Soil Tests

Table 2. The effect of tillage on nutrient levels, n=3.

		Tillage					
	Sig. of	No Till		Chisel		Moldboard	
Sept. 1985[1]	Tillage	mean	stdev	mean	stdev	mean	stdev
Nutrient[2]		lb/ac					
Nitrate	(.348)	96	12	89	9	81	8
Phosphorus	(.564)	13	5	13	4	9	3
Potassium	(.178)	337	59	305	11	256	62
pH	(.284)	8.1	.1	8.1	.1	8.2	.1
June 24, 1986[3]							
Nitrate	(.169)	64	37	81	14	149	59

1. Samples were taken from both winter and spring wheat areas then mixed.
2. Nitrate sample depth was 0-24", while the other nutrient levels were determined on a 0-8" sample.
3. Samples were taken from spring wheat areas only.

Table 3. The effect of tillage on percent of the soil surface covered by barley residue in winter wheat in Sept., 1985, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	stdev	mean	stdev	mean	stdev
Variety	%					
Bighorn	65.7	6.50	26.0	5.57	9.00	3.61
Roughrider	60.0	9.00	28.0	5.20	8.67	2.08

Table 4. The effect of tillage on percent of the soil covered by barley residue on May 27, 1986, n=6.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
Crop	%					
Winter Wheat	69.7	6.38	47.0	9.78	17.8	2.79
Spring Wheat	50.5	3.33	20.7	4.41	5.83	2.56

Table 5. The effect of tillage on winter wheat stand on May 7, 1986 n=6 and spring wheat stand June 5, 1986, n=17.

		Tillage					
		No Till		Chisel		Moldboard	
Crop	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		plants/ac x 10^{-3}					
Winter Wheat[1]	(.001)						
Bighorn		562	136	601	33.1	423	104
Roughrider		623	98.4	479	75.1	431	93.1
Spring Wheat	(.918)	870	198	880	146	895	195

1. The effect of variety on stand of winter wheat was .599, and the interaction of variety x tillage was .104.

Table 6. The effect of tillage on the presence and density of weed species in spring wheat on June 5, 1986[1], n=6.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Mustard	(.314)	10.5	10.6	58.2	56.1	32.4	32.0
Alfalfa	(.836)	45.1	69.8	10.9	13.1	16.2	24.0
Buckwheat	(.186)	5.89	14.4	4.82	7.75	1.55	1.79
Smartweed	(.903)	23.6	57.7	.448	.695	.485	1.19
Lambsquartr	(.836)	1.47	3.61	.992	1.84	1.21	2.33
Quack		47.9	114	0.00	0.00	0.00	0.00
Ragweed	(.653)	4.95	8.57	11.6	27.4	.078	.189
Wht.Cockle	(.262)	.316	.775	8.10	19.2	3.50	3.61
Dandelion		1.79	3.53	.219	.536	0.00	0.00
Pigweed		0.00	0.00	.871	2.13	0.00	0.00
Vol. Barley	(.141)	16.1	25.9	.230	.562	.106	.260
Vol.Sunflow		0.00	0.00	0.00	0.00	.121	.297
Can.Thistle		0.00	0.00	.230	.562	0.00	0.00

1. The variety by tillage interaction was not significant (<.10) for any weed species.

Table 7. The effect of tillage on the presence and density of weed species[1] in winter wheat on June 5, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Mustard	(.426)	20.3	32.8	45.7	54.0	51.8	30.2
Alfalfa	(.267)	8.13	9.94	122	159	57.3	75.2
Buckwheat	(.399)	300	690	61.5	59.7	58.6	17.8
Smartweed	(.051)	433	775	79.0	156	2.25	5.51
Lambsqtr	(.847)	15.6	34.4	10.9	15.1	4.86	5.65
Ragweed	(.293)	1.76	4.30	1.22	29.9	7.91	10.1
WhtCockle		0.00	0.00	14.8	14.7	63.1	54.0
Dandelion		2.34	5.73	0.00	0.00	0.00	0.00
CanThistl		15.6	34.4	7.73	17.2	0.00	0.00
SowThistl		6.32	14.1	0.00	0.00	1.10	2.68
Wild Oat		.949	2.32	0.00	0.00	0.00	0.00
MarshEldr		0.00	0.00	9.05	14.5	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold face type.

Table 8. The effect of tillage on the growth stages of winter wheat on May 7, 1986 and spring and winter wheat on June 5, 1986. Haun's growth staging was used, n=30.

		Tillage					
		No Till		Chisel		Moldboard	
Crop	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		Haun's growth stage					
May 7, 1986							
Winter Wheat[1]	(.336)						
Bighorn		4.19	.419	4.34	.411	4.26	.417
Roughrider		4.17	.426	4.23	.295	4.24	.385
June 5, 1986							
Winter Wheat	(.015)	8.53	.230	8.55	.291	8.36	.275
Spring Wheat	(.001)	2.29	.229	2.14	.168	2.10	.152

1. The significance of variety was .413, and the variety x tillage interaction was .818.

Table 9. The effect of tillage and variety on leaf disease measured in wheat on July 3, 1986, n=3.

Leaf Position	Roughrider No Till	Roughrider Chisel	Roughrider Moldboard	Bighorn No Till	Bighorn Chisel	Bighorn Moldboard	Marshall No Till	Marshall Chisel	Marshall Moldboard
	Modified Hosford Scale								
Upper	7.33	6.67	7.33	8.33	8.00	8.00	4.33	4.33	4.67
Middle	7.67	7.67	7.00	8.00	8.00	7.66	4.00	3.33	4.00
Lower	8.67	8.67	8.67	9.00	9.00	8.67	6.00	5.00	5.66

Table 10. The significance values of leaf disease ratings measured on July 3, 1986, n=3.

Leaf Position	Winter Wheat Tillage	Winter Wheat Variety	Winter Wheat Till. x Var.	Marshall Tillage
	significance			
Upper	.599	.060	.790	.444
Middle	.609	.374	.940	.309
Lower	.444	.116	.444	.284

Table 11. The effect of tillage and variety on wheat yields[1], n=3.

Variety	Sig. of Tillage	No Till mean	No Till st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		bu/ac					
Winter wheat	(.004)[2]						
Bighorn		12.9	2.18	23.2	4.09	23.5	4.02
Roughrider		29.6	1.11	38.4	7.60	34.9	4.25
Spring wheat							
Marshall	(.003)	24.0	1.81	24.5	3.17	29.7	2.04

1. The results are based on the grain after it was cleaned.
2. The significance of variety was .000, and the interaction of variety x tillage was .045.

Table 12. The effect of tillage on the test weight of wheat.[1]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		lb/bu					
Winter wheat	(.676)[2]	n=3					
Bighorn		50.5	.866	49.8	1.89	52.7	1.61
Roughrider		55.2	1.89	57.2	1.44	55.2	1.44
Spring wheat		n=6					
Marshall	(.001)	44.8	1.60	46.4	1.28	48.1	1.28

1. The results are based on the grain after it was cleaned.
2. The effect of variety on test weight was .001 and the variety x tillage interaction was .150.

Table 13. The effect of tillage on the protein content of Bighorn and Roughrider winter wheat and Marshall spring wheat.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
% Protein		%					
Winter wheat[1]	(.852)	n=3					
Bighorn		14.9	.807	15.1	.808	14.7	.211
Roughrider		13.5	.618	13.7	.386	14.1	.715
Spring wheat	(.082)	n=6					
Marshall		16.0	.090	16.3	.353	16.2	.262
Protein Yield		lbs/ac					
Winter wheat[2]	(.067)	n=3					
Bighorn		121	42.6	181	33.2	180	29.5
Roughrider		208	17.2	274	61.4	256	43.3
Spring wheat	(.002)	n=6					
Marshall		192	14.3	201	23.9	242	16.0

1. The significance of variety on protein content was .018, and the interaction of variety x tillage was .550.
2. The significance of variety on protein-yield was .006 and the variety x tillage interaction was .614. Protein yield refers to the protein fraction x yield (lbs/ac).

DOUGLAS COUNTY

Table 14. Cultural practices at Douglas County, MN 1986.

Tillage
No Till
Chisel Plow - fall
Moldboard Plow - fall
The chisel and moldboard plow treatments were followed by a spring field cultivation.

Preceding Crop
Soybeans

Crop
Barley - Robust

Planting and Harvest Date
Planter was a Haybuster 107 drill, with 7" row spacing that had double disk openers and twin angled packing wheels.

Crop	Planting Date	Harvested
Barley	April 25, 1986	August 2, 1986

Fertilizer

Crop	Material (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		---lbs/ac-----			
Barley:	18-46-0[1] DAP (100 lbs/ac)	18	46	0	April 25, 1986
	46-0-0[2] Urea (217 lbs/ac)	100	0	0	Spring 1986

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
Bromoxynil(Buctril) + MCPA(ester) at 1.5pt./ac + .5pt\ac on May 28.

Soil Test
Soil samples were taken in the fall of 1985. Results were:

Crop	pH	Bray 1 P	Olsen P	K	NO_3-N 0-6"	NO_3-N 18-24"
		----------lbs/ac----------				
Barley	7.7	7	13	369	15	7

Table 15. The effect of tillage on the percent soil surface covered with soybean residue on April 25,1986 (after planting), n=18.

Tillage					
No Till		Chisel		Moldboard	
mean	std dev	mean	std dev	mean	std dev
%					
68.4	3.85	27.8	4.65	11.8	3.49

Table 16. The effect of tillage on barley population on May 21, 1986, n=36.

	Tillage					
	No Till		Chisel		Moldboard	
Sig. of	mean	std dev	mean	std dev	mean	std dev
Tillage	plants/ac x 10^{-3}					
(.027)	251	82.9	208	55.7	257	81.0

Table 17. The effect of tillage on barley growth stages 1986, n=60.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	std dev	mean	std dev	mean	std dev
Date	Tillage	Haun growth stage					
5/21	(.000)	2.84	.358	3.19	.365	3.14	.384
5/27	(.000)	3.81	.395	4.09	.361	4.09	.342
6/5	(.005)	5.70	.537	5.49	.444	5.78	.507
6/12	(.048)	7.26	.629	7.11	.446	7.32	.571
		Zadok's stage					
6/19	(.310)	46.9	2.95	46.5	2.51	47.3	2.73
6/27	(.139)	56.3	2.80	55.2	3.21	55.6	3.04
7/3	(.364)	83.0	1.25	83.1	1.10	83.3	1.13

Table 18. The effect of tillage on weed species[1] present and their density on May 21, 1986, n=12.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Foxtail	**(.000)**	**3.65**	**2.69**	**8.73**	**16.4**	**21.2**	**18.5**
Mustard	**(.082)**	**1.34**	**2.94**	**.950**	**1.04**	**6.87**	**11.1**
Lambsqtr	(.109)	.072	.119	.140	.308	2.44	3.01
Buckwht	(.563)	.244	.267	.808	1.22	2.91	3.19
Ragweed	**(.089)**	**.230**	**.358**	**.118**	**.165**	**.032**	**.109**
SowThisl		0.00	0.00	.008	.027	0.00	0.00
Nt.Shade		.146	.387	.008	.027	0.00	0.00
M.Elder		.192	.359	.006	.021	0.00	0.00
CanThisl		.024	.056	.083	.128	0.00	0.00
Mallow		.009	.032	.017	.057	0.00	0.00
Smartwd		.027	.094	.741	2.57	0.00	0.00
Pigweed	(.529)	.025	.086	.146	.399	.126	.324
BlkMedic		.058	.121	.017	.057	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 19. The effect of tillage on weed species[1] present and their density on June 9, 1986 (12 days after spraying with Bromoxynil plus MPCA), n=12.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Foxtail	**(.022)**	**6.69**	**12.2**	**52.0**	**135**	**112**	**110**
Mustard		0.00	0.00	0.00	0.00	.685	2.37
Buckwht		0.00	0.00	.078	.214	.912	1.37
Ragweed		0.00	0.00	.018	.062	0.00	0.00
Smartwd		0.00	0.00	.582	1.70	.817	1.56
Pigweed		0.00	0.00	0.00	0.00	.041	.141

1. Weed species which were significantly affected by tillage are in bold type.

Table 20. The effect of tillage on area covered with quack grass on May 21 and June 9, 1986, n=12.

	Tillage					
	No Till		Chisel		Moldboard	
Date	mean	std dev	mean	std dev	mean	std dev
	ft2/ft2x100					
5/21	.343	.415	1.92	3.03	0.00	0.00
6/9	2.40	2.09	4.41	0.00	3.00	0.00

Table 21. The effect of tillage on weed species[1] present and density in the untreated check areas on June 9, 1986. The area was covered with plastic during herbicide application, n=3.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	std dev	mean	std dev	mean	std dev
		plants/ac x 10^{-3}					
Foxtail	(.048)	23.8	33.7	16.3	8.77	129	54.9
Mustard		1.16	2.01	0.00	0.00	.581	1.01
Lambsqtr		0.00	0.00	0.00	0.00	4.65	2.66
Buckwheat		.581	1.01	0.00	0.00	3.49	3.02
CanThistl		.581	1.01	0.00	0.00	0.00	0.00
Mallow		.581	1.01	0.00	0.00	0.00	0.00
Smartweed		0.00	0.00	.581	1.01	3.49	6.04
Quack		0.00	0.00	0.00	0.00	2.32	4.03
SowThistl		.581	1.01	0.00	0.00	.581	1.01
Kochia		.581	1.01	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 22. The effect of tillage on barley yields, moisture, protein content, and test weight, n=3.

	yield[1]		% moisture		% protein		pro yield[2]		test wt	
Tillage	mean	stdev	mean	stdev	mean	stdev	mean	stdev	mean	stdev
	--bu/ac---		----%-----		----%-----		--lbs/ac--		--lbs/bu--	
No Till	63.1	3.85	17.7	.276	11.2	.394	294	24.2	46.3	.289
Chisel	63.2	3.39	17.4	.488	11.4	.445	292	20.8	47.5	0.00
Moldboard	61.9	2.01	17.9	.484	11.2	.101	282	11.0	47.3	.577
Sig. of Tillage	(.460)		(.387)		(.642)		(.328)			

1. The results are based on the grain after it was cleaned.
2. Protein yield refers to the protein fraction x yield (lbs/ac).

THE EFFECT OF TILLAGE SYSTEM, VARIETY, AND FUNGICIDE APPLICATION ON WINTER AND SPRING WHEAT, BARLEY, AND SOYBEAN PRODUCTION

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Many farmers see reduced tillage as an opportunity to make their operation more profitable. When adopting reduced tillage systems which eliminate primary tillage for small grain production reduced savings must be weighed against possible increased costs in weed and disease control. The following data was collected in an effort to evaluate tillage alternatives for small grain production.

The site is located in Norman county Minnesota. Plots are large (150 by 50 ft.) to accomodate farmer cooperators equippment. Main tillage plots were split with two varieties of winter and spring wheat. Research has shown that when planting winter wheat into standing small grain stubble winter survival is enhanced greatly due to snow catch. Two varieties of winter wheat were chosen two contrast a winter hardy variety (Roughrider) and a less winter hardy variety (Bighorn) which is shorter but has higher intrinsic yield potential.

Four crops were grown at this site. The spring was extremely wet near Ada, Minnesota this year which resulted in a June 2 planting date for the spring wheat. This site is on a Fargo-Hegne silty clay soil with poor to somewhat poor internal drainage which delayed spring wheat planting. This accounts for most of the yield difference between winter and spring wheat. Both winter and spring wheat had more leaf disease due to increased residue levels (see leaf disease ratings). There was statistically the same response to fungicide application for all tillage systems, however. The winter wheat response averaged 12.5 bu/ac and the spring wheat 4.0 bu/ac. There tended to be a larger response with the Bighorn variety. Tillage did not affect winter wheat yields although the tendency was for higher yields with less tillage with the Bighorn. Spring wheat yields were not statistically affected by tillage although the trend was for reduced yields with less tillage. Although the density of foxtail in the spring wheat was less than in the winter wheat it exerted more competitive pressure and probably explains the yield decline.

Barley and soybean yields were not affected by tillage. The barley yields were generally low due the late planting date and inadequate surface drainage. Soybean yields were 33 bu/ac regardless of tillage (table 27). The lack of soybean response to tillage is consistent with data from other locations in the state.

Statistics Reported significance values are the smallest level of significance which would lead to the rejection of the hypothesis that a given treatment did not affect a particular variable. For most field experimentation a significance value that is .10 or smaller is usually accepted as proof that differences in treatment averages are due to treatments and not to random variabilIty. If treatment variances were found to be unequal by an F.10 test, a natural log transformation was used to meet this assumption of analysis of variance.

NORMAN COUNTY

Table 1. Cultural practices at Norman County, MN, 1986.

Tillage

No Till-the soybean and barley plots were dragged in spring.
Chisel Plow - fall
Moldboard Plow - fall

Roughrider

The chisel and moldboard plow treatments on the plots were field cultivated twice with a drag behind it.

Preceding Crop Spring Wheat

Crops

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

Planting and Harvest Dates

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

	Planting		
Crop	Date	Rate	Harvested
Winter wheat	Sept. 25, 1985	80 lbs/ac	July 31, 1986
Spring wheat	June 2, 1986	120 lbs/ac	Sept. 15, 1986
Soybeans	June 2, 1986	94 lbs/ac	Oct. 13, 1986
Barley	June 2, 1986	96 lbs/ac	Sept. 15, 1986

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.

Soil Test

Soil samples were taken in the fall of 1985.
Results were:

Crop	pH	Olsen P	K	NO_3-N
		-------lbs/ac------		
Wheat	7.9	30	467	35
Barley	8.1	14	491	23
Soybean	8.0	27	481	22

Fertilizer

Crop	Material (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		---lbs/ac----			
		No Till			
Winter wheat:	18-46-0[1] DAP (140 lbs/ac)	25	64	0	Sept. 25, 1986
	28-0-0[2] UAN (35 gal/ac)	104	0	0	April 23, 1986
		Tilled			
	18-46-0[1] DAP (140 lbs/ac)	25	64	0	Sept. 25, 1985
	28-0-0[2] UAN (30 gal/ac)	89	0	0	April 23, 1986
		No Till			
Spring wheat:	28-0-0[2] UAN (36 gal/ac)	107	0	0	April 23, 1986
	18-46-0[1] DAP (110 lbs/ac)	20	51	0	June 2, 1986
		Tilled			
	28-0-0[2] UAN (30 gal/ac)	89	0	0	April 23, 1986
	18-46-0[1] DAP (110 lbs/ac)	20	51	0	June 2, 1986
		No Till			
Barley:	28-0-0[2] UAN (30 gal/ac)	89	0	0	April 23, 1986
	18-46-0[1] DAP (60 lbs/ac)	11	28	0	June 2, 1986
		Tilled			
	28-0-0[2] UAN (27 gal/ac)	80	0	0	April 23,1986
	18-46-0[1] DAP (60 lbs/ac)	11	28	0	June 2, 1986
		No Till			
Soybeans:	18-46-0[1] DAP (53 lbs/ac)	10	24	0	June 2, 1986
		Tilled			
	18-46-0[1] DAP (53 lbs/ac)	10	24	0	June 2, 1986

1. Drill applied.
2. 28% broadcast spraying.

Fungicides

Manzate 200 flowable at 1.5 qts/ac was applied on :

Winter wheat: 1st application - June 11
2nd application - June 23

Crookston Expt. Station sprayer was used at 175 psi with 50 gallons of water.

Spring wheat: 1st application - July 18
2nd application - July 25

Ada Co-op Sprayer was used at 70 psi with 26 gallons of water.

Growth Regulator

Cerone growth regulator was applied to Roughrider winter wheat on June 11 at a rate of 3/4 pt/ac with the first fungicide application.

Weed Control

Wheat	Chemical	Amount	Carrier Volume	Applied
winter	Brominal 3+3	.7 pts/ac	8 gal/ac	June 6
spring	Brominal 3+3(no till)	.7 pts/ac	8 gal/ac	June 6
	Hoelon (no till)	3 pts/ac	11 gal/ac	June 7
Soybeans	Roundup(no till)	1.2 pts/ac	6 gal/ac	June 6
	Basagran(tankmix)	1 pts/ac	12 gal/ac	June 28
	Blazer "	.8 pts/ac	"	"
	Poast "	1.5 pts/ac	"	"
	Oil "	1 qt/ac	"	"
Barley	Roundup(no till)	1.2 pts/ac	6 gal/ac	June 6
	MCPA	1 pt/ac	6 gal/ac	June 27

Table 2. The effect of tillage on soil cover by wheat residue on June 3, 1986.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	st dev	mean	st dev	mean	st dev
Crop-Variety	%					
Winter Wheat n=6						
Bighorn	80.0	13.6	22.7	8.92	7.00	3.46
Roughrider	84.7	11.4	21.0	8.38	7.00	4.22
Spring Wheat n=6						
Marshall	71.0	9.67	12.7	7.40	5.33	3.55
Stoa	75.3	15.0	10.7	5.48	3.67	3.17
Barley n=24						
Robust	73.2	16.9	16.0	6.78	6.67	4.52
Soybeans n=24						
McCalls	77.3	15.6	18.5	7.16	8.33	3.90

Table 3. The effect of tillage on plant population.[1]

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Crop-Variety	Tillage	----------plants/ac x 10^{-3}----------					
Winter Wheat[2]	(.041)	n=14					
Bighorn		718	170	682	166	678	169
Roughrider		825	203	724	95.0	726	150
Spring Wheat[3]	(.090)	n=12					
Marshall		1096	242	873	175	995	170
Stoa		1024	105	1036	159	1007	202
Barley	(.247)	n=12					
Robust		840	122	780	110	766	118
Soybeans	(.034)	n=12					
McCalls		176	29.0	171	30.1	201	25.8

1. Spring wheat, soybeans, and barley stand counts were taken on June 24, 1986. Winter wheat stand count was taken onApril 22, 1986.
2. The significance of variety was .298, and the variety x tillage interaction was .950.
3. The significance of variety was .280, and the variety x tillage interaction was .056.

Table 4. The effect of tillage on crop growth.

		Tillage					
		No Till		Chisel		Moldboard	
		mean	st dev	mean	st dev	mean	st dev
Crop-Variety	Sig.	----------Haun growth stage----------					
Winter Wheat	(.000)[1]	n=15					
Bighorn	6/3	8.13	.215	7.72	.208	7.99	.185
Roughrider	6/3	7.77	.308	7.56	.168	7.61	.220
Spring Wheat	(.493)[2]	n=3					
Marshall	6/24	3.93	.058	3.87	.058	3.77	.116
Stoa	6/24	4.07	.208	3.97	.058	4.27	.116
		n=30					
Marshall	7/14	8.98	.048	8.98	.038	8.88	.187
Stoa	7/14	9.00	0.00	9.00	0.00	9.00	0.00
Barley	(.552)	n=3					
Robust	6/24	3.90	.100	3.83	.058	3.90	.173
	(.112)	n=15					
Robust	7/14	4.54	.356	4.39	.285	4.39	.320
		----------Vegetative Stage[3]----------					
Soybeans	(.041)	n=30					
McCalls	7/14	5.10	.712	4.67	.758	5.07	.785

1. The significance of variety was .000, and the variety x tillage interaction was .033.
2. The significance of variety was .019, and the variety x tillage interaction was .110.
3. Method used Stages of Soybean Development Special Report 80, an Iowa State University Cooperative Extension Service bulletin.

Table 5. The effect of tillage on soil temperature in winter wheat on April 22, 1986, n=3.

		Tillage					
	Sig. of	No Till		Chisel		Moldboard	
	Tillage	mean	st dev	mean	st dev	mean	st dev
Variety[1]	(.051)	degrees Fahrenheit					
Bighorn		40.7	1.15	45.3	0.58	44.0	4.58
Roughrider		41.3	1.15	44.0	2.00	46.0	1.73

1. The significance of variety was .673, and the variety x tillage interaction was .439.

Table 6. The effect of tillage on the presence and density of weed species[1] in Bighorn winter wheat on June 3, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	(.315)	967	1214	464	270	219	210
Mustard		0.00	0.00	.990	2.42	0.00	0.00
Pigweed		0.00	0.00	39.0	54.9	6.22	6.54
Buckwheat	**(.000)**	**6.35**	**14.7**	**53.0**	**42.9**	**105**	**87.4**
Clover		0.00	0.00	3.03	7.41	4.84	7.84
CanThistl		1.82	4.45	0.00	0.00	0.00	0.00
PennyCres		0.00	0.00	0.00	0.00	3.63	8.89
Boxelder		0.00	0.00	8.47	9.92	12.9	21.3

1. Weed species which were significantly affected by tillage are in bold type.

Table 7. The effect of tillage on the presence and density of weed species[1] in Roughrider winter wheat on June 3, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	(.256)	622	538	526	265	271	238
Pigweed		3.63	8.89	0.00	0.00	0.00	0.00
Buckwheat	(.217)	60.1	49.1	57.5	52.7	163	106
Clover		0.00	0.00	6.05	9.65	25.9	34.1
CanThistl		2.14	5.23	0.00	0.00	0.00	0.00
Smartweed		1.82	4.45	0.00	0.00	0.00	0.00
PennyCres		0.00	0.00	3.63	8.89	0.00	0.00
Boxelder		0.00	0.00	4.54	11.1	19.1	33.3
Ragweed		0.00	0.00	0.00	0.00	1.82	4.45
SowThistl		0.00	0.00	0.00	0.00	1.82	4.45
Lambsqtr		0.00	0.00	0.00	0.00	1.91	4.68

1. Weed species which were significantly affected by tillage are in bold type.

Table 8. The effect of tillage on the presence and density of weed species[1] in Marshall spring wheat on June 24, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	**(.064)**	**684**	**603**	**226**	**173**	**213**	**219**
Mustard		0.00	0.00	.712	1.74	.648	1.59
Pigweed	**(.017)**	**5.19**	**12.7**	**16.6**	**36.5**	**10.1**	**4.43**
Buckwheat		0.00	0.00	7.56	12.1	1.51	2.50
SprngWht		185	89.2	0.00	0.00	0.00	0.00
Lambsqtr		0.00	0.00	0.00	0.00	.637	1.56

1. Weed species which were significantly affected by tillage are in bold type.

Table 9. The effect of tillage on the presence and density of weed species[1] in Stoa spring wheat on June 24, 1986, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	**(.023)**	**507**	**246**	**394**	**151**	**230**	**158**
Mustard		0.00	0.00	4.03	6.25	0.00	0.00
Pigweed		0.00	0.00	0.00	0.00	3.25	4.15
Buckwheat	(.183)	15.7	18.8	1.73	4.23	5.14	8.70
SprngWht		96.8	96.7	0.00	0.00	0.00	0.00
Boxelder		0.00	0.00	0.00	0.00	3.46	8.47

1. Weed species which were significantly affected by tillage are in bold type.

Table 10. The effect of tillage on the presence and density of weed species[1] in soybeans on June 24, 1986, n=12.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	st dev	mean	st dev	mean	st dev
Weed	Tillage	plants/ac x 10^{-3}					
Foxtail	**(.024)**	**153**	**153**	**232**	**98.0**	**133**	**82.7**
Mustard		0.00	0.00	2.30	4.50	9.73	12.1
Pigweed		0.00	0.00	1.82	6.29	4.04	6.69
Buckwheat	(.230)	1.76	2.86	.403	1.40	2.24	3.87
SprngWht	**(.100)**	**45.5**	**30.1**	**32.1**	**21.2**	**12.9**	**8.95**
Dandelion		.395	1.37	0.00	0.00	0.00	0.00
Lambsqtr		0.00	0.00	0.00	0.00	.889	2.11
Quack		3.47	8.23	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 11. The effect of tillage on the presence and density of weed species[1] in barley on June 24, 1986, n=12.

		Tillage					
		No Till		Chisel		Moldboard	
Weed	Sig. of Tillage	mean	st dev	mean	st dev	mean	st dev
		plants/ac x 10^{-3}					
Foxtail	(.253)	208	116	303	300	160	141
Mustard	**(.019)**	**.413**	**1.43**	**3.73**	**5.81**	**8.06**	**10.9**
Pigweed		0.00	0.00	1.06	2.74	4.21	6.73
Buckwheat	(.818)	4.13	5.50	4.88	8.71	3.45	4.66
Clover		.303	1.05	0.00	0.00	0.00	0.00
SprngWht	(.260)	42.5	63.8	38.4	29.3	16.6	15.3
Dandelion		.825	2.86	0.00	0.00	0.00	0.00
Lambsqtr		0.00	0.00	0.00	0.00	.356	1.23
Quack		0.00	0.00	.308	1.07	0.00	0.00
VolSunflr		.303	1.05	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 12. The significance of interactions between type of wheat (winter or spring), height of variety (tall or short), and tillage on the density of weeds.

	Interactions		
Weed	Wheat to Height	Wheat to Tillage	Height to Tillage
	significance		
Foxtail	.433	.383	.527
Mustard	.570	.497	.790
Pigweed	.992	.051	.022
Buckwheat	.545	.125	.001
Clover	.183	.011	.522
Canada Thistle	.990	.135	1.000
Sow Thistle	.321	.374	.374
Smartweed	.321	.374	.374
Spring Wheat	.206	.000	.203
Penny Cress	1.000	.614	.236
Boxelder	.299	.167	.402
Ragweed	.321	.374	.374
Lambsquarter	.170	.993	.993

1. Type of wheat considers whether it is a spring or winter wheat. Stoa-spring wheat and Roughrider-winter wheat are tall varieties. Marshall-spring wheat and Bighorn-winter wheat are shorter varieties. Tillage considers no till, chisel plow, and moldboard plow.

Table 13. The effect of tillage, fungicide, variety, and time on leaf disease of winter wheat at Norman County, 1986.

Date	Location	Tillage: No Till	Tillage: Chisel	Tillage: Moldboard	Fungicide[2]: Yes	Fungicide[2]: No	Variety: Bighorn	Variety: Roughrider
6/11[1]		----------Modified Hosford Tan Spot Scale----------						
	Top Leaf (6 to 8)	4.25	3.83	2.67			2.39	4.78*
6/23								
	Leaf 9	5.53	5.29	5.32	5.28	5.48	5.44	5.31
	Leaf 8	5.75	5.08	5.33	5.03	5.75*	5.94	4.83*
	Leaf 7	6.75	5.92	5.50	5.39	6.72*	6.11	6.00
7/14								
	Leaf 9	8.46	8.44	8.25	7.82	8.94*	8.47	8.29
	Leaf 8	8.83	8.79	8.50	8.42	9.00*	8.69	8.72
	Leaf 7	9.00	9.00	8.92	8.94	9.00	9.00	8.94

1. A modified Hosford (1982) scale was used to rate the incidence of leaf disease (see table 15). The June 11 values are a visual estimate of the percent of the leaf infected.
2. Manzate 200 flowable at 1.5 qts/ac was applied on winter wheat: 1st application - June 11, 1986
2nd application - June 23, 1986
Cerone growth regulator at 3/4 pt/ac was applied on: Roughrider: with fungicide on - June 11, 1986
* Means within a row under a given heading followed by an asterisk are significantly different at .100.

Table 14. The effect of tillage and variety on the incidence of leaf disease on spring wheat at Norman County, 7/14/86.[1]

Location	Tillage: No Till	Tillage: Chisel	Tillage: Moldboard	Variety: Marshall	Variety: Stoa
	----------Modified Hosford Score--------				
Leaf 9	4.42	3.25	3.92*	3.67	4.06
Leaf 8	5.42	5.08	4.83	5.67	4.56*
Leaf 7	5.67	5.38	5.00	6.50	4.19*

1. A modified Hosford (1982) scale was used to rate the incidence of leaf disease (see table 15).
* Means within a row under a given heading followed by an asterisk are significantly different at .100.

Table 15. A modified Hosford (1982) tan spot scale used to rate leaf disease.[1]

Location	Hosford Score: 0	1	2	3	4	5	6	7	8	9
	----------Percent of leaf infected----------									
Leaf 9	0	0	1	2	3	4	5-10	10-25	25-50	55-100
Leaf 8	0	1-3	3-5	5-7	7-10	10-25	25-50	50-75	75-95	95-100
Leaf 7	0	1	5	10	25-50	50-60	60-75	75-85	85-95	95-100

1. Hosford's (1982) tan spot rating system was modified by assigning a different range in percent leaf infected for each leaf level rated. This provides a more precise estimate of relative differences due to treatment.

Hosford,R. 1982. Tan Spot. In: Tan Spot of Wheat and Related Diseases Workshop Proceedings. North Dakota State University, Fargo, N.D. pp.1-24.

Table 16. The effect of fungicide on the yields in wheat. The effects of tillage are averaged over fungicide, n=9.[1]

		Fungicide			
		treated[2]		not treated	
	Sig. of	mean	std dev	mean	std dev
Variety	Fungicide	bu/ac			
Winter wheat	(.008)				
Bighorn		52.7	12.8	38.1	8.6
Roughrider		50.3	4.47	39.9	4.0
Spring wheat	(.094)				
Marshall		31.0	4.73	27.0	6.28
Stoa		18.0	4.09	14.6	2.78

1. The yields are based on the grain after it was cleaned.
2. Treated refers to fungicide on Bighorn, Marshall and Stoa, and fungicide plus cerone on Roughrider.

Table 17. The effect of tillage and fungicide on the yields of wheat, n=3.[1]

	Tillage					
	No Till		Chisel		Moldboard	
	treated[2]	not treated	treated	not treated	treated	not treated
Variety	bu/ac					
Winter wheat						
Bighorn	65.0	44.3	49.9	38.2	43.3	31.7
Roughrider	50.9	39.4	46.7	42.5	53.4	37.8
Spring wheat						
Marshall	27.1	23.4	31.2	27.0	34.7	30.7
Stoa	16.3	12.9	17.9	12.8	19.7	18.0

1. Results are based on the grain after it was cleaned.
2. Treated refers to fungicide on Bighorn, Marshall, and Stoa, and fungicide + cerone on the Roughrider.

Table 18. The significance of tillage, fungicide, variety and the interactions on wheat yield.

Wheat	Till	Fung	Var.	Til x Fun	Til x Var	Var x Fun	TilxFunxVar
	significance						
Winter	.132	.008	.733	.469	.132	.470	.801
Spring	.133	.094	.002	.834	.786	.755	.843

Table 19. The effect of tillage on barley yields, protein content, and test weight, n=6.

	yield[1]		% protein		pro yield[2]		test wt	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Tillage	---bu/ac----		-----%------		---lbs/ac---		---lbs/bu---	
No Till	20.0	4.27	12.9	.448	105	24.1	37.2	1.47
Chisel	20.2	4.87	12.9	.500	107	27.2	39.1	.736
Moldboard	18.3	2.48	13.5	.623	101	13.3	38.6	1.43
Sig. of Tillage	(.790)		(.126)		(.968)		(.017)	

1. The results are based on the grain after it was cleaned.
2. Protein yield refers to the protein fraction x yield (lbs/ac).

Table 20. The effect of tillage on the moisture of wheat and barley at harvest, n=6.

		Tillage					
		No Till		Chisel		Moldboard	
	Sig. of	mean	std dev	mean	std dev	mean	std dev
Variety	Tillage	----------% moisture----------					
Winter wheat							
Bighorn	(.025)	12.6	.437	13.2	.534	13.5	.556
Roughrider	(.308)	13.0	.696	13.3	.474	13.6	.690
Spring wheat							
Marshall	(.001)	10.1	.352	11.5	.555	10.8	.482
Stoa	(.018)	11.1	.711	10.4	.250	10.2	.485
Barley							
Robust	(.821)	8.87	.700	8.68	.356	8.74	.230

Table 21. The effect of tillage and fungicide on the protein content and the protein-yield of Bighorn and Roughrider winter wheat harvested on July 31, 1986, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
% protein	%					
fungicide						
Bighorn	11.5	1.13	11.9	1.34	12.0	1.69
Roughrider	13.1	.913	12.6	.665	13.6	1.76
no fungicide						
Bighorn	12.4	1.44	12.5	.576	12.4	.969
Roughrider	12.9	1.06	13.3	1.26	12.5	.732
protein-yield[1]	lbs/ac					
fungicide						
Bighorn	392	90.3	314	119	271	58.7
Roughrider	346	31.2	305	1.92	376	51.5
no fungicide						
Bighorn	282	57.7	249	18.5	202	35.8
Roughrider	264	22.5	294	37.8	244	23.9

1. Protein-yield refers to the protein fraction x yield (lbs/ac).

Table 22. The significance of tillage and fungicide effects on the protein content and protein-yield of Bighorn and Roughrider winter wheat.

	Tillage	Fungicide	Till x Fung
protein content	significance		
Bighorn	.953	.389	.978
Roughrider	.984	.551	.130
protein-yield	significance		
Bighorn	.150	.049	.834
Roughrider	.995	.028	.209

Table 23. The effect of tillage and fungicide on the protein content and the protein-yield of Marshall and Stoa spring wheat, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev
% protein	----------	----------	%	----------	----------	----------
fungicide						
Marshall	15.4	.362	14.7	.862	15.0	.690
Stoa	16.8	.829	17.9	1.06	18.1	1.06
no fungicide						
Marshall	15.5	.886	15.8	.219	15.2	.609
Stoa	17.3	.705	19.2	.201	18.5	.038
protein-yield[1]	----------	----------	lbs/ac	----------	----------	----------
fungicide						
Marshall	209	33.2	231	33.8	261	31.7
Stoa	139	22.6	159	40.6	178	33.1
no fungicide						
Marshall	183	46.2	213	31.9	233	58.4
Stoa	112	.864	124	15.0	167	10.4

1. Protein-yield refers to the protein fraction x yield (lbs/ac).

Table 24. The significance of tillage and fungicide effects on the protein content and protein-yield of Marshall and Stoa spring wheat.

	Tillage	Fungicide	Till x Fung
protein content	----------	significance	----------
Marshall	.410	.083	.180
Stoa	.012	.035	.320
protein-yield	----------	significance	----------
Marshall	.382	.402	.977
Stoa	.009	.023	.317

Table 25. The effect of tillage and fungicide on the test weights of spring and winter wheat, n=3.

	Tillage					
	No Till		Chisel		Moldboard	
	treated[2]	not treated	treated	not treated	treated	not treated
Variety	----------	----------	lb/bu	----------	----------	----------
Spring wheat						
Marshall	53.0	49.0	54.6	51.7	53.5	53.2
Stoa	48.2	47.2	48.5	46.0	49.0	47.8
Winter wheat						
Bighorn	58.1	56.8	58.2	56.0	57.0	55.7
Roughrider	59.2	58.3	59.8	58.2	59.3	58.7

1. Results are based on the grain after it was cleaned.
2. Treated refers to fungicide application.

Table 26. The significance of tillage and fungicide effects on the wheat test weights.

	Tillage	Fungicide	Till x Fung
Spring wheat	----------significance----------		
Marshall	.315	.112	.490
Stoa	.420	.080	.636
Winter wheat	----------significance----------		
Bighorn	.092	.007	.498
Roughrider	.371	.002	.097

Table 27. The effect of tillage on soybean yield, moisture, dockage, and test weight, n=3.

	yield		moisture		dockage		test wt	
	mean	st dev	mean	st dev	mean	st dev	mean	st dev
Tillage	---bu/ac----		-----%------		-----%-----		---lb/bu---	
No Till	32.4	.940	12.5	.172	2.00	.866	58.0	.500
Chisel	33.2	1.03	12.7	.226	2.33	1.53	58.2	.289
Moldboard	32.8	1.44	12.7	.434	2.33	1.15	58.2	.289
Sig. of Tillage	(.780)		(.614)		(.913)		(.790)	

CORN - TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1986

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The driftless soils 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 regional such as Fayett-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 systems 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 Experimental Farm. Four tillage treatments are replicated four times (Table 1), the first replicate is located on Palsgrove silt loam; the other three replicates are located on Rozetta silt loam. Each treatment is split into normal and mulched subtreatments. On the no-till (slot plant) plots an additional subtreatment (bare) is established by removing all residue prior to planting; the 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 in width and 80 feet in length. Row width was 36 inches in 1986. Pioneer 3747 was planted April 29, 1986 at 31,600 plants/acre. The conventional (moldboard) treatment was plowed about April 25 and secondary tillage with a disk was done April 28 on the conventional and chisel treatments. The paraplow treatment was carried out in both fall 1983 and 1984; any effect observed in 1986 was due to residual effects of these earlier treatments. All 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.

Nitrogen (250 lb N/acre as ammonium nitrate) was applied in April prior to planting. Starter fertilizer at planting was 200 lb/acre of 6-24-24. The insecticide was Furadan at 10 lb/acre. Pre-emergence herbicide was applied on April 30 (1.5 lb/A of Aatrex 4L and 1 qt/A of Dual 8E). Banvel was applied postemergence at 1 pint/A on May 21.

Percent cover was determined from slides taken May 28. Planting depth, rate of emergence, and silking date measurements were made on designated portions of each plot. Hourly spring soil temperatures, leaf number, soil moisture, bulk density, and percent cover were measured on chisel, paraplow and no-till treatments in Rep 3 for mulch added and bare or 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 late October.

Ten plot frames (45 3/4 x 45 3/4 inches) were emplaced soon after planting before the surface was weathered by rainfall. Infiltration measurements were made on paraplow mulch, no-till bare and mulch, and conventional normal and mulch treatments during the period May 27 to 30. Tensiometer measurements were made at three depths within the plot frame during the infiltration event.

Results - Corn yields

Except for July rainfall, precipitation amounts and distribution were favorable at Lancaster in 1986 and corn yields on most treatments ranged from 160 to 170 bu/A (tables 1 and 2). Corn yields of individual tillage, residue, and in-row residue management treatments were statistically different at the 10 percent level of significance. Average corn yields of the four replicates were significantly different, ranging

from 159.6 bu/A in rep. one to 168.6 bu/A in rep. three (table 3). Soil depth was again related to corn yield; however, the relationship was less strong than in each of the three previous years. In 1981 and 1982 no effect of depth on yield was observed. Thus the effect of rooting depth and available water holding capacity in the root zone on yields depends greatly on climatic conditions in the individual year as well as on the crop grown.

Seedbed Conditions and Corn Growth

The average planting depth and average standard deviation of planting depth were both statistically different at the 0.01 level of significance. The Trash Whip treatment had a significantly (0.01 level of significance) greater average planting depth (35 mm) and lower standard deviation (5.8 mm) than the fluted coulter (29 and 7.3 mm respectively). The greatest differences in planting depth between coulter and trash whip units was measured on the chisel mulch and conventional mulch treatments.

On the chisel mulch and conventional mulch treatments the heavy mulch and loose seedbed frequently prevented the coulter from cutting through the residue. In some cases, the residue was pushed into the loose soil by the coulter making it difficult for the disc opener on the planter unit to penetrate the residue. For no-till, average planting depth for coulter and trash whip units differed by less than 2 mm for individual residue treatments. However, for the paraplow, average planting depth for the trash whip units was approximately 8 and 3 mm deeper than the coulter for normal and mulch treatments respectively. The trash whip units were adjusted for no till and paraplow conditions and consequently ran excessively deep in the looser soil conditions on the moldboard and chisel treatments.

In-row residue cover was reduced about 20 to 25 percent by the trash whip attachment (TW) compared to the in-row cover resulting from the coulter unit (C) (table 1). The regression equation

Eq 1: % cover TW = -7.5 + 0.83 (% cover C)

explained 95% of the variation in % cover of the TW treatments for 1986. In 1986 the trash whip treatment significantly increased yields by 5 bu/A compared to the coulter unit on paraplow and no-till treatments. 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).

Percent in-row cover was less closely related to grain moisture in 1986 than in 1985:

For 1985 Eq 2: % Grain Moisture = 20.5 + 1.97 x 10^{-2} (% in-row cover); R^2 = 0.87
For 1986 Eq 3: % Grain Moisture + 19.1 + 0.69 x 10^{-2} (% in-row cover); R^2 = 0.47

Percent in-row cover was closely related to air growing degree days to 6-leaf (measured on rep 3):

Eq 4: Air GDD (planting to 6 leaf) = 296 - 0.54 (% in row cover); R^2 = 0.84

The effect of in-row residue cover and tillage on soil temperature and corn growth was evaluated at Lancaster in 1983, 1984, 1985 and 1986. Hourly soil temperatures were recorded for 1, 5, 10, 15, 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. Soil temperatures were measured using 4-couples in parallel for 15 cm and shallower depths. Leaf stage measurements were taken periodically. Eq 4 was developed using station air temperatures and leaf stage observations; the results in 1986 agree with previous observations.

Increasing the absorption of solar radiation by painting the soil surface black increased soil temperature and early corn growth. Adjacent strips 15 feet long and 1 foot wide (centered over the row) were painted on May 9 or 62.3 air GDD (°C) after planting. Black paint reduced the air GDD to 6-leaf by 15 GDD (equivalent to about 1/2 a leaf number) on the no-till bare treatment and by 5 GDD on the no-till mulch

and chisel mulch treatments. Similar comparisons were made at the Southwest Experiment Station, Lamberton.

Large differences in "final" (50 to 60 minute average) infiltration rates were measured between treatments (tables 5 and 6). Final infiltration rates from mulch treatments equalled or exceeded comparable normal or bare treatment. Large differences in infiltration and matric potential were measured on the no-till treatments with mulch cover. These differences are thought to be due to macropore flow. On the conventional mulch treatments, positive matric potential measured at the 8 and 18 cm depths indicate the presence of a flow restricting layer below the plow layer (table 7). Paraplow treatments with mulch continued to have final infiltrations rates equal to or greater than other treatments.

Final infiltration rates for 1981-1986 are given in table 6. The ratio of (bare/mulch) infiltration rates for conventional tillage was 0.81 which was slightly above the 6 year average of 0.57. The relationship of no till mulch to conventional bare was 1.15 which is close to the long term average of 1.18.

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 by itself is not sufficient to produce a high infiltration rate when significant restriction to flow occurs within the infiltrating profile.

Summary

Five and eight year yield results with continuous corn at Lancaster show nearly equal yields from conventional tillage, ridge till, and chisel treatments (table 8). In 1986 no-till (slot plant) 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.

Table 1. Effect of tillage and mulch treatments on percent cover, planting depth, emergence silking date, population, grain yield and moisture - 1986 Lancaster

Tillage	Residue	In-row Residue Mgt.	Percent Cover In-row	Percent Cover Entire Area	Planting Depth Avg. mm	Planting Depth S.D. mm	Days planting to 75% emergence	Date 50% plants silked July	Population at Harvest Plants/A	Grain Yield bu/A	Grain Moisture %
			------ % ------								
Paraplow											
	Normal (N)	C	33	51	29	8.0	14.5	16.5	28375	162.0	19.7
		TW	15	40	37	6.4	15.5		27650	166.3	19.0
	Mulch (1x+N)	C	77	89	25	10.1	20.	18.0	26800	169.7	19.5
		TW	66	78	28	7.4	19.		26560	170.4	19.5
No-Till											
	Bare (0)	C	8	13	34	7.0	<14	16.3	28190	154.7	19.4
		TW	4	11	35	3.8	<14		28740	164.7	19.2
	Normal (1x)	C	28	49	31	7.7	15	16.5	29650	165.3	19.4
		TW	14	32	32	6.4	14.5		30130	166.9	19.0
	Mulch (2x)	C	80	84	33	5.4	16.5	18.0	28980	161.0	19.6
		TW	54	74	32	6.1	15		28550	170.9	18.9
Fall Chisel											
	Normal N	C	9	14	37	3.2	<14	15.5	28860	159.2	19.1
		TW	-	-	36	4.6	14				
	Mulch (1x+N)	C	81	91	20	8.7	20	18.3	27410	163.4	19.8
		TW	-	-	39	6.3	17.5				
Conv. (Spring plow)											
	Normal (0)	C	2	4	39	4.0	<14	15.8	28800	163.8	18.8
		TW	-	-	41	4.6	14.5				
	Mulch (1x)	C	82	92	13	11.0	17	18.3	26440	155.5	19.7
		TW	-	-	38	6.8	15.5				
Significance level					0.01	0.01			0.01	0.10	0.05

S.D. = Standard deviation, C = Fluted coulter, TW = Trash whip unit

Table 2. 1986 Weather Summary, Lancaster Experiment Station

Month	Precipitation Total	Precipitation Departure	Growing Degree Days 1985	Growing Degree Days Depart.	AIR TEMPERATURE Avg. Max	AIR TEMPERATURE Avg. Min.	AIR TEMPERATURE Avg.	AIR TEMPERATURE Departure
	inches	inches	----------	----------	---------- of	----------	----------	----------
April	2.37	-0.96	-	-	59.1	39.6	49.4	2.0
May	3.90	0.19	319.3	20	68.4	48.5	58.5	-0.5
June	5.47	1.24	497.0	-16	77.6	55.0	66.3	-1.8
July	1.85	-2.26	680.6	25	82.2	62.6	72.4	0.1
August	3.65	-0.49	483.1	-111	76.4	54.0	65.2	-5.3
September	4.67	1.06	397.1	43	71.3	53.5	62.4	0.1

1.85 inches of precipitation was well spaced throughout July, 0.5 inches occurring on July 8-9 and again on July 11-12 and 0.65 on July 25.

Table 3. Average yields and depth to clay residuum by replicate and monthly precipation for 1981 through 1986, Lancaster, WI.

	Replicate Number				Monthly Precipitation			
Year	1	2	3	4	May	June	July	August
	bu/A				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
Avg. depth to clay residuum inches	29	41	46	62				

1981 - Subplots with population < 17,000 omitted.
1982 - Missing values estimated for 8 plots out of a total of 48 plots.
1983 - Subplots with population < 18,000 omitted Rep. II, III, IV.
* 1983 - 1.3 inches precipitation from July 3 to Aug. 25 (53 days).
** 1984 - 1.52 inches precipitation from July 18 to Aug. 31 (45 days).
*** 1985 - 1.59 inches precipitation from May 28 to July 25 (57 days)
Largest rain was 0.36 inches.

Table 4. Influence of tillage method and residue management on rate of emergence - 1986 Lancaster, WI.

Treatment			PERCENT EMERGENCE				
		Coulter or Trash Whip Unit	Days post plant				
Tillage	Residue		14	16	20	22	28
Paraplow	Normal	C	68	89	100	100	
		TW	47	81	100	100	
	Mulch	C	8	35	77	81	100
		TW	13	41	81	84	100
No-Till	Bare	C	92	97	100	100	
		TW	80	94	100	100	
	Normal	C	60	86	94	100	
		TW	72	86	100	100	
	Mulch	C	28	69	94	100	
		TW	46	91	100	100	
Chisel	Normal	C	86	92	100	100	
		TW	74	89	100	100	
	Mulch	C	13	38	75	84	100
		TW	27	59	100		
Conventional-Moldboard	Normal	C	89	95	100	100	
		TW	65	89	100	100	
	Mulch	C	11	44	89	89	100
		TW	27	81	97	97	100

Table 5. 1986 Lancaster Infiltration Rate Measurements

Treatment			appl. rate	water applied to	INFILTRATION RATE X MINUTES AFTER RUNOFF COMMENCES IN/HOUR										
Tillage	Residue	Rep.	in/hr	runoff	2.5	7.5	12.5	17.5	22.5	27.5	32.5	37.5	42.5	47.5	52.5	57.5
No-Till	Bare	E	4.48	0.26	3.48	3.00	1.80	1.56	1.08	1.20	1.68	1.80	1.32	1.32	1.32	1.08
		W	4.40	0.37	3.20	1.76	1.28	1.28	0.80	1.16	1.28	1.16	1.28	1.04	1.28	1.28
	Mulch	E	4.56	0.48	4.08	2.64	1.80	1.80	0.72	0.96	1.44	0.96	0.96	0.96	0.96	1.44
		W	4.32	0.56	3.96	3.48	3.24	2.52	2.64	2.88	2.52	2.52	2.40	2.64	3.00	3.00
Conventional (moldboard plow)																
	Normal	E	3.76	1.19	2.52	2.04	1.68	1.56	2.28	2.28	2.28	1.56	1.56	1.32	1.56	2.04
		W	4.32	1.44	3.12	2.28	2.28	2.40	1.92	2.04	1.80	2.04	1.80	2.04	1.80	1.92
	Mulch	E	4.00	1.20	1.68	1.80	1.80	1.80	1.80	1.80	1.68	1.56	1.80	1.80	2.04	2.28
		W	4.24	1.06	3.00	2.28	2.16	2.16	2.28	2.28	2.40	2.40	2.28	2.40	2.28	2.40
Paraplow																
	Mulch	E	4.56	0.70	4.32	3.48	3.48	3.36	3.00	3.00	-	-	-	-	-	-
		W	4.24	0.39	3.84	3.24	3.24	2.64	2.88	3.00	3.48	3.12	3.00	3.12	2.88	2.76

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

Tillage	Residue	1981	1982	1983	1984	1985	1986	Avg.
		in/hr						
No-Till	Bare	-	-	-	1.68	1.00	1.24	
	Mulch	1.46	1.10	3.53*	0.60	3.02	2.10	1.66+
Conventional	Bare	0.97	1.52	0.54	1.70	1.40	1.83	1.33
	Mulch	2.72	2.34	1.49	2.90	2.14**	2.25	2.31
					RATIO			
Conv Bare/Conv Mulch		0.36	0.65	0.36	0.58	0.65	0.81	0.57
No Till Mulch/Conv Bare		1.51	0.72	6.53	0.35	2.16	1.15	1.18+

* Soil disturbed prior to planting by anhydrous ammonia injection.
** 1 observation only
\+ Omit 1983

Table 7. Relationship of infiltration rates (average 40 - 60 minutes after runoff starts) to matric potential.

				Matric Potential Depth in Soil		
Tillage	Residue	Rep	in/hr	7.5	17.5	32.5
					cm H_2O	
No-till	Bare	E	1.26	-16	-111	- 22
		W	1.22	-24	---	+ 7
	Mulch	E	1.08	+ 4	- 89	-133
		W	2.76	+ 2	- 3	+ 12
Conventional	Normal	E	1.62	- 7	- 52	- 66
		W	1.89	---	---	---
	Mulch	E	1.98	+ 6	+ 10	+ 19
		W	2.34	+ 7	+ 22	+ 4
Paraplow	Mulch	E	3.00*	- 6	- 3	- 20
		W	2.94	- 4	- 4	- 52

* 20-30 minutes

Table 8. Continuous corn tillage yield results, Lancaster, WI. 1979-1986

Tillage Treatment with Normal Residue	1979	1980	1981	1982	1983	1984	1985	1986	79-83	79-86	84-86
	bu/A										
Ridge plant	162	157	157	147	100	-	-	-	145	-	-
Slot plant	163	146	151	141	85	108	120	165	137	135	131
Chisel	160	150	167	154	95	115	125	159	145	141	133
Conventional	169	159	168	151	89	121	133	164	147	144	139
Paraplow*	-	-	-	-	-	106	125	162	-	-	131

* Fall 1983 and Fall 1984

TILLAGE AND DIFFUSE SOURCE PHOSPHORUS POLLUTION IN THE CLEARWATER RIVER WATERSHED, MINNESOTA, 1986 (STEARNS, WRIGHT, AND MEEKER COUNTIES)

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The Clearwater River chain of lakes (which are phosphorus limiting) have in recent years suffered a degredation in water quality due to increased P loading. There has been several point sources that have been identified and corrective action taken to reduce their influence. Recently the focus has turned to diffuse sources of P loading. Many of the soils in this area are natively high in soil P. Since most of the P that enters the lakes is associated with the sediment it is logical that control of erosion coupled with proper fertilizer P management would abate this source of P. It is generally accepted that the most cost effective method of controlling erosion is with crop residue management through tillage. In an effort to evaluate tillage alternatives which are specific for the conditions in the watershed plots were established in three areas. These plots are large to accommodate farmer cooperator's equipment and in some cases have been split to evaluate fertilizer management.

It is desirable to characterize the indigenous soil phosphorus levels in the watershed since the focus of this project is abatement of diffuse sources. The native levels of P for the soils in the watershed are shown in figure 1 (after Soil Atlas data). These values are weighted soil horizon averages for the 12 to 60 inch depth. Relative level categories are with respect to crop production. In other words, "high" means a grower will not likely get a response to an application of P. Soils in the watershed are very heterogeneous when it comes to P levels. This is due to the genesis of the soils in this area. Most are recently alluviated (formed by rivers) or formed from glacial till which is by definition heterogeneous. About half of the watershed soils are medium to high in subsoil P.

There are several implications that can be made from this data. If erosion was allowed to occur (most P entering lakes is associated with sediment) on the soils with high native levels eutrophication could be accelerated. If growers in the watershed have a history of over application of fertilizer P or mismanagement of manure and allowed erosion to occur eutrophication could also have been accelerated. Or if a river such as Fairhaven or Three Mile Creek which pass through high soil P areas erode stream banks eutrophication could be accelerated.

All the above mentioned scenarios for P limited lake eutrophication have the common denominator of erosion. Most will argue that conservation tillage is the most cost effective method of controlling erosion. Following is the establishment year summary of data collected from tillage demonstration plots in the Clearwater River Watershed to be used in an educational effort to enhance adoption of conservation tillage techniques.

The results of the Stearns county site are shown in tables 1-7. The farmer cooperator at this site is a ridge till farmer. Because the soil at this site is compatible with spring tillage and the site was in a ridge till system, establishment of four tillage systems was possible during the first year. At this site there are four tillage systems to be used in a corn-soybean rotation. A summary of tillage treatments and cultural practices at this site are shown in table 1. Ridge till plots were planted on 38" rows and all other treatments on 8" rows. The plot area is on rented land which has had very little fertilizer applied in the last six years.

It is interesting to note the fertility levels at this site. All of the plots have soil test P levels in the high range. The soil test K levels are in the medium range. For this reason plots were split with row applied K on the narrow row soybeans and an N-P-K solution on the wide row soybeans (table 1). There was no difference in yield due to the fertilizer applications. There was a four bushel per acre advantage with the narrow row soybeans. This may be offset with equipment, labor, and fuel cost however. An economic analysis will shed light on this aspect.

Soil covered by corn residue is shown in table 3. Until next year there won't be a no till treatment. With this years tillage systems cover ranged from 3 to 27%. Soybeans emerged at the fastest rate with the ridge till system. On May 29th (13 days after planting) 95% of the soybeans were emerged with the ridge till system compared to the most residue free system (moldboard plow) at 78%. This would be more important for corn than soybeans, but it does illustrate the advantage of this system in early emergence. Cover in the row (controls soil temperature and rate of emergence) is about the same between these two treatments but soybeans were probably at a more shallow depth (and warmer).

The major weeds at this site were: buckwheat, foxtail, and lambsquarter (table 4). It is interesting to note that the chisel and moldboard treatments had the highest populations of these weeds just prior to herbicide application. Good control was obtained and weeds did not affect yields.

Wright county results are shown in tables 8 to 13. The soil at this site is not compatible with spring tillage. For this reason there is only two tillage treatments during the establishment year (ridge till and spring disc). In 1987 the no till, chisel and moldboard plow treatments will be evaluated.

On the east side (soybeans grown in 1986) there is evidence of over application of fertilizer or more likely manure. The cooperator at this site doesn't recall any manure being applied here for about 20 years. At that time there was a swine operation in this field. The extremely high levels of soil P and K have persisted in this field. On the west half of the site (corn in 1986) soil test P and K values are in the medium range and surprisingly uniform. This illustrates the importance of a good soil testing program. The field on the east doesn't need P or K for probably more than 30 years.

The percent soil covered with crop residue is higher at this site than the Stearns county site (table 10). Weed pressure at this site was minimal. Major weeds in the corn (table 11) were volunteer soybeans and buckwheat. It is interesting to note that there were more volunteer soybeans in the ridge till system on this date (May 29). The cultivation associated with this system would eliminate any differences later however. The major weed in the soybeans was lambsquarter (table 12). There were significantly less in the ridge till treatment.

Soybean yields are shown in table 13. There was no difference in yield due to the tillage systems at this site. It is unusual that there was no advantage to narrow rows (8" vs 30"). It is possible that the increased lambsquarter pressure masked out this response. Corn yield are shown in table 14. The spring disc option resulted in a 13 bu/ac yield increase. This is likely not due to tillage. The planter at this site had home made fertilizer openers mounted on an add on 3" tool bar ahead of the planter. When planting in the ridge till plots the fertilizer boot was pinched shut by this tool bar which prevented the application of starter fertilizer. The authors are convinced that the yield differences are due to the fertilizer response by the disc system.

The soil at the Meeker county site does not allow spring tillage. It also has a history of moldboard plowing. For these reasons tillage treatments were not able to be initiated at this site until the fall of 1986. The soil at this site is a complex of soils ranging in texture from clay loam to sandy loam (table 15). This is characteristic of this part of the county. The plot diagram is shown in figure 4. The plots are not symmetric to accommodate a water way to allow runoff of excess moisture.

Statistics Reported significance values are the smallest level of significance which would lead to the rejection of the hypothesis that a given treatment did not affect a particular variable. For most field experimentation a significance value that is .10 or smaller is usually accepted as proof that differences in treatment averages are due to treatments and not to random variability. If treatment variances were found to be unequal by an $F_{.10}$ test, a natural log transformation was used to meet this assumption of analysis of variance.

STEARNS COUNTY

Table 1. Cultural practices at Stearns County, MN. 1986.

Tillage - The site has been ridge till for 3 years.

Spring Disc-This is the establishment year so these plots were disced to eliminate ridges on May 6th. This treatment will become "no till" in 1987.

Ridge Till

Chisel Plow-Plots were spring disced, then chisel plowed, and disced again on May 6th.

Moldboard Plow-Plots were also spring disced, then moldboard plowed, and disced again on May 6th.

Preceding Crops

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

1986 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 plots were planted with a Tye No Till drill with 8" row spacing equipped with 2" fluted coulters.

	Planting		
Crop	Date	Rate	Harvested
		(Ridge Till)	
Soybeans	May 16, 1986	190,000 plants/ac	Oct. 16, 1986
		(All Others)	
		225,000 plants/ac	

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./ac of 9-18-9 only, 1985-60 lbs/ac of N and 4 gal./ac of 9-18-9.

Fertilizer

All plots were split with and without a row fertilizer treatment at planting.

Crop	Material Analysis (Rate)	Tillage	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
			---lbs/ac---			
Soybeans:	9-18-9[1] (4 gal/ac)	Ridge Till	4	8	4	May 16, 1986
	0-0-60[2] (90 lbs/ac)	All Others	0	0	54	May 16, 1986

1. Planter applied 1" below the seed.
2. Potash was surface banded ahead of and incorporated by the fluted coulters.

Soil

Estherville (Typic Hapludolls, sandy, mixed, mesic) sandy loam, 2 to 6 percent slopes. Soil is somewhat excessively drained.

Weed Control

$1^1/_2$ pt (3/4 lb)Basagran + 1/2 pt(1/8 lb) Blazer on June 17.
1 pt (2/10 lb) Poast + $2^1/_2$ lb ammonium sulfate on June 24.
1 qt (1 lb) Basagran on June 24.
All post emergence applications were applied with 1 qt./ac of crop oil.

Soil Test

Table 2. Nutrient levels sampled on April 21, 1986, n=4.

		Tillage							
	Sig. of	Spr. Disc		Ridge Till		Chisel		Moldboard	
Nutrient	Tillage	mean	stdev	mean	stdev	mean	stdev	mean	stdev
		lb/ac							
Phosphorus	(.897)	51	16	56	12	53	2	52	20
Potassium	(.510)	237	82	209	33	192	20	253	51
pH	(.478)	6.4	.2	6.6	.2	6.4	.2	6.4	.2

Table 3. The effect of tillage on percent of the soil surface covered by corn residue on May 29, 1986, n=16.

	Tillage							
	Spring Disc		Ridge Till		Chisel		Moldboard	
	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Location	%							
In Row	26.8	15.8	6.5	5.6	16.5	9.1	3.0	4.7
Between	20.3	12.3	25.5	15.2	17.5	11.5	4.0	7.0

Table 4. The effect of tillage on soybean stand, n=16.

		Tillage							
		Spring Disc		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Date	Tillage	plants/ac x 10^{-3}							
5/29	(.036)	155	46.0	157	9.3	134	48.8	186	47.0
6/11	(.000)	213	45.4	165	11.1	207	39.6	240	35.1

Table 5. The effect of tillage on the presence and density of weed species[1] on June 11, 1986, n=16.

		Tillage							
		Spr. Disc		Ridge Till		Chisel		Moldboard	
	Sig. of	mean	stdv	mean	stdv	mean	stdv	mean	stdv
Weed	Tillage	----------plants/ac x 10^{-3}----------							
Corn	(.688)	88.3	231	2.9	4.7	16.7	24.3	13.2	39.5
Buckwheat	**(.001)**	**2.04**	**3.52**	**1.61**	**2.09**	**4.98**	**9.45**	**40.4**	**39.3**
Smartweed	(.359)	4.76	7.89	.84	1.36	23.8	41.5	15.6	24.6
Clover	(.812)	1.88	4.01	3.65	4.33	7.50	27.9	6.21	14.1
Ragweed	(.405)	4.96	7.48	2.62	4.96	31.1	57.6	23.1	35.7
Quackgrass		0.00	0.00	1.08	2.56	3.16	10.1	.57	2.26
Foxtail	**(.000)**	**119**	**191**	**83.0**	**92.0**	**708**	**976**	**521**	**239**
Pigweed		1.77	2.69	.83	1.42	2.36	5.58	0.00	0.00
Pennycress		0.00	0.00	.64	1.28	0.00	0.00	0.00	0.00
Dandelion		0.00	0.00	.44	.72	.48	1.90	0.00	0.00
Lambsquart	**(.000)**	**25.4**	**15.7**	**4.43**	**3.44**	**87.3**	**72.4**	**111**	**66.1**
Mallow		.20	.78	0.00	0.00	0.00	0.00	3.22	12.9
Ash Tree		0.00	0.00	.24	.73	.52	2.06	0.00	0.00
Canada Th		0.00	0.00	.30	.83	0.00	0.00	0.00	0.00
Knotweed		0.00	0.00	1.33	3.48	0.00	0.00	0.00	0.00

1. Weed species which were significantly affected by tillage are in bold type.

Table 6. The effect of tillage and fertilizer[1] on the yields of soybeans yields, n=4.

		Tillage (.000)							
		Spr. Disc		Ridge		Chisel		Moldboard	
	Sig. of	mean	stdev	mean	stdev	mean	stdev	mean	stdev
Fertilizer	Fert.	----------yield bu/ac----------							
	(.613)								
fertilizer		40.6	1.80	36.4	1.34	39.8	.540	40.9	2.50
no fertilizer		39.7	1.99	35.6	.389	39.6	1.89	41.7	1.28

1. The fertilizer refers to 4 gal/ac 9-18-9 on ridge till plots and 90 lbs/ac 0-0-60 on the rest.
2. The significace of the interaction of tillage x fertilizer was .619.

Table 7. The effect of tillage and fertilizer[1] on the moisture of soybeans at harvest, n=4.

		Tillage (.003)							
	Sig. of	Spr. Disc		Ridge Till		Chisel		Moldboard	
Fertilizer	Fert.	mean	stdev	mean	stdev	mean	stdev	mean	stdev
	(.549)	----------% moisture----------							
fertilizer		14.4	.76	13.3	.71	13.7	1.26	13.8	.97
no fertilizer		14.4	.66	13.5	.60	14.3	1.29	13.4	.57

1. The fertilizer refers to 4 gal/ac 9-18-9 on ridge till plots and 90 lbs/ac 0-0-60 on the rest.
2. The significace of the interaction of tillage x fertilizer was .241.

WRIGHT COUNTY

Table 8. Cultural practices at Wright County, Mn. 1986.

Tillage

Spring Disc-This is the establishment year so these plots were disced to eliminate ridges. Tillage dates are:

Soybeans following corn:May 2, 1986.
Corn following soybeans:May 2, 1986.

Ridge Till-

Because this is an establishment year and this soil type is not compatible with spring tillage there are only two tillage treatments in 1986 (ridge till and spring disc). The no till, chisel and moldboard plow treatments will be established in the fall of 1986.

1986 Crops

Corn - Pioneer 3737
Soybeans - Pioneer 1677

Preceding Crop

Corn-soybean rotation since 1982.

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 equiped 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 2, 1986	30,000 plants/ac	Nov. 5, 1986
Soybeans	May 7, 1986	225,000 plants/ac	Oct. 10, 1986

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. No soil test information prior to 1986 is available.

Fertilizer

	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	8-23-30[1] (140 lbs/ac)	11	32	42	May 2, 1986
	28-0-0[2] UAN (37 gal/ac)	110	0	0	June 13, 1986

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

Soil

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

Weed Control

Corn

2 qt Lasso + 2 qt Bladex on May 2, with planter.

Soybeans[1]

1 qt (1 lb) Basagran + 1/2 pt (1/8 lb) Blazer on June 4.

1 pt (2/10 lb) Poast on June 12

1/2 pt (1/4 lb) Basagran + 1/4 pt (1/16 lb) Blazer on June 12

1. All post emergence applications were applied with 1 qt./ac of crop oil.

Soil Test

Table 9. Nutrient levels in the corn and soybean plots sampled on April 21, 1986, n=12 for spring disc and n=4 for ridge till.

			Tillage			
		Sig. of	Spring Disc		Ridge Till	
Crop	Nutrient	Tillage	mean	stdev	mean	stdev
			----------lb/ac----------			
Corn	Phosphorus	(.642)	31	8	31	15
	Potassium	(.138)	198	11	189	6
	pH	(.154)	6.3	.1	6.3	.1
Soybean	Phosphorus	(.129)	298	215	192	183
	Potassium	(.412)	613	362	487	236
	pH	(.298)	6.4	.3	6.6	.8

Table 10. The effect of tillage on percent of soil cover by residue on May 28, 1986, n=48 for spring disc and n=16 for ridge till.

	Crop							
	Corn following Soybeans				Soybeans following Corn			
	Spring Disc		Ridge Till		Spring Disc		Ridge Till	
Location	mean	stdv	mean	stdv	mean	stdv	mean	stdv
	----------%							
In Row	5.5	5.1	4.8	5.3	32.6	18.3	21.0	19.3
Between	12.0	9.1	19.8	7.9	30.0	18.5	50.8	14.5

Table 11. The effect of tillage on the presence and density of weed species[1] in Pioneer 3737 corn following soybeans on May 29, 1986, n=48 for spring disc and n=16 for ridge till.

		Tillage			
		Spr Disc		Ridge Till	
		mean	stdv	mean	stdv
	Sig. of	-----plants/ac x 10^{-3}------			
Weed	Tillage				
Soybeans	**(.086)**	**21.9**	**18.2**	**30.5**	**19.9**
Buckwheat	(.217)	8.48	7.24	30.3	41.1
Smartweed	(.222)	.17	.54	.98	1.68
Clover		0.00	0.00	3.08	6.24
Alfalfa		0.00	0.00	.301	.878
Common Ragweed	**(.000)**	**.17**	**.83**	**3.31**	**5.04**
Quackgrass	(.683)	4.96	12.2	3.55	11.1
Shephard's Purse		0.00	0.00	.61	1.37
Foxtail	**(.000)**	**.29**	**1.60**	**6.54**	**9.42**
Pigweed		.022	.158	0.00	0.00
Pennycress	(.746)	.135	.408	.301	.878
Lambsquarter	(.914)	.163	.503	.278	.835
Ash Tree	(.156)	.311	.603	1.11	1.97
Knotweed	(.204)	.099	.560	.346	.961

1. Weed species which were significantly affected by tillage are in bold type.

Table 12. The effect of tillage on the presence and density of weed species[1] in Pioneer 1677 soybeans following corn on May 28, 1986, n=48 for spring disc and n=16 for ridge till.

		Tillage			
		Spr Disc		Ridge Till	
		mean	stdv	mean	stdv
	Sig. of	-----plants/ac x 10^{-3}------			
Weed	Tillage				
corn	**(.056)**	**7.92**	**28.9**	**6.02**	**10.4**
Clover		0.00	0.00	.840	3.36
Alfalfa		1.10	4.52	0.00	0.00
Common Ragweed		.325	1.70	0.00	0.00
Quackgrass		1.97	13.6	0.00	0.00
Foxtail	(.308)	135	224	249	316
Pigweed	(.853)	3.99	13.6	1.14	3.02
Pennycress	(.989)	6.20	14.4	1.40	2.92
Giant Ragweed	(.467)	.597	4.14	1.42	3.07
Lambsquarter	**(.000)**	**623**	**540**	**239**	**137**
Dandelion		0.00	0.00	.609	1.79
Mallow	(.130)	14.7	44.0	.573	2.29

1. Weed species which were significantly affected by tillage are in bold type.

Table 13. The effect of tillage on soybean yields, moisture[1].

	Tillage			
	Spr Disc		Ridge Till	
Sig. of Tillage	mean	stdv	mean	stdv
	----------bu/ac----------			
(.583)	46.6	3.55	47.6	2.06
	--------% moisture--------			
(.245)	12.2	.48	11.9	.13
	-------plants/ac x 10^{-3}----			
(.000)	207	29.0	142	22.0

1. n=12 for spring disc, n=4 for ridge till and population on June 28, 1986, n=48 for spring disc and n=16 for ridge till.

Table 14. The effect of tillage on corn yields, moisture[1]

	Tillage			
	Spr Disc		Ridge Till	
Sig. of Tillage	mean	stdv	mean	stdv
	----------bu/ac----------			
(.042)	163	12	150	12
	--------% moisture--------			
(.329)	18.8	.40	18.6	.42
	-----plants/ac x 10^{-3}------			
(.144)	20.2	1.5	21.3	3.7

1. n=12 for spring disc, n=4 for ridge till and population on June 28, 1986, n=48 for spring disc and n=16 for ridge till.

MEEKER COUNTY

Table 15. Cultural practices at Meeker County, Mn. 1986

Tillage

Moldboard Plow-October 28, 1986
Chisel Plow-October 29, 1986
No Till-
Ridge Till-ridges formed July 18, 1986

Since this was the establishment year there was only one tillage treatment this year (moldboard plow). Ridges were established in the summer and the others in the fall.

Crops

Corn-Pioneer 3737
Soybeans-Pioneer 1677 and Corsoy

Preceding Crop

Corn-soybean rotation since 1978.

Fertilizer

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	82-0-0 (183 lbs/ac)	150	0	0	Spring
	4-15-40[1] (250 lbs/ac)	10	38	100	Planting

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

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.

THE EFFECT OF TILLAGE ON SOIL NITROGEN WITH CORN AND SOYBEAN PRODUCTION IN SOUTHEASTERN MINNESOTA

J.F. Moncrief, T.L. Wagar, L.J. Svien, J.J Kuznia, R.W. Hoff, and D.D. Brietbach

There has much debate as to the effects of tillage on water movement through soils. One argument is that some tillage strategies that reduce runoff and subsequently increase infiltration may increase the amount of nitrate nitrogen that is percolated into groundwaters. Another argument is that there is more runoff with some tillage strategies and this results in more surface water pollution. In an effort to investigate under what tillage systems nitrogen leaching is probable, mineral soil nitrogen has been monitored in the spring in six depth increments to five feet in tillage studies at Fillmore and Wabasha counties. For a more detailed description of production data comparing tillage strategies see the companion article.

The values for mineral nitrogen at Fillmore county are shown in tables 1 to 5. Statistics are summarized in table 4. This site has been in corn for two years. In 1984 this site was cropped to soybeans. Two soil samples were taken in each plot and composited. Statistics were run on the two 6" increments at the surface and then combining these two samples and running for five one foot increments to five feet. When run as one foot increments there was no effect of tillage (table 1) but a significant depth effect (table 2). The nitrate was highest in the top bottom increment. It was lowest in the second foot and increased with depth to five feet. The ammonium was higher in the top three feet. When looking at total mineral nitrogen the surface foot was the highest. The distribution of the nitrate and ammonium with depth was somewhat offsetting. The no till treatment had higher nitrate and lower ammonium in the top 12" (table 3). These trends again were offsetting resulting in similar total mineral nitrogen for all tillage treatments. When the total profile mineral nitrogen is considered there is no difference due to tillage. There was quite a lot of variability in the nitrogen values at this site.

Mineral nitrogen data at Wabasha county are shown in tables 6 to 10. This site has been in a corn-soybean rotation since 1984. There was generally more nitrogen following corn than soybeans. Two tillage treatments were changed in 1986. The paraplow treatment was changed to a spring disc and due to a change in row spacing the ridge till treatment was lightly disced. The soil samples were taken before tillage so nitrogen reflects previous tillage history. The ridge till treatment following soybeans had higher levels of nitrate and lower levels of ammonium (table 6). Samples were taken between the rows. Following corn there were higher levels of nitrate and total mineral nitrogen associated with the paraplow treatment (table 6) Ammonium concentrations were lower with the no till treatment (table 6). The highest concentrations of nitrogen following soybeans were found in the upper and third foot increments (table 7). Nitrate concentrations following corn were highest in the fourth foot and then decreased to the surface. This was similar to the Fillmore site. When considering the top two 6" increments several things are significant (tables 8 and 9). The ammonium increased with depth after soybeans. There was an interaction between tillage and depth after corn. The ridge till treatment had more ammonium and total mineral nitrogen in the top 6". The paraplow treatment had higher ammonium and total mineral nitrogen in the 6-12" increment. When considering total profiles mineral nitrogen (table 10) it appears that the ridge till system had lower levels of ammonium.

These data must be interpreted with caution since it characterizes the profile nitrogen at one point in time (spring before tillage) but it does illustrate that tillage can affect nitrogen transformations and movement through the soil.

FILLMORE COUNTY

Tillage

No Till
Disc - Disced twice on April 10th and once on May 6th.
Chisel-Chisel plowed with a Glencoe Soil Saver on May 3rd and again on May 6th.
Moldboard - Disced and Moldboard Plowed on April 10th, and disced again on May 6th.

Cultivation

Each plot is split with one half cultivated and the other half not.

Crop Corn-Pioneer 3737 **Preceding Crop** Corn

Planting and Harvest Date

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

	Planting		
Crop	Date	Rate	Harvested
Corn	May 7, 1986	28,300 plants/ac	Oct. 28, 1986

Fertilization History

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

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	
Crop		----lbs/ac----			Date Applied
Corn:	16-41-8[1] (125 lbs/ac)	20	51	10	May 6, 1985
	82-0-0 (134 lbs/ac)	110	0	0	May 22, 1985

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

Fertilizer

	Material Analysis (Rate)	Actual N	P_2O_5	K_2O	
Crop		----lbs/ac----			Date Applied
Corn:	82-0-0 (244 lbs/ac)	200	0	0	May 22, 1986
	9-23-30 (125 lbs/ac)	11	29	38	May 7, 1986 (with planter)

Soil

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

Weed Control

All plots were sprayed with 1 pint/ac of Buctril on June 4, 1986. Corn was at 5 leaf stage.

Insect Control

6.9 lbs/ac Counter at time of planting.

Soil Test

Soil samples were taken on April 23rd to a depth of five feet in increments of 0-6" 6-12" 12-24" 24-36" 36-48" 48-60" for nitrate analysis. Two samples were taken per plot and then combined for a composite sample.

Table 1. The effect of tillage and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) for five one foot increments on April 23, 1986 at Fillmore county, MN., n=15.

Source of N	Tillage: No Till mean	No Till st dev	Disc mean	Disc st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
	Corn the preceding year							
NO_3^--N	31.6	20.7	30.6	16.3	27.8	11.2	25.4	10.8
NH_4^+-N	15.9	9.08	19.5	8.38	16.5	7.70	19.9	9.33
Tol-N	47.5	26.3	50.1	18.6	44.3	17.3	45.3	15.2

Table 2. The effect of depth and preceding crop on the NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) on April 23, 1986 at Fillmore county, MN. , n=12.

Source of N	Depth (inches): 0-6 mean	6-12 mean	0-12 mean	12-24 mean	24-36 mean	36-48 mean	48-60 mean
	Corn the preceding year						
NO_3^--N	17.4	15.1	32.5	20.7	28.0	29.5	33.6
NH_4^+-N	10.5	12.3	22.8	18.4	20.7	14.6	13.2
Tol-N	28.0	27.4	55.3	39.1	48.7	44.1	46.8

Table 3. The interaction of tillage x depth (0-6" an 6-12") and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) on April 23, 1986, at Fillmore county, MN., n=3.

Source of N	Depth	Tillage: No Till mean	No Till st dev	Disc mean	Disc st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		Corn the preceding year							
NO_3^--N	0-6"	29.2	25.3	14.2	7.31	14.7	2.76	11.6	4.69
	6-12"	17.1	6.97	13.4	5.24	15.8	4.28	14.0	3.85
NH_4^+-N	0-6"	9.06	4.14	11.4	6.03	10.8	2.33	10.8	5.18
	6-12"	8.57	4.68	12.4	3.09	11.4	4.97	16.7	0.72
Tol-N	0-6"	38.2	24.0	25.6	13.0	25.6	4.08	22.4	3.94
	6-12	25.6	9.75	25.8	8.08	27.2	8.50	30.7	4.26

Table 4. The significance of tillage, depth, the interaction of tillage x depth and preceding crop on the NO_3^--N, NH_4^+-N and total mineral nitrogen on April 23, 1986, at Fillmore county, MN..

Source of N	Analysis of 0-6" and 6-12": Till.	Depth	Till. x Depth	Analysis of 1 ft. increments to five feet: Till.	Depth	Till. x Depth
	Corn the preceding year					
NO_3^--N	.097	.900	.386	.659	.044	.255
NH_4^+-N	.093	.167	.271	.291	.010	.364
Tol-N	.660	.781	.186	.414	.070	.194

Table 5. The effect of tillage on NO_3^--N, NH_4^+-N and total mineral nitrogen from 0 to 5 feet (lbs/ac) on April 23, 1986, at Fillmore county, MN., n=4.

Total lbs/A of	Sig. of Tillage	No Till mean	No Till st dev	Disc mean	Disc st dev	Chisel mean	Chisel st dev	Moldboard mean	Moldboard st dev
		----------Corn the preceding year----------							
NO_3^--N	(.960)	158	96.4	153	46.5	139	27.0	127	45.2
NH_4^+-N	(.498)	79.7	42.6	97.3	27.7	82.4	14.3	99.4	20.5
Tol-N	(.950)	238	131	250	65.2	221	37.8	227	50.4

WABASHA COUNTY

Row Width

In 1986, row crop width was changed from 38" to 30".

Tillage

No Till

Spring Disc Ridge - disc to break down 38" ridges, will be 30" ridge till in 1987, see spring disc below for tillage.

Ridge formed - corn June 26, 1986
- soybeans July 11&15, 1986

Spring Disc - area following corn disc twice on April 25, 1986
- area following soybeans disc once on April 25, 1986

Chisel Plow - April 25,1986 - field cultivator May 5, 1986

Crops	Preceding Crops
Corn - Pioneer 3737	1983 - Sweet Clover
Soybeans - Pioneer 1677	1984-85 - Corn-Soybean rotation.

Planting and Harvest Date

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

Crop	Planting Date	Planting Rate	Harvested
Corn	May 5, 1986	30,800 plants/ac	Oct. 22, 1986
Soybeans	May 7, 1986	225,000 plants/ac	Oct. 22, 1986

Fertilization History

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied	
		----lbs/ac----				
All plots except chisel plow.	28-0-0 (7 gal/ac)	75	0	0	May 14, 1984	
Corn:	7-21-7 (12.5 gal/ac)	10	29	10	May 16&18, 1984	
Corn:	7-21-7 (25 gal/ac)	20	60	20	May 13, 1985	Placement 2" beside and 2" below seed.
Corn:	82-0-0 (170 lbs/ac)	140	0	0	June 19, 1985	

Fertilizer

Crop	Material Analysis (Rate)	Actual N	Actual P_2O_5	Actual K_2O	Date Applied
		----lbs/ac----			
Corn:	46-0-0 (337 lbs/ac)	155	0	0	April 24, 1986
Corn:	9-23-30 (170 lbs/ac)	15	39	51	May 5, 1986

Soil

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

Weed Control

Corn

Banded 1 3/4 pt Dual + 3 1/2 pt Bladex/ac with the planter on May 5, 1986.

Soybeans

Roundup was sprayed on the soybean plots at 4 qt/ac on April 23, 1986 (very windy - 30mph). Weeds present were smooth brome, quackgrass, and cockle.

1 pt Roundup + 1/2% surfactant on May 7, 1986.

1 1/2 pt (3/4 lb) Basagran + 1/2 pt (1/8 lb) Blazer + 1 qt oil concentrate on May 30, 1986.

1 pt (2/10 lb) Poast + 1 qt oil concentrate on June 12,1986.

1 pt (1/2 lb) Basagran + 1 qt oil concentrate on June 12, 1986.

Soil Test

The soil pH=6.6 P=70 lbs/ac K=275 lbs/ac, tested on April 9, 1984.

Soil samples were taken April 22, 1986 to a depth of 5' in increments of 0-6", 6-12", 12-24", 24-36", 36-48",and 48-60" for nitrate analysis.

Table 6. The effect of tillage and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) for five one foot increments on April 22, 1986, at Wabasha county, MN., n=20.

Source of N	No Till mean	No Till st dev	Ridge till mean	Ridge till st dev	Paraplow mean	Paraplow st dev	Chisel mean	Chisel st dev
	----------Soybeans the preceding year----------							
NO_3^--N	20.2	5.90	23.0	6.61	19.2	5.82	20.7	7.10
NH_4^+-N	10.0	4.81	9.05	4.28	11.4	5.94	11.1	4.85
Tol-N	30.2	8.85	32.1	8.58	30.6	8.72	31.8	11.0
	----------Corn the preceding year----------							
NO_3^--N	28.4	9.26	31.9	10.5	39.4	17.1	28.9	9.42
NH_4^+-N	9.90	4.78	11.8	7.79	11.2	6.63	11.7	4.92
Tol-N	38.3	8.50	43.7	12.0	50.6	16.8	40.6	9.20

Table 7. The effect of depth and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) for five on foot increments on April 22, 1986, at Wabasha county, MN., n=16.

Source of N	0-6	6-12	0-12	12-24	24-36	36-48	48-60
	----------Soybeans the preceding year----------						
NO_3^--N	12.4	12.0	24.4	19.6	22.3	20.4	17.1
NH_4^+-N	9.11	7.61	16.8	8.58	13.5	7.37	5.80
Tol-N	21.5	19.6	41.2	28.2	35.7	27.8	22.9
	----------Corn the preceding year----------						
NO_3^--N	11.8	12.3	24.1	32.4	35.9	41.8	26.6
NH_4^+-N	10.7	8.86	19.6	8.22	14.5	7.31	5.71
Tol-N	22.5	21.1	43.7	40.6	50.4	49.1	32.3

Table 8. The interaction of tillage x depth (0-6" an 6-12") and preceding crop on the average NO_3^--N, NH_4^+-N and total mineral nitrogen (lbs/ac) on April 22, 1986, at Wabasha county, MN., n=4.

Source of N	Depth	Tillage: No Till mean	No Till st dev	Ridge till mean	Ridge till st dev	Paraplow mean	Paraplow st dev	Chisel mean	Chisel st dev
		Soybeans the preceding year							
NO_3^--N	0-6"	12.3	2.98	11.7	2.70	10.3	1.35	15.3	7.89
	6-12"	11.6	3.61	12.1	2.57	11.4	3.14	12.7	3.68
NH_4^+-N	0-6"	8.54	1.30	8.99	2.19	9.40	1.80	9.49	0.43
	6-12"	7.16	1.61	6.18	0.78	8.65	0.36	8.44	2.46
Tol-N	0-6"	20.9	3.66	20.7	1.04	19.7	2.26	24.8	7.85
	6-12	18.7	4.17	18.3	3.23	20.1	3.47	21.2	5.69
		Corn the preceding year							
NO_3^--N	0-6"	9.86	7.65	12.2	5.51	13.5	6.26	11.7	2.87
	6-12"	11.7	3.76	14.1	4.28	14.0	3.41	9.26	2.54
NH_4^+-N	0-6"	8.41	0.41	15.8	6.23	9.36	2.69	9.15	2.67
	6-12"	8.18	1.45	7.80	0.46	11.5	3.59	7.99	1.41
Tol-N	0-6"	18.3	7.40	28.0	2.88	22.9	8.41	20.9	0.26
	6-12"	19.9	3.19	21.9	4.40	25.4	5.14	17.3	3.92

Table 9. The significance of tillage, depth, the interaction of tillage x depth and preceding crop on the NO_3^--N, NH_4^+-N and total mineral nitrogen on April 22, 1986, Wabasha county, MN.

Source of N	Analysis of 0-6" and 6-12": Till.	Depth	Till. x Depth	Analysis of 1 ft. increments to five feet: Till.	Depth	Till. x Depth
	Soybeans the preceding year					
NO_3^--N	.285	.771	.698	.042	.000	.310
NH_4^+-N	.145	.017	.468	.071	.000	.747
Tol-N	.279	.187	.715	.618	.000	.832
	Corn the preceding year					
NO_3^--N	.707	.986	.700	.010	.000	.803
NH_4^+-N	.147	.123	.040	.075	.000	.388
Tol-N	.013	.172	.050	.003	.000	.698

Table 10. The effect of tillage on NO_3^--N, NH_4^+-N and total mineral nitrogen from 0 to 5 feet on April 22, 1986, at Wabasha county, MN., n=4.

Total lbs/A of	Sig. of Tillage	Tillage: No Till mean	No Till st dev	Ridge till mean	Ridge till st dev	Paraplow mean	Paraplow st dev	Chisel mean	Chisel st dev
		Soybeans the preceding year							
NO_3^--N	(.306)	101	23.4	115	25.1	95.9	27.8	103	22.5
NH_4^+-N	(.109)	50.1	4.80	45.1	1.94	56.9	7.57	55.6	11.8
Tol-N	(.818)	151	26.3	160	25.6	153	21.4	159	29.8
		Corn the preceding year							
NO_3^--N	(.370)	151	11.1	159	34.2	197	55.7	145	19.4
NH_4^+-N	(.240)	46.6	4.02	58.6	9.87	55.9	13.1	58.3	5.39
Tol-N	(.342)	197	10.2	218	37.2	253	52.4	203	21.2