Early Whole Plant Analysis. Total dry matter, tissue N and N uptake of the early whole plant samples (10 plants/plot) taken on July 13-14 are presented in Table 3. Chisel plowing resulted in significantly higher dry matter and total N uptake. Annual application of manure had greater dry matter and N uptake than any other treatment (manure or fertilizer) followed by the year of manure application. Year after manure application and fertilized treatments had lower dry matter and N uptake than the other treatments. The N concentration in the fertilized treatments, however, was higher than the carry over manure treatments.

Plant Population and Stover Yield. Table 4 summarizes the total plant population, stover yields, and stover moisture at harvest. Tillage had no significant influence on plant population or stover dry matter. Stover moisture was significantly greater on no till treatments than chisel.

Previous years potassium affected plant population; however the population of the fertilizer treatments was unaffected by additional potassium. Population increased 4 to 12,000 plants/A where 200 lbs/A K_2O was applied annually on previous year manure application.

The stover yields were highest for the annual manure and fertilized treatments and lowest on year after manure treatment.

Grain Yields, Grain Moisture and Total Dry Matter. Tillage did not significantly affect grain yields and total dry matter (Table 5), but had a significant effect on grain moisture. No till treatments had higher grain moisture than chisel. Annual manure treatment had the greatest average grain and stover yields. Year after manure had the lowest grain and dry matter yields. Year of application and fertilized treatments were intermediate in yield and dry matter. Grain moisture was highest in the no till treatments on the fertilizer treatments followed by carry over manure treatments which had the greatest in row cover. Previous K_2O fertilization significantly increased grain yields.

Grain and Stover N (1987). The results of the N concentration analysis of grain and stover from 1987 are included in this report (Table 6). Both grain and stover N were higher for the manure applied treatments than the carry over treatments. Additional potassium interacted significantly with manure application-higher stover and grain N in the manure applied treatments but lower values in the carry over manure treatments with the addition of potassium. An interaction was observed between tillage, additional K and manure application on stover N. The effect of tillage was nonsignificant on N concentration.

Grain and Stover N (1988). As in 1987, tillage had no significant effect on grain and stover N concentration in 1988 (Table 7); manure had a highly significant effect on grain and stover N. Additional potassium did not affect grain and stover N.

Harvest Index. Tillage did not influence grain and stover yield but tillage had a marked effect on harvest index (Table 8). The analysis of harvest index, a ratio of total grain dry matter to that of total dry matter (grain and stover), shows that no till treatments had more grain per total dry matter than the chisel treatments. The carry over manure treatments had a higher harvest index than any other N treatments.

Soil Water Sampling. Suction water samplers were established on manure and check treatments to monitor nitrate in soil water at 5 ft depth. Due to the drought, it was difficult to obtain samples. The nitrate concentration on the five sample dates is given in Table 9. Annual application of manure had greater nitrate concentrations than other manure treatments. N concentration generally declined with time; however it is difficult to infer any trend from these limited samples.

Soil Moisture. Tensiometers were installed in various manure treatments to monitor soil moisture throughout the season. Because of this years drought, the soil matric potential was more negative than the tensiometer range. Gravimetric soil moisture was taken before planting in April and after harvest in November (Tables 10 and 11). The soil moisture ranged from 20.4 to 23.3% (wt./wt. basis) in April across all tillage and N treatments.

In the first week of November, soil moisture differed markedly by depth with greater moisture in the upper 2 feet depth due to water recharge from fall precipitation. No till treatments had generally higher moisture in the profile than chisel plowing although the difference was not significant. Soil water was not significantly different for in row or between row positions. Check treatments and carry over manure treatments had higher moisture in the top 3 ft depth than any other treatments. However, the ammonium nitrate treatment had lower water content than other treatments in the depth below 3 ft.

Soil Nitrogen (Spring). Soil N analysis data for 0-6", 6-12", 1-2' and 2-5' depth measured in the spring 1988 are presented in Table 12. The ammonium nitrate fertilized treatment had at least twice the amount of total N that was present in any of the manure treatments. Most of this difference was in the lower 3 ft depth. Tillage and N treatments were not significantly different. About 2/3 of the total N in manure treatments was in ammonium form; whereas, more than half was in nitrate form in the fertilizer treatments.

Soil Nitrogen (Fall). A summary of soil N sampled in and between the rows at 1 ft increment to the five feet depth is given in Table 13. The effect of tillage on profile N was not significant. Total nitrogen in the profile was higher for the ammonium nitrate than manure or check treatments (Table 14). Manure applied treatments had higher N than carry over or check. Most of the N in manure treatments was in the ammonium form while more than two thirds of N was in the nitrate form in the fertilizer treatment. There was a significant difference in N due to position of sampling-more N in between the rows than in the row(Table 15). Ammonium nitrate resulted in higher total N between the rows while manure application resulted in higher total N in the row (Table 16). Check and carry over manure did not yield any difference due to row position. About half of the total N in the profile was in the top two feet depth (Table 17). There was greater N in the ammonium form in the rows than between the rows, and greater N in the nitrate form between the rows than in the rows throughout the profile (Table 18). No till treatments had higher N in the rows while Chisel treatments had higher levels between the rows (Table 19).

Table 1. Cultural practices at Goodhue County, MN. IN 1988.

Tillage	**Cropping History**
No Till (Ridged in 1988 on June 29)	Corn since 1981-P 3906.
Chisel Plow-Chiseled on May 16,1988.	1988- Corn Pioneer 3737

Manure Application

Injected liquid dairy manure at the following rate and analysis on May 2,1988.

		Rate		
		Mean	St.Dev	n
Manure	(gal/A)	8623	1010	15
Total-N	(lbs/A)	175	21	15
NH_4-N	(lbs/A)	69	8	15

Planting Information for 1988 Crop Year

A four row 38 inch Hinecker Series 1 Econo Till planter with clearing disks raised.

Planting Date	Rate	Harvested
May 17, 1988	30,000 plants/A	October 7-8, 1988

Fertilizer 1988

Material Analysis	Rate	Tillage	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			--- lb/A ---				
34-0-0	618 lbs/A	No Till	210	0	0	May 12, 1988	Broadcast before tillage on
	500 lbs/A	Chisel	170	0	0		fertilized check treatments

Soil

Timula (Typic Eutrochrepts, coarse-silty, mixed, mesic) silt loam, 2 to 12% slope. Soil is well drained.

Insect Control

6.5 lbs/A (.98 lb/A) Lorsban 15G applied on May 17, 1988.

Weed Control

3 qts/A (3 lbs/A) Lasso + 2.5 qts/A (2.5 lbs/A) bladex + 1 qt/A (.75 lb/A) Roundup on May 20,1988.

Table 2. Residue cover as affected by tillage, row position and manure application in Goodhue County, MN on June 6, 1988.

Location[1]	Year[2]	No Till	Chisel	Mean
		%		
In Row	Year after	67.0	38.0	52.5
	Year of	5.0	9.0	7.0
Between rows	Year after	60.0	22.0	41.0
	Year of	18.0	8.0	13.0

Significance of residue cover

Source	In row	Bet. rows
Tillage(T)	.264	.079
Year(Y)	.184	.156
T*Y	.437	.295

[1] Position of measurements with respect to rows.
[2] Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 3. Early whole plant analysis as affected by tillage, and N source and frequency of application in Goodhue Co. MN on July 13-14, 1988.

Frequency[1] & Source of N	DRY MATTER No Till	DRY MATTER Chisel	DRY MATTER Mean	N CONCENTRATION No Till	N CONCENTRATION Chisel	N CONCENTRATION Mean	N UPTAKE No Till	N UPTAKE Chisel	N UPTAKE Mean
	g/plant			%			mg/plant		
Manure (Yr.after)	42.9	47.3	45.1	1.76	1.61	1.68	758	760	759
Manure (Yr.of)	51.9	56.1	54.0	1.98	1.92	1.95	1031	1080	1055
Manure (Annual)	54.0	61.1	56.4	2.06	2.16	2.10	1113	1318	1181
Ammonium Nitrate	32.6	46.0	39.3	2.32	2.01	2.17	744	929	836
Mean	43.4	52.6	48.7	2.03	1.93	1.98	911	1022	958

Pr>F

	Till(T)	Freq.(F)	T*F
Dry matter	.015	.019	.780
N conc.	.105	.001	.099
N uptake	.059	.005	.568

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 4. Total plant population, stover yield, and moisture as influenced by tillage, and N source and frequency of application in Goodhue Co. MN on Oct 11, 1988.

Frequency & Source of N	K_2O lb/A	PLANT POPULATION No Till	Chisel	Mean	STOVER DRY MATTER No Till	Chisel	Mean	STOVER MOISTURE No Till	Chisel	Mean
		-- plants/A*10^{-3}		---	------ tons/A		-----	------- %		--------
Manure[1]	0	21.5	26.6	24.0	1.3	1.7	1.5	48	45	46
(Yr. after)	200	33.4	30.7	32.0	1.2	1.6	1.4	50	48	49
	Mean	27.5	28.6	28.0	1.2	1.7	1.5	49	47	48
Manure	0	27.2	23.7	25.5	1.8	1.8	1.8	49	44	47
(Yr. of)	200	25.8	27.5	26.6	1.9	1.8	1.8	51	47	49
	Mean	26.5	25.6	26.1	1.8	1.8	1.8	50	45	48
Manure	0	25.2	25.8	25.4	2.3	1.9	2.1	52	50	51
(Annual)	200	28.4	28.7	28.5	1.8	1.9	1.9	54	52	53
	Mean	26.7	27.3	26.9	2.1	1.9	2.0	53	51	52
Ammonium	0	25.2	27.8	26.5	-	-	-	-	-	-
Nitrate	200	26.0	27.1	26.6	1.8	2.0	1.9	58	48	53
	Mean	25.6	27.4	26.5	1.8	2.0	1.9	58	48	53
Mean		26.6	27.2	26.9	1.8	1.8	1.8	52	48	50

	Pr>F						
	Till (T)	Freq. (F)	T*F	K rate (K)	K*T	K*F	K*F*T
Plant population	.713	.648	.901	.062	.490	.006	.058
Stover dry matter	.683	.103	.361	.493	.570	.828	.630
Stover moisture	.048	.253	.810	.358	.934	.980	.920

[1]Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 5. Grain yields, grain moisture, and total dry matter as influenced by tillage, and N source and frequency of application in Goodhue Co. MN in 1988.

Frequency[1] & Source of N	K_2O lb/A	GRAIN YIELDS No Till	Chisel	Mean	GRAIN MOISTURE No Till	Chisel	Mean	TOTAL DRY MATTER No Till	Chisel	Mean
		bu/A			%			tons/A		
Manure	0	111.4	126.0	118.7	23.0	19.0	21.0	4.0	4.8	4.4
(Yr. after)	200	137.7	125.2	131.5	20.9	17.8	19.3	4.4	4.6	4.5
	Mean	124.6	125.6	125.1	22.0	18.4	20.2	4.3	4.7	4.5
Manure	0	148.6	130.6	139.6	18.9	18.7	18.8	5.4	5.0	5.2
(Yr. of)	200	139.2	143.8	141.5	19.0	18.4	18.7	5.1	5.0	5.1
	Mean	143.9	137.2	140.5	18.9	18.6	18.7	5.3	5.0	5.1
Manure	0	144.8	133.2	140.9	19.6	18.0	19.1	5.7	5.1	5.4
(Annual)	200	158.0	139.1	151.3	18.5	20.0	19.0	5.4	5.2	5.3
	Mean	151.1	136.2	146.0	19.1	19.0	19.1	5.6	5.1	5.4
Ammonium	0	126.0	129.1	127.6	32.1	21.5	26.8	-	-	-
Nitrate	200	145.3	144.4	144.9	29.0	18.9	23.9	5.2	5.4	5.3
	Mean	135.7	136.8	136.2	30.5	20.2	25.4	5.2	5.4	5.3
Mean		141.1	133.9	137.9	22.0	19.0	20.7	5.1	5.0	5.1

	Pr>F						
	Till(T)	Freq.(F)	T*F	K rate(K)	K*T	K*F	K*F*T
Grain Yields	.553	.081	.685	.045	.357	.727	.374
Grain moisture	.036	.000	.071	.164	.673	.168	.529
Total dry matter	.621	.208	.332	.827	.761	.920	.835

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 6. Grain N, and stover N as influenced by tillage, and N source and frequency of application in Goodhue Co. MN in 1987.

Frequency[1] & Source of N	K_2O lb/A	N CONC.-GRAIN N-T	Chisel	Mean	N CONC.-STOVER N-T	Chisel	Mean	Significance	Grain N	Stover N
		%			%					
Manure	0	1.86	1.79	1.83	0.55	0.53	0.54	Tillage (T)	.359	.579
(Yr. after)	200	1.73	1.71	1.72	0.42	0.52	0.47	Freq (F)	.040	.002
	Mean	1.80	1.75	1.78	0.49	0.53	0.51	T*F	.901	.697
Manure	0	1.94	1.89	1.91	0.64	0.67	0.66	K Rate(K)	.374	.262
(Yr. of)	200	1.98	1.93	1.96	0.67	0.64	0.66	K*T	.545	.090
	Mean	1.96	1.91	1.94	0.66	0.66	0.66	K*F	.041	.092
Manure	0	1.98	1.95	1.97	0.66	0.65	0.66	K*F*T	.905	.049
(Annual)	200	1.97	1.99	1.98	0.67	0.67	0.67			
	Mean	1.98	1.97	1.98	0.67	0.66	0.67			

[1] Manure applied in the spring of 1986 (year after) and 1987 (year of).

Table 7. Grain N, stover N, grain N uptake, total N uptake as influenced by tillage, and N source and frequency of application in Goodhue Co. MN in 1988.

Frequency[1] & Source of N	K_2O lb/A	GRAIN N NT	GRAIN N Chl	GRAIN N Mean	STOVER N NT	STOVER N Chl	STOVER N Mean	GRAIN N UPTAKE NT	GRAIN N UPTAKE Chl	GRAIN N UPTAKE Mean	TOTAL N UPTAKE NT	TOTAL N UPTAKE Chl	TOTAL N UPTAKE Mean
		----- % -----			----- % -----			--- lbs/A ---			--- lbs/A ---		
Manure	0	1.3	1.3	1.3	0.5	0.5	0.5	69	79	74	82	96	90
(Yr. after)	200	1.4	1.4	1.4	0.5	0.5	0.5	88	80	84	99	95	97
	Mean	1.3	1.3	1.4	0.5	0.5	0.5	78	80	79	90	96	93
Manure	0	1.5	1.5	1.5	0.7	0.6	0.6	105	92	99	129	113	121
(Yr. of)	200	1.5	1.5	1.5	0.7	0.6	0.7	100	106	103	126	129	128
	Mean	1.5	1.5	1.5	0.7	0.6	0.7	103	99	101	127	121	124
Manure	0	1.6	1.6	1.6	0.8	0.7	0.8	108	100	104	145	128	137
(Annual)	200	1.6	1.5	1.5	0.7	0.6	0.7	116	99	108	141	124	133
	Mean	1.6	1.6	1.5	0.8	0.7	0.8	112	100	106	143	127	135

Pr>F

	Till (T)	Freq. (F)	T*F	K rate (K)	K*T	K*F	K*F*T
Grain N	.950	.000	.782	.861	.746	.515	.847
Stover N	.463	.007	.853	.220	.809	.180	.912

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 8. Total grain dry matter and harvest index as influenced by tillage, and N source and frequency of application in Goodhue Co. MN in 1988.

HARVEST INDEX Frequency[1] & Source of N	K_2O lb/A	No Till	Chisel	Mean
Manure	0	0.69	0.66	0.67
(Yr. after)	200	0.74	0.65	0.70
	Mean	0.72	0.65	0.69
Manure	0	0.67	0.64	0.65
(Yr. of)	200	0.63	0.65	0.64
	Mean	0.65	0.64	0.65
Manure	0	0.61	0.64	0.62
(Annual)	200	0.66	0.63	0.65
	Mean	0.63	0.63	0.63
Ammonium	0	-	-	-
Nitrate	200	0.66	0.64	0.65
	Mean	0.66	0.64	0.65
Mean		0.67	0.64	0.66

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 9. Nitrate levels in water samples collected from suction water samplers placed at 5 ft depth as affected by tillage, and frequency of manure application in Goodhue Co. MN in 1988.

Tillage	Frequency[1] and Source of N	Nitrate Concentration[2] 7/28	8/05	8/11	8/24	11/22	Weighted Mean
		ppm					
No Till	Annual	17.8 (2)	-	8.7 (1)	14.5 (1)	10.3 (1)	13.4
	Biennial (Yr of)	11.8 (2)	-	10.7 (1)	-	-	11.5
	Biennial (Yr aft)	-	19.2 (1)	15.8 (1)	9.8 (1)	3.8 (1)	10.4
	Mean	14.8	19.2	11.7	12.2	7.1	11.8
Chisel	Annual	46.8 (1)	-	-			46.8
	Biennial (Yr of)	7.1 (1)	17.7 (2)	-	3.4 (1)	2.3 (1)	8.4
	Biennial (Yr aft)	11.6 (1)	21.2 (3)	8.2 (1)	7.4 (1)	0.4 (1)	12.3
	Mean	21.8	19.8	8.2	5.4	1.4	22.5
Mean (Weighted)		12.8	19.7	10.9	8.8	4.2	17.3

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).
[2] The numbers in the parentheses are the number of observations. Missing numbers indicate that there was not enough sample in the samplers.

Table 10. Soil moisture as affected by tillage, and N source and frequency of application in Goodhue Co. MN on April 14-15, 1988.

Frequency[1] & Source of N	0-6 in. No Till	0-6 in. Chisel	6-12 in. No Till	6-12 in. Chisel	1-2 ft No Till	1-2 ft Chisel	2-5 ft No Till	2-5 ft Chisel
	% (wt./wt.)							
Manure (Yr. after)	22.5	22.4	22.2	22.3	23.3	22.1	21.6	21.1
Manure (Yr. of)	23.0	20.9	21.1	22.0	22.5	21.9	21.4	21.7
Manure (Annual)	22.1	22.2	22.1	21.6	22.4	21.6	22.7	20.5
Ammonium Nitrate	22.4	22.0	22.8	21.7	22.6	22.1	24.9	20.4
Mean	22.5	21.9	22.1	21.9	22.7	21.9	22.7	20.9

Source	Pr>F
Tillage (T)	.177
Frequency and source of N (F)	.482
T*F	.395
Depth (D)	.197
T*D	.102
F*D	.594
T*F*D	.019

[1] Manure applied in the spring of 1986 (year after) and 1987 (year of).

Table 11. Soil moisture as affected by tillage, and N source and frequency of application in Goodhue Co. MN on Nov 2-3, 1988, n=3.

Freq[1] & Source	ROW[2]	0-1 FT NT	0-1 FT Chl	0-1 FT Mean	1-2 FT NT	1-2 FT Chl	1-2 FT Mean	2-3 FT NT	2-3 FT Chl	2-3 FT Mean	3-4 FT NT	3-4 FT Chl	3-4 FT Mean	4-5 FT NT	4-5 FT Chl	4-5 FT Mean
		% (wt./wt.)														
Manure	IR	20.7	20.6	20.7	21.0	20.5	20.8	17.1	14.8	16.0	16.2	13.6	14.9	16.8	16.3	16.6
(Yr.aft)	BR	21.6	20.9	21.2	21.1	19.9	20.5	17.7	15.1	16.4	16.7	14.5	15.6	16.4	16.6	16.5
	Mean	21.2	20.7	21.0	21.1	20.2	20.7	17.4	14.9	16.2	16.4	14.0	15.2	16.6	16.5	16.6
Manure	IR	21.4	20.6	21.0	20.5	19.8	20.2	15.2	14.5	14.9	16.9	16.2	16.6	19.1	17.0	19.0
(Yr.of)	BR	21.2	19.2	20.0	19.5	19.2	19.4	14.0	14.3	14.2	15.7	16.5	16.1	17.6	17.5	17.6
	Mean	21.3	19.9	20.6	20.0	19.5	19.8	14.6	14.4	14.5	16.3	16.9	16.6	18.3	17.2	17.8
Check	IR	19.3	22.4	20.9	19.5	19.2	19.4	15.6	13.8	14.7	16.1	14.2	15.2	15.6	14.7	15.2
	BR	20.6	19.9	20.3	20.7	19.6	20.2	17.6	15.5	16.6	17.0	14.3	15.7	14.6	14.3	14.5
	Mean	20.0	21.1	20.6	20.2	19.4	19.8	16.6	14.7	15.7	16.5	14.3	15.4	15.1	14.5	14.8
Ammonium	IR	21.9	20.3	21.1	20.7	19.3	20.0	14.4	13.0	13.7	14.1	11.5	12.8	15.1	13.4	14.3
Nitrate	BR	20.5	20.0	20.4	20.0	20.3	20.2	14.8	11.7	13.3	14.0	12.3	12.8	14.8	16.0	14.1
	Mean	21.2	20.2	20.7	20.4	19.8	20.1	14.6	12.3	13.5	14.1	11.9	13.0	14.9	14.7	14.8

Source	In Row	Bet Row	Mean
Tillage (T)	.414	.462	.435
Frequency and source of N(F)	.331	.610	.484
T*F	.261	.558	.751
Depth(D)	.000	.000	.000
T*D	.306	.791	.756
F*D	.061	.112	.086
T*F*D	.631	.681	.634

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).
[2] Location of sampling with respect to the row position, IR=in row, and BR=between rows.

Table 12. Soil nitrogen as affected by tillage, and N source and frequency of application in Goodhue Co. MN on April 14-15, 1988, n=2.

Frequency[1] & Source of N	Depth	TOTAL-N No Till	TOTAL-N Chisel	NH_4-N No Till	NH_4-N Chisel	NO_3-N No Till	NO_3-N Chisel
		lb/A					
Manure	0-6"	8.9	7.6	5.1	4.9	3.7	2.8
(Yr. after)	6-12"	5.9	7.3	4.2	4.8	1.7	2.4
	1-2'	10.8	9.7	7.8	6.9	3.0	2.8
	2-5'	22.1	24.5	19.8	17.6	2.2	6.9
TOTAL	(0-5')	47.7	49.1	36.9	34.2	10.6	14.9
Manure	0-6"	10.5	5.6	6.9	3.6	3.6	2.0
(Yr. of)	6-12"	6.2	5.7	4.0	3.4	2.2	2.3
	1-2'	12.7	8.5	7.2	7.1	5.5	1.4
	2-5'	28.2	24.3	21.0	21.3	7.2	3.0
TOTAL	(0-5')	57.6	44.1	39.1	35.4	18.5	8.7
Manure	0-6"	5.3	7.1	4.8	4.4	0.5	3.0
(Annual)	6-12"	4.3	4.0	3.9	3.3	0.7	1.0
	1-2'	8.4	7.8	7.4	6.2	1.0	1.6
	2-5'	20.2	39.6	17.2	31.4	3.0	8.2
TOTAL	(0-5')	38.2	58.5	33.3	45.0	4.9	13.5
Ammonium	0-6"	9.7	11.2	5.0	6.9	4.7	4.3
Nitrate	6-12"	9.9	13.8	4.0	3.7	5.9	10.1
	1-2'	23.8	24.3	9.0	8.3	14.8	16.0
	2-5'	62.4	59.1	23.2	21.7	39.2	37.4
TOTAL	(0-5')	105.8	108.4	41.2	40.6	64.6	67.8

Source	Total-N	NH_4-N	NO_3
Tillage (T)	.9712	.9554	.7306
Frequency and source of N(F)	.1844	.6910	.2281
T*F	.5244	.6304	.5465
Depth(D)	.0156	.0001	.3007
T*D	.7160	.8537	.6772
F*D	.4148	.7001	.5198
T*F*D	.4974	.3322	.4747

[1] Manure applied in the spring of 1986 (year after) and 1987 (year of).

Table 13. Soil nitrogen tests as affected by tillage, N source and frequency of application in Goodhue Co. MN on Nov 2-3, 1988, n=3.

N Freq[1] & Source	ROW[2]	0-1 FT NT	0-1 FT CH	1-2 FT NT	1-2 FT CH	2-3 FT NT	2-3 FT CH	3-4 FT NT	3-4 FT CH	4-5 FT NT	4-5 FT CH	0-5 FT NT	0-5 FT CH
		TOTAL-N lbs/A											
Manure	IR	56.8	29.5	33.1	21.6	13.8	16.7	10.6	14.0	13.6	14.5	127.9	96.3
(Yr.aft)	BR	22.2	33.6	17.8	24.2	13.1	15.1	9.3	14.3	12.7	14.8	75.1	102.0
	MEAN	**39.5**	**31.6**	**25.5**	**22.9**	**13.5**	**15.9**	**10.0**	**14.3**	**13.2**	**14.7**	**101.5**	**99.2**
Manure	IR	21.6	18.5	17.2	13.8	15.0	13.7	14.2	12.2	14.4	13.6	82.4	71.8
(Yr.of)	BR	24.5	17.6	16.9	13.2	15.7	13.1	13.7	9.3	13.6	12.8	84.4	66.0
	MEAN	**23.1**	**18.1**	**17.1**	**13.5**	**15.4**	**13.4**	**14.0**	**10.8**	**14.0**	**13.2**	**83.4**	**68.9**
Check	IR	17.3	15.8	15.0	16.1	15.7	13.3	12.2	11.8	12.2	12.0	73.5	69.0
	BR	18.5	18.2	16.1	15.2	14.6	14.6	12.0	12.8	12.3	12.6	72.4	73.4
	MEAN	**17.9**	**17.0**	**15.6**	**15.7**	**15.2**	**14.0**	**12.1**	**12.3**	**12.3**	**12.3**	**72.9**	**71.2**
Ammonium	IR	69.0	35.5	20.6	22.3	25.5	17.2	34.5	23.4	39.9	46.6	213.1	145.0
Nitrate	BR	75.3	73.5	48.6	69.5	35.9	45.6	27.9	45.2	25.4	66.4	189.5	300.2
	MEAN	**72.2**	**54.5**	**34.6**	**45.9**	**30.7**	**31.4**	**31.2**	**34.3**	**32.7**	**56.5**	**201.3**	**222.5**
		AMMONIUM-N											
	ROW	NT	CH	NT	CH	NT	CH	NT	CH	NT	CH	NT	CH
Manure	IR	16.2	18.2	13.0	15.0	12.2	13.8	9.8	12.6	12.5	13.0	63.7	72.6
(Yr.aft)	BR	14.8	16.9	12.5	14.5	11.8	13.0	8.5	12.8	12.3	13.0	59.9	70.2
	MEAN	**15.5**	**17.6**	**12.8**	**14.8**	**12.0**	**13.4**	**9.2**	**12.7**	**12.4**	**13.0**	**61.8**	**71.4**
Manure	IR	18.3	13.0	15.9	12.7	14.2	12.7	12.8	11.7	13.6	12.5	74.8	62.6
(Yr.of)	BR	20.8	15.0	14.7	11.5	14.8	11.8	11.2	8.2	13.0	11.0	74.5	57.5
	MEAN	**19.6**	**14.0**	**15.3**	**12.1**	**14.5**	**12.3**	**12.0**	**10.0**	**13.3**	**11.8**	**74.7**	**60.1**
Check	IR	13.6	13.2	13.2	15.0	13.2	12.2	10.5	11.1	10.7	11.3	61.2	62.8
	BR	14.9	14.5	14.3	13.6	13.7	13.5	10.3	10.6	11.1	11.0	64.3	63.2
	MEAN	**14.3**	**13.9**	**13.8**	**14.3**	**13.5**	**12.9**	**10.4**	**10.9**	**10.9**	**11.2**	**62.8**	**63.0**
Ammonium	IR	22.9	17.5	15.1	12.5	14.2	12.5	12.5	11.5	13.0	11.0	77.7	65.0
Nitrate	BR	15.1	16.2	16.2	13.8	12.8	12.2	10.1	9.8	11.5	13.6	65.7	65.6
	MEAN	**19.0**	**16.9**	**15.7**	**13.2**	**13.5**	**12.4**	**11.3**	**10.7**	**12.3**	**12.3**	**71.7**	**65.3**
		NITRATE-N											
	ROW	NT	CH	NT	CH	NT	CH	NT	CH	NT	CH	NT	CH
Manure	IR	40.6	11.2	20.2	6.6	1.6	2.9	0.7	1.4	1.1	1.5	64.2	23.6
(Yr.aft)	BR	7.4	16.7	5.4	9.7	1.2	2.1	0.9	1.5	0.4	1.9	15.3	31.9
	MEAN	**24.0**	**14.0**	**12.8**	**8.2**	**1.4**	**2.5**	**0.8**	**1.5**	**0.8**	**1.7**	**39.8**	**27.8**
Manure	IR	3.4	5.5	1.2	1.1	0.8	1.0	1.4	0.5	0.9	1.1	7.7	9.2
(Yr.of)	BR	3.7	2.6	2.2	1.7	0.9	1.2	2.5	1.1	0.6	1.9	9.9	8.5
	MEAN	**3.6**	**4.1**	**1.7**	**1.4**	**0.9**	**1.1**	**2.0**	**0.8**	**0.8**	**1.5**	**9.0**	**8.9**
Check	IR	3.7	2.6	1.7	1.1	2.5	1.1	1.7	0.7	1.5	0.6	11.1	6.1
	BR	3.6	3.8	1.7	1.6	0.9	1.1	1.6	2.2	1.2	1.6	9.0	10.3
	MEAN	**3.7**	**3.2**	**1.7**	**1.4**	**1.7**	**1.1**	**1.7**	**1.5**	**1.4**	**1.1**	**10.1**	**8.2**
Ammonium	IR	46.0	18.0	5.5	9.8	11.3	4.7	22.1	12.0	26.9	36.0	111.8	80.5
Nitrate	BR	60.2	57.3	32.1	55.8	23.1	33.4	17.8	35.4	14.0	52.8	147.2	231.1
	MEAN	**53.1**	**37.7**	**18.8**	**32.8**	**17.2**	**19.1**	**20.0**	**23.7**	**20.5**	**44.4**	**129.5**	**157.8**

Pr>F	Till(T)	Freq(F)	T*F	Row(R)	T*R	F*R	T*F*R	Depth(D)	R*D	T*R*D	F*R*D
Total-N	.7042	.0001	.7818	.0353	.1786	.0664	.5649	.0005	.0536	.0125	.3175
NH_4-N	.2715	.2655	.1313	.1037	.6992	.0862	.0169	.0116	.3006	.5448	.0007
NO_3-N	.8888	.0001	.7401	.0325	.1674	.0585	.6418	.0250	.0374	.0474	.2888

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).

[2] Location of sampling with respect to the row position, IR=in row, and BR=between rows.

Table 14. Effect of source and frequency of N on soil N averaged over chisel and no till treatments in 5'depth in Goodhue Co.,MN Nov 2-3, 1988.

N Freq[1] & Source	Total-N	NH_4-N	NO_3-N
	lbs/A		
Manure (Yr of)	100.5	66.5	34.0
Manure (Yr after)	77.0	67.5	9.0
Check	72.0	63.0	9.0
Ammon. nitrate	212.0	68.5	142.5
Pr>F for Freq.	.0001	.2655	.0001

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).

Table 15. Effect of position of soil sampling on soil total-N averaged over tillage and N treatments in 5' depth in Goodhue Co. MN, on Nov. 2-3, 1988.

Position	Total-N	NH_4-N	NO_3-N
	lbs/A		
In Row	107.0	67.5	39.5
Bet rows	123.5	65.0	58.5
Pr>F	.0353	.1037	.0325

Table 16. Effect of source and frequency of N and row position on soil N in 5' depth averaged over tillage in in Goodhue Co. MN on Nov. 2-3, 1988.

N Frq[1] & Source	Row[2]	Total-N	NH_4-N	NO_3-N
		lbs/A		
Manure (Yr of)	IR	112.0	68.0	44.0
	BR	88.5	65.0	23.5
Manure (Yr after)	IR	77.0	68.5	8.5
	BR	75.0	66.0	9.0
Check	IR	70.0	62.0	8.5
	BR	73.5	63.5	9.5
Ammon. nitrate	IR	167.0	71.0	96.0
	BR	256.5	65.5	191.0
	Pr>F	.0664	.0862	.0585

[1] Manure applied in the spring of 1987 (year after) and 1988 (year of).
[2] Location of sampling with respect to the row position, IR=in row, and BR=between rows.

Table 17. Soil profile N at various depths averaged over tillage, and N treatments in Goodhue Co. MN on Nov 2-3, 1988.

Depth (ft)	Total-N	NH_4-N	NO_3-N
	lbs/A		
0-1	34.2	16.3	17.9
1-2	23.8	14.0	9.9
2-3	18.7	13.0	5.6
3-4	17.4	10.9	6.5
4-5	21.1	12.1	9.0
Pr>F	.0005	.0116	.0250

Table 18. Soil profile N with respect to row position at various depth in averaged over tillage and N treatments in Goodhue Co. on Nov 2-3, 1988.

Depth Feet	Row[1]	Total-N	NH_4-N	NO_3-N
		lbs/A		
0-1	IR	33.0	16.6	16.4
	BR	35.4	16.0	19.4
1-2	IR	20.0	14.0	5.9
	BR	27.7	13.9	13.8
2-3	IR	16.4	13.1	3.2
	BR	20.9	13.0	8.0
3-4	IR	16.6	11.6	5.1
	BR	18.1	10.2	7.9
4-5	IR	20.8	12.1	8.7
	BR	21.3	12.0	9.3
	Pr>F	.0536	.3006	.0374

[1] Location of sampling with respect to IR=in row, and BR=between rows.

Table 19. Soil profile N as affected by tillage and row position of sampling averaged over N averaged over N treatments in Goodhue Co. MN on Nov 2-3, 1988.

Depth		NO TILL			CHISEL		
Feet	Row[1]	Total-N	NH_4-N	NO_3-N	Total-N	NH_4-N	NO_3-N
		lbs/A					
0-1	IR	41.2	17.8	23.4	24.8	15.5	9.3
	BR	35.1	16.4	18.7	35.7	15.7	20.1
1-2	IR	21.5	14.3	7.2	18.4	13.8	4.7
	BR	24.9	14.4	10.4	30.5	13.3	17.2
2-3	IR	17.5	13.4	4.0	15.2	12.8	2.4
	BR	19.8	13.3	6.5	22.1	12.6	9.5
3-4	IR	17.9	11.4	6.5	15.3	11.7	3.6
	BR	15.7	10.0	5.7	20.4	10.4	10.1
4-5	IR	20.0	12.4	7.6	21.6	11.8	9.8
	BR	16.0	12.0	4.0	26.7	12.1	14.5
	Pr>F	.0125	.5448	.0474			

[1] Location of samples with respect to row position, IR=in row, and BR=between rows.

The Effect of Tillage on Corn and Soybean Production on a Typic Hapludalf in Southeastern Minnesota[1]

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

Abstract: A range in tillage from chisel plowing to no till was evaluated for corn and soybean production on a well drained silt loam soil in southeastern Minnesota. Although tillage did affect early corn growth it did not affect corn yields or grain moisture. Tillage affected early growth of soybeans and yields. The soybeans grown with a no till and ridge till system resulted in a five bushel per acre reduction in yield. It is suggested that the yield loss was due to increased weed competition by velvet leaf and row spacing for the ridge till and no till systems respectively.

This is the fifth year of a study to evaluate tillage effects on crop production in a corn-soybean rotation in southeastern Minnesota. For the fifth year tillage has not affected corn yields. The primary affect on soybean yields has been a row spacing response to narrow rows (30" vs 8") of 10 percent.

Tillage ranges from no till to chisel plowing. The planter at this site is a conventional planter equipped with 2" fluted coulters. The reduction of "in row" cover by crop residue was much greater for soybean residue than corn residue (table 4). There was a 20% cover reduction by soybean residue with the ridge till and no till systems. Cover was similar in and between the row for these two systems following corn. In row cover by crop residues was correlated with early growth of corn and soybeans (table 5). When in row cover by soybean residue was less than 20%, corn growth was not affected. No till grown corn had about .4 leaves per plant less growth on July 6. Other systems had similar growth. No till and ridge till soybeans which both had about 55% "in row" cover had about one half trifoliate less than chisel plowed or spring disced grown soybeans which resulted in about 25% cover by corn residue.

Increased tillage resulted in reduced corn stands (chisel plowing and spring discing). The stand differences due to tillage did not affect corn yields. Soybean stands were not affected by tillage.

The weed pressure at this site is generally low (tables 6, 7, and 8). Tillage had little influence on weed species present or their densities in corn. Elimination of full width tillage (no till and ridge till) resulted in increased dandelions (table 6). Spring discing increased volunteer corn in soybeans (table 7). A similar trend in tillage effects on dandelions occurred in the soybeans. The no till and ridge till systems had the most and least weeds in soybeans respectively. Weed densities are low but in this dry year it is likely that the moderate level of weeds in the no till soybeans (bottom of table 8) may have been responsible for the five bushel per acre reduction in yield with this system.

Grain yields and moisture are shown in tables 9 and 10 for corn and soybeans respectively. Corn yields were not affected by tillage. The delayed early growth associated with the no till system (.4 leaves per plant) did not result in an increase in grain moisture. The no till and ridge till grown soybeans resulted in about a 5 bushel per acre reduction in yield. It is likely that the row spacing difference (30" vs 8") is responsible for the reduction in yield with the ridge till system. The similar reduction in yield with no till grown soybeans (5 bushels per acre) is probably due to increased velvet leaf competition.
In summary, for the fifth year tillage has not affected corn yields following soybeans on a well drained silt loam soil in southeastern Minnesota. Soybean yields were five bushels per acre less with a no till and ridge till system. The probable causal agent is increased weed competition by velvet leaf and row spacing for the no till and ridge till systems respectively.

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WABASHA COUNTY

Table 1. Cultural practices for Wabasha County, MN in 1988.

Tillage

No Till

Ridge Till-all but no till corn plots were cultivated and then ridges formed on June 15, 1988
-soybeans ridge formed on July 11, 1988

Spring Disc-corn and soybeans were disced in the spring then field cultivated prior to planting

Chisel-chisel plowed in the fall and field cultivated in the spring

Cropping History

1983-Sweet Clover

1984-87 Corn-Soybean rotation

Crops 1988

Corn-Pioneer 3737

Soybeans-Pioneer 1677

Planting and Harvest Date

The planter used on all corn plots and ridge till soybean plots was a John Deere Max-Emerge six row (30") planter equipped with 2" fluted coulters. The planter used on no till, spring disc, and chisel plow soybean plots was a Tye No Till Drill with 8" row spacing.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 5, 1988	27,700 plants/A	October 13, 1988
Soybeans	May 12, 1988	210,000 plants/A	October 13, 1988

Fertilization History For Corn

		Actual			
Material		N	P_2O_5	K_2O	
Analysis	Rate	--- 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

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

Fertilizer Applied to Corn in 1988

		Actual			
Material		N	P_2O_5	K_2O	
Analysis	Rate	--- lbs/A ---			Date Applied
5-14-42[1]	95 lbs/A	5	13	40	May 5, 1988
82-0-0	183 lbs/A	150			April 22, 1988

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

Soil

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

Weed Control

Corn

1 qt/A (2 lbs/A) Dual + 3 qt/A (3 lbs/A) Bladex broadcast with the planter on May 5, 1988.

Soybeans

1.3 qts/A (1 lb/A) Roundup + 1 pt/A (.5 lb/A) 2,4-D May 12, 1988.

1 pt/A (.5 lb/A) Basagran + .5 pt/A (.125 lb/A) Blazer + 1 qt/A oil concentrate on June 1, 1988.

1 pt/A (.5 lb/A) Basagran + 1 pt/A (.188 lb/A) Poast + 1 qt/A Dash oil concentrate + 1 gal/A 28% on June 11, 1988.

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	Disc	Ridge	Chisel	Avg
		lbs/A				
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	Disc	Ridge	Chisel	Avg
		lbs/A				
P	(.602)	62	66	67	60	64
K	(.075)	215	187	200	177	195

Table 4. Effect of tillage on soil covered by corn and soybean residue in Wabasha Co. on July 6, 1988, n=16.

	Soybean Residue in Corn, Tillage						Corn Residue in Soybeans, Tillage					
	No Till	Disc	Ridge	Chisel			No Till	Disc	Ridge	Chisel		
Residue Location	% cover				Sig.	n	% cover				Sig.	n
In Row	28.3	19.8	21.0	8.8	.000	16	55.5	26.6	52.5	27.0	.000	16
Between Row	48.3	27.5	40.8	10.5	.000	16	59.0	23.5	55.3	29.8	.000	16

Table 5. Effect of tillage on corn and soybean growth stage and population in Wabasha Co. on July 6, 1988.

	Crop: Corn, Tillage						Soybean, Tillage					
	No Till	Disc	Ridge	Chisel			No Till	Disc	Ridge	Chisel		
Variable	leaves/plant				Sig.	n	nodes/plant				Sig.	n
Growth Stage	4.3	4.8	4.7	4.7	.000	80	2.6	2.9	2.4	2.8	.000	80
	plants/A x 10^{-3}						plants/A x 10^{-3} n=16					
Population	24.2	22.3	23.5	21.1	.103	16	133.8	134.5	155.3	152.9	.429[1]	16

1. The ridge till treatment was excluded from the statistical analysis for soybean stands.

Table 6. Effect of tillage on the percent cover by weeds in corn at Wabasha Co. on July 7, 1988, n=4.

Weed	Tillage: No Till	Disc	Ridge	Chisel	Sig.
	% cover				
Velvetleaf	2.0	2.5	1.8	2.3	.681
Lambsquarter	0.0	0.3	3.5	2.3	
Milkweed	0.3	0.8	0.3	0.3	.516
White Cockle	0.0	1.5	1.8	0.5	
Pigweed	0.0	0.0	1.3	1.5	
Quackgrass	0.8	0.8	0.8	2.5	.591
Canada Thist	1.8	0.3	1.3	0.8	.185
Dandelion	2.0	0.5	1.8	0.3	.012
Curly Dock	0.0	0.0	0.0	0.3	
Smartweed	0.0	0.0	0.5	0.3	
Yellow Nutedg	0.0	0.3	0.0	0.0	
Sow thistle	0.0	0.0	0.0	0.3	
Ragweed	0.0	0.0	0.3	0.0	
Lfy Spurge	0.0	0.0	0.3	0.0	
Boxelder	0.3	0.0	0.0	0.0	

Table 7. Effect of tillage on the percent cover by weeds in soybeans at Wabasha Co. on July 7, 1988, n=4.

Weed	Tillage: No Till	Disc	Ridge	Chisel	Sig.
	% cover				
Lambquarter	0.0	0.0	0.0	0.8	
Milkweed	1.0	0.5	0.5	0.8	.855
White Cockle	0.3	0.3	1.5	0.5	.179
Pigweed	0.0	0.0	0.0	0.8	
Quackgrass	0.8	1.0	1.3	2.3	.715
Canada Thist	0.3	0.0	0.3	0.3	
Dandelion	3.3	0.8	1.5	0.5	.155
Curly Dock	0.0	0.5	0.0	0.0	
Burdock	0.0	0.5	0.0	0.0	
Vol Corn	0.3	4.8	0.3	1.0	.000
Shep. Purse	0.0	0.0	0.3	0.0	

Table 8. Effect of tillage on weed ranking in soybeans at Wabasha Co. on Oct. 13, 1988, n=4.

Weed	Tillage: No Till	Disc	Ridge	Chisel	Sig.
	weed severity[1]				
Pigweed	0.8	1.5	0.3	1.1	.055
Velvetleaf	1.9	0.0	0.3	0.9	
Foxtail	0.0	0.0	0.3	0.0	
Milkweed	0.4	0.3	0.0	0.0	
Canada Thist	0.0	0.0	0.3	0.0	
Vol Corn	0.0	0.0	0.3	0.0	
Overall Weeds					
Avg. tillage	2.3	1.5	1.0	1.5	.074

1. Weed severity scale; 1=slight, 2.5=moderate, and 5=heavy.

Table 9. Effect of tillage on corn yields and moisture in Wabasha Co. on Oct. 13, 1988, n=4.

Variable	Tillage: No Till	Disc	Ridge	Chisel	Sig.
	bu/A				
Grain Yield	143.5	148.2	141.5	143.0	.761
	%				
Moisture	16.4	16.1	15.7	16.4	.492

Table 10. Effect of tillage on soybean yields and moisture in Wabasha Co. on Oct. 13, 1988, n=4.

Variable	Tillage: No Till	Disc	Ridge	Chisel	Sig.
	bu/A				
Grain Yield	41.4	44.8	39.6	45.6	.058
	%				
Moisture	9.2	9.1	8.8	8.9	.122

The Effect of Tillage on Soybean Production on an Aquic Argiudoll[1]

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

Abstract: Tillage affected early soybean growth and grain yields on a Aquic Argiudoll soil in Southcentral Minnesota. Moldboard plowing resulted in the highest growth and yields followed by a ridge till system. Other tillage treatments resulted in yields that were ten bushels per acre less.

Tillage plots were established in Steele county, MN. in 1985 on an Aquic Argiudoll (Le Sueur, clay loam) soil. Corn and soybeans have been grown in rotation.

The soil cover measurements in table 2 were made after cultivation. Residue has been concentrated in the row. The "in row" cover in this table would not be expected to be correlated with the early growth in table 3. The soybeans grown with moldboard plowing are about one node ahead of most other tillage treatments. The ridge till soybeans were intermediate in growth on this date (June 23). It is likely that the early growth followed "in row" cover before cultivation. Tillage did not affect soybean stands.

This site is relatively weed free (table 4).

Soybean yields followed the early growth observations in table 3. Moldboard plowing resulted in the highest yields followed by soybeans grown with ridge till (table 5). The other tillage treatments are a distant third. The authors do not have an explanation for the yield differences at this time.

STEELE COUNTY

Table 1. Cultural practices at Steele County, MN. 1988.

Tillage

No Till
Ridge Till
Spring Disc-Field cultivated prior to planting
Fall Chisel Plow-Field cultivated prior to planting
Fall Moldboard Plow-Field cultivated prior to planting
Cultivated tillage plots and formed ridges on June 22, 1988.

Cropping History

1985-Corn, 1986-Soybeans, 1987-Corn

1988 Crop

Soybeans-Pioneer 1677

Planting and Harvest Date

Planter used on was a Hiniker Econotill planter with 30 inch row spacing.

	Planting		
Crop	Date	Rate	Harvested
Soybeans	May 19, 1988	180,000 plants/A	October 7, 1988

Weed Control

4 qts/A (4 lbs/A) Lasso applied on May 20, 1988.
1 pt/A (.188 lb/A) Poast + 2 pts/A Oil applied on June 19, 1988.

Soil

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

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1 Support for this project was in part provided by the Soil Conservation Service which is greatly appreciated.
2 John F. Moncrief and Joe J. Kuznia are an Associate Professor and Assistant Scientist respectively. Tim J. Arlt is the County Agricultural Agent in Steele Co. MN. Tim L. Wagar is an Area Crops and Soils Extension Agent at Rochester, MN.

Fertilization History

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			--- lbs/A ---				
	0-0-60	250 lbs/A	0	0	150	Fall 1984	Broadcast
Corn:	7-21-7[1]	10 gals/A	8	24	8	April 29, 1985	Applied with the seed.
	82-0-0	163 lbs/A	134	0	0	May 30, 1985	Injected
Soybeans	none						
Corn:	0-0-60	250 lbs/A	0	0	150	pre-plant 1987	Broadcast
	82-0-0	159 lbs/A	130	0	0	June 5, 1987	Injected

Table 2. Effect of tillage on soil covered by corn residue in Steele Co. on June 23, 1988.

Location[1]	Mldbd	Chisel	Ridge	NoTill	SprDsc	Sig.
	---------- cover ----------					
In Row	3.7	41.3	53.0	67.0	39.0	.000
Between Row	1.0	11.3	44.7	24.7	9.7	.000

1. Corn was cultivated on June 22, 1988 which concentrated the residue in the row area, n=12.

Table 3. Effect of tillage on early growth of soybean and population in Steele Co. on June 23, 1988, n=12.

Variable	Mldbd	Chisel	Ridge	NoTill	SprDsc	Sig.
	---------- nodes/plant ----------					
Stage	5.3	4.3	4.8	4.3	4.3	.000
	---------- plants/A x 10^{-3} ----------					
Pop.	146.4	129.5	126.3	139.3	129.8	.281

Table 4. Effect of tillage on weed severity in soybeans at Steele Co. on June 23, 1988, n=3.

Weed	Moldboard	Chisel	Ridge	No Till	Spring Disc	Sig.
	---------- % cover ----------					
Foxtail	0.5	8.3	5.3	17.3	5.2	.522
Milkweed	0.0	0.2	0.2	0.0	0.0	
Pigweed	0.0	0.2	0.3	0.0	0.0	
Lambsquarter	0.0	0.3	5.3	2.0	0.0	
Vol. Corn	0.2	2.3	0.0	0.0	3.3	
Ragweed	0.0	0.0	6.0	5.7	0.0	
Marestail	0.0	0.0	0.7	9.0	0.0	
F. Pennycress	0.0	0.0	0.0	1.0	0.0	
Quackgrass	0.0	0.0	0.0	0.3	0.0	
Burdock	0.0	0.0	0.2	0.0	0.0	
Cocklebur	0.0	0.0	1.7	5.0	0.0	
Canada Thistle	0.0	0.0	0.2	0.2	0.0	

Table 5. Effect of tillage on soybean yields and moisture at Steele Co. on October 7, 1988, n=3.

Variable	Moldboard	Chisel	Ridge	No Till	Spring Disc	Sig.
	---------- bu/A ----------					
Grain:Yield	44.8	31.1	40.5	28.7	22.8	.081
	---------- % ----------					
Moisture	9.0	9.3	9.1	9.0	9.0	.027

Conservation Tillage Demonstration/Research in the Clearwater River Watershed-1988[1]

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

Abstract: Tillage was evaluated in the Clearwater River Watershed in Central Minnesota. Although tillage affected early growth of corn, yields were not affected. Soybean yields were not affected by tillage at two sites but ridge till grown soybeans resulted in higher yields at a third likely due to better weed control. Corn grown with ridge till and no till systems responded to row placed phosphorus over spring broadcast phosphorus on a soil testing 25 lbs P/acre. Soybeans did not respond to applied phosphorus. Ridge till corn and soybeans were not adversely affected by combine traffic on ridges in the fall of 1987.

In recent years there has been concern for the water quality in the Clearwater River Chain of Lakes due to entry of phosphorus from various sources. There has been entry of phosphorus from agricultural sources due largely to erosion. Phosphorus from agricultural activities that enter water bodies is usually associated with the sediment that is carried off fields during heavy rainfall. Most will agree that the solution to this problem is at the source. In the case of the agricultural contribution, erosion control in conjunction with banded phosphorus applications is the obvious answer. Phosphorus is applied below the surface and erosion is controlled with crop residue.

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

Meeker County

The soil ranges in texture from clay loam to fine sandy loam. The planter used was a conservation tillage planter equipped with clearing discs, smooth coulter-gauge wheel, and a 2" fluted coulter. In row soil cover by crop residue was greater than 35% for the no till system with both sources of residue (table 4). Tillage affected early growth and soybean population (table 5). Conservation tillage systems showed delayed growth but much higher stands than moldboard plowing.

Ammonium polyphosphate broadcast in the spring increased soybean stands with all but the chisel system (table 6). This trend is also apparent in table 7. Phosphorus increased soybean stands with ridge tillage but did not affect early soybean growth (table 8).
When in row cover by soybean residue was less than 20% early corn growth was not affected (table 9). Corn stands were not affected by tillage at this site. Method of phosphorus application did not affect early growth very much (table 10). Moldboard plowing had more growth with broadcast phosphorus and ridge tillage corn grew better with row placed phosphorus. Chisel and no till systems showed no effect of method of placement.

This site has very few weeds (tables 11, and 12). The only tillage effect on the weeds is the increased volunteer corn in soybeans with the chisel system.

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1 Support for this project was provided by the following: the Minnesota Pollution Control Agency, the Clearwater River Watershed District, the Soil Conservation Service, and the Soil and Water Conservation Districts of Meeker, Stearns, and Wright Counties. Their support is greatly appreciated. This project would not have been possible without the assistance provided by SCS and SWCD staff in Meeker, Stearns, and Wright Counties in the treatment establishment and data collection.
2 John F. Moncrief and Joe J. Kuznia are an Associate Professor and Assistant Scientist respectively in the Department of Soil Science, University of Minnesota, St. Paul, MN. 55108. Mary B. Kells is the Tri-County Conservation Project Coordinator, St. Cloud, MN.

Corn grain yields and moisture are shown in table 13. There was no effect of tillage on corn grain yields. Grain moisture was increased almost 5% as tillage was reduced from moldboard plowing to no till and followed "in row" cover trends. Tillage affects on grain moisture did not follow early growth trends however.

There was a tillage by method of phosphorus placement interaction with grain yields (table 14). Corn grown with the no till and ridge till systems responded to row applied over broadcast phosphorus even though the broadcast rate was double that of row applied. Corn grown with the chisel and moldboard plowing systems did not show a difference in yield due to phosphorus placement.

There was no effect of tillage on soybean yield or grain moisture even though there was large differences in early growth (table 15). Soybeans did not respond to applied phosphorus (table 16) or method of placement (table 17 and 18).

Ridge till plots were split with a traffic variable in the fall of 1987 at harvest. One third and one half of the corn and soybean plots (for 1988) were tracked by the combine. Yields were hand harvested to measure the effect of this treatment before combining in 1988 to measure the general tillage effects. Some research suggests that compaction due to traffic may reduce the availability of phosphorus. For this reason method of phosphorus application was also used as a variable. The results of this study are shown in tables 19 and 20 for the corn and soybeans respectively. Traffic by the combine on the ridges the year before did not affect corn or soybean yields. There was an advantage to row phosphorus over broadcast for corn but it did not interact with the traffic variable.

In summary tillage did not affect corn or soybean yields although it did have an influence on early growth. Row applied phosphorus with the planter was important for corn grown with no till and ridge tillage systems. Soybeans did not respond to phosphorus. Traffic by the combine in 1987 on the ridge did not affect the yields of corn or soybeans in 1988.

MEEKER COUNTY

Table 1. Cultural practices at Meeker County MN. 1988.

Tillage
- No Till
- Ridge Till
- Fall Chisel Plowed-Field cultivated prior to planting
- Fall Moldboard Plowed-Field cultivated prior to planting
  - Ridged corn plots on June 14, 1988.
  - Ridged soybean plots on July 7, 1988.

Cropping History
Corn-soybean rotation since 1978.

1988 Crop
Corn-Pioneer 3737
Soybeans-Pioneer 1677

Planting and Harvest Dates
Corn-was planted with a two row Hiniker Series 1 EconoTill planter with 30 inch row spacing.
Soybeans-ridge till was planted with a two row Hiniker Series 1 EconoTill planter with 30 inch row spacing and all other tillage treatments were planted with a Tye No Till drill with 8 inch row spacing.

	Planting		
Crop	Date	Rate	Harvested
Corn	May 5, 1988	32,000 plants/A	September 24, 1988
Soybeans	May 5, 1988	225,000 plants/A	September 24, 1988

Fertilizer History

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/A ---			
Corn:	82-0-0	183 lbs/A	150	0	0	Spring
	4-15-40[1]	250 lbs/A	10	38	100	Planting
Corn:	4-15-40	300 lbs/A	12	45	120	October 27, 1986
	7-21-7[1]	17 gal/A	13	40	13	April 28, 1987
	82-0-0	159 lbs/A	130	0	0	May 15, 1987
Soybeans:	4-15-40	300 lbs/A	12	45	120	October 27, 1986
	0-46-0[2]	45 lbs/A	0	21	0	May 5, 1987

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

1988 Fertilizer

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			--- lbs/A ---				
Corn:	10-34-0	19 gals/A	22	76	0	April 28, 1988	Broadcast
	10-34-0	9 gals/A	11	36	0	May 5, 1988	Row placement 2" x 2"
	82-0-0	183 lbs/A	150	0	0	June 7, 1988	Anhydrous applicator
Soybeans:	10-34-0	10 gals/A	12	40	0	April 28, 1988	Broadcast
	10-34-0	5 gals/A	6	20	0	May 5, 1988	Row placement 2" x 2"
	0-46-0	358 lbs/A	0	165	0	May 5, 1988	Surface banded ahead of and incorporated by 2" fluted coulters

Soil

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

Weed Control

Corn

1 qt/A (2 lbs/A) Dual + 2 qts/A (2 lbs/A) Bladex applied on May 11, 1988.

Soybeans

1.5 qts/A (1.125 lbs/A) Roundup applied to No Till and Ridge Till plots on May 11, 1988.

1 pt/A (.5 lb/A) Basagran + .5 pt/A (.125 lb/A) Blazer + 1 qt/A oil concentrate on May 31, 1988.

1 pt/A (.5 lb/A) Basagran + 1 pt/A (.188 lb/A) Poast + 1 qt/A Dash oil concentrate + 1 gal/A 28% on June 10, 1988.

Soil Test

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

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

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

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

Table 4. Effect of tillage on soil covered by corn and soybean residue in Meeker Co. in 1988, n=16.

	Soybean Residue in corn 6/14/88					Corn residue in soybean 6/16/88				
	Tillage					Tillage				
	No Till	Ridge	Chisel	Moldboard		No Till	Ridge	Chisel	Moldboard	
Residue Location	% cover				Sig.	% cover				Sig.
In Row	66.8	20.8	18.8	0.8	.000	73.5	21.8	33.3	10.5	.000
Between Row	59.5	36.8	14.8	1.5	.000	58.8	53.5	23.3	9.8	.000

Table 5. Effect of tillage on early growth of soybean and population in Meeker Co. on June 16, 1988, n=24.

	Tillage				
	No Till	Ridge[1]	Chisel	Moldboard	
Variable	nodes/plant				Sig.
Growth Stage	4.1	4.0	4.5	5.0	.016
	plants/A x 10^{-3}				
Population	123.5	146.5	124.6	97.4	.042

1. Ridge till was excluded in statistical analysis for soybeans.

Table 6. Effect of tillage and fertilizer on soybean population in Meeker Co. on June 16, 1988[1].

	Tillage				
	No Till	Ridge	Chisel	Moldboard	Average
Fertilizer[2]	plants/A x 10^{-3}				
Broadcast	145.3	155.9	115.9	117.5	133.7
No Fertilizer	98.0	126.3	133.9	93.1	112.8

1. The p value for the main effect of population for fertilizer and tillage by fertilizer interaction is .016, (n=32), .051, (n=8) respectively.
2. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A.

Table 7. Effect of tillage and fertilizer interaction on soybean population in Meeker Co. on June 16, 1988[1].

	Tillage			
	No Till	Chisel	Moldboard	Average
Fertilizer[2]	plants/A x 10^{-3}			
Broadcast	145.3	115.9	117.5	126.3
Row	127.3	124.1	81.6	111.0
No Fertilizer	98.0	133.9	93.1	108.3

1. The p value for the main effect of population for fertilizer and tillage by fertilizer interaction is .077 (n=24), .027, (n=8) respectively.
2. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A, and a row rate of 0-46-0 at 165 lbs P_2O_5/A.

Table 8. Effect of fertilizer on soybean population and early growth with a ridge tillage system at Meeker Co. on June 16, 1988.

	Ridge Till	
	Population[1]	Growth stage[2]
Fertilizer[3]	plants/A x 10^{-3}	nodes/plant
Broadcast	155.9	3.9
Row	157.3	4.0
No Fertilizer	126.3	4.0

1. The p value for population is .008, n=8.
2. The p value for growth stage is .807, n=80.
3. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A, and a row rate of 10-34-0 at 20 lbs P_2O_5/A.

Table 9. Effect of tillage on corn early growth and population in Meeker Co. on June 14, 1988.

Variable	Tillage: No Till	Ridge	Chisel	Moldboard	Sig.	n
	leaves/plant					
Growth Stage	6.9	7.5	7.4	7.5	.007	160
	plants/A x 10^{-3}					
Population	30.5	31.6	31.4	32.6	.647	16

Table 10. Effect of tillage and fertilizer on corn early growth at Meeker Co. on June 14, 1988[1].

Fertilizer[2]	Tillage: No Till	Ridge	Chisel	Moldboard	Avg
	leaves/plant				
Broadcast	6.9	7.4	7.4	7.7	7.3
Row	6.9	7.6	7.4	7.4	7.3

1. The p value for the main effect of corn growth for fertilizer and tillage by fertilizer interaction is .420 (n=320), .038, (n=80) respectively.
2. Fertilizer was broadcast as 10-34-0 at 76 lbs P_2O_5/A, and a row rate of 10-34-0 at 36 lbs P_2O_5/A.

Table 11. Effect of tillage on weeds present in corn at Meeker Co. on June 22, 1988, n=4.

Weed	Tillage: No Till	Ridge	Chisel	Moldboard	Sig.
	% cover				
Foxtail	8.3	0.3	8.9	9.3	.385
Horsetail	3.9	1.1	8.5	3.8	.215
Lambsquarter	0.0	0.0	0.0	0.3	
Ragweed	0.0	0.0	0.0	0.2	
Vol. Soybean	0.0	0.0	0.3	0.0	
Nutsedge	0.0	0.1	0.3	0.3	

Table 12. Effect of tillage on weeds present in soybeans at Meeker Co. on June 22, 1988, n=4.

Weed	Tillage: No Till	Ridge	Chisel	Moldboard	Sig.
	% cover				
Vol. Corn	0.3	0.1	4.5	0.5	.001
Foxtail	8.8	4.5	8.0	5.5	.795
Quackgrass	0.5	0.0	0.5	0.3	
Horsetail	0.6	1.8	0.0	0.3	
Lambsquarter	0.0	0.0	0.0	0.1	
Milkweed	0.0	0.0	0.1	0.0	

Table 13. Effect of tillage on corn yields and moisture in Meeker Co. on Sept. 24, 1988, n=8.

Variable	Tillage: NoTill	Ridge	Chisel	Moldbd	Sig.
	bu/A				
Grain Yield	38.8	44.1	40.6	44.9	.179
	%				
Moisture	30.1	28.1	27.6	25.5	.001

Table 14. Effect of tillage and fertilizer on corn yield and moisture at Meeker Co. on Sept. 24, 1988.

	Fertilizer[3]	Tillage[1]: NoTill	Ridge	Chisel	Moldbd	Avg[2]
		bu/A				
Grain Yield	Broadcast	34.3	39.5	41.1	43.8	39.7
	Row	43.3	48.7	40.1	46.0	44.5
		%				
Moisture	Broadcast	30.2	28.6	27.9	25.5	28.1
	Row	29.9	27.7	27.4	25.5	27.6

1. The p level of yield and moisture for the tillage by fertilizer interaction is .064 and .680, (n=4) respectively.
2. The p level of yield and moisture for the main effect of fertilizer is .006 and .117, (n=16) respectively.
3. Fertilizer was broadcast as 10-34-0 at 76 lbs P_2O_5/A, and a row rate of 10-34-0 at 36 lbs P_2O_5/A.

Table 15. Effect of tillage on soybean yield and moisture in Meeker Co. on Sept. 24, 1988, n=8.

Variable	NoTill	Ridge[1]	Chisel	Moldbd	Sig.
	Tillage				
	bu/A				
Grain Yield	15.2	13.8	13.8	13.6	.367
	%				
Moisture	12.5	12.3	11.8	12.6	.442

1. Ridge till was excluded in statistical analysis for soybeans.

Table 16. Effect of tillage and fertilizer on soybean yield and moisture in Meeker Co. on Sept. 24, 1988.

	Fertilizer[3]	NoTill	Ridge	Chisel	Moldbd	Avg[2]
		Tillage[1]				
		bu/A				
Grain Yield	Broadcast	13.5	14.1	12.3	13.4	13.3
	No Fertilizer	16.8	13.5	15.3	13.8	14.9
		%				
Moisture	Broadcast	12.6	12.2	11.9	13.0	12.4
	No Fertilizer	12.5	12.3	11.7	12.1	12.1

1. The p value of yield and moisture for the tillage by fertilizer interaction is .534 and .358, (n=4) respectively.
2. The p value of yield and moisture for the main effect of fertilizer is .202 and .180, (n=16) respectively.
3. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A.

Table 17. Effect of tillage and fertilizer on soybean yield and moisture in Meeker Co. on Sept. 24, 1988.

	Fertilizer[3]	NoTill	Chisel	Moldbd	Avg[2]
		Tillage[1]			
		bu/A			
Grain Yield	Broadcast	13.5	12.3	13.4	13.1
	Row	15.9	12.8	13.5	14.1
	No Fertilizer	16.8	15.3	13.8	15.3
		%			
Moisture	Broadcast	12.6	11.9	13.0	12.5
	Row	12.7	11.8	12.1	12.2
	No Fertilizer	12.5	11.7	12.1	12.1

1. The p level of yield and moisture for the tillage by fertilizer interaction is .783 and .334, (n=4) respectively.
2. The p level of yield and moisture for the main effect of fertilizer is .196 and .128, (n=12) respectively.
3. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A, and a row rate of 0-46-0 at 165 lbs P_2O_5/A.

Table 18. Effect of fertilizer on soybean yield and moisture in ridge till at Meeker Co. on Sept. 24, 1988, n=4.

Fertilizer[3]	Grain Yield[1]	Moisture[2]
	Ridge Till	
	bu/A	%
Broadcast	14.1	12.2
Row	14.5	12.1
No Fertilizer	13.5	12.3

1. The p level for yield is .872.
2. The p level for moisture is .775.
3. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A, and a row rate of 10-34-0 at 20 lbs P_2O_5/A.

Table 19. Effect of traffic and fertilizer on ridge till corn yield and moisture at Meeker Co. on Sept. 21, 1988[1].

	Fertilizer[5]	Traffic[2]	No Traffic	Avg[3]
		bu/A		
Grain Yield	Broadcast	40.1	45.1	42.6
	Row	46.5	43.8	45.1
	Average[4]	43.3	44.5	
		%		
Moisture	Broadcast	33.3	33.1	33.2
	Row	30.4	30.4	30.4
	Average	31.9	31.8	

1. Ridge till plots were split with a traffic variable. One third of the ridges were tracked by the combine on September 30 at harvest in 1987.
2. The p level of yield and moisture for the traffic by fertilizer interaction is .342 and .849, (n=8) respectively.
3. The p level of yield and moisture for the main effect of fertilizer is .513 and .010, (n=16) respectively.
4. The p level of yield and moisture for the main effect of traffic is .719, and .851, (n=16) respectively.
5. Fertilizer was broadcast as 10-34-0 at 76 lbs P_2O_5/A, and a row rate of 10-34-0 at 36 lbs P_2O_5/A.

Table 20. Effect of traffic and fertilizer on ridge till on soybeans yield and moisture at Meeker Co. on Sept. 24, 1988[1].

	Fertilizer[5]	Traffic[2]	No Traffic	Avg[3]
		bu/A		
Grain Yield	Broadcast	11.9	12.3	12.1
	Row	12.0	11.8	11.9
	No Fertilizer	12.0	11.7	11.8
	Average[4]	12.0	11.9	
		%		
Moisture	Broadcast	15.5	15.1	15.3
	Row	14.8	16.6	15.7
	No Fertilizer	14.0	14.2	14.1
	Average	14.8	15.3	

1. Ridge till plots were split with a traffic variable. One third of the ridges were tracked by the combine on September 30 at harvest in 1987.
2. The p level of yield and moisture for the traffic by fertilizer interaction is .750 and .549, (n=8) respectively.
3. The p level of yield and moisture for the main effect of fertilizer is .811 and .815, (n=16) respectively.
4. The p level of yield and moisture for the main effect of traffic is .719, and .248, (n=24) respectively.
5. Fertilizer was broadcast as 10-34-0 at 40 lbs P_2O_5/A, and a row rate of 10-34-0 at 20 lbs P_2O_5/A.

Stearns County

The soil at this site is coarse textured and shallow over gravel. Less than 2" of rain fell in June and July at this site. Soybeans were grown after corn in 1987. With the exception of the ridge till system there is little difference between "in row" and "between row" cover (table 22). Early soybean growth was correlated to "in row" cover. Tillage did not affect soybean stands (table 23). Weed observations were made 12 days after post emergence herbicides were applied (table 24). Foxtail is the dominate weed at this site and was higher under no till and chisel plowing conditions. There was very little weeds with the ridge till system. During this dry year cultivation was a very effective method of weed control.

Although soybean yields were very low, they were highest with the ridge till system (table 25). This is likely due to better weed control and less harvest loss. The foxtail growth in the early season before post emergence herbicides were applied likely depleted crucial soil water with all the systems but ridge till. Also soybeans were taller with this system and easier to combine.

STEARNS COUNTY

Table 21. Cultural practices at Stearns County, MN. 1988.

Tillage

No Till
Ridge Till
Chisel Plowed and disced on May 12, 1988.
Moldboard Plowed and disced on May 12, 1988.

Cropping History

1981-red clover and oats, 1982-corn, 1983-soybeans, 1984-corn, 1985-corn, 1986-soybeans, 1987-corn

1988 Crop

Soybeans - Pioneer 1677

Planting and Harvest Dates

Ridge till plots were planted with a four row Buffalo Till planter equipped with 12" sweeps at a 38"row spacing. All other soybean treatments were planted with a Tye No Till drill with 8" row spacing equipped with 2" fluted coulters.

	Planting			
Crop	Date	Planter	Rate	Harvested
Soybeans	May 13, 1988	Row	198,000 plants/A	October 12, 1988
	May 13, 1988	Drill	224,400 plants/A	October 12, 1988

Fertilization History

The fertilization history at this site is as follows: 1981-none, 1982-low rate of dry starter, 1983-low rate of starter and 0-0-60, 1984-4 gal/A of 9-18-9 only, 1985-60 lbs/A of N and 4 gal/a of 9-18-9, 1986-all soybean plots were split with and without a row fertilizer treatment at planting, and in 1987 all corn plots were split with three rates of starter.

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

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

Soil

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

Weed Control

1.5 qts/A (1.125 lbs/A) Roundup + 1 gal/A 28% applied to no till and ridge till on May 11, 1988.
1 pt/A (.5 lb/A) Basagran + .5 pt/A (.125 lb/A) Blazer + 1 qt/A oil concentrate on May 31, 1988.
1 pt/A (.5 lb/A) Basagran + 1 pt/A (.188 lb/A) Poast + 1 qt/A Dash oil concentrate + 1 gal/A 28% on June 10, 1988.

Table 22. Effect of tillage on soil covered by corn residue in soybeans in Stearns Co. on June 15, 1988, n=16.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Residue Location	% cover				Sig.
In Row	72.0	36.0	25.0	5.3	.000
Between Row	73.8	48.0	22.0	2.5	.000

Table 23. Effect of tillage on early growth of soybeans and population in Stearns Co. on June 16, 1988, n=80.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Variable	nodes/plant				Sig.
Growth Stage	2.8	3.4	3.2	3.6	.000
	plants/A x 10^{-3}				
Population	225.3	170.1	250.6	265.3	.126[1]

1. The ridge till treatment was excluded from the statistical analysis.

Table 24. Effect of tillage on percent cover by weeds in soybeans at Stearns Co. on June 22, 1988, n=4.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Weed	% cover				Sig.
Vol Corn	0.1	0.0	0.9	1.0	
Foxtail	80.0	2.5	50.0	18.8	.000
Quackgrass	0.3	0.0	0.0	0.3	
Milkweed	4.0	0.3	1.0	1.1	.102

Table 25. Effect of tillage on soybean yield and moisture in Stearns Co. on October 12, 1988, n=4.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Variable	bu/A				Sig.
Grain Yield	1.5	4.0	0.9	1.6	.006
	%				
Moisture	10.5	11.0	11.0	11.7	.157

Wright County

The soil at this site has very little storage capacity and less than an inch of rain fell in June and July (see weather data from tillage studies this publication). For these reasons there was no corn grain yield and very little soybean grain yield at this site. It is useful however to see how tillage affected growth under the extreme drought conditions.

The cover by corn and soybean residue and the corresponding early growth are shown in tables 27 and 28 respectively. Soil cover by crop residue without tillage was 94% and 57% for the corn and soybean residue sources respectively. The "in row" soil cover in the no till treatment was reduced 37% and 13% for corn and soybean residue respectively. The planter at this site is equipped with add on 10" sweeps that can be raised hydraulically. The cover in and between the row with the ridge till, moldboard, and chisel systems was similar for both sources of residue.

Early corn growth was similar for all systems except moldboard plowing which had about .5 leaves per plant more growth on June 16. It is unusual that the ridge till cover in the row was similar to that of the moldboard plowing system but early growth was not similar. The early growth of the soybeans did follow "in row" cover trends (ridge till and moldboard plowing are similar). Tillage did not affect plant populations for either crop on the June 16 date although the trend was for higher corn stand with the no till treatment. Since the ridge

till soybeans were planted with a planter and other treatments with a no till drill a comparison between these treatments cannot be made.

Corn was relatively weed free (good herbicide control) and there were no tillage effects on species or density of weeds present (table 29). This site received 1.29 inches of rain shortly after planting (see weather summary for tillage sites, this publication). Soybean weed observations were made 12 days after an application of post emergence herbicide and weeds were still present (table 30). Foxtail growth was similar in all systems but the ridge till. This reflects the aggressive cultivation that is associated with this system. Volunteer corn was higher in chisel and moldboard plowed plots.

Corn yield and final stand are shown in tables 31 and 32. There were no ears formed and only half the corn produced tassels. For this reason dry matter production was used to assess tillage effects. Tillage affected dry matter yields, plant size, and final stand. Dry matter production was higher with the ridge till and no till treatments. This was due to less mortality and larger plants. Stand losses between June 16 and September 28 were 0, 1, 3, and 3 thousand plants per acre for the no till, ridge till, chisel, and moldboard plowing treatments respectively (tables 28 and 31).

Soybean yields were all less than 2 bushels per acre and not affected by tillage (table 33).

WRIGHT COUNTY

Table 26. Cultural practices at Wright County, MN. 1988.

Tillage
No Till
Ridge Till
Chisel Plow-October 8, 1987.
Moldboard Plow-October 8, 1987.

Preceding Crops
Corn-soybean rotation since 1982.

1988 Crops
Corn - Pioneer 3737
Soybeans - Pioneer 1677

Planting and Harvest Dates

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

	Planting		
Crop	Date	Rate	Harvested
Corn	May 6, 1988	29,900 plants/A	September 28, 1988
Soybeans	May 12, 1988	225,000 plants/A	October 8, 1988

Fertilization History

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

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/a ---			
Corn:	8-23-30[1]	140 lbs/A	11	32	42	May 2, 1986
	28-0-0[2] UAN	37 gal/A	110	0	0	June 13, 1986
Corn:	8-20-32[1]	140 lbs/A	11	28	45	May 4, 1987
	82-0-0	183 lbs/A	150	0	0	June 15, 1987

1. Planter placement 2" beside and 2" below row.
2. Surface banded between rows.

1988 Fertilizer

Corn plots were split with stater fertilizer.

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/A ---			
Corn:	9-20-33[1]	140 lbs/A	13	28	46	May 6, 1988
	82-0-0	150 lbs/A	123	0	0	June 8, 1988

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

Soil

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

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

Weed Control

Corn

1.5 qts/A (1.5 lbs/A) Lasso + 1.2 qts/A (2.4 lbs/A) Dual on May 6, 1988 with planter.

Soybeans

1.3 qts/A (1 lb/A) Roundup + 1 pt/A (.5 lb/A) 2,4-D applied to no till and ridge till treatments on May 6, 1988.

1 qt/A (1 lb/A) Lorox + 2 qts/A (2 lbs/A) Lasso applied with the planter for the ridge till system on May 12, 1988.

1 pt/A (.5 lb/A) Basagran + .5 pt/A (.125 lb/A) Blazer + 1 qt/A oil concentrate on May 31, 1988.

1 pt/A (.5 lb/A) Basagran + 1 pt/A (.188 lb/A) Poast + 1 qt/A Dash oil concentrate + 1 gal/A 28% on June 10, 1988.

Table 27. Effect of tillage on crop residue in Wright Co. 1988 on May 12, 1988, n=16.

	Soybean Residue in Corn					Corn Residue in Soybeans				
	Tillage					Tillage				
	No Till	Ridge	Chisel	Moldboard		No Till	Ridge	Chisel	Moldboard	
Location	% cover				Sig.	% cover				Sig.
In Row	57.3	7.8	22.3	4.5	.000	43.8	7.0	24.0	7.8	.000
Between Row	93.5	32.0	29.5	6.0	.000	57.0	35.0	23.8	7.8	.000

Table 28. Effect of tillage on corn and soybean early growth and population in Wright Co. on June 16, 1988.

	Crop											
	Corn						Soybean					
	Tillage						Tillage					
	No Till	Ridge	Chisel	Moldboard			No Till	Ridge	Chisel	Moldboard		
Variable	leaves/plant				Sig.	n	nodes/plant				Sig.	n
Growth Stage	8.3	8.1	8.4	8.9	.000	160	3.9	4.3	3.8	4.1	.042	80
	plants/A x 10^{-3}						plants/A x 10^{-3}					
Population	31.3	29.5	29.3	28.9	.214	32	231.0	179.2	258.8	256.3	.384[1]	16

1. The ridge till treatment was excluded from the statistical analysis for soybean stands.

Table 29. Effect of tillage on weed severity in corn at Wright Co. June 22, 1988, n=4.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Weed	% cover				Sig.
Foxtail	0.5	0.3	1.6	5.5	.115
Volsoybean	0.0	0.0	0.1	0.0	
Quackgrass	1.5	0.5	0.6	0.3	.354
CanadaThis	0.0	0.0	0.0	0.0	
Milkweed	0.0	0.0	0.0	0.0	
Ragweed	0.0	0.0	0.0	0.0	
Buckwheat	0.3	0.0	0.0	0.0	

Table 30. Effect of tillage on weed severity in soybeans at Wright Co. on June 22, 1988, n=4.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Weed	% cover				Sig.
Foxtail	21.3	0.8	20.0	19.5	.064
Milkweed	1.6	0.0	1.3	0.3	
Volcorn	1.3	0.5	8.8	7.8	.003
Lambsquart	1.0	0.0	0.8	1.0	
Pigweed	1.3	0.0	0.0	1.3	
Pennycress	0.3	0.0	0.0	0.0	
Curlydock	0.3	0.0	0.0	0.0	

Table 31. Effect of tillage on corn yield and final stand in Wright Co., on Sept. 28, 1988, n=16.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Variable	tons/A				Sig.
Stover Yield	0.82	0.64	0.54	0.54	.001
	gram/plant				
Plant size	23.9	20.5	19.4	18.5	.008
	plants/A x 10^{-3}				
Final Stand	31.5	28.5	25.4	26.2	.025

Table 32. Effect of tillage and starter fertilizer on corn dry matter yield and plant size in Wright Co., Sept. 28, 1988[1].

	Tillage			
Variable	No till	Ridge	Chisel	Moldboard
Stover Yield	tons/A			
Starter[2]	0.82	0.59	0.56	0.53
No Starter	0.82	0.69	0.52	0.55
Plant size	gram/plant			
Starter	23.6	19.5	21.0	18.5
No Starter	24.3	21.5	17.7	18.5

1. The p value for the tillage by starter interaction is .415 and .098 for stover yield and plant size respectively, n=8.
2. Starter (9-20-33) was applied with the planter on May 6, 1988 at a rate of 140lb/A.

Table 33. Effect of tillage on soybean yield and moisture in Wright Co. Oct. 8, 1988, n=4.

	Tillage				
	No Till	Ridge	Chisel	Moldboard	
Variable	bu/A				Sig.
Yield	0.3	1.8	1.6	0.4	.306
	%				
Moisture	14.2	10.5	12.6	11.8	.120

The Effect of Tillage on Winter and Spring Wheat, Barley, and Soybean Production on a Lacustrine Soil in Northwestern Minnesota[1]

J.F. Moncrief, K.J. Pazdernik, and J.J. Kuznia[2]

Abstract: Three tillage systems are evaluated on a silty clay soil in a soybeans-barley-wheat rotation. There was little effect of tillage on spring wheat or barley yields if nitrogen was managed properly. Bighorn winter wheat showed higher winter losses when grown with plowing systems and had lower yields. No till grown soybeans had higher yields than those grown with moldboard and chisel plowing.

This is the third year of a three year project to evaluate the effect of tillage on the production of winter and spring wheat, barley and soybeans on a Vertic Haplaquoll soil in northwestern Minnesota. The crop rotation is barley-wheat-soybeans. Wheat plots are split with winter and spring wheat. Each crop is grown every year. For summaries the preceding two years refer to this publication in 1987 and 1988.

The spring soil test in 1988 revealed a tillage effect on nitrate nitrogen (2' samples). Following both barley and soybeans there was more nitrate nitrogen with moldboard plowing . The nitrogen rate for barley the preceding year applied April 24, 1987 was 100 lbs N/acre as drill applied diammonium phosphate (18 lbs N/acre) and broadcast urea (82 lbs N/acre). It is unlikely that there were denitrification losses in 1987. These differences probably reflect differences in mineralization of soil organic matter (4-5% OM) due to physical changes in the soil environment with tillage. Nitrogen rates for wheat following barley were adjusted based on soil tests for each tillage system. There were two nitrogen rates for barley following soybeans, zero and the recommended rate based on soil test nitrate.

Differences in soil test P and K probably reflect tillage effects on phytocycling of these two nutrients. This has been observed at other locations.

Cover by barley and soybean residue is shown in tables 3 to 8. The effect of no tillage on the amount of soil cover is similar for both barley and soybean residue. Chisel and moldboard plowing reduces the cover by soybean residue more than barley residue. The effect of secondary tillage in the spring is apparent when comparing the effect of plowing treatments on cover by barley residue in winter and spring wheat. There is also a small increase in cover over the row with all systems. This probably reflects the action of the double disc openers on the drill which was not very effective in removing residue from the row area.

There appeared to be a trend of tillage affecting winter wheat stand in the fall of 1987 (table 9). Less tillage resulted in higher stands. Bighorn went into the winter with a slightly higher stand than Roughrider.

The level of weeds that occurred in winter wheat closely followed winter stand loss (table 10 and 12). There were more weeds in chisel and moldboard plowing plots and generally more weeds in Bighorn plots (table 12). Stand losses are shown in table 19. No till winter wheat had fewer weeds for both varieties. There were very little weeds in spring wheat (tables 11 and 13).

Grain yields, moisture, and test weights are shown in table 14. These estimates were taken in areas of the plot where there was little stand loss of winter wheat with a small plot combine (4 foot head). The winter wheat yields reflect tillage differences independent of stand loss. Yields adjusted for stand loss are shown in table 15.

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1 This project is supported by the Soil Conservation Service. There support is greatly appreciated. Data collection was aided by Fred Kollman, the District Conservationist in Norman County.

2 John F. Moncrief and J.J. Kuznia are Associate Professor and Assistant Scientist respectively in the Department of Soil Science, University of Minnesota, St. Paul, MN. 55108. Ken J. Pazdernik is the Agricultural Extension Agent in Norman County, Ada, MN.

There was little difference in the yield for the winter and spring wheats with the exception of the Bighorn which suffered major stand losses with plowing systems. Tillage did not affect spring or winter wheat when stand losses were avoided in the yield sample.

When yields were adjusted for stand losses tillage had a significant effect on winter wheat yields (table 15). The spring wheat was not quite ready for combining on the July 25 sampling date. On August 18 they were sampled again with the growers combine. These data are shown in table 16. Again there was no effect of tillage on spring wheat yields although yields were slightly higher than the July 25 harvest.

Stand survival is shown in table 17. No till winter wheat had an 85% stand at harvest. The plowing systems resulted in about a 50% stand. Bighorn and Roughrider plots had 51% and 71% stands respectively at harvest.

Barley yields were not affected by tillage (table 18). This is consistent with the prior two years. Small grain planted into soybean stubble minimizes stand and nitrogen problems.

Check plot yields support the differences in soil nitrate that were measured in the spring (table 19). More tillage resulted in higher yields. When nitrogen was applied yield differences tended in a reverse direction.

Soybean yields were higher grown with no tillage (table 20). In the previous two years there were no difference in soybean yields due to tillage. The advantage of no till grown soybeans may have been due reduced runoff of the 5.38 inches of rain that fell in the last week of July and the first week of August.

NORMAN COUNTY

Table 1. Cultural practices at Norman County, MN. 1988.

Tillage

No Till
Fall Chisel Plowed
Fall Moldboard Plowed
The spring seeded chisel and moldboard plow treatments were field cultivated twice with a drag behind it before seeding.

Planting and Harvest Dates

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

	Planting		
Crop	Date	Rate	Harvested
Winter wheat	Aug. 31, 1987	86 lbs/A	July 25, 1988
Spring wheat	April 22, 1988	100 lbs/A	July 25, 1988
			Aug. 18, 1988
Barley	April 22, 1988	90 lbs/A	July 25, 1988
Soybeans	May 10, 1988	94 lbs/A	Sept. 6, 1988

Cropping History

1985-Spring Wheat, 1986-87 three year (barley, wheat soybean) rotation.

1988 Crops

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

Soil

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

Weed Control

Spring Wheat

1 pt/A (.5 lb/A) Bronate (.25 lb/A Bromoxynil & .25 lb/A MCPA) applied on June 3, 1988.

Barley

1 pt/A (.5 lb/A) Bronate (.25 lb/A Bromoxynil & .25 lb/A MCPA) applied on June 3, 1988.

Soybeans

1.25 pts/A (.47 lb/A) Roundup applied to No Till plots on May 13, 1988.

1.25 pts/A Galaxy applied on June 6, 1988.

1 pt/A (.188 lb/A) Poast + 1 qt/A Dash applied on June 10, 1988.

1.5 pts/A (.375 lb/A) Blazer applied on June 25, 1988.

Fertilizer

Crop	Tillage	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
				--- lb/A ---				
Winter wheat:	All	18-46-0	90 lb/A	16	41	0	Aug. 31, 1987	Drill
	No Till	46-0-0	152 lb/A	70	0	0	April 21, 1988	Broadcast
	Chisel	46-0-0	87 lb/A	40	0	0	April 21, 1988	Broadcast
	Moldboard	46-0-0	65 lb/A	30	0	0	April 21, 1988	Broadcast
Spring wheat:	All	18-46-0	95 lb/A	17	44	0	April 22, 1988	Drill
	No Till	46-0-0	152 lb/A	70	0	0	April 21, 1988	Broadcast
	Chisel	46-0-0	87 lb/A	40	0	0	April 21, 1988	Broadcast
	Moldboard	46-0-0	65 lb/A	30	0	0	April 21, 1988	Broadcast
Barley:	All	18-46-0	95 lb/A	17	44	0	April 22, 1988	Drill
	NoTill & Chisel	46-0-0	120 lb/A	55	0	0	April 21, 1988	Split barley plots
	Moldboard	46-0-0	65 lb/A	30	0	0	April 21, 1988	with broadcast urea

Soil Test

Table 2. Soil test results at Norman Co. for barley (previous crop soybeans) and winter and spring wheat (previous crop barley), nitrate nitrogen sampled to a depth of 2 feet, phosphorus and potassium sampled to a depth of 6 inches, sampled Spring 1988.

	Tillage															
	NoTil	Chisl	Moldbd		NoTil	Chisl	Moldbd		NoTil	Chisl	Moldbd		NoTil	Chisl	Moldbd	
	Nitrate Nitrogen				Phosphorus				Potassium				Organic Matter			
Previous Crop	----- lbs/A[1] -----			Avg	----- lbs/A[2] -----			Avg	-----lbs/A[3] -----			Avg	------- %[4] -------			Avg
Soybeans	53	55	75	61	36	36	24	32	600	575	520	565	4.8	4.5	3.9	4.4
Barley	43	71	99	71	38	21	25	28	643	583	627	618	4.0	3.8	3.6	3.8
Average	48	63	87	66	37	28	25	30	622	579	573	591	4.4	4.1	3.8	4.1

1. The p value for nitrate nitrogen for the main effect of previous crop, tillage, and tillage by previous crop interaction is .103 (n=9), .002 (n=6), .034 (n=3) respectively.
2. The p value for phosphorus for the main effect of previous crop, tillage, and tillage by previous crop interaction is .588 (n=9), .092 (n=6), .178 (n=3) respectively.
3. The p value for potassium for the main effect of previous crop, tillage, and tillage by previous crop interaction is .169 (n=9), .246 (n=6), .275 (n=3) respectively.
4. The p value for organic matter for the main effect of previous crop, tillage, and tillage by previous crop interaction is .008 (n=9), .254 (n=6), .760 (n=3) respectively.

Table 3. The effect of tillage on soil cover in and between the row by barley residue in winter wheat. Data was collected on August 31, 1987, n=12[1].

	IN-ROW RESIDUE				BETWEEN ROW RESIDUE			
	Tillage							
	No Till	Chisel	Moldboard		No Till	Chisel	Moldboard	
Crop-Variety	%							
Winter Wheat	(Barley residue)			Avg.				Avg.
Bighorn	90.7	45.7	16.3	50.9	87.7	36.0	12.3	45.3
Roughrider	89.7	32.0	11.3	44.3	88.0	31.3	8.7	42.7

1. Tillage is significant < .100 in all cases.

Table 4. Effect of tillage on soil covered by barley residue in Winter wheat in Norman Co. on August 31, 1987[1].

	Tillage			
	No Till	Chisel	Moldboard	Average
Residue Location	% cover			
In Row	90.2	38.8	13.8	47.6
Between Row	87.8	33.7	10.5	44.0
Average	89.0	36.3	12.2	

1. The p value for residue for the main effect of location, tillage, and the tillage by residue location interaction is .036 (n=72), .000 (n=48), and .635 (n=24) respectively.

Table 5. The effect of tillage on soil cover in and between wheat rows on April 22, 1988.

	IN-ROW RESIDUE				BETWEEN ROW RESIDUE			
	Tillage							
	No Till	Chisel	Moldboard		No Till	Chisel	Moldboard	
Crop-Variety	%							
Winter Wheat[1]	(Barley residue)			Average				Average
Bighorn	81.0	35.7	19.7	45.4	89.7	24.7	8.3	40.9
Roughrider	84.0	33.7	15.0	44.2	91.3	30.0	10.0	43.8
Average	82.5	34.7	17.3	44.8	90.5	27.3	9.2	42.3
Spring Wheat[2]	(Barley Residue)							
Marshall	76.0	18.7	9.3	34.7	79.3	16.3	6.3	34.0
Stoa	77.7	25.0	7.0	36.6	79.7	18.0	5.7	34.4
Average	76.8	21.8	8.2	35.6	79.5	17.2	6.0	34.2
Barley	(soybean Residue)							
Robust	78.0	11.5	2.3		80.3	8.5	2.3	

1. The p value for in-row residue for the main effect of winter wheat for variety, tillage, and tillage by variety interaction is .624 (n=36), .000 (n=24), .460 (n=12) respectively. The p value for between row residue for the main effect of winter wheat for variety, tillage, and tillage by variety interaction is .137 (n=36), .000 (n=24), .584 (n=12) respectively.
2. The p value for in-row residue for the main effect of spring wheat for variety, tillage, and tillage by variety interaction is .568 (n=36), .000 (n=24), .558 (n=12) respectively. The p value for between row residue for the main effect of spring wheat for variety, tillage, and tillage by variety interaction is .862 (n=36), .000 (n=24), .926 (n=12) respectively.

Table 6. The effect of tillage and wheat type on soil cover in and between wheat rows on April 22, 1988.

	IN-ROW RESIDUE				BETWEEN ROW RESIDUE			
	Tillage							
	No Till	Chisel	Moldboard		No Till	Chisel	Moldboard	
	%							
Crop[1]	(Barley residue)			Average				Average
Winter Wheat	82.5	34.7	17.3	44.8	90.5	27.3	9.2	42.3
Spring Wheat	76.8	21.8	8.2	35.6	79.5	17.2	6.0	34.2
Average	79.7	28.3	12.8	40.2	85.0	22.3	7.6	38.3

1. The p value of wheat in-row residue for the main effect of crop, tillage, and tillage by crop interaction is .003 (n=72), .000 (n=48), .238 (n=24) respectively. The p value of wheat between row residue for the main effect of crop, tillage, and tillage by crop interaction is .002 (n=72), .000 (n=48), .079 (n=24) respectively.

Table 7. Effect of tillage on soil covered by barley residue in wheat (Winter and Spring) in Norman Co. on April 22, 1988.

	Tillage			
	No Till	Chisel	Moldboard	Average
Residue Location	% cover			
In Row	79.7	28.3	12.8	40.2
Between Row	85.0	22.3	7.6	38.3
Average	82.3	25.3	10.2	

1. The p value of residue for the main effect of location, tillage, and the tillage by residue location interaction is .164 (n=144), .000 (n=96), and .024 (n=48) respectively.

Table 8. Effect of crop on soil covered by barley residue in wheat (Winter and Spring) in Norman Co. on April 22, 1988[1].

	Tillage			
	No Till	Chisel	Moldboard	Average
Crop	% cover			
Winter wheat	86.5	31.0	13.3	43.6
Spring wheat	78.2	19.5	7.1	34.9

1. The p value of residue for the main effect of location, tillage, and the tillage by residue location interaction is .000 (n=144) and .044 (n=48) respectively.

Table 9. The effect of tillage and wheat variety on population at Norman Co. on Oct. 1, 1987, n=18.

	Tillage			
Crop-Variety	No Till	Chisel	Moldboard	
Winter Wheat	plants/A x 10^{-3}			Average
Bighorn	793.8	697.0	759.9	750.3
Roughrider	779.3	726.1	605.0	703.5
Average	786.6	711.5	682.5	

1. The p value for the main effect of stand for variety, tillage, and the tillage by variety interaction is .389 (n=54), .337 (n=36), and .364 (n=18) respectively.

Table 10. The effect of tillage and variety on weeds in winter wheat on July 25, 1988, n=3.

	Bighorn Wheat				Roughrider Wheat			
	Tillage							
	No Till	Chisel	Moldboard		No Till	Chisel	Moldboard	
Weed	% cover			Sig.	% cover			Sig.
Canada Thistle	2.7	0.0	0.0		1.7	0.0	0.0	
Wild Oat	5.0	23.3	0.0		0.0	16.7	6.7	
Lambsquarter	0.0	11.0	67.7		0.0	0.0	11.7	
Buckwheat	6.7	33.3	25.0	.486	8.3	50.0	16.7	.002
Foxtail	11.7	30.0	0.0		0.0	20.0	10.0	
G. Ragweed	0.7	1.7	0.0		0.0	3.3	0.0	

Table 11. The effect of tillage and variety on weeds in spring wheat on July 25, 1988, n=3.

	Marshall Wheat				Stoa Wheat			
	Tillage							
	No Till	Chisel	Moldboard		No Till	Chisel	Moldboard	
Weed	% cover			Sig.	% cover			Sig.
Wild Oat	2.0	14.0	12.0	.358	3.0	5.3	7.7	.593
Foxtail	0.7	0.0	0.0		0.0	0.0	0.0	

Table 12. The effect of tillage, on cover by weeds in winter wheat on July 25, 1988.

	Tillage (n=6)				Variety (n=9)		
	No Till	Chisel	Moldboard		Bghn	Rrdr	
Weed	% cover			Sig.	% cover		Sig.
Canada Thist	2.2	0.0	0.0		0.9	0.6	.643
Wild Oat	2.5	20.0	3.3	.062	9.4	7.8	.828
Lambsquarter	0.0	5.5	39.7		26.2	3.9	.016
Buckwheat	7.5	41.7	20.8	.060	21.7	25.0	.737
Foxtail	5.8	25.0	5.0	.038	13.9	10.0	.679
G. Ragweed	0.3	2.5	0.0		0.8	1.1	.573

Table 13. The effect of tillage, on cover by weeds in spring wheat on July 25, 1988.

	Tillage (n=6)				Variety (n=9)		
	No Till	Chisel	Moldboard		Mrsl	Stoa	
Weed	% cover			Sig.	% cover		Sig.
Wild Oat	2.5	9.7	9.8	.302	9.3	5.3	.319
Foxtail	0.3	0.0	0.0		0.2	0.0	

Table 14. Effect of tillage and variety on wheat yield, moisture and test weight in Norman Co. in 1988. Harvest date was on July 25, 1988, n=3[1].

	Tillage											
	No Till	Chisel	Moldboard		No Till	Chisel	Moldboard		No Till	Chisel	Moldboard	
Crop-Variety	Grain Yield				Moisture				Test Weight			
Winter wheat	bu/A[2]			Avg.	% [3]			Avg.	lbs/bu[4]			Avg.
Bighorn	23.1	14.7	21.6	19.8	8.7	17.7	16.7	14.4	59.8	56.7	58.0	58.2
Roughrider	24.0	24.2	26.8	25.0	9.5	15.5	13.6	12.8	58.7	58.5	59.0	58.7
Average	23.6	19.4	24.2	22.4	9.1	16.6	15.1	13.6	59.3	57.6	58.5	58.4
Spring wheat												
Marshall	30.2	25.6	24.3	26.7	16.6	20.5	26.3	21.1	54.7	54.7	52.2	53.8
Stoa	25.4	25.2	22.7	24.4	16.0	19.3	22.7	19.3	53.5	54.3	53.3	53.7
Average	27.8	25.4	23.5	25.6	16.3	19.9	24.5	20.2	54.1	54.5	52.8	53.8

1. The yield estimates were made with a plot combine with a 4 foot head and 75 foot harvest length in areas where there was very little stand loss. This gives a yield estimate for winter and spring wheat independent of stand loss.
2. The p value for **winter wheat** yield for the main effect of variety, tillage, and tillage by variety interaction is .189 (n=9), .511 (n=6), .419 (n=3) respectively. The p value for **spring wheat** yield for the main effect of variety, tillage, and tillage by variety interaction is .314 (n=9), .716 (n=6), .758 (n=3) respectively.
3. The p value for **winter wheat** moisture for the main effect of variety, tillage, and tillage by variety interaction is .591 (n=9), .088 (n=6), .917 (n=3) respectively. The p value for **spring wheat** moisture for the main effect of variety, tillage, and tillage by variety interaction is .505 (n=9), .012 (n=6), .732 (n=3) respectively.
4. The p value for **winter wheat** test weight for the main effect of variety, tillage, and tillage by variety interaction is .959 (n=9), .563 (n=6), .896 (n=3) respectively. The p value for **spring wheat** test weight for the main effect of variety, tillage, and tillage by variety interaction is .488 (n=9), .601 (n=6), .325 (n=3) respectively.

Table 15. The effect of tillage and variety of wheat yield adjusted for stand loss at Norman Co. on July 25, 1988.[1]

	Tillage			
	No Till	Chisel	Moldboard	
Crop-Variety	Grain Yield			
Winter wheat[2]	bu/A			Average
Bighorn	18.9	6.5	6.6	10.7
Roughrider	21.3	13.3	19.2	17.9
Average	20.1	9.9	12.9	14.3
Spring wheat[3]				
Marshall	29.0	23.9	22.5	25.1
Stoa	24.4	24.3	21.4	23.4
Average	26.7	24.1	22.0	24.3

1. Yield estimates (75' x 4' sample size), in areas where there was little stand loss were multiplied times a visual estimate of the percent stand over the whole plot.
2. The p value for winter wheat yield for the main effect of variety, tillage, and tillage by variety interaction is .288 (n=9), .425 (n=6), .425 (n=3) respectively.
3. The p value for spring wheat yield for the main effect of variety, tillage, and tillage by variety interaction is .039 (n=9), .090 (n=6), .323 (n=3) respectively.

Table 16. The effect of tillage and variety on yield on spring wheat at Norman Co. on August 18, 1988.

Crop-Variety	Tillage: No Till	Chisel	Moldboard	Average
Spring Wheat	bu/A			
Marshall	25.9	26.5	25.6	26.0
Stoa	26.8	24.4	27.9	26.4
Average	26.3	25.4	26.8	26.2

1. These yield estimates were made with a production combine (20′ x 200′ sample size). The p value for spring wheat yield for the main effect of variety, tillage, and tillage by variety interaction is .853 (n=9), .923 (n=6), .648 (n=3) respectively.

Table 17. The effect of tillage and variety of wheat on percent stand at Norman Co. on July 25, 1988[1].

Crop-Variety	Tillage: No Till	Chisel	Moldboard	Average
	Percent Stand			
Winter wheat	%			
Bighorn	81.7	41.7	30.0	51.1
Roughrider	88.3	53.3	71.7	71.1
Average	85.0	47.5	50.8	61.1
Spring wheat				
Marshall	96.0	93.3	92.7	94.0
Stoa	95.0	96.7	93.3	95.0
Average	95.5	95.0	93.0	94.5

1. This is a visual estimate of the percent of the plot with a good stand of wheat. The p value for spring wheat percent stand for the main effect of variety, tillage, and tillage by variety interaction is .017 (n=9), .007 (n=6), .092 (n=3) respectively. The p value for winter wheat percent stand for the main effect of variety, tillage, and tillage by variety interaction is .592 (n=9), .549 (n=6), .621 (n=3) respectively.

Table 18. Effect of tillage on barley grain yield, moisture, and test weight in Norman Co. on July 25, 1988, n=6.

Variable	Tillage: No Till	Chisel	Moldboard	Sig.
Grain Yield	bu/A 56.7	56.7	56.4	.959
Moisture	% 9.1	10.2	11.6	.043
Test Weight	lbs./bu 44.6	43.2	42.9	.123

Table 19. Effect of tillage and nitrogen rate on barley yield, moisture, and test weight at Norman Co. on July 25, 1988.

Variable	Tillage[1]: No Till		Chisel		Moldboard		Average[2]	
	Nitrogen Rate lbs/A							
	55	0	55	0	30	0	N	No N
	bu/A							
Grain Yield	62.0	51.3	60.2	53.1	56.8	56.1	59.7	53.5
	%							
Moisture	9.2	9.0	10.9	9.5	11.3	11.8	10.5	10.1
	lbs/bu							
Test Weight	44.2	45.0	42.5	43.8	42.8	43.0	43.2	43.9

1. The p value of the tillage by nitrogen interaction for barley yield, moisture and test weight is .222, .128, .075; (n=3) respectively.
2. The p value of nitrogen for barley yield, moisture and test weight is .034, .282, .006; (n=9) respectively.

Table 20. The effect of tillage on soybean yield and moisture at Norman Co. on Sept. 6, 1988, n=3.

Variable	Tillage: No Till	Chisel	Moldboard	Sig.
Grain Yield	bu/A 29.6	22.2	24.6	.010
Moisture	% 8.9	9.8	9.4	.262

The Effect of Tillage on Crop Production in West Central Minnesota[1]

J.F. Moncrief and J.J. Kuznia[2]

Abstract: Although tillage affected the amount of weeds present in soybeans following spring wheat it did not affect grain yields. At another site barley following soybeans was not affected by tillage.

Douglas County

This is the third year of this study. The rotation is barley, wheat, and soybeans. In 1988 soybeans were grown. The soil at this site is a Barnes-Langhei loam and is well drained. There has been little effect of tillage on crop yields at this site.

There were very little weeds at this site but several species were significantly affected by tillage (table 2). There was more foxtail and canada thistle with the no till system. Quackgrass density was higher with the chisel and moldboard plowing systems. The no till system received an application of Roundup on May 3, 1988.

Plant stands were lower with chisel plowing. Soybean grain yields were not affected by tillage (table 3) and yield levels were high in light of the low rainfall early in the season (3.25 inches in June and July). Rainfall in July and August totaled 5.88 inches.

DOUGLAS COUNTY

Table 1. Cultural practices at Douglas County, MN. 1988

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

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

1988 Crop
Soybeans-Pioneer 1082

Planting and Harvest Date

Planter was a Great Western with 6.75 inch row spacing.

	Planting		
Crop	Date	Rate	Harvested
Soybeans	May 13, 1988	225,000 plants/A	October 5, 1988

1 Support for this project in part was provided by the Soil Conservation Service which is greatly appreciated. Data collection was assisted by Lisa M. Axton, Lee R. Johnson, Larry J. Zilliox, and Dennis Q. Miller, Becker County Agricultural Extension Agent, Becker County District Conservationist, Douglas County Agricultural Extension Agent and Douglas County District Conservationist respectively. Without their help this study would not have 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.

Fertilization History

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			--- lbs/A ---			
Winter Wheat	18-46-0[1]	100 lbs/A	18	46	0	September 29, 1986
	46-0-0[2]	217 lbs/A	100	0	0	May 29, 1987
Spring Wheat	18-46-0[1]	100 lbs/A	18	46	0	April 21, 1987
	46-0-0[2]	217 lbs/A	100	0	0	May 29, 1987

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

Soil

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

Weed Control

No Till Plots:

1 qt/A (.75 lb/A) Roundup + .75 pt/A (.375 lb/A) 2,4-D applied May 3, 1988.

Chisel and Moldboard Plots:

1 qt/A (1 lb/A) Treflan applied May 13, 1988 just prior to planting and incorporated in with two passes with a field cultivator.

No Till Plots:

1.5 pts/A (.28 lb/A) Poast + 1 gal/A 9-18-9 applied July 7, 1988.

Chisel and Moldboard Plots:

1 pt/A (.5 lb/A) Basagran + 1 pt/A (.25 lb/A) Blazer + 1 gal/A 9-18-9 applied on July 8, 1988.

Table 2. Effect of tillage on weed severity in soybeans at Douglas Co. on October 5, 1988, n=3.

Weed	Tillage: No Till	Chisel	Moldboard	Sig.
	-------- % cover --------			
Foxtail	5.3	3.0	3.3	.060
Quackgrass	1.3	2.0	3.3	.004
Ragweed	1.0	1.3	1.0	.444
Canada Thist	2.7	1.7	1.7	.005

Table 3. Effect of tillage on soybean yields, moisture, and population in Douglas Co. on Oct. 5, 1988, n=3.

Variable	Tillage: No Till	Chisel	Moldboard	Sig.
	---------- bu/A ----------			
Grain:Yield	39.5	39.6	40.7	.820
	---------- % ----------			
Moisture	11.8	12.3	12.2	.147
	---- plants/A x 10^{-3} -----			
Population	236.2	196.6	229.7	.068

Becker County

This is the third year of tillage demonstration at this site. The crop rotation is similar to the Douglas County site; wheat, soybeans, and barley. This is the barley year.

It is surprising that the soybeans in 1987 resulted in the soil cover (shown in table 5) when tillage was eliminated. Tillage did not affect barley yields however (table 6). It did have a small but statistically significant effect on test weight however. Barley following soybeans have not been affected by tillage in five site years that are available collectively from the Norman, Douglas, and Becker County studies.

BECKER COUNTY

Table 4. Cultural practices at Becker County, MN. 1988.

Tillage

No Till
Fall Chisel Plowed on October 26, 1988
Fall Moldboard Plowed on October 26, 1988
Spring tillage consisted of a pass with a Multi Weeder on April 18, 1988.

Cropping History

1985-Barley, 1986-Winter and Spring wheat
1987-Soybeans

1988 Crop

Barley-Robust

Planting and Harvest Dates

Planter was a Haybuster No Till Disc Drill.

Crop	Planting Date	Planting Rate	Harvested
Barley	April 12, 1988	2 bushel/A	July 26, 1988

Fertilization History

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			---	lbs/A	---		
Soybeans	18-46-0[1]	110 lbs/A	20	51	0	June 2, 1987	Drill

Fertilizer 1988

Crop	Material Analysis	Rate	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	Method of Application
			---	lbs/A	---		
Barley	9-23-30[1]	110 lbs/A	10	25	33	April 12, 1988	Drill
	46-0-0	130 lbs/A	60	0	0	April 18, 1988	Broadcast

Soil

Hamerly clay loam (Aeric Calciaquolls, fine-loamy, frigid)-Winger silty clay loam (Typic Calciaquolls, fine-silty, frigid) complex, 2 percent slope. Soil is somewhat poorly drained to moderately well drained soil.

Weed Control

12 lbs/A (1.2 lbs/A) Far-Go 10G granules applied on November 3, 1988.
.5 pt/A (.25 lb/A) 2,4-D applied on May 23, 1988.
.75 pt/A (.375 lb/A) 2,4-D applied on June 15, 1988.

Table 5. Effect of tillage on soil covered by soybean residue in barley at Becker Co. on April 21, 1988,[1].

Residue Location	Tillage: No Till	Chisel	Moldboard	Avg.
	--------	% cover	--------	
In Row	86.2	13.3	2.4	34.0
Between Row	89.8	8.2	0.9	33.0

1. Tillage was significant < .100 in all cases, n=18.

Table 6. Effect of tillage on barley yield, moisture and test weight in Becker Co. on July 26, 1988, n=6.

Variable	Tillage: No Till	Chisel	Moldboard	Sig.
	--------	bu/A	--------	
Grain:Yield	71.5	76.2	74.6	.224
	--------	%	--------	
Moisture	10.5	10.2	9.9	.009
	--------	lbs/A	--------	
Test Weight	45.5	45.7	45.3	.011

CORN-TILLAGE RESIDUE MANAGEMENT, LANCASTER, WI. 1988

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

ABSTRACT: Severe drought conditions throughout the 1988 growing season drastically reduced corn grain yields, which ranged from 43 bu/A for conventional moldboard plow normal to 68 bu/A for no-tillage mulch treatments. Mulch increased grain yield 20 bu/A on conventional moldboard plow treatments, and in general yields were highest on mulch treatments for all tillage systems studied. A reversal of crop height occurred for high and low cover treatments between 70 to 95 days postplant; the reversal apparently corresponded to the earlier onset of drought stress on low cover treatments. Plant populations were not significantly different between treatments. The effect of in-row cover on grain moisture was more than twice as great as previously measured, again presumably due to water conservation and growth delay effects of the mulch. Surface mulch approximately doubled the infiltration rate on the moldboard plowed treatment but did not increase infiltration rates on the no-tillage treatment.

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., 1987 a). A simulation model 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., 1987 b). 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 (Staricka, 1984; Swan et al., 1989 a and b). 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 losses from cropland in Minnesota, ranging from 4.0 to 6.6 t/ac/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 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 to 80 percent surface cover. Plots are approximately 90 to 100 feet

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in width and 80 feet in length. Row width was 36 inches in 1988. Pioneer 3737 was planted May 4, 1988 at 31,000 plants per acre. The conventional (Moldboard) treatment was plowed about April 27 and crop residue applied on April 28. No-till and chisel plots were 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 9 inch area over the row. Fluted coulters were used on all four rows on the conventional and Ro-till treatments.

Nitrogen (250 lb/A of N as 28% N) was broadcast April 12. Starter fertilizer at planting was 200 lb/A of 6-24-24. The insecticide was Counter at 10 lb/A. Pre-emergence herbicide was applied on May 4 following planting (2.5 Qt/A of Bladex 80W and 2.5 pt/A of Dual 8E). A tank mix of Buctril and Banvel was applied postemergence on May 24 at 1 pint/A and 0.5 pints/A, respectively.

Percent cover was determined from slides taken May 18. 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 Ro-till treatments in Rep 3 for mulch added, bare, and normal treatments. Soil temperature was measured at depths of 1, 5, 10, 15, and 50 cm. Yields for individual plots were determined by hand harvesting 60 foot of row (two subsamples each consisting of paired 15 ft lengths of row) in October.

Ten plot frames (45 3/4 x 45 3/4 inches) were emplaced May 5 before the surface was weathered by rainfall. Infiltration measurements were made on Ro-till mulch, no-till bare and mulch, and conventional normal and mulch treatments during the period May 16- may 19. Paired tensiometer measurements were made at three depths within the plot frame during the infiltration event.

RESULTS-CORN YIELDS AND CROP HEIGHT

Severe drought conditions were present throughout the 1988 growing season at Lancaster. Precipitation was 13.02 inches below normal for the April to October period and air GDD (degrees F) were 422 above normal for May through September (Table 2). Consequently corn yields ranged from 43.1 bu/A for conventional normal to 68.1 bu/A for no-till mulch treatments (Table 1). Grain yields of individual tillage, residue, and in-row residue management treatment were significantly different at the 5 percent level of significance. Plant population was not significantly different between treatments. A reversal of crop height for high and low cover treatments occurred between 70 and 95 days post-plant (Figures 1 and 2). For the first 70 to 80 days mulch treatments were 20 to 30 cm shorter than bare or normal treatments; however, by day 70 for the ro-till and day 85 for chisel and no-till, crop height of the mulch treatments exceeded crop height of bare and normal treatments. On the no-till bare treatment drought stress was observed by day 62 prior to pollen shed on day 68. On the no-till mulch treatment tasseling did not occur until after day 75. The earlier incidence of drought stress on bare and normal treatments and the delayed phenologic stage of growth on mulch treatments apparently both contributed to the observed reversal in crop height.

For each tillage treatment grain yields from mulch treatments equalled or exceeded those from normal or bare treatments; mulch increased grain yield 20 bu/A on the conventional tillage treatment. Average corn grain yields of the replicates ranged from 52.4 bu/A for rep. one to 64.6 bu/A in rep. three. As in 1983, 1984, 1985, and 1986, corn grain yield increased as soil depth increased; however, in 1981, 1982 and 1987 rep. average grain yields were not related to average soil depth. Thus the effect of rooting depth and available water holding capacity in the root zone on grain yields depends greatly on the climatic conditions in the individual year as well as on the crop grown (Table 3).

SEEDBED CONDITIONS AND CORN GROWTH

For the 12 treatments, the average planting depths were statistically different at the 0.01 level of significance; the average standard deviation of planting depths were not statistically different.

The trash whip attachment (TW) reduced in-row residue cover nearly one-half compared to the in-row cover

resulting from the coulter unit (C) (Table 1). The equation

$$\text{Eq 1: \% cover TW} = 1.6 + 0.51\ (\text{\% cover C})$$

explained 98% of the variation in % cover of the TW treatments in 1988. The effect of increasing in-row residue cover (by mulch additions) was to increase the number of days required to reach 75% emergence (Table 4) and to delay the date of silking (Table 1). The equation

$$\text{Eq 2: Days to 75\% emergence} = 15.0 + 0.071(\text{\% in-row cover})$$

explained 86% of the variation in days to 75% emergence.
Percent in-row cover was closely related to grain moisture (GM) in 1988 and the increase in grain moisture per percent of cover was more double that measured in previous years.

$$\text{1985 Eq 3: \% G M} = 20.5 + 1.97 \times 10^{-2}\ (\text{\% in-row cover});R^2 = 0.87$$
$$\text{1986 Eq 4: \% G M} = 19.1 + 0.69 \times 10^{-2}\ (\text{\% in-row cover});R^2 = 0.47$$
$$\text{1987 Eq 5: \% G M} = 17.1 + 1.24 \times 10^{-2}\ (\text{\% in-row cover});R^2 = 0.49$$
$$\text{1988 Eq 6: \% G M} = 14.3 + 5.39 \times 10^{-2}\ (\text{\% in-row cover});R^2 = 0.80$$

The greater effect of in-row cover on grain moisture in 1988 is presumably due to both the delay in growth and to water conservation by the mulch which prolonged plant growth during the drought. Grain moisture of individual treatments was significantly different (0.01 level of significance).

Percent in-row cover was closely related to air growing degree days (GDD) measured from planting to 6-leaf in 1988 as in previous years; however, the change in air GDD per % of in-row cover was three times greater than that measured previously, apparently caused by the insulation effects of the higher mulch rate of approximately 7 tons/A applied in 1988. A similar effect was observed in 1981 when mulch rates of 7 or more tons/A were applied.

$$\text{1984 Eq 7: Air GDD(6-leaf)} = 285 + 0.53\ (\text{\% in-row cover});R^2=0.96$$
$$\text{1985 Eq 8: Air GDD(6-leaf)} = 273 + 0.47\ (\text{\% in-row cover});R^2=0.91$$
$$\text{1986 Eq 9: Air GDD(6-leaf)} = 296 + 0.54\ (\text{\% in-row cover});R^2=0.84$$
$$\text{1987 Eq 10: Air GDD(6-leaf)} = 278 + 0.52\ (\text{\% in-row cover});R^2=0.79$$
$$\text{1988 Eq 11: Air GDD(6-leaf)} = 274 + 1.49\ (\text{\% in-row cover});R^2=0.91$$

The close agreement of the intercept at zero cover in 1988 (274) with that measured in previous years indicates that the corn growth relationship to Air GDD on low residue treatments in 1988 was similar to that measured in previous years in spite of the drought conditions.

The effect of in-row residue cover and tillage on soil temperature and corn growth was evaluated at Lancaster in 1983, 1984, 1985, 1986, 1987, and 1988. Hourly soil temperatures were recorded for 1, 6, 11, 16, 50, and 100 cm depths under the row on chisel normal and mulch, no-till bare and mulch, and paraplow normal and mulch treatments in 1984, 1985, and 1986. In 1987 the Ro-till treatment replaced the paraplow treatment. No-till normal (trash whip) was also measured in 1987 and 1988. Soil temperatures were measured using 4-couples in parallel for 16 cm and shallower depths. Leaf stage observations were taken periodically through 6-leaf stage. Equation 11 was developed using station air temperatures and leaf stage observations from rep 3.

Adjacent strips 15 feet long and 1 foot wide (centered over the row) were painted on May 6 on no-till bare and mulch treatments. Black paint increased to absorption of solar radiation increased soil temperatures on the no-till bare treatment sufficiently to reduce the air GDD to 6-leaf by 7.5 degrees C. However the black painted no-till mulch treatment required 32 additional air GDD to reach the 6-leaf stage apparently due to greater mulch depth and thus greater insulating properties on the painted treatment.

In 1988, large differences in "final" (50-60 minute average) infiltration rates were measured between treatments

(Tables 5 and 6). Final infiltration rates from conventional tillage mulch treatments were 43% greater than conventional tillage normal residue treatments (Table 7). For the eight year period of measurement, mulch has approximately doubled the infiltration rate on conventional tillage. Infiltration rates on the ro-till mulch were between the rates measured on the conventional normal and mulch treatments. In 1988 there was little increase in infiltration rate due to mulch on the no-till treatment, and both treatments averaged approximately 0.8 in/hr. For the eight year period the final infiltration rates on the no-till mulch treatment averaged approximately the same as that measured with the conventional moldboard tillage without residue (normal). Large increases in final infiltration rates were measured on no-till mulch compared to other treatments when nitrogen injection immediately preceded planting. Increases were also measured following the use of the paraplow.

Measurements with tensiometers at 3, 7 and 16 inch depths inside the infiltration frames during the infiltration runs have shown the presence of a flow restricting layer below the plow layer on moldboard mulch treatments. Crust formation on the moldboard normal treatments is indicated by the negative matric potentials measured in the plow layer. The surface crust formed by raindrop impact on the bare surface of the moldboard normal treatment restricts the flow rate sufficiently so that flow restriction from the layer below the plow layer is not observed during the infiltration run. Similar results have been observed in some but not all of the previous years when tensiometer measurements were made. Even though water was applied for more than 60 minutes, infiltrating water did not penetrate to the 3-inch tensiometer depth on the no till bare treatment in 4 out of 6 measurements.

The results again illustrate the requirement 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 is not 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. Nine year yield results (1979-1988) show nearly equal yields for conventional, chisel and no-till treatments (Table 8). In 1986, 1987, and 1988 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.

LIST OF REFERENCES

Staricka, J. A. 1985. Tillage crop management model for corn production in southeastern Minnesota. M.S. thesis, Univ. of Minnesota, St. Paul.

Swan, J. B., E. C. Schneider, J. F. Moncrief, W. H. Paulson, and A. E. Peterson. 1987a. Estimating corn growth, yield, and grain moisture from air growing degree days and residue cover. Agron. J. 79:53-60.

Swan, J. B., M. J. Shaffer, W. H. Paulson, and A. E. Peterson. 1987b. Simulating the effects of soil depth and climatic factors on corn yield. Soil Sci. Soc. of Am. J. 51:1025-1032.

Swan, J. B. , J. A. Staricka, M. J. Shaffer, W. H. Paulson, and A. E. Peterson. 1989. Corn yield response to water stress, heat units ,and management: model development and calibration. submitted to Soil Sci. Soc. Am. J. Div. S-6.

Swan, J. B., J. A. Staricka, A. E. Peterson, R. L. Higgs, and J.F. Moncrief. 1989. Corn yield response to water stress, heat units, and management: model validation. submitted to Soil Sci Soc. Am. J. Div S-6.

Swan, J. B., R. L. Higgs, W. H. Paulson, and A. E. Peterson. 1988. Effect of tillage and residue management on seed depth, soil temperature, and corn growth. p. 286. in Agronomy Abstracts. ASA, Madison, WI.

FIG 1 CROP HEIGHT VS TIME FOR NO-TILLAGE TREATMENTS

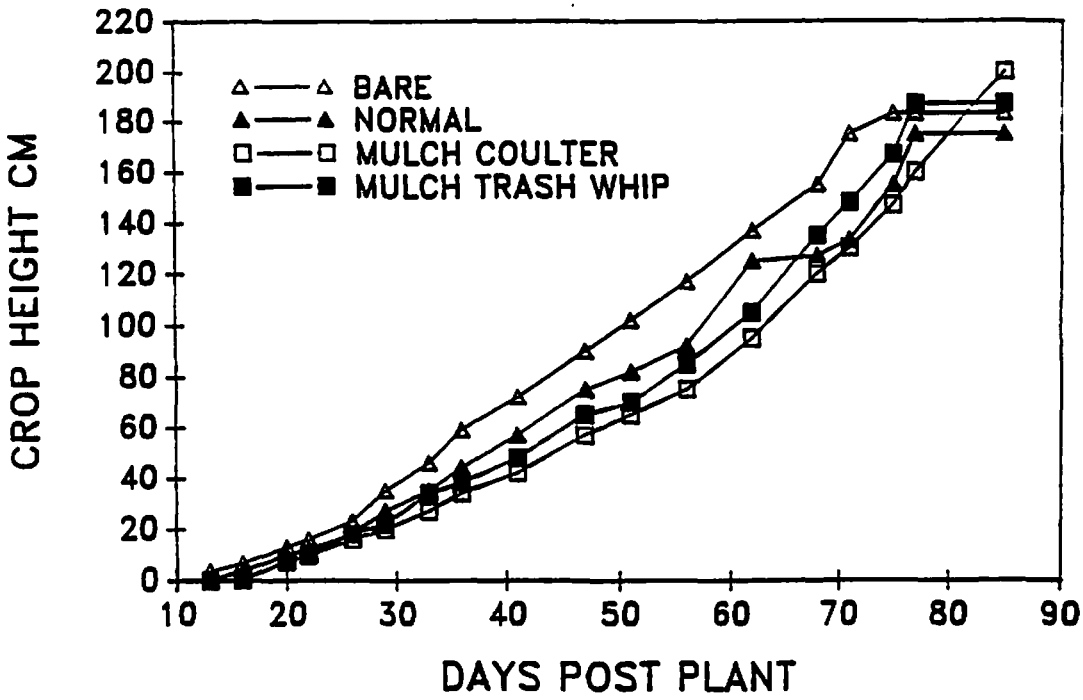

FIG 2 CROP HEIGHT VS TIME FOR CHISEL AND RO-TILL TREATMENTS

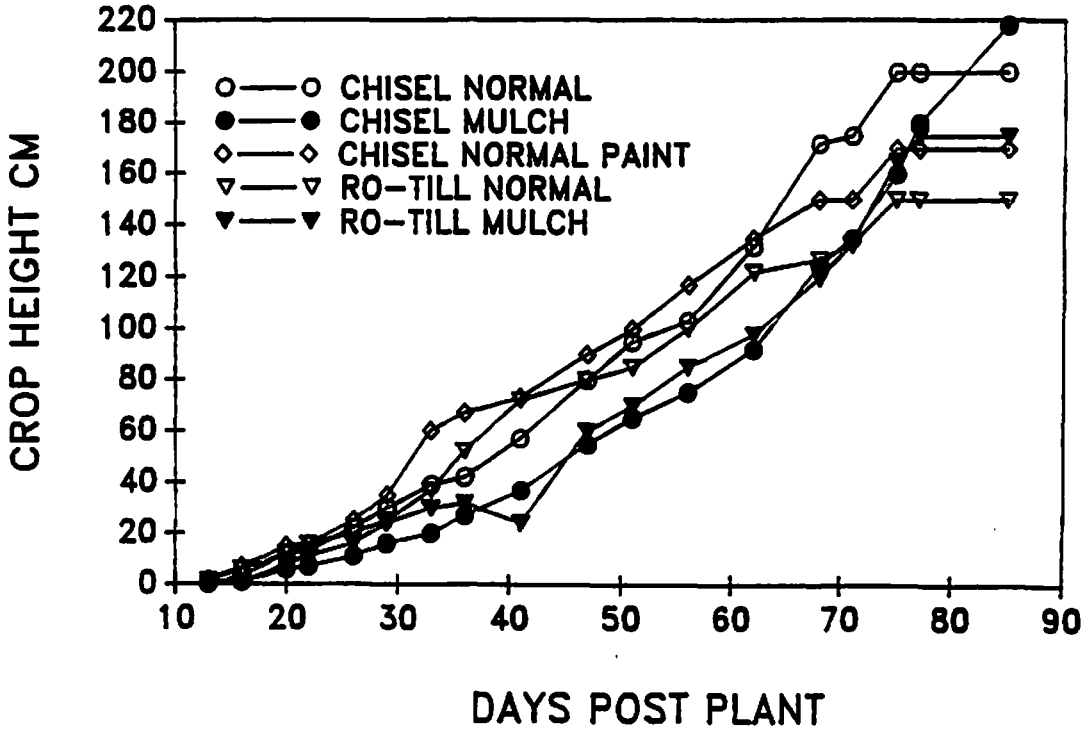

Table 1. Effect of Tillage and Mulch Treatments on Percent Cover, Planting Depth, Emergence, Silking Date, Population and Grain Yield-1988-Lancaster, WI.

Treatments			Percent Cover		Planting Depth		Days	Date	Avg.	Ave.	Avg.
		In-Row Residue		Entire	Avg.	S.D.	Post Plant to 75%	50% Silked	Poplin at Harvest	Grain Yield	Grain Moisture
Tillage	Residue	MGT	In Row	Area	mm	mm	Emergence	July	PL/A	Bu/Ac	%
NoTill	Normal	C	43	70	26.5	7.4	18	17	26320	58.8	16.7
	(N)	TW	24	41	34.1	5.4			27950	62.3	16.1
	Bare	C	7	6	28.4	7.6	15	14	25770	58.1	13.8
	(O)	TW	5	6	37.0	6.1			27410	56.9	15.0
	Mulch	C	92	95	35.4	10.0	19.5	20	25530	66.4	18.9
	(2X)	TW	52	66	38.8	6.6			26620	68.1	18.5
Bush Hog	Normal (N)	C	12	29	35.1	7.0	16.5	15.5	26920	54.2	14.6
	Mulch (2X)	C	75	88	33.5	8.4	21	21	25650	67.6	19.8
Chisel	Normal (N)	C	7	13	35.9	6.6	16.5	14.5	26320	56.5	14.5
		TW	5	8	42.0	7.2			25650	55.5	14.5
	Mulch (1X)	C	91	97	38.6	7.3	21	20.5	26860	60.8	19.0
		TW	44	58	34.4	6.1			25170	56.3	17.9
Conv	Normal (N)	C	2	3	42.4	6.2	14	13.5	24380	43.1	13.4
	Mulch (1X)	C	93	96	43.5	7.0	23.5	21	24320	63.3	17.3
	Significance Level								NS	0.05	0.01

Table 2. 1988 Weather Summary Lancaster, WI Agricultural Research Station

Month	Precipitation inches		Growing Degree Days		Air Temperatures			
	Total	Departure	1988	Departure	Average Max	Average Min	Average Daily	Departure
	- - - inches - - -		- - - - - - - - - - - - - - - - - - of					- - - - - - - - - - - - - - - - - -
April	1.16	-1.87	--	--	59.0	34.7	46.8	-0.2
May	0.87	-1.58	375	+ 71	76.5	47.6	62.0	+3.9
June	0.42	-3.99	613	+ 93	86.0	56.4	71.2	+4.0
July	1.80	-2.40	721	+ 58	89.7	61.5	75.6	+3.9
August	2.92	-1.51	712	+119	86.8	63.4	75.1	+6.1
September	3.96	+0.40	439	+ 81	76.0	51.3	63.6	+2.6
October	1.27	-1.07	--	--	54.6	32.5	43.6	-6.4
Total Growing Season	12.40	-13.02	2860	+422				

Last day in spring with minimum temperature: 32° or less 4/27 (32°F)
28° or less 4/21 (17°F)

First day in fall with minimum temperature: 32° or less 10/4 (31oF)
28° or less 10/5 (28°F)

Table 3. Average Yields and Depth to Clay Residuum by Replicate and Monthly precipitation for 1981 through 1988, Lancaster, WI.

Year	Replicate Number 1	2	3	4	Monthly Precipitation May	June	July	August
	---------- Bu/Ac ----------				---------- inches ----------			
1981	146.8	146.7	142.1	147.1	0.85	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	56.9	64.6	62.6	0.87	0.42	1.80	2.92
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 or 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 t Aug. 31 (45 days.
***1985 - 1.59 inches precipiation 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 - 1988 Lancaster, WI.

Treatment Tillage	Residue	Coulter or trash whip unit	Percent Emergence ----------Days Post Plant ---------- 13	15	17	21	23	27	30
No-Till	Normal	C	4	17	67	96	99	100	-
	Bare	C	44	76	90	99	100	-	-
	Mulch	C	1	6	43	89	97	98	100
Bush Hog Ro-Till	Normal	C	10	31	84	97	98	99	100
	Mulch	C	1	3	16	77	79	97	100
Chisel	Normal	C	13	40	82	97	100	-	-
	Mulch	C	0	1	18	75	88	98	100
Conventional	Normal	C	61	85	88	98	99	100	-
	Mulch	C	1	10	34	68	73	94	100
Air Growing Degree Days from planting		'F	151.5	173.	204.	269.5	295	377.5	445.0
(including plant date May 4)		'C	84.2	96.1	113.3	149.7	163.9	209.7	247.0

All treatments reached 100% emerged by Day 30.
May 4 = Day 1

Table 5. 1988 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	4.32	0.36	1.92	0.96	1.20	0.48	0.24	0.24	0.24	0.24	0.24	0.48	0.72	0.72
		W	4.32	0.50	1.44	1.20	1.44	0.48	0	0.48	0.48	0	0	0.48	0.96	0.96
	Mulch	E	4.32	0.40	3.48	2.52	1.92	1.44	1.20	0.96	0.72	0.24	0.96	0.48	0.72	0.72
		W	4.40	0.59	3.20	2.12	2.00	1.88	1.76	1.04	1.04	0.56	1.04	0.80	0.80	1.04
Conv.	Normal	E	5.04	1.64	4.20	3.48	2.88	2.88	2.40	2.40	1.80	1.32	1.44	2.16	1.68	2.16
		W	4.80	1.84	3.96	3.48	3.00	2.76	2.40	2.28	1.32	1.44	1.44	1.44	1.68	1.68
	Mulch	E	4.80	1.92	-	0.96	0.72	0.72	0.96	1.68	1.44	1.20	1.56	1.56	1.80	2.04
		W	4.56	3.19	4.08	3.48	3.36	3.36	3.48	3.36	3.36	3.36	3.36	3.36	3.36	3.12
Bush Hog	Mulch	E	4.24	1.06	2.08	1.84	1.84	1.84	1.60	1.36	1.60	1.36	1.12	1.84	1.84	2.32
Ro-Till		W	4.16	1.11	3.68	2.24	2.00	2.24	2.00	1.76	1.76	1.28	1.52	1.52	1.52	2.00

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

Tillage	Treatment Residue	1981	1982	1983	1984	1985	1986	1987	1988	Avg.
		----------	----------	----------	----------	inches/hour	----------	----------	----------	----------
No Till	Bare	--	--	--	1.68	1.00	1.24	1.26	0.84	
	Mulch	1.46	1.10	3.53*	0.60	3.02	2.10	1.22	0.82	1.47+
Conventional	Bare	0.97	1.52	0.54	1.70	1.40**	1.83	1.15	1.80	1.36
	Mulch	2.72	2.34	1.49	2.90	2.14**	2.25	4.81	2.58	2.65
		----------	----------	----------	Ratio	----------	----------	----------	----------	
Conv. Bare/Conv. Mulch		0.36	0.65	0.36	0.58	0.65	0.81	0.24	0.70	0.51
No Till Mulch/Conv. Bare		1.51	0.72	6.53	0.35	2.16	1.15	1.06	0.46	1.00+

* 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 - 1988 Lancaster.

Treatment			Infilt	cm soil depth 7.5	17.5	40	7.5	7.5	17.5	40
Tillage	Residue	Rep.	in./hr	cm H_2O						
No-Till	Bare	E	0.54	-202	- 87	- 75	-33	-113	-	-
		W	0.64	-160	-107	+ 9	-10	- 12	-40	-
	Mulch	E	0.72	- 36	- 49			- 24	+24	-
		W	0.92	- 6	- 32	- 95		- 30	-	+ 12
Conven.	Normal	E	1.86	- 12	- 6	- 85		+ 3	- 5	-219
		W	1.56	- 10	- 4	-240		+ 4	- 5	- 1
	Mulch	E	1.74	+ 8	+ 9	+ 35	+12	+ 8	-10	-
		W	3.30	+ 6	+ 7	- 33	+22	+ 13	+ 9	+ 28
Ro-Till	Mulch	E	1.78	+ 2	- 31	+ 2		+ 3	+ 2	
		W	1.64	- 58	+ 12	- 3		- 19	-39	

Table 8. 1979-1988 Continuous corn tillage yield results, Lancaster, WI.

Tillage Treatment with normal residue	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	79-83	79-88
	bu/A											
Ridge plant	162	157	157	147	100	---	---	---	---		145	---
No-Till (slot plant)	163	146	151	141	85	108	120	165	177	59	137	132
Chisel	160	150	167	154	95	115	125	159	168	57	145	135
Conventional	169	159	168	151	89	121	133	164	168	43	147	137
Paraplow*	---	---	---	---	---	106	125	162	---	---	---	---
Ro-Till	---	---	---	---	---	---	---	---	172	54	---	---

*Fall 1983 and Fall 1984

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