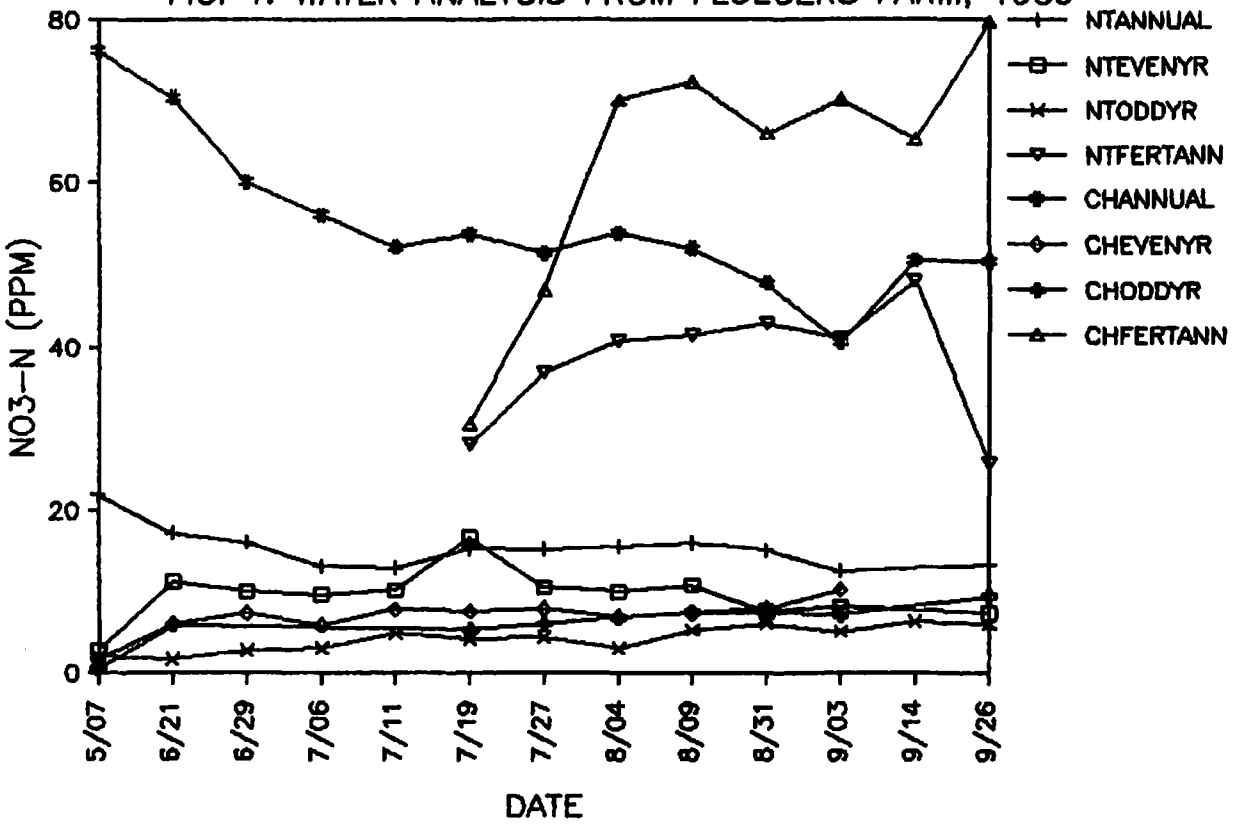
FIG. 1: WATER ANALYSIS FROM FLUEGERS FARM, 1989



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

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Abstract: The results of the third year of the study initiated in 1987 to evaluate the effects of tillage, and frequency of injected swine manure on corn yield, N uptake and soil N distribution are presented in this report. N applied as anhydrous ammonia at the rate of 170 lb N/A resulted in 25 bu/A more grains than manure from an anaerobic pit applied equivalent to 160 lb N/A or from an open lagoon applied equivalent to 143 lb N/A. Grain yield was not affected by tillage, and was at least 30 bu/A more in the year of application of N treatments than the year following application. Insecticide application produced an additional 8 bu/A grain. Chisel plowing, in the year of application of N treatments and the N treatments applied with manure from lagoon resulted in the greatest response to insecticide. N uptake was higher in fertilizer treatments than in manure treatments.

Surface cover by corn residue was greater in the ridge till system, and in between the rows. Soil moisture in the profile was greater in the spring than in the fall. Total profile N in the spring was greater in fertilizer treatments than in manure treatments, and was more than 1/2 to 2/3 in ammonium form. Nitrate N in soil water samples at 5 ft. depth was higher in fertilized treatments than the manure treatments. Nitrate in water was greater with ridge tillage than in chisel plowed treatments, and did not change much with time between July to September.

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 till treatments. Additional treatments included a fertilized treatment, applied annually and every alternate year with anhydrous ammonia at a recommended rate of 170 lbs N/A, and a check treatment receiving neither manure nor fertilizer. In 1989, the treatment with lower rate of pit manure was replaced with manure from an open lagoon. The manure applied from an anaerobic pit was equivalent to 168 lb N/A and from an open lagoon was equivalent to 143 lb N/A. Most cultural practices followed were similar from year to year; the 1989 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 1989 are summarized in this report.

RESULTS AND DISCUSSION

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 2. The source of N had highly significant effects on grain yield and total dry matter. Among the biennial treatments the anhydrous ammonia produced about 25 bu/A more grain and 1 ton/A more total dry matter than either of the manure sources (Table 5). Both the grain yield and the total dry matter were higher in the treatments receiving N in 1989 than in previous year (Table 6). Chisel plowing resulted in higher grain yield than ridge tillage in treatments receiving anhydrous ammonia, the increase was not so pronounced in manure treatments (Table 7). The grain moisture and total dry matter was significantly higher in ridge till as compared to chisel plow in the treatments receiving N in 1989; the difference was less obvious for N treatments applied in the previous year (Table 8).

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Plant Population and Stover Yield. The plant population, final stover dry matter and stover moisture at harvest in the biennial treatments were not affected by tillage (Table 3). The source and year of N application had a significant effect on stover dry matter and moisture content at harvest. The anhydrous ammonia application resulted in higher stover yield than the manure application and the stover moisture was higher for manure from the lagoon followed by the manure from the pit and anhydrous ammonia, respectively (Table 5). Higher plant population, and greater stover dry matter and stover moisture were observed in treatments receiving N in 1989 than those receiving in 1988 (Table 6). There was a tillage by year of N application interaction on stover dry matter and stover moisture: the stover dry matter being significantly higher in ridge till in the year of application and stover moisture was higher in the year following application of N treatments (Table 9). The stover moisture was generally higher in the treatments receiving N in 1988 than those receiving in 1989 except for the N from lagoon source where difference due to year of application was less evident (Table 8). The treatments applied with manure from the lagoon in 1989 were applied with manure from the pit source at lower rates in the previous years.

Harvest Index. The harvest index, a ratio of total grain dry matter to that of total dry matter (grain and stover combined, Table 4) was significantly affected by tillage, and the year of N application. Chisel plowing resulted in higher index than the ridge tillage and it was also higher for the treatments receiving N in 1989 than in the previous year (Table 2).

Insecticide Effects. In order to assess the effects of insecticide application, all the treatments were further split into insecticide and non-insecticide subplots. In general, the treatments receiving insecticide had significantly higher yield, stover dry matter, and total dry matter at harvest (Table 10). The stover dry matter was higher in ridge tillage than in chisel plowing in absence of insecticide. Insecticide application particularly resulted in higher quantities with chisel plowing than in ridge tillage (Table 11). The insecticide effects were most evident in treatments applied with anhydrous ammonia and manure from the lagoon (Table 12). With insecticide, the grain yield was higher in all the N treatments in chisel plowing and in treatments receiving N from the pit in ridge tillage (Table 13). A higher stand, greater grain yield, and greater total dry matter were observed for the insecticide applied treatments receiving N in 1989 (Table 14). The difference in both grain and silage yield was greater in chisel plowed treatments receiving N in 1989 than any other treatments (Table 15).

Stover N, Grain N, and N Uptake. Tillage had no significant effect on N concentration in grain and stover, and in total N uptake by corn. However, N source and year of application of biennial treatments had highly significant effect on N concentration and N uptake. Biennial application of anhydrous ammonia had higher N in grain and stover, and had higher N uptake than either manure treatments. The manure from the lagoon resulted in higher grain N than manure from pit; the stover N was however higher with manure from the pit. N uptake was not much different in either manure treatments (Table 16). Both grain N and stover N was higher in the year of N application, and N uptake was about 95 lbs/A more in the year of application than in the year following application (Tables 17 and 18).

Surface Residue Cover. Residue measurements were made on June 7, 1989 both in and between the rows in duplicate in the biennial manure and fertilizer treatments in both tillages. Residue was about 50% more in the ridge till than chisel plow (Table 19), and about 50% more in between the rows than in the rows. Residue was not different with respect to row position in the year of application of fertilized treatment while all other treatments had higher residue in between the rows in the year following their application.

Soil Profile Moisture. Gravimetric soil moisture in soil samples taken to a depth of 5 ft. at 1 ft. increment in spring and fall soil samples is given in Table 20. The soil samples were taken from selected treatments in all the four replications in and between the rows separately with 3 cores composites per sample. The moisture was slightly greater in the spring in the top 2 ft. than in the depths below. In the fall, the soil was wetter in the top 0-1 ft. increment and in bottom 4-5 ft. increment than in the middle. The profile was wetter in top 2 ft. in chisel plow than in the ridge till, and in bottom 3 ft. in ridge till than in chisel plow in the spring (Table 21). In fall, ridge till was generally wetter throughout the profile than the chisel plowed treatments. Fertilizer applied treatments were drier in the surface than manure applied or check plots (Table 23). The treatments applied with manure from the pit were drier in the bottom 4 ft. of the profile than other treatments (Table 22). The check plots were generally wetter, and had higher moisture throughout the profile than the other treatments.

Soil Profile Nitrogen. Total inorganic N and ammonium-N determinations were made on the samples taken in and between the rows separately to a depth of 5 ft. at 1 ft. increment on selected treatments. The total inorganic nitrogen in the 5 ft. soil profile was highest in treatments applied with anhydrous ammonia annually, followed by biennial application of the fertilizer, pit manure and check (Table 22). More than 2/3 of nitrogen was in ammonium form in most treatments except in treatments with pit manure applied or anhydrous in the year of application. In these two treatments, the nitrogen was about half in nitrate form.

Chisel plowed treatments had more N than ridge till with pit manure and anhydrous in the year of application (Table 24) while the difference due to tillage was not obvious in check and annual anhydrous treatments. N in ammonium form was more than in nitrate form in chisel plowed treatments with pit manure and in the ridge till with check or annual anhydrous ammonia. Nitrogen in ammonium form was more than nitrate form in the top 3 ft. depth than in the bottom 3 ft. depth. Nitrate nitrogen was more in the surface one ft. depth and bottom 2 ft. increments than in the middle of the profile (Table 25).

Ammonium form of N was more in the rows in the top 3 ft. depth; whereas, nitrate form of N was more in the row than in between the rows below the surface 1 ft.(Table 26). In general, more N was found in the form of ammonia in between the rows, and in the form of nitrate in the rows (Table 27).Total inorganic N was higher in between the rows in the surface 1 ft. increment, but in the rows in the bottom 4-5 ft. depth (Table 28). Chisel plowing had more total N in treatments with pit manure and biennial anhydrous but the tillage effect was not observed in the other treatments (Table 29). The significance values for various main effects and interactions for soil moisture and N in fall and spring are given in Table 30.

Soil Water Sampling. Suction water samplers were established during the middle of July on manure (biennial) and fertilizer (annual) treatments to monitor nitrate-nitrogen in soil water at 5 ft depth . The data obtained in 1989 are presented in Fig. 1. Among the N treatments, both fertilizer treatments yielded consistently higher nitrate-nitrogen at 5 ft depth than the biennial manure treatments. There was not much difference in the biennial treatments due to the year of N application. The ridge till system produces considerably higher nitrate levels than chisel plowing in fertilized treatments. The nitrate levels, however, were fairly uniform throughout the sampling period indicating little movement of water and N during that period.

Table 1. Cultural practices at Goodhue County, MN 1989.

Tillage
Ridge Till- cultivated on June 15, 1989
Chisel Plow- Chiseled on May 15, 1989

Cropping History
Corn since 1974
1989-Corn Pioneer 3906

Manure Application
Injected liquid swine manure with following rate and analysis on May 9, 1989.

		Rate of Application (1989)			
		Pit Source		Lagoon Source	
		Mean	Std. Dev.	Mean	Std. Dev.
Manure	(gal/A)	12000	1000	13000	700
Total-N	(lbs/A)	160	33	143	27
NH_4-N	(lbs/A)	106	15	95	20
K	(lbs/A)	76	14	127	20
Solids: Total	(%)	7	6	0.9	0.2
Volatile	(%)	68	4	49	6
Fixed	(%)	32	4	51	6

Planting Information
A six row Deustch Alis planter equipped with wide clearing disks in 1989.

Crop	Date	Rate	Harvested
Corn	May 16,1989	32,000 plants/A	October 11-12, 1989

Fertilizer

Material Analysis	Actual N -lb/A-	Date Applied	Method of Application
82-0-0	170	May 17, 1989	Injected

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 lbs/A (1.35 lb/A) Counter 15G applied in furrow on May 16, 1989.

Table 2. The effect of tillage and N source on corn grain yield, grain moisture and total dry matter in Goodhue Co., MN in 1989.[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 (Pit)	Yr.of	131	129	130	21.7	20.4	21.1	5.99	5.49	5.74
	Yr.after	77	93	85	21.1	20.8	21.0	3.67	4.30	3.98
	Mean	104	111	108	21.4	20.6	21.0	4.83	4.90	4.87
Manure (Lagoon)	Yr.of	125	120	123	22.1	20.6	21.4	5.94	5.22	5.58
	Yr.after	87	94	91	21.3	21.9	21.6	4.24	4.27	4.26
	Mean	106	107	107	21.7	21.3	21.5	5.09	4.75	4.92
Anhydrous Ammonia	Yr.of	142	153	148	24.1	21.2	22.7	6.39	6.80	6.60
	Yr.after	102	131	117	21.9	21.1	21.5	4.76	5.56	5.16
	Mean	122	142	133	23.0	21.2	22.1	5.58	6.18	5.88

	Pr>F						
	Tillage(T)	N Source(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Grain Yield	.121	.000	.000	.082	.149	.468	.957
Grain moisture	.162	.151	.449	.392	.080	.411	.816
Total dry matter	.819	.007	.000	.297	.098	.700	.779

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

Table 3. 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 1989[1].

Source of N	Year[2]	PLANT POPULATION Ridge	Chisel	Mean	STOVER DRY MATTER Ridge	Chisel	Mean	STOVER MOISTURE Ridge	Chisel	Mean
		plants/A*10^{-3}			tons/A			%		
Manure (Pit)	Yr.of	26.7	26.0	26.4	2.86	2.44	2.65	49.4	49.5	49.5
	Yr.after	24.1	23.8	24.0	1.81	2.09	1.95	51.7	50.5	51.1
	Mean	25.4	24.9	25.2	2.33	2.27	2.30	50.6	50.0	50.3
Manure (Lagoon)	Yr.of	26.0	26.9	26.5	2.94	2.41	2.68	52.9	53.9	53.4
	Yr.after	26.2	25.2	25.7	2.13	2.05	2.09	54.9	52.1	53.5
	Mean	26.1	26.1	26.1	2.54	2.23	2.39	53.9	53.0	53.5
Anhydrous Ammonia	Yr.of	27.8	26.4	27.1	3.04	3.12	3.08	42.7	48.3	46.2
	Yr.after	25.0	27.7	26.4	2.39	2.51	2.45	49.7	49.9	49.8
	Mean	26.4	27.1	26.8	2.72	2.82	2.77	46.2	49.1	48.0

	Pr>F						
	Tillage(T)	N Source(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T
Population	.900	.120	.007	.743	.319	.200	.014
Stover dry matter	.730	.008	.000	.332	.049	.887	.364
Stover moisture	.623	.001	.006	.222	.015	.048	.414

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

Table 4. Corn harvest index as affected by tillage, and N source in Goodhue Co., MN in 1989.

Source of N	Year[2]	HARVEST INDEX[1] Ridge	Chisel	Mean	Source	Pr>F
Manure	Yr.of	0.52	0.56	0.54	Tillage(T)	.052
(Pit)	Yr.after	0.50	0.51	0.51	N source(N)	.480
	Mean	0.51	0.54	0.52	Year (Y)	.010
Manure	Yr.of	0.50	0.53	0.52	T*N	.712
(lagoon)	Yr.after	0.50	0.52	0.51	T*Y	.833
	Mean	0.50	0.53	0.51	Y*N	.411
Anhydrous	Yr.of	0.52	0.54	0.53	Y*N*T	.201
Ammonia	Yr.after	0.49	0.55	0.52		
	Mean	0.51	0.55	0.53		

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

Table 5. The effect of N source on corn grain yield, stover dry matter, stover moisture, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

Source of N	GRAIN YIELD ---bu/A---	STOVER MOISTURE -----%----	TOTAL DRY MATTER -----tons/A----	STOVER DRY MATTER ------tons/A----
Manure(Pit)	108	50.3	4.86	2.30
Anhydrous	132	47.7	5.87	2.76
Manure(Lagoon)	107	53.5	4.92	2.38
Pr>F (N Source)	.000	.001	.007	.008

[1] Averaged over tillage, insecticide, and year of application of N 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 1989[1].

Year[2]	GRAIN YIELD ---bu/A---	STOVER MOISTURE -------%-------	TOTAL DRY MATTER -----tons/A-----	STOVER DRY MATTER ------tons/A----	PLANT POPULATION -Plants/A*10^{-3} -
Year of	133.4	49.5	5.97	2.81	26.6
Year After	97.5	51.4	4.46	2.16	25.4
Pr>F (Year)	.000	.006	.000	.000	.007

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

Table 7. The effect of tillage and N source on corn grain yield in Goodhue Co., MN, in 1989.

Source of N	GRAIN YIELD[1] Ridge Till	Chisel Plow
	----------bu/A---------	
Manure(Pit)	104.8	110.8
Anhydrous Ammonia	121.8	142.4
Manure(Lagoon)	106.2	106.9
Pr>F (N Source)	.082	

[1] Averaged over tillage and year of application.

Table 8. The effect of source and year of N application on stover moisture in Goodhue Co., MN in 1989.

Source of N	STOVER MOISTURE[1] --------%-------- Yr Of[2]	Yr Aft.
Manure(Pit)	49.4	51.1
Anhydrous	45.6	49.8
Manure(Lagoon)	53.4	53.5
Pr>F (N Source*Year)	.001	

[1]Means of tillage and insecticide treatments. [2] Year of application of the biennial treatments.

Table 9. The effect of tillage and year of N application on corn grain moisture, stover dry matter, stover moisture, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

	GRAIN MOISTURE		STOVER DRY MATTER		STOVER MOISTURE		TOTAL DRY MATTER	
	Ridge	Chisel	Ridge	Chisel	Ridge	Chisel	Ridge	Chisel
Year[2]	------%-------		---- tons/A ----		------ % -----		--- tons/A ---	
Yr.of	22.6	20.8	2.95	2.66	48.4	50.6	6.11	5.84
Yr.after	21.4	21.2	2.11	2.22	52.1	50.9	4.22	4.71
Pr>F (Till*Year)	.080		.049		.015		.098	

[1] Means of biennial N treatments. [2] Year refers to the year of application of the biennial treatments.

Table 10. The effect of insecticide application on corn grain yield, stover dry matter, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

	GRAIN YIELD	STOVER DRY MATTER	TOTAL DRY MATTER
Insecticide	---bu/A---	----- tons/A ----	----- tons/A ----
Yes	120	2.58	5.42
No	111	2.38	5.02
Pr>F (Insect.)	.001	.005	.002

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

Table 11. The effect of tillage and insecticide application on corn grain yield, stover dry matter, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

		GRAIN YIELD	STOVER DRY MATTER	TOTAL DRY MATTER
Tillage	Insect.	----bu/A---	----- tons/A -----	----- tons/A ----
Ridge	Yes	113	2.57	5.21
	No	109	2.49	5.13
Chisel	Yes	126	2.60	5.62
	No	114	2.28	4.92
Pr>F (Till*Insect.)		.091	.077	.014

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

Table 12. The effect of N source and insecticide application on corn grain yield, stover dry matter, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

		GRAIN YIELD	STOVER DRY MATTER	TOTAL DRY MATTER
Source of N	Insect.	------bu/A----	----- tons/A ---- -	----- tons/A ----
Manure(Pit)	Yes	108	2.33	4.91
	No	108	2.27	4.81
Anhydrous	Yes	136	2.80	5.93
	No	129	2.74	5.82
Manure(Lagoon)	Yes	115	2.62	5.40
	No	98	2.15	4.44
Pr>F (N source*Insect.)		.014	.027	.007

[1] Means of all the tillage treatments.

Table 13. The effect of tillage, N source and insecticide application on corn grain yield, stover dry matter, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

Source of N	Insect.	GRAIN YIELD Ridge	GRAIN YIELD Chisel	STOVER DRY MATTER Ridge	STOVER DRY MATTER Chisel	TOTAL DRY MATTER Ridge	TOTAL DRY MATTER Chisel
		-----bu/A-----		----- tons/A ----		-----tons/A ----	
Manure(Pit)	Yes	98.0	117.8	2.21	2.46	4.50	5.32
	No	111.9	103.9	2.46	2.07	5.16	4.46
Anhydrous	Yes	126.2	145.2	2.71	2.89	5.61	6.25
	No	117.5	139.7	2.73	2.75	5.54	5.10
Lagoon	Yes	114.8	115.5	2.78	2.46	5.51	5.29
	No	97.5	98.3	2.29	2.01	4.68	4.20
Pr>F (Till*N source*Insect.)		.018		.149		.038	

[1] Means of tillage, and year of application.

Table 14. The effect of year of N and insecticide application on corn grain yield, plant population, grain moisture, and total dry matter at harvest in Goodhue Co., MN in 1989[1].

Year[2]	Insect.	GRAIN YIELD ----bu/A---	PLANT POPULATION - plants/A*10^{-3} -	TOTAL DRY MATTER ----- tons/A ----	GRAIN MOISTURE ------%-------
Year of	Yes	140.1	27.3	6.31	21.4
	No	126.8	26.0	5.64	21.9
Year after	Yes	99.1	25.2	4.52	21.5
	No	95.9	25.5	4.41	21.1
Pr>F (Year*Insect.)		.032	.034	.028	.056

[1] Means of tillage, and year of application.
[2] Year refers to the year of application of the biennial treatments.

Table 15. The effect of tillage, year of N and insecticide application on corn grain yield and stover dry matter at harvest in Goodhue Co., MN in 1989[1].

Year[2]	Insect.	GRAIN YIELD Ridge	GRAIN YIELD Chisel	STOVER DRY MATTER Ridge	STOVER DRY MATTER Chisel
		----bu/A-----		---- tons/A ----	
Year of	Yes	137.3	142.9	2.95	2.96
	No	128.2	125.4	2.95	2.36
Year after	Yes	88.8	109.4	2.18	2.25
	No	89.2	102.5	2.03	2.19
Pr>F (Till*Year*Insect.)		.091		.016	

[1] Means of all biennial N treatments.
[2] Year refers to the year of application of the biennial treatments.

Table 16. The effect of N source on corn grain and stover N, and total N uptake in Goodhue Co., MN in 1989[1].

Source of N	GRAIN N	STOVER N	TOTAL N UPTAKE
	---%---	----%----	----lbs/A----
Manure(Pit)	1.048	.495	88.16
Anhydrous	1.369	.639	125.03
Manure(Lagoon)	1.108	.431	87.98
Pr>F (N source)	.002	.000	.001

[1] Means of tillage, and year of N application.

Table 17. The effect of the year of N application on corn grain and stover N, and total N uptake in Goodhue Co., MN in 1989[1].

Year[2]	GRAIN N	STOVER N	TOTAL N UPTAKE
	---%---	---%----	----lbs/A-
Year of	1.314	.588	125.70
Year After	1.036	.458	74.39
Pr>F (Year)	.000	.000	.000

[1]Means of tillage and biennial N treatments. [2] Year of application of biennial treatments.

Table 18. The effect of the year of N application on corn grain N, stover N, and total N uptake in Goodhue Co., MN in 1989[1].

Source of N	Year[2]	GRAIN N	STOVER N	TOTAL N UPTAKE
		---%---	----%----	---lbs/A----
Manure	Yr.of	1.150	.439	103.89
(lagoon)	Yr.after	1.066	.424	72.08
Manure	Yr.of	1.240	.537	109.95
(Pit)	Yr.after	0.855	.438	58.46
Anhydrous	Yr.of	1.553	.766	159.54
Ammonia	Yr.after	1.186	.504	88.22
Pr>F (N Source*Year)		.027	.000	.005

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

Table 19. Corn residue as affected by N source and year of application in Goodhue Co., MN on 6/7/89[1].

Source of N	Row	Residue (%) Ridge Yr Of[2]	Ridge Yr Aft	Chisel Yr Of	Chisel Yr Aft
Manure	In	39	55	18	23
(Pit)	Bet.	60	64	32	37
Manure	In	41	46	18	17
(lagoon)	Bet.	63	49	54	39
Anhydrous	In	58	39	52	22
Ammonia	Bet.	60	63	51	63

Pr>F

Till(T)	N Sour.(N)	Year(Y)	T*N	T*Y	Y*N	Y*N*T	Row(R)	T*R	N*R	Y*R	T*Y*R	T*N*R	N*Y*R	T*N*Y*R
.082	.130	.505	.242	.604	.121	.963	.0001	.171	.635	.582	.272	.421	.001	.844

[1] Residue counts made on insecticide applied treatments.
[2] Yr refers to the year of application of the biennial treatment.

Table 20. Gravimetric soil moisture by depth in Goodhue Co., MN in 1989[1].

Depth (ft.)	Moisture(%,wt./wt.) April 24-25	November 2-9
0-1	25.0	22.0
1-2	24.8	20.9
2-3	21.5	20.0
3-4	20.8	20.8
4-5	21.3	22.7
Pr>F (Depth)	.000	.000

Table 21. Gravimetric soil moisture by tillage and depth in Goodhue Co., MN[1].

Depth (ft.)	Moisture(%,wt./wt.) April 24-25 Ridge	April 24-25 Chisel	November 2-9 Ridge	November 2-9 Chisel
0-1	24.9	25.2	22.1	21.8
1-2	24.6	25.0	20.5	21.2
2-3	21.8	21.3	20.3	19.8
3-4	21.9	19.8	21.7	20.0
4-5	21.9	20.6	22.6	22.8
Pr>F (Till*Depth)	.023		.006	

[1] N treatments sampled are listed in Table 22.

Table 22. The effect of the year of N application inorganic nitrogen in the top 5' soil profile in Goodhue Co., MN on April 24-25, 1989.

Source of N	Year[1]	TOTAL N	NH_4-N	NO_3-N
		----------lbs/A--------		
Manure(Pit)	Year of	63.2	42.2	21.0
Check	Annual	60.9	43.7	17.2
Anhydr. amm.	Annual	68.8	50.9	16.9
Anhydr. amm.	Year of	64.4	44.0	20.4
Pr>F (N source)		.059	.152	.729

[1] Year refers to the year of application of the biennial treatment, the samples taken in insecticide applied plots only.

Table 23. The effect of N source and frequency on soil moisture in Goodhue Co., MN on November 2-9, 1989.

Source of N	Year[1]	0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.
		moisture(%, wt./wt.)				
Manure (Pit)	Yr.of	22.0	19.3	18.9	20.9	23.2
Anhydrous Ammonia	Yr.of	21.6	20.2	20.2	21.0	23.3
Anhydrous Ammonia	Yr.after	22.6	20.8	19.6	21.2	22.6
Anhydrous Ammonia	Annual	21.4	21.4	19.7	20.8	22.0
Check	Annual	22.2	22.5	21.7	20.3	22.3
Pr>F (N Source*Depth)				.0024		

[1] Year application of the biennial treatments, the means are across the tillages, and in treatments applied with insecticides.

Table 24. The effect of tillage and the year of N application on inorganic N in the top 5' soil profile in Goodhue Co., MN on April 24-25, 1989.

Frequency &		TOTAL N		NH_4-N		NO_3-N	
		lbs/A					
Source of N	Year[1]	Rdge	Chsel	Rdge	Chsel	Rdge	Chsel
Manure(Pit)	Year of	62.5	64.5	39.5	45.0	23.0	19.0
Check	Annual	61.5	60.5	49.0	38.5	12.5	22.0
Anhydr. amm.	Annual	69.0	68.0	50.5	51.5	18.5	15.5
Anhydr. amm.	Year of	61.0	67.5	48.5	39.5	12.5	28.5
Pr>F (Till*N Source)		.425		.137		.041	

[1] Year of application of the biennial treatment (1988 = year of); samples taken in insecticide applied treatments, and averaged over the row position.

Table 25. The inorganic nitrogen by depth in the top 5' soil profile in Goodhue Co., MN on 4/24-25/1989

Depth (ft.)	TOTAL N	NH_4-N	NO_3-N
	lbs/A		
0-1	14.0	10.2	3.8
1-2	12.6	9.5	3.2
2-3	13.4	10.3	3.0
3-4	11.8	7.8	3.9
4-5	12.5	7.4	4.9
Pr>F (Depth)	.001	.000	.167

Table 26. The inorganic nitrogen by depth and row position in the top 5' soil profile in Goodhue Co., MN on April 24-25, 1989[1].

Depth (ft.)	Row Position	TOTAL N	NH_4-N	NO_3-N
		lbs/A		
0-1	In	12.8	9.4	3.4
	Bet.	15.2	11.0	4.2
1-2	In	12.5	8.3	4.2
	Bet.	12.7	10.6	2.2
2-3	In	13.0	9.7	3.3
	Bet.	13.8	11.0	2.8
3-4	In	11.8	8.2	3.6
	Bet.	11.8	7.5	4.3
4-5	In	13.6	7.5	6.1
	Bet.	11.5	7.3	3.8
Pr>F (Depth*Row)		.001	.338	.215

[1] Averaged over tillages and selected N treatments (Table 24) with insecticide.

Table 27. The inorganic nitrogen by row position in the top 5' soil profile in Goodhue Co., MN on April 24-25, 1989[1].

Row Position	TOTAL N	NH_4-N	NO_3-N
	----------lbs/A----------		
In Row	63.5	43.0	20.5
Bet. Row	65.0	47.5	17.5
Pr>F (Row)	.440	.110	.251

[1] Averaged over tillages, selected N treatments (Table 24) with insecticide.

Table 28. The total inorganic nitrogen by depth and row position in the top 5' soil profile in Goodhue Co., MN on April 24-25, 1989[1].

Depth (ft.)	TOTAL N (lb/A) In Row	Bet. Row
0-1	12.8	15.2
1-2	12.5	12.7
2-3	13.0	13.8
3-4	11.8	11.8
4-5	13.6	11.5
Pr>F (Depth*Row)	.079	

[1] Averaged over tillages, selected N treatments (Table 24) with insecticide.

Table 29. Total inorganic N by tillage N source and depth in the top 5 ft. soil profile in Goodhue Co., MN on April 26- May 2, 1989[1].

N source	Tillage	Total inorg. N (lb/A) 0-1 ft.	1-2 ft.	2-3 ft.	3-4 ft.	4-5 ft.	0-5 ft.
Manure(pit, yr of)[2]	Ridge	14.0	13.4	12.1	11.7	11.3	62.5
	Chisel	12.1	12.4	14.6	12.4	12.8	64.3
Check (annual)	Ridge	13.7	11.6	14.3	11.5	10.3	61.4
	Chisel	11.9	13.6	12.0	12.1	10.8	60.4
Anhy. (annual)	Ridge	15.2	11.7	12.2	13.1	16.7	68.9
	Chisel	15.4	13.1	14.8	10.8	14.0	68.1
Anhy. (yr of, 88)	Ridge	13.9	12.4	11.7	11.5	11.8	61.3
	Chisel	16.0	12.8	15.2	11.2	12.7	67.8
Pr>F (Till*N source*Depth)				.0788			

[1] Averaged over the row position.
[2]Manure applied in the spring of 1988 (yr of).

Table 30 . Significance table for spring and soil moisture, and spring soil N.

	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
Soil moisture															
Spring	.639	.583	.596	.317	.404	.937	.773	.000	.023	.656	.485	.982	.937	.988	.959
Fall	.758	.776	.408	.302	.528	.991	.981	.000	.006	.002	.123	.923	.602	.996	.997
Spring N	.520	.059	.425	.440	.594	.525	.441	.001	.355	.079	.079	.001	.342	.006	.917
NH_4-N	.661	.152	.137	.111	.500	.171	.205	.000	.987	.893	.704	.338	.306	.516	.337
NO_3-N	.591	.729	.104	.251	.398	.334	.686	.167	.637	.733	.832	.215	.408	.100	.431

FIG. 1: WATER ANALYSIS FROM NORDS FARM, 1989

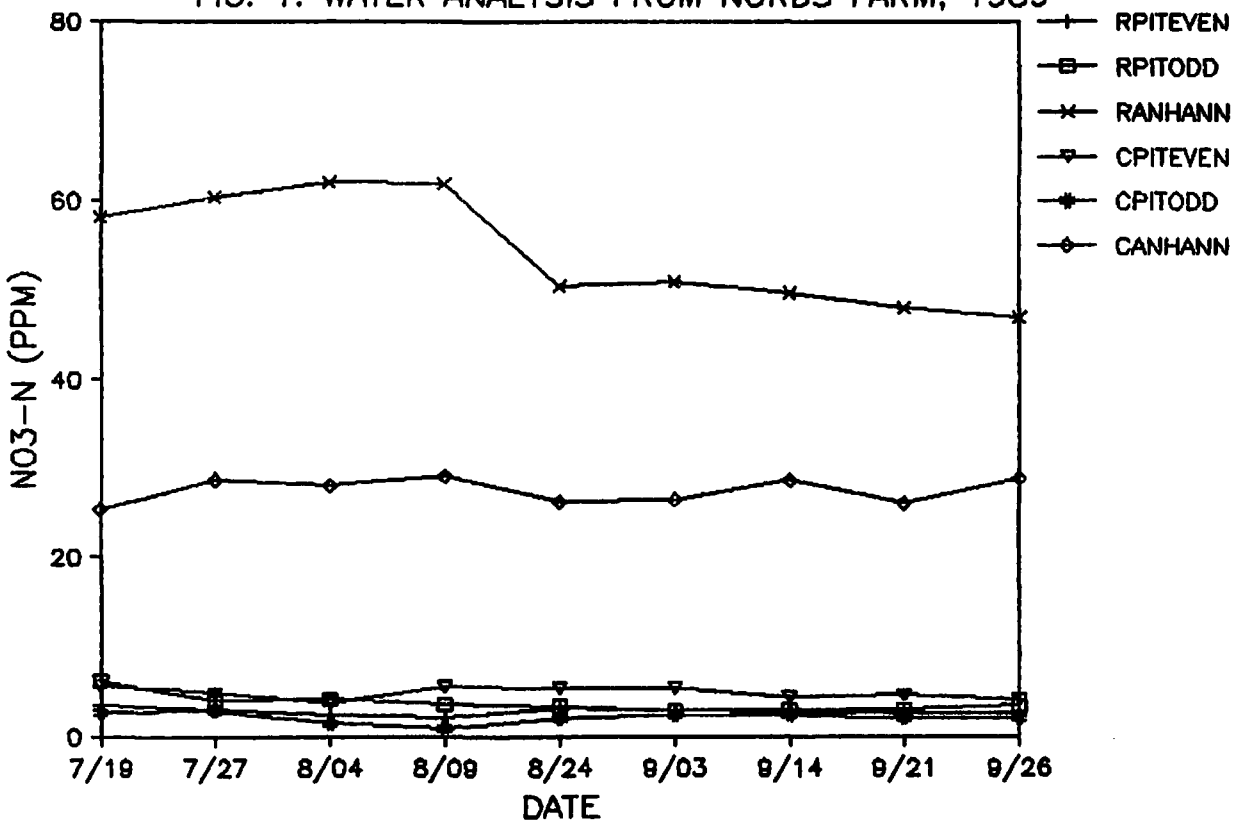


FIG. 2. EFFECT OF TILLAGE AND SOIL DEPTH
ON SOIL WATER ON APRIL 24–25, 1989, NORD FARM

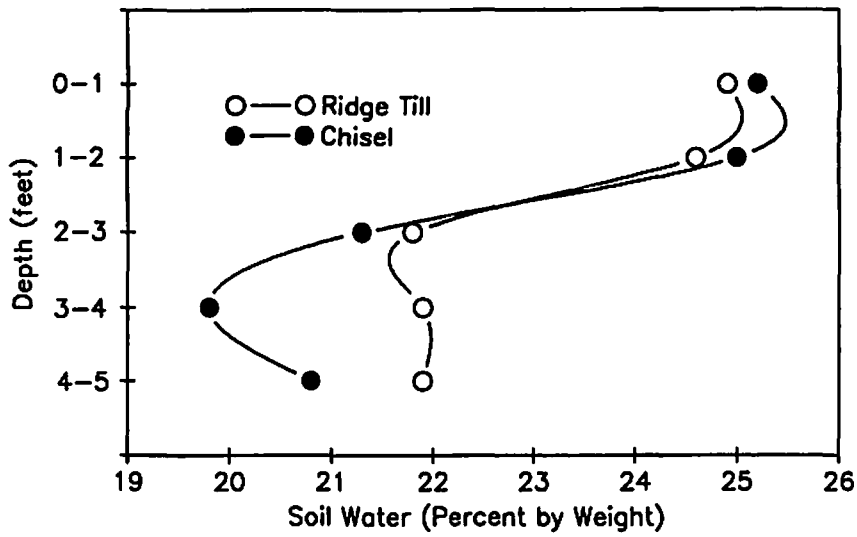
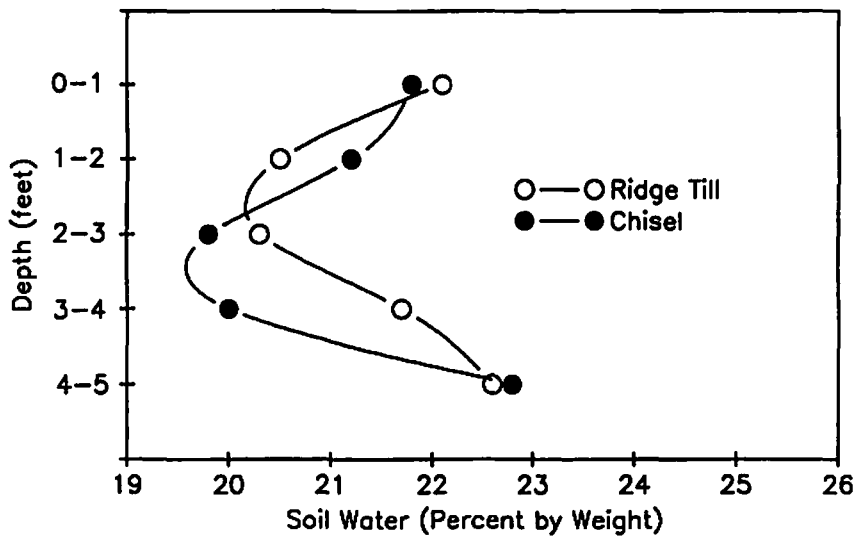


FIG. 3. EFFECT OF TILLAGE AND SOIL DEPTH
ON SOIL WATER ON NOVEMBER 2–7, 1989, NORD FARM



Tillage System Effects on Corn and Soybean Growth and Yield on a Well Drained Silt Loam Soil[1]

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

Tillage was evaluated for corn and soybean production on a well drained silt loam soil for a sixth year. Corn and soybean yields were lower with ridge till and no till systems. This is the first time tillage has reduced corn yields. Soybean yield reductions appeared to be related to stand establishment with ridge tillage and increased density of velvet leaf under no till conditions.

This study is in it's sixth year. The purpose is to evaluate tillage system effects corn and soybean growth and yield. The soil at this site was developed in loess and is well drained.

Methods and Materials

The experimental design is a randomized complete block with four tillage treatments and four replications for both corn and soybeans. Crop residue was measured using a line transect technique. Stand estimates were made on two ten foot row samples from adjacent rows at two randomly selected monitoring sites in each tillage plot. Grain yields were estimated with a combine with a six row head.

Results and Discussion

Soil cover by soybean and corn residue is shown in table 4 and 5 respectively. Soil cover by corn reside ranged from 8 to 80%. Soil cover by soybean residue ranged from 10 to 56%. Although corn stands were not affected by tillage early growth was delayed when "in row" cover was greater than 20% (table 6). Similarly soybean stands were not affected by tillage but early growth was delayed when "in row" cover was greater than 20% (table 7). The planter at this site did not have row cleaning tillage tools. Early growth of both corn and soybeans was delayed due to inadequate removal of crop residue in the row area.

Grain yields were affected by tillage system for both corn and soybeans (tables 8 and 9). Chisel plowing and spring discing resulted in higher yields. Stands were inadequate with the ridge till soybeans. Both no till and ridge till plots had velvet leaf at harvest that was not present in the other two systems. The authors do not have an explanation for the reduction in corn yields with these two systems. This is the only year of the six that tillage affected corn yields.

WABASHA COUNTY

Table 1. Cultural practices for Wabasha County, MN in 1989.

Tillage

No Till
Ridge Till
Spring Disc-seedbed prepared with a field cultivator on May 10, 1989.
Chisel Plow-seedbed prepared with a field cultivator on May 10, 1989.
All corn plots except no till were cultivated June 24, 1989.
Corn was ridged on June 28, 1989.

Cropping History

1983-Sweet Clover
1984-1988 Corn-Soybean rotation

Crops 1989

Corn-Pioneer 3737
Soybeans-Pioneer 1677

[1] *This project is supported by the Soil Conservation Service, the Minnesota Extension Service, and the Wabasha County Soil and Water Conservation District. There support is greatly appreciated. Much of the data collection was aided by SCS, SWCD, MES field staff. Without their assistance this project would have not been possible.*

[2] *John F. Moncrief and Joe J. Kuznia are Associate Professor and Assistant Scientist respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN. 55108. Tim L. Wagar is an area Crops and Soils Extension Agent stationed at Rochester, MN.*

Planting and Harvest Date

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

Crop	Planting Date	Planting Rate	Harvested
Corn	May 10, 1989	28,000 plants/A	October 24, 1989
Soybeans	May 23, 1989	205,000 plants/A	October 24, 1989

Fertilization History For Corn

Material Analysis	Rate	Actual N (lbs/A)	Actual P_2O_5 (lbs/A)	Actual K_2O (lbs/A)	Date Applied
28-0-0[1]	7 gal/A	75	0	0	May 14, 1984
7-21-7	12.5 gal/A	10	29	10	May 16 & 18, 1984
7-21-7[2]	25 gal/A	20	60	20	May 13, 1985
82-0-0	170 lbs/A	140	0	0	June 19, 1985
46-0-0	337 lbs/A	155	0	0	April 24, 1986
9-23-30[2]	170 lbs/A	15	39	51	May 5, 1986
9-23-30[2]	130 lbs/A	12	30	39	April 30, 1987
82-0-0	159 lbs/A	130	0	0	June 8, 1987
5-14-42[1]	95 lbs/A	5	13	40	May 5, 1988
2-0-0	183 lbs/A	150	0	0	April 22, 1988

1. Nitrogen was not applied to chisel plowed plots in 1984.
2. Placement 2" beside and 2" below seed.

Fertilizer Applied to Corn in 1989

Material Analysis	Rate	Actual N (lbs/A)	Actual P_2O_5 (lbs/A)	Actual K_2O (lbs/A)	Date Applied
6-15-40[1]	110 lbs/A	7	17	44	May 10, 1989
82-0-0	159 lbs/A	130	0	0	Spring Pre-plant

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

Soil

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

Weed Control

Corn

2 qt/A (2 lbs/A) Lasso + 2 qt/A (2 lbs/A) Bladex broadcast with the planter on May 10, 1989.

Soybeans

1 qt/A (.75 lb/A) Roundup + .5 pt/A (.25 lb/A) 2,4-D May 23, 1989.

1 pt/A (.5 lb/A) Basagran + .5 pt/A (.125 lb/A) Blazer + 1 qt/A oil concentrate on June 13, 1989.

1 pt/A (.5 lb/A) Basagran + 1 pt/A (.188 lb/A) Poast + 1 qt/A Dash oil concentrate + 3 qt/A 28% on June 22, 1989.

Velvetleaf was present in visually significant amounts in the no till and ridge till soybean plots at harvest.

Soil Test

Table 2. Soil test results for corn to be planted following soybeans on April 16, 1987.

Nutrient	Sig. of Tillage	Tillage: No Till (lbs/A)	Disc	Ridge	Chisel	Avg
P	(.256)	64	58	57	54	58
K	(.833)	220	209	204	201	208

Table 3. Soil test results for soybeans to be planted following corn on April 16, 1987.

Nutrient	Sig. of Tillage	Tillage: No Till (lbs/A)	Disc	Ridge	Chisel	Avg
P	(.602)	62	66	67	60	64
K	(.075)	215	187	200	177	195

Table 4. Effect of tillage and position relative to the row on soil covered by soybean residue in corn at Wabasha Co. on June 16, 1989[1].

	Tillage				
	NoTill	Disc	Ridge	Chisel	
Location	% cover				Avg.
In Row	55.8a	6.3c	25.5b	12.0c	24.9
Between Row	56.0a	6.0c	43.8b	10.8c	29.1
Average	55.9a	6.1c	34.6b	11.4c	

1. The p value for residue location, tillage, and tillage by location interaction are .080 (n=64), .001 (n=32), .013 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 5. Effect of tillage and position relative to the row on soil covered by corn residue in soybeans at Wabasha Co. on June 16, 1989[1].

	Tillage				
	NoTill	Disc	Ridge	Chisel	
Location	% cover				Avg.
In Row	82.3a	17.0c	48.5b	8.3d	35.8
Between Row	80.8a	12.8c	66.8b	10.0c	34.5
Average	81.5a	14.9c	57.6b	9.1c	

1. The p value for residue location, tillage, and tillage by location interaction are .090 (n=48), .001 (n=32), .018 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 6. Effect of tillage on corn population and early growth at in Wabasha Co.

	Tillage				
	NoTill	Disc	Ridge	Chisel	
	plants/A X 10^{-3}				Sig.
6/16/89	30.3a[1]	28.9a	31.3a	30.2a	.183
(n=16)	leaves/plant				
6/22/89	4.7c	5.3a	4.9b	5.3a	.001
(n=80)					

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

Table 7. Effect of tillage on soybean population and early growth at Wabasha Co.

	Tillage				
	NoTill	Disc	Ridge[2]	Chisel	
	plants/A X 10^{-3}				Sig.
6/16/89	154.9a[1]	141.9a	61.8	141.9a	.556
(n=12)	nodes/plant				
6/22/89	2.1b	2.2b	1.9c	2.4a	.001
(n=80)					

1. 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 8. Effect of tillage on corn yields and moisture at Wabasha Co. on October 24, 1989[1].

	Tillage				
	NoTill	Disc	Ridge	Chisel	
	bu/A				Sig.
Grain Yield	158b	173a	160b	172a	.005
	%				
Moisture	14.0a	14.2a	14.4a	14.2a	.972

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

Table 9. Effect of tillage on soybean yields and moisture at Wabasha Co. on October 24, 1989[1].

	Tillage				
	NoTill	Disc	Ridge	Chisel	
	bu/A				Sig.
Grain Yield	44b	47a	39b	47a	.020
	%				
Moisture	7.2a	7.4a	7.2a	8.7a	.338

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

Tillage System, Applied Nitrogen, and Cultivation Effects on Corn Growth and Yield on a Well Drained Silt Loam Soil Following Alfalfa[1]

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

Tillage and cultivation were evaluated on the nitrogen response by second year of corn grown after alfalfa. Grain yields were reduced under no till condition but two other conservation tillage systems resulted in similar grain yields to those with moldboard plowing. Conservation tillage reduced nitrogen uptake by corn. There was an average cultivation response due mainly to Woolly Cupgrass control of 25 bushels per acre.

This study is in it's second of corn following alfalfa. The purpose is to evaluate tillage system interactions and row cultivation on corn growth and yield as well as changes in weed density. Also of interest is the effect of tillage on the amount of nitrogen available following alfalfa. The soil at this site was developed in loess and is well drained.

Methods and Materials

The experimental design is a randomized complete block with four tillage treatments and four replications. Each main tillage plot is split with four N rates which are further split with row cultivation. Nitrogen was applied as broadcast urea on April 29, 1989. Crop residue was measured using a line transect technique. Stand estimates were made on two ten foot row samples from adjacent rows at two randomly selected monitoring sites in each nitrogen subplot. Weed measurements were made by visually estimating the amount of cover by weeds by species and assigning ratings based on a 1 to 5 range with: 1=<15%, 3=15-25%, 4=25-50%, 5=50-75%, and 6=>75%. Grain and stover yields were estimated by hand harvesting grain and chopping stover in two 15 ft. rows. Subsamples were taken for moisture and nitrogen analysis.

Results and Discussion

Soil cover by corn residue is shown in tables 2 and 3. Soil cover by corn residue before cultivation in the row ranged from 2 to 33%. Soil cover by residue between the row before cultivation ranged from 4 to 55%. Cultivation reduced cover 10% to 20% in conservation tillage treatments (table 3).

Soil cover in the row by corn residue was correlated with reduced early growth. Differences were small when soil cover in the row was less than 25% (table 4). Growth was reduced .8 leaves with 33% soil cover in the row under no till conditions. Cultivation also reduced growth slightly (.09 leaf).

Although corn stand establishment was affected by tillage (July 5, table 5), they were not affected by cultivation. Stands later at harvest (Oct. 3, table 17) were further reduced under no till conditions.

The major weed present at this site is Woolly Cupgrass. Conservation tillage options increased the density of this weed (table 7). Bromegrass was limited to the no till plots (table 10). Bromegrass showed a small but significant response to applied nitrogen (table 8). Yellow nutsedge was the only weed present that was reduced due to cultivation the year before (table 9). Moldboard plowing reduced foxtail densities over other tillage systems. Woolly Cupgrass was higher under no till conditions(table 13). Woolly Cupgrass responded the most to cultivation (table 14). Foxtail was reduced more due to cultivation under conservation tillage systems (table 16). Woolly Cupgrass responded similarly to cultivation under all tillage systems.

Grain yields were reduced in corn grown with a no till system (table 17). Grain moisture was increased with this system. This reflects the influence of soil cover in the row. Nitrogen had a small but statistically significant affect on grain moisture also (table 18, 1.5%). Corn responded to 75 lbs/acre of applied N. The average yield and stand response to cultivation was 25 bu/acre and 2.6 thousand plants per acre respectively (table 19).

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[1] *This project is supported by the U.S. Fish and Wildlife Service, the Soil Conservation Service, the Minnesota Extension Service, and the Winona County Soil and Water Conservation District. There support is greatly appreciated. Much of the data collection was aided by MES, SCS, and SWCD field staff. Without their assistance this project would have not been possible.*

[2] *John F. Moncrief and Joe J. Kuznia are Associate Professor and Assistant Scientist respectively in the Soil Science Department at the University of Minnesota, St. Paul, MN. 55108. Tim L. Wagar is an area Crops and Soils Extension Agent stationed at Rochester, MN.*

Tillage affected nitrogen uptake by grain and stover (table 20). Nitrogen uptake generally increased with increasing tillage. Cultivation also increased N uptake by corn (table 22). Without cultivation corn grain yield responded to higher levels of applied nitrogen (table 23). This was also true of total nitrogen uptake (table 24).

In the spring of the year soil water levels were higher with the no till system (table 25). It appears that there was more consumption of soil water with the moldboard plowing system which resulted in lower levels of soil water in the fall (table 25). Differences in soil water in the fall due to tillage in the fall were below two feet.

WINONA COUNTY

Table 1. Cultural practices at Winona County, MN. 1989.

Tillage

No Till
Spring Disc-May 8,1989
Spring Chisel Plowed-May 8, 1989
Spring Moldboard Plowed-May 8, 1989
All plots were split with cultivation on June 28, 1989.

Planting Information for 1989 Crop Year

A two row Hiniker Series 1 EconoTill planter with 30" row spacing.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 9, 1989	32,000 plants/A	October 2, 1989

Cropping History

1979-81 Alfalfa, 1982-83 Corn, 1984 Oats and Alfalfa, 1985-87 Alfalfa, 1988 Corn

Manure History

20 loads of solid dairy manure (300 bu. spreader) in 1980, 1982, & 1983

1989 Crop

Corn Pioneer 3737

Fertilizer 1988

			Actual						
Crop	Material Analysis	Rate	N	P_2O_5	K_2O	S	Zn	Date Applied	Method of Application
			------- lbs/A --------						
Corn	16-42-5-7-20	110 lbs/A	18	46	6	8	22	May 2, 1988	Starter 2" x 2" with planter
	46-0-0	65 lbs/A	30	0	0	0	0	April 29, 1988	Broadcast
	46-0-0	130 lbs/A	60	0	0	0	0	April 29, 1988	Broadcast
	46-0-0	196 lbs/A	90	0	0	0	0	April 29, 1988	Broadcast

Fertilizer 1989

			Actual				
Crop	Material Analysis	Rate	N	P_2O_5	K_2O	Date Applied	Method of Application
			--- lbs/A ----				
Corn	7-21-7	15 gals/A	11	33	11	May 9, 1989	Starter 2" x 2" with planter
	46-0-0	65 lbs/A	33	0	0	May 8, 1989	Broadcast
	46-0-0	130 lbs/A	64	0	0	May 8, 1989	Broadcast
	46-0-0	196 lbs/A	89	0	0	May 8, 1989	Broadcast

Soil

Seaton silt loam (Typic Hapludalfs, fine-silty, mixed, mesic), 3-6% slope, soil is well drained.

Weed Control

3 pt/A (1.5 lb/A) Prowl + 2 lb/A (1.8 lb/A) Bladex 90 DF applied on May 23, 1989.
1 pt/A (.5 lb/A) Banvel applied on June 13, 1989.
Main tillage plots were split with cultivation on June 28, 1989.

Insect Control

6.4 lbs/A (.96 lb/A) Counter 15G at planting.

Table 2. Effect of tillage and position relative to the row on soil covered by corn residue in corn at Winona Co. on May 23, 1989[1].

	Tillage				
	No Till	Disc	Chisel	Moldboard	
Location	% cover				Avg.
In Row	32.5a	15.5b	23.8c	2.0d	18.4
Between Row	55.5a	19.0c	32.8b	3.5d	27.7
Average	44.0a	17.3c	28.3b	2.8d	

1. The p value for residue location, tillage and tillage by location interaction are .003 (n=64), .001 (n=32), .570 (n=16) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 3. Effect of tillage and cultivation on position relative to the row on soil covered by corn residue in corn at Winona Co. on July 5, 1989[1].

	Tillage									
	No Till		Disc		Chisel		Moldboard		Average	
	In Row	Btwn Row	In Row	Btwn Row	In Row	Btwn Row	In Row	Btwn Row	In Row	Btwn Row
	% cover									
Cultivation	34.3	33.9	9.9	10.0	13.0	20.3	4.6	4.4	15.4	16.5
No Cultvation	38.0	56.8	11.8	25.3	13.1	34.9	3.3	5.3	17.1	30.5
Average	36.1	45.3	10.8	17.6	13.1	27.6	3.9	4.8	16.0	23.8

1. The p value for residue cultivation, tillage by cultivation, cultivation by location, tillage by cultivation by location are .015 (n=256), .092 (n=64), .001 (n=128), .947 (n=32) respectively.

Table 4. Effect of tillage on early growth of corn at Winona Co. on July 5, 1989[1].

	Tillage				
	NoTill	Disc	Chisel	Mldbd	
	leaves/plant				Avg.
Cultivation	7.69	8.19	8.01	8.51	8.10
No Cultivation	7.73	8.28	8.22	8.51	8.19
Average	7.71c	8.24ab	8.11b	8.51a	

1. The p value for tillage, cultivation and tillage by cultivation interactions are .005 (n=320), .089 (n=640), .144 (n=160) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 5. Effect of tillage and cultivation on corn population at Winona Co. on July 5, 1989[1].

	Tillage				
	NoTill	Disc	Chisel	Mldbd	
	plants/Ax10^{-3}				Avg.
Cultivation	22.0	25.8	24.6	23.7	24.0
No Cultivation	19.9	25.4	25.0	23.1	23.4
Average	21.0b	25.6a	24.8a	23.4a	

1. The p value for cultivation, tillage and tillage by cultivation interaction are .458 (n=128), .010 (n=64), .658 (n=32) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 6. Effect of N rate and cultivation on corn population at Winona Co. on July 5, 1989[1].

	N Rate (lbs/A)			
	11	44	75	100
	plants/Ax10^{-3}			
Cultivation	23.7	24.2	25.2	22.9
No Cultivation	22.5	24.1	23.0	23.9
Average	23.1a	24.1a	24.1a	23.4a

1. The p value for N rate and cultivation by N rate interactions are .392 (n=64), .072 (n=16), respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 7. Effect of tillage on weed severity[1] prior to cultivation in corn at Winona Co. on June 28, 1989[2].

	Tillage				
	NoTill	Disc	Chisel	Mldbd	Sig.
Weeds	Rating				
Quackgrass	0.32	0.00	0.06	0.00	
Foxtail	0.00	0.22	0.38	0.00	
Woolly Cupgrass	3.94a	2.50b	2.94b	2.00c	.001
Bromegrass	2.03	0.00	0.03	0.13	
Y.Nutsedge	0.10a	1.19a	1.13a	0.22a	.187
Horsetail	0.03a	0.19b	0.38b	0.09b	.001
Pigweed	0.10	0.00	0.00	0.00	
C. Thistle	0.00	0.09	0.00	0.00	
Alfalfa	0.71	0.00	0.00	0.00	

1. Weed severity ratings on scale 0 to 5, (0 =none, 5=severe).
2. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 8. Effect of N rate on weed severity[1], in corn at Winona Co. on June 28, 1989[2].

Weeds	N Rate (lb/A) 11	44	75	100	Sig.
	Rating				
Woolly Cupgrass	2.7a	2.8a	2.9a	3.0a	.553
Y.Nutsedge	0.6a	0.7a	0.6a	0.7a	.270
Bromegrass	0.2b	0.7a	0.5a	0.7a	.019

1. Weed severity ratings on scale 0 to 5, (0=none, 5=severe).
2. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 9. Effect of cultivation on weed severity[1], in corn at Winona Co. on June 28, 1989[1].

Weeds	Cultivation	No Cultivation	Sig.
	Rating		
Woolly Cupgrass	2.84a	2.81a	.962
Y.Nutsedge	0.44b	0.89a	.025
Bromegrass	0.64a	0.43a	.182
Foxtail	0.13a	0.17a	.398
Horsetail	0.08a	0.27a	.288
Alfalfa	0.19a	0.16a	.474

1. Weed severity ratings on scale 0 to 5, (0=none, 5=severe).
2. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 10. Effect of tillage and N rate on weed severity[1], of corn at Winona Co. on June 28, 1989.

Weed	Tillage: No Till, N Rate (lbs/A) 11	44	75	100	Disc, N Rate (lbs/A) 11	44	75	100	Chisel, N Rate (lbs/A) 11	44	75	100	Moldboard, N Rate (lbs/A) 11	44	75	100	Sig.[2]
Bromegrass	0.7	2.4	2.1	2.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.5	0.0	0.0	.014
Horsetail	0.0	0.0	0.1	0.0	0.8	0.0	0.0	0.0	0.0	0.8	0.0	0.8	0.4	0.0	0.0	0.0	.010

1. Weed severity ratings on scale 0 to 5, (0=none, 5=severe), n=8.
2. The p value for the tillage by N rate interaction.

Table 11. Effect of N rate and cultivation from the previous year on weed severity[1], in corn at Winona Co. on June 28, 1989.

Weed	N Rate (lbs/A): 11 Cult.	11 No Cult.	44 Cult.	44 No Cult.	75 Cult.	75 No Cult.	100 Cult.	100 No Cult.	Sig.[2]
	Rating								
Woolly Cupgrass	2.7	3.1	2.8	2.8	2.7	2.4	2.9	3.2	.065
Bromegrass	0.1	0.8	0.8	0.9	0.3	0.6	0.3	0.5	.001

1. Weed severity ratings on scale 0 to 5, (0 =none, 5=severe), n=16.
2. The p value for the N rate by cultivation interaction.

Table 12. Effect of tillage, N rate, and cultivation on weed severity[1], in corn at Winona Co. on June 28, 1989[2].

	Tillage: No Till, N Rate (lbs/A) 11	44	75	100	Disc, N Rate (lbs/A) 11	44	75	100	Chisel, N Rate (lbs/A) 11	44	75	100	Moldboard, N Rate (lbs/A) 11	44	75	100
	Bromegrass rating															
Cultivation	0.3	2.8	3.3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0
No Cultivation	1.3	2.0	1.0	2.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.5	0.0	0.0
	Nutsedge rating															
Cultivation	0.0	0.0	0.0	0.0	0.8	0.3	1.3	0.8	0.8	1.3	0.8	1.0	0.0	0.0	0.3	0.0
No Cultivation	0.0	0.0	0.8	0.0	2.3	2.8	0.0	1.5	1.0	1.0	1.5	1.8	0.0	0.5	0.5	0.5

1. Weed severity ratings on scale 0 to 5, (0=none, 5=severe).
2. The p value for tillage by N rate by cultivation interaction for bromegrass and nutsedge are .001, .014 respectively, n=4.

Table 13. Effect of tillage on weed severity[1], in corn at Winona Co. on August 31, 1989.

Weed	Tillage: NoTill	Disc	Chisel	Mldbd	Sig.
	Rating				
Foxtail	2.3a	2.0a	2.2a	1.3b	.007
W. Cupgrass	4.3a	2.4b	2.4b	2.0b	.011
Velvetleaf	1.1a	1.0b	1.0b	1.0b	.016

1. Weed severity ratings on scale 0 to 5, (0 =none, 5=severe).
2. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 14. Effect of cultivation on weed severity[1], in corn at Winona Co. on August 31, 1989.

Weed	Cultivation	No Cultivation	Sig.
	Rating		
Foxtail	1.4	2.5	.001
W. Cupgrass	1.8	3.7	.001
Velvetleaf	1.0	1.0	.454

1. Weed severity ratings on scale 0 to 5, (0=none, 5=severe), n=64.

Table 15. Effect of N rate on foxtail weed severity[1], in corn at Winona Co. on August 31, 1989[2].

Weed	N Rate (lbs/A): 11	44	75	100	Sig.
	Rating				
Foxtail	2.19b	1.84b	1.81b	1.97ab	.075
W Cupgrass	2.67a	2.66a	2.84a	2.89a	.369
Velvetleaf	1.06a	1.00a	1.00a	1.06a	.131

1. Weed severity ratings on scale 0 to 5, (0=none, 5=severe).
2. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 16. Effect of tillage and cultivation on weed severity[1], in corn at Winona Co. on August 31, 1989.

Weed	Tillage: No Till		Disc		Chisel		Moldboard		Sig.[2]
	Cult.	No Cult.	Cult.	No Cult.	Cult.	No Cult.	Cult.	No Cult.	
Foxtail	2.06	2.50	1.13	2.88	1.37	3.06	1.00	1.63	.084
W Cupgrass	3.50	5.00	1.38	3.38	1.38	3.50	1.00	3.00	.227
Velvetleaf	1.19	1.06	1.00	1.00	1.00	1.00	1.00	1.00	.454

1. Weed severity ratings on scale 0 to 5, (0 =none, 5=severe), n=16.
2. The p value for tillage by cultivation interaction.

Table 17. Effect of tillage on corn grain yield, moisture, stover yield, moisture and final stand at Winona Co. on October 3, 1989[1].

	Tillage: NoTill	Disc	Chisel	Mldbd	Sig.
	bu/A				
Grain Yield	82b	134a	140a	146a	.001
	%				
Moisture	28.7a	24.7b	24.6b	25.0b	.001
	ton/A				
Stover Yield	2.42b	2.83a	2.98a	2.96a	.001
	%				
Moisture	41.6a	44.1a	42.9a	42.5a	.300
	plants/Ax10^{-3}				
Final Stand	19.3b	25.0a	25.4a	25.0a	.003

1. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 18. Effect of N rate on corn grain yield, moisture, stover yield, moisture and final stand at Winona Co. on October 3, 1989[1].

	N Rate (lbs/A): 11	44	75	100	Sig.
	bu/A				
Grain Yield	109b	126a	135a	132a	.001
	%				
Moisture	26.9a	25.8ab	25.1b	25.2b	.087
	ton/A				
Stover Yield	2.68a	2.79a	2.89a	2.83a	.321
	%				
Moisture	42.7a	42.0a	42.8a	43.6a	.655
	plants/Ax10^{-3}				
Final Stand	22.8a	23.8a	24.5a	23.5a	.243

1. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 19. Effect of cultivation on corn grain yield, moisture, stover yield, moisture and final stand at Winona Co. on October 3, 1989, n=64.

	Cultivation	No Cultivation	Sig.
	bu/A		
Grain Yield	138	113	.003
	%		
Moisture	26.1	25.5	.209
	ton/A		
Stover Yield	2.80	2.79	.759
	%		
Moisture	43.4	42.1	.244
	plants/Ax10^{-3}		
Final Stand	25.0	22.4	.001

Table 20. Effect of tillage on % grain N, protein, grain N uptake, % stover N, stover N uptake, and total N uptake at Winona Co. on October 3, 1989[1].

	Tillage				
	NoTill	Disc	Chisel	Mldbd	Sig.
	%				
Grain N	1.39a	1.33b	1.35ab	1.32b	.071
	%				
Grain Protein	8.7a	8.3b	8.5ab	8.2b	.071
	lbs/A				
Grain N Uptake	53.7b	85.2a	89.9a	91.6a	.001
	%				
Stover N	0.94a	0.89a	0.95a	0.82a	.216
	lbs/A				
Stover N Uptake	45.9b	49.9b	56.6a	48.6b	.068
	lbs/A				
Total N Uptake	99.7c	135.2b	146.5a	140.2ab	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 21. Effect of N rate on % grain N, protein, grain N uptake, % stover N, stover N uptake, and total N uptake at Winona Co.on October 3, 1989[1].

	N Rate (lbs/A)				
	11	44	75	100	Sig.
	%				
Grain N	1.27d	1.34c	1.37b	1.42a	.001
	%				
Grain Protein	7.9d	8.3c	8.5b	8.9a	.001
	lbs/A				
Grain N Uptake	65.2c	80.0b	86.9a	88.3a	.001
	%				
Stover N	0.79c	0.88b	0.91b	1.02a	.001
	lbs/A				
Stover N Uptake	41.9c	49.1b	52.2b	57.9a	.001
	lbs/A				
Total N Uptake	107.1c	129.1b	139.2a	146.2a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=32).

Table 22. Effect of cultivation on % grain N, protein, grain N uptake, % stover N, and stover N uptake, and total N uptake at Winona Co. on October 3, 1989, n=64.

	Cultivation	No Cultivation	Sig.
	%		
Grain N	1.38	1.32	.009
	%		
Grain Protein	8.6	8.2	.009
	lbs/A		
Grain N Uptake	90.0	70.3	.001
	%		
Stover N	0.93	0.87	.010
	lbs/A		
Stover N Uptake	51.9	48.7	.191
	lbs/A		
Total N Uptake	141.8	119.0	.002

Table 23. Effect of cultivation an N rate on corn grain yield, moisture, stover yield, moisture and final stand at winona Co. on October 3, 1989, n=16.

	Cultivation				No Cultivation				
	N Rate (lbs/A)				N Rate (lbs/A)				
	11	44	75	100	11	44	75	100	Sig.[1]
	bu/A								
Grain Yield	126	142	144	140	92	110	125	123	.027
	%								
Moisture	27.7	26.0	25.2	25.4	26.2	25.5	25.0	25.1	.884
	ton/A								
Stover Yield	2.66	2.90	2.81	2.84	2.71	2.68	3.00	2.81	.292
	%								
Moisture	43.6	42.6	43.6	44.1	41.9	41.4	42.0	43.1	.998
	plants/Ax10^{-3}								
Final Stand	24.7	25.4	25.3	24.6	21.1	22.3	23.7	22.5	.312

1. The p value for cultivation by N rate interaction.

Table 24. Effect of cultivation and N rate on % grain N, protein, grain N uptake, % stover N, and stover N uptake, and total N uptake at Winona Co. on October 3, 1989, n=64.

	Cultivation				No Cultivation				
	N Rate (lbs/A)				N Rate (lbs/A)				
	11	44	75	100	11	44	75	100	Sig.[1]
	%								
Grain N	1.30	1.39	1.40	1.44	1.24	1.28	1.34	1.40	.447
	%								
Grain Protein	8.1	8.7	8.7	9.0	7.7	8.0	8.4	8.8	.447
	lbs/A								
Grain N Uptake	77.0	93.0	94.8	95.0	53.4	67.1	79.1	81.6	.015
	%								
Stover N	0.84	0.88	0.97	1.02	0.73	0.88	0.84	1.03	.115
	lbs/A								
Stover N Uptake	44.8	51.7	53.5	57.6	39.0	46.4	50.9	58.3	.702
	lbs/A								
Total N Uptake	121.8	144.6	148.3	152.6	92.5	113.5	130.0	139.9	.031

1. The p value for cultivation by N rate interaction.

Table 25. Effect of tillage on the average soil moisture to a depth of five feet in Winona Co. 1989[1].

	Tillage				
	No Till	Disc	Chisel	Moldboard	
	%wt/wt				Sig.
5/3/89[2]	20.4a	19.5b	19.5b	19.5b	.027
11/8/89	18.3a	18.0a	18.0a	17.0b	.035

1. Means within the same row with the same letter are not significantly different (α=.10, n=40).
2. Soil samples were taken before tillage.

Table 26. Effect of tillage and cultivation on soil moisture in Winona Co. November 8, 1989.[1]

	Tillage			
	No Till	Disc	Chisel	Moldboard
	%wt/wt			
Cultivation	18.5	17.7	18.1	17.0
No Cultivation	18.0	18.4	17.8	17.0

1. The p value of the tillage by cultivation interaction is .063, n=20.

Table 27. Effect of cultivation on soil moisture at Winona Co.[1].

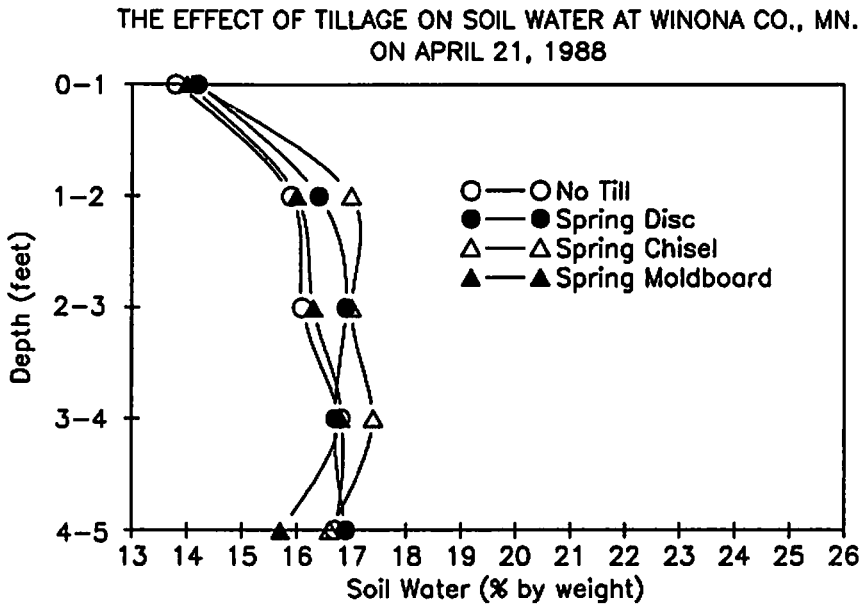
	Cultivation	No Cultivation	
	%wt/wt		Sig.
5/3/89	19.6b	19.9a	.086
11/8/89	17.8a	17.8a	.869

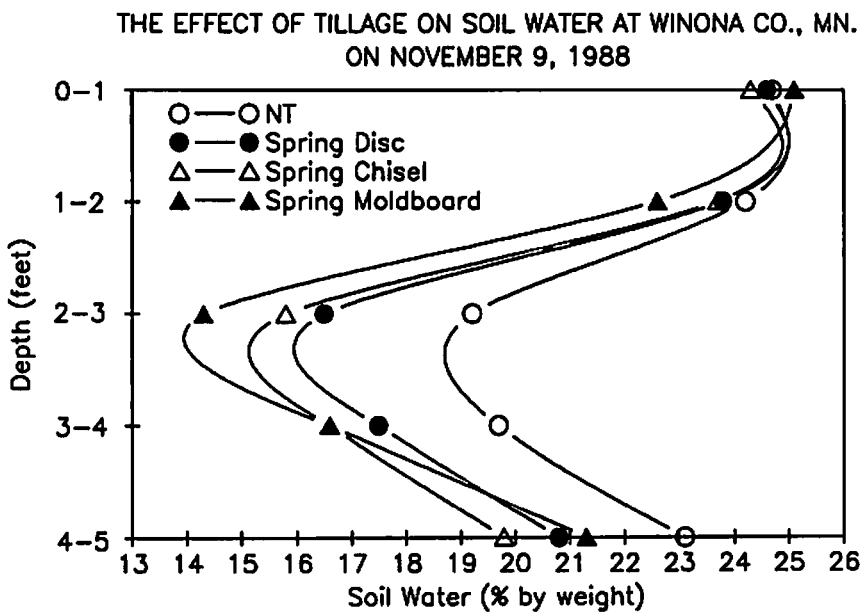
1. Means within the same row with the same letter are not significantly different (α=.10, n=80).

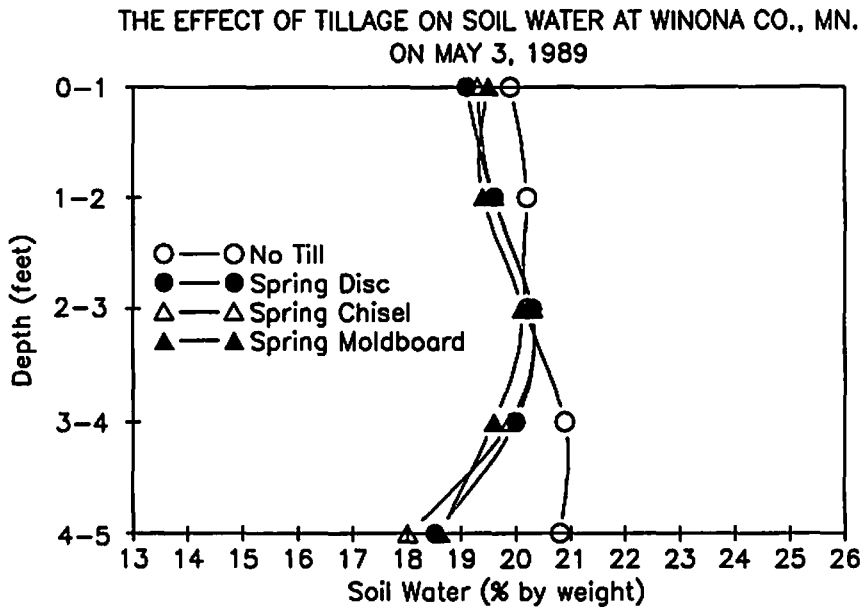
Table 28. Effect of tillage and depth on soil water at Winona Co. 1989.

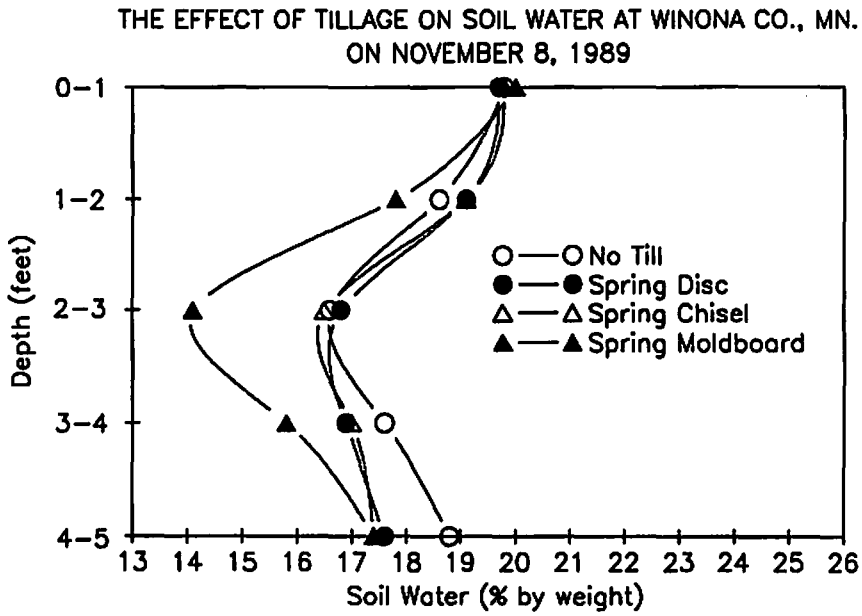
	Tillage									
	No Till		Disc		Chisel		Moldboard		Depth	
	Spring[1]	Fall[2]	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Depth (feet)	% wt/wt									
0-1	19.9	19.8	19.1	19.7	19.3	19.8	19.5	20.0	19.5bc	19.8a
1-2	20.2	18.6	19.6	19.1	19.6	19.1	19.4	17.8	19.7ab	18.7b
2-3	20.2	16.6	20.3	16.8	20.3	16.5	20.1	14.1	20.3a	16.0e
3-4	20.9	17.6	20.0	16.9	19.9	17.0	19.6	15.8	20.1a	16.8d
4-5	20.8	18.8	18.5	17.6	18.0	17.4	18.6	17.4	19.0c	17.8c
Average	20.4	18.3	19.5	18.0	19.5	18.0	19.5	17.0	19.7	20.7

1. Soil samples were taken before tillage. The p value of spring sampling (May 3, 1989) for the tillage by depth interaction is .516, n=8, and for depth .004, n=32.
2. The p value of fall sampling (November 8, 1989) for the tillage by depth interaction is .082, n=8, and for depth .001, n=32.


THE EFFECT OF TILLAGE ON SOIL WATER AT WINONA CO., MN.
ON APRIL 21, 1988
No Till
Spring Disc
Spring Chisel
Spring Moldboard
Depth (feet)
0-1
1-2
2-3
3-4
4-5
13 14 15 16 17 18 19 20 21 22 23 24 25 26
Soil Water (% by weight)


THE EFFECT OF TILLAGE ON SOIL WATER AT WINONA CO., MN.
ON NOVEMBER 9, 1988
NT
Spring Disc
Spring Chisel
Spring Moldboard
Depth (feet)
0-1
1-2
2-3
3-4
4-5
13 14 15 16 17 18 19 20 21 22 23 24 25 26
Soil Water (% by weight)


THE EFFECT OF TILLAGE ON SOIL WATER AT WINONA CO., MN.
ON MAY 3, 1989
Depth (feet)
0–1
1–2
2–3
3–4
4–5
No Till
Spring Disc
Spring Chisel
Spring Moldboard
13 14 15 16 17 18 19 20 21 22 23 24 25 26
Soil Water (% by weight)


THE EFFECT OF TILLAGE ON SOIL WATER AT WINONA CO., MN.
ON NOVEMBER 8, 1989
Depth (feet)
0–1
1–2
2–3
3–4
4–5
No Till
Spring Disc
Spring Chisel
Spring Moldboard
13 14 15 16 17 18 19 20 21 22 23 24 25 26
Soil Water (% by weight)

Tillage System Effects on Corn Phenology Nitrogen Response, and Yield Under Irrigation[1]

J.F. Moncrief, M.J. Wiens, and J.J. Kuznia[2]

Tillage effects on nitrogen response of third year of corn following alfalfa were evaluated. Conservation tillage reduced early growth of corn and stand establishment. Corn responded to higher rates of applied nitrogen when grown under conservation tillage.

This is the third year of corn following alfalfa. The purpose is to evaluate tillage system effects on the amount of nitrogen available to corn from alfalfa. The soil at this site is excessively well drained. This site is irrigated. In the first year of corn there was a prominent effect of tillage on the nitrogen response by corn, in the second this effect was subtle, and this year the tillage effect on N response was intermediate.

Methods and Materials

The experimental design is a randomized complete block with three tillage treatments and four replications. All main tillage plots were split with four N rates. Crop residue was measured using a line transect technique. Soil cover by crop residue was characterized in and between the row. "In row" is defined as the four inch width centered over the row. "Between row" is defined as the remainder. Stand estimates were made on two ten foot row samples from adjacent rows at two randomly selected monitoring sites in each nitrogen subplot. Crop residue measurements were also made at these monitoring sites. Leaves were tallied on ten plants in these two adjacent rows until 12 leaves were present. Grain yields were estimated by hand harvesting one row 50 ft. long. After ears were removed stover was chopped and weighed and a subsample of both grain and stover taken for moisture determination and chemical analysis.

Results and Discussion

Soil cover by corn residue is shown in table 2, 3, and 4. The fluted coulter on this planter influenced the soil cover in the row very little (table 2). In row soil cover ranged from 10 to 92 percent. Past nitrogen treatments did not affect the amount of soil cover (table 3 and 4).

Early growth responses to tillage, and nitrogen are shown in tables 5 and 6 respectively. In row cover by corn residue delayed the growth of corn compared to moldboard plowing by about 1/2 to 1 1/2 leaves for the disc and no till treatments respectively. This delay persisted over the period of observation (5/22-7/10).

Nitrogen from previous years affected the early growth by increasing the growth as the nitrogen rate increased from 84 to 206 lbs/acre. Check plots (small amount with planter) had the same growth as the high rate until 6/19 (almost two weeks after the first nitrogen application on 6/6) when higher nitrogen treatments overtook this treatment. At the end of the observation period (7/10) check plot growth was much less than higher nitrogen treatments. A couple of representative dates in table 7 shows that the higher growth in the N check plots was more pronounced with the conservation tillage systems.

Plant emergence and stand establishment are shown in tables 8,9, and 10. Corn emergence was delayed about one and two weeks under discing and no till conditions respectively. There was slight reductions in stand with corn grown under discing conditions and much larger reductions under no till conditions (table 8). Stands were also slightly higher in the N check plots (table 9). Tillage also affected the stand response to prior nitrogen treatments (table 10). Nitrogen check plots emerged quicker and had higher final stands under no tillage conditions. The highest N rate had lower stands under moldboard plowing conditions.

Visual N deficiency of corn are shown in tables 11, 12, and 13. Visual estimates of N deficiency symptoms showed higher levels of N stress at a given N rate with conservation tillage. Visual symptoms decreased at higher nitrogen rates with conservation tillage (table 13).

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[1] *This project is supported by the Staples Technical College Irrigation Center, the Soil Conservation Service, the Minnesota Extension Service, and the Soil and Water Conservation Districts of Wadena and Todd County Soil and Water Conservation Districts.*

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Tillage effects on silk emergence were similar to plant emergence (table 14). Nitrogen also affected silk emergence similarly to plant emergence (table 15). And finally the tillage and nitrogen interaction effect on silk emergence was similar to plant emergence (table 16).

Main effects of tillage and nitrogen on grain and stover yields and moisture are shown in tables 17 and 18. Tillage and nitrogen interacted in their effects on most of these variables. Interactions are shown in table 19. The nitrogen response was linear under no till conditions. The response was similar with discing and moldboard plowing.

Tillage and N rate effects on N uptake are shown in tables 20, 21, and 22. Again, in several cases there was an interaction between these two variables and N uptake. Response under no till conditions was much different than the discing and moldboard systems. Tillage affects on nitrogen availability appears to be small between the spring discing and moldboard plowing systems. Although reduced availability under no till conditions are large this system was used as a check as an extreme and would probably not be a viable system for a farmer.

WADENA COUNTY

Table 1. Cultural practices at Staples Irrigation Center, Wadena County, MN. 1989.

Tillage
No Till
Spring Disc-May 9, 1989
Spring Moldboard Plow-May 9, 1989

Previous Crop
1984-86 Alfalfa, 1987-Corn, 1988-Corn

1989 Crop Corn-Pioneer 3790

Planting and Harvest Date

The planter is a John Deere Max-Emerge planter equipped with 2" fluted coulters.

Crop	Planting Date	Planting Rate	Harvested
Corn	May 10, 1989	35,600 plants/A	October 10, 1989

Fertilizer 1987

Material Analysis	Rate[3]	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
		---- lbs/A ---				
17-7-23-6[1]	93 lbs/A	16	6	21	6	May 11, 1987
46-0-0[2]	0 lbs/A	0	0	0	0	June 16, 1987
46-0-0[2]	75 lbs/A	35	0	0	0	June 16, 1987
46-0-0[2]	146 lbs/A	67	0	0	0	June 16, 1987
46-0-0[2]	221 lbs/A	102	0	0	0	June 16, 1987

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 16, 51, 83, and 118 lbs/A.

Fertilizer 1988

Material Analysis	Rate[3]	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
		---- lbs/A ---				
24-8-15-8[1]	85 lbs/A	20	7	13	7	April 27, 1988
46-0-0[2]	0 lbs/A	0	0	0	0	June 1, 1988
46-0-0[2]	137 lbs/A	63	0	0	0	June 1, 1988
46-0-0[2]	254 lbs/A	117	0	0	0	June 1, 1988
46-0-0[2]	400 lbs/A	184	0	0	0	June 1, 1988

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 20, 83, 137, and 204 lbs/A.

Fertilizer 1989

Material Analysis	Rate[3]	Actual N	Actual P_2O_5	Actual K_2O	Actual S	Date Applied
		---- lbs/A ---				
20-7-20-7[1]	95 lbs/A	19	7	19	7	May 10, 1989
46-0-0[2]	0 lbs/A	0	0	0	0	June 6, 1989
46-0-0[2]	137 lbs/A	33	0	0	0	June 6, 1989
46-0-0[2]	254 lbs/A	64	0	0	0	June 6, 1989
46-0-0[2]	400 lbs/A	95	0	0	0	June 6, 1989
46-0-0[2]	0 lbs/A	0	0	0	0	June 30, 1989
46-0-0[2]	137 lbs/A	32	0	0	0	June 30, 1989
46-0-0[2]	254 lbs/A	64	0	0	0	June 30, 1989
46-0-0[2]	400 lbs/A	92	0	0	0	June 30, 1989

1. Planter applied 2" below and 2" beside row.
2. Broadcast as urea and irrigated in.
3. The resulting N rates are: 19, 84, 147, and 206 lbs/A.

Soil

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

Weed Control

2 pt/A (2 lb/A) Dual + 1.5 qt/A (1.5 lbs/A) Bladex on May 12, 1989.

Table 2. Effect of tillage and position relative to the row on soil covered by corn residue in corn at Wadena Co. on May 15, 1989[1].

	Tillage			
	NoTill	Disc	Mldbd	
Location	----- % cover ------			Avg.
In Row	92.2a	42.8b	9.5c	48.1
Between Row	97.6a	45.9b	10.3c	51.3
Average	94.9a	44.3b	9.9c	

1. The p value for residue location, tillage and tillage by location interaction are .198 (n=192), .001 (n=128), .943 (n=64) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 3. Effect of N rate and position relative to the row on soil covered by corn residue in corn at Wadena Co. on May 15, 1989[1].

	N Rate (lbs/A)			
	19	84	147	206
Location	-------- % cover --------			
In Row	43.8	50.5	47.4	50.9
Between Row	49.9	52.8	50.3	52.0
Average	46.8	51.7	48.8	51.4

1. The p value for residue for N rate and N rate by location interaction are .481 (n=96), .813 (n=48) respectively. Means within the same row with the same letter are not significantly different (α=.10).

Table 4. Effect of tillage, residue position and N rate on soil covered by corn residue in corn at Wadena Co. on May 15, 1989[1].

	Tillage								
	NoTill		Disc		Moldboard		No Till	Disc	Moldbd
	In Row	Btwn Row	In Row	Btwn Row	In Row	Btwn Row	Average		
N Rate	---------- % cover ----------								
19 lb/A	84.0	95.8	39.3	42.8	8.0	11.3	89.9	41.0	9.6
84 lb/A	95.8	99.3	44.8	48.8	11.0	10.5	97.5	46.8	10.8
147 lb/A	95.0	96.8	37.0	44.5	10.3	9.5	95.9	40.8	9.9
206 lb/A	94.0	98.5	50.0	47.8	8.8	9.8	96.3	48.9	9.3

1. The p value for tillage by N rate by location interaction is .898 (n=16) and the p value for tillage by N rate interaction is .981 (n=32).

Table 5. Effect of tillage on early growth of corn at Wadena Co[1].

	Tillage			
	NoTill	Disc	Mldbd	
Date	---- leaves/plant --			Sig.
5/22/89	0.64c	1.48b	1.80a	.001
5/25/89	0.68c	1.69b	2.06a	.001
5/30/89	0.88c	2.12b	2.74a	.001
6/2/89	1.00c	2.55b	2.90a	.001
6/6/89	1.89c	3.36b	3.96a	.001
6/9/89	2.53c	4.01b	4.74a	.001
6/13/89	3.17c	4.99b	5.78a	.001
6/15/89	3.63c	5.31b	6.03a	.001
6/19/89	4.18b	6.52a	6.35a	.080
6/22/89*	6.12c	7.96b	8.65a	.001
6/26/89	6.95c	8.47b	9.32a	.001
6/29/89	7.43c	9.12b	10.21a	.001
7/3/89	8.40c	10.36b	11.39a	.001
7/10/89	10.21c	11.36b	11.95a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=64. *n=32).

Table 6. Effect of N rate on early growth of corn at Wadena Co[1].

	N Rate (lbs/A)				
	19	84	147	206	
Date	-------- leaves/plant --------				Sig.
5/22/89	1.32a	1.27a	1.30a	1.34a	.636
5/25/89	1.54a	1.39b	1.46a	1.52a	.003
5/30/89	1.99a	1.83c	1.88bc	1.97ab	.027
6/2/89	2.25a	2.06c	2.12bc	2.17ab	.010
6/6/89[2]	3.15a	2.89b	3.07a	3.18a	.001
6/9/89	3.87a	3.70b	3.71b	3.77ab	.094
6/13/89	4.67a	4.51b	4.66ab	4.74a	.096
6/15/89	5.00a	4.96a	4.92a	5.08a	.182
6/19/89	5.57a	5.60a	5.75a	5.81a	.849
6/22/89*	7.33c	7.54b	7.69ab	7.75a	.001
6/26/89	7.95c	8.22b	8.45a	8.37ab	.001
6/29/89[2]	8.52c	8.79b	9.17a	9.21a	.001
7/3/89	9.41c	10.06b	10.33b	10.41a	.001
7/10/89	10.65d	11.19c	11.35b	11.51a	.039

1. Means within the same row with the same letter are not significantly different (α=.10, n=48, *n=24).
2. N application on 6/6 and 6/30.

Table 7. Effect of tillage and N rate on early growth of corn at Wadena Co (n=16).

	Tillage												
	No Till				Disc				Moldboard				
	N Rate (lbs/A)				N Rate (lbs/A)				N Rate (lbs/A)				
	19	84	147	206	19	84	147	206	19	84	147	206	
Date	leaves/plant												Sig.[1]
6/6/89	2.13	1.64	1.83	1.99	3.40	3.16	3.44	3.46	3.92	3.88	3.96	4.09	.019
6/9/89	2.83	2.49	2.32	2.50	4.06	3.95	4.03	4.01	4.73	4.64	4.77	4.81	.041
7/10/89	9.47	10.14	10.49	10.75	10.56	11.44	11.61	11.81	11.90	11.97	11.94	11.97	.001

1. The p value for the tillage by N rate interaction.

Table 8. Effect of tillage on corn population at Wadena Co[1].

	Tillage			
	NoTill	Disc	Mldbd	
Date	plants/Ax10^{-3}			Sig.
5/22/89	21.2c	39.6b	45.4a	.001
5/25/89	34.1c	40.7b	46.4a	.001
5/30/89	36.4c	44.4b	46.8a	.001
6/2/89	38.7c	45.0b	46.9a	.001
6/6/89	39.8c	45.6b	47.3a	.001
6/9/89	40.1c	45.3b	47.0a	.001
6/13/89	39.8c	45.2b	46.9a	.001
6/15/89	39.9c	45.3b	46.9a	.001
6/19/89	39.8c	45.1b	46.9a	.001
6/22/89*	39.6b	46.3a	47.2a	.001
6/26/89	39.6c	45.5b	47.1a	.001
6/29/89	39.7c	45.5b	47.0a	.001
7/3/89	39.7c	45.3b	46.9a	.001
7/10/89	39.8c	45.4b	47.1a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=64, *n=32).

Table 9. Effect of N rate on corn population at Wadena Co[1].

	N Rate			
	19	84	147	206
Date	plants/Ax10^{-3}				Sig.
5/22/89	39.8a	33.1b	33.8b	34.8b	.001
5/25/89	42.6a	38.5b	40.0b	40.5b	.016
5/30/89	44.6a	41.1b	41.9b	42.5b	.016
6/2/89	44.7a	42.6a	43.5a	43.3a	.212
6/6/89	45.5a	43.2b	44.6ab	43.6b	.064
6/9/89	45.4a	42.9b	44.5ab	43.9ab	.059
6/13/89	45.4a	42.8b	44.3ab	43.6b	.032
6/15/89	45.4a	42.8c	44.4ab	43.5bc	.030
6/19/89	45.4a	42.4c	44.5ab	43.6bc	.010
6/22/89*	44.6a	43.1a	45.2a	44.6a	.442
6/26/89	45.3a	43.1a	44.2a	43.9a	.121
6/29/89	45.5a	42.9b	44.1ab	43.8b	.051
7/3/89	45.3a	42.7c	44.4ab	43.6bc	.043
7/10/89	45.4a	42.8b	44.4ab	43.8ab	.039

1. Means within the same row with the same letter are not significantly different (α=.10, n=48, *n=24).

Table 10. Effect of tillage and N rate on population of corn at Wadena Co (n=16).

	Tillage												
	No Till				Disc				Moldboard				
	N Rate (lbs/A)				N Rate (lbs/A)				N Rate (lbs/A)				
	19	84	147	206	19	84	147	206	19	84	147	206	
Date	plants/Ax10^{-3}												Sig.[1]
5/22/89	30.9	17.8	17.1	19.1	41.7	35.5	40.3	40.7	46.7	46.0	44.1	44.6	.104
6/6/89	42.7	38.1	40.6	37.7	46.0	42.8	46.4	47.3	47.9	48.6	46.7	45.8	.024
6/9/89	42.9	37.9	40.8	38.8	45.4	43.0	46.0	47.2	47.8	47.7	46.7	45.8	.060
6/13/89	42.7	38.2	40.0	38.3	45.8	42.6	46.1	46.5	47.6	47.5	46.7	45.8	.104
6/15/89	42.9	38.2	40.2	38.2	45.6	42.6	46.4	46.5	47.8	47.4	46.6	45.8	.084
6/19/89	42.6	38.2	40.1	38.4	45.7	41.5	46.6	46.6	47.8	47.4	46.7	45.7	.038
6/26/89	42.6	38.1	39.5	38.3	45.6	43.1	46.4	47.0	47.8	48.0	46.7	46.2	.072

1. The p value for the tillage by N rate interaction.

Table 11. Effect of tillage on corn plant color at Wadena Co[1].

	Tillage			
	NoTill	Disc	Mldbd	
Date	color scale[2]			Sig.
6/26/89	2.6c	3.2b	3.9a	.009
7/10/89	3.0b	3.8a	4.1a	.003

1. Means within the same row with the same letter are not significantly different (α=.10, n=16).
2. Color scale is 1=yellow, 5=green.

Table 12. Effect of N rate on corn plant color at Wadena Co[1].

	N Rate lb/A			
	19	84	147	206
Date	color scale[2]				Sig.
6/26/89	2.3c	3.2b	3.7ab	3.8a	.001
7/10/89	2.3c	3.8b	4.1ab	4.4a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=12).
2. Color scale is 1=yellow, 5=green.

Table 13. Effect of tillage and N rate on plant color of corn at Wadena Co (n=4).

	Tillage												
	No Till				Disc				Moldboard				
	N Rate (lbs/A)				N Rate (lbs/A)				N Rate (lbs/A)				
	19	84	147	206	19	84	147	206	19	84	147	206	
Date	color scale												Sig.[1]
6/26/89	1.3	2.8	3.0	3.5	2.3	3.0	4.0	3.5	3.5	3.8	4.0	4.5	.051
7/10/89	1.3	3.0	3.8	4.0	2.3	4.3	4.3	4.5	4.3	4.3	4.3	4.8	.015
Average	1.3	2.9	3.4	3.8	2.3	3.7	4.2	4.0	3.9	4.1	4.2	4.7	

1. The p value for the tillage by N rate interaction.

Table 14. Effect of tillage on silk emergence at Wadena Co[1].

	Tillage			
	NoTill	Disc	Mldbd	
Date	%			Sig.
7/28/89	9.7c	66.5b	85.8a	.001
7/31/89	30.9c	82.9b	93.9a	.001
8/3/89	43.5c	88.4b	99.2a	.001
8/7/89	73.8c	96.0b	99.8a	.001
8/9/89	77.2b	98.1a	99.9b	.001
8/15/89	92.4b	100.0a	100.0a	.001
8/18/89	96.6b	100.0a	100.0a	.014

1. Means within the same row with the same letter are not significantly different (α=.10, n=64).

Table 15. Effect of N rate on silk emergence at Wadena Co[1].

	N Rate (lbs/A)				
	19	84	147	206	
Date	%				Sig.
7/28/89	31.3c	55.9b	63.3a	65.5a	.001
7/31/89	53.9c	69.7b	73.6b	79.8a	.001
8/3/89	60.9c	78.4b	82.0b	86.8a	.001
8/7/89	77.5c	92.0b	94.2ab	95.7a	.001
8/9/89	82.4b	94.1a	93.5a	96.8a	.001
8/15/89	94.0b	99.2a	98.4a	98.3a	.001
8/18/89	96.9b	99.8a	98.9a	100.0a	.003

1. Means within the same row with the same letter are not significantly different (α=.10, n=48).

Table 16. Effect of tillage and N rate on silk emergence of corn at Wadena Co (n=16).

	Tillage												
	No Till				Disc				Moldboard				
	N Rate (lbs/A)				N Rate (lbs/A)				N Rate (lbs/A)				
	19	84	147	206	19	84	147	206	19	84	147	206	
Date	%												Sig.[1]
7/28/89	1.0	7.3	15.2	15.1	29.6	69.8	82.0	84.8	63.3	90.8	92.6	96.5	.002
7/31/89	11.0	25.0	39.0	48.6	64.5	87.9	84.6	94.7	86.3	96.1	97.1	96.1	.001
8/3/89	12.5	43.5	51.0	67.0	73.3	91.8	95.0	93.5	96.9	100.0	100.0	100.0	.001
8/7/89	44.4	79.0	83.6	88.2	89.0	97.0	99.2	98.8	99.1	100.0	100.0	100.0	.001
8/9/89	52.5	83.6	82.3	90.3	95.1	98.8	98.4	100.0	99.5	100.0	100.0	100.0	.001
8/15/89	82.2	97.5	95.2	94.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	.001
8/18/89	90.4	99.4	96.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	.001

1. The p value for the tillage by N rate interaction.

Table 17. Effect of tillage on corn grain yield, moisture, stover yield, moisture, and plants with ears at Wadena Co. on October 10, 1989[1].

	Tillage			
	NoTill	Disc	Mldbd	
	bu/A			Sig.
Grain Yield	75c	135b	148a	.001
	%			
Moisture	26.4a	21.6b	21.7b	.001
	ton/A			
Stover Yield	2.13b	2.63a	2.91a	.011
	%			
Moisture	49.8a	48.1a	49.1a	.567
	plants/Ax10⁻³			
Plants With Ears	23.3b	31.1a	33.0a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=16).

Table 18. Effect of N rate on corn grain yield, moisture, stover yield moisture, and plants with ears at Wadena Co. on October 10, 1989[1].

	N Rate (lbs/A)				
	19	84	147	206	
	bu/A				Sig.
Grain Yield	54d	112c	145b	165a	.001
	%				
Moisture	22.3c	24.2a	23.5ab	23.0bc	.007
	ton/A				
Stover Yield	1.50d	2.59c	2.89b	3.14a	.001
	%				
Moisture	51.1a	50.0a	48.5ab	46.6b	.075
	plants/Ax10⁻³				
Plants With Ears	26.0c	29.2b	30.0ab	31.2a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=12).

Table 19. Effect of tillage and N rate on grain yield, moisture, stover yield, moisture and final stand of corn at Wadena Co., (n=4).

	Tillage												
	No Till				Disc				Moldboard				
	N Rate (lbs/A)				N Rate (lbs/A)				N Rate (lbs/A)				
	19	84	147	206	19	84	147	206	19	84	147	206	Sig.[1]
	bu/A												
Grain Yield	28	58	91	123	64	123	168	183	69	156	176	190	.001
	%												
Moisture	23.7	27.9	27.1	26.9	21.3	22.5	21.7	20.9	22.0	22.0	21.5	21.2	.018
	ton/A												
Stover Yield	1.11	2.12	2.35	2.96	1.65	2.58	2.99	3.07	1.79	3.10	3.34	3.40	.074
	%												
Moisture	49.5	50.7	50.8	48.3	53.2	50.7	47.3	42.5	51.1	48.6	47.6	49.2	.235
	plants/Ax10^{-3}												
Plants With Ears	17.1	22.8	25.1	28.2	27.8	30.7	32.1	33.8	33.2	34.2	32.8	31.7	.005

1. The p value for the tillage by N rate interaction.

Table 20. Effect of tillage on % grain N, protein, grain N uptake, % stover N, stover N uptake, and total N uptake at Wadena Co. on October 10, 1989[1].

	Tillage			
	NoTill	Disc	Mldbd	Sig.
	%			
Grain N	1.04c	1.11b	1.18a	.009
	%			
Grain Protein	6.52c	6.94b	7.40a	.009
	lbs/A			
Grain N uptake	39.0c	74.3b	86.6a	.001
	%			
Stover N	0.40	0.41	0.45	.163
	lbs/A			
Stover N uptake	17.1c	22.0b	27.5a	.012
	lbs/A			
Total N uptake	56.1c	100.2b	114.1a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=16).

Table 21. Effect of N rate on % grain N, protein, grain N uptake, % stover N, stover N uptake, and total N uptake at Wadena Co. on October 10, 1989[1].

	N Rate (lbs/A)				
	19	84	147	206	Sig.
	%				
Grain N	0.92d	1.04c	1.19b	1.31a	.001
	%				
Grain Protein	5.72d	6.49c	7.44b	8.17a	.001
	lbs/A				
Grain N uptake	23.6d	56.2c	83.5b	103.3a	.001
	%				
Stover N	0.37c	0.35b	0.43b	0.52a	.001
	lbs/A				
Stover N uptake	10.6d	18.3c	25.8b	33.1a	.001
	lbs/A				
Total N uptake	34.9d	74.5c	109.3b	136.5a	.001

1. Means within the same row with the same letter are not significantly different (α=.10, n=12).

Table 22. Effect of tillage and N rate on % grain N, protein, grain N uptake, % stover N, stover uptake and total N uptake at Wadena Co. on October 10, 1989, (n=4).

	Tillage												
	No Till				Disc				Moldboard				
	N Rate (lbs/A)				N Rate (lbs/A)				N Rate (lbs/A)				
	19	84	147	206	19	84	147	206	19	84	147	206	Sig.[1]
	%												
Grain N	0.91	1.00	1.07	1.21	0.90	1.02	1.22	1.30	0.94	1.10	1.29	1.40	.229
	%												
Grain Protein	5.66	6.22	6.66	7.58	5.63	6.36	7.60	8.15	5.87	6.89	8.05	8.78	.229
	lbs/A												
Grain N uptake	11.4	27.4	46.0	70.7	27.8	59.6	96.9	113.1	31.1	81.6	107.6	126.2	.186
	%												
Stover N	0.45	0.32	0.35	0.48	0.37	0.34	0.43	0.50	0.29	0.38	0.52	0.59	.001
	lbs/A												
Stover N uptake	9.9	13.8	16.5	28.3	11.7	17.2	25.6	30.8	10.5	24.0	35.2	40.3	.004
	lbs/A												
Total N uptake	21.7	41.1	62.6	99.0	43.5	76.8	122.5	143.9	41.5	105.6	142.8	166.5	.072

1. The p value for the tillage by N rate interaction.

The Effect of Tillage on Corn Phenology and Response to Applied Nitrogen Following Alfalfa Under Irrigated Conditions: a Three Year Summary[1]

J.F. Moncrief, M.J. Wiens, and J.J. Kuznia[2]

The purpose of this study is to evaluate the impact of tillage on the amount of nitrogen available to corn following alfalfa. The study was conducted on an excessively well drained soil under irrigation. Tillage reduced the amount of nitrogen available to corn during the first year. In the second year nitrogen responses were similar between tillage systems. During the third year there was a reduction in nitrogen available under conservation tillage systems. Tillage also affected corn emergence and phenology. Soil cover by corn residue was much more detrimental to corn development than alfalfa residue. When residue levels were greater than 40% there were large delays in emergence and development.

There has been a recent emphasis of farmers to adopt conservation tillage systems to meet the conservation compliance provisions of the 1985 Food Security Act. There has also been concern that nitrate-nitrogen losses to groundwater have been occurring on the sandy soils of central Minnesota. This study was conducted to investigate the effect of management of crop residues for erosion control on corn development and nitrogen availability from alfalfa.

Corn is one of the most sensitive crops to the effects of crop residues in the row area. This is primarily for the following reasons: 1.) poor seed to soil contact which reduces the rate of imbibition of soil water, 2.) reduced soil temperatures, and 3.) alleopathic inhibition of germination and early growth.

Most of the sensitive soils to erosion and contamination by nitrate are being farmed for milk production. One factor that is needed to reduce nitrogen losses to groundwater are more precise nitrogen credits from preceding alfalfa crops. This may include tillage affects on nitrogen available from alfalfa, soil organic matter, and fertilizer.

Methods and Materials

Experimental Design

The design is a split plot with tillage main plots and nitrogen subplots with four replications. There are three tillage and four nitrogen treatments.

Soil

The soil at this site is a Verndale (Udic Argiborolls, coarse-loamy, mixed) sandy loam with a slope of 0 to 2 percent. Organic matter is 2.8 percent in the top 10 inches. There is very little organic matter below this depth. The surface 20 inches is a sandy loam texture and below this coarse sand.

Alfalfa

Alfalfa density was measured on April 28, 1987 by a stratified random technique. Crown density was measured in four one meter square samples at randomly selected one meter rectangular coordinates within each proposed tillage plot. Crowns were identified as viable or non viable based on visible signs of growth at this time.

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[1] Support for this project was provided by the U.S.D.A., Soil Conservation Service, the Minnesota Department of Agriculture, Energy and Sustainable Agriculture Program, and the Staples Area Technical College, Irrigation Center. Their support is greatly appreciated. A special thanks to Ms. Becky Sheets who was responsible for much of the data collection.

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Table 1. Alfalfa crown density on proposed tillage plots on April 28, 1987 before establishment of tillage and nitrogen treatments (n=16).

Tillage	Viable	Non Viable	Total
	----Crowns/ft.^{2}-----		
No Till	1.68	.98	2.66
Spring Disc	1.97	1.02	2.99
Moldboard	1.87	1.09	2.95

Tillage

All tillage was done in the spring of each year. Three tillage systems were evaluated: moldboard plowing with plow packer attached, double discing with light tandem finishing disc, and no tillage. There was no row cultivation. Moldboard plowing was approximately 6 inches deep and had no secondary tillage, discing was 3 to 4 inches deep. The planter used was a conventional four row planter equipped with 2 inch fluted coulters ahead of disc openers for seed placement and separate disc openers for dry fertilizer placement 2 inches beside the seed. Row spacing was 30 inches.

A single cross hybrid was used (Pioneer 3790).

Nitrogen

Nitrogen was applied in two applications in 1987 and 1988, a small amount of nitrogen was applied with the planter and the remainder was applied at the time indicated in table 3. In 1989 a small amount of nitrogen was applied with the planter and the remainder split between two equal applications at the times indicated in table 3. Nitrogen was applied as urea. Broadcast applications preceded irrigation of .3 to .5 inches of water to minimize immobilization and volatilization losses. Irrigation was kept to a minimum to minimize leaching as urea before fertilizer was hydrolyzed to ammonium.

Table 2. Dates of planting, harvest, and first frost.

	Planting	Harvest	Frost
1987	5/11	10/1	10/2
1988	4/27	9/29	10/2
1989	5/10	10/10	9/23

Table 3. Dates of nitrogen application, rates, and corn growth.

	1987	1988	1989	Nitrogen Rates[1] 1987	1988	1989
Planting	5/11	4/27	5/10	---lbs/acre---		
Growth	8 leaf	8 leaf	3 leaf	16	20	26
Date	6/16	6/1	6/1	51	63	90
				83	117	150
Growth			9 leaf	118	184	208
Date			6/30			

1. Nitrogen applied as urea with the planter or broadcast ahead of .3 to .5 inches of irrigation. The first rate is planter applied nitrogen, the remaining rates are planter applied plus broadcast.

Cover by Crop Residue

Two rows at two locations (stratified random technique) were located within each nitrogen subplot and ten feet lengths marked with flags after planting. These were used as monitoring sites throughout the season. A line transect method (a ten foot line with 25 points) was used to measure soil cover in and between the row. "In row" is defined as four inches centered over the row, the remainder is defined as between the row.

Emergence and Early Growth

At the same monitoring sites during emergence plants were counted every other or third day. Leaves were also counted and recorded until about 12 leaves. Leaves were estimated to the nearest 1/4 leaf.

Silk Emergence

At anthesis plants with emerged silk were tallied within monitoring sites daily until all plants had emerged silk.

Color Evaluation

After pollination color of plants were evaluated based on a scale of from one to five with five being the darkest green and one being light green or yellow.

Grain and Stover Yields

A fifty foot row within each plot was hand harvested, shelled, and weighed to estimate yields. About a 500 gm. subsample was taken to estimate moisture. Samples were weighed in the field and dried to constant weight at 60°C and weighed again. Dry weight was assumed to be at 0 moisture.

The same fifty foot row was chopped and weighed after grain was picked to estimate stover yields.

Nitrogen Analysis

Stover and grain samples were ground to pass a 1mm sieve and analyzed for total nitrogen with a micro Kjeldahl technique.

Results and Discussion

Tillage Effects on Corn Phenology

Growing Degree Days and Precipitation

Growing degree days are shown in figure 1. Accumulation of growing degree days in 1988 and 1987 were very similar until about 30 days after planting. Temperatures were lower in 1989 but final cumulative growing degree days were similar at the end of the season.

Precipitation was very much below normal in 1987 and 1988.

Soil Cover

Soil cover is shown in table 4. It is surprising that the amount of soil cover resulting from tillage treatments was similar for the three years of the study. Soil cover was similar following alfalfa and corn for a given tillage system. There was also very little effect of the planter mounted fluted coulter on removal of crop residue from within the row.

Table 4. The effect of tillage on soil cover by crop residue in and between the row[1].

	Tillage					
	No Till		Disc		Moldboard	
	In	Btw	In	Btw	In	Btw
Year	%					
1987	92	97	48	41	13	11
1988	84	90	64	57	9	6
1989	92	98	43	46	10	10
Avg.	89	95	51	48	10	9

1. "In row" is defined as being a 4 inch strip centered over the row. "Between row" is defined as the remainder.

Emergence

Emergence is shown in figure 2. In 1987 although soil cover ranged from 10 to 90% in the corn row over the range of tillage systems studied emergence was affected very little by tillage. Tillage had a statistically significant effect on stand on the eighth, ninth, and tenth day following planting only. About eighty percent of plants were emerged within a three day period (eight days following planting). Alfalfa plant residues had very little effect on corn emergence and emergence was rapid. Final stands were similar.

In 1988 corn grown under no till conditions were just beginning to emerge about 10 days after planting while those grown with moldboard plowing were completely emerged. Disc and no till treatment corn were fully emerged at 17 and 21 days following planting respectively. Unlike 1987 following alfalfa at similar residue levels, tillage expanded the emergence period 11 days following corn in 1988. Final stands were also similar in 1988.

In 1989 corn under moldboard plowing was fully emerged by 11 days after planting. Disc and no till treatment corn were emerged by 20 and 23 days after planting respectively. Final stands were similar for the disc and moldboard systems. No till grown corn had final stands reduced about 15%. At these plant densities grain yields would not be expected to be affected.

Alfalfa residue in 1987 at similar levels of soil cover as corn in subsequent years had very little influence on the rate of emergence or final stand. Corn residue delayed emergence in 1988 although final stands were similar between treatments. In 1989 "in row" cover by corn residue from the prior two years had more of an influence on emergence and reduced final stands. This provides evidence as to the importance of crop rotation on minimizing influences of "in row" cover by crop residue.

Early Growth

Early growth is shown in figure 3. Similar to emergence tillage had only a small effect on leaf development in 1987. The three tillage lines are almost congruent. Although differences are small they are in many cases statistically significant however. It took about 44 days to reach for moldboard plow grown corn to reach 12.0 leaves. Disc and no till treatments had corn with 11.8 and 11.1 leaves respectively.

In 1988 tillage effects were apparent from emergence and larger than in 1988. These differences also persisted. At 44 days after planting corn grown with moldboard plowing had reached 11.1 leaves. Disc and no till grown corn was at 9.7 and 8.6 leaves respectively.

In 1989 "in row" cover by corn residue had a large effect on corn growth. Moldboard and disc systems were closer in early growth than the previous year. No till grown corn was delayed by almost two leaves. It also took moldboard grown corn 62 days to reach 12 leaves rather than the 44 days in the previous two years. This is supported by the plotted growing degree days in figure 1.

Alfalfa crop residues in the corn row had a statistically significant but very small influence on early growth of corn. Corn residues had greater influence at similar cover levels. It appears that there is a somewhat additive affect which increases tillage influences on early growth when growing corn after corn. Corn growth was similar in 1987 and 1988. In 1989 early growth was 40 % slower.

Silk Emergence

Silk emergence is shown in figure 4. It took 4 days for 90 % silk emergence in 1987. In 1987 tillage effects on silk emergence showed a trend that was similar to emergence and early growth. Day 72 is the only day with statistically significant differences due to tillage. There is very little influence of tillage on silk emergence.

In 1989 silk emergence took over 20 days for no till grown corn. Moldboard, disc, and no till grown corn had 90 % silk emergence at 82, 88, and 97 days after planting respectively. There were large influences by tillage system on silk emergence date in this year.

Similar to tillage influences on emergence and early growth, silk emergence was influenced very little in 1987 but had large differences in 1989.

Grain Moisture

Tillage influences on grain moisture are shown in figure 5. Tillage increased grain moisture in all three years of the study. Differences in 1987 were very small (1.0%). In 1988 and 1989 although corn grown with the discing treatment had less than 1% higher grain moisture than moldboard plowing, no till grown corn following corn resulted in about 6% higher grain moisture. This is consistent with the tillage effect on corn emergence, early growth and silk emergence.

Tillage Effects on Nitrogen Response

Visual Deficiency Symptoms

The effect of tillage and applied nitrogen on visual symptoms of nitrogen deficiency in 1987 and 1989 are shown in figure 6 and 7 respectively. In 1987 there was very little difference in greenness due to nitrogen

application with corn grown with moldboard plowing. Disc and no till grown corn exhibited visual symptoms of nitrogen deficiency. At the 118 pound per acre rate these two systems still showed less greenness than corn grown with moldboard plowing.

In 1989 corn showed nitrogen deficiency with all tillage systems when only 28 pounds per acre nitrogen was applied with the planter. When additional nitrogen was applied moldboard and disc treatments had similar color at the July 10 observation. No till grown corn still had visibly less green color even when over 200 pounds per acre nitrogen was applied. The second nitrogen application was applied on June 30 after the first observation but 10 days before the second. Corn grown with the moldboard and disc systems showed very little nitrogen stress at the second observation (July 10) with broadcast applications.

Grain Yields

Tillage and nitrogen effects on grain yields are shown in figure 8. When only 16 to 28 pounds per acre of nitrogen was applied with the planter yields were 169, 95, 54 bushels per acre for 1987, 1988, and 1989 respectively. This reflects the amount of nitrogen that was available from alfalfa and soil organic matter for first, second, and third year corn following alfalfa. Tillage did not to appear to effect the apparent available nitrogen from alfalfa to corn with only small amount of planter applied nitrogen (figure 9).

Grain yield responses showed prominent tillage and nitrogen interactions in 1987 and 1989. In 1988, although there were statistically significant tillage effects, they did not interact with applied nitrogen. First year corn did not respond to applied nitrogen when alfalfa was followed with moldboard plowing. As tillage was reduced there was less nitrogen available to first year corn. In 1989 there was a similar tillage effects. The response to applied nitrogen by no till corn in 1989 was linear.

Summary

Corn grown after alfalfa with conservation tillage systems and a planter equipped with fluted coulters resulted in high levels of "in row" cover by crop residues. Soil cover in the row with alfalfa residues had little effect on corn phenology. Similar amounts of soil cover by corn residue in the row had large effects on delayed corn phenology. This was documented by delayed emergence, vegetative growth, silk emergence and grain moisture.

Corn grown with these conservation tillage systems also required higher rates of nitrogen following alfalfa.

Differences between moldboard plowing and spring discing were small. A no till approach produced large differences in delayed corn phenology and higher rates of applied nitrogen.

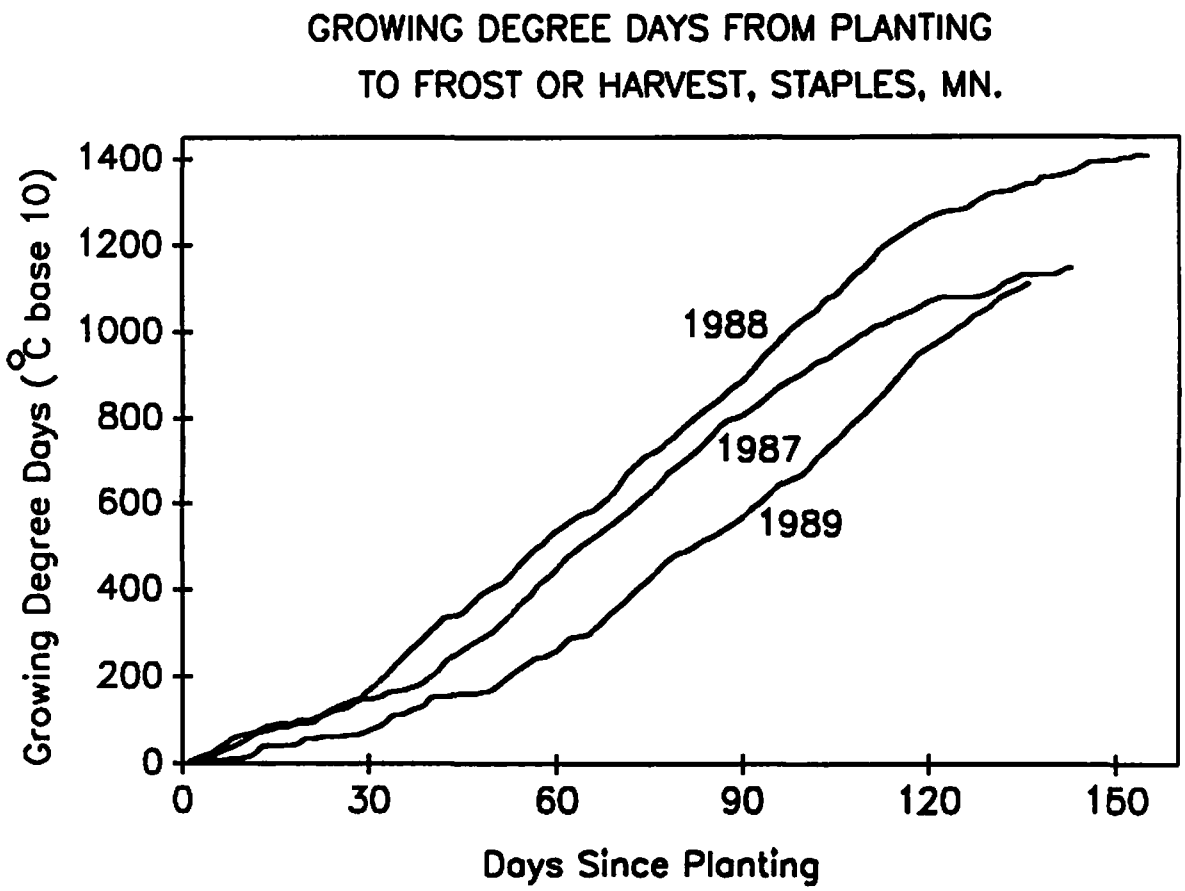


Figure 1. Cumulative growing degree days between planting and either frost or harvest, which ever came first.

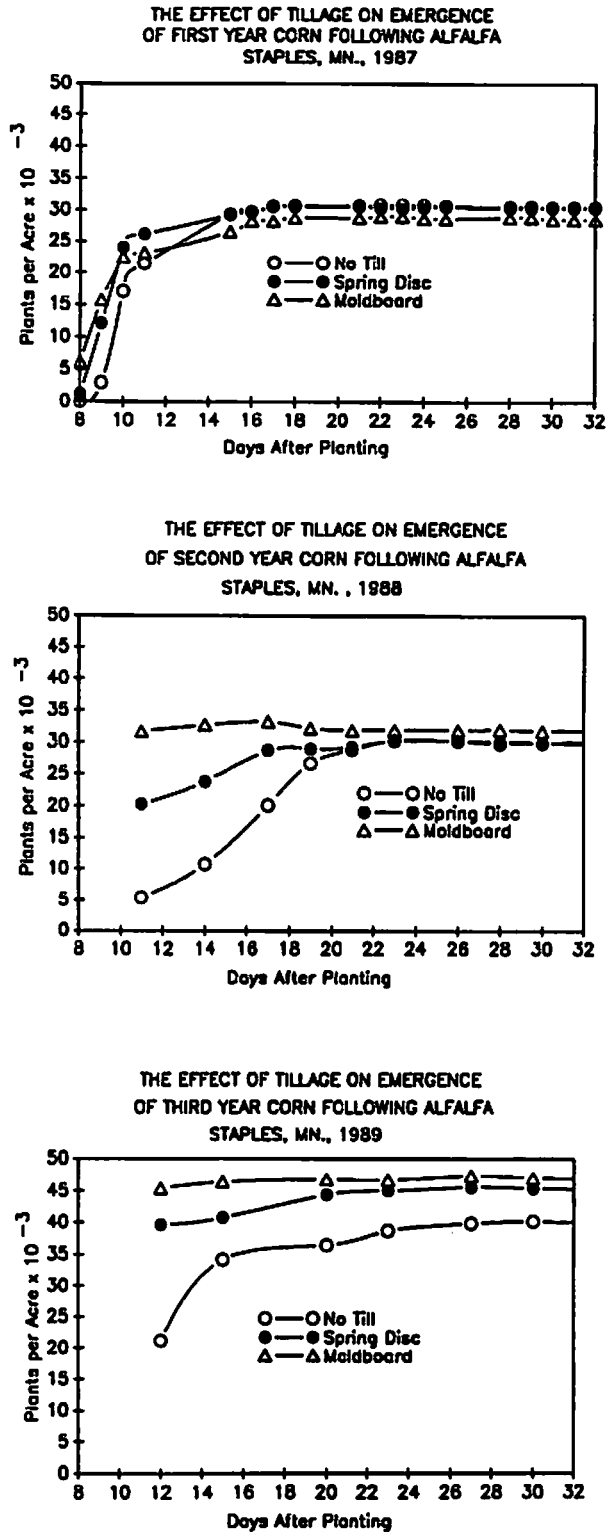
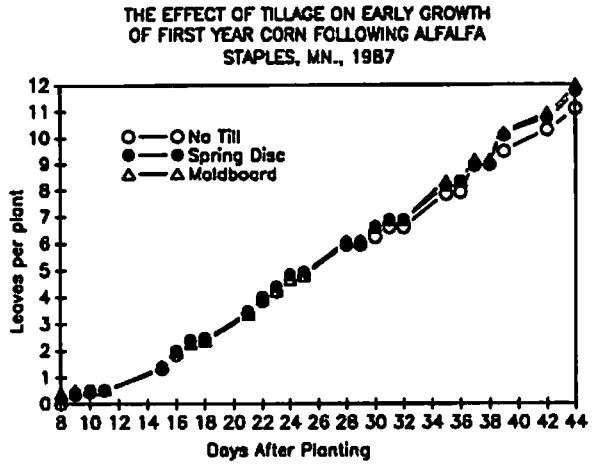
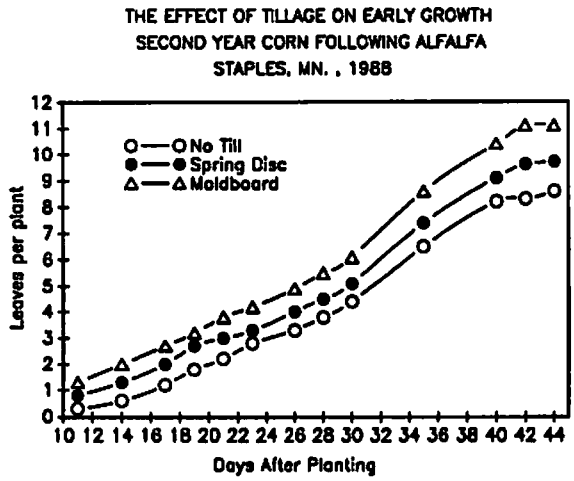


Figure 2. The effect of tillage on the rate of corn emergence following alfalfa.





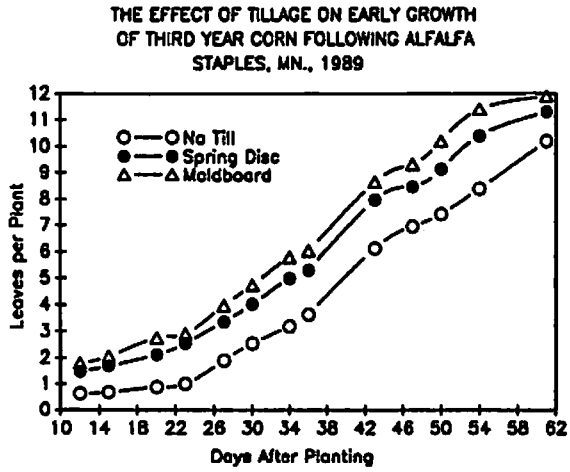
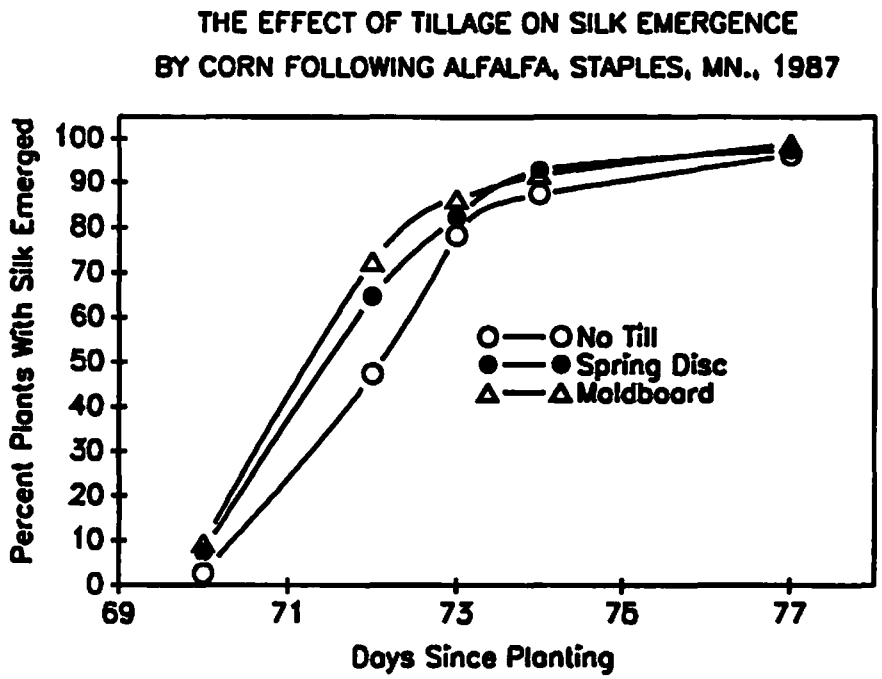


Figure 3. The effect of tillage on early growth of corn following alfalfa.



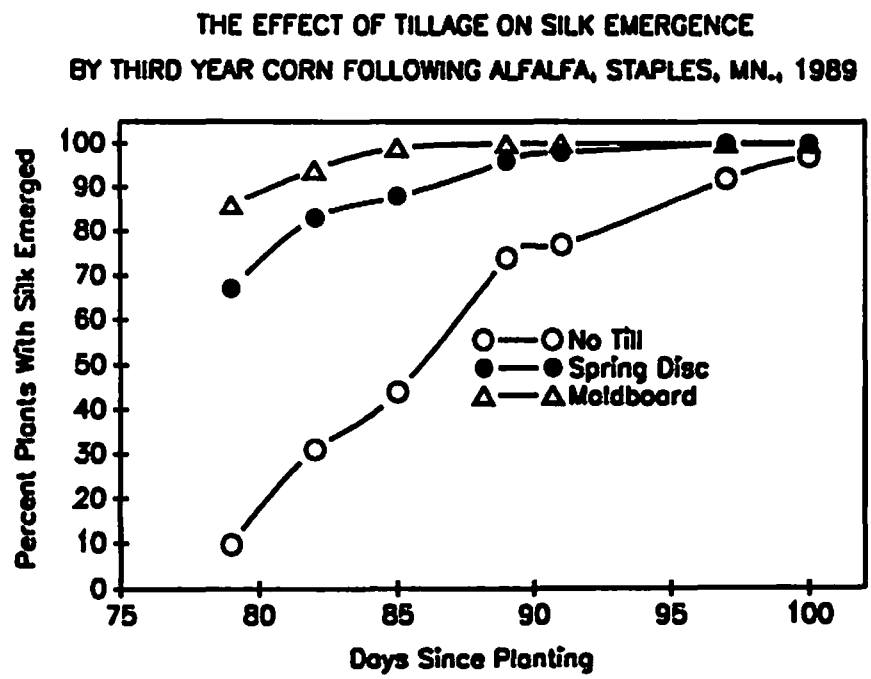


Figure 4. The effect of tillage on the rate of silk emergence by first and third year corn following alfalfa.

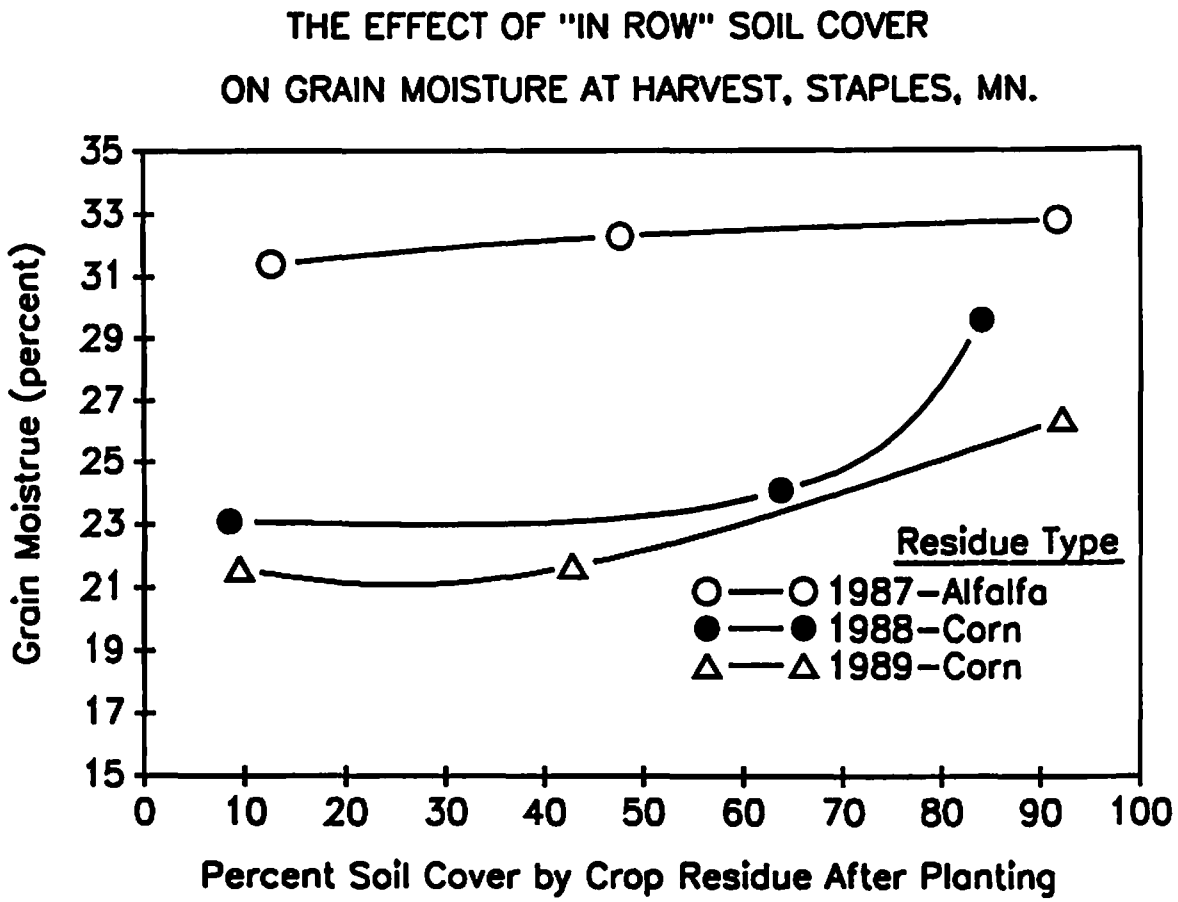
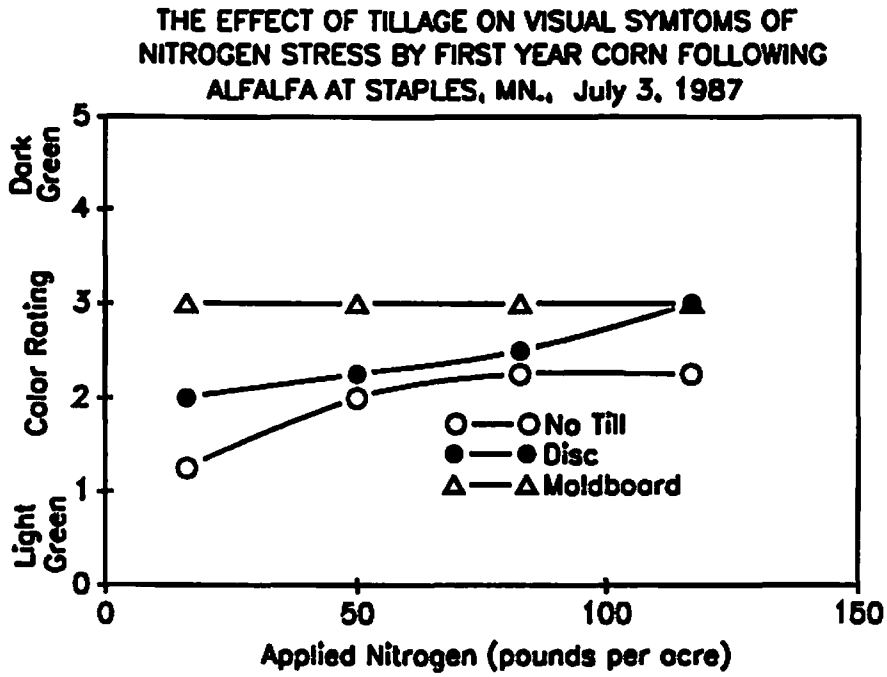


Figure 5. The effect of soil cover in the row by crop residue on corn grain moisture levels at harvest.



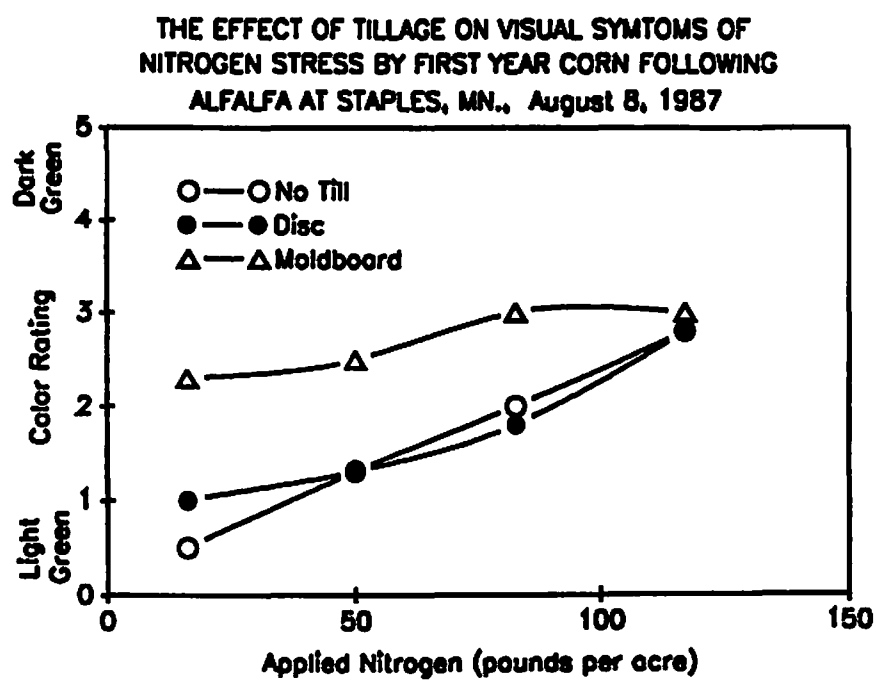
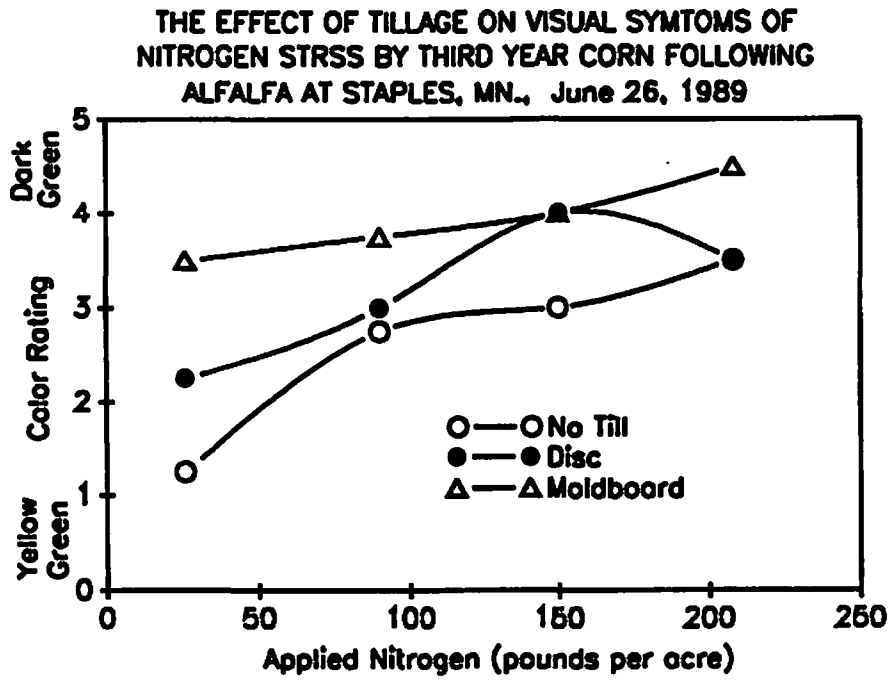


Figure 6. The effect of tillage and applied nitrogen on visual symptoms of nitrogen deficiency by first year corn following alfalfa.



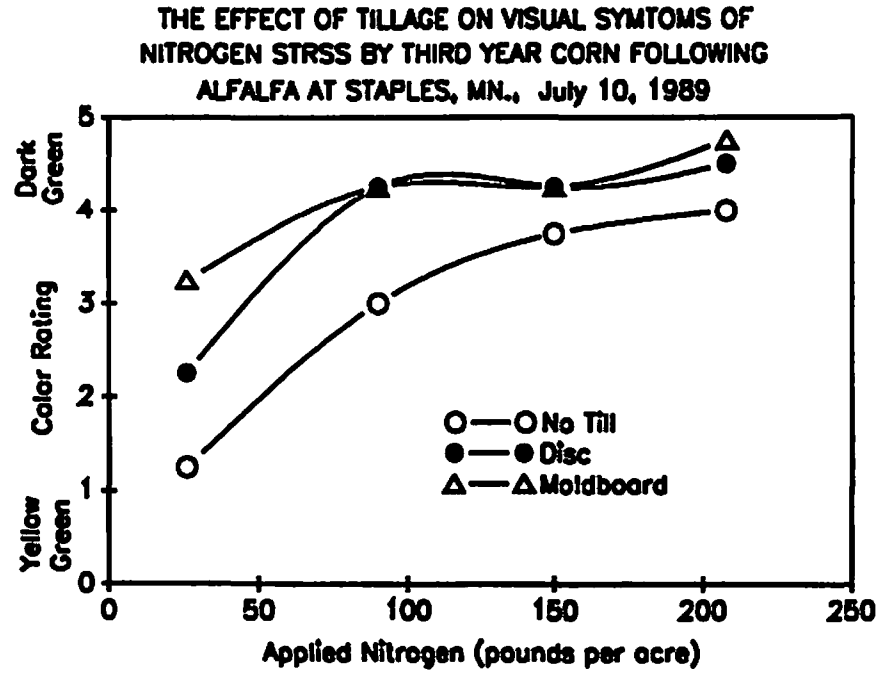
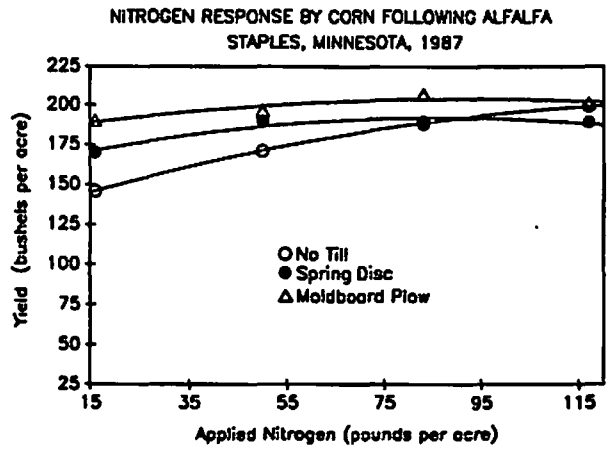
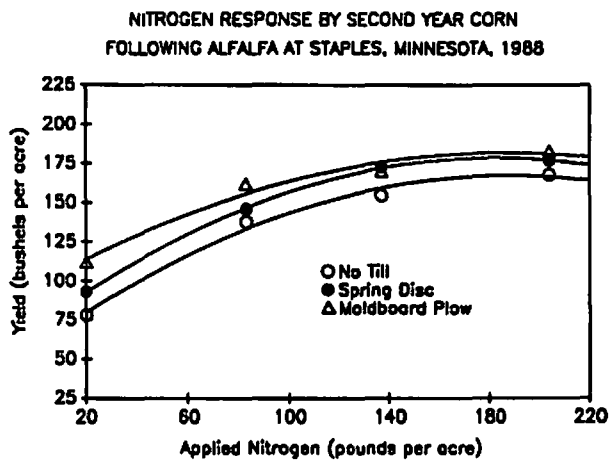


Figure 7. The effect of tillage and applied nitrogen on visual symptoms of nitrogen deficiency by second year corn following alfalfa.





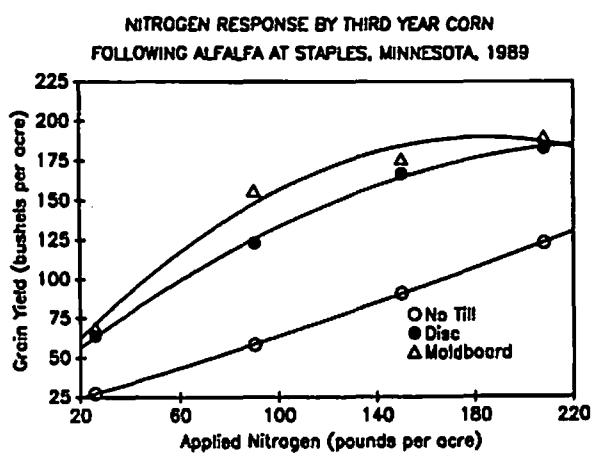


Figure 8. The effect of tillage and applied nitrogen on the grain yield response by corn following alfalfa.

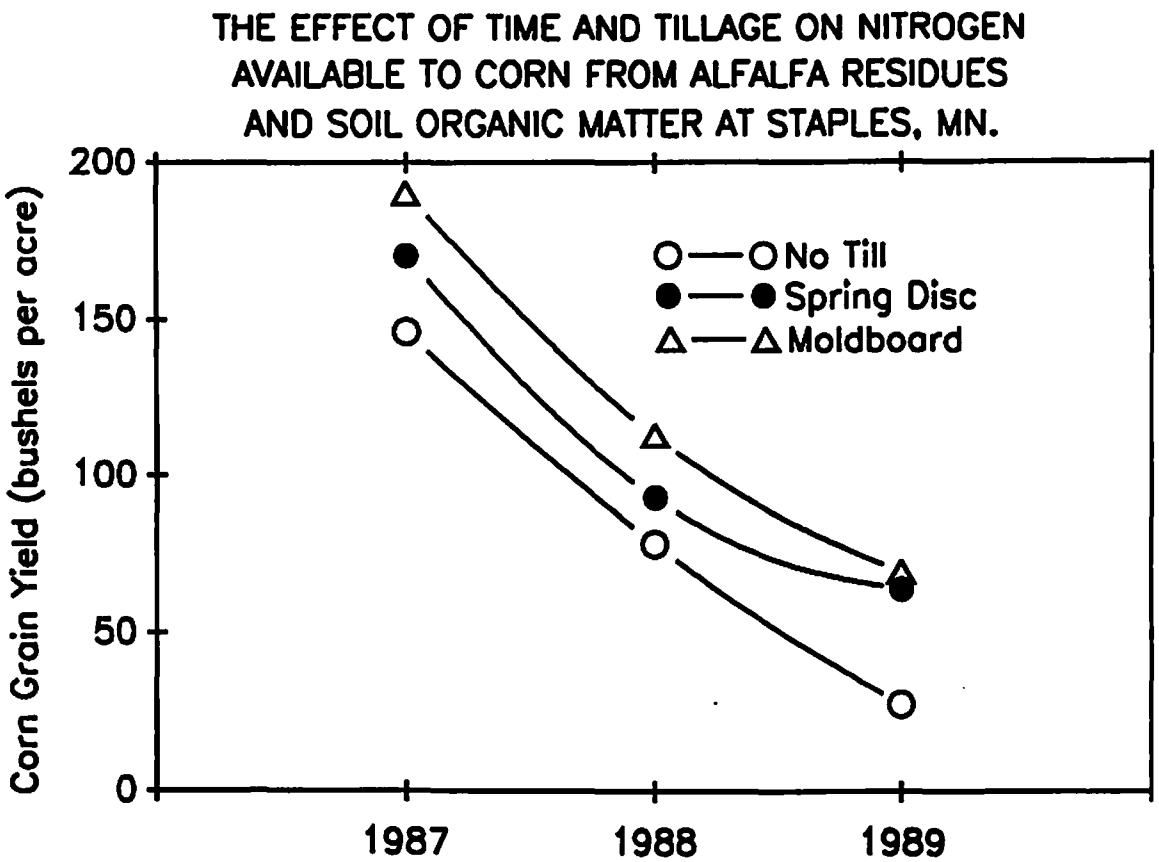


Figure 9. The decrease over time of nitrogen available to corn following alfalfa.

CORN-TILLAGE RESIDUE MANAGEMENT, LANCASTER, WI. 1989

J.B. Swan, A.E. Peterson, W.H. Paulson, R.L. Higgs, and D.L. Linden[1/]

ABSTRACT: Growing conditions were generally favorable in 1989 and corn yields for continuous corn ranged from 135 bu/A for no-till bare to 171 bu/A for the no-till normal residue treatment. Corn residue significantly increased yields on the no-till treatments. No-till bare treatments had significantly lower plant populations than no-till normal treatments. Surface residue treatments emerged later, silked later, and had higher grain moisture at harvest than comparable tillage treatments without surface residue. Surface residue decreased planting depth on conventional (moldboard), chisel and Bush Hog tillage treatments. Depth to residuum again affected grain yields with lowest Rep avg. yield (153 bu/A) on the shallowest depth (29 inches in Rep. 1) and greatest Rep. avg. yields (165 bu/A) on the 46-inch depth (Rep. 3). Exactly 1.00 inch of rainfall occurred after planting prior to installing the runoff plots, and final 20-minute infiltration rates were all below 0.6 in/hr. on the treatments without surface cover (no-till bare and normal moldboard). Infiltration rates on mulch treatments ranged from 1.28 to 2.72 in/hr.

Summary of Results from Lancaster Tillage Research:

Data from the corn tillage residue management research at Lancaster were used to develop a method to estimate corn growth, yield and grain moisture from air growing degree days (Swan et al., 1987a). A simulation model (NTRM) was used to determine grain yields as a function of soil depth for specific probability levels based on simulated site-specific daily climatic values generated for a 100-year frequency (Swan et al., 1987b). A model of the corn yield response to water stress, heat units, and management for the period 1972 through 1984 for the tillage-residue management research was developed, calibrated, and validated (Stricka, 1984, and Swan et al., 1990). The effect of tillage and residue management on seed depth, soil temperature, and corn growth was determined for the period 1984 through 1988 (Swan et al., 1988).

Introduction:

The driftless soil area has the greatest county average estimated soil loss from cropland in Minnesota, ranging from 4.0 to 6.6 t/A/yr. in the six counties involved. Typical soils of the region such as Fayette, Dubuque, Seaton, and associated soils, are highly erodible, form dense crusts if unprotected from raindrop impact, and consequently, have low final infiltration rates and high runoff from the intense storm events common to the region. New and improved tillage practices are increasingly being relied upon to meet environmental goals under more intense cropping systems. These systems modify the soil and water losses as well as the kind and concentration of the materials in the runoff. A more complete understanding of these tillage-residue management systems, and of their effect on soil physical conditions, will allow a more accurate prediction of their effect on the environment and will permit them to be more effectively incorporated into the overall farming systems of the region.

Experimental Procedures:

The experimental site is located on the Lancaster Agricultural Research Station. Four tillage treatments are replicated four times (Table 1). The first replicate is located on Palsgrove silt loam; the other three replicates are on Rozetta silt loam. Each treatment is split into normal and mulched subtreatments. On the no-till plots, an additional subtreatment (bare) - is established by removing all residue prior to planting; this residue is then placed on the adjacent no-till mulched plot. Corn residue additions are made after tillage but before planting to obtain approximately 60 and 80 percent surface cover. Plots are approximately 90 to 100 feet in width and 80 feet in length. Row width was 36 inches in 1989. Pioneer 3737 was planted April 27 at 31,000 plants per acre. The conventional (moldboard) treatment was plowed on April 25, chisel and conventional tillage plots were both disked on April 25, and corn residue was applied on April 25 and 26. No-till was planted with a 4-row John Deere 7000 Max-Emerge planter equipped with fluted coulters on one side and "trash whip" units on the other side which removed residue from an 8 to 90-inch area over the row. Fluted coulters were used on all four rows on the other tillage treatments.

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Nitrogen (250 lbs/A) was broadcast as urea. Starter fertilizer at planting was 200 lbs/A of 6-24-24. The insecticide was 7 1/2 lbs/A of Counter. Pre-emergence herbicide was applied on April 26 before planting (2.5 of Bladex 80W and 2.5 pt/A of Dual 8E). A post emergence application of 1 pt/A of Banvel was made on May 24.

Percent cover was determined from slides taken June 6, 1989. Planting depth, rate of emergence, and silking date measurements were made on designated portions of each plot. Crop height measurements were also recorded. Hourly soil temperatures, leaf number, soil moisture, bulk density, percent cover, and thermal conductivity were measured on chisel, no-till, and Bush Hog treatments in Rep 3. for mulch added, bare and normal treatments. Soil temperature was measured at depths of 1, 6, 11, 16, and 50 cm. Yields for individual plots were determined by hand harvesting 60-foot of row (two subsamples each consisting of paired 15-foot lengths of row) in October.

Ten plot frames (45 3/4 by 45 3/4 inches) were emplaced the first week in May after exactly 1.00 inches of precipitation. Infiltration measurements were made on Bush Hog mulch, no-till bare and mulch, and conventional normal and mulch treatments during the period June 5 through June 8. Tensiometer measurements were made within the plot frame at depths of 3, 7, and 16 inches.

Results-Corn Yields and Crop Height:

Although precipitation was below normal in April, May, June, and July, and was 3.52 inches below normal for the April-October growing season, corn yields ranged from 135 to 171 bu/A. Above average rainfall in August and close to normal air temperatures in 1989 contrasted dramatically with the severe drought and temperature extremes experienced in 1988. Grain yields of individual treatments were significantly different at the 1 percent level, and grain yields were significantly different at the 5 percent level between reps. Grain yields on the no-till bare treatment were significantly reduced compared to all other treatments. Yields on the no-till normal treatments were also significantly greater than the no-till mulch TW treatment. Normal and mulch treatments on the Bush Hog, Chisel, and conventional tillage treatments were not significantly different although plant population was reduced 1400 to 2600 plants per acre on the mulch treatments compared to the normal residue treatments. Plant population was significantly different at the 1 percent level and was not significantly different between reps. Plant population on the no-till normal, no-till mulch coulter, chisel normal and conventional normal treatments were significantly greater than on the no-till bare coulter, no-till mulch TW, and conventional mulch treatments. Tillage and residue effects on grain moisture were not significant.

Corn height reductions on no-till bare, relative to other no-till treatments, were measured starting July 3, 67 days after planting. Height reductions occurred later (about July 17) on the Bush Hog normal treatment. Except for the no-till bare and Bush Hog normal treatments, final corn heights for all other treatments ranged between 180-192 cm. These results contrast markedly with 1988 when a reversal of crop height for high and low cover treatments occurred on all treatments.

Seedbed Conditions and Corn Growth:

Surface residue reduced average seed depth and increased the standard deviation of seed depths on Bush Hog, chisel, and conventional tillage treatments. Compared to the no-till bare treatment, no-till mulch slightly increased seed depth. The no-till mulch TW treatment had lower standard deviation of seed depth than the no-till bare treatments. The effect of mulch on seed depths appeared to be less on no-till than on tilled treatments. Emergence (75%) was delayed from 5 to 8 days by mulch additions, while silking (50%) was delayed 1 to 2 days by mulch additions (Tables 1 and 4). Differences in grain moisture due to treatment were not significant.

Effect of Treatments on Infiltration Rate:

Large differences in "final" (40-60) minute average infiltration rates were measured between treatments in 1989 (Tables 5 and 6). Final infiltration rates from conventional tillage mulch treatments were approximately 5 times the rates for conventional tillage normal treatments. For the nine-year period of measurement, mulch has approximately doubled the infiltration rate on conventional tillage. Infiltration rates on the Bush Hog mulch treatment were also much greater than the conventional normal treatments. On the no-till treatments, double mulch increased final infiltration rates by nearly a factor of 6 in 1989. For the six years of data (1984-1989), double mulch increased the infiltration rate an average of 50 percent on the no-till treatment.

Matric potential measurements on the conventional mulch treatment were frequently positive indicating a flow restricting layer below the plow layer. Negative potential measurements at the three-inch depth under the conventional normal treatment indicate the presence of a surface crust, which is confirmed by the reduced infiltration rates. So little water entered the no-till bare treatment that half the

tensiometers at the three-inch depth did not indicate any water entering due to infiltration. The erratic nature of the tensiometer measurements on the no-till mulch is in accord with other measurements and observations of the major role of macropores in infiltration on this treatment.

The results again illustrate the requirements for rapid infiltration of 1) a porous surface layer with high saturated conductivity, 2) a protective mulch cover, 3) absence of flow restricting layers within the depth of infiltration. Residue cover alone has not been sufficient to produce a high infiltration rate when significant restriction to flow occurs within the infiltrating profile.

Summary:

Five-year yield results (1979-1983) with continuous corn at Lancaster show nearly equal yields from conventional (moldboard) tillage, ridge till, and chisel treatments. Ten-year yield results (1979-1989) show nearly equal yields for conventional, chisel and no-till treatments (Table 8). In 1986, 1987, 1988, and 1989, no-till was the highest yielding treatment. Thus farmers in the driftless soil area can choose between a variety of tillage options which have yields comparable to conventional tillage but which are superior in soil and water conservation and offer savings in time, labor, and fuel compared to the conventional moldboard plow tillage method.

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Table 1. Effect of tillage and residue management on, planting depth, emergence, silking date, population, grain moisture and yield - 1989, Lancaster, WI.

Treatments			Percent Cover		Planting Depth		Days Post Plant to 75% Emerg	Date 50% Silked July	Ave. Popln at Harvest PL/A	Ave.* Grain Yield Bu/A	Ave. Grain Moisture %
Tillage	Residue	In-Row Residue Mgt.	In-Row	Entire Area	Avg mm	S.D. mm					
No-Till	Normal	C			20.8	6.7	24.8	21.5	ab 27,230	a 171.4	18.1
	(N)	TW			22.1	4.9			a 28,560	ab 167.4	19.0
	Bare	C			25.9	6.4	23.5	22.8	e 22,690	d 134.8	17.6
	(O)	TW			26.5	6.4			cde 23,780	d 137.1	17.5
	Mulch	C			27.6	7.0	28.3	22.8	abc 26,620	ab 170.2	18.2
	(2X)	TW			27.8	4.4			de 23,410	c 153.0	18.4
Bush Hog	Normal (N)	C			28.9	5.5	25	21.3	abcd 26,260	bc 162.9	17.9
	Mulch (2X)	C			23.0	8.5	29	23.5	bcde 24,870	abc 159.6	18.4
Chisel	Normal (N)	C			31.0	5.0	25.7	21	abc 26,680	abc 156.5	17.5
	Mulch (X)	C			22.6	6.2	33.5	23.3	cde 23,900	abc 161.1	17.6
Conv.	Normal (N)	C			30.0	4.9	25.3	21.3	abc 26,920	abc 158.6	17.9
	Mulch (X)	C			21.4	8.4	33	23.8	de 23,290	ab 170.2	18.7
	Significance Level								0.01	0.01	NS

*Subplots with population <23,500 omitted

Table 2. 1989 Weather Summary, Univ. of Wisconsin, Lancaster Agricultural Research Station.

Month	Precipitation		Growing Degree Days		Air Temperatures			
	Total	Departure	1989	Departure	Avg. Max.	Avg. Min.	Avg. Daily	Departure
	- - - inches - - -		- - - - - - - - - - - - - - - - - -		of - - - - - - - - - - - - - - - - - -			
April	2.28	-0.72	-	-	56.4	34.1	45.2	-1.8
May	2.34	-1.07	245	-67	67.9	45.1	56.5	-1.5
June	2.44	-1.90	497	-22	78.1	54.3	66.2	-0.9
July	2.51	-1.82	701	+37	85.6	62.2	73.9	+2.2
Aug	5.16	+0.71	591	-2	80.0	58.4	69.2	+0.2
Sept	3.31	-0.24	272	-83	70.2	47.3	58.8	-2.2
Oct.	3.71	+1.32	-	-	61.8	38.4	50.1	+0.1
Total Growing Season	21.75	-3.52	2306	-122				

Last date in spring with minimu temperature:
32° or less 5/7
28° or less 5/7

First day in fall with minimum temperature:
32° or less 9/23
28° or less 10/13

Table 3. Average yields and depth of clay residuum by replicate and monthly precipitation for 1981 through 1989, Lancaster, WI.

Year	Replicate Number 1	2	3	4	Monthly Precipitation May	June	July	August
	Bu/A				inches			
1981	146.8	146.7	142.1	147.1	0.83	4.28	2.91	11.35
1982	150.0	143.4	142.8	147.3	5.46	3.45	5.29	4.06
1983	72.8	85.2	96.4	111.2	5.18	3.28	3.34*	3.12*
1984	107.3	110.4	118.0	120.1	3.92	7.77	2.57**	1.37**
1985	118.5	121.1	129.6	130.6	4.95	1.32***	2.11***	3.34
1986	159.5	162.4	168.6	164.8	3.90	5.47	1.85	3.65
1987	168.3	167.7	170.9	168.0	3.78	4.15	6.71	6.78
1988	52.4	56.2	64.6	62.6	0.87	0.42	1.80	2.92
1989	152.8	159.3	165.0	157.1	2.34	2.44	2.51	5.16
Avg. Depth to Clay Residuum inches	29	41	46	62				

1981 - Subplots with population < 17,000 omitted.
1982 - Missing values estimated for 8 plots out of a total of 48 plots.
1983 - Subplots with population < 18,000 omitted Rep. II, III, IV.
*1983 - 1.13 inches precipitation from July 3 to Aug. 25 (53 days).
**1984 - 1.52 inches precipitation from July 18 - Aug. 31 (45 days).
***1985 - 1.59 inches precipitation from May 28 to July 25 (57 days). Largest rain was 0.36 inches.

Table 4. Influence of tillage method and residue management on rate of emergence, 1989, Lancaster, WI.

Treatment Tillage	Residue	Percent Emergence Days Post Plant 20	22	24	26	28	31	35	40	48
No-Till	Normal	1	20	67	86	97	100	100	100	100
	Bare	7	41	81	89	98	100	100	100	100
	Mulch	0	4	22	50	73	92	94	97	100
Bush Hog	Normal	2	14	57	79	97	99	100	100	100
	Mulch	0	1	13	42	63	79	84	91	100
Chisel	Normal	2	15	54	79	94	97	100	100	100
	Mulch	0	1	20	34	60	69	79	84	100
Conv	Normal	4	16	59	83	98	99	100	100	100
	Mulch	0	1	11	26	52	61	90	95	100

GDD from plant Date April 27

April 17 = Day 1

Table 5. 1989 Lancaster, WI infiltration rate measurement.

Tillage	Residue	Rep.	application rate	Water applied before runoff	Infiltration rate X min. after runoff commences - in/hr. 2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5
			in/hr	inches	inches/hour											
No Till	Bare	E	4.24	0.12	0.88	0.64	0.40	0.16	0.16	0.40	0.40	0.40	0.40	0.40	0.16	0.16
		W	4.32	0.11	0.96	0.72	0.72	0.48	0.48	0.48	0.48	0.96	0.48	0.24	0.24	0.48
	Mulch	E	4.00	0.42	1.60	1.36	1.60	1.60	1.12	1.12	1.12	1.60	1.36	1.36	1.36	1.60
		W	4.00	0.35	2.56	2.08	2.08	2.08	2.08	1.84	1.60	1.84	2.08	2.08	2.08	2.08
Conv.	Normal	E	4.16	0.45	2.00	1.04	0.80	0.80	0.56	0.32	0.32	0.80	0.80	0.80	0.56	0.56
		W	3.84	0.28	1.56	1.44	0.48	0.48	0.36	0.24	0.24	0.24	0.12	0.24	0.24	0.24
	Mulch	E	3.68	1.23	3.20	2.48	2.48	2.48	2.24	2.00	2.48	2.48	2.72	2.72	2.72	2.72
		W	4.16	0.42	2.48	2.24	2.00	1.76	2.24	2.24	1.76	2.00	1.76	1.52	1.52	2.00
Bush Hog	Mulch	E	3.92	0.71	3.20	2.36	2.12	2.00	1.76	1.28	1.04	1.04	1.40	1.40	1.52	1.28
Ro-Till		W	4.00	1.50	2.64	2.64	2.52	2.52	2.52	2.52	2.16	2.16	2.16	2.16	2.04	2.04

Table 6. Infiltration rate 55 minutes after runoff begins (paired observations), Lancaster, 1989.

Tillage	Treatment Residue	1981	1982	1983	1984	1985	1986	1987	1988	1989	Avg.
		inches/hour									
No Till	Bare	--	--	--	1.68	1.00	1.24	1.26	0.84	0.32	--
	Mulch	1.46	1.10	3.53*	0.60	3.02	2.10	1.22	0.82	1.75	1.73
Conv	Bare	0.97	1.52	0.54	1.70	1.40	1.83	1.15	1.80	0.45	1.26
	Mulch	2.72	2.34	1.49	2.90	2.14**	2.25	4.81	2.58	2.21	2.60
		Ratio									
Conv. Bare/Conv. Mulch		0.36	0.65	0.36	0.58	0.65	0.81	0.24	0.70	0.20	0.48
No Till Mulch/Conv. Bare		1.51	0.72	6.53	0.35	2.16	1.15	1.06	0.46	3.89	1.37

* Soil disturbed prior to planting by anhydrous ammonia injection.

** 1 observation only

+ omit 1983

Table 7. Relationship of infiltration rates (Avg. 40 to 60 min. after runoff starts) to matric potential - 1989 Lancaster.

Treatment			Infilt	cm soil depth			
				7.5	7.5	17.5	40
Tillage	Residue	Rep.	in./hr	cm H_2O			
No-Till	Bare	E	0.28	-12	-222	+12	-290
		W	0.36	-39	-438	-48	-392
	Mulch	E	1.42	-14	-18	+13	-54
		W	2.08	-13	-5	+4	-8
Conv	Normal	E	0.68	-30	-38	-1	-104
		W	0.21	-10	-3	-1	-
	Mulch	E	2.12	0	-7	+10	+15
		W	1.70	0	+4	-17	-54

Table 8. 1979 - 1989 Continuous corn tillage yield results, Lancaster, WI.

Tillage Treatment with normal residue	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	79-83	79-89
	bu/A												
Ridge plant	162	157	157	147	100	---	---	---	---	---	---	145	---
No-Till (slot plant)	163	146	151	141	85	108	120	165	177	59	171	137	135
Chisel	160	150	167	154	95	115	125	159	168	57	157	145	137
Conventional	169	159	168	151	89	121	133	164	168	43	159	147	139
Paraplow*	---	---	---	---	---	106	125	162	---	---	---	---	---
Bush Hog	---	---	---	---	---	---	---	---	172	54	163	---	---

* Fall 1983 and Fall 1984