8a	129.3
No-till	23,687ab	10.9b	46.7	31.2a	130.2
Annual Paraplow, Chisel	25,312a	14.0ab	53.1	27.8b	135.8
Biennial Paraplow, Chisel	23,687ab	11.8ab	52.7	29.3ab	136.4
Chisel	24,875ab	14.4a	55.2	29.4ab	135.1
ANOV sig. level	.05	.05	NS	.01	NS

*Data followed by the same letter are not statistically different according to Student-Newman-Kuels test (P = .05).

DAVIS PAC

PARAPLOW STUDY - 1988

Frequency of paraplowing is being evaluated on a 2 year basis as at the Agronomy Farm and SEPAC.

Date	Crop Year	Treatments
Fall 1984	1985	Annual & biennial plots
Fall 1985	1986	Annual only
Fall 1986	1987	Annual & biennial plots
Fall 1987	1988	Annual only
Fall 1988	1989	Annual & biennial plots
Fall 1989	1990	Annual only

CULTURAL PRACTICES USED - 1988

DAVIS PAC

Hybrid	Pioneer 3352
Date planted	May 5
Seeding rate	26,100 ppa
Seedbed preparation	For moldboard, paraplow + moldboard: field cultivate and roterra.
Fertilizer	113#/ac 18-46-0 starter 150# N/ac as NH_3 (sidedress)
Insecticide	Counter 15 G, 9#/ac
Weed control	Pre-plant: Roundup for thistles, 4 pt/ac At planting: Bladex 4L 2 pt/ac Atrazine 4L 2 pt/ac Dual 8E 2 pt/ac Gramoxone 2 pt/ac on paraplow and no-till X-77 2 pt/100 gal. water
Cultivation	Once on moldboard, paraplow + moldboard
Harvest area	4-30" rows x 200' Reps I, II. 4-30" rows x 200' Reps III, IV.

Stand, growth and yield

Paraplowing of no-till exhibited faster plant growth through the season and higher yields over no-till alone, but the yield difference was not significant. Lower grain moisture content at harvest (significant at .01 level) suggests that paraplow -- no-till treatments matured earlier. There were no significant differences in the moldboard treatments. Due to the variability within treatments and between blocks, it is questionable whether this year's information is useful. (Another tough year at the Davis PAC!).

Table 14. Corn response to paraplowing, continuous corn, Davis PAC, 1988.

Tillage	Stand 4 wks.	Height 4 wks.	Height 8 wks.	Harv. Moist.	Yield @ 15½%
	ppa	in	in	%	bu/ac
Annual Paraplow, No-till	23,625	13.6ab*	34.8	30.1b	95.0
Biennial paraplow, No-till	24,437	13.9ab	34.2	29.4b	103.0
No-till	24,000	12.5b	29.8	32.9a	86.9
Annual Paraplow, Moldboard	23,437	16.2ab	38.2	25.7c	90.3
Biennual Paraplow, Moldboard	22,687	17.6a	37.7	25.8c	98.6
Moldboard	23,500	17.9a	39.3	26.1c	93.8
ANOV sig. level	NS	.05	NS	.01	NS

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

DAVIS PAC T BY 2000 DEMONSTRATIONS

This non-replicated tillage comparison on the high clay soils of East-central Indiana crossed 3 different soil types following clover sod. On the Glynwood silt loam (2% slope), no-till corn yield was reduced, but on erodible Morley silty clay loam (10% slope) and depressional Pewamo silty clay loam, no-till yields were better than yields with plowing, chiseling or disking.

Most interesting, were yields on the Pewamo. No-till is often not competitive on this poorly drained, depressional soil, but it had the best corn yields in 1988. Apparently no-till corn roots were able to key up with the receding moisture in the well structured soil following clover sod.

Soybean tillage demonstrations at this same site were not harvestable due to poor stands, poor weed control, drouth stress and spider mite damage. These demonstrations will be maintained in 1989 in corn/bean rotation.

Table 15. Corn response to tillage by soil, corn following clover sod, T by 2000, Davis PAC, 1988.

Soil	Tillage	Stand 4 wks.	Height 4 wks.	Harv. Moist.	Yield @ 15½%
		ppa	in	%	bu/ac
Glynwood silt loam, 2% slope	Spring plow	24,750	9.3	25.3	130.3
	Spring chisel	24,680	7.0	26.9	108.0
	Spring disk	24,000	17.0	20.1	81.9
	No-till	21,000	7.0	35.3	86.2
Morley silty clay loam, 10% slope	Spring plow	6,250	3.3	34.7	45.1
	Spring chisel	20,750	4.0	32.3	46.1
	Spring disk	25,500	6.5	31.8	33.9
	No-till	24,250	4.8	35.8	58.4
Pewamo silty clay loam, <1% slope	Spring plow	15,500	3.3	29.1	145.6
	Spring chisel	26,000	6.8	27.8	148.1
	Spring disk	24,000	9.5	25.9	119.7
	No-till	25,250	11.5	25.4	160.8

WHITLEY CO. T BY 2000 DEMONSTRATION

This was a replicated (3x) trial with 3 tillage systems for corn and beans for 1989 only. Although no-till corn was severely stressed until mid-July, it produced the best yield on this 8% slope Morey silt loam. Soybean stand and weed control was too variable to determine accurate response to tillage.

Table 16. Corn response to tillage, continuous corn, T by 2000, Whitely Co., 1988[a/]

Tillage	4 weeks Stand ppa	4 weeks Height inches	8 weeks Height inches	Harv. Moist. %	Bu/ac @15½%	Residue cover on 5/27 %
Sp. plow	25,875	9.4	39.0	32.4	76.3	14
Sp. chisel	26,500	10.3	49.9	29.6	92.4	32
No-till	25,625	8.9	42.0	31.8	114.5	65

[a/]Average of reps I and III.
Stand and weeds were variable in rep II.

Corn planted 5/11 and harvested 10/27.
Hybrid - Dekalb?
Starter fertilizer 113 #/A 18-46-0.

Herbicides:	Atrazine	2 pt/ac
	Bladex	2 pt/ac
	Lasso	2 qt/ac
Insecticide:	Counter	9 lbs/ac

Table 17. Rainfall and Growing Degree Days from Planting to Maturity, 3 locations, corn, 1988.

	Agronomy Farm Becks 65X (2723)			SEPAC Pioneer 3184 (2860)			Davis PAC Pioneer 3352 (2755)		
Week ending	Planting & Maturity* Dates	Rain (inches)	GDD	Planting & Maturity Dates	Rain (inches)	GDD	Planting & Maturity Dates	Rain (inches)	GDD
	4-26								
5-2		.15	56						
5-9		.29	101	5-3	.32	82	5-5	.09	88
5-16		.21	115		.66	121		.25	107
5-23		.24	122		.58	110		.93	109
5-31		.19	113		.46	100		.17	93
6-6		.00	136		.00	126		.00	129
6-13		.12	132		.19	119		.40	121
6-20		.00	166		.22	150		.17	159
6-27		.00	180		.03	183		.00	180
7-5		.13	116		.00	135		.10	119
7-11		1.03	187		.27	188		.37	184
7-18		.06	198		.67	189		.14	189
7-25		2.38	158		2.77	163		3.12	159
8-1		.59	178		.17	173		.89	169
8-8		1.65	193		3.16	183		.52	194
8-15		.35	210		.01	193		.30	199
8-22		.41	183		.23	184		.10	170
8-29		.17	128		.83	131		1.44	123
9-4	9-4	.96	121		1.59	117		.95	114
9-12					.03	100		.00	98
9-19					1.22	138	9-19	1.49	128
9-26				9-21	.96	129			
Total		8.93	2793		14.37	3014		11.43	2832

*Maturity = black layer formation.

LOG OF FIELD ACTIVITIES - 1988

March	29	SEPAC-Hauled directed sprayer back to AF.
	30	Davis PAC-Hauled paraplow back to AF.
April	5	Af-calibrate J.D. Max Emerge planter
	7	Whitley Co.-lay out T by 2000 plots
	12	AF Diagnostic Center-planted corn for ICI demonstration.
	13	AF Diagnostic Center-planted corn for ICI demonstration.
	14	AF Diagnostic Center-planted corn in conventional till plots.
	18	AF-Applied NH3 on tillage corn (250 lbs N/ac) and strip corn (140 lbs N/ac).
	19	AF-Applied NH3 on paraplow corn (250 lbs N/ac).
	20	AF-Planted strip corn.
	21	Throckmorton PAC-Applied NH3 on erosion study at 150 lbs N/ac.
	25	AF-Disc and field cultivate tillage corn and paraplow corn.
	26	AF-Planted tillage corn, paraplow corn and Harm's corn in the Diagnostic Center.
May	3	SEPAC-Planted tillage corn.
	4	SEPAC-Planted paraplow corn and tillage soybeans.
	5	Davis PAC-Planted E. Kladivko's corn and soybeans. Planted paraplow corn.
	10	Davis PAC-Planted T by 2000 corn and ridge soybeans.
	11	Whitley Co.-Planted T by 2000 corn and Mengels corn.
	12	AF-Planted west 8 rows of tillage soybean plots.
	13	Diagnostic Center-Planted soybeans. AF-Planted Abney's 4 rows of tillage soybeans and all strip soybeans.
	16	Throckmorton PAC-Flagged, staked and tilled in erosion plots for S. Livingston.
	17	Throckmorton PAC-Plant corn and soybeans in erosion plots.
	18	AF-Strip corn 4 weeks stand and height.
	23	Pinney PAC-Haul T. Bauman's tractor and planter to AF
	25	AF-Trim plots
	26	AF-Sprayed Basagran (1.5 pts + 2.0 pts COC) paraplow corn.
	27	AF-Tillage corn and paraplow corn 4 weeks stand and height.
	31	AF-Sprayed Basagran on tillage and strip corn.
June	1	AF-Sidedressed strip corn 60 lbs N/ac.
	2	SEPAC-Tillage and paraplow corn and soybeans 4 weeks stand and height.
	3	SEPAC-sidedressed paraplow corn 180 lbs N/ac.
	7	Davis PAC-T by 2000 stand and height. Spray 3 plots for dandelions by hand.
	8	Whitley Co.-T by 2000 4 weeks stand and height.
	9	AF-Tillage soybean 4 weeks stand and height. Cultivated tillage and paraplow corn with T. Bauman's danish-tine cultivator.
	10	Throckmorton PAC-Replant 1/2 of corn and soybeans in erosion study.
	13	AF-Ridge strip corn.
	15	Davis PAC-Sidedress NH3, 150 lbs N/ac, on paraplow, T by 2000

		and E. Kladivko's.
	17	AF-Ridged tillage corn after soybeans.
	23	AF-Field Day.
	24	AF-Ridged tillage c/c.
	27	AF-Tillage and paraplow corn 8 weeks height.
July	1	Davis PAC-8 week paraplow height.
	5	AF-Tillage soybean 8 weeks height.
	6	SEPAC-8 weeks height tillage corn, paraplow corn and tillage soybeans.
	7	SEPAC-Ridged corn/soybeans.
	8	Davis PAC-pick up tractor and ridger. Gordon ridged E. Kladivko's? T by 2000 8 weeks corn height.
	11	Throckmorton PAC-Ridge 1st planting corn, cultivate corn and soybeans.
	12	AF-Sprayed tillage and strip beans for spider mites. Dimethylate 4EC 1 pt/ac at 25 gal. water/ac and 50 psi.
	14	Whitley Co.-T by 2000 8 week corn height.
	22	AF-Sprayed tillage soybeans with 2,4DB for morningglory at 1 1/2 pts/ac, 30 psi and 26 gal. water/ac.
	26	Throckmorton PAC-Ridge 1st plant soybeans, 2nd plant corn. Cultivate all beans except no-till.
August	3	Throckmorton PAC-Ronnie Blankenship sprayed for spider mites.
	11	Randolf Co. Field Day-Hauled paraplow.
	15	Throckmorton PAC-Ridged replant soybeans.
	26	AF-Paratill tryout.
September	22, 25, 26, 27, 28, 29, and 30	AF-Harvest in strip corn.
	25	AF-Harvest tillage soybeans.
	30	AF-Glean soybeans.
October	4	SEPAC-Harvest tillage soybeans by hand and using Entomology's green thresher.
	7	AF-Harvest tillage corn and paraplow corn.
	11	David PAC-Harvest paraplow corn. SEPAC-Harvest paraplow corn.
	12	SEPAC-Harvest tillage corn.
	13	SEPAC-Fall chisel in paraplow and tillage.
	13-14	AF-Spread P&K on tillage and paraplow. Gandy setting = 75.
	20	Davis PAC-Harvest T by 2000 corn.
	26	SEPAC-Paratilled annuals and biennial plots.
	27	Davis PAC-Paratilled annuals and Biennial plots. Whitley Co.-Harvest T by 2000 corn.
	31	AF-Harvest Steinhardt's compaction plots.
November	1	AF-Ridge soybean plots in tillage and strip.
	2	AF-Paratill in paratill study. 8 of 12 rows. Paratill in tillage study - west 4 rows of all plots.
	3	AF-Chisel in tillage study. Moldboard plow in tillage study.

December	1	AF-Finished paratilling in Paratill Study. Moldboard plowed in Paratill Study.
	7	Davis PAC-Spread P&K on E. Kladivko's and on the Paraplow Study. Ridged after soybeans in E. Kladivko's and T by 2000.