Table 1. Cultural practices at the Flueger Farm in Goodhue County, MN in 1990.

Tillage

No Till

Chisel Plowed and field cultivated on May 26, 1990.

Cropping History

Corn since 1981-P 3906

1989 Corn Pioneer 3737

1990 Corn Pioneer 3751

Manure Application

Injected liquid dairy manure at the following rate and analysis on May 5, 1990.

		1990 rate	
		Mean	Std. Dev.
Manure	(gal/A)	8500	300
Total-N	(lbs/A)	240	14
NH_4-N	(lbs/A)	108	23

Planting Information

A four row 38 inch John Deere Maxemerge planter with 2" fluted coulters.

Planting Date	Rate	Harvested
May 28, 1990	32,500 plants/A	October 13, 1990

Fertilizer

Material Analysis	Tillage	Amount	Actual N -lbs/A-	Date Applied	Method of Application
82-0-0	Both		175	June 25, 1990	Injected after planting
9-23-30	Both	111 lbs/A		May 28, 1990	As a starter

(From 1982-88, no till and chisel plowed plots received 210 lbs N/A and 170 lbs N/A, as ammonium nitrate, respectively, and 170 lbs N/A for both tillages in 1989.)

Soil

Seaton silt loam (Typic hapludalfs, fine-silty, mixed, mesic), 2 to 12% slope. Soil is well drained.

Insect Control

10.5 lbs/A Lorsban applied in furrow on May 28, 1990.

Weed Control

3 pt./A Prowl, 2.5 lb/A 90 DF Bladex applied in 20 lb/A water as carrier on May 23, 1990. Cultivated all treatments on June 25, 1990.

Table 2. Significance table for surface residue cover in Goodhue Co., MN on 6/18/1990.

Till(T)	N Freq(F)	T*F	K(K)	T*K	F*K	T*F*K	Row(R)	T*R	F*R	K*R	T*F*R	F*K*R	T*F*K*R
.064	.426	.441	.113	.666	.169	.425	.000	.132	.836	.283	.029	.595	.418

Table 3. Surface residue cover as affected by tillage, N source and row position in Goodhue Co.,MN on 6/18/90.

N SOURCE AND FREQUENCY	ROW POSITION	RESIDUE (%)	
		NO TILL	CHISEL
MANURE (YEAR OF)	IN	24.3	16.3
	BET	41.3	36.7
MANURE (YEAR AFTER)	IN	56.7	12.7
	BET	62.3	40.3
MANURE (ANNUAL)	IN	46.2	20.4
	BET	50.6	50.4
ANHYDROUS AMMONIA	IN	35.0	20.0
	BET	72.3	36.3
Pr>F		.029	

Table 4. Corn plant population, stover yield, and stover moisture at harvest as influenced by tillage, and N source and frequency of application in Goodhue Co., MN in 1990.

Frequency & Source of N	K_2O lb/A	PLANT POPULATION No Till	Chisel	Mean	STOVER DRY MATTER No Till	Chisel	Mean	STOVER MOISTURE No Till	Chisel	Mean
		-- plants/A*10^{-3} ---			------ tons/A -----			------- % --------		
Manure[1]	0	26.0	28.6	27.3	2.30	2.88	2.59	52.9	41.5	45.0
(Yr. after)	200	28.2	30.0	28.9	2.82	2.70	2.77	40.8	46.5	43.7
	Mean	27.5	29.4	28.3	2.60	2.79	2.67	46.0	44.0	44.4
Manure	0	25.9	29.3	27.6	3.72	2.98	3.13	45.3	44.8	47.2
(Yr. of)	200	25.9	29.8	27.8	2.91	2.36	2.64	42.8	44.7	43.3
	Mean	25.9	29.6	27.7	3.09	2.67	2.88	44.0	44.7	45.1
Manure	0	28.5	29.0	28.6	3.72	3.40	3.65	41.7	39.6	41.3
(Annual)	200	28.5	31.1	29.3	3.28	2.77	3.10	48.4	45.4	47.4
	Mean	28.5	30.3	29.0	3.51	3.02	3.38	44.8	43.1	44.3
Anhydrous-Ammonia	200	30.4	28.4	29.4	3.06	2.70	2.88	47.9	36.7	42.3
Mean		**27.9**	**29.5**	**28.5**	**3.15**	**2.79**	**3.00**	**45.5**	**42.1**	**44.1**

	Till(T)	Freq.(F)	T*F	K rate(K)	K*T	K*F	K*F*T
Plant population	.158	.641	.305	.067	.485	.559	.384
Stover dry matter	.105	.096	.222	.164	.474	.293	.656
Stover moisture	.173	.382	.061	.668	.274	.250	.263

[1]Manure applied in the spring of 1989 (year after) and 1990 (year of).

Table 5. Corn plant population as influenced by previous K application in Goodhue Co., MN in 1990[1].

K_2O lb/A	PLANT POPULATION -- plants/A*10^{-3} --
0	28.0
200	28.9
Pr>F (K rate)	.067

[1] Averaged over tillage and N treatments.

Table 6. Corn stover moisture as influenced by tillage and N application in Goodhue Co., MN in 1990[1].

Frequency & Source of N	STOVER MOISTURE No Till	Chisel
	------%--------	
Manure[1] (Yr. after)	46.0	44.0
Manure (Yr. of)	44.0	44.7
Manure (Annual)	44.8	43.1
Anhydrous Ammonia	47.9	36.7
Pr>F (Till.*N Source & Freq.)	.061	

[1] Averaged over K treatments.

Table 7. Corn grain yield, grain moisture, and total dry matter as influenced by tillage, and N source and frequency of application in Goodhue Co., MN in 1990.

Frequency[1] & Source of N	K_2O lb/A	GRAIN YIELD No Till	Chisel	Mean	GRAIN MOISTURE No Till	Chisel	Mean	TOTAL DRY MATTER No Till	Chisel	Mean
		---------bu/A--------			---------%----------			--------tons/A-----		
Manure	0	128	129	129	33.9	31.3	32.6	5.39	6.21	5.80
(Yr. after)	200	146	156	150	31.1	30.1	30.7	6.06	6.03	6.04
	Mean	140	144	142	32.0	30.6	31.4	5.77	6.12	5.93
Manure	0	146	155	150	31.8	28.7	30.2	6.69	6.70	6.69
(Yr. of)	200	142	151	146	29.9	29.6	29.8	6.29	6.04	6.16
	Mean	144	153	148	30.9	29.1	30.0	6.49	6.37	6.43
Manure	0	166	171	167	30.1	27.9	29.7	7.50	7.73	7.55
(Annual)	200	175	162	170	30.8	29.0	30.2	7.07	6.57	6.90
	Mean	170	166	169	30.5	28.6	29.9	7.30	7.04	7.22
Anhydrous Ammonia	200	164	153	159	34.2	29.7	31.9	6.93	6.33	6.63
Mean		**156**	**153**	**155**	**31.3**	**29.6**	**30.6**	**6.74**	**6.44**	**6.62**

	Pr>F Till(T)	Freq.(F)	T*F	K rate(K)	K*T	K*F	K*F*T
Grain Yield	.988	.095	.856	.168	.855	.079	.690
Grain moisture	.156	.054	.424	.294	.019	.004	.756
Total dry matter	.811	.047	.714	.326	.439	.443	.894

[1] Manure applied in the spring of 1989 (year after) and 1990 (year of).

Table 8. Effects of tillage and K application on corn grain moisture in Goodhue Co., MN in 1990[1].

K_2O lb/A	GRAIN MOISTURE No Till	Chisel
	------%------	
0	31.4	29.5
200	31.3	29.6
Pr>F (K rate*Till)	.019	

[1] Averaged over N and tillage treatments.

Table 9. Corn grain yield, and grain moisture as influenced by K rate, N source and frequency of application in Goodhue Co., MN in 1990[1].

Frequency & Source of N	K_2O lbs/A	GRAIN MOISTURE ------ %------	GRAIN YIELD --- bu/A ---
Manure[2] (Yr. after)	0	32.6	129
	200	30.7	150
Manure (Yr. of)	0	30.2	150
	200	29.8	146
Manure (Annual)	0	29.7	167
	200	30.2	170
Anhydrous Ammonia	200	31.9	159
Pr>F (N source & freq.*K)		.004	.079

[1] Averaged over tillage treatments.
[2] Manure applied in the spring of 1989 (year after) and 1990 (year of).

Table 10. Harvest index of corn as influenced by tillage, and N source and frequency of application in Goodhue Co., MN in 1990.

Frequency[1] & Source of N	K_2O lb/A	HARVEST INDEX No Till	Chisel	Mean	Source	Pr>F
Manure	0	0.57	0.54	0.56		
(Yr. after)	200	0.53	0.55	0.54	Tillage (T)	.272
	Mean	0.55	0.55	0.55	Freq (F)	.986
Manure	0	0.51	0.56	0.53	T*F	.145
(Yr. of)	200	0.53	0.61	0.57		
	Mean	0.52	0.58	0.55	K Rate(K)	.223
Manure	0	0.50	0.56	0.52	K*T	.600
(Annual)	200	0.54	0.58	0.55	K*F	.334
	Mean	0.52	0.57	0.53		
Anhy. ammon.	200	0.56	0.57	0.57	K*F*T	.403

[1] Manure applied in the spring of 1989 (year after) and 1990 (year of).

Table 11. Significance table for 1989 fall soil moisture and nitrogen.

	Till(T)	N Freq(F)	T*F	ROW(R)	T*R	F*R	T*F*R	DEP(D)	T*D	F*D	T*F*D	R*D	T*R*D	F*R*D	T*F*R*D
MOISTURE	.448	.947	.226	.041	.813	.419	.188	.131	.805	.276	.636	.495	.699	.603	.771
TOTAL-N	.351	.000	.330	.000	.690	.013	.177	.000	.215	.000	.376	.016	.933	.377	.028
AMMO.-N	.594	.098	.530	.000	.079	.034	.554	.000	.142	.226	.000	.654	.871	.729	.868
NITR.-N	.403	.000	.353	.000	.952	.029	.117	.000	.349	.000	.795	.011	.957	.446	.022

Table 12. Gravimetric soil moisture by depth in Goodhue Co., MN during Oct. 24-Nov.2, 1989.

DEPTH (ft.)	MOISTURE (%, $g.g^{-1}$)
0-1	18.1
1-2	18.1
2-3	17.0
3-4	16.9
4-5	16.9
Pr>F	.131

Table 13. Gravimetric soil moisture by row position in Goodhue Co., MN during Oct. 24-Nov.2, 1989.

ROW POSITION	MOISTURE (%, g.g-1)
IN ROW	17.0
BET ROWS	17.8
Pr>F	.041

Table 14. Gravimetric soil moisture as affected by tillage, frequency of N application and row position in Goodhue Co., MN during Oct. 24-Nov.2, 1989.

N SOURCE AND FREQUENCY	ROW POSITION	MOISTURE (%, $g.g^{-1}$)	
		NO TILL	CHISEL
MANURE (YR OF)	IN	17.7	16.9
	BETWEEN	19.2	16.2
MANURE (ANNUAL)	IN	18.1	17.3
	BETWEEN	18.4	16.8
ANHYDROUS AMMONIA	IN	17.7	14.7
	BETWEEN	18.1	17.1
CHECK	IN	16.3	16.9
	BETWEEN	17.0	19.5
Pr>F		.188	

Table 15. Effects of the frequency of N application on soil mineral N in Goodhue Co., MN during Oct. 24- Nov. 2, 1989.

N SOURCE AND FREQUENCY	AMOUNT (lbs/A)		
	TOTAL-N	AMMON.-N	NITRATE-N
MANURE (YR OF)	125.9	74.8	51.6
MANURE (ANNUAL)	182.0	60.1	121.9
ANHYDROUS AMMONIA	299.9	68.5	231.4
CHECK	93.9	68.5	25.8
Pr>F	.001	.098	.000

Table 16. Soil mineral N distribution in the profile by depth segments in Goodhue Co., MN during Oct. 24- Nov. 2, 1989.

DEPTH (ft.)	AMOUNT (lbs/A)		
	TOTAL-N	AMMON.-N	NITRATE-N
0-1	55.4	22.3	48.3
1-2	43.8	16.1	27.7
2-3	31.6	15.1	16.5
3-4	14.3	7.1	7.2
4-5	14.3	7.1	7.2
Pr>F	.000	.000	.000

Table 17. Soil mineral N distribution in 5 ft. soil profile as affected by frequency of N applicaton and row position in Goodhue Co., MN during Oct. 24- Nov. 2, 1989.

SOURCE & FREQUENCY OF N APPLICATION	ROW POSITION	AMOUNT (lbs/A)		
		TOTAL-N	AMMON.-N	NITR.-N
MANURE (YR OF)	IN	106.9	70.3	39.3
	BETWEEN	143.3	79.4	64.0
MANURE (ANNUAL)	IN	137.0	49.5	87.4
	BETWEEN	227.0	70.7	156.3
ANHYDROUS AMMONIA	IN	249.3	59.9	189.4
	BETWEEN	350.8	76.8	273.8
CHECK	IN	91.7	66.8	24.9
	BETWEEN	96.5	70.2	26.3
Pr>F		.013	.034	.029

Table 18. Soil NH4-N in 5 ft. soil profile as affected by tillage and row position in Goodhue Co., MN during Oct. 24- Nov. 2, 1989.

TILLAGE	NH4-N (lbs/A)	
	IN ROW	BETWEEN ROWS
NO TILL	64.0	73.0
CHISEL	59.0	75.8
Pr>F	.079	

Table 19. Soil NH4-N by depth in soil profile as affected by the frequency of N application and tillage in Goodhue Co., MN during Oct. 24- Nov. 2, 1989.

SOURCE & FREQUENCY OF N APPLICATION	TILLAGE	NH4-N (lbs/A)				
		0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.
MANURE (YR OF)	NO TILL	30.8	16.2	16.9	7.8	7.8
	CHISEL	15.1	20.4	17.0	8.8	8.8
MANURE (ANNUAL)	NO TILL	21.8	14.1	13.1	6.3	6.3
	CHISEL	21.9	11.6	12.0	5.8	5.8
ANHYDROUS AMMONIA	NO TILL	22.4	15.6	14.4	7.2	7.2
	CHISEL	27.4	15.6	14.2	6.5	6.5
CHECK	NO TILL	21.3	17.1	16.3	6.9	6.9
	CHISEL	19.5	17.4	16.3	7.7	7.7
Pr>F		.000				

Table 20. Effects of tillage, frequency of N application and row position on soil NO3-N by depth in Goodhue Co., MN during Oct. 24- Nov. 2, 1989.

SOURCE & FREQUENCY OF N APPLICATION	ROW POSIT-ION	NO3-N (lbs/A)									
		0-1 ft.		1-2 ft.		2-3 ft.		3-4 ft.		4-5 ft.	
		NT	CHL	NT	CHL	NT	CHL	NT	CHL	NT	CHL
MANURE (YR OF)	IN	28.7	11.0	7.7	5.8	4.9	4.6	2.9	2.4	2.9	2.4
	BET	57.0	5.0	12.1	12.6	6.9	18.3	5.2	1.6	5.2	1.6
MANURE (ANNUAL)	IN	65.0	9.4	16.2	3.6	20.1	8.6	8.2	2.7	8.2	2.7
	BET	68.3	99.8	42.4	26.7	29.6	14.8	7.9	7.8	7.9	7.8
ANHYDROUS AMMONIA	IN	66.7	98.8	44.0	53.2	30.4	23.3	8.8	22.4	8.8	22.4
	BET	126.0	84.4	87.2	103.5	33.8	44.6	16.1	17.9	16.1	17.9
CHECK	IN	11.5	10.2	3.7	2.7	3.2	5.5	1.9	4.6	1.9	4.6
	BET	10.7	19.6	3.9	5.7	1.7	5.6	1.1	1.6	1.1	1.6
Pr>F		T*F*R*D= .022, F*D=.000 , R*D=.011									

Table 21. Significance table for soil analysis in Goodhue Co., MN on 5/2/90.

	Till(T)	N Freq(F)	T*F	ROW(R)	T*R	F*R	T*F*R	DEP(D)	T*D	F*D	T*F*D	R*D	T*R*D	F*R*D	T*F*R*D
MOISTURE	.359	.013	.972	.833	.970	.071	.359	.000	.000	.048	.226	.153	.176	.485	.969
TOTAL-N	.197	.000	.965	.518	.377	.994	.851	.009	.104	.000	.614	.289	.216	.921	.807
AMMO.-N	.224	.573	.685	.157	.697	.617	.489	.000	.553	.099	.848	.349	.499	.710	.976
NITR.-N	.610	.000	.975	.648	.404	.981	.907	.000	.103	.000	.573	.449	.269	.981	.517

Table 22. Effect of frequency of N application and row position on gravimetric soil moisture in Goodhue Co., ON 5/2/90.

SOURCE & FREQUENCY ON N APPLICATION	MOISTURE (%, $g.g^{-1}$)		
	IN ROW	BET ROWS	MEAN
MANURE (YEAR AFTER)	25.8	25.2	25.5
MANURE (YEAR OF)	25.5	24.7	25.1
MANURE (ANNUAL)	25.4	25.7	25.5
ANHYDROUS AMMONIA	24.1	25.5	24.8
CHECK	22.7	22.5	22.6
Pr>F	.071		.013

Table 23. Gravimetric soil moisture by tillage and depth in Goodhue Co., on 5/2/90.

DEPTH (ft.)	MOISTURE (%, $g.g^{-1}$)		
	NO TILL	CHISEL	MEAN
0-1	23.9	23.4	23.7
1-2	24.7	23.5	24.1
2-3	26.2	24.4	25.4
3-4	27.5	25.8	26.7
4-5	23.6	24.6	24.0
Pr>F	.000		.000

Table 24. Gravimetric soil moisture by frequency of N application and depth in Goodhue Co., on 5/2/90.

SOURCE & FREQUENCY OF N APPLICATION	MOISTURE (%, $g.g^{-1}$)				
	0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.
MANURE (YR AFT)	24.7	24.4	25.3	27.5	25.6
MANURE (YR OF)	23.3	24.3	27.0	26.9	24.0
MANURE (ANNUAL)	24.7	24.8	26.2	27.6	24.4
ANHYDR. AMMONIA	23.2	23.8	25.1	27.2	24.7
CHECK	21.9	23.0	23.3	23.9	20.8
Pr>F	.000				

Table 25. Effect of frequency of N application on soil mineral N in Goodhue Co., on 5/2/90.

SOURCE & FREQUENCY OF N APPLICATION	AMOUNT (lbs/A)		
	TOTAL-N	AMMON-N	NITR-N
MANURE (YR AFT)	81.5	52.5	29.0
MANURE (YR OF)	82.5	50.5	34.0
MANURE (ANNUAL)	126.5	48.5	78.0
ANHYDROUS AMMON.	251.5	50.0	201.5
CHECK	60.5	45.0	15.5
Pr>F	.000	.009	.000

Table 26. Soil mineral N by depth in Goodhue Co.,MN on 5/2/90.

DEPTH (ft.)	Amount (lbs/A)		
	TOTAL-N	AMMON-N	NITR-N
0-1	24.9	16.6	8.3
1-2	25.5	9.5	16.0
2-3	27.5	8.4	19.1
3-4	23.5	7.6	15.9
4-5	19.9	7.1	12.8
Pr>F	.000	.009	.000

Table 27. Effect of frequency of N application on soil mineral N by depth in Goodhue Co., on 5/2/90.

SOURCE & FREQUENCY OF N APPLICATION	NO3-N (lbs/A)					
	0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.	**0-5 ft.**
MANURE (YR AFT)	6.8	9.9	4.9	3.7	4.0	**29.3**
MANURE (YR OF)	9.2	10.0	7.0	4.9	3.0	**34.1**
MANURE (ANNUAL)	8.4	18.6	24.1	15.8	11.2	**78.1**
ANHYDROUS AMMON.	10.2	37.2	55.6	54.3	44.3	**201.6**
CHECK	7.2	2.9	1.6	1.4	2.3	**15.4**
Pr>F	.000					

FIGURE -1

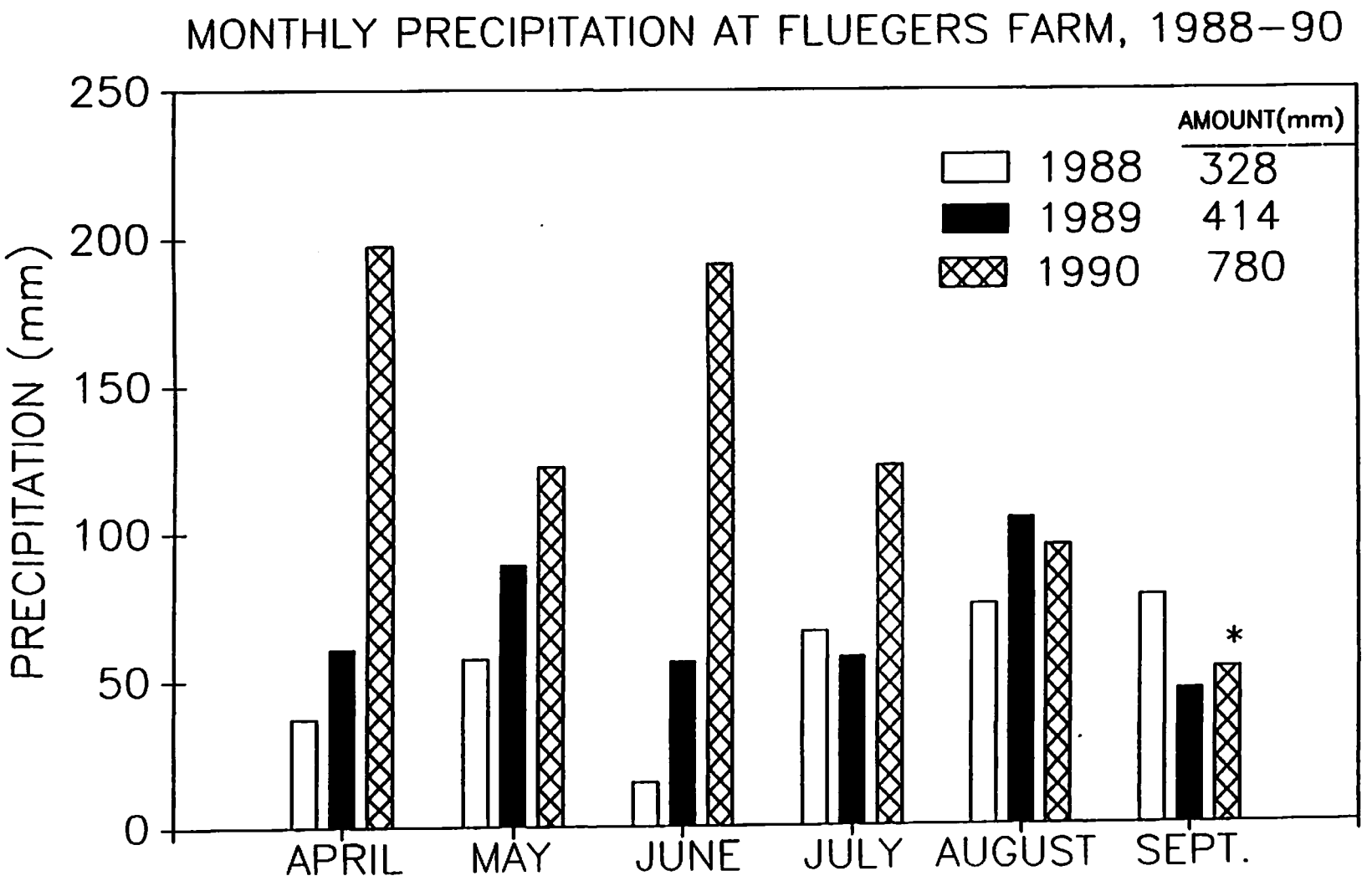

MONTHLY PRECIPITATION AT FLUEGERS FARM, 1988–90
PRECIPITATION (mm)
250
200
150
100
50
0
AMOUNT(mm)
1988 328
1989 414
1990 780
*
APRIL
MAY
JUNE
JULY
AUGUST
SEPT.

FIGURE -2

TILLAGE EFFECTS ON SOIL WATER N AT 1.5m DEPTH

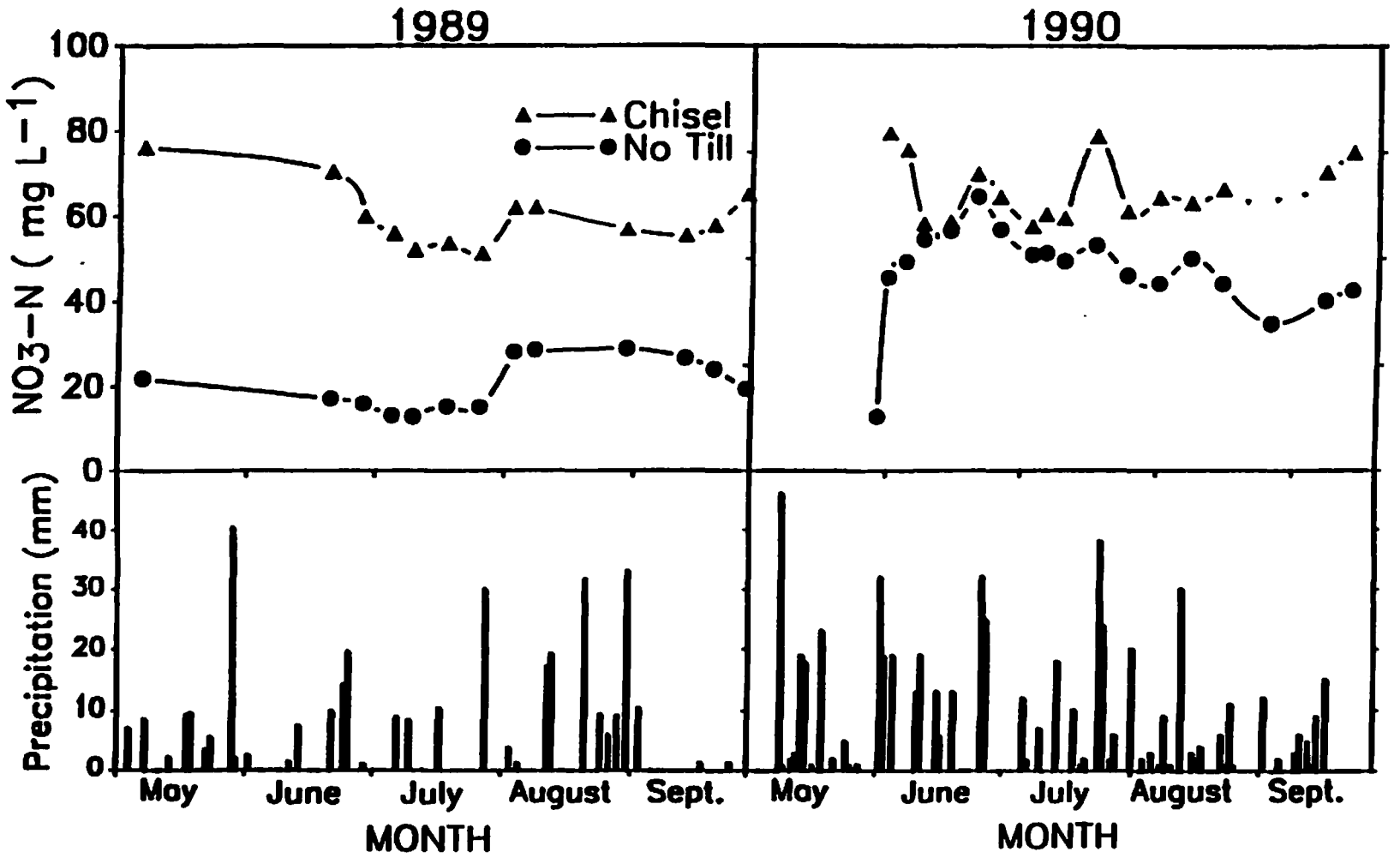
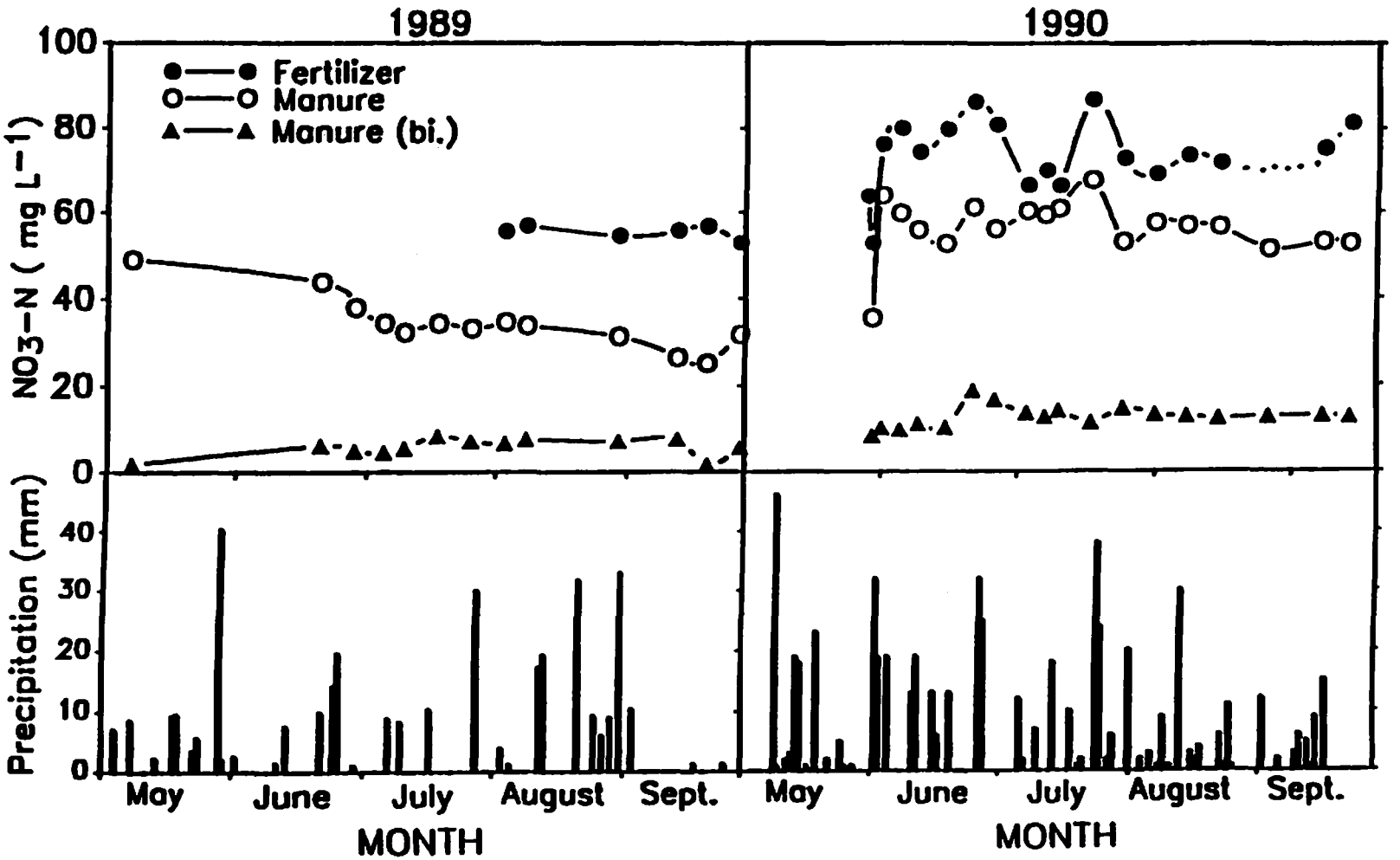


FIGURE -3

EFFECTS OF N SOURCE AND FREQUENCY ON SOIL WATER N AT 1.5m DEPTH



EFFECT OF TILLAGE AND SOURCE OF SWINE MANURE ON SOIL N, CORN YIELD, AND N UPTAKE[1]

J. R. Joshi, J. F. Moncrief, D. A. Andow, J. B. Swan, and G. L. Malzer[2]

Abstract: This was the fourth year of a study utilizing liquid swine manure under two conservation tillage systems (ridge tillage and chisel plowing). Liquid swine manure was applied from an anaerobic pit and an open lagoon at the rate of about 11,000 gallons/A equivalent to 152 lb N/A and 93 lb N/A, respectively. The manure treatments along with an anhydrous ammonia treatment at 170 lb/A rate were applied biennially. Also included in the study were a check without any N and an anhydrous ammonia treatment applied annually.

The system of tillage had no significant effects on grain or stover yields. The application of anhydrous ammonia resulted in higher yields than manure from either sources. The grain yields in the manure treatments were similar; whereas, the stover yields were higher by 0.45 ton/A in the treatments with manure from lagoon source than those receiving manure from the pit. The amount of surface residue was higher in the ridge tillage, and in the year when manure was not applied. There was a greater accumulation of soil N in the profile compared to the levels seen in the previous years, the increase being consistent with the amount of N added. Although tillage effects were significant in the amount of N, chisel plowed treatments had greater amounts in between the rows than in the rows. Soil water N levels increased by 10 to 20 ppm in manure and fertilizer treatments in both tillages compared to the levels in the previous year. The trend with respect to the tillage and N treatments were similar: nitrate was greater in ridge tillage than chisel plowing, and in anhydrous ammonia treatments than in manure treatments.

INTRODUCTION

In 1987, a study was initiated at the Nord Farm in Goodhue County, MN to evaluate the effects of tillage and manure application on soil N distribution, corn yield and N uptake. This was the third year of initial establishment of the treatments.

Liquid swine manure is injected every other year. In 1987-88, manure from an anaerobic pit receiving manure from farrowing house was applied at two rates: approximately 12,000 and 7,300 gal/A on ridge and chisel plowing treatments. Additional treatments included an anhydrous ammonia treatment, applied annually and every alternate year at a recommended rate of 170 lbs N/A, and a check treatment receiving neither manure nor fertilizer. Since 1989, the treatment with lower rate of pit manure was replaced with manure from an open lagoon. Most cultural practices followed were similar from year to year; the 1990 practices are summarized in Table 1.

The experiment is laid out in a randomized complete block split-split plot design with four replications. Tillage is the main plot and N source is the subplot. N source is further split by the year of N application as a sub-sub plot. The results of yield and soil analyses for 1990 are summarized in this report.

RESULTS AND DISCUSSION

Surface Residue Cover. Residue measurements were made on June 25, 1990 both in and between the rows in duplicate in the biennial manure and fertilizer treatments in both tillages. A table of significance using the analysis of variance is given in Table 2. On an average, there was about twice as much residue in between the rows than in the rows (Table 3). Among the biennial N treatments, the amount of residue was not different for the anhydrous ammonia treatment in the year of its application and in the year following its application. However, there was about 10-15% more residue in the year following application of the manure treatments as compared to the year of application. The difference in the amount of residue due to injection was seen both in and between the rows. There was more than twice as much residue in between the rows than in the rows in ridge till : whereas, in chisel plowing, the difference in the amount of residue was considerably less than in ridge till.

[1] This project is supported in part by a Low Input Sustainable Agriculture (LISA) grant, the Minnesota Department of Agriculture, the College of Agriculture Center for Agricultural Impacts on Water Quality, and the Soil Conservation Service. Their support is greatly appreciated.

[2] Graduate Research Asst., Assoc. Professor of Soil Sci., Assoc. Professor of Entomol., Professor of Agronomy at Iowa State Univ., and Professor of Soil Sci., Univ. of Minnesota, St. Paul, MN, 55108, respectively.

Plant Population and Stover Yield. The plant population, stover dry matter and stover moisture at harvest in the biennial treatments were not affected by tillage (Table 4). The source of N did not affect the plant population or stover moisture at harvest but had a significant effect on stover dry matter. Total stover dry matter was highest in anhydrous ammonia treatment followed by manure from lagoon, and the manure from pit. The year of the application of the biennial N treatments had a significant effect on stand, stover dry matter, and stover moisture (Table 6). There was an increase of about 800 plants/A and 0.75 ton stover dry matter per acre, and a decrease of about 8% in stover moisture in the year of N application. The difference in the stand was higher in manure treatments.

Grain Yield, Grain Moisture and Total Dry Matter. A summary of total grain yield, grain moisture and total dry matter at harvest is given in Table 5. Tillage did not affect grain yield and total dry matter at harvest, but the ridge till system resulted in higher grain moisture than chisel plowing. The grain yields, grain moisture and total dry matter were significantly affected by the N source. Biennial application of anhydrous ammonia had an average of 139 bu/A followed by manure from the lagoon source with 118 bu/A and the manure from pit source(114 bu/A). Grain moisture was slightly lower with pit manure than the other N treatments. The total dry matter yield was highest with anhydrous ammonia followed by manure from lagoon, and manure from the pit. There was a significant decrease in the grain yield and total dry matter yield, and an increase in grain moisture in the year after application of the N treatments. The average decrease in the grain yields in the year following the application of the biennial N treatments was about 42 bu/A. The average increase in the grain moisture ranged from 2% in the year after application of N treatments (Table 6). The pit manure treatment had the lowest difference in grain moisture in the year of and the year following application.

Harvest Index. The harvest index, a ratio of total grain dry matter to that of total dry matter (grain and stover combined, Table 7) was not affected significantly by any treatments. It ranged from 0.52 to 0.60.

Insecticide Effects. In order to assess the effects of insecticide application, all the treatments were further split into insecticide and non-insecticide subplots. There was a difference of about 4 bu/A in grain yields between the treatments with or without insecticides (Table 8). The difference was not significant.

Soil Profile Nitrogen: Fall 1989. Total inorganic N, ammonium-N, and gravimetric soil moisture determinations were made on Fall soil samples taken in and between the rows separately to a depth of 5 ft. at 1 ft. depth increment in selected treatments. A table of significance on soil moisture and soil N in 1989 using the analysis of variance is given in Table 9. The effects of various treatments on soil moisture have already been included in 1989 report.

Of the various N treatments analyzed, total inorganic N in the 5 ft. soil profile was highest in anhydrous ammonia treatment applied annually followed by biennial anhydrous ammonia in the year of its application, biennial manure from pit source in the application year, and check (Table 10). Anhydrous ammonia even in the year following its application had higher N in soil profile than pit manure in its application year, which was not much different than the check. There was no significant difference between the treatments in the amount of ammonium-N. The nitrate-N made up the bulk of the difference in the total mineral N.

The amount of various N forms was highest in the top 0-1 ft. increment and gradually decreased down the profile (Table 11). Both the ridge till and chisel-plowed treatments had similar amounts of N in the row positions but chisel-plowing resulted in slightly higher N in between the rows (Table 12). At lower N rates, the difference in the amount of N in and between the rows was not so wide as compared to the higher N treatments where there was 2-3 times greater N in between the rows than in the rows (Table 13). The amount of nitrate-N in annual anhydrous ammonia treatment was considerably higher throughout the profile up to 5 ft. depth; whereas, it was mainly concentrated in the upper 0-2 ft. portion of the profile in the other treatments.

Soil Moisture: Spring 1990. Total inorganic N and gravimetric soil moisture determinations were made on soil samples taken during April 23-25, 1990 to a depth of 5 ft. at 1 ft. depth increment both in and between the row position. A table of significance of soil moisture and total inorganic N using the analysis of variance are given in Table 14. The soil moisture at the time of sampling ranged between 19.4 to 23.2% by weight (Table 15). The soil profile was slightly drier in 3-4 ft. depth increment and was wetter in the depths above and below. On an average, there was higher moisture in the rows than in between the rows (Table 16).

Soil Profile Nitrogen : Spring 1990. The total inorganic N in the profile in the Spring of 1990 was about 10-40 lbs/A lower than in the previous Fall (Table 17). However, the trend was similar: annual application of anhydrous ammonia had higher N than biennial anhydrous ammonia, biennial manure, and check treatments, respectively. The difference was mainly in the amount of nitrate-N. The highest amount of N was still in the top layer and the quantity decreased gradually with depth (Table 18). There was slightly higher N, mainly in ammonium form, in the rows than in between the rows in treatments with pit manure; whereas, most of the N was higher in between the rows in the other treatments (Table 19). The quantity of nitrate-N in ridge till was fairly uniform in and between the rows (Table 20), but was much higher in between the rows than in the rows

in chisel plowing. The nitrate-N was fairly well distributed down to 5 ft. depth in anhydrous ammonia treatments but was mostly in the upper 0-2 ft. in manure and check treatments (Table 21).

Soil Water Nitrogen. Suction water samplers were established on manure (pit source) and anhydrous ammonia (annual) treatments to monitor nitrate-N in soil water at 5 ft. depth.

The effects of tillage on soil water N during 1989-90 growing seasons are presented in Fig. 1. The concentration of nitrate-N in soil water in 1989 stayed constant throughout the season suggesting little movement of water and N during sampling period. Ridge till consistently yielded about 10 ppm higher N than chisel plowing. In 1990, similar effects of tillage were observed. However, the nitrate levels increased in the spring and summer in both tillages suggesting a movement of water and N down the profile following as there were frequent precipitation events in 1990 compared to the dry season of 1988 and an intermediate season in 1989.

The effects of N source and frequency on soil water N are given in Fig. 2. There was more than 4 times higher concentration with anhydrous ammonia treatment than the either manure treatments in 1989 and the nitrate levels stayed mostly constant. In 1990, the trends due to the source of N remained similar, there was an increase in nitrate levels. Treatments in which manure applied in 1990 showed a greater increase the treatments that received manure the previous year.

Table 1. Cultural practices at the Nord Farm in Goodhue County, MN 1990.

Tillage

Ridge Till- cultivated on June 28, 1990
Chisel Plow- Chiseled on May 29, 1990

Cropping History

Corn since 1974
1989-Corn Pioneer 3906
1990-Corn Pioneer 3751

Manure Application

Injected liquid swine manure with following rate and analysis on May 24-25, 1990.

		Rate of Application (1990)			
		Pit Source		Lagoon Source	
		Mean	Std. Dev.	Mean	Std. Dev.
Manure	(gal/A)	11,200	580	10,900	745
Total-N	(lbs/A)	152	14	93	1
NH_4-N	(lbs/A)	75	11	53	2

Planting Information

A six row Deustch Alis planter equipped with 1" fluted coulter and clearing disks in 1990.

Crop	Date	Rate	Harvested
Corn	May 29,1990	32,000 plants/A	October 22-24, 1990

Fertilizer

Material Analysis	Amount	Actual N -lb/A-	Date Applied	Method of Application
82-0-0		175	June 26, 1990	Injected after planting
7-21-7	10 gal/A		May 29, 1990	As a starter

Soil

Seaton silt loam (Typic Hapludalfs, fine-silty, mixed, mesic), Mt. Carroll silt loam (Mollic Hapludalfs, fine-silty, mixed, mesic) and a Port Byron silt loam (Typic Hapludolls, fine-silty, mixed, mesic).

Insect Control

9 lb a.i./A Counter 15G applied in furrow on May 29, 1990.

Table 2. Significance table for surface residue cover in Goodhue Co., 1990.

Till(T)	N Source(N)	T*N	Year(Y)	T*Y	N*Y	T*N*Y	Row(R)	T*R	N*R	T*N*R	Y*R	T*Y*R	N*Y*R	T*N*Y*R
.000	.057	.262	.000	.155	.084	.136	.000	.000	.980	.906	.027	.907	.434	.141

Table 3. Effect of tillage, N source and frequency, and row position on surface residue cover in Goodhue Co., MN in 1990.

Source and Frequency of N	Year of N application	Ridge Till			Chisel Plow		
		In Row	Bet Rows	Mean	In Row	Bet Rows	Mean
Manure (Pit)	Year After	22	75	49	26	38	32
	Year Of	23	51	37	11	17	14
	Mean	**22**	**63**	**43**	**18**	**27**	**23**
Anhy. Ammon. (Bi.)	Year After	44	75	59	25	43	34
	Year Of	44	87	65	19	21	20
	Mean	**44**	**81**	**62**	**22**	**32**	**27**
Manure (Lagoon)	Year After	42	88	65	23	40	31
	Year of	32	60	46	15	19	17
	Mean	**37**	**74**	**55**	**19**	**29**	**24**
Mean		**34**	**72**	**53**	**20**	**29**	**25**

Table 4. The effect of tillage and N source on corn plant population at harvest, stover dry matter, and stover moisture at harvest in Goodhue Co., MN in 1990[1].

		PLANT POPULATION			STOVER DRY MATTER			STOVER MOISTURE		
		Ridge	Chisel	Mean	Ridge	Chisel	Mean	Ridge	Chisel	Mean
Source of N	Year[2]	- plants/A*10^{-3} -			----- tons/A ----			-------- % ------		
Manure (Pit)	Yr.of	29.3	28.2	28.7	2.22	2.22	2.22	36.6	28.4	32.5
	Yr.after	27.7	26.2	27.0	1.76	1.65	1.70	42.6	39.5	41.1
	Mean	28.5	27.2	27.8	1.99	1.93	1.96	39.6	33.9	36.8
Manure (Lagoon)	Yr.of	29.1	28.8	29.0	3.20	2.56	2.88	33.8	35.6	34.7
	Yr.after	28.2	27.7	28.0	2.20	1.78	1.99	44.7	41.4	43.0
	Mean	28.7	28.2	28.5	2.70	2.17	2.43	39.2	38.5	38.9
Anhydrous Ammonia	Yr.of	27.2	28.9	28.0	3.12	3.17	3.15	31.4	30.1	30.7
	Yr.after	28.4	28.4	28.4	2.31	2.24	2.26	37.2	37.4	37.3
	Mean	27.8	28.6	28.2	2.71	2.71	2.71	34.3	33.7	34.0
Mean		28.3	28.0	28.2	2.47	2.27	2.37	37.7	35.4	36.5

	Pr>F						
	Tillage(T)	N Source(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Population	.466	.688	.032	.342	.325	.059	.652
Stover dry matter	.407	.000	.000	.174	.709	.101	.467
Stover moisture	.590	.351	.006	.798	.698	.940	.604

[1] Averaged over insecticide treatments.
[2] Year refers to the year of application of the biennial treatments.

Table 5. The effect of tillage and N source on corn grain yield, grain moisture and total dry matter in Goodhue Co., MN in 1990[1].

Source of N	Year[2]	GRAIN YIELD Ridge	Chisel	Mean	GRAIN MOISTURE Ridge	Chisel	Mean	TOTAL DRY MATTER Ridge	Chisel	Mean
		----- bu/A -----			------- % -------			----- tons/A -----		
Manure	Yr.of	139	125	132	24.7	23.8	24.2	5.41	5.21	5.31
(Pit)	Yr.after	96	94	95	27.1	26.2	26.7	4.14	3.79	3.97
	Mean	118	109	114	26.0	25.0	25.5	4.78	4.50	4.64
Manure	Yr.of	147	137	142	25.3	24.6	24.9	6.67	6.06	6.37
(Lagoon)	Yr.after	95	92	93	27.5	27.4	27.4	4.67	3.78	4.22
	Mean	121	115	118	26.4	26.0	26.2	5.67	4.92	5.29
Anhydrous	Yr.of	159	158	158	27.1	25.1	25.6	6.84	7.18	7.00
Ammonia	Yr.after	121	118	119	26.0	26.0	26.5	5.26	5.61	5.44
	Mean	140	138	139	26.6	25.5	26.0	6.05	6.39	6.22
Mean		**126**	**121**	**123**	**26.3**	**25.5**	**25.9**	**5.50**	**5.27**	**5.38**

	Pr>F						
	Tillage(T)	N Source(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Grain Yield	.536	.002	.000	.837	.327	.146	.599
Grain moisture	.013	.082	.000	.480	.939	.005	.796
Total dry matter	.651	.015	.000	.432	.732	.255	.854

[1] Averaged over insecticide treatments.
[2] Year refers to the year of application of the biennial treatments.

Table 6. The effect of year of N application on corn grain yield, stover dry matter, stover moisture, total dry matter, and plant population at harvest in Goodhue Co., MN in 1990[1].

Year[2]	GRAIN YIELD	GRAIN MOISTURE	TOTAL DRY MATTER	STOVER DRY MATTER	STOVER MOISTURE	PLANT POPULATION
	--bu/A--	--%--	--tons/A--	--tons/A--	--%--	-Plants/A*10^{-3} -
Year of	144.2	24.9	6.23	2.75	32.6	28.6
Year After	102.6	26.9	4.54	1.99	40.4	27.8
Pr>F (Year)	.000	.000	.000	.000	.000	.032

[1] Averaged over tillage, insecticide, and biennial N treatments.
[2] Year refers to the year of application of the biennial treatments.

Table 7. Corn harvest index as affected by tillage, and N source in Goodhue Co., MN in 1990.

Source of N	Year[2]	HARVEST INDEX[1] Ridge	Chisel	Mean
Manure	Yr.of	0.59	0.57	0.58
(Pit)	Yr.after	0.58	0.54	0.56
	Mean	0.58	0.56	0.57
Manure	Yr.of	0.52	0.56	0.54
(lagoon)	Yr.after	0.52	0.53	0.52
	Mean	0.52	0.54	0.53
Anhydrous	Yr.of	0.54	0.56	0.55
Ammonia	Yr.after	0.56	0.60	0.58
	Mean	0.55	0.58	0.56
Mean		**0.56**	**0.55**	**0.55**

Source	Pr>F
Tillage(T)	.729
N source(N)	.207
Year (Y)	.676
T*N	.402
T*Y	.935
Y*N	.499
Y*N*T	.529

[1] Averaged over insecticide treatments.
[2] Year refers to the year of application of the biennial treatments.

Table 8. The effect of insecticide application on corn grain yield at harvest in Goodhue Co., MN in 1990[1].

Insecticide	GRAIN YIELD ---bu/A---
Yes	125
No	122
Pr>F (Insect.)	.172

[1] Means of all biennial N, insecticide and tillage treatments.

Table 9. Significance table for soil moisture and soil profile N in fall 1989.

	Till(T)	NSource(N)	T*N	Row(R)	T*R	N*R	T*N*R	Depth(D)	T*D	N*D	T*N*D	R*D	T*R*D	N*R*D	T*N*R*D
Moisture	.758	.776	.408	.302	.528	.991	.981	.000	.006	.002	.123	.923	.602	.996	.997
N	.647	.000	.953	.000	.132	.000	.813	.000	.979	.001	.864	.000	.898	.025	.341
NH_4-N	.535	.897	.695	.261	.345	.445	.205	.000	.846	.378	.985	.324	.896	.602	.987
NO_3-N	.738	.000	.776	.000	.156	.000	.912	.000	.958	.000	.531	.000	.826	.011	.131

Table 10. Effects of N source on soil profile N in 5 ft. soil profile in Goodhue Co., MN on Nov. 2-9, 1989.

N SOURCE AND FREQUENCY	AMOUNT (lbs/A)		
	TOTAL-N	AMMON.-N	NITRATE-N
ANHYDROUS AMMONIA (ANNUAL)	269	92	177
ANHYDROUS AMMONIA (BIENNIAL, YR OF)	181	88	93
ANHYDROUS AMMONIA (BIENNIAL, YR AFT)	125	87	38
PIT MANURE (BIENNIAL, YR OF)	110	88	22
CHECK	103	82	21
Pr>F	.000	.897	.000

Table 11. Soil profile N by depth in 5 ft. soil profile in Goodhue Co., MN on Nov. 2-9, 1989.

DEPTH (ft.)	AMOUNT (lbs/A)		
	TOTAL-N	AMMONIUM-N	NITRATE-N
0-1	48	26	22
1-2	32	18	14
2-3	29	16	13
3-4	25	14	11
4-5	23	13	10
Pr>F	.000	.000	.000

Table 12. Soil profile N by tillage and row position in 5 ft. soil profile in Goodhue Co., MN on Nov. 2-9, 1989.

TILLAGE	ROW POSITION	AMOUNT (lbs/A)		
		TOTAL-N	AMMON.-N	NITRATE-N
RIDGE TILL	IN ROW	138	85	53
	BETWEEN ROWS	165	86	79
CHISEL PLOW	IN ROW	138	88	50
	BETWEEN ROWS	191	92	99
Pr>F		.132	.345	.156

Table 13. Soil profile N by N source and row position in Goodhue Co., MN on Nov. 2-9, 1989.

N SOURCE & FREQUENCY	ROW POSITION	NO3-N (lbs/A)					
		0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.	0-5 ft.
PIT MANURE (BI, YR OF)	IN	9.4	2.5	2.3	2.2	2.2	18.5
	BETWEEN	13.6	4.2	2.4	2.4	2.5	25.0
ANHY. AMM. (BI, YR OF)	IN	23.0	6.7	6.0	7.3	9.7	51.7
	BETWEEN	56.5	37.7	13.5	12.2	10.3	132.0
ANHY. AMM.(BI, YR AFT)	IN	10.8	4.9	5.2	7.4	6.5	34.9
	BETWEEN	14.8	5.3	7.3	8.4	4.8	40.7
ANHY. AMM. (ANNUAL)	IN	22.5	20.2	31.5	30.1	28.9	133.7
	BETWEEN	51.1	56.7	49.3	38.1	28.6	220.7
CHECK	IN	7.6	2.8	1.9	2.1	2.6	17.2
	BETWEEN	8.9	2.2	7.4	2.9	2.3	24.7
Pr>F		N*R*D=.001					N*R=.000

Table 14. Significance table for soil moisture and soil profile N in spring 1990.

	Till(T)	N Source(N)	T*N	Row(R)	T*R	N*R	T*N*R	Depth(D)	T*D	N*D	T*N*D	R*D	T*R*D	N*R*D	T*N*R*D
Moisture	.953	.874	.970	.090	.245	.205	.161	.018	.907	.300	.295	.334	.729	.803	.606
N	.987	.000	.150	.001	.150	.004	.798	.000	.177	.116	.260	.170	.483	.132	.897
NH_4-N	.858	.809	.142	.615	.241	.048	.015	.000	.488	.175	.663	.895	.875	.241	.009
NO_3-N	.463	.000	.295	.001	.023	.062	.281	.000	.127	.016	.266	.213	.308	.544	.809

Table 15. Gravimetric soil moisture by depth in Goodhue Co., MN during April 23-25, 1990.

DEPTH (ft.)	MOISTURE (%, wt./wt.)
0-1	23.1
1-2	23.2
2-3	21.6
3-4	19.4
4-5	22.9
Pr>F	.018

Table 16. Gravimetric soil moisture by row position in Goodhue Co., MN during April 23-25, 1990.

ROW POSITION	MOISTURE (%, wt./wt.)
IN ROW	22.8
BETWEEN ROWS	21.3
Pr>F	.090

Table 17. Soil profile N as affected by N source in Goodhue Co., MN during April 23-25, 1990.

N SOURCE & FREQUENCY	AMOUNT (lbs/A)		
	TOTAL-N	AMMONIUM-N	NITRATE-N
PIT MANURE (BI, 1989)	102	74	28
ANHY. AMMON. (BI, 1988)	146	73	73
ANHY. AMMON. (ANNUAL)	229	70	159
CHECK	89	68	21
Pr>F	.000	.809	.000

Table 18. Soil profile N by depth in Goodhue Co., MN during April 23-25, 1990.

DEPTH (ft.)	AMOUNT (lbs/A)		
	TOTAL-N	AMMON.-N	NITRATE-N
0-1	40.4	21.9	18.5
1-2	30.0	14.4	16.0
2-3	27.4	13.6	13.8
3-4	22.5	11.4	11.1
4-5	20.5	10.1	10.4
Pr>F	.000	.000	.000

Table 19. Soil profile N as affected by N source and row position in Goodhue Co., MN during April 23-25, 1990.

N SOURCE & FREQUENCY	ROW POSITION	AMOUNT (lbs/A)		
		TOTAL-N	AMMONIUM-N	NITRATE-N
PIT MANURE (yr of)	IN	108	79	29
	BETWEEN	96	69	27
ANHY. AMMO. (yr of)	IN	127	71	56
	BETWEEN	165	74	91
ANHY. AMMO. (annual)	IN	203	65	138
	BETWEEN	254	76	178
CHECK	IN	82	68	14
	BETWEEN	95	68	27
Pr>F		.004	.048	.062

Table 20. Soil profile NO3-N as affected by tillage and row position in Goodhue Co., MN during April 23-25, 1990.

TILLAGE	NO3-N (lbs/A)	
	IN ROW	BET ROWS
RIDGE TILL	69	75
CHISEL PLOW	50	88
Pr>F	.023	

Table 21. Soil profile NO3-N as affected by tillage, N source and depth in Goodhue Co., MN during April 23-25, 1990.

N SOURCE & FREQUENCY	NO3-N (lbs/A)				
	0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.
PIT MANURE (bi, 1989)	12.9	6.8	3.4	2.5	2.5
ANHY. AMMO. (bi, 1989)	21.5	21.9	10.6	8.3	11.1
ANHY. AMMO. (annual)	31.6	33.0	38.4	31.4	23.9
CHECK	8.1	3.3	2.6	1.9	4.8
Pr>F	.016				

FIGURE -1

TILLAGE EFFECTS ON SOIL WATER N AT 1.5m DEPTH

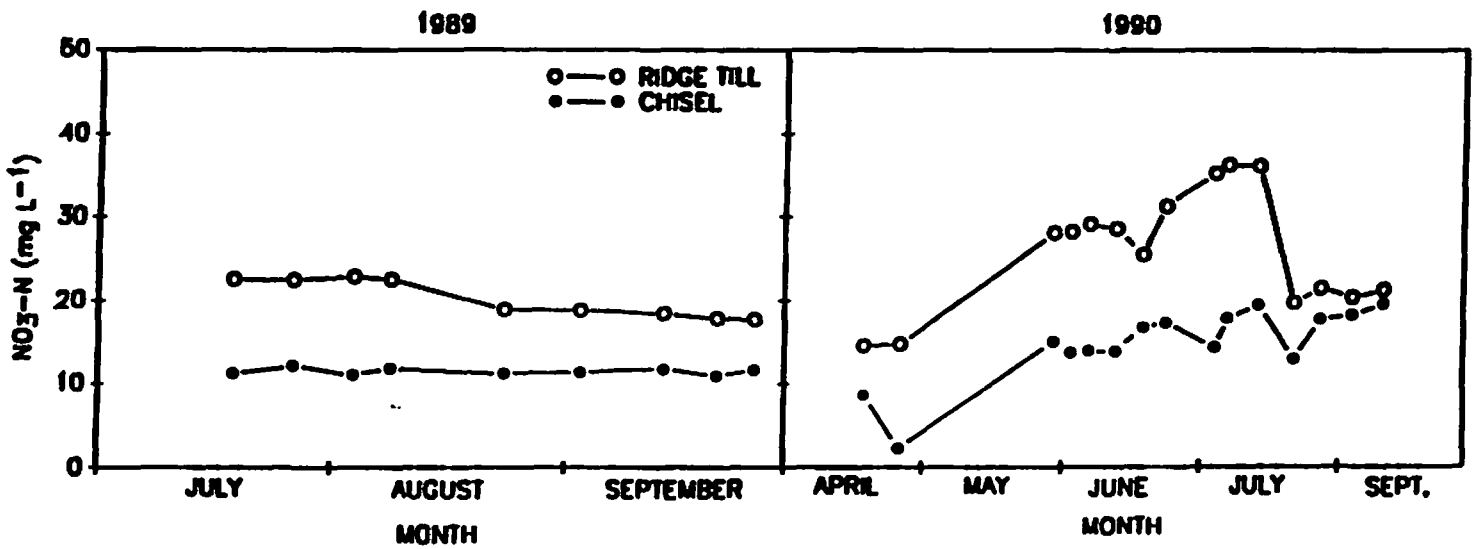
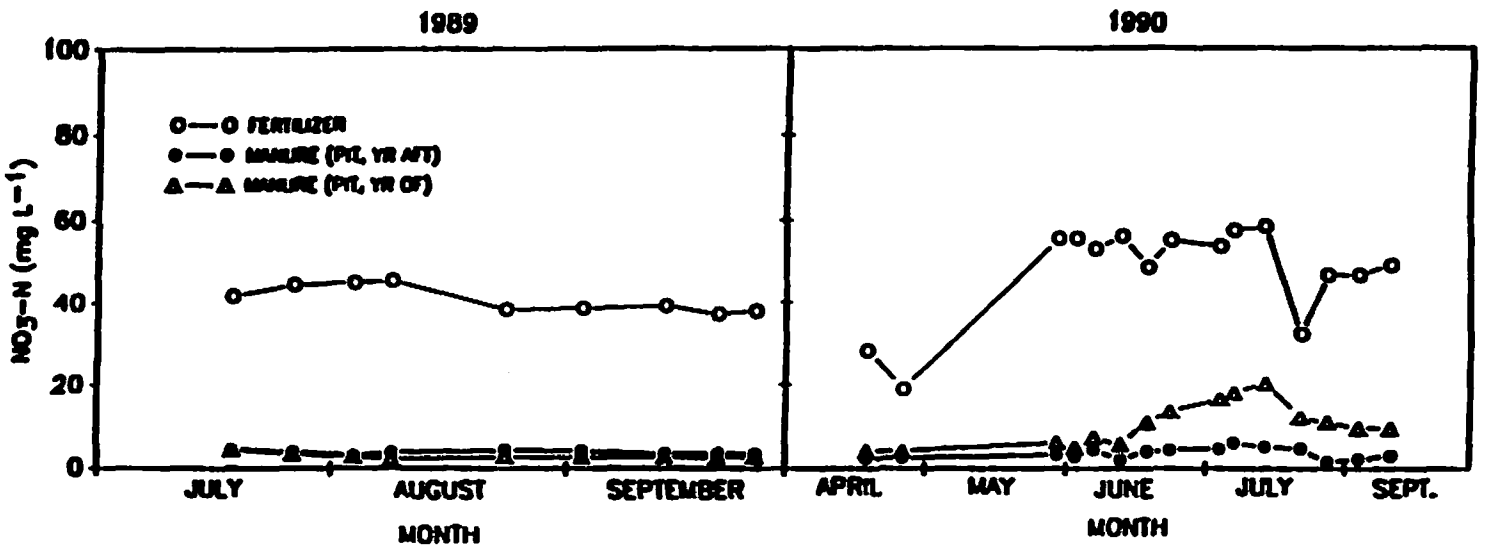


FIGURE -2

EFFECTS OF N SOURCE AND FREQUENCY ON SOIL WATER N AT 1.5m DEPTH



Tillage and time of application effects on corn response to manure in Meeker County, MN[1]

J.F. Moncrief, M.B. Kells, and J.J. Kuznia[2]

Chisel plowing provided adequate soil cover by crop residue to control soil erosion. There was no effect of tillage or nitrogen source on corn stand establishment. There was no effect of tillage on nitrogen availability to corn with the possible exception of the an increase with moldboard plowing of fall applied manure. Due to low rainfall, there was no difference in available N and grain yields with fall or spring applications of manure. There was a 22 bushel per acre increase in grain yield due to a response to nitrogen. Chisel plowing resulted in a 18 bushel per acre reduction in yield and an increase of grain moisture of 2.7 percent. This was likely due to a higher than recommended level of "in row" soil cover (16 percent vs 2.5 for chisel and moldboard plowing respectively), the cool spring in 1990 a uniform northern aspect with about 8% slope.

Methods and Materials

Fall and spring applications of dairy and pig manure are being compared to evaluate losses due to rainfall. At this site soil test values for nitrate and ammonium have been measured in late June. Ear leaf concentrations of nitrogen (7/30/90) have also been used to evaluate the time and N source treatments.

The composition of the manures at the Meeker county site are shown in table 1 for fall and spring applications. This site has a soil test P and K of 47 and 238 lbs/acre respectively. Soil test show that the N and K are needed.

The rate of manure was similar in the fall and spring. The rate of N was not however. In the fall N applied as pig and dairy manure was 146 and 86 pounds per acre respectively. In the spring the N rates were 108 and 164 pounds per acre with pig and dairy manure respectively. The manure composition is quite variable at this site.

As well as evaluating two sources of manure, tillage systems, and times of manure application, anhydrous ammonia and no nitrogen were also control treatments. The statistical analysis was done with two experimental designs: a randomized complete block with two tillage treatments split with six N source treatments, and a randomized complete block with two times of application split with two levels of tillage split with two sources of manure. The anhydrous ammonia and no nitrogen treatments were excluded from this analysis.

Results and Discussion

Corn yields were about 80 bushels per acre at this site in 1989. Soil cover after planting in 1990 was fairly high considering the yield levels in the previous year (tables 2 and 3). There was almost 40% cover with the chisel plowing system. The spring tines that clear the row area worked fairly well reducing the cover to about 16% in the row although this is higher than an ideal of less than 10%. Soil cover by corn residue was low with moldboard plowing.

There was bedding in the dairy source of manure. The soil cover by corn residue between the row was higher when manure was applied in the spring after fall moldboard plowing but a reverse trend with fall chisel plowing (table 3). The soil cover in the row after chisel plowing was higher with the hog source of manure because the tine row cleaners were more effective at removing straw bedding from the dairy source of manure rather than fecal material from the hog manure source.

Corn stands were quite good and not affected by tillage or manure treatments (tables 4 and 5). Any yield differences due to manure or tillage are not due to differences in corn stand.

By the end of July tillage and manure treatments were visible in the height of corn (tables 4 and 5). Anhydrous ammonia and fall applied manure treatments resulted in corn that was taller than plots with no nitrogen applied (table 4). In the fall there appeared to be an advantage to moldboard plowing after manure

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application. Spring manure and anhydrous ammonia treatments were not affected by tillage. On average moldboard plowing resulted in corn that was about four inches taller than those grown with a chisel system.

Although tillage affected corn height at the end of July, it did not affect the color (tables 4 and 5). Nitrogen source did have an affect on corn color. Anhydrous ammonia was the greenest, followed by fall manure treatments. Spring manure treatments resulted in corn that was only slightly greener than check plots.

Ear leaf N concentrations were similarly affected by N source but not tillage (tables 4 and 5). Fall and spring applied manure treatments resulted in corn with similar leaf N levels and were much higher than check plots. Anhydrous ammonia grown corn was higher than manure treatments. The trends in ear leaf N concentrations were followed closely by grain yields although N source was not statistically significant.

The two sources of manure were equally effective in providing N to corn whether fall or spring applied (125 and 127 bushels per acre respectively, table 5). This is not surprising in view of the rainfall that occurred between the fall and spring manure applications (figure 1). There was very little rainfall and little N was lost due to leaching in the fall or early spring. There were substantial leaching rains during the growing season especially during May and June. It is likely that the mineral portion of the manure that was applied was nitrified (converted to nitrate) and subject to leaching or denitrification (converted to gases) losses during these rains. Anhydrous ammonia, due to the inhospitable environment in the injection zone for nitrifying bacteria, is nitrified more slowly than manure sources and would be less likely to leach.

Soil mineral N on June 25, 1990 is presented in tables 6-8. Although soil samples represent 10 core composites for each plot, there was too much variability in these data to discern treatment differences. There was no statistically significant effect of tillage or N source on soil nitrogen. The anhydrous ammonia band was avoided when samples were taken in this treatment. Most of the soil ammonium was in the top one foot of soil. There was slightly higher levels of ammonium than nitrate. Soil nitrogen levels are generally low due to the heavy rainfall in the early summer (figure 1).

However, the trends in total soil nitrogen on this date follow the treatment influences in tissue levels of N.

Meeker County

Table 1. Cultural practices at Meeker County, MN. 1990.

Tillage
Fall Chisel Plowed, spring field cultivated
Fall Moldboard Plowed, spring field cultivated

1990 Crop
Corn-Pioneer 3751

Planting and Harvest Dates
Plots were planted with a four row John Deere Maximerge planter equipped with spring tine row cleaners at a 38 inch row spacing.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 8, 1990	28,000 seeds/A	October 15, 1990

1990 Fertilizer and Manure Analysis

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	----	lb/A	----	Date Applied
Corn	9-23-30[1]	150 lb/A	14	35	45	May 8, 1990
	82-0-0[2]	85 lb/A	70	0	0	April 24, 1990

1. Planter placement 2" beside and 2" below row.
2. Anhydrous ammonia was applied on selected plots.

Chemical composition of dairy and pig manure from barn gutters and an anaerobic pit from farrowing house at Meeker County, Fall-1989.

Manure Type and Rate of Application		Nitrogen					Phosphorus		Potassium	
		Mineral	Organic	Total	$	Available	P_2O_5	$	K_2O	$
Source	Rate	-------	lb/A	--------		- lb/A --	lb/A		lb/A	
Dairy	13.2 t/A	62	97	159	15.90	86	107	21.40	134	13.40
Pig	4,100 g/A	120	75	195	19.50	146	212	46.68	100	10.00

1. It is assumed that fertilizer cost .10, .20, and .10 per pound of N, P_2O_5, and K_2O respectively.

Chemical composition of dairy and pig manure from barn gutters and an anaerobic pit from farrowing house at Meeker County, Spring-1990 (4/5/90 for liquid and 5/18/90 for dairy).

Manure Type and Rate of Application		Nitrogen					Phosphorus		Potassium	
		Mineral	Organic	Total	$	Available	P_2O_5	$	K_2O	$
Source	Rate	------- lb/A --------				- lb/A --	lb/A		lb/A	
Dairy	11.6 t/A	149	61	210	21.00	164	89	17.80	217	21.70
Pig	4,100 g/A	93	43	136	13.60	108	127	25.40	82	8.20

1. It is assumed that fertilizer cost .10, .20, and .10 per pound of N, P_2O_5, and K_2O respectively.

Soil

The soils present at this site are as follows: 60% is Koronis fine sandy loam (Mollic Haplaudalfs, fine-loamy, mixed, mesic) with good internal drainage; 20% Cordova loam (Typic Argiaquolls, fine-loamy, mixed, mesic) with poor internal drainage; and the remaining 20% is Marcellon loam (Aquic Argiudolls, fine-loamy, mixed, mesic) with somewhat poor internal drainage.

Weed Control

3 qt/A (3.0 lb/A) Lasso applied preemergence on May 24, 1990.
.5 lb/A (0.45 lb/A) Atrazine 90 DF + 1 pt/A (0.25 lb/A) Buctril applied on June 22, 1990.

Insect Control

7 lb/A (1.05 lb/A) Counter 15G applied with planter.

Table 2. Effect of tillage and nitrogen source on soil cover by corn residue, 1990[1].

Treatments	Row Position[2] In	Between	Avg.
	--------- %	----------	
Tillage			
Moldboard	2.5b	11.0b	6.8b
Chisel	16.3a	37.8a	27.1a
Signif. (Pr > F)	0.017	0.002	0.003
	n=48	n=48	n=96
Nitrogen Source			
Fall Hog	13.0a	30.0a	21.5a
Spring Hog	12.0ab	25.8a	18.9ab
Fall Dairy	6.8bc	23.5ab	15.1b
Spring Dairy	10.0abc	26.0a	18.0ab
Anhydrous	5.3c	23.8ab	14.5b
Check	9.5abc	17.5b	13.5b
Signif. (Pr > F)	0.149	0.113	0.185
	n=16	n=16	n=32
Interactions			
Tillage X Nitrogen Source			
Mldbd Fall Hog	2.5	8.5	5.5
Mldbd Spring Hog	2.5	16.5	9.5
Mldbd Fall Dairy	2.0	12.0	7.0
Mldbd Spring Dairy	4.0	16.5	10.3
Mldbd Anhydrous	2.0	5.5	3.8
Mldbd Check	2.0	7.0	4.5
Chisel Fall Hog	23.5	51.5	37.5
Chisel Spring Hog	21.5	35.0	28.3
Chisel Fall Dairy	11.5	35.0	23.3
Chisel Spring Dairy	16.0	35.0	25.8
Chisel Anhydrous	8.5	42.0	25.3
Chisel Check	17.0	28.0	22.5
Signif. (Pr > F)	0.208	0.018	0.188
	n=8	n=8	n=16

1. Means within the same column with the same letter are not significantly different (α=.10).
2. In row is defined as a strip 4 inches wide centered over the row. Between row is the remainder (38 inch rows).

Table 3. Effect of time, tillage, and manure source on residue and its relative position to the row, 1990[1].

Treatments	Row Position In	Between	Avg.
	------- %	----------	
Application Time			
Fall	11.0a	26.8a	18.3a
Spring	9.9a	25.9a	18.4a
Signif. (Pr > F)	0.478	0.635	0.893
	n=32	n=32	n=64
Tillage			
Moldboard	2.8b	13.4b	8.1b
Chisel	18.1a	39.3a	28.7a
Signif. (Pr > F)	0.001	0.001	0.001
	n=32	n=32	n=64
Manure Source			
Hog	12.5a	27.9a	20.2a
Dairy	8.4a	24.8a	16.6a
Signif. (Pr > F)	0.101	0.351	0.180
	n=32	n=32	n=64
Interactions[2]			
Application Time X Tillage			
Fall Moldboard	2.3	10.3	6.3
Fall Chisel	17.5	43.3	30.4
Spring Moldboard	3.3	16.5	9.9
Spring Chisel	18.8	35.3	27.0
Signif. (Pr > F)	0.940	0.056	0.064
	n=16	n=16	n=32
Tillage X Manure Source			
Moldboard Hog	2.5	12.5	7.5
Moldboard Dairy	3.0	14.3	8.6
Chisel Hog	22.5	43.3	32.9
Chisel Dairy	13.8	35.3	24.5
Signif. (Pr > F)	0.067	0.149	0.087
	n=16	n=16	n=32

1. Means within the same column with the same letter are not significantly different (α=.10).
2. Only interactions with a (Pr > F) value less than .100 are reported.

Table 4. Effect of tillage and nitrogen source on corn response at Meeker Co., Ecker farm, 1990[1].

Treatment	Grain Yield	Grain Moisture	Grain Protein	Protein Yield	Population	Plant Height	Color Rating	Earleaf N
	bu/A	%	%	lb/A	plants/A x 10^{-3}	ft	1=Yellow 5=green	%
Tillage (n=24)								
Moldboard	133.9a	24.5b	8.00a	563.1a	27.5a	6.99a	4.24a	2.34a
Chisel	117.9b	27.2a	7.70a	478.0b	27.7a	6.65b	4.14a	2.42a
Signif. (Pr > F)	.007	.016	.102	.019	.861	.079	.266	.743
Nitrogen Source (n=8)								
Fall Hog	122.4ab	26.2a	7.86a	508.5ab	27.4a	6.72a	4.16b	2.47ab
Spring Hog	130.7ab	25.8a	7.76a	533.0ab	27.6a	6.72bc	4.00b	2.33b
Fall Dairy	127.1ab	25.4a	7.96a	530.9ab	27.5a	7.13ab	4.28b	2.50ab
Spring Dairy	123.5ab	26.1a	7.77a	505.5ab	27.7a	6.41c	4.03b	2.41b
Anhydrous	136.5a	25.3a	8.05a	575.8a	27.9a	7.28a	4.78a	2.71a
Check	115.0b	26.5a	7.73a	469.7b	27.4a	6.67bc	3.94b	1.99c
Signif. (Pr > F)	.282	.400	.545	.344	.989	.037	.007	.001
Interactions								
Tillage X Nitrogen Source (n=4)								
Mldbd Fall Hog	135.8	24.4	8.19	586.5	27.8	7.38	4.50	2.47
Mldbd Sp Hog	127.9	24.8	7.85	527.6	26.7	6.69	3.75	2.27
Mldbd Fall Dairy	139.3	24.1	8.06	586.9	27.3	7.38	4.44	2.48
Mldbd Sp Dairy	136.3	24.2	7.92	567.0	26.9	6.69	4.25	2.53
Mldbd Anhydrous	147.4	23.9	8.28	636.5	27.8	7.31	4.75	2.67
Mldbd Check	116.7	25.7	7.71	474.3	28.5	6.50	3.88	1.85
Chisel Fall Hog	108.9	27.9	7.52	430.6	27.1	6.06	3.81	2.48
Chisel Sp Hog	133.5	26.8	7.67	538.5	28.5	6.75	4.25	2.38
Chisel Fall Dairy	115.0	26.6	7.85	475.0	27.7	6.88	4.13	2.51
Chisel Sp Dairy	110.8	27.9	7.61	444.1	28.5	6.13	3.81	2.28
Chisel Anhydrous	125.6	26.7	7.81	515.1	27.9	7.25	4.81	2.74
Chisel Check	113.4	27.4	7.75	464.8	26.3	6.81	4.00	2.13
Signif. (Pr > F)	.365	.600	.579	.383	.050	.085	.145	.580

1. Means within the same columns with the same letter are not significantly different (α=.10).

Table 5. Effect of application time, tillage, and manure source on various plant characteristics of corn at Meeker Co., Ecker farm, 1990[1].

Treatment	Grain Yield	Grain Moisture	Grain Protein	Protein Yield	Population	Plant Height	Color Rating	Earleaf N
	bu/A	%	%	lb/A	plants/A x 10^{-3}	ft	1=Yellow 5=green	%
Application Time (n=16)								
Fall	124.8a	25.8a	7.91a	519.7a	27.5a	6.92a	4.22a	2.49a
Spring	127.1a	25.9a	7.76a	517.3a	27.6a	6.56a	4.02a	2.37a
Signif. (Pr > F)	.730	.625	.534	.992	.795	.271	.322	.495
Tillage (n=16)								
Moldboard	134.8a	24.4b	8.00a	567.0a	27.2a	7.03a	4.23a	2.44a
Chisel	117.0b	27.3a	7.66a	472.0b	27.9a	6.45b	4.00a	2.47a
Signif. (Pr > F)	.045	.001	.139	.053	.254	.009	.259	.829
Manure Source (n=16)								
Hog	126.5a	26.0a	7.81a	520.8a	27.5a	6.72a	4.16a	2.40a
Dairy	125.3a	25.7a	7.86a	518.2a	27.6a	6.77a	4.08a	2.45a
Signif. (Pr > F)	.833	.476	.560	.918	.855	.796	.588	.618
Interactions								
Application Time X Tillage (n=8)								
Fall Moldboard	137.6	24.3	8.13	586.7	27.6	7.38	4.47	2.47
Fall Chisel	112.0	27.2	7.69	452.8	27.4	6.47	3.97	2.50
Spring Moldboard	132.1	24.5	7.88	547.3	26.8	6.69	4.00	2.40
Spring Chisel	122.1	27.4	7.64	491.3	28.5	6.44	4.03	2.33
Signif. (Pr > F)	.309	.839	.640	.362	.170	.077	.208	.639
Application Time X Manure Source (n=8)								
Fall Hog	122.4	26.2	7.86	508.5	27.4	6.72	4.16	2.47
Fall Dairy	127.1	25.4	7.96	530.9	27.5	7.13	4.28	2.50
Spring Hog	130.7	25.8	7.76	533.0	27.6	6.72	4.00	2.33
Spring Dairy	123.5	26.1	7.77	505.5	27.7	6.41	4.03	2.41
Signif. (Pr > F)	.300	.170	.625	.325	1.00	.052	.745	.793
Tillage X Manure Source (n=8)								
Moldboard Hog	131.9	20.4	8.02	557.0	27.3	7.03	4.13	2.37
Moldboard Dairy	137.8	17.8	7.99	576.9	27.1	7.03	4.34	2.51
Chisel Hog	121.2	26.5	7.59	484.6	27.8	6.41	4.03	2.43
Chisel Dairy	112.9	25.3	7.73	459.5	28.1	6.50	3.97	2.39
Signif. (Pr > F)	.220	.560	.392	.375	.648	.796	.331	.389
Application Time X Manure Source X Tillage (n=4)								
Fall Hog Mldbd	135.8	24.4	8.19	586.5	27.8	7.38	4.50	2.47
Fall Dairy Mldbd	139.3	24.1	8.06	586.9	27.3	7.38	4.44	2.48
Fall Hog Chisel	108.9	27.9	7.52	430.6	27.1	6.06	3.81	2.48
Fall Dairy Chisel	115.0	26.6	7.85	475.0	27.7	6.88	4.13	2.51
Sp Hog Mldbd	127.9	24.8	7.85	527.6	26.7	6.69	3.75	2.27
Sp Dairy Mldbd	136.3	24.2	7.92	567.0	26.9	6.69	4.25	2.53
Sp Hog Chisel	133.5	26.8	7.67	538.5	28.5	6.75	4.25	2.38
Sp Dairy Chisel	110.8	27.9	7.61	444.1	28.5	6.13	3.81	2.28
Signif. (Pr > F)	.151	.090	.129	.093	.522	.052	.027	.354

1. Means within the same columns with the same letter are not significantly different (α=.10).

Table 6. The effect of time of manure application and depth on soil ammonium N (lbs/acre) Meeker County, MN, 6/25/90[1].

	Fall Applied		Spring Applied				
Depth	Pig	Dairy	Pig	Dairy	Anhyd.	Check	**Average**
0-1 feet	42	33	41	43	45	43	**41**
1-2 feet	27	26	29	29	26	30	**28**
Total	**69**	**60**	**70**	**73**			
Average	**65**		**72**		**72**	**73**	

1. The p values for time, N source, depth, and the time by N source interaction are: .086, .812, <.001, and .452 respectively (excluding the anhydrous ammonia and check treatments).

Table 7. The effect of time of manure application and tillage on soil nitrate (lbs/acre) Meeker County, MN, 6/25/90[1].

	Fall Applied		Spring Applied				
Depth	Pig	Dairy	Pig	Dairy	Anhyd.	Check	**Average**
0-1 feet	41	29	31	32	39	21	**32**
1-2 feet	40	37	25	29	34	18	**31**
Total	**81**	**66**	**56**	**61**			
Average	**74**		**59**		**73**	**39**	

1. The p values for time, N source, depth, and the time by N source interaction are: .427, .456, .898, and .208 respectively (excluding the anhydrous ammonia and check treatments).

Table 8. The effect of time of manure application and depth on total soil mineral N (lbs/acre) Meeker County, MN, 6/25/90[1].

	Fall Applied		Spring Applied				
Depth	Pig	Dairy	Pig	Dairy	Anhyd.	Check	**Average**
0-1 feet	82	63	72	76	85	64	**74**
1-2 feet	68	64	54	58	60	47	**59**
Total	**150**	**126**	**126**	**134**			
Average	**138**		**130**		**144**	**111**	

1. The p values for time, N source, depth, and the time by N source interaction are: .623, .218, .006, and .029 respectively (excluding the anhydrous ammonia and check treatments).

The tillage effect on grain yields was much more consistent than the effect of N source. There was a 16 bushel per acre reduction in yield with the chisel plowing system (tables 4 and 5). The yield reduction associated with chisel plowing was also correlated with an almost 3% increase in grain moisture. Increases in grain moisture indicate slowed corn development. This can be the result of "in row" cover reducing soil temperatures. Cover in the row by crop residue was 16% with the chisel plowing system. This may of had an influence on corn development due to the uniform northern aspect with about 8% slope at this site. Data from other locations suggests that soil cover by corn residue in a strip one third the row width should be less than 20% to minimize any impact on corn establishment and early growth.

Stand was not affected by the corn residue in the row area. When "in row" residue levels slow the growth of corn there is usually also a stand reduction.

Increased grain moisture can also be the result of nutrient stress. Tissue levels of nitrogen suggests that nitrogen deficiency was not the cause. Phosphorus and potassium are likely not limiting because 30 and 45

pounds per acre respectively were applied with the planter based on the soil test level at this site. It is not likely that nutrient stress was the causal agent.

The best guess is that the delayed development of the corn grown with the chisel plowing system was due to excessive corn residue in the row area.

The grain nitrogen (protein) levels followed trends that were similar to ear leaf nitrogen trends although fall applied manure and anhydrous ammonia treatments were closer and slightly higher than spring applied manure or nothing. Also moldboard plowing both sources of fall applied manure seemed to provide an advantage for N availability in 1990. This trend is consistent for color ratings, grain yields, grain N, and N uptake by grain (table 9). Tillage effects on these variables without manure applied (check plots) suggest that the advantage is not due to increased mineralization of soil organic matter with moldboard plowing but to the available N from manure.

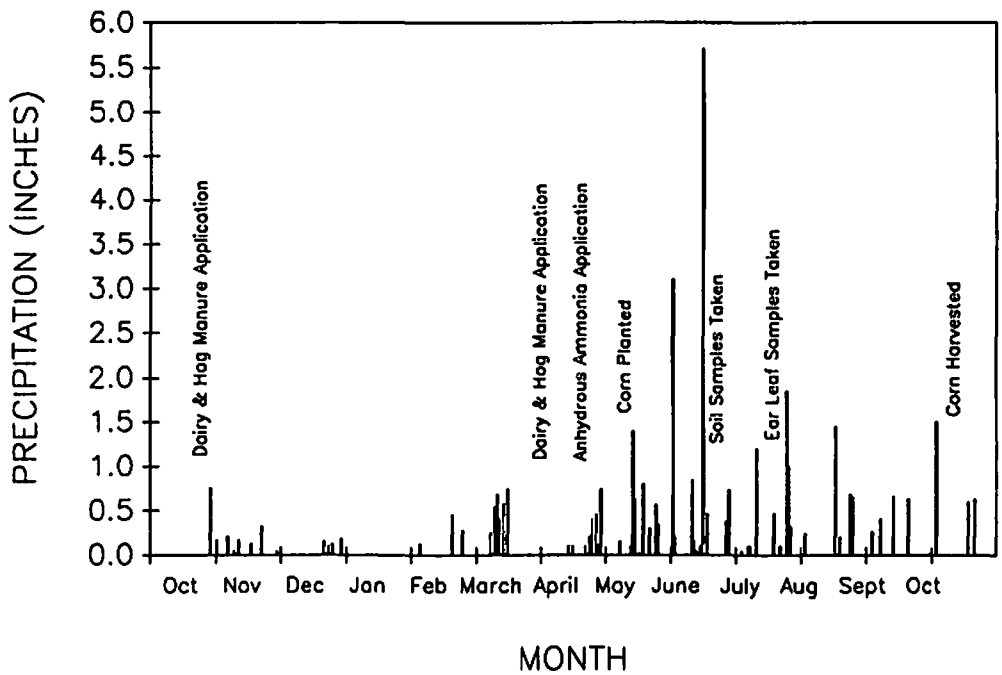
Table 9. The effect of time of manure application and tillage on grain N uptake (lbs/acre), Meeker County, MN, 10/15/90[1].

	Fall Applied		Spring Applied				
Depth	Pig	Dairy	Pig	Dairy	Anhyd.	Check	**Average**
Moldboard	94	94	84	91	102	76	**90**
Chisel	69	76	86	71	82	74	**76**
Average	**81**	**85**	**85**	**81**			
	83		**83**		**92**	**75**	

1. The p values for tillage, N source, and the tillage by N source interaction are: .019, .344, and .383 respectively.

Nitrogen uptake by grain (which usually accounts for 2/3 of the total plant uptake) are shown in table 9. Final N uptake data show that fall and spring applied manure resulted in the same nitrogen uptake. There were very little losses from fall applied manure do to low rainfall during fall and spring period. Moldboard plowing to incorporate the fall applied manure showed a small advantage over chisel plowing. These data follow yield response trends as well as other soil and plant N diagnostic measurements.

Figure 1.
MEEKER COUNTY, ECKER FARM PRECIPITATION
1989–1990



Tillage effects on soybean response to residual effects of manure in Stearns County, MN[1]

J.F. Moncrief, M.B. Kells, and J.J. Kuznia[2]

Conservation tillage reduced the early growth of soybeans in 1990. As tillage was reduced early growth was also reduced. Differences in early growth were not correlated with soil cover in the row area or final grain yields. Plant tissue N was less at 10% bloom with chisel plowing than other tillage systems. Chisel plowing also resulted in a yield reduction over moldboard plowing with other systems being intermediate. Manure application in 1989 resulted in higher N concentrations in plant tissue at 10% bloom. Nitrogen concentrations in grain were similar for all treatments.

Manure was applied at the Stearns county site in the spring of 1989 following soybeans and preceding corn. The soil test P and K at this site is 53 and 223 lbs/acre respectively. Although the manure pack-barnyard source of manure was applied at a similar rate as the fresh barn gutter source the water content was about one half. Most of the nitrogen was in the organic form which means it will require bacterial breakdown before being available to corn and provide more residual nitrogen for succeeding crops.

Methods and Materials

Two manure sources were evaluated for ability to provide nitrogen for corn in 1989 and residual N, P, and K for soybeans in 1990: fresh manure from barn gutters and a manure pack around a hay rack in the barnyard. In the corn year (1989) in addition to a 5 lbs/acre of nitrogen applied with the planter, commercial nitrogen treatments had two equal applications (33 lbs/acre) applied during cultivation as urea-ammonium nitrate solution (UAN). Manure treatments had additional nitrogen applied during the second cultivation. Tillage treatments evaluated were: spring moldboard and chisel plowing followed by a light discing, ridge till and no till systems. Manure applications were not made on the no till plots. Manure was applied in the last two weeks of April in 1989 prior to chisel plowing but following moldboard plowing. A treatment summary is presented in table 1.

The experimental design is a split plot with tillage main plots and manure/fertilizer subplots for each source of manure. Each source of manure was compared with UAN. The two sources of manure were not compared to each other.

Soil cover was estimated by a line transect method and characterized for "in" and "between row" areas at two monitoring sites within each subplot. At each monitoring site treatment responses were evaluated by observations on two adjacent corn rows. Soil cover measurements were made over 10 feet of row with a line with 25 points. "In row" is defined as a four inch strip centered over the row and "between row" the remainder. Early corn growth was estimated by tallying the leaves on the plants within the ten feet of row. Stands were similarly estimated by tallying the number of plants in ten feet of row at each monitoring site.

Soybean trifoliate samples were taken at 10% bloom (July 25) and analyzed for nitrogen.

Grain yields were estimated by combining two rows of soybeans 300 feet long and weighing to the nearest 5 pounds with a weigh wagon. Subsamples were taken for moisture determination and nitrogen analysis.

Results and Discussion

Soil cover by corn residue and soybean stands are shown in table 2. Even with the relatively modest corn yields the year before there is more than fifty percent soil cover by crop residue with only the tillage associated with the no till drill. There is adequate soil cover for erosion control with all the conservation tillage systems. All the soybean stands are high enough not to be yield limiting (table 3). The ridge till stand is lower because it was established with a ridge till planter.

The effects of tillage and manure on soybean early growth are also shown in table 3. Tillage effects on early growth were not very well correlated to soil cover in the row. This suggests that the soil temperature reduction associated with crop residues over the row area was not responsible for differences in early

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[1] *Support for this project was provided by the Agricultural Utilization and Research Institute, the Central Minnesota Initiative Fund, the Soil Conservation Service, the Clearwater River Watershed District, and the Minnesota Extension Service. Their support is greatly appreciated.*

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. M.B. Kells is the Tri-County Project coordinator.*

growth. As tillage decreased early growth also decreased. Tillage effects on early growth of soybeans is very rarely correlated with yields. There was no effect of manure application in 1989 on early growth of soybeans in 1990.

One objective of this study was to evaluate residual nitrogen from manure on response by soybeans in the year after application. Very striking visual symptoms of what appeared to be nitrogen stress in unmanured plots were observed in July but had become less apparent in August. Plant tissue levels of nitrogen on July 25, 1990 are shown in table 4. There was a trend for a higher level of tissue nitrogen in manured plots which apparently did not interact with tillage. Soybeans grown with chisel plowing however had lower N concentrations than the other tillage systems tested.

Yields are given in table 5 and were quite high for this soil. Tillage system affected soybean yields. Yields were somewhat consistent with tissue nitrogen concentrations in that chisel plowing resulted in a 3.4 bushel per acre reduction in yield. Also, manure in 1989 increased yields 2.4 bushels per acre.

Protein concentration in grain (also nitrogen) was not affected by tillage or previous manure application (table 7).

STEARNS COUNTY

Table 1. Cultural practices at Stearns County, MN. 1990.

Tillage
No Till
Ridge Till
Spring Chisel Plowed and tandem disced twice
Spring Moldboard Plowed and tandem disced twice
Cultivated on July 5, 1990, and
ridges formed on July 17, 1990.

Cropping History
1981-red clover and oats, 1982-corn,
1983-soybeans, 1984-corn, 1985-corn,
1986-soybeans, 1987-corn, 1988-Soybeans
1989-corn

1990 Crop Soybeans-Pioneer 9161

Planting and Harvest Dates
Ridge till plots were planted with a four row Buffalo Till planter equipped with 12" sweeps at a 36 inch row spacing. Other tillage treatments were planted with a Tye no till drill with 8 inch row spacing equipped with 2 inch fluted coulters ahead of the double disc openers.

	Planting		
Crop	Date	Rate	Harvested
Soybeans	May 29, 1990	225,000 seeds/A	October 11, 1990

Fertilization History 1981-1987
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/A of 9-18-9 only, 1985-60 lb/A of N and 4 gal/a of 9-18-9, 1986-all soybean plots were split with and without a row fertilizer treatment at planting, and in 1987-all corn plots were split with three rates of starter.

				Actual			
	Material			N	P_2O_5	K_2O	
Crop	Analysis	Rate	Tillage	----	lb/A	----	Date Applied
Soybeans	9-18-9[1]	4 gal/A	Ridge Till	4	8	4	May 16, 1986
	0-0-60[2]	90 lb/A	All Others	0	0	54	May 16, 1986
Corn	Starter Fertilizer Treatments						
	9-18-9[1]	0 gal/A	All	0	0	0	April 29, 1987
	9-18-9[1]	4.9 gal/A	All	4.7	10	4.7	April 29, 1987
	9-18-9[1]	9.7 gal/A	All	9.3	18.5	9.3	April 29, 1987
	Nitrogen Management						
	28-0-0	11 gal/A	No Till[3]	33	0	0	June 1, 1987
	28-0-0	11 gal/A	All Others[4]	33	0	0	June 1, 1987
	28-0-0	11 gal/A	No Till[3]	33	0	0	June 25, 1987
	28-0-0	11 gal/A	All Others[4]	33	0	0	June 25, 1987

1. Planter placement 1" below the seed.
2. Potash was surface banded ahead of and incorporated by the fluted coulters.
3. Nitrogen was surface banded.
4. Nitrogen was surface banded and incorporated by cultivation.

1989 Fertilizer and Manure Analysis

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			---- lb/A ----			
Corn	9-18-9[1]	5 gal/A	5	10	5	May 11, 1988
	28-0-0[2]	11 gal/A	33	0	0	June 15, 1989
	28-0-0[3]	11 gal/A	33	0	0	June 30, 1989

1. Planter placement 1" below the seed.
2. Urea-ammonium nitrate (UAN) solution was surface banded and incorporated by cultivation on all non-manure plots. Solution was surface banded with no incorporation on no till plots.
3. Urea-ammonium nitrate (UAN) solution was surface banded and incorporated by cultivation on all plots manured and non-manured. Solution was surface banded with no incorporation on no till plots.

Analysis and rate of application of manure.

Manure Source	Date Applied	NH_4	NO_3	Mineral	Organic	Total N	Total P	Total K	Manure Density	Manure Rate	Solids Total	Solids Volatile	Solids Fixed
		----------			%	----------			lb/ft³	T/A	--------	%	--------
Barn Gutter[1]	4/13/89	.260	.012	.272	.264	.536	.109	.424	64.8	16.4	27.66	45.96	54.04
Barnyard[2]	4/25/89	.050	.003	.053	.639	.692	.204	.377	33.8	15.0	16.50	64.62	35.38

1. Fresh daily manure collected every other day from barn gutters and applied the last two weeks of April.
2. A manure pack collected near a hay rack in the barnyard and applied April 25, 1989.

Rate of applied, available and value[1] of nitrogen[2], phosphorus, and potassium.

Source	Mineral	Organic	Nitrogen	$	Available Nitrogen 1989	Available Nitrogen 1990	P_2O_5	$	K_2O	$
	-- Applied N lb/acre ---				------ lb/A ------		lb/A		lb/A	
Barn Gutter	89	87	176	17.60	111	11	82	16.40	167	16.70
Barnyard	16	192	208	20.80	64	24	140	28.00	136	13.60

1. It is assumed that fertilizer cost .10, .20, and .10 per pound of N, P_2O_5, and K_2O respectively.
2. It is assumed that all of the mineral N and 25% of the organic N will be available during the year of application.

Soil

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

Weed Control - 1.5 pt/A (0.281 lb/A) Poast + 2 pt/A (1.0 lb/A) Basagran applied on June 25, 1990.

Table 2. Effect of tillage and row position on corn residue in soybeans at Stearns Co. on May 30, 1990.

Location	Tillage NoTill	Ridge	Chisel	Mldbd	Avg.
	--------- % cover ----------				
In Row	36.8a	6.3c	14.5b	3.0c	15.1b
Between Row	56.3a	39.0b	24.8c	3.3d	30.8a
Average	46.5a	22.6b	19.6b	3.1c	

1. The p value for residue location, tillage and tillage by location interaction are .001 (n=64), .001 (n=32), and .001 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 3. Effect of tillage and manure applied in 1989 on population (5/30/90) and early growth (7/12/90) of soybeans at Stearns Co[1].

Manure 1989	Tillage Ridge[2]	Chisel	Mldbd	Avg.
	---- plants/A X 10^{-3}		----	
Manure	160.3	172.3	177.6	175.0a
No Manure	158.4	183.0	192.8	187.9a
Average	159.4	177.6a	185.2a	
Manure 1989	------ nodes/plant ------			
Manure	5.2	5.7	5.5	5.5a
No Manure	5.1	5.6	5.9	5.5a
Average	5.1b	5.7a	5.7a	

1. The p value for manure, tillage, and tillage by manure interaction for population are .207 (n=32), .444 (n=32), and .824 (n=16). The p value for manure, tillage, and tillage by manure interaction for growth stage are .554 (n=240), .072 (n=160), and .325 (n=80) respectively. Means within the same row with the same letter are not significantly different (α=.10).
2. The ridge till treatment was excluded from statistical analysis of population because a different planter was used.

Table 4. Effect of tillage and manure applied in 1989 on % N in trifoliate leaf tissue at Stearns Co. on July 25, 1990[1].

	Tillage			
	Ridge	Chisel	Mldbd	
Manure 1989	---------- % N ----------			Avg.
Manure	5.97	5.63	5.91	5.84a
No Manure	5.89	5.55	5.79	5.74a
Average	5.93a	5.59b	5.85a	

1. The p value for manure, tillage, and tillage by manure interaction are .195 (n=12), .002 (n=8), and .962 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 5. Effect of tillage and manure applied in 1989 on soybean yield and moisture at Stearns Co. on October 10 & 15, 1990[1].

	Tillage			
	Ridge	Chisel	Mldbd	
Manure 1989	---------- bu/A ----------			Avg.
Manure	43.6	39.6	45.7	43.0a
No Manure	40.0	37.6	44.3	40.6a
Average	41.8ab	38.6b	45.0a	
Manure 1989	---------- % ----------			
Manure	8.6	8.8	9.0	8.8a
No Manure	8.6	8.8	8.9	8.8a
Average	8.6a	8.8a	9.0a	

1. The p value for manure, tillage, and tillage by manure interaction for yield are .123 (n=12), .070 (n=8), and .802 (n=4) respectively. The p value for manure, tillage, and tillage by manure interaction are .695 (n=12), .431 (n=8), and .981 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 6. Effect of tillage and manure applied in 1989 on soybean protein at Stearns Co. 1990[1].

	Tillage			
	Ridge	Chisel	Mldbd	
Manure 1989	---------- % ----------			Avg.
Manure	45.2	44.2	43.8	44.4a
No Manure	45.1	44.9	44.2	44.7a
Average	45.2a	44.5ab	44.0a	

1. The p value for manure, tillage, and tillage by manure interaction are .065 (n=12), .073 (n=8), and .198 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 7. Effect of tillage on % N in trifoliate leaf tissue, early growth, population, protein content, yield and moisture of soybeans with **no manure** applied.

	Tillage				
	No Till	Ridge	Chisel	Mldbd	
	------- plants/A X 10^{-3} -----				Sig.
Population	267.5a	160.4[1]	183.0b	192.8b	.001
	--------- nodes/plant -------				
Early Growth	4.9c	5.1c	5.6b	5.9a	.001
	---------- % N ----------				
Leaf N	5.77a	5.89a	5.55b	5.79a	.056
	---------- bu/A ----------				
Yield	42.7ab	40.0ab	37.6b	44.3a	.198
	---------- % ----------				
Moisture	8.3b	8.6ab	8.8ab	8.9a	.205
	---------- % ----------				
Protein	44.1a	45.1a	44.9a	44.2a	.229

Tillage effects on corn growth, stand establishment, and yield, Isanti County, MN[1]

J.F. Moncrief, S. D. Grosland, and J.J. Kuznia[2]

Corn residue levels in the row higher than 20% resulted in a corn growth delay of 1 leaf and 3% higher grain moisture. At these levels yields were reduced more than 30 bushels per acre. The yield reduction was due to stand loss and delayed development. Corn grain response to plant population was linear from 18 to 31 thousand plants per acre. Planter applied P resulted in an average grain yield increase of 16 bushels per acre at a high soil test.

This is the fourth year of a study that evaluates conservation tillage on corn growth and yield in a continuous corn cropping sequence. Also being evaluated at this site are corn population and planter applied P effects on corn yield.

The cultural practices at this site are shown in table 1. Soil cover by crop residue and the corn response to tillage are shown in table 2. Clearing discs were evaluated on the no till plots. Soil cover by crop residue was 20% or less with all but the no till system. Cover in the row was reduced from 82% to 52% with planter mounted clearing discs under no till conditions. The high level of soil cover in the row with this treatment resulted in decreased early growth, plant stands, grain moisture and yields. Soil cover by corn residue must be less than 20% to minimize any detrimental effects on corn growth.

The corn grain response to plant population appeared to be linear from about 18 to 30 thousand plants per acre (table 4).

At a high and very high soil test P level there was a 22 and 10 bushels per acre grain yield response respectively (table 6).

ISANTI COUNTY

Table 1. Cultural practices of conservation tillage plot on corn at Isanti County, MN. 1990.

Tillage

No Till
Spring Disc
Spring Chisel and tandem disced twice
Spring Moldboard and tandem disced twice
Spring tillage was done on May 6, 1990.

Cropping History

1986-Soybeans, 1987-Corn Pioneer 3790,
1988-Corn Pioneer 3772, 1989-Corn Pioneer 3751

1990 Crop

Corn Pioneer 3788

Planting and harvest information

A six row John Deere 7000 planter with 30 inch row spacing and equipped with 2 inch fluted coulters, disc row cleaners, and Yetter coulters for fertilizer.

Crop	Date	Rate	Harvested
Corn	May 6, 1987	27,200 seeds/A	Oct. 6, 1987
Corn	May 3, 1988	28,500 seeds/A	Oct. 14, 1988
Corn	May 3, 1989	29,000 seeds/A	Oct. 26, 1989
Corn	**May 7, 1990**	**29,600 seeds/A**	**Nov. 13, 1990**

Fertilizer 1987

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Mg	Date Applied
		------ lb/A ------					
Corn	12-14-26-4-3[1] (277 lb/A)	33	39	72	11	8	May 6, 1987
	82-0-0 (146 lb/A)	120	0	0	0	0	June 5, 1987

1. Planter applied 2" beside and 2" below seed.

[1] *Support for this project was provided by the Soil Conservation Service and the Minnesota Extension Service. Their support is greatly appreciated.*

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. S. D. Grosland is the County Agricultural Agent in Isanti County, MN.*

Fertilizer 1988

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Mg	Date Applied
		------ lb/A ------					
Corn	12-14-26-4-3[1] (277 lb/A)	33	39	72	11	8	May 3, 1988
	82-0-0 (220 lb/A)	180	0	0	0	0	June 3, 1988

1. Planter applied 2" beside and 2" below seed.

Fertilizer 1989

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Mg	Date Applied
		------ lb/A ------					
Corn	12-14-26-4-3[1] (277 lb/A)	33	39	72	11	8	May 3, 1989
	82-0-0 (146 lb/A)	120	0	0	0	0	June 5, 1989

1. Planter applied 2" beside and 2" below seed.

Fertilizer 1990

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Date Applied
		---- lb/A -----				
Corn	12-14-27-4[1] (250 lb/A)	30	35	68	10	May 7, 1990
	82-0-0 (146 lb/A)	120	0	0	0	June 25, 1990

1. Planter applied 2" beside and 2" below seed.

1987 Soil Test

Organic Matter	pH	Bray 1 Phosphorus	Potassium	Sulfur	Zinc
		------- lb/A --------		---- ppm ---	
Medium	7.0	115	238	15	1.1

Soil

The soil at this site is a Ames fine sandy loam (Typic Albaqualfs, fine, montmorillonitic, mesic), 0 to 2 percent slope and is moderate to slowly drained.

Weed Control

1 pt/A (1.0 lb/A) Dual + 1 lb/A (0.9 lb/A) Bladex 90DF + 1 lb/A (0.9 lb/A) Atrazine 90DF on May 10, 1990.

Table 2. Effect of tillage on residue, stand, early growth, harvest stand, grain yield, and grain moisture at Isanti Co., 1990[1].

Tillage	Residue 6/20/90 In Row	Between Row	Avg.	6/20/90 Early Growth	6/20/90 Population	11/13/90 Harvest Population	Grain 11/13/90 Yield	Moisture
	---------- % ----------			leaves	plants/A	plants/A	bu/A	--- % --
No till w/o row cleaner	81.5	84.3	82.9a	2.3d	17,200c	18,900b	84.4c	25.3a
No till w/ row cleaner	51.5	72.5	62.0b	2.7c	22,900b	19,800b	105.4b	24.0b
Disk	20.3	21.8	21.0c	3.4b	27,700a	26,500a	137.0a	22.5c
Chisel	17.0	19.3	18.1c	3.4b	26,100a	24,900a	138.2a	22.1cd
Moldboard	7.8	7.5	7.6d	3.6a	26,600a	27,000a	136.4a	21.7d
Average	35.6b	41.1a						
Signif. (Pr > F)	0.003		0.001	0.001	0.001	0.001	0.001	0.001
			n=32	n=80	n=8	n=8	n=4	n=4

1. Means within the same group with the same letter are not significantly different (α=.10).

Table 3. Cultural practices of population plot on corn at Isanti County, MN. 1990.

Tillage

Spring Chisel and tandem disced twice
Spring tillage was done on May 6, 1990.

Cropping History

1986-Soybeans, 1987-Corn Pioneer 3790,
1988-Corn Pioneer 3772, 1989-Corn Pioneer 3751

1990 Crop

Corn Pioneer 3788

Planting and harvest information

A six row John Deere 7000 planter with 30 inch row spacing and equipped with 2 inch fluted coulters.

Crop	Date	Harvested
Corn	May 6, 1987	Oct. 6, 1987
Corn	May 3, 1988	Oct. 14, 1988
Corn	May 3, 1989	Oct. 26, 1989
Corn	**May 7, 1990**	**Nov. 13, 1990**

Fertilizer 1987

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Mg	Date Applied
		------ lb/A ------					
Corn	12-14-26-4-3[1] (277 lb/A)	33	39	72	11	8	May 6, 1987
	82-0-0 (146 lb/A)	120	0	0	0	0	June 5, 1987

1. Planter applied 2" beside and 2" below seed.

Fertilizer 1988

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Mg	Date Applied
		------ lb/A ------					
Corn	12-14-26-4-3[1] (277 lb/A)	33	39	72	11	8	May 3, 1988
	82-0-0 (220 lb/A)	180	0	0	0	0	June 3, 1988

1. Planter applied 2" beside and 2" below seed.

Fertilizer 1989

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Mg	Date Applied
		------ lb/A ------					
Corn	12-14-26-4-3[1] (277 lb/A)	33	39	72	11	8	May 3, 1989
	82-0-0 (146 lb/A)	120	0	0	0	0	June 5, 1989

1. Planter applied 2" beside and 2" below seed.

Fertilizer 1990

Crop	Material Analysis (rate)	Actual N	P_2O_5	K_2O	S	Date Applied
		---- lb/A -----				
Corn	12-14-27-4[1] (250 lb/A)	30	35	68	10	May 7, 1990
	82-0-0 (146 lb/A)	120	0	0	0	June 25, 1990

1. Planter applied 2" beside and 2" below seed.

Soil

The soil at this site is a Ames fine sandy loam (Typic Albaqualfs, fine, montmorillonitic, mesic), 0 to 2 percent slope and is moderate to slowly drained.

Weed Control

1 pt/A (1.0 lb/A) Dual + 1 lb/A (0.9 lb/A) Bladex 90DF + 1 lb/A (0.9 lb/A) Atrazine 90DF on May 10, 1990.

Table 4. Effect of seed population on early plant stand grain yield, grain moisture, test weight, and harvest plant stand at Isanti Co., 1990[1].

Sprocket Setting	6/20/90 Population	11/13/90 Population	Average Population	11/13/90 Grain Yield	Grain Moisture	Grain Test Wt.
Seeds/A	plants/A	plants/A	plants/A	bu/A	-- % ---	lb/bu
19,600	18,000	17,600d	17,800	117.6c	24.8d	51.0a
21,780	19,200	19,600cd	19,400	122.9bc	25.7c	51.0a
24,500	19,600	21,000c	20,300	123.9bc	27.2a	51.0a
26,300	23,100	23,700b	23,400	129.4b	26.1bc	51.0a
28,400	24,800	25,900b	25,400	129.4b	26.7ab	51.0a
29,600	27,900	26,000b	27,000	128.4b	26.7ab	51.0a
32,980	30,100	29,600a	29,900	138.0a	27.2a	51.0a
34,300	31,800	30,000a	30,900	145.1a	26.4abc	51.0a
	n=4	n=2		n=2	n=2	n=2
Signif. (Pr > F)		0.001		0.005	0.009	0.0

1. Means within the same column with the same letter are not significantly different (α=.10).

Table 5. Cultural practices of planter applied P plot on corn at Isanti County, MN. 1990.

Tillage

Spring Disced on twice on May 6, 1990.

1990 Crop

Corn Pioneer 3790

Planting and harvest information

A six row John Deere 7000 planter with 30 inch row spacing and equipped with 2 inch fluted coulters, and Yetter coulters for fertilizer.

Crop	Planting Date	Planting Rate	Harvested
Corn	May 8, 1990	29,600 seeds/A	Nov. 16, 1990

Cropping History

1985-Soybeans then continued with a corn soybean rotation.

1990 Soil Test

Soil Type	Organic Matter	pH	Bray 1 Phosphorus	Potassium
			------- lb/A --------	
Hayden	Low	6.4	140	236
Bluffton	High	6.5	60	184

Fertilizer 1990

Soil Type	Crop	Material Analysis (rate)	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
			---- lb/A -----				
Hayden	Corn	12-14-27-4[1] (250 lb/A)	30	35	68	10	May 8, 1990
		12-0-35-4[1] (250 lb/A)	30	0	88	10	May 8, 1990
		82-0-0 (146 lb/A)	120	0	0	0	June 25, 1990
Bluffton	Corn	12-14-27-4[1] (250 lb/A)	30	35	68	10	May 8, 1990
		12-0-35-4[1] (250 lb/A)	30	0	88	10	May 8, 1990
		82-0-0 (146 lb/A)	120	0	0	0	June 25, 1990

1. Plots split with starter on each soil type, planter applied 2" beside and 2" below seed.

Soil

Hayden silt loam (Typic Hapludalfs, fine-loamy, mixed, mesic), 2 to 7 percent slope and its surface drainage is medium but internal drainage is somewhat restricted.

Bluffton loam and silty clay loam (Typic Haplaquolls, fine-loamy, mixed, frigid), drainage is poor.

Weed Control

2 qt/A (3.35 lb/A) Eradicane + 1 lb/A (0.9 lb/A) Bladex 90DF + 1 lb/A (0.9 lb/A) Atrazine 90DF on May 10, 1990.

Table 6. Effect of phosphorus in starter fertilizer on corn grain yield (n=3), moisture (n=3), and test weight (n=3) at Isanti Co. on November 16, 1990[1].

	Soil Type					
	Hayden			Bluffton		
Starter	Yield	Moisture	Test Wt	Yield	Moisture	Test Wt
	bu/A	--- % --	lb/bu	bu/A	--- % --	lb/bu
30-00-87-11	145.1b	22.5a	54.2b	122.1b	26.8a	52.5b
30-35-69-11	155.8a	21.6a	55.5a	145.4a	24.3a	54.0a
Signif. (Pr > F)	0.080	0.210	0.015	0.066	0.222	0.001

1. Means within the same column with the same letter are not significantly different (α=.10).

Tillage effects on continuous corn in Dodge County, MN[1]

J.F. Moncrief, T.L. Wagar, and J.J. Kuznia[2]

This is the 5th year of a study evaluating tillage system (main plots) with deep tillage (subplots). There was no affect of deep tillage or primary tillage on grain yields.

This study was established in 1986. Main plots are tillage with deep chiseling subplots with a continuous corn rotation. In previous years there has been a consistent advantage to deep tillage independent of other tillage. In 1990 there was neither a significant effect of tillage or deep tillage. Although there was no effect of tillage on grain yields it did affect grain moisture however. A 1.5 percent reduction in grain moisture with conservation tillage options suggests delayed corn development.

DODGE COUNTY

Table 1. Cultural practices at Dodge County, MN. 1990.

Tillage

Ridge Till
Fall Disc
Fall Chisel Plow
Fall Moldboard Plow

All plots split with a Mohawk chisel plow, 8-10 inches deep, done in the fall prior to fall tillage. Shanks are spaced on 28 inch centers and are a point type that run in the center of the row.

Secondary tillage, a light discing was done prior to planting.

All plots were rotary hoed on June 9, 1990, cultivated once on June 25, 1990, and ridges formed on July 16, 1990.

Preceding Crop

1985-1989 Corn

1990 Crop

Corn-Pioneer 3737

Planting and Harvest Date

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

	Planting		
Crop	Date	Rate	Harvested
Corn	May 29, 1990	28,000 seeds/A	October 12, 1990

Fertilization History

			Actual				
	Material		N	P_2O_5	K_2O		
Crop	Analysis	Rate	---	lb/A	---	Date Applied	Method of Application
Corn:	46-0-0	370 lb/A	170	0	0	April 16, 1987	Broadcast
	7-21-7	10 gal/A	8	24	8	April 29, 1987	Applied with the seed
Corn:	82-0-0	213 lb/A	175	0	0	April 5, 1988	Injected
	7-21-7	5.5 gal/A	4	13	4	April 20, 1988	Applied with the seed
Corn:	82-0-0	220 lb/A	180	0	0	April 19, 1989	Injected
	7-21-7	6.3 gal/A	5	15	5	May 10, 1989	Applied with the seed

1990 Fertilizer

			Actual				
	Material		N	P_2O_5	K_2O		
Crop	Analysis	Rate	---	lb/A	---	Date Applied	Method of Application
Corn:	82-0-0	213 lb/A	175	0	0	April 16, 1990	Injected
	7-21-7	6 gal/A	5	14	5	May 29, 1990	Applied with the seed

Soil

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

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[1] *Support for this project was provided by the Soil Conservation Service and the Minnesota Extension Service. Their support is greatly appreciated.*

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. T.L. Wagar is the Southeast Area Crops and Soils Agent at Rochester, MN.*

Weed Control

2 pt/A (2.0 lb/A) Dual + 2.2 lb/A (2.0 lb/A) Bladex 90 DF applied preemergence on May 30, 1990.

Insecticide Control

8 lb/A (1.2 lb/A) Force 15G at time of planting.

Table 2. Effect of tillage and deep chiseling on corn yield · moisture and protein at Dodge Co. on October 12, 1990[1].

	Tillage				
	Moldboard	Ridge Till	Disc	Chisel	
	bu/A				Avg.
Deep Chisel	119	125	129	118	123a
No Deep Chisel	126	125	125	119	124a
Average	122a	125a	127a	119a	
	% moisture				
Deep Chisel	30.4	31.5	31.3	31.3	31.1a
No Deep Chisel	29.9	31.4	31.7	31.9	31.2a
Average	30.1a	31.4b	31.5b	31.6b	
	% protein				
Deep Chisel	8.4	8.7	9.1	8.4	8.7a
No Deep Chisel	8.4	8.6	8.9	8.4	8.6a
Average	8.4b	8.6b	9.0a	8.4b	

1. The p value for deep chisel, tillage, and tillage by deep chisel interaction for yield are 0.671 (n=12), 0.578 (n=6), and 0.595 (n=3) respectively. The p value for deep chisel, tillage, and tillage by deep chisel interaction for moisture are 0.801 (n=12), 0.070 (n=6), and 0.209 (n=3) respectively. The p value for deep chisel, tillage, and tillage by deep chisel interaction for grain protein are 0.158 (n=12), 0.032 (n=6), and 0.574 (n=3) respectively. Means within the same row with the same letter are not significantly different (α=.10).

CONSERVATION TILLAGE, AND CORN AND SOYBEAN PRODUCTION IN THE CLEARWATER RIVER WATERSHED:[1] A FOUR YEAR SUMMARY

J.F. Moncrief, J.J. Kuznia, M.B. Kells, and B.A. Kjeldahl[2]

This project evaluates conservation tillage for corn and soybean production in the Clearwater River Watershed which occupies the contiguous corners of Meeker, Stearns, and Wright Counties. Generally corn and soybean early growth was affected by tillage but did not show consistent yield responses. Conservation tillage systems were generally more profitable than moldboard plowing systems.

PROJECT BACKGROUND

In recent years there has been concern for the water quality in the Clearwater River Chain of Lakes due to entry of phosphorus from various sources. There has been direct discharge of effluent either from lake shore owners or industry that has contributed. Also phosphorus has entered the lakes from eroded stream banks from some soils in the watershed that are natively high in phosphorus. There has also been entry of phosphorus from agricultural sources due largely to erosion. Phosphorus from agricultural activities that enters water bodies is usually associated with the sediment that is carried off fields during heavy rainfall. Most will agree that the solution to this problem is at the source. In the case of the agricultural contribution erosion control in conjunction with banded phosphorus applications is the obvious answer. Phosphorus is applied below the surface and erosion is controlled with crop residue.

Most will also agree that the most cost effective method of controlling erosion is by crop residue management with conservation tillage. In an effort to evaluate conservation tillage options under the specific conditions of the watershed, plots were established in Stearns and Wright counties in the spring of 1986 and in Meeker county in the fall of 1986. Corn and soybeans were grown at Meeker and Wright counties every year and alternated at the Stearns county site. The tillage systems being evaluated are: moldboard and chisel plowing, ridge till, and no till. Soybeans were planted with a no till drill in all treatments except the ridge till.

An evaluation of tillage effects on corn and soybean yields, as well as an economic summary for the history of the project will be presented.

BANDED PHOSPHORUS APPLICATION

The effect of phosphorus placement on corn grain yields is shown in table 1. In 1988 at the Meeker county site a comparison between broadcast and planter applied P was made. In other years the comparison was between planter applied P (also small amounts of N and K) and no fertilizer. On average there was a five bushel per acre advantage to planter applied fertilizer. The soil test P ranged from 24 to 53 pounds per acre. This is in the medium to high level. The motivation for applying fertilizer P with the planter is the likelihood of getting a corn response even with relatively high background soil test levels. This is largely due to minimizing soil "tie up" because fertilizer is being mixed with a smaller volume of soil. In some cases the yield response interacted with tillage while others did not. Since starter-tillage interactions were not consistent averages over tillage systems are presented.

The average row fertilizer response is valued at $11.50 per acre at $2.20 per bushel. Phosphorus rates varied from 5 to 36 pounds per acre. Most of the row P corn grain response is obtained with a relatively low rate. The P value at the rates used ranged from $1.10 to $7.90 per acre.

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[1] *Data collection was assisted by many local people with the Soil Conservation Service, the Soil and Water Conservation Districts, and the Minnesota Extension Service. This project would not have been possible without their assistance. Also thanks to Richard Echman, Richard Kuechle, and Lyndon Johnson, farmer-cooperators, for their valuable assistance and advice. Financial support was provided by the Central Minnesota Initiative Fund, and the Minnesota Pollution Control Agency, and the Soil Conservation Service. Their support is greatly appreciated.*

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department, University of Minnesota. M.B. Kells is the Tri County Conservation Project Coordinator, Waite Park, MN. B.A. Kjeldahl is an Undergraduate Research Assistant at the University of Minnesota.*

Table 1. Corn response to row applied fertilizer at planting.

Year	No Row phosphorus	Row phosphorus
	bu/acre	
1988	40	45[1]
1989	107	106[1]
1990	128	133[1]
1987	81	91[2]
1990	107	114[3]
Average	93	98

1. Meeker county data that in 1988 compares 76 and 36 lbs P_2O_5 per acre broadcast and row applied with the planter respectively, in 1989 and 1990 35 and 42 lbs P_2O_5 per acre respectively row applied with the planter was compared to no P applied. The soil test P is 25 pounds per acre.
2. Stearns county data compares 5 or 9 lbs P_2O_5 per acre row applied with the planter to no P. The soil test P is 53 pounds per acre.
3. Wright county data compares 20 lbs P_2O_5 per acre to no P. The soil test P is 24 pounds per acre.

GROWTH AND YIELD

MEEKER COUNTY

Soil Cover by Soybean Residue,
Corn Growth, Stand Establishment,
Grain Moisture, and Yield

Soil cover by soybean residue is shown in table 2. There is adequate soil cover to control erosion with the no till and ridge till systems although it was marginal in 1987. The soil cover between the row needs to be close to 30% to provide adequate erosion control. Soil cover in the row area is higher than desirable to minimize detrimental influences on corn growth under no till conditions. Corn growth is delayed when the soil cover by crop residue in the row is higher than 20% (table 3). In 1987 soil moisture dominated the early growth of corn. The conservation tillage systems resulted in quicker emergence and early growth due to higher levels of soil moisture. The soil was very cloddy under moldboard plowing in this year. On average corn grown with ridge tillage and chisel plowing was similar to that of moldboard plowing. No till grown corn was .25 leaves delayed in growth over the other systems.
Stand was only affected in one year at this site (1987-table 4). Due to cloddy conditions there was a stand loss with moldboard plowing. Average stands were within 700 plants per acre. Stand differences would not be expected to affect yield.

Grain moisture was only affected by tillage one year at this site (1990-table 5). Average grain moisture varied .7% between tillage systems.

Corn yields were affected by tillage in 1990 only (table 6). In this year it was very cool in the early season. It is possible that the delayed growth associated with the no till system was responsible for the 10 bushels per acre yield decline with this system. The yield loss with the ridge till system is likely due to stand loss at cultivation that was not reflected in the stand measurements. Average yields were within five bushels per acre between tillage systems.

Table 2. The effect of tillage on soil cover by soybean residue at Meeker County, MN (p value <.001 for all years).

	IN-ROW COVER					BETWEEN-ROW COVER				
	1987	1988	1989	1990	Ave.	1987	1988	1989	1990	Ave.
	%									
No till	29.0	66.8	13.3	30.0	34.8	24.0	59.5	66.9	58.5	52.2
Ridge	20.0	20.8	6.4	12.3	14.9	22.0	36.8	47.9	33.0	34.9
Chisel	10.0	18.8	5.8	20.0	13.7	10.0	14.8	10.9	21.8	14.4
Moldboard	3.0	0.8	2.0	3.5	2.3	2.0	1.5	2.4	6.0	3.0
Date	5/27	6/14	5/11	6/12		5/27	6/14	5/11	6/12	

Table 3. The effect of tillage on early corn growth, Meeker County, MN.

	1987	1988	1989	1990	Ave.
	leaves/plant				
No till	3.31	6.88	1.45	2.55	3.55
Ridge	3.76	7.47	1.71	2.69	3.91
Chisel	3.25	7.41	2.02	2.61	3.82
Moldboard	3.00	7.54	2.06	2.61	3.80
p value	.001	.007	.004	.097	
Date	5/27	6/14	6/2	6/12	

Table 4. The effect of tillage on corn stand at Meeker County, MN.

	1987	1988	1989	1990	Ave.
	plants/acre				
No till	37.4	30.5	29.0	29.0	31.5
Ridge	37.7	31.6	29.2	29.7	32.1
Chisel	36.6	31.4	29.7	30.1	32.0
Moldboard	34.3	32.6	29.9	28.6	31.4
p value	.092	.647	.631	.351	
Date	5/27	6/14	6/2	6/12	

Table 5 Effect of tillage on corn grain moisture, Meeker County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	%				
1987	21.2	21.5	20.6	19.9	.311
1988	29.9	27.7	27.4	25.5	.680
1989	21.2	21.0	22.1	21.3	.442
1990	22.8	22.1	23.0	25.5	.001
Avg.	23.8	23.1	23.3	23.1	

Table 6. Effect of tillage on corn yield following soybeans, Meeker County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	bu/acre				
1987	189	187	179	189	.176
1988	46	40	49	43	.179
1989	103	113	103	108	.333
1990	136	134	125	124	.055
Ave.	119	119	114	116	

Soil Cover by Corn Residue, Soybean Growth, Stand Establishment, Grain Moisture, and Yield

Soil cover by corn residue is shown in table 7. There is adequate soil cover by corn residue in all conservation tillage systems. Tillage delayed development of soybeans a maximum of .38 nodes at this site (table 8). It did not affect yields however (table 9). This is consistent with other Minnesota data which show soybeans to be fairly insensitive to the effects of changes in soil physical properties associated with conservation tillage.

Table 7. The effect of tillage on soil cover by corn residue at Meeker County, MN (p value <.001 for all years).

	IN-ROW COVER					BETWEEN-ROW COVER				
	1987	1988	1989	1990	Ave.	1987	1988	1989	1990	Ave.
	%									
No till	45.0	73.5	52.6	56.6	56.9	43.0	58.8	61.6	55.5	54.7
Ridge	35.0	21.8	17.5	9.3	20.9	39.0	53.5	40.3	32.8	41.4
Chisel	35.0	33.3	22.8	30.2	30.3	29.0	23.3	25.1	35.0	28.1
Moldboard	8.0	10.5	4.8	4.3	6.9	7.0	9.8	4.4	4.5	6.4
Date	5/27	6/16	5/22	5/30		5/27	6/16	5/22	5/30	

Table 8. The effect of tillage on early soybean growth, Meeker County, MN.

	1987	1988	1989	1990	Ave.
	nodes/plant				
No till	2.30	4.11	5.44	2.79	3.66
Ridge	2.40	3.95	5.28	2.90	3.63
Chisel	2.20	4.42	5.73	2.86	3.80
Moldboard	2.43	4.86	5.79	2.94	4.01
p value	.396	.016	.001	.060	
Date	5/27	6/16	7/6	6/12	

Table 9. Effect of tillage on soybean yield, Meeker County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	bu/acre				
1987	52.0	51.0	50.0	51.0	.896
1988	13.6	13.8	13.8	15.2	.367
1989	28.0	29.0	30.0	30.0	.452
1990	49.8	48.9	50.0	42.8	.482
Avg.	35.9	35.7	36.0	34.8	

WRIGHT COUNTY

Soil Cover by Soybean Residue,
Corn Growth, Stand Establishment,
Grain Moisture, and Yield

Tillage effects on soil cover by crop residue are shown in table 10. Soil cover was adequate for erosion control only one year with the chisel plowing system at this site. There was very little effect of crop residue on corn growth at this site. Soil cover in the row was low with all systems and early corn growth showed minimal response to tillage (table 11).

Stands were affected three years out of four. Tillage affects on stand were variable however and average stand values were similar and not expected to affect yield.

Grain moisture was never affected by tillage at this site. This is consistent with the lack of response by early corn to tillage.

Grain yields were affected the first year. This was due to lambsquarter in the ridge and no till plots. Plots were not sprayed with 2,4-D amine this year. Average yields were within six bushels per acre of the moldboard system.

Table 10. The effect of tillage on soil cover by soybean residue at Wright County, MN (p value <.001 for all years).

	IN-ROW COVER					BETWEEN-ROW COVER				
	1987	1988	1989	1990	Ave.	1987	1988	1989	1990	Ave.
	%									
No till	49.5	57.3	19.0	55.8	45.4	78.2	93.5	49.5	71.3	73.1
Ridge	7.2	7.8	2.3	1.8	4.8	31.2	32.0	21.8	9.7	23.7
Chisel	14.5	22.3	3.8	3.0	10.9	19.7	29.5	9.3	6.0	16.1
Moldboard	1.7	4.5	0.3	0.3	1.7	2.5	6.0	0.8	4.3	3.4
Date	6/1	5/12	5/11	6/12		6/1	5/12	5/11	6/12	

Table 11. The effect of tillage on early corn growth, Wright County, MN.

	1987	1988	1989	1990	Ave.
	leaves/plant				
No till	3.83	8.28	1.74	2.75	4.15
Ridge	4.26	8.06	2.03	2.93	4.32
Chisel	3.59	8.37	1.92	2.87	4.19
Moldboard	3.59	8.93	1.97	2.82	4.33
p value	.252	<.001	.001	.038	
Date	6/1	6/16	6/1	6/12	

Table 12. The effect of tillage on corn stand at Wright County, MN.

	1987	1988	1989	1990	Ave.
	plants/acre				
No till	27.1	31.3	31.5	31.2	30.3
Ridge	30.7	29.5	29.9	30.6	30.2
Chisel	28.3	29.3	32.0	30.2	30.0
Moldboard	27.4	28.9	30.2	28.2	28.7
p value	.046	.214	.066	.010	
Date	6/1	6/16	6/1	6/12	

Table 13. Effect of tillage on corn grain moisture, Wright County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	%				
1987	14.2	14.3	15.3	16.1	.136
1988	----	----	----	----	
1989	25.0	23.9	23.6	24.9	.653
1990	15.4	15.0	14.6	14.7	.364
Avg.	18.2	13.3	17.8	18.6	

Table 14. Effect of tillage on corn yield following soybeans, Wright County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	bu/acre				
1987	121	123	110	106	.034
1988	---	---	---	---	
1989	85	75	104	79	.203
1990	111	110	105	115	.720
Avg.	106	103	106	100	

Soil Cover by Corn Residue,
Soybean Growth, Stand Establishment,
Grain Moisture, and Yield

Soil cover by corn residue is shown in table 15. Cover was adequate for erosion control in most years with conservation tillage systems at this site. In 1988 there was a total crop failure due to the drought and subsequently very little residue in 1989.

As with the corn, the soybeans showed no consistent early growth response to tillage. Average early growth values showed about .1 and .2 nodes per plant reduction in growth for the chisel or ridge till and no till systems respectively.

There was a large reduction in soybean yields in the first year of the study. This is most likely due to a row spacing response. Ridge till soybeans were planted on 30" rows and all other systems on 7" row spacing. There was no affect of tillage on soybean yields the next three years. Average soybean yields were about 2 bushels per acre lower with the ridge till system.

Table 15. The effect of tillage on soil cover by corn residue at Wright County, MN (p value <.001 for all years).

	IN-ROW COVER					BETWEEN-ROW COVER				
	1987	1988	1989	1990	Ave.	1987	1988	1989	1990	Ave.
	%									
No till	61.0	43.8	34.3	54.3	48.4	60.0	57.0	45.5	64.5	56.8
Ridge	20.0	7.0	3.8	7.3	9.5	47.7	35.0	14.5	33.5	32.7
Chisel	44.0	24.0	10.8	17.5	24.2	46.7	23.8	9.4	22.3	25.6
Moldboard	5.7	7.8	3.6	5.3	5.6	5.5	7.8	3.4	7.5	6.1
Date	6/1	5/12	5/22	6/12		6/1	5/12	5/22	6/12	

Table 16. The effect of tillage on early soybean growth, Wright County, MN.

	1987	1988	1989	1990	Ave.
	nodes/plant				
No till	2.40	3.94	4.82	2.75	3.48
Ridge	2.40	4.29	4.53	2.93	3.54
Chisel	2.97	3.84	4.53	2.87	3.55
Moldboard	2.90	4.14	4.78	2.82	3.66
p value	.174	.042	.001	.038	
Date	6/1	6/16	7/5	6/12	

Table 17. Effect of tillage on soybean yield following corn, Wright County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	bu/acre				
1987	39.1	38.1	31.1	40.2	.004
1988	0.4	1.6	1.8	0.3	.306
1989	26.3	25.5	25.9	28.2	.455
1990	38.2	42.2	39.6	38.0	.443
Avg.	26.0	26.9	24.6	26.7	

STEARNS COUNTY

Soil Cover by Soybean Residue, Corn Growth, Stand Establishment, Grain Moisture, and Yield

There was adequate cover for erosion control by soybean residue with conservation tillage systems at this site in all but 1989 following the drought year of 1988 (table 18). Early growth of corn was reduced when soil cover by soybean residue exceeded 20% (table 19-only the no till treatment).

There was no affect of tillage on stand establishment (table 20). All systems resulted in about 20,000 plants per acre. Although corn development was delayed by .4 leaves per plant under no till conditions there was no measurable difference in grain moisture (table 21).

Corn yields were lower under a no till system in 1987. This was likely due to giant foxtail competition. In 1989 yields were higher with no tillage. On average yields were similar between tillage systems.

Table 18. The effect of tillage on soil cover by soybean residue at Stearns County, MN (p value <.001 for all years).

	IN-ROW COVER			BETWEEN-ROW COVER		
	1987	1989	Ave.	1987	1989	Ave.
	%					
No till	30.0	33.3	31.7	77.5	37.8	57.7
Ridge	16.7	3.3	10.0	61.7	36.8	49.3
Chisel	22.5	9.3	15.9	32.5	6.3	19.4
Moldboard	5.0	4.0	4.5	5.5	2.8	4.2
Date	5/29	6/1		5/29	6/1	

Table 19. The effect of tillage on early corn growth, Stearns County, MN.

	1987	1989	Ave.
	leaves/plant		
No till	3.88	1.65	2.77
Ridge	4.20	1.92	3.06
Chisel	4.30	1.96	3.13
Moldboard	4.35	2.00	3.18
p value	<.001	.001	
Date	5/29	6/1	

Table 20. The effect of tillage on corn stand at Stearns County, MN.

	1987	1989	Ave.
	--- plants/acre		----
No till	19.1	20.7	19.9
Ridge	20.7	20.7	20.7
Chisel	20.1	21.1	20.6
Moldboard	20.6	20.8	20.7
p value	.417	.958	
Date	5/29	6/1	

Table 21. Effect of tillage on corn grain moisture, Stearns County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	----------	%	----------		
1987	18.9	19.0	20.1	19.7	.780
1989	19.7	20.0	19.0	19.5	.263
Avg.	19.3	19.5	19.6	19.6	

Table 22. Effect of tillage on corn yield following soybeans, Stearns County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	---------	bu/acre	----------		
1987	92	101	91	80	.002
1989	63	60	53	82	.108
Avg.	78	81	72	81	

Soil Cover by Corn Residue, Soybean Growth, Stand Establishment, Grain Moisture, and Yield

Soil cover by corn residue was only marginally adequate for erosion control with the chisel plowing system (table 23). Early soybean growth was positively correlated with soil cover in the row with corn residue (table 24). Growth was reduced by .3 and .9 nodes per plant with 20% and 54 per cover in the row with the ridge till and chisel plowing or no tillage respectively.

As with the Wright County site in 1987, yields were lower with the ridge till system in 1986. This was likely due to a row spacing response. Ridge tillage resulted in higher yields in 1988 although yields were extremely low. The chisel plowing system resulted in lower yields in 1990. In no year were grain yields correlated tillage effects on early growth. On average the chisel and ridge till systems resulted in a yield decline of 2 bushels per acre.

Table 23. The effect of tillage on soil cover by corn residue at Stearns County, MN (p value <.001 for all years).

	IN-ROW COVER				BETWEEN-ROW COVER			
	1986[1]	1988	1990	Ave.	1986[1]	1988	1990	Ave.
	----------			%	----------			
No till	26.8	72.0	36.8	54.4	20.3	73.8	56.3	65.1
Ridge	6.5	36.0	6.3	21.2	25.5	48.0	39.0	43.5
Chisel	16.5	25.0	14.5	19.8	17.5	22.0	24.8	23.4
Moldboard	3.0	5.3	3.1	4.2	4.0	2.5	3.3	2.9
Date	5/29	6/15	5/30		5/29	6/15	6/30	

1. This site was ridge tilled prior to this study. In 1986 ridges were disced to prepare for the no till treatment. This year is not included in the average values.

Table 24. The effect of tillage on early soybean growth, Stearns County, MN.

	1988	1990	Ave.
	---- nodes/plant		-----
No till	2.75	4.94	3.85
Ridge	3.44	5.11	4.28
Chisel	3.21	5.63	4.42
Moldboard	3.58	5.90	4.74
p value	<.001	<.001	
Date	6/16	7/12	

Table 25. Effect of tillage on soybean yield following corn, Stearns County, MN.

	Tillage				
	Mldbd	Chsl	Ridge	NoTil	Sig.
Year	---------	bu/acre	----------		
1986	40.9	39.8	36.4	40.6	.000
1988	1.6	0.9	4.0	1.5	.006
1990	44.2	37.6	40.0	42.7	.070
Avg.	28.9	26.1	26.8	28.3	

INPUTS, OUTPUT, AND TILLAGE SYSTEM

Crop production inputs that are affected by tillage system such as tractor costs, tillage implements, fuel, labor, and herbicides are tallied for each of the tillage systems being evaluated at each of the three sites.

This is weighed against the crop output generated by each system. Tillage affected grain yields at some sites in some years but was not consistent. Because of this, the average yield over all years of the demonstration for each tillage system at each site is used to estimate output.

MEEKER COUNTY

Conservation tillage methods for corn and soybean production in Meeker County showed higher profitability than moldboard plowing. No till corn had a 3 bushels per acre yield decrease. This decrease was made up for in lower variable costs. Herbicide costs were twice as high with the no till system, but this was compensated for with the reduction in machinery and fuel costs. The machinery and fuel categories were cut by about 1/3 from the moldboard system. Soybeans under the no till system had lower variable costs that more than made up the 1.1 bushels per acre decrease in yield. Machinery and fuel costs were cut by 80%, although herbicide costs rose by 300%.

Ridge tillage also showed a significant increase in profitability over moldboard plowing. Corn yields were 5 bushels lower with the ridge till system, but lower variable costs made up for that difference. Soybeans had a slight, 0.1 bushel yield increase with ridge till. The lower machinery and fuel costs with ridge till contributed to the increase in net profit in ridge till soybeans.

Chisel plowing showed a slight increase in profitability in Meeker County. Chisel and moldboard plowed systems resulted in similar corn yields. A slight decrease in variable costs was found in the chisel plowed system. These differences came from the machinery/fuel categories. Soybeans yields had very little variance, the chisel plowed system had a 0.2 bushel average yield decrease. The higher profitability again came from the savings in the machinery and fuel costs.

Table 26. Profitability of conservation tillage systems compared to a moldboard plowing system at Meeker County.

	No-till		Ridge till		Chisel		Moldboard	
	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean
Bushels	116.0	34.8	114.0	36.0	119.0	35.7	119.0	35.9
Gross return	255.20	191.40	250.80	198.00	261.80	196.35	261.80	197.45
Variable costs-								
Machinery/labor	18.49	7.98	41.55	36.46	53.94	36.60	55.53	39.37
Fuel	1.50	1.40	3.30	2.80	6.00	4.90	6.50	5.40
Herbicides	26.96	33.47	14.63	11.70	13.74	11.39	13.74	11.39
Total costs	46.95	42.85	59.48	48.16	73.68	52.89	75.77	56.16
Return over variable costs	208.25	148.55	191.32	149.84	188.12	143.46	186.03	141.29
Comparison to moldboard system	+22.22	+7.26	+5.29	+8.55	+2.09	+2.17		
Corn/soy average	+14.74		+6.92		+2.13			

WRIGHT COUNTY

The demonstration in Wright County resulted in average net return for corn grain with the no till system less than for the moldboard system. The variable costs for corn were equal, but the no till showed a yield reduction of 5.7 bushels. This was due to competition by lambsquarter in the first year of the

demonstration. No till corn had higher herbicide costs, but lower machinery costs than moldboard tillage, so the variable costs for corn were approximately even. Profitability of the no till soybeans was not reduced as much as corn. The yield of no till soybeans was 0.7 bushels higher, but the variable costs were also greater for no till. The herbicide costs were substantially higher with no till grown soybeans.

Ridge tillage showed an increase in average returns over moldboard. This was due to the increase in profitability of corn. The yield of ridge till corn was increased by 0.5 bushels per acre, but more importantly, the variable costs were reduced. Herbicide costs in corn and soybeans were equal for ridge till, chisel, and moldboard systems. The ridge till system showed a reduction in variable costs because of the lower machinery and fuel costs. Ridge till soybeans were not as profitable as the moldboard system. The variable costs were lower, but not enough to make up for the 1.4 bushel loss in yield.

Chisel plowing also showed a slight increase in profitability over moldboard plowing. Corn was less profitable, because of lower yields. The variable costs were lower in the machinery and fuel categories, but not enough to make up for the 3 bushel yield reduction. Soybeans were more profitable under the chisel plowing system. This is due to the increased yield and lower variable costs, again due to lower machinery and fuel costs.

Table 27. Profitability of conservation tillage systems compared to a moldboard plowing system at Wright County.

	No-till		Ridge till		Chisel		Moldboard	
	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean
Bushels	100.0	26.7	106.3	24.6	102.7	26.9	105.7	26.0
Gross return	220.00	146.85	233.86	135.30	225.94	147.95	232.54	143.00
Variable costs-								
Machinery/labor	36.62	14.20	28.55	22.94	39.52	19.94	41.73	23.26
Fuel	1.70	1.40	3.40	2.80	5.80	4.90	6.40	6.20
Herbicides	17.76	33.47	9.82	10.22	9.32	11.39	9.32	11.39
Total costs	56.08	49.07	41.77	35.96	54.64	36.23	57.45	40.85
Return over variable costs	163.92	97.78	192.09	99.34	171.30	111.72	175.09	102.15
Comparison to moldboard system	-11.17	-4.37	+17.00	-2.81	-3.79	+9.57		
Corn/soy average	-7.77		+7.10		+2.89			

STEARNS COUNTY

The no till system in Stearns County shows a greater average profitability than moldboard plowing. Corn is more profitable because of 3.5 bushel higher average yields and lower variable costs. Machinery and fuel costs are substantially lower, although herbicide costs are higher. Soybeans were not as profitable under no till as moldboard system. The no till grown soybeans had a .6 bushel per acre lower yield than with a moldboard system, and variable costs were greater. This is due to no till herbicide costs about three times higher than the moldboard system. Machinery costs for no till were about half of what they were under the moldboard system.

Ridge till corn and soybeans were both more profitable than the moldboard system. Corn yields were lower, but variable costs were also much lower. This is due to lower machinery and fuel costs with about equal herbicide costs. Soybean yields were 2.1 bushels lower, but lower variable costs due to the lower machinery and fuel costs made up for this difference.

The profitability of the chisel plowing system was about equal to that of moldboard. Corn was more profitable, due to a 2.8 bushel yield increase and slightly lower variable costs. Soybeans were not as profitable with chisel plowing, due to lower yields. Variable costs were slightly lower in the machinery and fuel categories, but not enough to make up for the 2.8 bushel yield difference.

Table 28. Profitability of conservation tillage systems compared to a moldboard plowing system at Stearns County.

	No-till		Ridge till		Chisel		Moldboard	
	Corn	Soybean	Corn	Soybean	Corn	Soybean	Corn	Soybean
Bushels	81.2	28.3	71.8	26.8	80.5	26.1	77.7	28.9
Gross return	178.64	155.65	157.96	147.40	177.10	143.55	170.94	158.95
Variable costs-								
Machinery/labor	21.04	15.64	14.47	14.47	33.68	25.35	36.50	29.39
Fuel	1.20	1.40	2.00	2.00	4.90	4.20	5.90	5.50
Herbicides	22.36	33.47	9.90	9.95	9.40	11.39	9.40	11.39
Total costs	44.60	50.51	26.37	26.42	47.98	40.94	51.80	46.28
Return over variable costs	134.04	105.14	131.59	120.98	129.12	102.61	119.14	112.67
Comparison to moldboard system	+14.90	-7.53	+12.45	+8.31	+9.98	-10.06		
Corn/soy average	+7.37		+10.38		-.04			

Profitability analysis makes the following assumptions:

1. Corn is priced at $2.20/bushel
2. Soybeans are priced at $5.50/bushel
3. Labor costs are at $5/hour
4. Fuel costs are $1/gallon

Tillage effects on corn and soybean production in Meeker County, MN[1]

J.F. Moncrief, M.B. Kells, and J.J. Kuznia[2]

Conservation tillage systems provided adequate soil cover by corn and soybean residue for erosion control. Early corn growth (dry matter production) was slightly less with ridge till and more so with no till grown corn compared to chisel and moldboard systems. Starter fertilizer had more influence on early corn growth than tillage. Early dry matter production was 50% higher with starter fertilizer. Corn grain moisture was 2.9% higher with a no till system compared to other tillage systems evaluated. When starter fertilizer was applied at planting grain moisture was 2.5% lower. Corn grain yields were 10 bushels per acre lower with ridge till and no till systems. There was a 5 bushel per acre increase in corn grain yields due to row applied fertilizer across all tillage systems. Systems with high levels of "in row" cover with corn residue (chisel and no till) tended to have slightly slower early soybean development. Soybean grain yields were not affected by tillage. Row applied P and K had no effect on soybeans grown with a ridge till system.

Results and Discussion

Soil cover by corn and soybean residue resulting from the tillage systems demonstrated at this site are shown in tables 4 and 8. The soil cover by soybean residue is marginally adequate for erosion control with the chisel system but adequate with the ridge till and no till systems. After corn there is adequate cover with all conservation tillage systems for erosion control. The soil cover in the row by soybean residue should be less than 20% to minimize impact on the early development of corn. The chisel plowing system is marginal in this respect. There was some row cleaning with the no till system but in row cover was 30% after planting.

The soybean residue in the row area did not have any impact on corn stand establishment (table 5). It did however, affect early development. The no till system had about .1 leaf less than the other systems. The ridge till system tended to have the highest early development. Trends in dry matter production were slightly different. Chisel and moldboard plowing resulted in a slightly higher dry matter production by corn over the ridge tillage system at this time. Corn grown under no till conditions was a distant 3rd in early dry matter production. Row applied fertilizer at planting had a large influence on dry matter production and corn development.

The dry matter response did not interact with tillage. However, the starter fertilizer influence on corn development did depend on the tillage system (Table 5). It is usually the case that conservation tillage options will respond to starter fertilizer more frequently and more than with moldboard plowing. The ridge till system resulted in the largest benefit to planter applied fertilizer. This is common. What is not common is almost an equal response by corn grown with moldboard plowing and the absence of a response by corn grown with a no till system.

Grain yields and moisture are also shown in table 7. Tillage effects on the early growth of corn follows a similar trend in grain moisture. This is common in Minnesota research. Early delay of corn development carries through to physiological maturity. Grain yields were about 10 bushels per acre less with ridge till and no till systems. This is first year at this site that tillage had an affect on grain yields.

Starter fertilizer increased early dry matter production by 50% and development by about .1 leaf. Row fertilizer reduced grain moisture by 2.4 percent. There was a 5 bushel per acre response to row fertilizer which did not interact with tillage system.

Tillage effects on soybean production are shown in tables 9-11. Stands were slightly higher with the no till system. All stands were high enough to eliminate it as a yield influencing factor. Early growth was reduced slightly with soybeans grown with tillage systems that resulted in high levels of crop residue in the row (30 and 57% with chisel plowing and no till systems respectively.

Grain yields were not affected by tillage. This has been the case at this site for five years. Row applied

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fertilizer had no affect on soybean growth or yields with a ridge till system. Soybean row spacing (30" vs 8") had no effect on soybean yields.

MEEKER COUNTY

Table 1. Cultural practices at Meeker County MN. 1990.

Tillage

No Till
Ridge Till
Fall Chisel Plowed-Field cultivated prior to planting
Fall Moldboard Plowed-Field cultivated prior to planting
Ridged corn plots on July 6, 1990.
Ridged soybean plots on July 19, 1990.

Cropping History

Corn-soybean rotation since 1978.

1990 Crop

Corn-Pioneer 3790
Soybeans-Pioneer 9161

Planting and Harvest Dates

Corn - was planted with a two row Hiniker Series 1 EconoTill planter with 30 inch row spacing.
Soybeans - ridge till was planted with a two row Hiniker Series 1 EconoTill planter with 30 inch row spacing and all other tillage treatments were planted with a Tye no till drill with 8 inch row spacing equipped with 2 inch fluted coulter ahead of the double disc openers.

	Planting			
Crop	Date	Planter	Rate	Harvested
Corn	May 10, 1990	Row	32,000 seeds/A	October 10, 1990
Soybeans	May 8, 1990	Drill	225,000 seeds/A	October 10, 1990
Soybeans	May 10, 1990	Row	225,000 seeds/A	October 10, 1990

Fertilizer History 1985-1989

			Actual			
	Material		N	P_2O_5	K_2O	
Crop	Analysis	Rate	----	lb/A	----	Date Applied
Corn:	82-0-0	183 lb/A	150	0	0	Spring 1985
	4-15-40[1]	250 lb/A	10	38	100	Planting 1985
Corn:	4-15-40	300 lb/A	12	45	120	October 27, 1986
	7-21-7[1]	17 gal/A	13	40	13	April 28, 1987
	82-0-0	159 lb/A	130	0	0	May 15, 1987
Soybeans:	4-15-40	300 lb/A	12	45	120	October 27, 1986
	0-46-0[2]	45 lb/A	0	21	0	May 5, 1987
Corn:	10-34-0[3]	19 gal/A	22	76	0	April 28, 1988
	10-34-0[1]	9 gal/A	11	36	0	May 5, 1988
	82-0-0	183 lb/A	150	0	0	June 7, 1988
Soybeans:	10-34-0[3]	10 gal/A	12	40	0	April 28, 1988
	10-34-0[1]	5 gal/A	6	20	0	May 5, 1988
	0-46-0[2]	358 lb/A	0	165	0	May 5, 1988
Corn:	7-21-7[4]	15 gal/A	12	35	12	May 10, 1989
	82-0-0	183 lb/A	150	0	0	May 31, 1989
Soybeans:	7-21-7[5]	15 gal/A	12	35	12	May 22, 1989

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.
3. Broadcast applied.
4. Planter placement 2" x 2" on 1/2 the plots.
5. Planter placement 2" x 2" on 1/2 the plots, Ridge Till only.

1990 Fertilizer

			Actual				
	Material		N	P_2O_5	K_2O		
Crop	Analysis	Rate	----	lb/A	----	Date Applied	Method of Application
Corn:	7-21-7	18 gal/A	14	42	14	May 10, 1990	Row placement 2" x 2" on 1/2 the plots
	82-0-0	220 lb/A	180	0	0	July 5, 1990	Anhydrous applicator
Soybeans:	7-21-7	18 gal/A	14	42	14	May 10, 1990	Row placement 2" x 2" on 1/2 the plots Ridge Till only

Soil

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

Weed Control

Corn

2.5 qt/A (2.5 lb/A) Lasso + 2.2 lb/A (2.0 lb/A) Bladex 90 DF applied on May 24, 1990.

Soybeans

1.5 pt/A (0.188 lb/A) Fusilade 2000 + 1 pt/A (0.459 lb/a) Galaxy a premix of (0.375 lb/A Basagran + 0.084 lb/a Blazer) + 2 qt/A oil concentrate on June 14, 1990.

1 pt/A (0.5 lb/A) Basagran + 2 pt/A (0.375 lb/A) Poast + 1 qt/A Dash oil concentrate + 2 qt/A 28% UAN on June 26, 1990.

Soil Test

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

	Tillage					
	No Till	Ridge	Chisel	Moldboard		
Nutrient	lb/A				Avg.	Sig.
P	21.2	25.2	27.9	22.8	24.4	.862
K	182.7	177.6	173.1	146.2	169.9	.258

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

	Tillage					
	No Till	Ridge	Chisel	Moldboard		
Nutrient	lb/A				Avg.	Sig.
P	26.0	20.6	32.7	23.7	25.5	.262
K	208.7	234.9	200.1	173.1	204.2	.016

Table 4. Effect of tillage and row position on soybean residue in corn at Meeker Co. on May 10, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Location	% cover				Avg.
In Row	30.0a	12.3c	20.0b	3.5d	16.4b
Between Row	58.5a	33.0b	21.8c	6.0d	29.8a
Average	44.3a	22.7b	20.9b	4.8c	

1. The p value for residue location, tillage and tillage by location interaction are .001 (n=64), .001 (n=32), and .001 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 5. Effect of tillage and starter on early growth and emergence of corn at Meeker Co[1].

	Tillage				
Population	NoTill	Ridge	Chisel	Mldbd	
June 12, 1990	plants/A X 10^{-3}				Avg.
Starter	29.0	30.2	30.2	28.4	29.4a
No Starter	29.0	29.3	30.1	28.9	29.3a
Average	29.0a	29.7a	30.1a	28.6a	
July 6, 1990	plants/A X 10^{-3}				
Starter	29.5	30.3	30.1	28.9	29.7a
No Starter	29.2	28.7	30.1	28.6	29.2a
Average	29.3a	29.5a	30.1a	28.7a	
Growth stage					
June 12, 1990	leaves/plant				
Starter	2.6	2.8	2.6	2.7	2.7a
No Starter	2.5	2.6	2.6	2.5	2.6b
Average	2.5b	2.7a	2.6ab	2.6ab	

1. The p value for starter, tillage, and tillage by starter interaction for June 12, population are .780 (n=64), .351 (n=32), and .816 (n=16) respectively. The p value for starter, tillage, and tillage by starter interaction for July 6, population are .293 (n=64), .461 (n=32), and .691 (n=16) respectively. The p value for starter, tillage, and tillage by starter interaction for growth stage are .001 (n=320), .097 (n=160), and .041 (n=80) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 6. Effect of tillage and starter fertilizer on dry matter, percent nitrogen, and nitrogen uptake on early whole plant samples of corn at Meeker Co. on June 19, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Dry Matter	grams/plant				Avg.
Starter	1.95	2.23	2.35	2.50	2.26a
No Starter	1.08	1.48	1.70	1.58	1.46b
Average	1.51c	1.85b	2.03a	2.04a	
Tissue N	% N/plant				
Starter	2.35	2.54	2.58	3.03	2.63a
No Starter	2.21	2.69	2.84	2.98	2.68a
Average	2.28c	2.61b	2.71ab	3.00a	
N Uptake	mg N/plant				
Starter	46.1	56.2	61.1	75.4	59.7a
No Starter	23.2	39.2	48.4	46.9	39.4b
Average	34.7d	47.7c	54.8b	61.1a	

1. The p value for starter, tillage, and tillage by starter interaction for dry matter are .001 (n=16), .001 (n=8), and .705 (n=4) respectively. The p value for starter, tillage, and tillage by starter interaction for tissue N are .561 (n=16), .014 (n=8), and .354 (n=4) respectively. The p value for starter, tillage, and tillage by starter interaction for N uptake are .001 (n=16), .001 (n=8), and .123 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 7. Effect of tillage and starter fertilizer on corn yield and moisture at Meeker Co on October 10, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Grain Yield	bu/A				Avg.
Starter	127.4	126.5	137.0	140.2	132.8a
No Starter	123.6	121.9	132.0	132.6	127.5b
Average	125.5b	124.2b	134.5a	136.4a	
Moisture	%				
Starter	23.9	21.9	21.1	21.5	22.1b
No starter	27.0	24.2	23.0	24.0	24.6a
Average	25.5a	23.0b	22.1b	22.8b	

1. The p value for starter, tillage, and tillage by starter interaction for yield are .012 (n=16), .055 (n=8), and .888 (n=4) respectively. The p value for starter, tillage, and tillage by starter interaction for moisture are .001 (n=16), .001 (n=8), and .652 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 8. Effect of tillage and row position on corn residue in soybeans at Meeker Co. on June 12, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Location	% cover				Avg.
In Row	56.5a	9.3c	30.3b	4.3c	25.1b
Between Row	55.1a	32.8b	35.0b	4.5c	31.9a
Average	56.0a	21.0c	32.6b	4.4d	

1. The p value for residue location, tillage and tillage by location interaction are .016 (n=64), .001 (n=32), and .009 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 9. Effect of tillage on population (n=16) and early growth (n=80) of soybeans at Meeker Co.

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Population[1]	plants/A X 10^{-3}				Sig.
6/12/90	239.0a[2]	152.6	192.2a	196.6a	.159
7/19/90	222.2a	149.3	190.7a	185.8a	.175
Growth stage	nodes/plant				
6/12/90	2.79b	2.90a	2.86ab	2.94a	.069

1. The ridge till treatment was excluded from statistical analysis of population because a different type planter was used.
2. Means within the same row with the same letter are not significantly different (α=.10).

Table 10. Effect of tillage on soybean yield and moisture at Meeker Co. on October 10, 1990.

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
	bu/A				Sig.
Grain Yield	42.8a[1]	50.0a	48.9a	49.8a	.482
	%				
Moisture	9.1a	8.2a	7.7a	7.9a	.639

1. Means within the same row with the same letter are not significantly different (α=.10, n=4).

Table 11. Effect of starter fertilizer on population, growth stage, yield, and moisture of ridge till grown soybeans at Meeker Co. on October 10, 1990.

	Ridge Till		
	Starter[1]	No Starter	
Population (n=16)	plants/A X 10^{-3}		Sig.
June 12, 1990	154.1a[2]	152.6a	.760
July 19, 1990	152.8a	149.3a	.603
Growth Stage (n=80)	nodes/plant		
	2.8a	2.9a	.269
Yield (n=4)	bu/A		
	46.1a	50.0a	.621
Moisture (n=4)	%		
	8.1a	8.2a	.623

1. Starter was 18 gals/A 7-21-7.
2. Means within the same row with the same letter are not significantly different (α=.10).

Tillage effects on corn and soybean production in Wright County, MN[1]

J.F. Moncrief, M.B. Kells, and J.J. Kuznia[2]

Soil cover by crop residue was adequate with no tillage following soybeans and ridge till and no till systems following corn. Corn stands were reduced 2 thousand plants per acre with moldboard plowing. Early corn dry matter production was reduced slightly with ridge tillage and greatly with no tillage. Early corn development was reduced with a no till system only. There was no effect of tillage on corn grain yields. Tillage did not affect stand establishment of soybeans. Early soybean development was reduced with ridge till and no till systems. There was no effect of tillage on soybean grain yields.

Methods and Materials

Tillage systems evaluated are: fall chisel and moldboard plowing, ridge till, and no tillage. The soil at this site is very draughty. The rotation is corn and soybeans with each crop present each year.

Results and Discussion

Treatment effects on soil cover are shown in tables 2 and 6. Following soybeans the soil cover by crop residue is less than adequate at this site with all except the no till treatment. Following corn there is adequate soil cover with the ridge till and no till treatments. The soil cover following corn is marginal following chisel plowing and discing.

Tillage and starter fertilizer effects on corn growth and stand are shown in table 3. Stands were reduced with moldboard plowing by about 2 thousand plants per acre. Ridge till grown corn also had faster development than that grown with moldboard plowing. The ridge till system resulted in slightly less early dry matter production and the no till system a distant third. This implies that the slight reduction in dry matter production associated with the ridge till system is not related to soil temperature.

Early growth differences did not follow through to grain yields. There was no effect of tillage on corn grain yields at this site.

Starter fertilizer increase early growth (table 4) and development (table 3) greatly (66 and 5% respectively). There was also a significant grain yield response (7 bushels per acre, table 5). This response was consistent across all the tillage systems.

Tillage effects on soybean growth and yield are shown in tables 7 and 8. Tillage did not affect soybean stand at this site. There was a reduction in development associated with the ridge till and no till systems. This delayed growth was not reflected in grain yields however. It is unusual that the row spacing difference between the ridge till and other systems did not affect grain yields. It is not unusual that soybean yields were not affected by tillage.

WRIGHT COUNTY

Table 1. Cultural practices at Wright County, MN. 1990.

Tillage
- No Till
- Ridge Till
- Fall Chisel Plow
- Fall Moldboard Plow
  - Corn-Cultivated May 14, 1990, ridged July 2, 1990.
  - Soybeans-Ridged July 2, 1990.

Preceding Crops
- Corn-soybean rotation since 1982.

1990 Crops
- Corn-Pioneer 3751
- Soybeans-Pioneer 9061

[1] *Support for this project was provided by the Agricultural Utilization and Research Institute, the Central Minnesota Initiative Fund, the Soil Conservation Service, the Clearwater River Watershed District, and the Minnesota Extension Service. Their support is greatly appreciated.*

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. M.B. Kells is the Tri-County Project coordinator.*

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 ahead of the double disc openers.

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 with sweeps raised.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 11, 1990	29,600 seeds/A	November 9, 1990
Soybeans	May 11, 1990	250,000 seeds/A	October 10, 1990

Fertilization History

From 1983 to 1986 both corn and soybeans received 100 to 150 lb/ac of a 5-12-36 fertilizer applied with the planter. Prior to that only the corn received fertilizer with the planter. Fertilizer since 1986 is as follows:

			Actual				
Crop	Material Analysis	Rate	N	P_2O_5	K_2O	S	Date Applied
			------ lb/a ------				
Corn:	8-23-30[1]	140 lb/A	11	32	42	0	May 2, 1986
	28-0-0[2] UAN	37 gal/A	110	0	0	0	June 13, 1986
Corn:	8-20-32[1]	140 lb/A	11	28	45	0	May 4, 1987
	82-0-0	183 lb/A	150	0	0	0	June 15, 1987
Corn:	9-20-33[1]	140 lb/A	13	28	46	0	May 6, 1988
	82-0-0	150 lb/A	123	0	0	0	June 8, 1988
Soybeans:	4-10-47-7[3]	131 lb/A	5	13	62	9	May 22, 1989
Corn:	6-14-42-7[1]	143 lb/A	9	20	60	10	May 11, 1989
	82-0-0	134 lb/A	110	0	0	0	June 14, 1989

1. Planter placement 2" beside and 2" below row.
2. Surface banded between rows.
3. Soybean ridge till plots were split with starter, planter placement 2" beside and 2" below row.

1990 Fertilizer

			Actual			
Crop	Material Analysis	Rate	N	P_2O_5	K_2O	Date Applied
			---- lb/A ----			
Soybeans	9-23-30[1]	87 lb/A	8	20	26	May 11, 1990
Corn	9-23-30[1]	87 lb/A	8	20	26	May 11, 1990
	82-0-0	120 lb/A	98	0	0	June 27, 1990

1. Planter placement 2" beside and 2" below row, all corn plots and soybean ridge till plots were split with starter fertilizer at planting.

Soil

Soybeans - Kanaranzi loam (Typic Hapludolls, fine-loamy over sandy or sandy-skeletal, mixed, mesic), 2 to 6 percent slope on 95 percent of the plot area. Fairhaven loam (Typic Hapludolls, fine-loamy over sandy or sandy-skeletal, mixed, mesic), 0 to 2 percent slope on 5 percent of the plot area. Both soils are well drained.

Corn - Kanaranzi loam (Typic Hapludolls, fine-loamy over sandy or sandy-skeletal, mixed, mesic), 2 to 6 percent slope on 90 percent of the plot area. Salida gravelly sandy loam (Entic Hapludolls, sandy-skeletal, mixed, mesic), 3 to 6 percent slope on 10 percent of the plot area. Both soils are well drained.

Weed Control

Corn

2.5 qt/A (2.5 lb/A) Lasso + 2 qt/A (2 lb/A) Bladex on May 24, 1990.

Soybeans

2 pt/A (0.918 lb/a) Galaxy a premix of (0.75 lb/A Basagran + 0.168 lb/a Blazer) + 1 qt/A oil concentrate on June 14, 1990.

1 pt/A (0.5 lb/A) Basagran + 1.25 pt/A (0.234 lb/A) Poast + 1 qt/A Dash oil concentrate + 2 qt/A 28% UAN on June 26, 1990.

Table 2. Effect of tillage and row position on soybean residue in corn at Wright Co. on May 30, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Location	% cover				Avg.
In Row	55.8a	1.8b	3.0b	0.3b	15.2b
Between Row	71.3a	9.8b	6.0b	4.3b	22.8a
Average	63.5a	5.8b	4.5b	2.3b	

1. The p value for residue location, tillage and tillage by location interaction are .001 (n=64), .001 (n=32), and .175 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 3. Effect of tillage and starter fertilizer on population and early growth of corn at Wright Co. on June 12, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Population	plants/A X 10^{-3}				Avg.
Starter	29.9	30.6	30.9	28.0	29.9a
No Starter	32.5	30.6	29.5	28.4	30.2a
Average	31.2a	30.6a	30.2a	28.2b	
Growth stage	leaves/plant				
Starter	2.8	3.0	2.9	2.9	2.9a
No Starter	2.7	2.8	2.8	2.7	2.8b
Average	2.7c	2.9a	2.9ab	2.8bc	

1. The p value for starter, tillage, and tillage by starter interaction for population are .633 (n=64), .011 (n=32), and .380 (n=16) respectively. The p value for starter, tillage, and tillage by starter interaction for growth stage are .001 (n=320), .038 (n=160), and .148 (n=80) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 4. Effect of tillage and starter fertilizer on dry matter, percent nitrogen and nitrogen uptake on early whole plant samples of corn at Wright Co. on June 19, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Dry Matter	grams/plant				Avg.
Starter	1.80	2.18	2.23	2.18	2.09a
No Starter	1.03	1.13	1.45	1.43	1.26b
Average	1.41b	1.65ab	1.84a	1.80a	
Tissue N	% N/plant				
Starter	3.20	3.04	3.58	3.71	3.38b
No Starter	3.55	3.49	3.65	3.74	3.61a
Average	3.38b	3.26b	3.62a	3.73a	
N Uptake	mg N/plant				
Starter	54.4	66.1	79.7	80.6	71.0a
No Starter	36.3	38.8	53.1	53.0	45.3b
Average	46.8b	52.5b	66.4a	66.8a	

1. The p value for starter, tillage, and tillage by starter interaction for dry matter are .001 (n=16), .057 (n=8), and .186 (n=4) respectively. The p value for starter, tillage, and tillage by starter interaction for tissue N are .006 (n=16), .024 (n=8), and .132 (n=4) respectively. The p value for starter, tillage, and tillage by starter interaction for N uptake are .001 (n=16), .007 (n=8), and .869 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 5. Effect of tillage and starter fertilizer on corn yield and moisture at Wright Co. on November 9, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Grain Yield	bu/A				Avg.
Starter	119.0	111.2	113.3	112.9	114.1a
No Starter	111.0	99.5	107.9	109.4	106.9b
Average	115.0a	105.3a	110.6a	111.2a	
Moisture	%				
Starter	14.8	14.5	14.8	15.5	14.9a
No Starter	14.6	14.7	15.2	14.9	14.8a
Average	14.7a	14.6a	15.0a	15.2a	

1. The p value for starter, tillage, and tillage by starter interaction for yield are .052 (n=16), .720 (n=8), and .834 (n=4) respectively. The p value for starter, tillage, and tillage by starter interaction for moisture are .965 (n=16), .364 (n=8), and .855 (n=4) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 6. Effect of tillage and row position on corn residue in soybeans at Wright Co. on June 12, 1990[1].

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
Location	% cover				Avg.
In Row	54.3a	7.3c	17.5b	5.3c	21.1b
Between Row	64.5a	33.5b	25.3b	7.5c	32.7a
Average	59.4a	20.4b	21.4b	6.4c	

1. The p value for residue location, tillage and tillage by location interaction are .001 (n=64), .001 (n=32), and .001 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 7. Effect of tillage on population (n=16) and early growth (n=80) of soybeans at Wright Co. on June 12, 1990.

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
	plants/A X 10^{-3}				Sig.
Population[1]	324.3a[2]	140.3	304.2a	338.5a	.293
	nodes/plant				
Growth stage	2.7b	2.6b	2.9a	2.9a	.001

1. The ridge till treatment was excluded from statistical analysis of population because a different planter was used.
2. Means within the same row with the same letter are not significantly different (α=.10).

Table 8. Effect of tillage on soybean yield and moisture at Wright Co. on October 10, 1990.

	Tillage				
	NoTill	Ridge	Chisel	Mldbd	
	bu/A				Sig.
Grain Yield	38.0a[1]	39.6a	42.2a	38.2a	.443
	%				
Moisture	7.9a	9.2a	8.2a	8.3a	.652

1. Means within the same row with the same letter are not significantly different (α=.10, n=4).

Table 9. Effect of starter fertilizer on population, growth stage, yield, and moisture of ridge till grown soybeans at Wright Co. on October 10, 1990.

	Ridge Till		
	Starter[1]	No Starter	
	plants/A X 10^{-3}		Sig.
Population (n=16)	145.6a[2]	140.3a	.311
	nodes/plant		
Growth Stage (n=80)	2.7a	2.6a	.246
	bu/A		
Yield (n=4)	39.3a	39.6a	.884
	%		
Moisture (n=4)	7.9a	9.2a	.377

1. Starter was 87 lb/A 9-23-30.
2. Means within the same row with the same letter are not significantly different (α=.10).

Tillage effects on soybeans following barley and spring wheat in Douglas County, MN[1]

J.F. Moncrief, L. Zilliox, and J.J. Kuznia[2]

There was no effect of tillage on soybean yields following barley or spring wheat.

This site was established in 1984 and has been in a small grain-soybean rotation for the last three years. In 1989 one half of the plot area was in barley and the other half in spring wheat. In 1990 soybeans were planted.

Grain yields are shown in table 2. There was no effect of tillage on soybean yields following either barley or wheat. This is consistent with other years and sites.

DOUGLAS COUNTY

Table 1. Cultural practices at Douglas County, MN. 1990

Tillage
No Till
Fall Chisel Plow-field cultivated twice in spring
Fall Moldboard Plow-field cultivated twice in spring

1990 Crop
Soybeans-9061

Preceding Crop
1985-Soybeans, 1986-Barley-Robust,
1987-Spring Wheat-Pioneer 2369 and
Winter Wheat-Bighorn and Roughrider
1988-Soybeans-Pioneer 1082
1989-Spring Wheat-Pioneer 2369
Barley-Robust

Planting and Harvest Date
Planter was a Great Plains with 6.75 inch row spacing with 1 inch fluted coulters mounted on the tongue.

Crop	Planting Date	Planting Rate	Harvested
Soybeans	May 12, 1990	225,000 seeds/A	October 5, 1990

Fertilization History

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			---- lb/A ----			
Barley	18-46-0[1]	100 lb/A	18	46	0	April 25, 1986
	46-0-0[2]	217 lb/A	100	0	0	Spring 1986
Winter Wheat	18-46-0[1]	100 lb/A	18	46	0	September 29, 1986
	46-0-0[2]	217 lb/A	100	0	0	May 29, 1987
Spring Wheat	18-46-0[1]	100 lb/A	18	46	0	April 21, 1987
	46-0-0[2]	217 lb/A	100	0	0	May 29, 1987
Tillage						
All	18-46-0[1]	100 lb/A	18	46	0	April 26, 1989
No Till	46-0-0[2]	283 lb/A	130	0	0	May 2, 1989
All Others	46-0-0[2]	217 lb/A	100	0	0	May 2, 1989

1. Drill applied with seed.
2. Urea was broadcast.

Soil
Complex of: Barnes-Langhei loams (Udic Haploborolls, fine-loamy, mixed)-(Typic Udorthents, fine-loamy, mixed (calcareous), frigid), 2 to 6 percent slopes, well-drained eroded. The Langhei occurs on eroded knobs and Barnes on uniform slopes and valleys.

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[1] *Support for this project was provided by the Soil Conservation Service and the Minnesota Extension Service. Their support is greatly appreciated.*

[2] *J.F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist in the Soil Science Department at the University of Minnesota, St. Paul, MN, 55108. L. Zilliox is the County Agricultural Agent in Douglas County, MN.*

Weed Control

Chisel and Moldboard Plots:

1 qt/A (1 lb/A) Treflan applied May 7, 1990, just prior to planting and incorporated with two passes with a field cultivator.

No Till Plots:

1 pt/A (0.188 lb/A) Poast.

All Plots:

1 pt/A (0.5 lb/A) Basagran + 1 pt/A (0.25 lb/A) blazer + 1 qt/A oil concentrate.

Table 2. The effect of tillage on soybean yield and moisture Douglas Co. on October 5, 1990[1].

	Tillage			
Previous Crop	No Till	Chisel	Moldboard	
	----------	bu/A	----------	Avg.
Barley	38	35	37	37a
Spring Wheat	36	35	38	36a
Average	37a	35a	38a	
	-------	% moisture	---------	Avg.
Barley	6.0	5.7	5.7	5.8a
Spring Wheat	5.8	5.6	5.7	5.7a
Average	5.9a	5.6b	5.7ab	

1. The p value for tillage, previous crop, and tillage by previous crop interaction for yield are 0.750 (n=6), 0.925 (n=9), and 0.939 (n=3) respectively. The p value for tillage, previous crop, and tillage by previous crop interaction for moisture are 0.095 (n=6), 0.656 (n=9), and 0.748 (n=3) respectively. Means within the same row with the same letter are not significantly different (α=.10).