TILLAGE EFFECTS ON WINTER AND SPRING WHEAT, BARLEY, AND SOYBEAN PRODUCTION ON THE LACUSTRINE SOILS OF NORTHWESTERN MINNESOTA

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In an effort to evaluate the production of winter and spring wheat, barley, and soybeans on the poorly drained soils (Aquolls) of the Red River Valley in northwestern Minnesota plots were established in 1986 in Norman County, Minnesota. The soil at this site is a complex of Fargo-Hegne silty clay (table 1). The rotation followed is wheat (plots are split between winter and spring wheat), soybeans, and barley.
Soil test results for barley following soybeans are shown in table 2. Tillage affected soil mineral nitrogen in the barley plots. There was less mineral N in the 6 to 24 inch depth increment without tillage. This suggests that there was more mineralization of soil nitrogen in the fall and spring following primary tillage or more losses without tillage. When wheat followed barley (table 3) similar trends were present but not statistically significant.

Soil cover by crop residue is shown in table 2. The soil cover left following planting when winter wheat followed barley was adequate for erosion control with the no till and chisel plowing systems. When spring secondary tillage was done on chisel plowed plots for spring wheat, the soil cover was less than desirable levels for adequate erosion control. Barley followed soybeans and had adequate cover on only the no till treatment. Soybeans followed wheat and again had less than adequate cover on all except the no till treatment.

Statistical analysis suggests that tillage only affected plant population of barley grown after soybeans. Winter wheat stands were quite variable and reduced within no tillage plots. This was most likely due to an open winter and shallow planting in no till plots. Winter wheat did not have the benefit of "snow catch" due to barley stubble to provide insulation. The growth of the Roughrider wheat was less variable than the Bighorn and influenced by tillage (table 4). The Marshall spring wheat advanced less quickly than the Stoa. Barley and soybeans tended to grow slower with conservation tillage but differences were not statistically significant.

The effect of tillage and crop on weed density by species is shown in tables 7 to 17. The major weeds in the soybeans following wheat were foxtail, mustard, and volunteer wheat. Chisel plowing resulted in higher levels of foxtail. Mustard was higher in the chisel and moldboard plowed plots. These data were collected before applying post emergence broadleaf and grass herbicides. There were very few weeds at harvest and did not affect soybean yields.

Barley following soybeans had higher levels of volunteer soybeans in chisel plowed plots. There were low levels of weeds in barley plots and they did not affect yields.

There were significant effects of tillage on weed densities in winter wheat (tables 9 and 10). Mustard and buckwheat were higher in moldboard plowed plots. No till plots had higher levels of curlydock. No till and chisel plowed plots had higher levels of foxtail.

Spring wheat showed higher levels of pigweed in chisel plowed plots. The effect of tillage on the appearance of foxtail was similar to the winter wheats. There were winter wheat varietal effects on buckwheat, mustard, dandelions, and pigweed (table 13). This was a result of less competition due to shorter straw, tillage effects on weed seed distribution, and less wheat stand depending on the weed species. Pigweed were present in higher numbers in chisel plowed plots with Stoa spring wheat but higher with Marshall spring wheat in moldboard plowed plots (table 14).

Winter and spring wheats are compared in table 15. Winter wheat had higher densities of foxtail, mustard, buckwheat, lambquarters, and cockle. There was also a significant tillage by crop (winter vs. spring wheat) interaction on mustard density. Higher densities were found with chisel and moldboard plowing for winter wheat production. Tall and short wheat varietal comparisons are shown in table 16. Buckwheat

competed better in short wheat. Over all varieties of wheat foxtail densities were higher with less tillage (table 17). Mustard had higher densities with more tillage.

Wheat plots were split with a fungicide application. Ratings for leaf lesions are shown in tables 18 and 19. Significance values from the analysis of variance are shown in table 20. There were no significant effects of tillage on leaf diseases in either winter or spring wheat. Fungicide application reduced disease ratings at all times of observation. There was a greater response to fungicide application by the Stoa spring wheat over the Marshall at the June 27 observation. There was an interaction on the July 13 observation of spring wheat between tillage, variety, and fungicide application (table 18). There was generally more of a response by the Stoa wheat and varietal effects were reversed in the chisel plowed treatments.

Grain yields are shown in tables 21 to 23. Statistical significance of treatments are shown in table 24. Tillage affected winter wheat yields but not spring wheat yields (table 22). Winter wheat yields were five bushels per acre lower when grown without tillage. This yield reduction is due to reduced stand and the subsequent increase in weed pressure rather than disease problems. This is also the explanation for the tillage by winter wheat variety interaction.

There was more stand loss due to no tillage in the Bighorn plots and subsequent competition by buckwheat (table 13). There was a trend of a yield increase with less tillage with spring wheat. This is due to less mature wheat (as evidenced by harvest moisture-table 25) at the time of a severe hail storm that resulted in less loss due to broken stems (on July 21).

There was a significant response to fungicide application (7.4 bu/acre) by winter wheat but not spring wheat (table 21). The response was greater in the conservation tillage systems by the Roughrider but not affected by tillage in the Bighorn plots. The Bighorn also responded much more to fungicide application than the Roughrider.

Grain test weights are shown in tables 28 to 30. There were significant tillage, varietal and interactions on test weights in winter wheat. Unlike the Bighorn winter wheat, Roughrider had a higher test weight and was not affected by tillage.

Grain protein data is presented in tables 31 to 34 for wheat. Similar mirror images of treatment yield responses by protein occurred due to a dilution affect of increased yields.

Barley data are shown in table 35. Yields, moisture, protein, and test weight of barley grown after soybeans were not affected by tillage.

Soybean data are shown in table 36. Yields and moisture of soybeans following wheat were also not affected by tillage. This has been consistent in Minnesota research.

Table 1. Cultural practices at Norman County, MN. 1987.

Tillage

No Till-the soybean and barley plots were dragged in spring.
Chisel Plow-fall
Moldboard Plow-fall
The spring seeded chisel and moldboard plow treatments were field cultivated twice with a drag behind it before seeding.

Preceding Crop 1985-Spring Wheat, 1986-start of three year (wheat, barley, soybean) rotation.

1987 Crops

Winter wheat - Bighorn
- Roughrider
Spring wheat - Marshall
- Stoa
Barley - Robust
Soybeans - McCalls

Planting and Harvest Dates

A Haybuster No Till Disc Drill was used to plant all plots.

Crop	Planting Date	Planting Rate	Harvested
Winter wheat	Sept. 26, 1986	90 lbs/ac	July 29, 1987
Spring wheat	April 24, 1987	90 lbs/ac	July 29, 1987
Barley	April 24, 1987	96 lbs/ac	July 29, 1987
Soybeans	May 8, 1987	94 lbs/ac	Oct. 1, 1987

Soil

Fargo silty clay, 0 to 1 percent slopes (Vertic Haplaquolls, fine, montmorillonitic, frigid) on 50 percent of the plot and Hegne (Typic Calciaquolls, fine, frigid)-Fargo (Vertic Haplaquolls, fine, montmorillonitic, frigid) silty clays on the rest of the plot. Both soils are poorly drained.

Weed Control

Wheat	Chemical		Amount	Applied
Winter	Roundup		1.2 pt/ac	Sept. 9
	Hoelon	(tankmix)	3.0 pt/ac	June 3
	Buctril	"	1.0 pt/ac	"
	MCPA Ester	"	0.5 pt/ac	"
Spring	Hoelon	(tankmix)	3.0 pt/ac	June 3
	Buctril	"	1.0 pt/ac	"
	MCPA Ester	"	0.5 pt/ac	"
Soybeans	Brominal 3+3(no till)	(tankmix)	2.2 pt/ac	May 11
	Roundup "	"	1.4 pt/ac	"
	Poast	(tankmix)	1.5 pt/ac	June 6
	Herbimax Oil	"	2.0 pt/ac	"
	Basagran	(tankmix)	1.5 pt/ac	June 9
	Blazer	"	1.0 pt/ac	"
	Herbimax Oil	"	2.0 pt/ac	"
Barley	MCPA Ester		1.0 pt/ac	June 4

Fungicides

1st application: Diathane M45 at 2 lb/ac + 2 oz/ac sticker on June 16, 1987 with the Ada Co-op sprayer.

2nd application: Manzate 200 DF at 1.5 qt/ac with 7 gal/ac water on June 26, 1987 using a spray foil.

Fertilizer

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			----lb/ac----			
			No Till			
Winter wheat:	18-46-0[1]	137 lb/ac	25	63	0	Sept. 26, 1986
	46-0-0[2]	220 lb/ac	101	0	0	April 29, 1987
			Tilled			
	18-46-0[1]	137 lb/ac	25	63	0	Sept. 26, 1986
	46-0-0[2]	152 lb/ac	70	0	0	April 29, 1987
			No Till			
Spring wheat:	46-0-0[2]	220 lb/ac	101	0	0	April 24, 1987
	18-46-0[1]	100 lb/ac	18	46	0	April 29, 1987
			Tilled			
	46-0-0[2]	152 lb/ac	70	0	0	April 24, 1987
	18-46-0[1]	100 lb/ac	18	46	0	April 29, 1987
			No Till & Tilled			
Barley:	46-0-0[2]	175 lb/ac	81	0	0	April 24, 1987
	18-46-0[1]	100 lb/ac	18	46	0	April 29, 1987
			No Till & Tilled			
Soybeans:	18-46-0[1]	53 lb/ac	10	24	0	May 8, 1987

1. Drill applied.
2. Urea broadcast.

Soil Test

Table 2. Soil test results at Norman County barley sites on June 3, 1987.

Nutrient	Depth Inches	Sig. of Tillage	No Till mean	No Till stdev	Chisel mean	Chisel stdev	Moldboard mean	Moldboard stdev
			---------- lb/ac ----------					
NO_3	0-6	(.963)	35.9	21.8	31.5	10.1	34.4	14.6
	6-24	(.117)	62.1	32.1	133.6	4.3	118.4	58.5
	0-24	(.157)	98.0	12.3	165.2	6.0	152.8	65.6
NH_4	0-6	(.366)	16.2	7.1	8.2	5.3	9.1	4.9
	6-24	(.525)	32.7	8.4	38.3	12.1	30.0	2.8
	0-24	(.710)	48.9	13.1	46.5	17.0	39.0	5.2
NO_3+NH_4	0-6	(.822)	52.1	25.2	39.8	15.2	43.5	18.2
	6-24	(.100)	94.8	39.5	171.9	8.3	148.4	61.2
	0-24	(.224)	146.9	24.3	211.6	22.9	191.9	67.5
K	0-6	(.400)	664.4	51.7	628.7	74.2	584.5	81.2

Table 3. Soil test results at Norman County wheat sites on June 3, 1987.

		WINTER WHEAT							SPRING WHEAT					
			Tillage							Tillage				
			No Till		Chisel		Moldboard			No Till		Chisel		Moldboard
	Depth	Sig. of	mean	stdev	mean	stdev	mean	stdev	Sig. of	mean	stdev	mean	stdev	mean	stdev
Nutrient	Inch.	Tillage	lbs/ac						Tillage	lbs/ac					
NO_3	0-6	(.210)	24.9	2.5	50.2	3.8	38.5	25.5	(.489)	48.3	17.6	45.2	12.6	32.4	8.2
	6-24	(.843)	79.4	39.9	102.4	27.0	82.5	61.5	(.706)	103.3	16.2	89.2	56.0	78.6	24.1
	0-24	(.657)	104.3	38.4	152.6	27.4	120.9	86.9	(.636)	151.6	30.1	134.4	68.3	111.0	30.4
NH_4	0-6	(.324)	8.8	3.2	11.9	1.4	10.7	0.8	(.016)	11.8	0.3	11.9	0.7	10.2	0.9
	6-24	(.583)	21.3	7.7	28.3	4.1	25.2	6.8	(.874)	27.7	5.3	25.8	5.4	26.7	6.8
	0-24	(.314)	30.1	6.4	40.3	2.7	36.0	7.5	(.758)	39.5	5.1	37.6	5.0	37.0	6.0
NO_3+NH_4	0-6	(.190)	33.7	5.7	62.2	4.4	49.2	26.1	(.419)	60.1	17.9	57.1	11.8	42.6	7.4
	6-24	(.816)	100.7	47.5	130.7	30.9	107.7	68.2	(.711)	130.9	19.6	115.0	60.3	105.3	30.1
	0-24	(.617)	134.4	44.5	192.9	29.8	156.9	94.2	(.625)	191.0	31.1	172.1	71.7	148.0	36.1
K	0-6	(.048)	718.0	79.3	589.4	25.5	555.0	8.5	(.160)	616.2	56.5	594.3	17.0	540.3	45.0

Table 4. The effect of tillage on in-row an between-row soil cover on barley residue for wheat, soybean residue for barley and wheat residue for soybeans. For wheat and barley, data was collected on April 24, 1987; soybeans on May 8, 1987.

	IN-ROW RESIDUE						BETWEEN ROW RESIDUE					
	Tillage											
	No Till		Chisel		Moldboard		No Till		Chisel		Moldboard	
	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Crop-Variety	%						%					
Winter Wheat	n=12											
Bighorn	76.3	10.8	32.3	7.5	15.7	11.3	69.3	8.7	22.0	11.3	9.0	9.3
Roughrider	82.6	7.3	26.0	11.5	16.7	4.7	71.7	18.0	16.0	5.1	12.0	6.3
Spring Wheat	n=12											
Marshall	76.3	16.4	13.3	11.6	12.7	7.5	66.0	24.9	7.7	6.2	8.0	4.5
Stoa	66.3	15.8	10.3	4.9	14.7	11.4	62.3	12.2	9.0	5.1	9.7	7.9
Barley	n=18											
Robust	62.0	17.1	11.6	4.9	5.6	3.9	46.2	13.8	6.7	3.6	2.0	2.4
Soybeans	n=18											
McCalls	66.9	17.9	11.6	11.2	7.1	5.5	63.8	16.3	11.6	8.5	5.8	4.5

Table 5. The effect of tillage on plant population.

Crop-Variety	Sig. of Tillage	No Till mean	No Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
		------ plants/ac x 1000 -------					
Winter Wheat[1]	(.453)	n=6					
Bighorn		232	102	232	97	276	71
Roughrider		397	170	445	112	494	222
Spring Wheat[2]	(.312)	n=6					
Marshall		440	171	547	130	300	194
Stoa		281	124	368	190	436	197
Barley	(.058)	n=9					
Robust		716	132	807	157	891	164
Soybeans	(.864	n=18					
McCalls		180	83.6	168	51.0	178	54.7

1. The significance of variety was .000, and the variety x tillage interaction was .838.
2. The significance of variety was .240, and the variety x tillage interaction was .056.

Table 6. The effect of tillage on crop growth.

Crop-Variety	Sig. of Tillage	No Till mean	No Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
		----- Zadoks growth stage ----					
Winter Wheat[1]	(.000)	n=30					
Bighorn		45.0	5.3	46.6	3.0	45.1	5.1
Roughrider		44.0	2.3	46.1	2.3	49.7	3.4
Spring Wheat[2]	(.674)	n=30	--- Haun growth stage ---				
Marshall		3.49	.29	3.54	.53	3.40	.36
Stoa		3.74	.47	3.63	.62	3.85	.56
Barley	(.223)	n=45	--- Haun growth stage ---				
Robust		3.75	.69	3.80	.54	3.95	.48
Soybeans	(.214)	n=45	------ Node number ------				
McCalls		1.73	.44	1.73	.44	1.87	.34

1. The significance of variety was .022, and the variety x tillage interaction was .000.
2. The significance of variety was .001, and the variety x tillage interaction was .072.

Table 7. The effect of tillage on weeds in soybeans on June 3, 1987, n=6.

Weed	Sig. of Tillage[1]	No Till mean	No Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
		---------- % cover ----------					
Foxtail	(.061)	18.3	6.8	24.5	8.8	15.5	10.0
VolWheat	(.624)	2.5	1.8	2.5	1.0	1.9	1.4
Pigweed	(.078)	0.6	0.2	2.0	2.1	0.9	0.6
Ragweed	(.758)	0.1	0.2	0.1	0.2	0.2	0.3
Mustard	(.001)	0.7	0.3	2.9	1.8	4.8	3.3
Buckwheat	(.126)	0.3	0.3	0.5	0.0	0.3	0.3
Lambsquartr	--	0.0	0.0	0.1	0.2	0.1	0.2
Quackgrass	--	0.1	0.2	0.0	0.0	0.1	0.2

1. Due to unnatural variances, a natural log transformation was used for significance.

Table 8. The effect of tillage on weeds in barley on June 3, 1987, n=6.

Weed	Sig. of Tillage[1]	No Till mean	No Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
		---------- % cover ----------					
Foxtail	(.383)	2.7	1.4	1.9	1.0	2.2	0.8
VolSoybean	(.038)	1.2	1.9	2.7	1.2	1.5	0.8
Pigweed	--	0.4	0.2	0.3	0.3	0.0	0.0
Ragweed	(.475)	1.5	2.0	0.3	0.4	0.2	0.3
Mustard	(.211)	1.0	1.0	1.8	0.9	1.8	0.8
Buckwheat	(.223)	6.5	5.0	4.8	5.0	2.7	0.8
Lambsquartr	(.320)	0.3	0.3	0.6	0.7	0.4	0.2
Quackgrass	--	0.4	0.4	0.0	0.0	0.0	0.0
Dandelion	--	0.3	0.3	0.0	0.0	0.0	0.0
Curlydock	--	0.1	0.2	0.0	0.0	0.0	0.0
CommonRgwd	--	0.2	0.3	0.0	0.0	0.0	0.0
Smartweed	--	0.1	0.2	0.0	0.0	0.0	0.0

1. Due to unnatural variances, a natural log transformation was used for significance.

Table 9. The effect of tillage on weeds in Bighorn wheat on June 3, 1987, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage[1]	% cover					
Foxtail	(.114)	15.5	9.8	15.5	14.8	8.2	3.7
Pigweed	(.434)	0.5	0.5	1.4	1.1	1.0	0.5
Ragweed	--	0.0	0.0	0.0	0.0	0.1	0.2
Mustard	(.001)	0.7	0.7	2.0	2.5	6.3	4.2
Buckwheat	(.457)	22.0	21.7	11.7	2.9	15.7	4.1
Lambsqurtr	(.943)	1.8	2.2	1.4	1.3	1.3	1.9
Pennycress	(.639)	0.1	0.2	0.1	0.2	0.2	0.4
Quackgrass	--	0.3	0.5	0.0	0.0	0.0	0.0
Dandelion	--	0.6	0.2	0.0	0.0	0.1	0.2
Curlydock	(.213)	0.2	0.4	0.4	0.4	0.8	1.2
CommonRgwd	(.782)	0.3	0.3	0.3	0.3	0.3	0.3
Smartweed	--	0.0	0.0	0.2	0.4	0.2	0.4
Cockle	(.755)	1.0	2.0	3.5	6.6	1.2	0.9
Milkweed	(.234)	0.4	0.5	0.2	0.4	0.2	0.4

1. Due to unnatural variances, a natural log transformation was used for significance.

Table 10. The effect of tillage on weeds in Roughrider winter wheat on June 3, 1987 n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage[1]	% cover					
Foxtail	(.007)	17.3	12.3	8.0	3.7	3.8	1.8
Pigweed	(.306)	0.3	0.5	0.2	0.3	0.5	0.4
Ragweed	--	0.0	0.0	0.1	0.2	0.3	0.8
Mustard	(.149)	0.5	0.4	1.9	1.7	2.4	3.8
Buckwheat	(.092)	6.7	4.9	9.0	1.3	8.0	2.4
Lambsqurtr	(.136)	1.9	2.9	0.4	0.4	1.6	1.8
Pennycress	--	0.0	0.0	0.1	0.2	0.0	0.0
Quackgrass	--	0.1	0.2	0.0	0.0	0.0	0.0
Dandelion	--	0.3	0.3	0.0	0.0	0.0	0.0
Curlydock	(.087)	1.0	0.9	0.2	0.3	0.2	0.3
CommonRgwd	(.142)	0.3	0.3	0.2	0.4	0.1	0.2
Smartweed	--	0.2	0.3	0.0	0.0	0.0	0.0
Cockle	(.273)	0.9	0.9	2.8	1.5	1.5	2.7

1. Due to unnatural variances, a natural log transformation was used for significance.

Table 11. The effect of tillage on weeds in Marshall spring wheat on June 3, 1987, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage[1]	% cover					
Foxtail	(.002)	12.7	8.7	4.8	1.9	3.8	1.0
Pigweed	(.403)	0.4	0.5	0.7	0.8	1.1	1.6
Mustard	(.674)	0.2	0.3	0.8	0.6	0.8	0.4
Buckwheat	(.145)	3.7	3.2	1.9	1.0	2.7	1.0
Lambsqurtr	(.138)	0.8	1.6	0.2	0.3	0.1	0.2
Quackgrass	--	0.2	0.3	0.1	0.2	0.0	0.0
Dandelion	--	0.3	0.4	0.0	0.0	0.0	0.0
Curlydock	--	0.2	0.4	0.0	0.0	0.0	0.0
CommonRgwd	--	0.2	0.3	0.0	0.0	0.0	0.0
Smartweed	--	0.1	0.2	0.0	0.0	0.1	0.2
Cockle	(.465)	0.3	0.3	0.3	0.4	0.2	0.3

1. Due to unnatural variances, a natural log transformation was used for significance.

Table 12. The effect of tillage on weeds in Stoa spring wheat on June 3, 1987, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage[1]	% cover					
Foxtail	(.013)	14.3	10.2	8.3	3.0	4.7	2.3
Pigweed	(.084)	0.6	1.2	1.8	2.2	0.5	0.3
Ragweed	--	0.0	0.0	0.1	0.2	0.0	0.0
Mustard	(.578)	0.6	0.4	1.0	0.5	0.8	0.3
Buckwheat	(.694)	3.2	1.2	2.8	1.0	2.7	1.2
Lambsqurtr	--	0.3	0.3	0.0	0.0	0.0	0.0
Quackgrass	--	0.3	0.3	0.0	0.0	0.0	0.0
Dandelion	--	0.3	0.3	0.0	0.0	0.0	0.0
Curlydock	--	0.0	0.0	0.1	0.2	0.0	0.0
Smartweed	--	0.0	0.0	0.1	0.2	0.0	0.0
Cockle	--	0.2	0.3	0.4	0.2	0.0	0.0
Milkweed	--	0.3	0.4	0.0	0.0	0.0	0.0

1. Due to unnatural variances, a natural log transformation was used for significance.

Table 13. The effect of tillage, variety, and tillage by variety on weeds in winter wheat on June 3, 1987.

		Tillage							Variety			Tillage					
		No Till		Chisel		Moldboard						No Till		Chisel		Moldboard	
	Sig. of	mean	stdev	mean	stdev	mean	stdev	Sig. of	Bghn	Rrdr	Sig. of	Bghn	Rrdr	Bghn	Rrdr	Bghn	Rrdr
Weed	Tillage	n=12	-------	% cover		----------		Variety	n=18	% ---	TillxVar	n=6	-------	% cover		----------	
Foxtl	(.008)	16.4	10.6	11.8	11.0	6.0	3.6	(.189)	13.1	9.7	(.309)	15.5	17.3	15.5	8.0	8.2	3.8
Pigwd	(.339)	0.4	0.7	0.8	1.0	0.8	0.5	(.009)	1.0	0.3	(.150)	0.5	0.3	1.4	0.2	1.0	0.5
Ragwd	--	0.0	0.0	0.0	0.1	0.2	0.6	(.355)	0.0	0.1	--	0.0	0.0	0.0	0.1	0.1	0.3
Mustd	(.003)	0.6	0.3	2.0	2.1	4.4	4.3	(.097)	3.0	1.6	(.103)	0.7	0.5	2.0	1.9	6.3	2.4
Bckwt	(.550)	14.3	17.0	10.3	2.5	11.8	5.1	(.009)	16.4	7.9	(.239)	22.0	6.7	11.7	9.0	15.7	8.0
Lamqr	(.225)	1.8	2.5	0.9	1.0	1.5	1.8	(.649)	1.5	1.3	(.414)	1.8	1.9	1.4	0.4	1.3	1.6
Prycs	(.878)	0.0	0.1	0.1	0.2	0.1	0.3	(.289)	0.1	0.0	--	0.1	0.0	0.1	0.1	0.2	0.0
Qukgs	--	0.2	0.4	0.0	0.0	0.0	0.0	(.177)	0.1	0.0	--	0.3	0.1	0.0	0.0	0.0	0.0
Dndln	--	0.5	0.3	0.0	0.0	0.0	0.1	(.043)	0.2	0.1	--	0.6	0.3	0.0	0.0	0.1	0.0
Crlyd	(.461)	0.6	0.8	0.3	0.3	0.5	0.7	(1.00)	0.4	0.4	(.015)	0.2	1.0	0.4	0.2	0.8	0.2
CRgwd	(.914)	0.3	0.3	0.2	0.3	0.2	0.3	(.242)	0.3	0.2	(.541)	0.3	0.3	0.3	0.2	0.3	0.1
Smtwd	(1.00)	0.1	0.2	0.1	0.3	0.1	0.3	(.522)	0.1	0.1	--	0.0	0.2	0.2	0.0	0.2	0.0
Cockl	(.268)	1.0	1.5	3.1	4.6	1.3	1.9	(.863)	1.9	1.7	(.924)	1.1	0.9	3.5	2.8	1.2	1.5
Mlkwd	(.734)	0.2	0.4	0.1	0.3	0.2	0.6	--	0.3	0.0	--	0.4	0.0	0.2	0.0	0.3	0.0

Table 14. The effect of tillage, variety, and tillage by variety on weeds in spring wheat on June 3, 1987.

		Tillage							Variety			Tillage					
		No Till		Chisel		Moldboard						No Till		Chisel		Moldboard	
	Sig. of	mean	stdev	mean	stdev	mean	stdev	Sig. of	Mars	Stoa	Sig. of	Mars	Stoa	Mars	Stoa	Mars	Stoa
Weed	Tillage	n=12	-------	% cover		----------		Variety	n=18	% ---	TillxVar	n=6	-------	% cover		----------	
Foxtl	(.001)	13.5	9.0	6.6	3.0	4.3	3.0	(.294)	7.1	9.1	(.837)	12.7	14.3	4.8	8.3	3.8	4.7
Pigwd	(.176)	0.5	0.9	1.2	1.6	0.8	1.2	(.466)	0.7	0.9	(.098)	0.4	0.6	0.7	1.8	1.1	0.5
Ragwd	--	0.0	0.0	0.0	0.1	0.0	0.0	--	0.0	0.0	--	0.0	0.0	0.0	0.1	0.0	0.0
Mustd	(.021)	0.4	0.4	0.9	0.6	0.8	0.3	(.206)	0.6	0.8	(.527)	0.2	0.6	0.8	1.0	0.8	0.8
Bckwt	(.193)	3.4	2.3	2.4	1.1	2.7	1.1	(.768)	2.8	2.9	(.465)	3.7	3.2	1.9	2.8	2.7	2.7
Lamqr	(.158)	0.5	1.1	0.1	0.2	0.0	0.1	(.232)	0.4	0.1	--	0.8	0.3	0.2	0.0	0.1	0.0
Qukgs	--	0.3	0.3	0.0	0.1	0.0	0.0	(.644)	0.1	0.1	--	0.2	0.3	0.1	0.0	0.0	0.0
Dndln	--	0.3	0.3	0.0	0.0	0.0	0.0	(.633)	0.1	0.1	--	0.3	0.3	0.0	0.0	0.0	0.0
Crlyd	--	0.1	0.3	0.0	0.1	0.0	0.0	(.653)	0.1	0.0	--	0.2	0.0	0.0	0.1	0.0	0.0
CRgwd	--	0.1	0.2	0.0	0.0	0.0	0.0	--	0.1	0.0	--	0.2	0.0	0.0	0.0	0.0	0.0
Smtwd	(1.00)	0.0	0.1	0.0	0.1	0.0	0.1	(.581)	0.1	0.0	--	0.1	0.0	0.0	0.1	0.1	0.0
Cockl	(.105)	0.2	0.3	0.3	0.3	0.1	0.2	(.764)	0.2	0.2	--	0.3	0.2	0.3	0.4	0.2	0.0
Mlkwd	--	0.1	0.3	0.0	0.0	0.0	0.0	--	0.0	0.1	--	0.0	0.3	0.0	0.0	0.0	0.0

Table 15. The effect of crop (winter wheat by spring wheat) and crop by tillage interaction on weeds on June 3, 1987.

		Crop			Tillage					
					No Till		Chisel		Moldboard	
	Sig. of	Wint	Sprg	Sig. of	Wint	Sprg	Wint	Sprg	Wint	Sprg
Weed	Crop	n=36- % cover -		Tillxcrop	n=12 --------- % cover ----------					
Foxtail	(.032)	11.4	8.1	(.637)	16.4	13.5	11.8	6.6	6.0	4.3
Pigweed	(.448)	0.7	0.8	(.738)	0.4	0.5	0.8	1.2	0.8	0.8
Ragweed	(.251)	0.1	0.0	--	0.0	0.0	0.0	0.0	0.2	0.0
Mustard	(.001)	2.3	0.7	(.008)	0.6	0.4	2.0	0.9	4.4	0.8
Buckwheat	(.000)	12.2	2.8	(.795)	14.3	3.4	10.3	2.4	11.8	2.7
Lambquarters	(.000)	1.4	0.2	(.624)	1.8	0.5	0.9	0.1	1.5	0.0
Pennycress	--	0.1	0.0	--	0.0	0.0	0.1	0.0	0.1	0.0
Quackgrass	(.538)	0.1	0.1	--	0.2	0.3	0.0	0.0	0.0	0.0
Dandelion	(.112)	0.2	0.1	--	0.5	0.3	0.0	0.0	0.0	0.0
Curlydock	(.001)	0.4	0.0	--	0.6	0.1	0.3	0.0	0.5	0.0
CommonRagweed	(.000)	0.2	0.0	--	0.3	0.1	0.2	0.0	0.2	0.0
Smartweed	(.408)	0.1	0.0	(.598)	0.1	0.0	0.1	0.0	0.1	0.0
Cockle	(.002)	1.8	0.2	(.246)	1.0	0.2	3.1	0.3	1.3	0.1
Milkweed	(.154)	0.2	0.0	--	0.2	0.1	0.1	0.0	0.2	0.0

Table 16. The effect of tall wheat varieties (Roughrider and Stoa) by short wheat varieties (Bighorn and Marshall) and tall by short varieties by tillage on weeds on June 3, 1987.

		Height			Tillage					
					No Till		Chisel		Moldboard	
	Sig. of	Short	Tall	Sig. of	Short	Tall	Short	Tall	Short	Tall
Weed	Height	n=36 % cover -		TillxHigh	n=12------- % cover ----------					
Foxtail	(.676)	10.1	9.5	(.563)	14.1	15.0	10.2	8.2	6.0	4.3
Pigweed	(.362)	0.9	0.6	(.580)	0.5	0.5	1.0	1.0	1.0	0.5
Ragweed	(.246)	0.0	0.1	--	0.0	0.0	0.0	0.1	0.0	0.2
Mustard	(.256)	1.8	1.2	(.185)	0.4	0.6	1.4	1.5	3.5	1.6
Buckwheat	(.044)	9.6	5.4	(.374)	12.8	4.9	6.8	5.9	9.2	5.3
Lambquarters	(.449)	0.9	0.7	(.680)	1.3	1.1	0.8	0.2	0.7	0.8
Pennycress	(.270)	0.1	0.0	--	0.0	0.0	0.0	0.0	1.0	0.0
Quackgrass	(.521)	0.1	0.1	--	0.3	0.2	0.0	0.0	0.0	0.0
Dandelion	(.127)	0.2	0.1	--	0.5	0.3	0.0	0.0	0.0	0.0
Curlydock	(.910)	0.3	0.2	(.116)	0.2	0.5	0.2	0.1	0.4	0.1
CommonRagweed	(.147)	0.2	0.1	(.836)	0.2	0.1	0.1	0.1	0.2	0.0
Smartweed	(.396)	0.1	0.0	--	0.0	0.1	0.1	0.0	0.1	0.0
Cockle	(.845)	1.1	1.0	(.964)	0.7	0.5	1.9	1.6	0.7	0.8
Milkweed	(.407)	0.2	0.0	--	0.2	0.1	0.1	0.0	0.2	0.0

Table 17. The effect of tillage on weeds of wheats (overall), n=24.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	stdev	mean	stdev	mean	stdev
Weed	Tillage	% cover					
Foxtail	(.000)	15.0	9.8	9.2	8.3	5.1	2.9
Pigweed	(.180)	0.5	0.8	1.0	1.3	0.8	0.9
Ragweed	--	0.0	0.0	0.4	0.1	0.1	0.4
Mustard	(.002)	0.5	0.4	1.4	1.6	2.6	3.5
Buckwheat	(.511)	8.9	13.1	6.4	4.5	7.3	5.9
Lamquarters	(.096)	1.2	2.0	0.5	0.8	0.8	1.4
Pennycress	(.861)	0.2	0.1	0.0	0.1	0.0	0.2
Quackgrass	--	0.2	0.3	0.0	0.1	0.0	0.0
Dandelion	--	0.4	0.3	0.0	0.0	0.0	0.1
Curlydock	(.516)	0.3	0.6	0.2	0.3	0.2	0.6
CommonRagweed	(.510)	0.2	0.2	0.1	0.3	0.1	0.2
Smartweed	(1.00)	0.1	0.2	0.1	0.2	0.1	0.2
Cockle	(.142)	0.6	1.1	1.7	3.5	0.7	1.5
Milkweed	(.407)	0.2	0.4	0.0	0.2	0.1	0.4

Table 18. The effect of tillage on disease in wheat on June 27, 1987.

	Tillage								
	No Till		Chisel		Moldboard		Variety	Fungicide n=9	
	fung	noFung	fung	noFung	fung	noFung	Avg n=18	fung	noFung
Crop-Variety n=3	Hosford Scale								
Bighorn	5.33	7.33	6.00	6.67	6.33	7.67	6.56	5.89	7.22
Roughrider	6.87	8.00	6.33	7.00	6.67	7.33	7.00	6.56	7.44
average n=6	6.00	7.67	6.17	6.83	6.50	7.50			
Overall n=12	6.83		6.50		7.00		n=18	6.22	7.33
Marshall	2.33	4.33	2.33	2.67	2.33	4.67	3.11	2.33	3.89
Stoa	1.67	2.00	1.67	4.00	2.00	3.33	2.44	1.78	3.11
average	2.00	3.17	2.00	3.33	2.17	4.00			
Overall	2.58		2.67		3.08			2.06	3.50

Table 19. The effect of tillage on disease in spring wheat on July 13, 1987.

	Tillage								
	No Till		Chisel		Moldboard		Variety	Fungicide n=9	
	fung	noFung	fung	noFung	fung	noFung	Avg n=18	fung	noFung
Crop-Variety n=3	Hosford Scale								
Marshall	5.17	7.17	4.83	7.17	5.50	6.33	6.03	5.17	6.89
Stoa	5.33	7.67	6.00	7.83	5.33	6.83	6.50	5.56	7.44
average n=6	5.25	7.42	5.42	7.50	5.42	6.58			
Overall n=12	6.33		6.46		6.00		n=18	5.37	7.17

Table 20. The significance of tillage, fungicide, variety and the interactions on wheat yields.

Wheat	Date	Till.	Fung.	Var.	Till x Fung	Till x Var	Var x Fung	Till x Fung x Var
		significance						
Winter	6-27	.524	.021	.189	.438	.383	.431	.816
Spring	6-27	.514	.005	.021	.871	.150	.827	.075
Spring	7-13	.548	.005	.221	.455	.647	.811	.768

Table 21. The effect of fungicide on the yields of wheat. The effects of tillage are averaged over fungicide, n=9.

	Fungicide			
	fung		no fung	
	mean	stdev	mean	stdev
Crop-Variety	bu/ac			
Winter wheat				
Bighorn	41.1	10.1	29.8	11.7
Roughrider	40.5	6.0	37.0	7.3
average	40.8		33.4	
Spring wheat				
Marshall	43.1	5.8	40.4	7.3
Stoa	31.2	8.9	31.4	4.6
average	37.1		35.9	

Table 22. The effect of tillage on the yields of wheat. The effect of fungicide are averaged over tillage, n=6.

	Tillage						
	No Till		Chisel		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Crop-Variety	bu/ac						
Winter wheat							
Bighorn	23.4	11.1	38.6	7.0	44.4	6.5	35.5
Roughrider	32.5	7.0	40.6	5.0	43.1	3.1	38.7
average	27.9		39.6		43.7		
Spring wheat							
Marshall	43.6	6.9	40.7	9.3	41.0	1.8	41.8
Stoa	33.3	5.8	32.1	8.9	28.5	5.9	31.3
average	38.5		36.4		34.7		

Table 23. The effect of tillage and fungicide on the yields of wheat, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	fung	no fung	fung	no fung	fung	no fung
Crop-Variety	bu/ac					
Winter wheat						
Bighorn	29.7	17.0	44.2	33.0	49.4	39.4
Roughrider	34.8	30.1	44.3	36.8	42.2	43.9
Spring wheat						
Marshall	46.7	40.6	41.0	40.4	41.7	40.3
Stoa	33.4	33.1	34.2	30.0	25.9	31.1

Table 24. The significance of tillage, fungicide, variety and the interactions on wheat yields.

Wheat	Till.	Fung.	Var.	Till x Fung	Till x Var	Var x Fung	Till x Fung x Var
	significance						
Winter	.004	.013	.056	.206	.066	.064	.449
Spring	.292	.709	.004	.410	.512	.353	.450

Table 25. The effect of tillage on the moisture of wheat at harvest. The effect of fungicide are averaged over tillage, n=6.

	Tillage						
	No Till		Chisel		Moldboard		
	mean	stdv	mean	stdv	mean	stdv	Avg
Crop-Varty	%						
Winter wht							
Bighorn	12.0	4.25	7.7	1.28	9.1	1.80	9.6
Roughrider	8.8	2.20	7.1	1.66	6.4	2.25	7.4
average	10.4		7.4		7.8		
Spring wht							
Marshall	18.2	3.87	14.5	2.48	15.6	3.58	1.61
Stoa	13.6	7.96	12.7	2.69	11.5	1.48	1.26
average	15.9		13.6		13.6		

Table 26. The effect of tillage and fungicide on the moisture of wheat at harvest, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	fung	no fung	fung	no fung	fung	no fung
Crop-Varty	%					
Winter wht						
Bighorn	9.26	14.76	6.88	8.51	7.73	10.38
Roughrider	7.96	9.67	7.02	7.09	7.75	5.05
Spring wht						
Marshall	20.36	16.09	12.41	16.55	16.82	14.33
Stoa	17.13	10.11	12.63	12.67	11.43	11.63

Table 27. The significance of tillage, fungicide, variety and the interactions on wheat moisture at harvest.

Wheat	Till.	Fung.	Var.	Till x Fung	Till x Var	Var x Fung	Till x Fung x Var
	significance						
Winter	.099	.383	.057	.317	.506	.101	.434
Spring	.684	.376	.092	.288	.686	.684	.623

Table 28. The effect of fungicide on the test weight of wheat at harvest. The effects of tillage are averaged over fungicide, n=9.

	Fungicide			
	fung		no fung	
	mean	stdev	mean	stdev
Crop-Variety	lb/bu			
Winter wheat				
Bighorn	56.9	2.01	54.6	3.02
Roughrider	60.1	0.55	58.8	0.43
average	58.5		56.7	
Spring wheat				
Marshall	59.3	1.12	58.8	1.56
Stoa	58.0	1.27	56.9	2.35
average	59.1		54.4	

Table 29. The effect of tillage on the test weight of wheat at harvest. The effects of fungicide are averaged over tillage, n=6.

	Tillage						
	No Till		Chisel		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Crop-Variety	lb/bu						
Winter wheat							
Bighorn	53.2	2.99	56.8	1.57	57.3	1.64	55.8
Roughrider	59.7	0.98	59.1	0.74	59.7	0.68	59.5
average	56.4		58.0		58.5		
Spring wheat							
Marshall	58.3	1.41	59.8	1.41	59.2	0.98	59.1
Stoa	56.9	2.27	57.8	2.27	57.7	1.32	57.4
average	57.6		58.8		58.4		

Table 30. The significance of tillage, fungicide, variety and the interactions on wheat test weights at harvest.

Wheat	Till.	Fung.	Var.	Till x Fung	Till x Var
	significance				
Winter	.035	.013	.001	.501	.024
Spring	.195	.122	.021	.938	.830

Table 31. The effect of fungicide on the protein content of wheat at harvest. The effects of tillage are averaged over fungicide, n=9.

	Fungicide			
	fung		no fung	
	mean	stdev	mean	stdev
Crop-Variety	%			
Winter wheat				
Bighorn	12.0	1.14	12.3	1.58
Roughrider	12.9	0.69	12.8	0.72
Spring wheat				
Marshall	13.3	0.83	13.3	0.91
Stoa	14.3	0.87	14.5	0.89

Table 32. The effect of tillage on the protein content of wheat at harvest. The effect of fungicide are averaged over tillage, n=6.

	Tillage						
	No Till		Chisel		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Crop-Variety	%						
Winter wheat							
Bighorn	13.0	1.20	11.5	0.87	11.9	1.61	12.2
Roughrider	13.0	0.47	12.4	0.62	13.1	0.84	12.8
average	13.0		12.0		12.5		
Spring wheat							
Marshall	13.5	0.66	13.5	1.25	13.0	0.54	13.3
Stoa	14.6	1.09	14.0	0.80	14.5	0.71	14.4
average	14.4		13.8		13.8		

Table 33. The effect of tillage and fungicide on the protein content of wheat at harvest, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	fung	no fung	fung	no fung	fung	no fung
Crop-Variety	%					
Winter wheat						
Bighorn	12.4	13.6	11.4	11.7	12.3	11.6
Roughrider	13.0	13.1	12.8	12.1	13.0	13.2
average	12.7	13.4	12.1	11.9	12.6	12.4
Spring wheat						
Marshall	13.7	13.3	13.4	13.5	12.8	13.3
Stoa	14.1	15.0	14.3	13.8	14.4	14.7
average	13.9	14.2	13.9	13.7	13.6	14.0

Table 34. The significance of tillage, fungicide, variety and the interactions on wheat protein content at harvest.

Wheat	Till.	Fung.	Var.	Till x Fung	Till x Var	Var x Fung	Till x Fung x Var
	significance						
Winter	.003	.595	.002	.044	.020	.103	.022
Spring	.794	.730	.043	.791	.645	.766	.601

Table 35. The effect of tillage on barley yields, moisture, protein content, and test weight, n=3.

	yield		% moisture		% protein		test wt	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Tillage	-- bu/ac --		---- % ----		---- % ----		-- lb/bu --	
No Till	54.6	3.38	5.26	0.59	10.8	0.34	46.2	0.76
Chisel	58.5	2.83	5.14	0.40	11.1	0.61	45.8	0.28
Moldboard	57.3	5.52	6.42	6.11	11.3	0.21	46.0	0.86
Sig. of Tillage	(.449)		(.899)		(.189)		(.826)	

Table 36. The effect of tillage on soybean yield and moisture, n=3.

	yield		% moisture	
	mean	st dev	mean	st dev
Tillage	----bu/A----		-----%-----	
No Till	26.4	3.68	9.13	0.23
Chisel	25.3	1.35	9.38	0.32
Moldboard	24.8	1.39	9.65	1.01
Sig. of Tillage	(.540)		(.663)	

CONSERVATION TILLAGE CORN AND SOYBEAN RESEARCH IN SOUTHEASTERN MINNESOTA-1987

J.F. Moncrief, T.L. Wagar, D.D. Breitbach, and J.J. Kuznia

Plots have been established in southeastern Minnesota to evaluate various conservation tillage strategies on the well drained loess soils. Plots are large to accomodate growers equippment. At individual locations plots are sometimes split with treatments to investigate management problems if the opportunity presents itself.

Statistics

The statistical significance for main effects of treatments is usually shown in parenthesis next to the treatment heading in the table (for example-tillage (.100). This number can be interpreted as the probability that differences between averages is due to chance and not the particular treatment (in the example tillage). In the example tillage is significant at a .100 probability (on a scale from 0 to 1). There is 10% chance that this is due to random variability or chance and a 90% chance that it is due to the different tillage systems being evaluated. Most researchers accept probabilities of .100 or less as being due to treatments and not chance for field trials.

As an aid in interpreting the statistical probabilities reported here it is suggested that any probability value .100 or less be accepted as evidence that differences in averages are due to the treatments being considered and not to chance.

The significance of interactions between variables is usually reported in footnotes below the tables. If there is a significant interaction between variables it means that the effect of a particular variable is not constant over the range of a second variable.

At Carver county there was no effect of tillage system on corn grain yields. Plots were hand harvested to evaluate yield losses. During hand harvesting, in an effort to estimate potential harvest loss due to European Corn Borer, the dropped ears and stalks broken below the ear were tallied. There was also no effect of tillage on the number of dropped ears and stalks broken below the ear. The yield loss due to European Corn Borer losses were subtracted from the hand harvested yield estimate to give yield after this loss. The final yield estimate at this site was taken with a four row combine by taking the center eight rows out of each plot. The ridge till system was not combine harvested due to stand loss during cultivation. Yield differences of combine estimates were also not statistically significant. Our estimates suggest a European Corn Borer loss of 8 bu./ac. or about 4%. The difference between hand harvesting and combine yields was about 14%. This is about 10% after corn borer losses which is about what is expected.

CARVER COUNTY

Table 1. Cultural practices at Carver County, MN 1987.

Tillage
- Till Plant (No Till)
- Ridge Till-ridge formed on June 26, 1987.
- Disc Chisel-chiseled on April 29, 1987 and light disced on April 30, 1987.
- Moldboard Plow-plowed on April 29, 1987 and light disced on April 30, 1987.
  Ridge, moldboard and disc were cultivated on June 12, 1987.

Preceding Crop
1985-86 Corn

1987 Crop
Corn-Pioneer 3737

Planting and Harvest Date

	Planting		
Crop	Date	Rate	Harvested
Corn	May 8, 1987	28,000 plants/ac	Oct. 7, 1987

Fertilizer History

Crop	Material Analysis (rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----	lb/ac	----	
Corn:	82-0-0 (220 lbs/ac)	180	0	0	May 21, 1986
	9-23-30[1] (150 lbs/ac)	14	35	45	May 22, 1986

1. Applied 2" beside and 2" below seed.

Fertilizer

Crop	Material Analysis (rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----	lb/ac	----	
Corn:	9-23-30[1] (150 lbs/ac)	14	35	45	May 8, 1987
	82-0-0 (183 lbs/ac)	150	0	0	May 13,1987

1. Applied 2" beside and 2" below seed.

Insecticide-8 lb/ac (1.6 lb/ac) Thimet 20-G applied at planting.

Soil

Lester (Mollic Hapludalfs, fine-loamy, mixed, mesic) loam 2 to 6 percent slopes. Soil is well drained.

Weed Control

3 qt/ac (3 lb/ac) Lasso + $2^1/_4$ qt/ac Bladex ($2^1/_4$ lb/ac) applied on May 14, 1987.

Table 2. The effect of tillage on the corn population at harvest on October 7, 1987, n=6.

Sig. of Tillage	No Till mean	No Till stdev	Ridge Till mean	Ridge Till stdev	Chisel mean	Chisel stdev	Moldboard mean	Moldboard stdev
	plants/ac x 1000							
(.470)	24.9	1.53	23.9	1.88	24.4	1.04	23.5	1.71

Table 3. The effect of tillage on corn yield and moisture at harvest on October 7, 1987.

Harvest Method		Sig. of Tillage	No Till mean	No Till stdev	Ridge Till mean	Ridge Till stdev	Chisel mean	Chisel stdev	Moldboard mean	Moldboard stdev
			bu/ac							
Hand harvested (standing and dropped ears)	n=6	(.769)	181	14.4	184	15.1	187	10.2	188	7.6
Hand harvested (minus dropped ears)	n=6	(.685)	174	17.3	173	19.4	182	12.1	180	11.6
Combine harvested	n=3	(.320)	157	18.1	---	----	158	11.4	166	8.2
			% moisture							
Moisture (hand harvested samples)	n=6	(.050)	18.4	0.8	18.7	0.9	18.2	0.7	17.3	0.9

This is an establishment year at the **Dodge County** site. All plots were spring disced. Ridges were established at cultivation. In the fall, primary tillage was done for the moldboard and chisel plow systems. There is a suspected compaction problem at this site. For this reason, all plots were split with a subsoiling treatment also in the fall.

DODGE COUNTY

Table 4. Cultural practices at Dodge County, MN. 1987.

Tillage

In the 1987 crop year there are only two tillage systems:
Spring Disc - Disced 3 times on April 17, 1987.
Ridge Till - Disced 3 times on April 17, 1987 and ridged on June 10, 1987.
Both were cultivated on June 1, 1987.

No Till - To be established for 1988 crop year.
Chisel Plow - To be established for 1988 crop year.
Moldboard Plow - To be established for 1988 crop year.

1987 Crop	Preceding Crop
Corn - Pioneer 3732	1985-86 Corn

Planting and Harvest Date

A six row John Deere 7000 with 28 inch row spacing was used.

	Planting		
Crop	Date	Rate	Harvested
Corn	April 29, 1987	28,000 plants/ac	Oct. 6, 1987

Fertilizer

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	----	lb/ac	----	Date Applied
Corn:	46-0-0	370 lbs/ac	170	0	0	April 16, 1987
	7-21-7[1]	10 gal/ac	8	24	8	April 29, 1987

1. Applied with the seed.

Insecticide

8 lbs/ac (1.2 lbs/ac active ingredient) Counter applied at planting.

Soil

The soil at this site is a Skyberg (Udollic Ochraqualfs, fine-loamy, mixed mesic) silt loam, with 0 to 2 percent slope. This soil is somewhat poorly drained.

Weed Control

3 qt/ac (3 lbs/ac) Lasso + 2 lbs/ac Atrazine (1.6 lbs/ac) applied on May 6, 1987.

Table 5. The effect of tillage on the corn yield and moisture at harvest on October 6, 1987, n=3.

	Tillage			
Sig. of	Ridge Till		Spring Disc	
Tillage	mean	stdev	mean	stdev
	--------- bu/ac ---------			
(.957)	167	3.02	167	1.17
	------ % moisture -------			
(.893)	22.8	0.36	22.7	0.74

At Fillmore county there was a significant effect of tillage and cultivation. The chisel and moldboard plowed treatments yielded 5 and 13 bu./ac. more than the spring disc and no till treatments. It is interesting to note that the no till plots were not cultivated in 1987. The yield difference is due to the difference in weed pressure from cultivation in 1985 and 1986.

FILLMORE COUNTY

Table 6. Cultural practices at Fillmore County, MN. 1987.

Tillage

Till Plant (No Till)
Disc - Fall 1986
Chisel- Fall 1986 with Soil Saver disc chisel
Moldboard - Fall 1986

Cultivation

Each plot is split with one half cultivated and the other half not on May 29, 1987.

1987 Crop	Preceding Crop
Corn - Pioneer 3737	1985-86 Corn

Planting and Harvest Date

Planter was a John Deere Maxemerge 4 row (38") planter equipped with John Deere row cleaners.

	Planting		
Crop	Date	Rate	Harvested
Corn	April 29, 1987	28,100 plants/ac	Oct. 8, 1987

Fertilization History

1983-injected 5-6000 gal/ac of liquid dairy manure.

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/ac	---	Date Applied
Corn:	16-41-8[1]	125 lb/ac	20	51	10	May 6, 1985
	82-0-0	134 lb/ac	110	0	0	May 22, 1985
Corn:	9-23-30[1]	125 lb/ac	11	29	38	May 7, 1986
	82-0-0	244 lb/ac	200	0	0	May 22, 1986

1. Applied 2" beside and 2" below seed.

Fertilizer

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/ac	---	Date Applied
Corn:	9-23-30[1]	100 lb/ac	9	23	30	April 29, 1987
	82-0-0	232 lb/ac	190	0	0	May 12, 1987

1. Applied 2" beside and 2" below seed.

Soil

Tama (Typic Argiudolls, fine-silty, mixed, mesic) and Downs (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loams, eroded, 2 to 6 percent slopes. Soil is well drained.

Weed Control

2 qt/ac (2 lbs/ac) Lasso + $2^1/_3$ ($2^1/_3$ lbs/ac) Bladex on May 4, 1987.

Insect Control
6.9 lbs/ac Counter at time of planting.

Table 7. The effect of tillage and cultivation on severity of velvet leaf at harvest, September 25, 1987, n=6.

	Tillage(.943)							
	No Till		Disc		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Cultivat[1]	severity[2]							
Cult.	3.00	1.00	2.00	0.00	2.00	0.00	1.33	1.15
Not Cult.	4.67	0.58	4.00	0.00	4.00	1.00	4.00	0.00
average	3.83	1.17	3.00	1.10	3.00	1.26	2.67	1.63

1. The significance of cultivation was .074 and the significance of tillage x cultivation was .596.
2. Severity rating:1-none, 2-slight, 3-moderate, 4-severe and 5-very severe.

Table 8. The effect of tillage and cultivation on severity of foxtail at harvest, September 25, 1987, n=6.

	Tillage(.030)							
	No Till		Disc		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Cultivat[1]	severity[2]							
Cult.	3.33	1.15	0.00	0.00	0.00	0.00	0.00	0.00
Not Cult.	4.33	1.15	0.00	0.00	1.00	1.73	0.00	0.00
average	3.83	1.17	0.00	0.00	0.50	1.22	0.00	0.00

1. The significance of cultivation was .043 and the significance of tillage x cultivation was .349.
2. Severity rating:1-none, 2-slight, 3-moderate, 4-severe and 5-very severe.

Table 9. The effect of tillage and cultivation on corn yields, September 25, 1987, n=6.

	Tillage(.094)							
	No Till		Disc		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Cultivat[1]	bu/ac							
Cult.	160	4.0	163	10.4	171	9.0	167	14.3
Not Cult.	144	11.6	156	0.9	160	8.0	162	8.0
average	152	11.5	160	7.6	166	9.5	165	10.6

1. The significance of cultivation was .030 and the significance of tillage x cultivation was .684.

Table 10. The effect of tillage and cultivation on corn moisture, September 25, 1987, n=6.

	Tillage(.010)							
	No Till		Disc		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Cultivat[1]	%							
Cult.	22.6	0.71	21.8	0.93	21.1	1.80	21.8	0.34
Not Cult.	22.2	0.60	21.8	0.87	20.5	0.55	21.6	0.27
average	22.5	0.62	21.8	0.81	20.8	1.23	21.8	0.29

1. The significance of cultivation was .222 and the significance of tillage x cultivation was .862.

The Steele county site also had a significant effect of tillage on grain yields. The till plant treatments were planted with a six row conservation planter in 1987. Consequently this is an establishment year for the ridge till treatment. Till plant ridge had the ridges established in 1986. The till plant flat resulted in the lowest yields. The ridge till and moldboard treatments were comparable. No till and chisel plowed corn yields were also comparable. Damage from residual Command applied on the soybeans in 1986 (see same publication 1987) was affected by tillage (table 12) but not correlated with yields (table 15). Tillage effects on plant population in the early season were not present at harvest (compare table 12 and 13).

STEELE COUNTY

Table 11. Cultural practices at Steele County, MN. 1987.

Tillage

Slot Plant (No Till)
Ridge Till - Ridges formed on May 28, 1987.
Chisel Plow - Chiseled on April 15, 1987 with a John Deere 8650 then field cultivated with a Wilrich 42' field cultivator on April 16, 1987.
Moldboard Plow - Plowed on April 15, 1987 with a John Deere 4240 then field cultivated with a Wilrich 42' field cultivator on April 16, 1987.
Slot Plant - (No Till) Old paraplow plots.
All plots were cultivated on May 7, 1987.

1987 Crop
Corn - Pioneer 3737

Preceding Crop
1985-Corn, 1986-Soybeans

Planting and Harvest Date

Planter used on the till plant and ridge till plots was a Hiniker Econotill planter. The remaining plots were seeded with a John Deere Maxemerge 7000 eight row (30") planter.

		Planting		
Planter	Crop	Date	Rate	Harvested
Hiniker	Corn	April 16, 1987	26,200 plants/ac	Oct. 9, 1987
John Deere	Corn	April 16, 1987	27,700 plants/ac	Oct. 9, 1987

Fertilization History

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/ac	---	Date Applied
	0-0-60	250 lb/ac	0	0	150	Fall 1984
Corn:	7-21-7[1]	10 gal/ac	8	24	8	April 29, 1985
	82-0-0	163 lb/ac	134	0	0	May 30, 1985
Soybeans	none					

1. Applied with the seed.

Fertilizer

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/ac	---	Date Applied
Corn:	0-0-60	250 lb/ac	0	0	150	pre-plant 1987
	82-0-0	159 lb/ac	130	0	0	June 5, 1987

Soil

Le Sueur (Aquic Argiudolls, fine-loamy, mixed, mesic) clay loam, 2 to 4 percent slopes. Soil is moderately well drained to somewhat poorly drained.

Weed Control

2 qt/ac (2 lbs/ac) Bladex + $1^1/_2$ pt/ac ($1^1/_2$ lbs/ac) Dual on April 23, 1987.

Table 12. The effect of tillage on plant population and population damaged by Command on May 22, 1987.

		TILLAGE									
		Moldboard		Chisel		RidgeTill		TillPlant		SlotPlant	
	Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
	Tillage	plants/acx1000									
Population	(.111)	28.7	3.1	25.0	3.9	25.3	3.3	27.9	4.1	24.1	3.8
		%									
Damaged	(.000)	0.0	0.0	63.4	26.5	29.7	39.2	18.0	11.7	6.8	11.4

Table 13. The effect of tillage on plant populations at harvest on October 9, 1987, n=6.

TILLAGE (.697)									
Moldboard		Chisel		RidgeTill		TillPlant		SlotPlant	
mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
plants/acx1000									
26.2	1.3	26.1	0.7	26.4	1.7	27.0	1.0	26.2	1.0

Table 14. The effect of tillage on ears lost due to dropping on October 9, 1987, n=6.

TILLAGE (.195)									
Moldboard		Chisel		Ridge Till		TillPlant		SlotPlant	
mean	stdv	mean	stdv	mean	stdv	mean	stdv	mean	stdv
ears/ac									
435	275	217	364	580	355	726	449	580	355

Table 15. The effect of tillage on yield and moisture at harvest on October 9, 1987.

	TILLAGE									
	Moldboard		Chisel		Ridge Till		Till Plant		Slot Plant	
Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bushels/ac									
(.095)	184	7.2	173	10.4	179	2.2	166	11.9	171	5.9
	% moisture									
(.166)	12.8	.89	12.6	.51	11.8	.82	12.7	.12	12.9	.75

The **Wabasha** county site showed no effect of tillage on either corn or soybean yields. This has been consistent for four years.

WABASHA COUNTY

Table 1. Cultural practices for Wabasha County, MN in 1987.

Tillage

No Till
Ridge Till - corn ridge formed on June 8, 1987
- soybeans cultivated June 8, 1987 and ridge formed on July 8, 1987
Spring Disc - following corn disc twice on May 8, 1987
- following soybeans disced once on April 30, 1987
Field Cultivate - April 25,1986 - field cultivator May 8, 1987

Crops	Preceding Crops
Corn - Pioneer 3737	1983 - Sweet Clover
Soybeans - Pioneer 1677	1984-86 - Corn-Soybean rotation

Planting and Harvest Date

Planter used on all corn plots was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters. Planter used on no till, spring disc and chisel plow soybean plots was a Kinze No Till Drill with 10" row spacing. Planter used on spring disc ridge was a John Deere Maxemerge six row (30") planter equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
Corn	April 30, 1987	28,000 plants/ac	September 29, 1987
Soybeans	May 13, 1987	225,000 plants/ac	September 29, 1987

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		--- lbs/ac ---			
All plots except chisel plow.	28-0-0 (7 gal/ac)	75	0	0	May 14, 1984
Corn:	7-21-7 (12.5 gal/ac)	10	29	10	May 16&18, 1984
Corn:	7-21-7[1] (25 gal/ac)	20	60	20	May 13, 1985
Corn:	82-0-0 (170 lbs/ac)	140	0	0	June 19, 1985
Corn:	46-0-0 (337 lbs/ac)	155	0	0	April 24, 1986
Corn:	9-23-30 (170 lbs/ac)	15	39	51	May 5, 1986

1. Placement 2" beside and 2" below seed.

Fertilizer

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/ac ---			
Corn:	9-23-30[1]	130 lbs/ac	12	30	39	April 30, 1987
Corn:	82-0-0	159 lbs/ac	130	0	0	June 8, 1987

1. Placement 2" beside and 2" below seed.

Soil

Fayette (Typic Hapludalfs, fine-silty, mixed, mesic) silt loam.

Weed Control

Corn

$1^1/_2$ pt/ac ($1^1/_2$ lbs/ac) Dual + $2^1/_2$ qt/ac ($2^1/_2$ lbs/ac) Bladex broadcast with the planter on April 30, 1987.

Soybeans

1 pt/ac (.375 lbs/ac) Roundup + 1% surfactant on May 13, 1986.

1 pt/ac ($^1/_2$ lb/ac) Basagran + $^1/_2$ pt/ac ($^1/_8$ lb/ac) Blazer + 1 qt oil concentrate on June 11, 1987.

1 pt/ac ($^1/_2$ lb/ac) Basagran + 1 pt/ac ($^2/_{10}$ lb/ac) Poast + 1 qt/ac Dash oil concentrate + 1 gal 28% on June 19, 1987.

Soil Test

Table 16. Soil test results for corn to be planted following soybeans on April 16, 1987.

Nutrient	Sig. of Tillage	No Till	Disc	Ridge	Chisel	Avg
		--------- lbs/ac ----------				
NH4-N	(.579)	4	4	4	3	4
NO3-N	(.429)	29	29	36	28	30
Total-N	(.443)	33	33	40	31	34
P	(.256)	64	58	57	54	58
K	(.833)	220	209	204	201	208

Table 17. Soil test results for soybeans to be planted following corn on April 16, 1987.

Nutrient	Sig. of Tillage	No Till	Disc	Ridge	Chisel	Avg
		--------- lbs/ac ----------				
NH4-N	(.772)	4	4	4	4	4
NO3-N	(.499)	16	16	22	18	18
Total-N	(.571)	20	20	26	22	22
P	(.602)	62	66	67	60	64
K	(.075)	215	187	200	177	195

Table 18. The effect of tillage on soil cover by soybean residue on June 3, 1987, n=8.

Location[1]	No Till mean	No Till stdv	Spring Disc mean	Spring Disc stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv
	---------- % ----------							
In Row	43.0	16.9	14.5	10.8	22.5	12.8	7.5	6.5
Between	59.5	15.1	24.0	19.3	33.0	17.9	17.5	13.3

1. The significance of tillage in-row was .000; between-row was .001.

Table 19. The effect of tillage on soil cover by corn residue on June 3, 1987, n=8.

Location[1]	No Till mean	No Till stdv	Spring Disc mean	Spring Disc stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv
	---------- % ----------							
In Row	82.5	15.4	59.5	20.2	37.5	20.0	37.0	12.7
Between	80.5	7.5	63.5	15.1	68.0	10.9	32.5	11.6

1. The significance of tillage in-row was .001; between-row was .000.

Table 20. The effect of tillage on population of corn and soybeans on June 3, 1987, n=16.

		Tillage							
		No Till		Spring Disc		Ridge Till		Chisel	
	Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Crop	Tillage	plants/ac x 1000							
Corn	(.760)	26	4.3	27	2.1	27	2.4	27	2.8
Soybeans	(.000[1])	117	32.1	143	30.2	147	23.5	173	17.1

1. The significance of no till, spring disc, and chisel till.

Table 21. The effect of tillage on visual weed rating at harvest for corn on September 29, 1987, n=4.[1]

	Tillage							
	No Till		Spring Disc		Ridge Till		Chisel	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	%							
(1.000)	1.00	.00	1.00	.00	1.00	.00	1.00	.00

1. The visual rating used is as follows; 1=None, 2=Slight, 3=Moderate, 4=Severe and 5=Very Severe.

Table 22. The effect of tillage on visual weed rating at harvest for soybeans on September 29, 1987, n=4.[1]

	Tillage							
	No Till		Spring Disc		Ridge Till		Chisel	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	%							
(1.000)	1.75	.96	1.75	.50	1.75	.50	1.75	.50

1. The visual rating used is as follows; 1=None, 2=Slight, 3=Moderate, 4=Severe and 5=Very Severe.

Table 23. The effect of tillage on corn yields and moisture at harvest on September 29, 1987, n=4.

	Tillage							
	No Till		Spring Disc		Ridge Till		Chisel	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	bu/ac							
(.267)	181	4.1	180	7.5	184	4.2	178	2.8
	%							
(.080)	21.5	.5	20.5	1.0	20.8	.9	19.8	.7

Table 24. The effect of tillage on soybean yields and moisture at harvest on September 29, 1987, n=4.

	Tillage							
	No Till		Spring Disc		Ridge Till		Chisel	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	bu/ac							
(.472)	60.9	2.8	58.4	2.5	56.9	5.9	59.4	3.3
	%							
(.156)	11.1	.4	11.5	.4	10.9	.7	11.6	.3

TILLAGE EFFECTS ON CORN AND SOYBEAN PRODUCTION IN THE CLEARWATER RIVER WATERSHED MEEKER, STEARNS, AND WRIGHT COUNTIES, 1987

J.F. Moncrief, D.D Breitbach, J.J. Kuznia, W.C. Stienstra, and M. Kells

Following is a summary of the results of tillage demonstrations in the Clearwater River Watershed in 1987. This is a joint effort by the following organizations: Clearwater River Watershed District, Soil and Water Conservation Districts, Soil Conservation Service, Minnesota Pollution Control Agency, and the Minnesota Extension Service. Technical expertise has been provided from academic departments of the College of Agriculture, University of Minnesota. Cooperation from Richard and Ken Kuechle, Richard Eckman, and Lyndon and Earl Johnson in Meeker, Stearns, and Wright County respectively, is greatly appreciated.

The purpose of this demonstration is to evaluate various conservation tillage systems under the soil and climatic conditions of the Clearwater River Watershed. It is hoped that by providing objective scientific data to growers, they can consider tillage systems that fit their situation and provide erosion control that will maintain water quality in the watershed. The 1987 growing season was very dry (about 6 inches below normal). Two of the three tillage demonstration sites are on droughty soils and yields were low.

The **Meeker** county site is located on a complex of Delft clay loam, Koronis fine sandy loam, and Marcellon loam. The plots are located on a side slope and probably receive moisture which flows along the glacial till contact below the soil. For this reason this site showed the least effect of the dry weather conditions. A corn-soybean rotation is demonstrated at this site.

Soil test values are shown in tables 2 and 3 for the corn and soybeans respectively. There was about 30 lbs NO_3 + NH_4-N/acre in the top 8 inches in April following both corn and soybeans. Soil test P and K is in the medium range. These are Bray 1 analysis for phosphorus. Because this is a high pH soil (greater than 7.4), the Olsen test would be more reliable for fertilizer recommendations. Following corn the soil test is lower when moldboard plowing is done. This has been observed at other sites. Two thirds of the K taken up in corn is left behind in the stover. When it is not incorporated with tillage it is concentrated at the soil surface and results in a higher soil test. Tillage did not have a significant effect on soil test K following soybeans due to one third less crop residue. Phosphorus did not result in significant tillage effects. Three fourths of the P that is taken up by the corn is removed with the grain.

The soil covered by residue is shown in tables 4 and 5 for corn and soybean residue respectively. There is more soil cover following corn than soybeans. The in row soil cover (4 inches centered on the row) is related to early corn growth due to changes in soil temperature. The between row soil cover is more related to control of sediment and phosphorus losses. In row soil cover that is less than 20% will likely not affect corn growth due to reduced soil temperatures. All the tillage systems demonstrated except the no till have in row cover that is 20% or less. Although cover by corn residue (planted to soybeans) is greater than 20%, soybeans are not sensitive to its effects. The early soybean and corn growth and population is shown in tables 6 and 8 respectively.

The ridge till corn has over one half more leaf growth than the other systems. The no till and ridge till corn germinated sooner and is much less variable than the systems that had fall primary tillage (chisel and moldboard plow). This is due to more moist soil conditions at planting and better seed to soil contact. The detrimental effects of cloddy conditions with the chisel and moldboard plowing was more important to early corn growth than the presence of crop residues over the row area in 1987. About one month later there was no difference in corn growth due to tillage (table 10). Soybean growth was not affected by tillage. Soybeans are much less sensitive to changes in soil temperature due to the presence of crop residue than corn due to the location of the growing point (above the soil surface) and later planting date. There was a slight reduction in soybean population with the chisel and no till systems but would not be expected to affect yields.

There were very few weeds at this site (tables 7 and 9) and were unaffected by tillage. At these levels weeds would not be expected to affect corn or soybean growth or yields.

There was a measurable effect of tillage on K uptake on the June 26 date (table 11). Systems that eliminate primary tillage result in lower K uptake. This can be minimized by the application of row fertilizer at planting. One month later differences due to tillage had disappeared (table 12). There was an effect of tillage on ear leaf N concentrations.

Moisture stress was measured on June 26 and July 24 (tables 13 and 14). There was no measurable effect of tillage at this site on moisture stress and levels were relatively low. There was a significant effect on stress by position on the landscape. The corn that was down slope showed lower levels of stress. Moisture stress levels at this site were low. Apparently corn is fed from moisture moving from upslope at this site.

Grain yields are shown in tables 15 and 17 for corn and soybeans respectively. There was no difference in yield due to tillage for either crop. Landscape position effects are shown in table 16. The early differences in corn growth did not effect yields. There was adequate growing degree days to mature all treatments and small differences in early growth due to tillage did result in grain yield differences.

There was no effect of tillage on soybean yields at this site. This is consistent with data from other sites. There is an average 5 bu/acre response to row applied phosphorus with the drill. Research that supports banded P applications for soybeans is scarce. This is an ideal method of application to minimize entry into surface waters. Since the soil at this site tends to be wet in most years it was decided to evaluate crop residue effects on fungicide response for control of phytophthora root rot. There was no advantage to a planter/drill applied fungicide at planting.

MEEKER COUNTY

Table 1. Cultural practices at Meeker County MN. 1987.

Tillage

No Till
Ridge Till-Corn ridges were formed on June 27, 1987 and soybean were formed on July 7, 1987.
Chisel-All plots were chiseled on October 29, 1986.
Moldboard-All plots were moldboard plowed on October 28, 1986.

Preceding Crop

Corn-soybean rotation since 1978.

1987 Crop

Corn-Pioneer 3737
Soybeans-Pioneer 1677

Planting and Harvest Dates

	Planting		
Crop	Date	Rate	Harvested
Corn	April 28, 1987	28,100 plants/ac	September 30, 1987
Soybeans	May 5, 1987	242,200 plants/ac	September 30, 1987

Fertilizer History-Prior to 1987[1]

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/ac ---			
Corn:	82-0-0	183 lbs/ac	150	0	0	Spring
	4-15-40[2]	250 lbs/ac	10	38	100	Planting

1. This is based on an interview with the cooperating farmer.
2. Planter placement 2" beside and 2" below row.

Fertilizer-1987

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/ac ---			
Corn	4-15-40	300 lbs/ac	12	45	120	October 27, 1986
	7-21-7[1]	17 gal/ac	13	40	13	April 28, 1987
	82-0-0	159 lbs/ac	130	0	0	May 15, 1987
Soybeans	4-15-40	300 lbs/ac	12	45	120	October 27, 1986
	0-46-0[2]	45 lbs/ac	0	21	0	May 5, 1987

1. Planter placement 2" beside and 2" below row.
2. Drill soybeans were split with row fertilizer which was surface banded ahead of and incorporated by the fluted coulters.

Fungicide Seed Treatment

Drill soybeans were split with Ridomil 5G at a rate of 6.1 lbs/ac ($^1/_3$ lb ai/ac).

Soil

The soils present at this site are as follows: 29% of plot area is Delft (Cumulic Haplaquolls, fine-loamy,mixed, mesic) clay loam, 43% is Koronis (Mollic Haplaudalfs, fine-loamy, mixed, mesic) fine sandy loam, and the remaining 28% is Marcellon (Aquic Argiudolls, fine-loamy, mixed, mesic) loam.

Weed Control

Corn

3 qt/ac (3 lbs/ac) Lasso + $2^1/_2$ qt/ac ($2^1/_2$ lbs/ac) Bladex on May 2, 1987.

2 qt/ac ($1^1/_2$ lbs/ac) Roundup spot sprayed on no till plots on May 2, 1987.

Soybeans

$1^1/_2$ pt/ac ($^3/_4$ lb/ac) Bassagran + 1 pt/ac ($^1/_5$ lb/ac) Poast + 1 qt/ac crop oil + 1 gal 28% on June 8, 1987.

Table 2. Soil test results for corn following soybeans on April 7, 1987.

Nutrient	Sig. of Tillage	No Till	Ridge	Chisel	Moldboard	Avg
		--------- lbs/ac				----------
NH_4-N[1]	(.327)	9.0	7.5	8.8	9.1	8.7
NO_3-N[1]	(.896)	21.0	22.3	20.2	25.9	22.4
Total-N	(.845)	30.0	29.8	29.1	35.1	31.0
P[2]	(.862)	21.2	25.2	27.9	22.8	24.4
K	(.258)	182.7	177.6	173.1	146.2	169.9

1. These values are for 8 inch samples.
2. Bray 1 phosphorus (this soil has a pH of 7.5).

Table 3. Soil test results for soybeans following corn on April 7, 1987.

Nutrient	Sig. of Tillage	No Till	Ridge	Chisel	Moldboard	Avg
		--------- lbs/ac				----------
NH_4-N[1]	(.740)	9.9	10.5	10.6	11.0	10.5
NO_3-N[1]	(.433)	12.0	20.6	16.1	18.9	16.9
Total-N	(.436)	21.9	31.2	26.8	29.9	27.4
P[2]	(.262)	26.0	20.6	32.7	23.7	25.5
K	(.016)	208.7	234.9	200.1	173.1	204.2

1. Thes values are for 8 inch samples.
2. Bray 1 phophorus (this soil has a pH of 7.5).

Table 4. The effect of tillage on soil covered by corn residue on May 27, 1987, n=16. May 27, 1987, n=16.

	Tillage[1]							
	No Till		Ridge Till		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Corn Residue	% cover							
In row	45	16	35	24	35	11	8	5
Between row	43	22	39	17	29	11	7	5

1. Significance of tillage for all positions relative to the row was .000.

Table 5. The effect of tillage on soil covered by soybean residue on May 27, 1987, n=16.

	Tillage[1]							
	No Till		Ridge Till		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Soybean Residue	% cover							
In row	29	17	20	14	10	8	3	3
Between row	24	11	22	16	10	8	2	3

1. Significance of tillage for all positions relative to the row was .000.

Table 6. The effect of tillage on soybean growth stage and population on May 27, 1987.

	Tillage							
	No Till		Ridge Till		Chisel		Moldboard	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	growth stage[1]							
(.396)	2.3	.6	2.4	.7	2.2	.7	2.4	.6
	plants/ac x 1000							
(<.000)	225	48	163	8	223	61	240	51

1. Soybean growth stages are as follows: 1=emergence (Ve), cotyledons above soil surface; 2=cotyledon (Vc) unifoliolate leaves unrolled sufficiently so the leaf edges are not touching; 3=first node, fully developed leaves at unifoliolate nodes and 4=second node; fully developed trifoliolate leaf at node above the unifoliolate node

Table 7. The effect of tillage on weed severity in soybeans on May 27, 1987.

		Tillage							
		No Till		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage	% cover							
Foxtail	--	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Horsetal	(.473)	1.5	7.1	6.8	12.2	5.0	4.2	1.0	1.2
Quackgrs	--	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
Lambqurt	--	0.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0
VolCorn	(.436)	0.3	0.5	0.8	1.5	0.0	0.0	0.0	0.0
Ragweed	(.436)	0.0	0.0	0.3	0.5	0.0	0.0	0.0	0.0

1. Due to uneven variances, a natural log transformation was used for significance.

Table 8. The effect of tillage on corn growth stage and population on May 27, 1987.

	Tillage							
	No Till		Ridge Till		Chisel		Moldboard	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	leaves/plant[1]							
(.001)	3.3	.5	3.8	.4	3.2	1.0	3.0	1.3
	plants/ac x 1000							
(.092)	37.4	4.3	37.7	2.7	36.6	2.9	34.3	6.3

1. Corn leaves are tallied as full leaves when leaf collars are visible.

Table 9. The effect of tillage on weed severity in corn on May 27, 1987.

		Tillage							
		No Till		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage	% cover							
Horsetal	(.436)	0.3	0.5	1.5	1.7	0.0	0.0	0.3	0.5
Quackgrs	(.685)	1.3	0.5	3.8	4.5	2.0	2.7	1.5	1.3
VolSoyb	(1.00)	0.3	0.5	0.3	0.5	0.3	0.5	0.3	0.5
Milkweed	--	0.0	0.0	0.0	0.0	0.3	0.5	0.0	0.0
CandThis	--	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5

1. Due to uneven variances, a natural log transformation was used for significance.

Table 10. The effect of tillage on corn plant weights, June 26, 1987.

Tillage (.400)							
No Till		Ridge Till		Chisel		Moldboard	
mean	stdv	mean	stdv	mean	stdv	mean	stdv
grams/plant							
28.3	6.6	24.5	3.1	29.5	2.9	31.5	8.4

Table 11. The effect of tillage on whole plant N and K on June 26, 1987.

		Tillage			
	Sig. of	No Till	Ridge	Chisel	Moldboard
Concentration	Tillage	% per plant			
N	(.344)	2.73	2.75	2.78	2.92
K	(.050)	1.83	1.96	2.66	2.63
Uptake		milligrams/plant			
N	(.226)	768	676	817	903
K	(.008)	524	465	785	818

Table 12. The effect of tillage on ear leaf concentration of N and K on July 24, 1987.

		Tillage			
	Sig. of	No Till	Ridge	Chisel	Moldboard
Nutrient	Tillage	%			
N	(.091)	2.86	2.73	2.81	3.00
K	(.736)	1.52	1.48	1.72	1.60

Table 13. The effect of tillage on corn leaf water potential on June 26, n=4 and July 24, 1987 n=8.

		Tillage							
		No Till		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Date	Tillage	(-bars)							
June 26	(.829)	8.2	2.7	8.4	2.0	8.8	1.8	7.9	2.4
July 24	(.404)	6.0	1.8	7.5	1.7	7.0	1.8	7.3	2.2

Table 14. The effect of aspect on corn leaf water potential on June 26, and July 24, 1987.

		Direction	
		South	North
Date	Sig.	(-bars)	
June 26	<.000	9.9	6.7
July 24	.139	7.4	6.4

Table 15. The effect of tillage on corn yields, September 30, 1987.[1]

	Tillage							
	No Till		Ridge Till		Chisel		Moldboard	
Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Tillage	bu/ac							
(.176)	189	12.0	179	7.0	187	9.1	189	20.7
	% moisture							
(.311)	19.9	.9	20.6	.8	21.5	1.9	21.2	1.8

1. The soils at the Meeker County site for the corn area are, 60% Koronis fine sandy loam, 25% Marcellon loam and 15% Delft clay loam.

Table 16. The effect of aspect on corn yield on September 30, 1987.

	Direction	
	South	North
Date	bu/ac	
September 30	184	190
	% moisture	
	.21	.21

Table 17. The effect of tillage, starter and fungicide on soybean grain yields for 1987, n=4.[1]

Treatment[6]		Tillage							
		No Till		Ridge Till		Chisel		Moldboard	
Starter[4]	Fungicide[5]	mean	stdev	mean	stdev	mean	stdev	mean	stdev
		bu/ac							
no	no	51	3.9	50[3]	4.1	51	3.5	52	4.3
no	yes			46	3.9				
yes	no	54	8.1			57	4.9	58	1.8
yes	yes	54	2.9			58	4.0	57	10.7

1. The soils at the Meeker County site for the soybean area are, 20% Koronis fine sandy loam, 20% Marcellon loam and 60% Delft clay loam.
2. The significance of tillage without starter or fungicide is .896.
3. The significance of fungicide is .178 for Ridge Till.
4. The significance of tillage and starter without fungicide and with or without starter is .408 and .011 respectively. The significance of the tillage x starter interaction is .550.
5. The significance of tillage and fungicide with starter and with or without fungicide is .360 and .977 respectively. The significance of the tillage x fungicide interaction is .886.
6. The application rate of starter was 21 lbs/ac P_2O_5, fungicide rate was 6.1 lbs/ac Ridomil.

The Stearns County site is located on a complex of Fairhaven silt loam, Estherville sandy loam, and Hawick sandy loam soil. The soil at this site is very droughty. Data collected from this site are shown in tables 18 to 32. Corn was grown after soybeans in 1987. The soil covered by soybean residue was lower in the row for all tillage systems (planter equipped with sweeps) although it is high enough to effect early growth and stand establishment in the no till system (table 19). The variability of the stand in the no till treatment was much higher than the other tillage systems (table 20) and affected grain yields. This was the result of slippage of the coulter-gauge wheel on the planter that drives the planter units and in row crop residue.

Residue and starter fertilizer effects on early growth are shown in table 21 and 24. Most of the benefit to row fertilizer is achieved with a low rate and the response is larger for the conservation tillage systems. On May 29 it was noticed that the lower leaves were fired on the plots that did not receive row fertilizer at planting (table 22). The plants did not show these symptoms on the June 26 sampling date. Lower leaf necrosis was also affected by tillage. The authors don't have an explanation for these observations.

The dominant weeds at this site are lambsquarter and giant foxtail. Chisel and moldboard plowing resulted in the highest density of foxtail and the lowest density of lambsquarter (table 23). These observations were made before cultivation (May 29). All plots except the no till were cultivated. A banded application of Lasso was used for weed control. Weeds probably affected corn yields in the no till plots only.

Tissue levels and uptake of N, P, and K on June 26 are shown in tables 25 and 26, respectively. Ear leaf concentrations are shown in table 27. Nitrogen and potassium were lower with the conservation tillage systems on the June 26 date. There were higher levels of phosphorus with conservation tillage. Starter fertilizer reduced nitrogen content due to dilution. Table 26 shows large increases in uptake of all three nutrients due to starter fertilizer addition. A tillage by starter interaction occured with potassium uptake that illustrates the importance of row applied K on this soil when using conservation tillage. Ear leaf concentrations of K suggest that even at the higher rate of starter fertilizer there wasn't enough available for the conservation tillage options. This illustrates the value of dry starter fertilizer on these soils that allows higher analysis of K and probably would overcome this tillage induced K deficiency. This factor probably influenced grain yields.

Plant moisture stress is shown in tables 28 and 29. There is a significant benefit of residue in reducing moisture stress. Starter fertilizer increased moisture stress. Moisture stress is correlated with dry matter production on June 26. This reflects moisture depletion by the larger plants. The July 24 moisture stress measurements still show a tillage and starter fertilizer effect.

Ridging effects on grain yields in a dry year were evaluated (tables 30 and 31). Ridge till plots were split with a cultivation split. There was no apparent effect in ridging on grain yields. Grain yields and moisture for all tillage treatments are shown in table 32. The greatest response to row fertilizer occurred with the no till corn. Yields were lower with this system due to stand variability, in row cover by crop residue, and nitrogen losses. Plant tissue analysis (data not shown) shows a reduction in available nitrogen with no till corn. Nitrogen was applied as urea-ammonium nitrate solution at cultivation. All treatments were cultivated except the no till which had the nitrogen solution surface banded between the rows. The decrease in yield with starter fertilizer application when corn was grown with moldboard plowing is probably due to the increased moisture stress with this treatment combination. Due to the lack of residue and the hastened development, corn was probably subjected to higher levels of moisture stress at silk emergence . Corn showed higher moisture stress earlier in the season and it persisted longer with this treatment. Starter fertilizer may also have encouraged shallow rooting which had lower soil moisture levels in the absence of crop residues.

STEARNS COUNTY

Table 18. Cultural practices at Stearns County, MN. 1987.

Tillage

No Till
Ridge Till
Chisel-Plots were chisel plowed, and then disced on April 28th.
Moldboard-Plots were moldboard plowed, and then disced on April 28th.

Preceding Crops

The cropping history at this site is as follows: 1981-red clover and oats, 1982-corn, 1983-soybeans, 1984-corn, 1985-corn, 1986-soybeans.

1987 Crop

Corn - Johnson SX 490 a single cross 100 day hybrid.

Planting and Harvest Dates

Ridge till plots were planted with a four row Buffalo Till planter equipped with 12" sweeps at a 38" row spacing. All other plots were planted with the sweeps raised.

	Planting		
Crop	Date	Rate	Harvested
Corn	April 29, 1987	22,100 plants/ac	September 22, 1987

Fertilization History-Prior to 1987[1]

The fertilization history at this site is as follows: 1981-none, 1982-low rate of dry starter, 1983-low rate of starter and 0-0-60, 1984-4 gal/ac of 9-18-9 only, 1985-60 lbs/ac of N and 4 gal/ac of 9-18-9, 1986-all plots were split with and without a row fertilizer treatment at planting as in the table that follows.

Crop	Material Analysis	Rate	Tillage	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
				-- lbs/ac --			
Soybeans	9-18-9[2]	4 gal/ac	Ridge Till	4	8	4	May 16, 1986
	0-0-60[3]	90 lbs/ac	All Others	0	0	54	May 16, 1986

1. This information is based on an interview with the cooperating farmer.
2. Planter placement 1" below the seed.
3. Potash was surface banded ahead of and incorporated by the fluted coulters.

Fertilizer

All plots were split with three fertilizer treatments at planting.

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O
		--- lbs/ac --		
Corn	9-18-9[1] (0 gal/ac)	0	0	0
	9-18-9[1] (4.9 gal/ac)	4.7	10	4.7
	9-18-9[1] (9.7 gal/ac)	9.3	18.5	9.3

1. Planter placement 1" below the seed.

Nitrogen was applied as a split application of liquid 28% at the rate of 11 gal/ac (33 lbs/ac actual N) on all plots by the method listed below.

Date	Tillage	Method of Application
June 1	No Till	Surface dribble
	Ch/Mb/RT	Incorporated while cultivating
June 25	No Till	Surface dribble
	Ch/Mb	Incorporated while cultivating
	Ridge	Incorporated while ridging

Soil

The soils at the Stearns County site are Fairhaven (Typic Hapludolls) loam which is well drained on 54 percent of the plot. On 36 percent of the plot Estherville (Typic Hapludolls) sandy loam which is somewhat excessively drained is present. On the remaining 10 percent of the plot Hawick (Entic Hapludolls) loamy sand is present, this soil is excessively drained. The slope average for all three soils is 2.5 percent with the the highest being 4 percent.

Weed Control

$4^1/_2$ lbs/ac (.675 lb ai/ac) Lasso II applied in a 10 inch band at planting.
$^1/_2$ pt/ac ($^1/_4$ lb ai/ac) 2,4-D Amine on May 19, 1987.

Table 19. The effect of tillage on percent of the soil surface covered by soybean residue on May 29, 1987, n=16.

	TILLAGE[1]							
	No Till		Ridge Till		Chisel		Moldboard	
Location	mean	stdev	mean	stdev	mean	stdev	mean	stdev
	%							
In Row	30.0	18.9	16.7	9.7	22.5	14.0	5.0	3.7
Between	77.5	17.9	61.7	13.5	32.5	17.2	5.5	3.5

1. Significance of tillage for both positions relative to the row was less than .000.

Table 20. The effect of tillage on population of corn on May 29, 1987, n=16.

TILLAGE(.417)							
No Till		Ridge Till		Chisel		Moldboard	
mean	stdev	mean	stdev	mean	stdev	mean	stdev
plants/ac x1000							
19.1	4.98	20.7	1.97	20.1	1.49	20.6	1.81

Table 21. The effect of tillage and starter on growth stages of corn, May 29, 1987, n=40.

lbs/ac starter[1] Fertilizer			TILLAGE(<.000) No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv	Avg
N	P_2O_5	K_2O	leaves/plant								
0	0	0	3.62	.38	4.22	.16	4.23	.25	4.30	.29	4.09
5	10	5	3.97	.47	4.17	.41	4.33	.26	4.40	.42	4.22
10	20	10	4.04	.45	4.22	.51	4.33	.40	4.35	.30	4.23
average			3.88	.46	4.20	.38	4.30	.31	4.35	.34	

1. The significance of starter was .001 and the interaction of tillage x starter was .002.

Table 22. The effect of tillage on the number of damaged leaves on plants, May 29, 1987, n=8.

	TILLAGE(.079) No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv	Avg
	percent damage								
0 0 0	25.3	21.6	22.9	21.4	19.9	12.2	9.8	12.9	19.5
5 10 5	10.5	25.7	0.0	0.0	0.0	0.0	0.5	1.5	2.8
10 20 10	4.8	9.9	2.2	4.5	0.6	1.6	0.6	1.7	2.0
average	13.5	21.3	8.4	16.0	6.8	12.3	3.7	8.5	

1. The significance of starter was .000 and the interaction of tillage x starter was .542.

Table 23. The effect of tillage on weed growth, by visual cover on May 29, 1987.

Weed	Sig. of Tillage	TILLAGE No Till mean	No Till st dev	Ridge Till mean	Ridge Till st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		percent cover							
Quackgrass		4.2	0.9	2.2	0.9	0.8	0.9	0.0	0.0
Milkweed		0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0
Foxtail	(.000)	1.2	0.5	1.5	0.6	10.0	4.1	8.0	8.1
Lambquarter	(.002)	4.7	2.9	4.7	2.6	1.2	0.9	0.2	0.5
Russian Thistle		0.7	1.5	0.5	0.6	0.0	0.0	0.2	0.5

Table 24. The effect of tillage on dry matter production, June 26, 1987, n=4.

lbs/ac starter[1] Fertilizer			TILLAGE(.000) No Till mean	No Till st dev	Ridge Till mean	Ridge Till st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev	Avg
N	P_2O_5	K_2O	grams/plant								
0	0	0	11.5	3.45	16.2	4.72	22.6	5.51	31.5	5.15	20.5
5	10	5	20.8	1.20	24.2	.799	26.5	4.65	34.2	3.94	26.4
10	20	10	22.2	2.04	26.9	2.98	30.1	3.80	36.8	8.86	29.0
average			18.2	5.40	22.4	5.58	26.4	5.31	34.2	6.16	

1. The significance of starter was .000, the interaction of tillage x starter was .024.

Table 25. The effect of tillage on whole plant concentration of N, P, and K on June 26, 1987.

lbs/ac Starter Fertilizer			TILLAGE No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv	Avg
N	P_2O_5	K_2O	% Nitrogen								
0	0	0	2.47	.49	2.60	.48	2.31	.43	2.29	.15	2.42
5	10	5	2.03	.23	2.67	.51	2.04	.16	1.99	.35	2.18
10	20	10	1.77	.16	2.51	.21	2.06	.24	1.88	.11	2.06
Sig.[1](.002)											
average			2.09	.42	2.60	.39	2.14	.30	2.05	.28	
N	P_2O_5	K_2O	% Phosphorus								
0	0	0	.43	.09	.39	.04	.36	.01	.37	.05	.39
5	10	5	.36	.04	.38	.04	.37	.02	.32	.08	.35
10	20	10	.39	.09	.35	.10	.39	.07	.33	.02	.37
Sig.[1](.050)											
average			.39	.07	.38	.06	.37	.04	.34	.05	
N	P_2O_5	K_2O	% Potassium								
0	0	0	.98	.10	1.08	.24	1.15	.18	1.90	.70	1.28
5	10	5	1.15	.21	1.07	.09	1.17	.18	2.10	.29	1.37
10	20	10	1.15	.35	1.20	.14	1.13	.20	1.57	.29	1.26
Sig.[1](.000)											
average			1.09	.23	1.12	.17	1.15	.17	1.85	.48	

1. The significance of tillage; the significance of starter for N was .011, P was .140 and K was .281. The tillage x starter interaction on N was .435, P was .391 and K was .111.

Table 26. The effect of tillage on plant uptake of N, P and K, June 26, 1987.

lbs/ac Starter Fertilizer			TILLAGE No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv	Avg
N	P_2O_5	K_2O	milligrams Nitrogen/plant								
0	0	0	288	99	420	143	518	124	720	96	486
5	10	5	420	25	650	143	543	107	666	92	570
10	20	10	394	51	674	84	624	117	691	160	596
Sig.[1](.002)											
average			367	84	582	165	561	115	692	111	
N	P_2O_5	K_2O	milligrams Phosphorus/plant								
0	0	0	50	18	63	14	81	20	114	12	77
5	10	5	74	5	92	9	97	16	107	19	92
10	20	10	86	14	94	21	119	25	120	25	105
Sig.[1](.014)											
average			70	20	83	20	99	25	114	19	
N	P_2O_5	K_2O	milligrams Potassium/plant								
0	0	0	114	34	181	87	265	97	622	337	296
5	10	5	240	49	258	27	312	81	721	152	383
10	20	10	257	87	323	51	336	27	571	155	372
Sig.[1](.000)											
average			204	87	254	81	304	74	637	219	

1. The significance of tillage; the significance of starter for N was .015, P was .002 and K was .003. The tillage x starter interaction on N was .103, P was .419 and K was .045.

Table 27. The effect of tillage on earleaf concentration of N, P and K on July 24, 1987.[1]

lbs/ac Starter Fertilizer			Sig. of Tillage	TILLAGE No Till mean	No Till stdev	Ridge Till mean	Ridge Till stdev	Chisel mean	Chisel stdev	Moldboard mean	Moldboard stdev	Avg
N	P_2O_5	K_2O	(<.000)	% Nitrogen								
0	0	0		2.22	.15	2.42	.06	2.37	.13	2.42	.03	2.36
5	10	5		2.02	.21	2.44	.14	2.15	.17	2.17	.09	2.20
10	20	10		1.94	.18	2.38	.09	2.39	.06	2.50	.35	2.30
			average	2.06	.20	2.41	.10	2.31	.16	2.36	.24	
N	P_2O_5	K_2O	(.017)	% Phosphorus								
0	0	0		.28	.05	.35	.07	.23	.12	.24	.07	.27
5	10	5		.27	.05	.32	.04	.27	.02	.20	.08	.26
10	20	10		.26	.09	.32	.06	.26	.03	.25	.08	.27
			average	.93	.10	1.10	.07	1.00	.07	1.01	.13	
N	P_2O_5	K_2O	(<.000)	% Potassium								
0	0	0		.48	.18	.47	.19	.65	.17	.95	.34	.64
5	10	5		.47	.12	.53	.09	.67	.19	1.08	.21	.69
10	20	10		.50	.12	.72	.33	.75	.14	.98	.24	.74
			average	.48	.13	.57	.24	.69	.16	1.01	.25	

1. The significance of starter for concentration of N,P and K was .014, .933 and .292 respectively. The signiifcance of the tillage x starter interaction for N, P, and K was .158, .741 and .694 respectively.

Table 28. The effect of tillage on plant leaf water potential on June 26, 1987.[1]

lbs/ac Starter Fertilizer			TILLAGE (.003)								
			No Till		Ridge Till		Chisel		Moldboard		
			mean	stdv	mean	stdv	mean	stdv	mean	stdv	Avg
N	P_2O_5	K_2O	(-bars)								
0	0	0	3.0	2.1	3.1	1.2	4.5	3.0	5.8	1.3	4.4
10	20	10	5.5	2.2	4.1	.6	5.9	3.0	7.8	2.9	5.8
average			4.2	2.4	3.6	1.1	5.2	3.0	6.8	2.4	

1. The significance of starter was .001 and the significance of tillage x starter interaction was .370.

Table 29. The effect of tillage on plant leaf water potential on July 24, 1987.[1]

			TILLAGE (.046)								
			No Till		Ridge Till		Chisel		Moldboard		
			mean	stdv	mean	stdv	mean	stdv	mean	stdv	Avg
N	P_2O_5	K_2O	(-bars)								
0	0	0	6.3	1.6	7.1	1.8	6.9	1.8	7.9	2.3	7.0
10	20	10	8.0	1.2	9.3	2.3	7.5	1.8	9.2	1.4	8.5
average			7.1	1.6	8.2	2.3	7.2	1.8	8.6	2.0	

1. The significance of starter was .000 and the significance of tillage x starter interaction was .632.

Table 30. The effect of cultivation and ridging on corn yield on September 22, 1987, n=2.

lbs/ac Starter Fertilizer			Sig. of Cultivation	Ridged		Not Ridged	
				mean	st dev	mean	st dev
N	P_2O_5	K_2O	(.852)	bu/ac[1]			
0	0	0		81.6	12.8	93.3	9.6
5	10	5		90.1	16.9	87.3	1.9
10	20	10		90.5	22.2	91.9	8.5

1. The significance of starter fertilizer was .521; the significance of the interaction of cultivation x starter fertilizer was .497.

Table 31. The effect of cultivation and ridging on corn harvest moisture on September 22, 1987, n=2.

lbs/ac Starter Fertilizer			Sig. of Cultivation	Ridged		Not Ridged	
				mean	st dev	mean	st dev
N	P_2O_5	K_2O	(.399)	% mosture[1]			
0	0	0		22.5	0.6	21.0	1.0
5	10	5		20.6	2.2	20.8	2.0
10	20	10		20.1	1.6	21.0	0.3

1. The significance of starter fertilizer was .383; the significance of the interaction of tillage x starter fertilizer was .692.

Table 32. The effect of tillage and starter fertilizer on corn yield and harvest moisture on September 22, 1987, n=4.

lbs/ac Starter Fertilizer			Sig. of Tillage	TILLAGE								
				No Till		Ridge Till		Chisel		Moldboard		
				mean	stdev	mean	stdev	mean	stdev	mean	stdev	Avg
N	P_2O_5	K_2O	(.000)	bu/ac[1]								
0	0	0		49.5	8.4	81.5	12.7	88.4	12.8	104.8	10.2	81.3
5	10	5		74.3	12.0	90.1	16.9	94.0	10.0	92.4	7.7	87.8
10	20	10		80.4	7.5	90.5	22.1	100.9	8.4	92.4	11.9	91.1
		average		68.1	16.4	87.4	16.6	94.5	11.0	96.6	11.0	
N	P_2O_5	K_2O	(.012)	% moisture[2]								
0	0	0		23.3	1.3	22.5	0.6	21.8	0.9	20.9	1.1	22.1
5	10	5		20.6	0.8	20.5	2.1	18.6	2.1	19.4	0.0	19.8
10	20	10		19.7	1.3	20.1	1.5	19.0	1.6	18.9	1.2	19.4
		average		21.3	1.9	21.1	1.8	19.9	2.1	19.7	1.3	

1. The significance of starter fertilizer was .010; the significance of the interaction of tillage x starter fertilizer was .002.
2. The significance of starter fertilizer was .000; the significance of the interaction of tillage x starter fertilizer was .780.

Data collected at the Wright County site are shown in tables 33 to 43. Soil cover by crop residue is shown in tables 34 and 35. There is generally more residue after corn than soybeans. In row cover by soybean residue is less than 20% for all but the no till system. Crop residue would have a minimal influence on corn growth. In row cover by soybean residue is less than 20% for all but the no till system (table 38). Similar to the Meeker site, higher in row cover by corn residue would also not effect soybean growth (table 36). Erosion control would be marginal with chisel plowing after soybeans and not adequate with moldboard plowing after either crop. Corn stands were higher with the ridge till system. This is due to more moist soil at planting and better seed to soil contact than the moldboard and chisel plowing options (table 38). Stand reduction with the no till treatment is due to in row crop residue (50%, table 35). The effect of tillage on early growth was similar to the Meeker county site. Ridge till corn was ahead of the other treatments and less variable in growth.

There were no significant weed problems in the soybeans (table 37). Tillage did effect the weeds in the corn. Lambsquarter was the dominant weed and there were higher densities in the no till and ridge till systems. These observations were made before ridging. There was also an application of 2,4-D on May 30 (table 33). The lambsquarter probably affected yields at this site.

Grain yields are shown in table 41 and 42 for soybeans and corn respectively. There is no difference in soybean yields due to tillage if the row spacing is the same. Ridge till soybeans were 8 bu/acre less than the narrow row soybeans (30 and 8 inches). Other research shows that the row spacing response by soybeans is greater in dry years. It is interesting that there was no row spacing response by the soybeans at the Meeker site. Last year there was no row width response at the Wright county site.

In two years at this site the average row width response was 3.6 bu/acre (about $18.00/acre at $5.00/bu). This cost would offset the cost of a conservation tillage drill. The cost of incorporating a preplant incorporated herbicide would be roughly equivalent to two cultivations with a ridge till cultivator. If primary tillage was also used costs would be higher than a ridge till system. Herbicide cost also would have roughly the same (banded preemerge for ridge till compared to preplant incorporated with spring discing). So a spring disc system with narrow rows would be roughly the same profitability as a ridge till system. Systems with primary tillage or no tillage would be less profitable for soybean production based on tillage and herbicide costs, and yields. It must be remembered that the specific circumstance of the individual's enterprise is the determining factor as to the profitability of any system.

Corn yields were higher with the moldboard and chisel plowing systems. Nitrogen was applied sidedress as anhydrous ammonia. Starter fertilizer was applied as 8-23-30 at 150 lbs/acre. Ear leaf tissue samples taken at silk emergence did not show any nutrient concentration differences that would explain these yield differences (table 40). There was early lambsquarter competition in the no till and ridge till treatments which likely explains part of the reduction in yield with these systems. It is probable that the early growth by corn grown with the ridge till system (table 38) resulted in a longer period of moisture stress and possibly at silk emergence which may explain the yield reduction with this system.

WRIGHT COUNTY

Table 33. Cultural practices at Wright County, MN. 1987.

Tillage

No Till

Ridge-Corn was ridged on June 17, 1987 and soybeans were ridged on June 23, 1987.

Chisel-All plots were chiseled on November 6, 1986.

Moldboard-Corn plots were light disced then all plots plowed on October 16, 1986.

Both the chisel and moldboard were split by cultivation. The corn was cultivated on May 29, 1987 and June 17, 1987 and the soybeans on June 6 and 23, 1987. During the first cultivation ridge plots were done also.

Preceding Crops

Corn-soybean rotation since 1982.

1987 Crops

Corn - Pioneer 3737 Soybeans - Pioneer 1677

Planting and Harvest Dates

Soybeans-Ridge till plots were planted with a John Deere Maxemerge planter equipped with Buffalo Till ridge cleaners with 10" sweeps. All other plots were planted with a Tye No Till drill with 8" row spacing equipped with 2" fluted coulters.

Corn-Ridge till plots were planted with a John Deere Maxemerge planter equipped with Buffalo Till ridge cleaners with 10" sweeps. All other plots were planted with the John Deere Maxemerge planter but the sweeps were raised.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 4, 1987	29,700 plants/ac	October 8, 1987
Soybeans	May 4, 1987	225,000 plants/ac	October 8, 1987

Fertilization History-Prior to 1987[1]

Since 1983 both corn and soybeans received 100 to 150 lbs/ac of a 5-12-36 fertilizer applied with the planter. Prior to that only the corn received fertilizer with the planter. 1986-corn was fertilized as follows:

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/ac	---	Date Applied
Corn:	8-23-30[2]	140 lbs/ac	11	32	42	May 2, 1986
	28-0-0[3] UAN	37 gal/ac	110	0	0	June 13, 1986

1. This information is based on an interview with the cooperating farmer.
2. Planter placement 2" beside and 2" below row.
3. Surface banded between rows.

Fertilizer-1987

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	---	lbs/ac	---	Date Applied
Corn:	8-20-32[1]	140 lbs/ac	11	28	45	May 4, 1987
	82-0-0	183 lbs/ac	150	0	0	June 15, 1987

1. Planter placement 2" beside and 2" below row.

Soil

Fairhaven (Typic Hapludolls, fine-loamy over sandy or sandy-skeletal, mixed, mesic) silt loam, 2 to 6 percent slopes, moderately eroded. Soil is well-drained.

Weed Control

Corn

2 qt/ac (2 lbs ai/ac) Lasso + $1^1/_2$ qt/ac ($1^1/_2$ lbs ai/ac) Bladex on May 4, 1987 with planter.
$^1/_2$ pt/ac ($^1/_4$ lb ai/ac) 2,4-D on May 30, 1987.

Soybeans

1 pt/ac ($^1/_2$ lb ai/ac) Basagran + $^1/_2$ pt/ac ($^1/_8$ lb ai/ac) Blazer + 1 pt/ac crop oil on May 25, 1987.
1 pt/ac ($^1/_2$ lb ai/ac) Basagran + $^1/_4$ pt/ac ($^1/_{16}$ lb ai/ac) Blazer + 1 pt/ac ($^2/_{10}$ lb ai/ac) Roast + 1 qt/ac Dash crop oil + 1 gal 28% on June 8, 1987.

Table 34. The effect of tillage on percent of the soil surface covered by corn residue on June 1, 1987, n=16.

	TILLAGE (<.000)							
	No Till		Ridge Till		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Location	% cover							
In Row	61.0	33.3	20.0	21.5	44.0	29.4	5.7	9.5
Between	60.0	29.3	47.7	22.4	46.7	27.0	5.5	9.2

Table 35. The effect of tillage on percent of the soil surface covered by soybean residue on June 1, 1987, n=16.

	TILLAGE (<.000)							
	No Till		Ridge Till		Chisel		Moldboard	
	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Location	% cover							
In Row	49.5	23.3	7.2	9.8	14.5	9.6	1.7	3.2
Between	78.2	19.0	31.2	20.4	19.7	10.5	2.5	5.2

Table 36. The effect of tillage on soybean population and growth stage, June 1, 1987, n=8.

	TILLAGE							
	No Till		Ridge Till		Chisel		Moldboard	
Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Tillage	1000 plants/ac							
(.000)	229	49	161	21	247	38	257	23
	stage[1]							
(.174)	2.4	.7	2.4	.5	3.0	.7	2.9	.7

1. Soybean growth stages are as follows: 1=emergence(Ve), cotyledons above soil surface; 2=cotyledon(Vc) unifoliolate leaves unrolled sufficiently so the leaf edges are not touching; 3=first node, fully developed leaves at unifoliolate nodes and 4=second node; fully developed trifoliolate lead at node above the unifoliolate nodes.

Table 37. The effect of tillage on weed population in soybean on June 1, 1987.

		TILLAGE							
		No Till		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage	% cover							
Purslne	(.132)	0.1	0.3	0.4	0.5	0.0	0.0	0.0	0.0
Lambqurt	(.436)	0.3	0.5	0.5	0.6	0.1	0.3	0.0	0.0
Foxtail	(.124)	3.8	0.9	7.0	3.6	4.5	2.1	8.0	3.4
Milkweed	(.583)	2.8	3.2	1.1	1.9	1.8	1.7	1.3	0.9
Ragweed	(.034)	0.1	0.3	0.4	0.3	0.0	0.0	0.0	0.0
VolCorn	(.264)	0.0	0.0	0.6	0.9	0.4	0.3	0.1	0.3
Quackgrs	(.461)	1.8	2.0	2.8	2.2	3.3	1.9	4.5	4.0
PenyCres	(.021)	2.5	2.4	3.5	1.3	0.4	0.5	0.4	0.5
ShepPurs	(.001)	1.5	1.9	4.0	1.2	0.0	0.0	0.0	0.0
Buckwhet	(.436)	0.8	1.5	1.3	2.5	1.0	2.0	0.5	1.0

Table 38. The effect of tillage on corn population and growth stages on June 1, 1987, n=8.

	TILLAGE							
	No Till		Ridge Till		Chisel		Moldboard	
Sig. of	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Tillage	1000's plants/ac							
(.046)	27.1	3.9	30.7	2.1	28.3	2.0	27.4	1.4
	leaves/plant							
(.252)	3.8	.3	4.3	.4	3.6	.9	3.6	1.0

Table 39. The effect of tillage on weed population in corn on June 1, 1987.

Weed	Sig. of Tillage	No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
		% cover							
Purslne	(.088)	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0
Lambqurt	(.006)	23.0	17.1	25.0	12.9	4.3	0.9	6.6	6.5
Foxtail	(.49)	03	03	04	03	10	14	08	05
Milkweed	(.308)	0.4	0.5	0.3	0.3	0.5	1.0	0.1	0.3
Pigweed	(.436)	0.0	0.0	0.0	0.0	0.1	0.3	0.1	0.3
Ragweed	(.327)	0.0	0.0	0.1	0.3	0.3	0.3	0.0	0.0
VolSoyb	(.436)	0.5	0.0	0.6	0.3	0.8	0.3	0.4	0.3
Quackgrs	(.308)	0.3	0.5	1.3	1.9	0.0	0.0	0.1	0.3
PenyCres	(.522)	0.8	0.9	0.1	0.3	0.4	0.5	0.6	0.9

Table 40. The effect of tillage on earleaf tissue concentration of nitrogen and potassium on July 24, 1987.

Nutrient	Sig. of Tillage	NoTill	Ridge	Chisel	Mboard	Avg
		%				
N	(.447)	2.50	2.37	2.53	2.53	2.48
K	(.986)	2.24	2.36	2.35	2.36	2.33

Table 41. The effect of tillage on soybean yields and moisture at harvest, October 8, 1987, n=4.

Sig. of Tillage	No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
	bu/ac							
(.004)	40.2	6.1	31.1	2.0	38.1	4.1	39.1	5.2
	% moisture							
(.561)	7.2	.4	7.0	.5	7.0	.4	7.4	.3

Table 42. The effect of tillage on corn yields and moisture at harvest, October 8, 1987, n=8.

Sig. of Tillage	No Till mean	No Till stdv	Ridge Till mean	Ridge Till stdv	Chisel mean	Chisel stdv	Moldboard mean	Moldboard stdv
	bu/ac							
(.034)	106	10.4	110	25.3	123	16.3	121	21.7
	% moisture							
(.136)	16.1	2.7	15.3	1.5	14.3	.8	14.2	1.4

Table 43. The effect of cultivation with chisel and moldboard plow on corn yields and moisture at harvest, October 8, 1987, n=4.

Sig. of Tillage	Chisel Plow cultivated mean	Chisel Plow cultivated st dev	Chisel Plow not cult mean	Chisel Plow not cult st dev	Moldboard Plow cultivated mean	Moldboard Plow cultivated st dev	Moldboard Plow not cult mean	Moldboard Plow not cult st dev
	bu/ac[1]							
(.798)	127	9.7	119	21.9	125	26.3	119	19.8
	% moisture[2]							
(.511)	14.2	0.8	14.5	0.8	14.0	1.8	14.6	1.3

1. The significance of cultivation was .366; the significance of the interaction of tillage x cultivation was .719.
2. The significance of cultivation was .040; the significance of the interaction of tillage x cultivation was .349.

TILLAGE, NITROGEN, CORN HYBRID, SOYBEAN VARIETY, AND SOYBEAN SEED TREATMENT EFFECTS ON YIELDS AT MORRIS, LAMBERTON, AND WASECA MN.-1986 AND 1987

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This is summary of a study initiated in 1986 to evaluate: the effect of tillage on nitrogen response by corn following soybeans and soybeans responding to residual soil nitrogen following corn; the effect of tillage on the performance of corn hybrids and soybean varieties; and the effect of tillage and soybean variety on the response to seed treatment with fungicides. This study is being conducted at the Morris, Lamberton, and Waseca Agricultural Experiment Stations. A corn-soybean rotation is being followed.

Tillage ranges from fall plowing with a moldboard, chisel, or paraplow or elimination of primary tillage (ridge till or no till systems). The paraplow is a unique type of subsoiler that leaves the surface relatively undisturbed but lifts the soil more than a conventional subsoiling operation. The tillage is reduced following soybeans in two treatments since less crop residue is being managed. The moldboard/chisel plow system is moldboard plowed following corn and chisel plowed following soybeans. The chisel/no till system is chisel plowed following corn and no tilled following soybeans. Only the ridge till plots were cultivated. Nitrogen was spring applied as anhydrous ammonia. Nitrogen rates at Lamberton and Waseca range from 0 to 200 lbs/acre in 40 lbs/acre increments. Rates were from 0 to 120 lbs/acre in 40 lbs/acre increments at the Morris location. In the second year of the study residual N from the previous corn year were evaluated. There were no discernable influence of residual N on soybean yields (data not presented). The corn and soybean hybrid or varieties are the same at the Lamberton and Waseca locations. Different hybrid or varieties were used at the Morris location due to the shorter season.

RESULTS-1986

Corn

There was one out of six studies that resulted in significant tillage effects on grain yields (tillage and hybrid study at Morris, table 1). The chisel plowing treatment was an average of 7 bu/acre less than the other systems at this site. At the other two sites there were no significant differences in corn yields due to tillage. There were also significant hybrid effects at all locations (table 2). Nitrogen response by corn is shown in table 3. Responses were to 40, 120 and 120 for the Lamberton, Waseca and Morris sites respectively. The Lamberton site showed a significant tillage by N rate interaction. The paraplow treatment was "yield limited" by some other factor at about 80 lbs N/acre.

Soybeans

There was a tillage effect on soybean yields at the Morris and Waseca sites. The ridge till system resulted in a yield reduction of 3 and 5 bu/acre for the Morris and Waseca sites respectively. There was also a tillage by variety interaction at two sites (.130 and .009 at Lamberton and Waseca respectively). These interactions are shown in Figure 1. Yield reductions with this system were much greater with the Elgin variety (especially at Waseca). There was a wide range in soybean yield due to variety. There was a 10 bu/acre reduction between the high and low yielding variety at the waseca site.

Soybean seed treatments resulted in a slight yield reduction at the Morris site, a slight yield increase at the Waseca site with one source of seed treatment and no response at the Lamberton site (table 7). There was a significant variety by seed treatment at the Lamberton site however. Some varieties responded positively and some negatively (table 8) to seed treatments resulting in a non significant main effect of seed treatment. These interactions are shown in Figure 2.

Table 1. The effect of tillage on corn yields following soybeans 1986.

	Location									
	Morris			Lamberton			Waseca			
Crop[1]	TxH[2]	TxN[3]	Avg.	TxH	TxN	Avg.	TxH	TxN	Avg.	Avg.
Cn Sb	Bu/acre									
NT NT	140ab	142	141	123	155	139	135	137	136	139
RT RT	141a	140	141	122	161	142	137	139	138	140
CH NT	140ab	141	140	117	158	138	141	138	140	139
MB CH	130b	136	133	117	160	139	134	135	135	136
PP PP	141a	139	140	117	146	132	136	133	135	136
Sig.	.091	.915		.643	.217		.422	.494		

1. Tillage is different following corn and soybeans in some cases. Tillage follows the crop listed in the heading and are:NT-no till, RT-ridge till, CH-chisel, MB-moldboard, and PP-paraplow.
2. This is the tillage by hybrid study, yields are averaged over hybrid, n=20.
3. This is the tillage by nitrogen study, yields are averaged over nitrogen rates, n=16 and 20 for Morris and the other two sites respectively.

Table 2. The effect of corn hybrid on grain yields, n=20.

	Location			
	Morris		Lmbtn[1]	Wsca
Hybrid	Bu/acre	Hybrid	-Bu/acre--	
P3906	137b	P3737	124a	157a
DK XL8	122c	P3732	131a	138c
DK 461	146a	DK 524	111b	146b
F 4211	135b	SC2410	120ab	130d
P 3790	149a	F 4327	112b	112e
Signif.	<.000		.010	<.000

1. The tillage by hybrid study did not receive nitrogen at this site.

Table 3. Nitrogen response by corn following soybeans, 1986.

	Nitrogen Rate (lb/acre)					
	0	40	80	120	160	200
Location	Bu/acre					
Morris[1](<.000)	114	139	149	156		
Lmbrtn[2](<.000)	131	155	157	161	165	167
Waseca[2](<.000)	82	123	147	153	154	157

1. The hybrid at the Morris location was P 3970, n=16. The number in parenthesis is the p value.
2. The hybrid at the Lamberton and Waseca locations was P 3737, n=20.

Table 4. The effect of tillage and N rate on yields-Lamberton, 1986[1].

	N rate (lbs/acre)					
	0	40	80	120	160	200
Tillage[2]	Bu/acre					
NT/NT	127	159	157	163	158	170
RT/RT	127	163	162	182	159	177
NT/CH	136	155	159	167	169	161
MD/CH	127	162	156	173	169	170
PP/PP	137	138	154	142	151	156

1. The significance of tillage, N rate, and the tillage by N rate interaction is .217, <.000, and .098 respectively.
2. The letter before the slash is following corn and the second following soybeans: NT-no till, RT-ridge till, CH-chisel, MD-moldboard, and PP-paraplow.

Table 5. The effect of tillage on soybean yields following corn, 1986, n=96.

	Location		
Crop[1]	Morris	Lbrtn.	Waseca
Cn Sb	Bu/acre		
NT NT	45.2a	47.3	44.5a
RT RT	42.0b	47.1	39.5b
CH NT	44.3ab	46.5	45.6a
MB CH	45.5a	47.7	45.9a
PP PP	45.3a	48.8	43.6a
Sig.	.055	.205	.011

1. Tillage is differenct following corn and soybeans in some cases.

Table 6. The effect of variety on soybean yields following corn, 1986, n=60.

	Location			
	Morris		Lmbrtn.	Waseca
Variety	Bu/acre	Variety	----Bu/acre----	
P 0877	45.8a	Corsoy79	47.5bc	42.9d
Simpson	45.9a	BSR 101	46.1c	46.6ab
Evans	44.9a	A 1937	47.7bc	47.3a
AP 120	40.7c	Sibley	47.8bc	43.0d
Swift	42.3b	Elgin	42.3d	37.4e
Dassel	45.2a	Hardin	49.7ab	45.0bc
Dawson	46.0a	P 1677	51.5a	44.3cd
Hodg.78	45.0a	Hodg.78	47.0c	43.9cd
Signif.	<.000		<.000	<.000

Table 7. The effect of seed treatment on soybean yields, 1986, n=160.

	Location		
	Morris	Lmbrt	Wsca
Fung.	-----Bu/acre-----		
none	44.9a	47.1	43.2b
Captan	44.4ab	48.1	44.8a
Apron	44.1b	47.2	43.4b
Sig.	.088	.390	.029

Table 8. The interaction between variety and seed treatment at Lamberton and Waseca, 1986.

	Location					
	Lmbrtn (<.000)[1]			Waseca (<.000)[1]		
	none	cptn	aprn	none	cptn	aprn
Variety	----------Bu/acre----------					
Corsoy79	47.9	47.6	47.0	42.7	43.0	42.9
BSR 101	45.7	47.2	45.6	47.3	45.5	47.0
A 1937	48.7	47.7	46.8	48.3	47.5	46.0
Sibley	48.0	47.6	47.8	43.2	42.4	43.5
Elgin	38.8	45.8	42.4	32.2	43.9	36.1
Hardin	49.9	49.6	49.7	45.7	45.8	43.5
P 1677	51.7	51.8	51.1	41.8	45.8	45.2
Hodg.78	46.3	47.5	47.4	44.7	44.2	42.9

1. The number in parenthesis is the significance of the variety by seed treatment interaction, n=20. See table 7 for main effects of seed treatment.

RESULTS-1987

Corn

Tillage affected grain yields at all but the tillage by hybrid study at Morris and are summarized in table 9. There was a yield decline with the no till and paraplow treatments at the Morris and Waseca locations. The fall chisel plowing treatment resulted in the highest grain yield at the Lamberton location. There were also significant main effects of corn hybrid at the Morris and Waseca location but not at Lamberton (table 10). The nitrogen response is shown in table 11. There was no response to nitrogen at the Morris site. Corn responded to the 40 and 80 lbs/acre rate at the Lamberton and Waseca sites respectively. There was no interaction at any site between tillage and N response. Tillage did interact with corn hybrid at the Morris site (table 12). The ridge till response to the P 3906 and DK XL8 was similar in another study at this location with corn grown after corn (sister study reported in this publication).

Soybeans

Tillage effects were not consistent in their effect on soybean yields but the trend was for the ridge till system to result in a small yield advantage and the paraplow treatment a small yield reduction (table 13). There were significant variety effects at all locations (table 14). The Swift, Dawson, and Hodgson 78 were the highest yielding varieties at the Morris location. Asgrow 1937 and Hardin were the high yielding varieties at the Lamberton and Waseca sites. Evans and Sibley were the lowest yielding varieties at the Morris and Lamberton and Waseca sites respectively.

There was a significant tillage by soybean variety interaction in the tillage-soybean-nitrogen study at the Lamberton and Morris sites (p value of <.000 and .042 respectively for the tillage by variety interaction). These interactions are shown in figure 3. At the Lamberton site the BSR 101 and Hodgson varieties were consistently lower yielding across the tillage systems evaluated. The Hardin and Asgrow 1937 reversed ranking depending on tillage system. Hardin was higher yielding when grown with chisel or paraplowing, about the same with ridge tillage or moldboard plowing and lower yielding than the Asgrow when grown with the no till system. At the Morris location the Hodgson 78 was higher yielding when grown with ridge tillage or moldboard plowing and about the same as the other varieties with the other tillage systems. The consistent trend at both locations is the similarity between ridge till and moldboard plowing in the variety response. There was no advantage with seed treated with fungicide at any site (table 14) regardless of tillage.

Table 9. The effect of tillage on corn yields following soybeans, 1987.

		Location								
		Morris			Lamberton			Waseca			
Crop[1]		TxH[2]	TxN[3]	Avg.	TxH	TxN	Avg.	TxH	TxN	Avg.	Avg.
Cn	Sb	----------Bu/acre----------									
NT	NT	122	114b	118	133b	131a	132	148d	132b	140	130
RT	RT	131	133a	132	130bc	121b	126	158ab	140ab	149	136
CH	NT	135	128a	132	132b	119b	126	151cd	147a	149	136
MB	CH	128	132ab	130	142a	132a	137	161a	150a	156	141
PP	PP	129	115b	122	126c	114b	120	154bc	140ab	147	130
Sig.		.158	.017		.001	.003		.005	.022		

1. Tillage is different following corn and soybeans in some cases. Tillage follows the crop listed in the heading and are:NT-no till, RT-ridge till, CH-chisel, MB-moldboard, and PP-paraplow.
2. This is the tillage by hybrid study, yields are averaged over hybrid, n=20.
3. This is the tillage by nitrogen study, yields are averaged over nitrogen rates, n=16 and 20 for Morris and the other two sites respectively.

Table 10. The effect of corn hybrid on grain yields, 1987, n=20.

	Location			
	Morris		Lmbtn	Wsca
Hybrid		Hybrid	-Bu/acre--	
P3906	137a	P3737	127	159a
DK XL8	123c	P3732	131	158a
DK 461	136a	DK 524	133	147b
F 4211	122c	SC2410	135	162a
P 3790	127b	F 4327	138	146b
Signif.	<.000		.396	<.000

Table 11. Nitrogen response by corn following soybeans, 1987.

	Nitrogen Rate (lb/acre)					
	0	40	80	120	160	200
Location	--------Bu/acre--------					
Morris[1](.456)	120	123	127	121		
Lmbrtn[2](.068)	112	125	128	127	121	127
Waseca2(<.000)	101	132	153	150	159	153

1. The hybrid at the Morris location was P 3970, n=16. The number in parenthesis is the p value.
2. The hybrid at the Lamberton and Waseca locations was P 3737, n=20.

Table 12. The effect of tillage and hybrid on yields at Morris, 1987.

	Tillage[1](.158)					
	N/N	R/R	C/N	M/C	P/P	Avg.
Hybrid<.000	------Bu/acre--------					
P 3906	128	142	132	142	141	137
DK XL8	122	115	132	111	134	123
DK 461	121	141	147	134	135	136
F 4211	126	122	130	117	116	122
P 3790	115	135	134	134	119	127
Average	122	131	135	128	129	

1.Tillage is different following corn and soybeans in some cases. The letter before the slash is following corn and the second following soybeans: N-no till, R-ridge till, C-chisel, M-moldboard, and P-paraplow.
2. The tillage by hybrid interaction was significant at .068.

Table 13. The effect of tillage on soybean yields following corn in 1987.

	Location									
	Morris			Lamberton			Waseca			
Crop[1]	TxVxS[2]	TxVxN[3]	Avg.	TxVxS	TxVxN	Avg.	TxVxS	TxVxN	Avg.	Avg.
Cn Sb	---Bu/acre---									
NT NT	42.3	39.5ab	40.9	39.3	42.3	40.8	42.0	43.6ab	42.8	41.5
RT RT	42.7	40.9a	41.8	38.7	44.4	41.6	42.4	44.2a	43.3	42.2
CH NT	42.2	38.1ab	40.2	39.5	43.6	41.6	42.3	41.5b	41.9	41.2
MB CH	41.2	39.0ab	40.1	38.8	44.6	41.7	42.0	43.0ab	42.5	41.4
PP PP	39.0	36.9b	38.0	37.0	42.4	39.7	42.6	41.4b	42.0	39.9
Sig.	.417	.100		.338	.623		.956	.056		

1. Tillage is different following corn and soybeans in some cases. Tillage follows the crop listed in the heading and are:NT-no till, RT-ridge till, CH-chisel, MB-moldboard, and PP-paraplow.
2. This is the tillage by variety by seed treatment study, yields are averaged over varieties and seed treatment, n=64 for the Morris site and 96 for the other two sites.
3. This is the tillage by variety by nitrogen study, yields are averaged over varieties and nitrogen rates, n=16 and 20 for Morris and the other two sites.

Table 14. The effect of seed treatment on soybean yields.

	Location		
	Mors	Imbt	Wsca
Fung.	---Bu/acre---		
none	41.3	37.8	42.2
Captan	41.4	38.8	42.5
Apron	41.7	39.4	42.1
Sig.	.443	.189	.704

Table 14. The effect of variety on soybean yields following corn, 1987.

	Location										
	Morris				Lamberton			Waseca			
	TxVxS[1]	TxVxN[2]	Avg.		TxVxS	TxVxN	Avg.	TxVxS	TxVxN	Avg.	Avg.
Variety	-----Bu/acre------			Variety	---Bu/acre---						
P 0877	41.7ab	38.4c	40.1	Corsoy79	38.7c	---	38.7	41.7bc		41.7	40.2
Simpson	41.7ab	39.3b	40.5	BSR 101	37.1d	41.0b	39.1	43.5ab	42.4b	43.0	41.1
Evans	38.4b	36.8d	37.6	A 1937	43.6a	45.9a	44.8	44.7a	43.6ab	44.2	44.5
AP 120	39.7b	---	39.7	Sibley	34.0f	---	34.0	39.2c	---	39.2	36.6
Swift	43.7a	---	43.7	Elgin	37.2d	---	37.2	41.3bc	---	41.3	39.3
Dassel	39.1b	---	39.1	Hardin	42.8a	46.8	44.8	43.5ab	45.1a	44.3	44.6
Dawson	43.5a	---	43.5	P 1677	40.3b	---	40.3	44.9a	---	44.9	42.6
Hodg.78	43.9a	41.1a	42.5	Hodg.78	35.7e	40.1b	37.9	39.0c	39.8c	39.4	39.9
Signif.	.008	<.000			<.000	<.000		<.000	<.000		

1. This is the tillage by variety by seed treatment study, yields are averaged over tillage and seed treatment, n=60.
2. This is the tillage by variety by nitrogen study, yields are averaged over tillage and nitrogen rates, n=80 and 120 for Morris and the other two sites respectively.

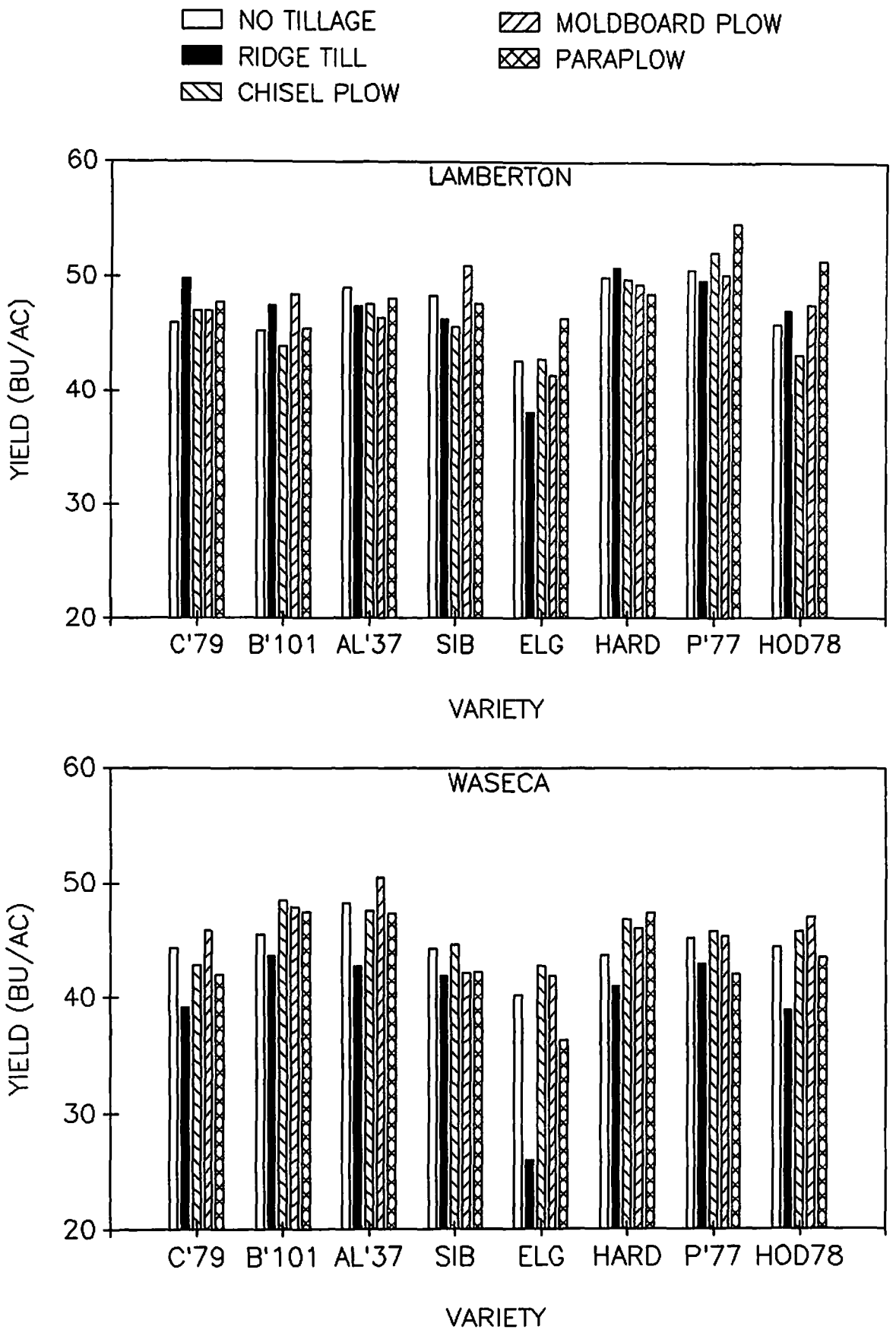

Figure 1. The interaction of soybean variety and tillage system, 1986.

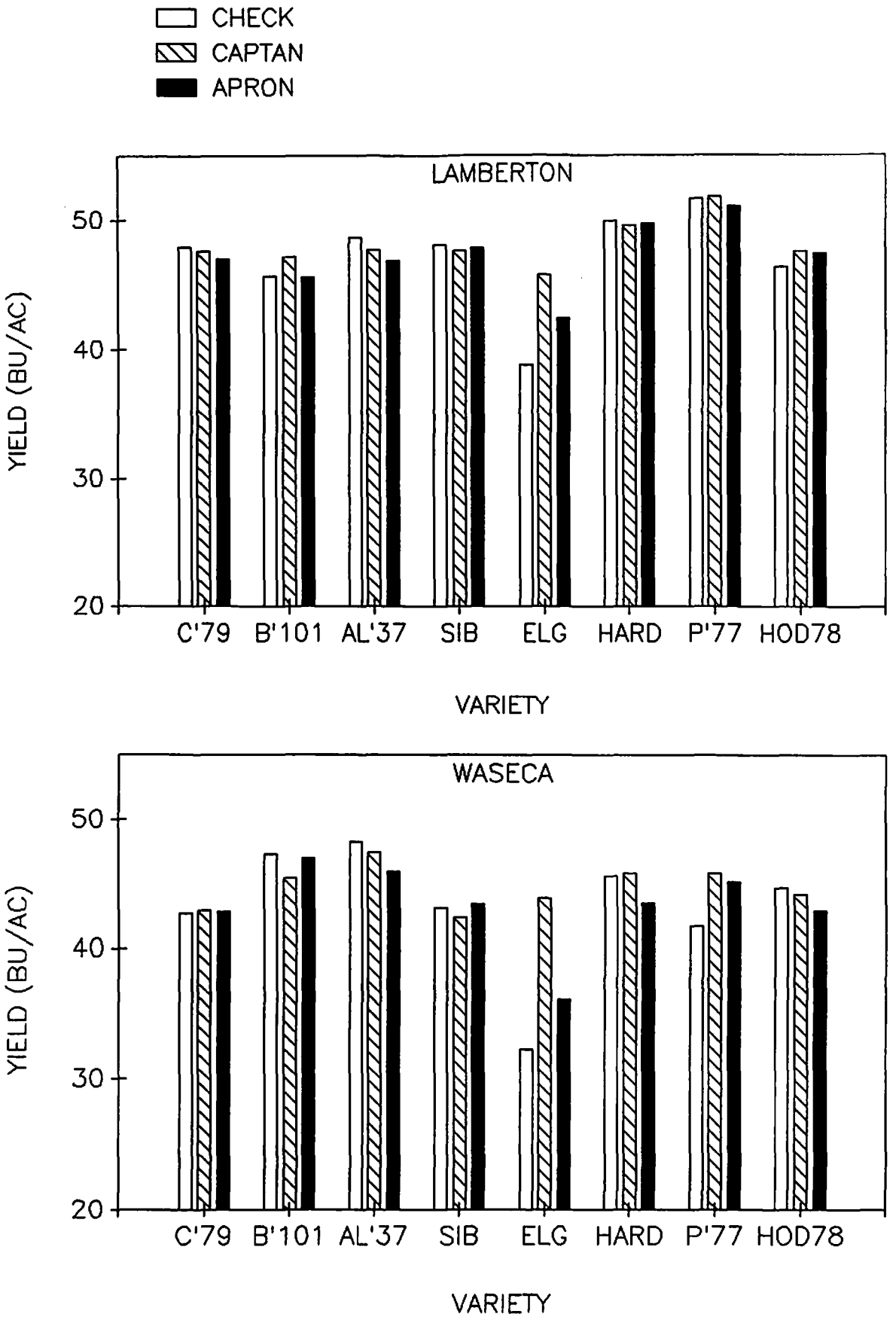

Figure 2. The interaction of soybean variety and seed treatment, 1986.

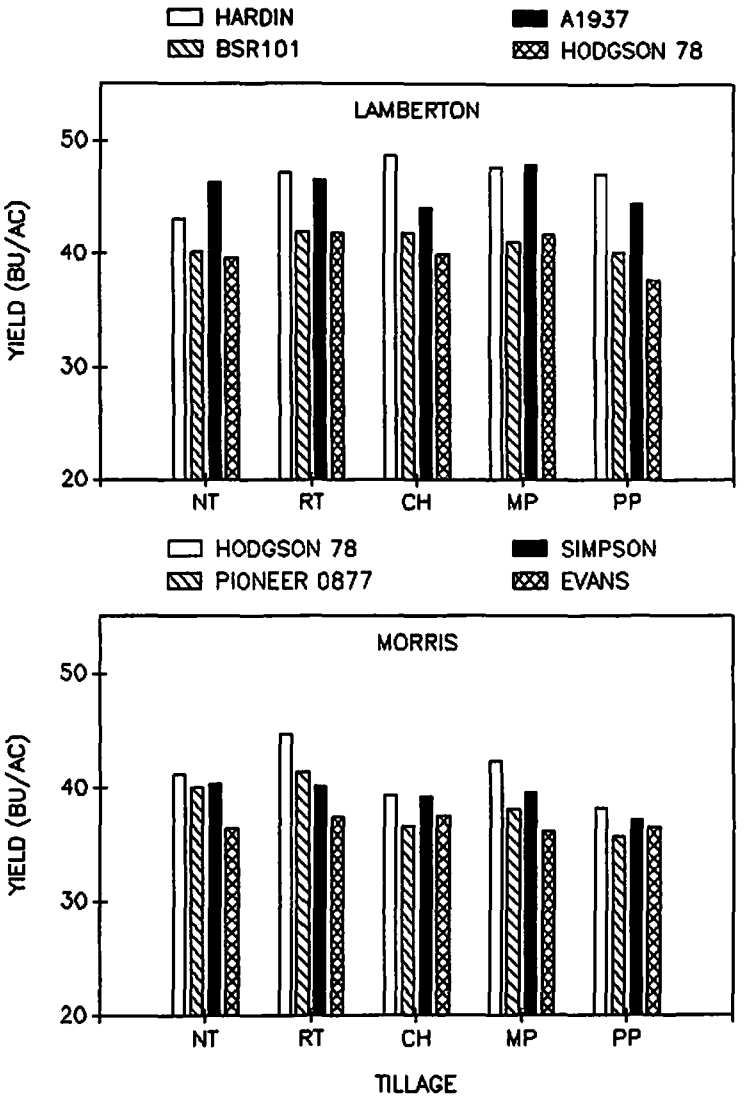

Figure 3. The effect of tillage and soybean variety on yields, 1987.

THE EFFECT OF TILLAGE ON THE NITROGEN RESPONSE BY CORN FOLLOWING ALFALFA

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A study was initiated in 1987 to evaluate the effect of tillage on the nitrogen response by corn following alfalfa. When crop residue is left on the soil surface temperatures are reduced that can affect the rate of mineralization of organic nitrogen in alfalfa residues. The purpose of this study is to help refine the nitrogen recommendations following alfalfa to address tillage effects. Tillage ranged from moldboard plowing to no till. Nitrogen was applied on June 16 as broadcast urea and irrigated in.

Crown counts were made in the spring to determine the variability of alfalfa stand (table 2). Tillage treatments have not been established at this time. There was no correlation between the proposed randomized tillage and nitrogen plots and alfalfa crown density. Soil cover by crop residue after planting is shown in table 5. Soil cover by crop residue ranged from about 10% with moldboard plowing to over 90% with no tillage. Although emergence was affected by tillage, final stands were quite good and not effected by tillage (tables 3 and 14). The difference in emergence due to tillage resulted in about one day difference in silk emergence (table 4) and one half to one percent difference in grain moisture at harvest (table 12). The effect of tillage on crop phenology during early growth is shown in table 15. Generally in row soil cover by crop residue retarded early growth. During the May 27 to June 1 period there was emergence of additional plants in the moldboard plow treatment that brought its average leaf number down temporarily. On June 16 nitrogen was applied as broadcast urea and irrigated in. Between June 8 and June 16 apparently the no till system was limited by less nitrogen released from the alfalfa. After nitrogen application no till corn grew faster than the other systems. During the last week of observation the no till corn appears to be limited by nitrogen (these values are averaged over all rates of nitrogen, including the check plots). For a fair evaluation of crop residue effects on temperature only the plots that received nitrogen should be used in the analysis after this date.

Weeds were present in low numbers and affected by tillage in some cases (table 6). Foxtail tended to be higher in the no till and disc treatments and lambsquarters higher with moldboard plowing. At these levels they would not be expected to affect grain yields. On July 9 weeds were wiped with a Roundup wick applicator. There were no weeds present at harvest.

Row fertilizer was applied with the planter (table 1) and included 16 lbs N/acre. Additional nitrogen was applied as broadcast urea and irrigated in at the eight leaf stage of corn growth. Nitrogen was less available with conservation tillage options. Color ratings which qualitatively evaluate tillage are shown in tables 7 and 8. There were main effects of tillage and nitrogen rate on plant color and also plant height (tables 7,8,9, and 10). An interaction between tillage and nitrogen rate on plant color was found on the July 3 date. These data support the yield differences shown in table 11. At the 102 lb N/acre rate of nitrogen there was no affect of tillage on grain yields. At lower rates differences become much greater. Similar trends are shown with the stover data (table 13).

Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1987.

Tillage	**Previous Crop**	**1987 Crop**
No Till	Alfalfa	Corn - Pioneer 3790
Spring Disc - Plots disced twice on May 8, 1987.		
Moldboard Plow - Plots plowed on May 8, 1987.		

Planting and Harvest Date

Planter for this site was a John Deere Maximerge planter equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 11, 1987	32,000 plants/ac	October 1, 1987

Fertilizer

Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
		---- lbs/ac ----				
17-7-23-6[1]	93 lbs/ac	16	6	21	6	May 11, 1987
46-0-0[2]	0 lbs/ac	0	0	0	0	June 16, 1987
46-0-0[2]	75 lbs/ac	35	0	0	0	June 16, 1987
46-0-0[2]	146 lbs/ac	67	0	0	0	June 16, 1987
46-0-0[2]	221 lbs/ac	102	0	0	0	June 16, 1987

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.

Soil

The soil at this site is a Verndale (Udic Argiborolls, coarse-loamy, mixed) with a slope of 0 to 2 percent. The soil is well drained.

Weed Control

1 qt/ac ($^3/_4$ lb/ac) Roundup + $^1/_2$ pt/ac (.125 lb/ac) Banvel on May 2, 1987.
1 qt/ac (2 lb/ac) Dual + $1^1/_2$ qt/ac ($1^1/_2$ lbs/ac) Bladex on May 14, 1987.
Weeds between the rows were wiped with a Roundup wick applicator at 4 inches high on July 9.

Table 2. The viability on alfalfa crown counts with proposed tillage on April 28, 1987.

	Tillage: No Till mean	No Till stdev	Disc mean	Disc stdev	Moldboard mean	Moldboard stdev
Viable	----------		crowns/m^2		----------	
16 lbs/ac	18.3	7.92	21.1	7.80	22.3	3.52
50 lbs/ac	20.5	8.25	22.7	7.05	23.2	7.28
83 lbs/ac	16.3	5.85	22.1	9.17	17.5	6.79
117 lbs/ac	17.1	4.46	18.6	11.2	17.1	6.34
NonViable	----------		crowns/m^2		----------	
16 lbs/ac	11.5	2.35	10.9	1.32	10.0	2.57
50 lbs/ac	10.6	4.64	9.3	1.13	11.9	6.61
83 lbs/ac	11.4	4.05	12.0	4.33	13.0	4.86
117 lbs/ac	8.6	2.74	11.9	4.76	11.6	3.13
Total	----------		crowns/m^2		----------	
16 lbs/ac	29.8	6.88	32.0	6.23	32.3	3.08
50 lbs/ac	31.1	7.69	32.0	6.07	35.1	4.85
83 lbs/ac	27.8	3.84	34.1	10.2	30.5	5.99
117 lbs/ac	25.6	3.29	30.6	13.9	28.8	6.67

Table 3. The effect of tillage on emergence of corn from May 9, to June 1, 1987. n=16.

Date	Sig. of Tillage	Tillage: No Till mean	No Till stdev	Disc mean	Disc stdev	Moldboard mean	Moldboard stdev
		--------- plants/ac x 1000 ---------					
May 19	(.000)	0.0	0.00	1.2	1.88	6.1	5.28
May 20	(.000)	2.9	2.97	12.1	7.51	15.7	6.61
May 21	(.030)	17.1	8.00	24.0	6.93	22.5	6.75
May 22	(.194)	21.5	9.13	26.2	5.03	23.2	7.05
May 26	(.311)	29.3	4.60	29.2	5.11	26.5	7.45
May 27	(.576)	29.7	4.24	29.6	4.63	28.2	4.98
May 28	(.209)	30.6	4.02	30.6	4.59	28.2	4.77
May 29	(.358)	30.7	4.02	30.5	4.68	28.7	4.32
June 1	(.355)	30.7	4.21	30.5	4.54	28.7	4.41

Table 4. The effect of tillage on silk emergence by date, n=16.

		Tillage(.014)					
		No Till		Disc		Moldboard	
Date[1]	Sig. of Tillage	mean	stdev	mean	stdev	mean	stdev
		%					
July 20	(.120)	2.7	4.5	7.5	9.5	9.4	11.3
July 22	(.007)	47.4	18.0	64.7	26.8	72.6	15.1
July 23	(.237)	78.4	15.0	82.2	19.1	86.3	9.2
July 24	(.304)	87.4	12.2	92.8	11.6	91.8	5.6
July 27	(.384)	96.3	6.5	97.4	3.7	98.9	2.5

1. Date of 50% silk emergence was July 21 for the moldboard plow treatment and July 22 for the disc and no till treatments.

Table 5. The effect of tillage on soil cover by corn residue on May 14, 1987, n=16.

	Tillage					
	No Till		Disc		Moldboard	
Location[1]	mean	stdev	mean	stdev	mean	stdev
	%					
In Row	91.7	6.4	47.7	24.5	12.7	19.7
Between	96.5	5.0	40.5	24.6	10.5	19.2

1. The significance of tillage with respect to both rows was <.000.

Table 6. The effect of tillage on the presence of weed species and density on July 2, 1987. n=12.

		Tillage					
		No Till		Disc		Moldboard	
Weed	Sig. of Tillage	mean	stdev	mean	stdev	mean	stdev
		severity[2]					
Pigweed	(.227)	2.25	0.50	2.75	0.96	1.75	0.50
Foxtail	(.003)	6.00	1.15	4.00	2.30	1.75	0.50
VolAlfl	--	2.25	0.50	1.25	0.50	0.00	0.00
Dandeln	--	0.75	0.50	0.75	0.50	0.00	0.00
Lambqur	(0)	0.75	0.50	0.75	0.50	1.00	0.00
Quackgr	(.422)	1.00	0.82	0.50	0.58	0.25	0.50
Buckwht	(0)	0.75	0.50	1.00	0.00	1.00	0.00
CanThis	(.422)	0.25	0.50	0.50	1.00	0.25	0.50
Alyssum	--	1.30	0.50	0.25	0.50	0.00	0.00
Nightsh	--	0.75	0.50	0.50	0.58	0.50	0.58
Milkwed	--	0.25	0.50	0.00	0.00	0.00	0.00
Crabgrs	--	0.00	0.00	0.25	0.50	0.25	0.50
Ragweed	--	0.00	0.00	0.00	0.00	0.50	0.58
Hwkberd	--	0.50	0.58	0.00	0.00	0.00	0.00
Ydsorrl	--	0.25	0.50	0.00	0.00	0.00	0.00
Whtcokl	--	0.25	0.50	0.25	0.50	0.00	0.00
SmPigwd	--	0.00	0.00	0.00	0.00	0.25	0.50
RusThis	--	0.25	0.50	0.00	0.00	0.00	0.00
Purslne	(.422)	0.50	0.58	0.50	0.58	0.50	1.00

1. Due to unequal variances, a natural log transformation was used before analysis of variance.
2. Severity scale used is as follows; 1-none, 5-moderate and 10-severe.

Table 7. The effect of tillage on color by nitrogen July 3, 1987, n=4. (Color index ranges from 1=yellow to 10=dark green).

	Tillage(.000)						
	No Till		Disc		Moldboard		
Nitrogen[1]	mean	stdev	mean	stdev	mean	stdev	Avg
	color rating						
16 lbs/ac	6.25	0.50	7.00	0.82	8.00	0.00	7.08
50 lbs/ac	7.00	0.00	7.25	0.50	8.00	0.00	7.42
83 lbs/ac	7.25	0.50	7.50	0.58	8.00	0.00	7.58
117 lbs/ac	7.25	0.50	8.00	0.00	8.00	0.00	7.75
average	6.94	0.57	7.44	0.63	8.00	0.00	

1. The significance of nitrogen was .000, the significance of tillage x nitrogen was .019.

Table 8. The effect of tillage on color by nitrogen August 8, 1987, n=4. (Color index ranges from 1=yellow to 10=dark green).

	Tillage(.000)						
	No Till		Disc		Moldboard		
Nitrogen[1]	mean	stdev	mean	stdev	mean	stdev	Avg
	color rating						
16 lbs/ac	5.5	1.0	6.0	0.8	7.3	0.5	6.3
50 lbs/ac	6.3	0.5	6.3	1.5	7.5	1.0	6.7
83 lbs/ac	7.0	1.4	6.8	0.5	8.0	0.0	7.3
117 lbs/ac	7.8	0.5	7.8	1.0	8.0	0.0	7.8
average	6.6	1.2	6.7	1.1	7.7	0.6	

1. The significance of nitrogen was .000, the significance of tillage x nitrogen was .324.

Table 9. The effect of tillage and nitrogen on plant height July 3, 1987, n=4.

	Tillage(<.000)						
	No Till		Disc		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Nitrogen[1]	feet						
16 lbs/ac	3.2	0.1	3.8	0.2	4.0	0.1	3.67
50 lbs/ac	3.4	0.1	3.8	0.2	4.0	0.1	3.71
83 lbs/ac	3.4	0.1	3.8	0.1	4.0	0.1	3.78
117 lbs/ac	3.4	0.1	3.8	0.1	4.0	0.2	3.72
average	3.4	0.1	3.8	0.2	4.0	0.1	

1. The significance of nitrogen was .014, the significance of tillage x nitrogen was .219.

Table 10. The effect of tillage and nitrogen on plant height August 9, 1987, n=4.

	Tillage(<.000)						
	No Till		Disc		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Nitrogen[1]	feet						
16 lbs/ac	7.7	0.2	8.2	0.2	8.2	0.1	8.02
50 lbs/ac	7.9	0.1	8.1	0.3	8.2	0.2	8.06
83 lbs/ac	7.9	0.3	8.2	0.2	8.3	0.3	8.15
117 lbs/ac	8.0	0.4	8.2	0.2	8.4	0.3	8.19
average	7.9	0.3	8.2	0.2	8.3	0.2	

1. The significance of nitrogen was .069, the significance of tillage x nitrogen was .542.

Table 11. The effect of tillage and nitrogen on yields of corn on October 1, 1987, n=4.

	Tillage(.000)						
	No Till		Disc		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Nitrogen[1]	bu/ac						
16 lbs/ac	146	8.4	170	16.6	190	12.0	168.8
50 lbs/ac	171	19.6	190	11.4	196	5.3	186.3
83 lbs/ac	189	13.7	188	10.7	207	8.5	195.1
117 lbs/ac	199	12.4	189	13.8	201	8.5	196.7
average	177	24.4	185	14.7	199	10.4	

1. The significance of nitrogen was .000, the significance of tillage x nitrogen was .009.

Table 12. The effect of tillage and nitrogen on harvest moisture on October 1, 1987, n=4.

	Tillage(.085)					
	No Till		Disc		Moldboard	
	mean	stdev	mean	stdev	mean	stdev
Nitrogen[1]	%					
16 lbs/ac	32.6	0.7	32.0	1.2	31.4	1.6
50 lbs/ac	33.1	1.4	32.0	0.6	31.9	1.0
83 lbs/ac	32.6	0.2	31.9	0.5	31.9	0.6
117 lbs/ac	32.5	0.3	33.1	2.1	31.9	0.6
average	32.8	0.8	32.3	1.3	31.8	1.0

1. The significance of nitrogen was .655, the significance of tillage x nitrogen was .770.

Table 13. The effect of tillage and nitrogen on stover harvest on October 1, 1987, n=4.

	Tillage(.000)						
	No Till		Disc		Moldboard		
	mean	stdev	mean	stdev	mean	stdev	Avg
Nitrogen[1]	ton/ac						
16 lbs/ac	3.3	0.3	3.8	0.2	4.0	0.6	3.72
50 lbs/ac	3.6	0.2	4.2	0.3	4.4	0.4	4.08
83 lbs/ac	3.9	0.2	4.1	0.3	4.7	0.3	4.25
117 lbs/ac	4.1	0.2	4.0	0.2	4.6	0.2	4.24
average	3.7	0.4	4.0	0.3	4.5	0.4	

1. The significance of nitrogen was .000, the significance of tillage x nitrogen was .147.

Table 14. The effect of tillage and nitrogen on final stand on October 1, 1987, n=4.

	Tillage(.254)					
	No Till		Disc		Moldboard	
	mean	stdev	mean	stdev	mean	stdev
Nitrogen[1]	plants/ac x 1000					
16 lbs/ac	28.4	0.88	28.2	1.27	28.2	0.49
50 lbs/ac	28.7	2.45	28.5	1.30	27.7	0.67
83 lbs/ac	29.0	0.92	27.7	2.02	29.3	0.96
117 lbs/ac	29.8	2.53	28.2	0.75	28.4	0.77
average	29.0	1.77	28.2	1.30	28.4	0.91

1. The significance of nitrogen was .705, the significance of tillage x nitrogen was .617.

Table 15. The effect of tillage on early corn growth, n=16.

		Tillage					
		No Till		Disc		Moldboard	
Date	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		leaves/plant					
May 19	(.000)	0.00	0.00	0.16	0.24	0.41	0.20
May 20	(.065)	0.34	0.24	0.41	0.20	0.50	0.00
May 21	(.069)	0.44	0.17	0.50	0.01	0.51	0.05
May 22	(.036)	0.50	0.00	0.51	0.03	0.54	0.07
May 26	(.036)	1.31	0.09	1.39	0.14	1.42	0.11
May 27	(.284)	1.85	0.17	1.99	0.19	1.94	0.38
May 28	(.190)	2.39	0.07	2.41	0.12	2.28	0.34
May 29	(.087)	2.46	0.06	2.47	0.05	2.39	0.17
June 1	(.059)	3.40	0.12	3.48	0.05	3.37	0.17
June 2	(.091)	3.85	0.26	4.01	0.24	3.93	0.28
June 3	(.018)	4.23	0.16	4.38	0.11	4.26	0.19
June 4	(.053)	4.66	0.19	4.82	0.18	4.67	0.25
June 5	(.241)	4.80	0.23	4.92	0.20	4.80	0.23
June 8	(.201)	5.93	0.20	6.02	0.24	6.08	0.30
June 9	(.191)	5.93	0.20	6.03	0.24	6.08	0.30
June 10	(.000)	6.22	0.26	6.60	0.26	6.63	0.32
June 11	(.003)	6.60	0.24	6.86	0.20	6.88	0.28
June 12	(.003)	6.60	0.24	6.86	0.20	6.88	0.28
June 15	(.000)	7.84	0.25	8.14	0.37	8.31	0.35
June 16	(.000)	7.91	0.28	8.31	0.30	8.31	0.35
June 17	(.402)	8.95	0.39	8.89	0.48	9.13	0.58
June 18	(.440)	8.94	0.39	8.94	0.42	9.13	0.57
June 19	(.000)	9.46	0.41	10.06	0.44	10.14	0.48
June 22	(.000)	10.28	0.23	10.75	0.45	10.91	0.39
June 24	(.000)	11.09	0.35	11.76	0.58	11.98	0.51

EFFECT OF TILLAGE AND APPLICATION OF SWINE MANURE ON CORN YIELD

J.R.Joshi, J.F.Moncrief, J.J.Kuznia, and J.B.Swan

Cooperator: D.Nord

A study was initiated in 1987 to determine the effects of tillage and frequency of manure application on corn yield and nitrogen uptake. A second purpose was to determine the amount of N taken up from manure applied prior to the current cropping year.

Procedure. Liquid swine manure was injected annually, every alternate year (even and odd year) at two rates(5,775 and 11,550 gal/ac) on ridge till and chisel till treatments. Two additional treatments with one receiving 170 lb. N/ac of anhydrous ammonia and the other receiving none were established in both tillage treatments for comparison.

Since 1987 was the year of establishment for this experiment, the treatments for an odd year were in effect for this year. The different cultural practices and the amount of N in the form of liquid swine manure and anhydrous ammonia are described in Table 1 below. Table 2 summarizes the effects of the various treatments on grain yield and grain moisture. The chisel tilled treatments resulted in generally lower grain yields and lower grain moisture, although the difference is not all significant. This is an establishment year, all the plots were spring chiseled and ridges were formed on ridge till plots. The effects of tillage were thus less likely to be evident for this year.

GOODHUE COUNTY

Table 1. Cultural practices at Nords Farm, Goodhue County, Mn. 1987

Tillage

Ridge Till

Chisel Plow

This was the establishment year for this site and the plots were all disced then sub-soiled and disced again prior to planting.

Preceding Crop — Corn since 1974.

1987 Crop — Corn - Pioneer 3906

Fertilizer History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O
		-- lbs/ac ---		
Corn	7-21-7[1] (10 gal/ac)	8	25	8
	82-0-0 (146 lbs/ac)	120	0	0

1. Planter applied.

Planting and Harvest Date

Planter was Allis Chalmers 385 six row (30").

Crop	Date	Rate	Harvested
Corn	May 11,1987	28,000 plants/ac	Sept. 24, 1987

Soil

Soils at this site are Seaton (Typic Haplaudalfs, fine-silty, mixed, mesic) silt loam, Mt. Carroll (Mollic Hapludalfs, fine-silty, mixed, mesic) silt loam and a Port Bryon (Typic Haplaudolls, fine-silty, mixed, mesic) silt loam.

Fertilizer

Crop	Material	Rate	Actual Total N	Actual NH_4-N	Date Applied
			--- lbs/ac ---		
Corn	pig manure[1]	5,775 gal/ac	55	39	May 7, 1987
	pig manure[1]	11,550 gal/ac	111	77	May 7, 1987
	82-0-0[1]	207 lbs/ac	170	170	May 18, 1987

1. Materials applied to appropiate plots.

Weed Control 3 pts/ac Prowl + 2 lbs/ac Bladex 90 DF. **Insect Control** 6.9 lbs/ac Counter.

Table 2. Effects of tillage and amount of manure application on grain yield and moisture of corn at harvest.

		YIELD			MOISTURE		
		Tillage[1]					
Year		Ridge mean	Chisel mean	Average	Ridge mean	Chisel mean	Average
1987	Source and rate of N[2]	-------- bu/ac		----------	---------- %		----------
	None	138.4	130.3	134.4	35.4	35.2	35.3
	anhydrous 170 lbs N/ac	171.8	163.4	167.6	36.2	36.6	36.4
	manure 55 lbs N/ac	151.9	151.0	150.5	35.0	34.6	34.8
	manure 110 lbs N/ac	163.2	152.2	157.7	34.3	34.0	35.2

1. Significance value due to tillage was 0.303 and .085 for grain yield and grain moisture, respectively.
2. Yields were highly significant due to N application for both grain yield and grain moisture.

Table 3. Effects of tillage and amount of manure application on silage dry matter yield and dry matter content of corn.

		YIELD			DRY MATTER		
		Tillage[1]					
Year		Ridge mean	Chisel mean	Average	Ridge mean	Chisel mean	Average
1987	Source and rate of N[2]	-------- ton/ac		----------	---------- %		----------
	None	2.33	2.65	2.49	29.3	33.3	31.3
	anhydrous 170 lbs N/ac	3.02	3.02	3.02	29.3	28.6	29.0
	manure 55 lbs N/ac	2.57	2.50	2.54	29.7	29.1	29.4
	manure 110 lbs N/ac	2.65	2.78	2.72	29.9	32.1	31.0

1. Significance due to tillage was 0.242 for silage dry matter yield and .004 for dry matter, respectively.
2. Differences due to N source and rate highly significant (.00).

EFFECT OF TILLAGE AND FREQUENCY OF MANURE APPLICATION ON N UPTAKE AND CORN YIELD - 1985-87 SUMMARY

J.R.Joshi, J.F.Moncrief, J.J.Kuznia, and J.B.Swan

Cooperator: Dale Flueger

A study was initiated in 1983 to determine the effects of tillage and frequency of manure application on corn yields and on N uptake. A second purpose of this study was to determine the amount and effect of nitrogen taken up from manure applied one or two years prior to the current cropping year.

Procedure. Liquid dairy manure is injected either annually, biennially or triennially on chisel plowed treatments and annually or biennially on no-till treatments. Yields are compared with check treatments which receive broadcast potassium but no nitrogen fertilizer. The results of this experiment for 1983-84 period are summarized in "Effect of Tillage and Frequency of Manure Application on N-uptake and Corn Yield - 1983-84 Summary" in the 1985 bluebook. Nitrogen and potassium uptake are measured and reference nitrogen measurements are made annually on selected plots.

This paper summarizes the results of the experiment for 1985-87 period. Table 1 provides the information on various cultural practices, soil type and cropping history of the research site for 1987. Most of these practices follow the same operations that were in effect in the earlier years.The results of soil analyses in terms of N in the form of NO3-N, NH4-N, and total N at 0-2 ft and 0-5 ft depths for various treatments in 1986 are summarized and analyzed in Tables 2-4 and those for 0-5 ft depth are presented in Tables 5-6. There are highly significant differences in soil NO3-N levels due to the frequency of manure application and by depth. Tillage differences in soil test values are expressed in generally lower values of NO3-N, NH4-N and total N for the no-till plots for each depth but do not appear to be significant statistically.

Tables 7-9 summarize the grain yield response for 1985, 1986 and 1987. The differences in the grain yields are highly significant due to tillage and N source and frequency of manure application for 1986 and 1987. This trend is also evident in the 1985 data. The grain moisture content appears to vary significantly with tillage and treatment in 1986 and by N source and frequency of manure application in 1987. Similarly, Tables 10-12 illustrate the differences in stover yield, stover dry matter and their significance for the three years. There are highly significant differences both in stover dry matter yield and content for the years 1986-87 due to N source and frequency. The 1985 data show similar trends.

Tables 13-14 summarize the amounts of the primary nutrients applied in the experiment as liquid dairy manure and the effects of various treatments in corn yields (for all the years the experiment has been set up). The amount of total nutrients, especially the different forms of N, varied from year to year. This may account for inconsistent results with some treatments for some years. In general, all the manure treatments resulted in significantly higher grain yields than the control. The yields were either comparable to or sometimes higher than those for the fertilized treatments. The average yields for the seven year experiment show that there is not much difference in yields obtained from manure applied annually or in the year of application to that of fertilized treatment. The yields in the year after the year of application were generally lower than the other manure treatments but certainly higher than the controls indicating considerable carry over from the previous years.

GOODHUE COUNTY

Table 1. Cultural practices at Fluegers Farm Goodhue County, Mn. 1987

Tillage
No Till
Chisel Plow - Chiseled on April 30,1987 and then with a soil finisher on May 6, 1987.

Preceding Crop
Corn since 1981.

1987 Crop
Corn - Pioneer 3906

Planting and Harvest Date
Planter was a Hinicker Econotill two row (38") equipped with 2 inch fluted coulters.

Crop	Date	Rate	Harvested
Corn	May 7,1987	30,000 plants/ac	Sept. 14, 1987

Manure Application
Injected 9200 gal/ac liquid dairy manure with the following analysis in 1987.

Crop	NH_4-N	Total-N	P	K
	--------- lbs/ac			----------
Corn	152	341	91	315

Fertilizer

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			-- lbs/ac --			
Corn	0-0-60[1]	330 lbs/ac	0	0	198	April 16, 1987
	7-21-7[2]	15 gal/ac	12	37	12	May 7, 1987

1. Surface applied to specified plots.
2. Applied 2" beside and 2" below seed.

Insect Control 6.9 lbs/ac Lorsban 15G.

Soil
Timula (Typic Eutrochrepts, coarse-silty, mixed, mesic) silt loam, 2 to 6 percent slope. Soil is well drained.

Weed Control
3 qts/ac Lasso + 2lbs/ac Atrazine + + $1^1/_2$ qts/ac Roundup on May 12, 1987.

Table 2. The effect of tillage, frequency of manure application on NO_3^--N (lbs/ac) NH_4^+-N (lbs/ac) and total mineral nitrogen (lbs/ac) in April 1986.

N Source & Frequency	Depth (ft)	Nitrate-Nitrogen (NO_3) No Till mean	No Till st dev	Chisel mean	Chisel st dev	Ammonium-Nitrogen(NO_3+NH_4) No Till mean	No Till st dev	Chisel mean	Chisel st dev	Total-Nitrogen (NO_3+NH_4) No Till mean	No Till st dev	Chisel mean	Chisel st dev
		---------- lbs/ac ----------											
Ammonium	0-2	96.2	59.0	83.1	33.2	31.4	23.3	36.2	17.1	128	58.5	119	37.5
Nitrate	2-5	183	45.3	197	61.3	27.0	27.0	21.9	16.3	210	47.1	218	58.0
Check	0-2	16.1	4.5	27.7	9.8	42.6	26.7	36.4	37.1	58.7	25.5	64.1	36.2
	2-5	4.7	4.2	16.5	17.9	15.2	14.8	17.8	10.0	19.4	9.7	34.2	8.9
Annual	0-2	39.3	15.1	35.8	10.8	22.5	12.8	44.5	23.2	61.8	6.7	80.3	33.9
	2-5	23.8	16.5	38.8	10.2	22.1	11.1	23.8	22.6	45.9	9.5	62.7	23.8
Biennual-82	0-2	19.6	4.6	26.7	4.3	22.3	6.4	26.2	7.0	42.3	5.2	52.9	5.1
	2-5	5.5	0.4	11.4	1.6	21.9	8.8	15.5	7.3	27.4	8.6	27.0	6.6
Biennual-83	0-2	28.1	8.5	44.2	26.2	38.6	25.2	18.7	6.4	66.6	26.3	62.9	20.5
	2-5	18.4	10.6	21.9	7.7	28.2	28.2	18.5	6.7	46.7	20.3	40.3	14.0
Triennual-82	0-2			26.0	10.6			22.1	4.3			48.1	6.3
	2-5			20.8	9.1			19.1	7.8			39.8	10.7
Triennual-83	0-2			18.2	2.7			24.0	6.2			42.2	6.5
	2-5			8.8	3.3			17.8	11.0			26.6	8.7
Triennual-84	0-2			23.6	8.3			44.2	35.5			67.9	42.1
	2-5			6.0	4.1			39.6	34.3			45.6	38.4

1. Manure treatments are defined as follows: Annual, Biennual and Triennual refer to the frequency of manure application, and the year refers to date of initiation.

Table 3. The significance of an F-test for treatment effects on NO_3^--N, NH_4^+-4 and total mineral nitrogen for no till and chisel plow, excluding triennual treatments from analysis for April 1986.

N Source & Frequency	Till.	Trt.	Depth	TilxTrt	TilxDep	Trtxdep	TilxTrtxDep
NO_3^--N	.497	.000	.014	.193	.178	.000	.554
NH_4^+-N	.906	.999	.038	.810	.688	.820	.758
Tot-N	.490	.000	.026	.384	.669	.000	.564

Table 4. The significance of an F-test for treatment effects on NO_3^--N, NH_4^+-4 and total mineral nitrogen for chisel plow in April 1986.

N Source & Frequency	Trt.	Depth	Trt x depth
NO_3^--N	.000	.016	.003
NH_4^+-N	.760	.019	.921
Tot-N	.000	.017	.004

Table 5. The effect of tillage, chemical and frequency of manure application on NO_3^--N, NH_4^+-4 and total mineral nitrogen from 0-5 feet (lbs/ac) in April 1986.

N Source & Frequency	Source of Nitrogen	Tillage: No Till mean	No Till st dev	Chisel mean	Chisel st dev
Chemical	NO_3^--N	280	87.4	280	83.3
	NH_4^+-N	58.4	49.9	58.1	30.4
	Tot-N	338	90.2	338	81.1
Check	NO_3^--N	20.9	8.5	44.2	27.6
	NH_4^+-N	57.8	29.2	54.1	38.4
	Tot-N	78.1	24.5	98.3	33.7
Annual	NO_3^--N	63.1	26.1	74.6	2.5
	NH_4^+-N	44.6	15.8	68.4	27.5
	Tot-N	108	15.9	143	26.7
Biennual-82	NO_3^--N	25.1	4.8	38.1	4.5
	NH_4^+-N	44.6	3.0	41.8	14.2
	Tot-N	69.7	5.1	79.9	10.1
Biennual-83	NO_3^--N	46.5	19.1	66.1	29.3
	NH_4^+-N	66.8	28.8	37.2	7.8
	Tot-N	113	13.1	103	30.7
Triennual-82	NO_3^--N			46.8	12.7
	NH_4^+-N			41.2	12.0
	Tot-N			88.0	5.9
Triennual-83	NO_3^--N			27.0	2.6
	NH_4^+-N			41.8	11.1
	Tot-N			68.8	12.7
Triennual-84	NO_3^--N			29.7	11.2
	NH_4^+-N			83.8	69.8
	Tot-N			113	80.2

1. Manure treatments are defined as follows: Annual, Biennual and Triennual refer to the frequency of manure application, and the year refers to date of initiation.

Table 6. The significance of tillage, treatment and applicable interactions on NO_3^--N, NH_4^+-4 and total mineral nitrogen from 0-5 feet (lbs/ac) in April 1986.

N Source & Frequency	Analysis of No Till & Chisel: Till.	Trt.	Till. x Trt.	Analysis of Chisel Treatment
NO_3^--N	.584	.000	.273	.000
NH_4^+-N	.899	.978	.451	.678
Tot-N	.573	.000	.552	.000

Table 7. The effect of tillage, frequency of manure application and potassium application on grain yields.

N Source & Frequency	K_2O lbs/ac	Tillage: No Till 1985	No Till 1986	No Till 1987	Chisel 1985	Chisel 1986	Chisel 1987
		bu/ac					
Check	200	128.3	55.3	62.3	77.5	89.4	102.7
Annual	0	146.8	154.0	166.1	149.5	150.0	155.0
	200	140.6	140.0	162.3	152.4	150.0	168.5
Biennual-82	0	115.4	146.0	150.3	120.2	154.0	144.7
	200	102.3	147.0	116.5	113.1	148.0	134.6
Biennual-83	0	131.1	104.0	168.2	146.4	134.0	158.8
	200	145.7	107.0	169.4	152.9	109.0	168.1
Triennual-82	0				138.6	120.0	108.9
	200				137.0	107.0	90.4
Triennual-83	0				101.8	147.0	136.7
	200				80.2	145.0	122.2
Triennual-84	0				108.3	113.0	157.9
	200				124.8	92.3	170.7

Table 8. The effect of tillage, frequency of manure application and potassium application on grain moisture.

N Source & Frequency	K_2O lbs/ac	Tillage: No Till 1986	No Till 1987	Chisel 1986	Chisel 1987
		%			
Check	200	34.1	30.2	32.2	27.9
Annual	0	31.6	30.5	32.0	30.3
	200	32.0	31.0	32.4	32.3
Biennual-82	0	32.6	30.4	31.8	30.7
	200	32.6	31.8	32.0	30.6
Biennual-83	0	33.5	27.5	30.6	29.9
	200	32.3	29.4	31.4	29.6
Triennual-82	0			33.8	31.5
	200			32.7	30.7
Triennual-83	0			31.7	29.7
	200			31.4	29.3
Triennual-84	0			32.0	29.1
	200			32.7	29.2

1. Manure treatments are defined as follows: Annual, Biannual and Triannual refer to the frequency of manure application, and the year refers to date of initiation.

Table 9. The significance of tillage, treatment and applicable interactions on grain yield and grain moisture for 1986 and 1987.

Variable	Crop Year	Analysis of No Till & Chisel: Till.	N Rate and Frequency	Till. x N Rate and Frequency	Analysis of Chisel Treatment
grain yield	1986	.002	.000	.001	.000
	1987	.015	.000	.000	.000
moisture	1986	.006	.036	.014	.013
	1987	.512	.000	.026	.000

Table 10. The effect of tillage, frequency of manure application and potassium application on stover yield.

N Source & Frequency	K_2O lbs/ac	Tillage: No Till 1985	No Till 1986	No Till 1987	Chisel 1985	Chisel 1986	Chisel 1987
		ton/ac					
Check	200	2.25	1.27	1.52	2.17	1.88	2.02
Annual	0	2.37	2.48	2.59	2.28	2.56	2.63
	200	2.42	2.69	2.75	2.53	2.59	2.80
Biennual-82	0	1.90	2.21	2.25	1.94	2.17	2.58
	200	1.89	2.51	2.15	2.14	2.09	2.40
Biennual-83	0	2.19	1.59	2.45	2.14	2.45	2.47
	200	2.40	1.88	2.60	2.38	2.25	2.56
Triennual-82	0				2.22	1.75	2.00
	200				2.17	2.07	1.98
Triennual-83	0				1.63	2.18	2.20
	200				1.62	1.93	1.89
Triennual-84	0				1.64	1.81	2.47
	200				1.97	1.83	2.64

Table 11. The effect of tillage, frequency of manure application and potassium application on % dry matter of stover.

N Source & Frequency	K_2O lbs/ac	Tillage: No Till 1986	No Till 1987	Chisel 1986	Chisel 1987
		%			
Check	200	40.4	35.6	40.0	37.5
Annual	0	38.1	34.8	37.0	34.7
	200	36.3	32.5	34.4	31.4
Biennual-82	0	31.4	37.9	37.2	40.1
	200	33.6	33.9	32.8	31.6
Biennual-83	0	44.5	39.7	42.7	36.1
	200	39.6	34.2	38.6	33.7
Triennual-82	0			39.2	39.1
	200			39.2	34.9
Triennual-83	0			39.4	39.8
	200			36.4	36.6
Triennual-84	0			49.3	40.6
	200			42.2	35.1

1. Manure treatments are defined as follows: Annual, Biennual and Triennual refer to the frequency of manure application, and the year refers to date of initiation.

Table 12. The significance of tillage, treatment and applicable interactions on stover yield and dry matter for 1986 and 1987.

Variable	Crop Year	Analysis of No Till & Chisel: Till.	N Rate and Frequency	Till. x N Rate and Frequency	Analysis of Chisel Treatment
stover yield	1986	.183	.001	.107	.492
	1987	.257	.000	.001	.001
dry matter	1986	.813	.004	.479	.001
	1987	.097	.000	.001	.002

Table 13. The amount of N, P_2O_5, and K_2O applied as liquid dairy manure from an anaerobic pit.

	1983	1984	1985	1986	1987	Average
	lbs/ac					
NH_4	148	171	137	204	152	164
Total N	260	347	292	251	341	298
P_2O_5	76	84	69	67	91	77
K_2O	233	274	266	189	315	274
Rate (gal/ac)	9,100	10,700	9,300	9,200	9,200	9,500

Table 14. The effect of frequency of manure application and tillage on corn yields on a Timula silt loam soil (Typic Eutrochrept) in Goodhue County, Minnesota.

	1983		1984		1985		1986		1987		Average	
	NT	Ch	NT	Ch	NT	Ch	NT	Ch	NT	Ch	NT	Ch
	bu/ac											
Fertilizer[1]	121	130	154	160	134	149	151	149	160	164	145	151
Annual	126	134	143	162	147	149	153	149	166	154	147	149
Yr. of app.	124	113	154	154	132	145	145	153	168	158	145	145
Yr. after	104	124	98	137	115	121	104	134	149	145	112	132
Control	55	90	66	85	62	77	55	89	62	103	60	89