Table 1. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on sweet corn yield and quality. Becker 1985.

	Code 5					Jubilee				
Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length Inches	% Moisture	% COC Eligible	Yield (T/A) Green	Yield (T/A) Husked	Ear Length Inches	% Moisture	% COC Eligible
0	0.92	0.59	5.6	71.3	16.7	0.81	0.56	4.6	77.6	0.0
50	2.34	1.37	4.9	71.6	20.0	2.43	1.63	5.1	71.0	1.5
100	4.28	2.78	6.6	70.4	42.3	6.47	4.54	6.4	72.4	30.3
150	7.87	5.68	7.8	70.2	77.8	8.69	6.45	7.1	73.2	68.0
200	9.22	6.58	8.4	73.6	93.7	10.21	7.56	7.5	73.8	88.1
100+NI	5.33	3.63	6.5	70.8	52.2	6.33	4.48	6.4	72.9	41.0
150+NI	9.18	6.64	7.8	72.2	86.7	8.89	6.05	7.2	73.8	70.0
100 Split	3.24	1.82	4.8	73.3	18.3	5.26	3.80	6.2	72.7	24.1
150 Split	7.70	5.60	7.6	72.8	93.7	9.67	6.72	7.3	76.5	76.8
Signif.	**	**	**	ns	**	**	**	**	**	**
BLSD (.05)	1.63	1.22	1.2	--	24.9	1.36	1.01	0.4	2.71	13.1

Factorial Arrangement
(Hybrid x N rate x Inhibitor)

	Yield Green	Yield Husked	Ear Length	Moisture	COC Eligible
Hybrid	*	+	+	**	*
N rate	**	**	*	+	**
Inhibitor	ns	ns	ns	++	+
Hybrid x N rate	+	+	ns	ns	ns
Hybrid x Inhibitor	+	+	ns	ns	ns
N rate x Inhibitor	ns	ns	ns	ns	ns
Hybrid x N rate x Inhibitor	ns	ns	ns	ns	ns

Factorial Arrangement
(Hybrid x N rate x Split)

Hybrid	**	**	ns	*	ns
N rate	**	**	**	ns	**
Split	ns	ns	+	*	ns
Hybrid x N rate	ns	+	*	+	ns
Hybrid x Split	ns	ns	*	ns	ns
N rate x Split	++	+	*	ns	*
Hybrid x N rate x Split	ns	ns	ns	ns	ns

+ = .20, ++ = .10, * = .05, ** = .01

Table 2. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentration in various plant tissues during the growing season and on total nitrogen uptake (Code 5). Becker.

Treatment lb N/A	% N Whole Plant (6-8 leaf)	% N Leaf Above Ear (Silking)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear (lb N/A)	N Content Husk (lb N/A)	N Content Stover (lb N/A)	Total N Uptake lb N/A
0	4.02	1.39	1.31	0.54	0.68	3.2	0.6	23.9	27.7
50	4.09	1.78	1.31	0.38	0.58	8.7	1.5	26.5	36.7
100	4.13	2.24	1.25	0.44	0.64	18.2	2.5	30.1	50.7
150	4.12	2.65	1.30	0.52	1.05	39.9	4.0	48.0	91.9
200	4.17	2.90	1.36	0.57	1.36	47.9	5.5	55.6	109.0
100+NI	4.28	2.47	1.34	0.48	0.87	26.9	3.0	40.3	70.3
150+NI	4.18	2.70	1.42	0.58	1.09	52.0	5.1	50.0	107.1
100 Split	4.08	2.07	1.16	0.45	0.53	10.9	2.6	28.2	41.6
150 Split	4.09	2.59	1.39	0.55	1.24	40.3	4.2	59.7	104.2
Signif.	ns	**	*	**	**	**	**	**	**
BLSD (.05)	--	0.20	0.16	0.11	0.24	10.1	1.1	11.4	19.3

Table 3. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentrations in various plant tissues during the growing season and on total nitrogen uptake. (Jubilee) Becker.

Treatment lb N/A	% N Whole Plant (6-8 leaf)	% N Leaf Above Ear (Silking)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear (lb N/A)	N Content Husk (lb N/A)	N Content Stover (lb N/A)	Total N Uptake lb N/A
0	4.16	1.22	1.46	0.61	0.61	2.2	0.4	14.9	17.5
50	4.39	1.38	1.38	0.44	0.46	8.6	0.9	14.7	24.2
100	4.35	1.97	1.29	0.48	0.61	28.6	2.7	29.6	61.0
150	4.35	2.52	1.37	0.53	0.82	44.4	3.7	41.8	89.9
200	4.44	2.97	1.51	0.67	1.11	56.6	5.6	54.6	116.9
100+NI	4.36	2.25	1.30	0.50	0.55	28.8	2.9	24.1	55.8
150+NI	4.39	2.63	1.42	0.61	0.80	43.2	5.2	37.6	85.9
100 Split	4.40	1.84	1.33	0.50	0.56	23.6	2.3	24.1	50.0
150 Split	4.31	2.65	1.51	0.65	0.94	51.8	5.2	44.5	101.6
Signif.	ns	**	ns	**	**	**	**	**	**
BLSD (.05)	--	0.25	--	0.10	0.22	9.0	1.5	10.1	15.3

Table 4. Influence of N-serve and N rate on leaf elemental concentrations at mid-silking: Becker, 1985.

Treatment lb N/A	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------%----------					----------ppm----------				
100	Code 5	2.24	0.26	2.56	0.53	0.33	87	53	13	9	6
150	Code 5	2.65	0.29	2.65	0.53	0.36	112	79	14	10	5
100+NI	Code 5	2.47	0.29	2.72	0.50	0.31	92	59	13	9	6
150+NI	Code 5	2.70	0.30	2.63	0.55	0.34	95	87	16	10	5
100	Jubilee	1.97	0.26	2.75	0.55	0.38	82	61	15	9	5
150	Jubilee	2.52	0.28	2.77	0.59	0.39	92	89	18	10	5
100+NI	Jubilee	2.25	0.28	2.81	0.49	0.33	86	59	14	9	5
150+NI	Jubilee	2.63	0.29	2.72	0.63	0.41	92	108	19	11	6
Statistics											
Hybrid		*	*	**	*	**	*	+	**	*	ns
N rate		**	+	ns	**	**	**	**	*	**	ns
Inhibitor		+	+	ns	ns	++	ns	ns	ns	ns	ns
Hybrid x N rate		ns	ns	ns	ns	ns	ns	ns	ns	ns	+
Hybrid x Inhibitor		ns	ns	ns	*	ns	ns	ns	ns	+	ns
N rate x Inhibitor		+	+	*	**	*	+	ns	+	ns	ns
N rate x Hybrid x Inhibitor		ns	ns	ns	ns	+	ns	ns	ns	ns	ns

+ = .20, ++ = .10, * = 0.5, ** = .01

Table 5. Effect of nitrogen rate, nitrification inhibitor, and sidedress applications on sweetcorn yield and quality. Waseca 1985.

	Code 5					Jubilee				
Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length Inches	% Moisture	% COC Eligible	Yield (T/A) Green	Yield (T/A) Husked	Ear Length Inches	% Moisture	% COC Eligible
0	1.38	1.02	4.5	69.9	31.4	2.99	1.89	5.0	72.7	11.0
50	3.01	2.08	5.8	67.6	30.1	5.00	3.40	5.8	70.9	30.6
100	5.17	3.58	5.4	68.2	52.5	6.15	4.02	6.5	71.4	43.8
150	6.87	5.36	6.5	69.3	76.6	7.64	5.33	6.8	67.0	59.3
200	6.30	4.60	6.6	71.4	71.4	8.33	5.47	7.4	72.6	71.6
100+NI	5.36	3.91	5.5	68.7	49.6	6.61	4.52	6.4	68.6	50.0
150+NI	6.00	4.23	6.1	68.8	60.5	7.16	4.81	6.7	70.8	46.8
100 Split	4.12	2.86	5.0	71.2	43.1	4.68	3.17	5.8	70.1	31.6
150 Split	3.54	2.50	5.1	66.9	45.8	7.33	4.86	6.4	69.0	46.4
Signif.	**	**	*	ns	**	**	**	**	ns	**
BLSD (.05)	1.20	0.97	1.2	--	20.0	1.69	1.20	0.7	--	23.9

Factorial Arrangement
(Hybrid x N rate x Inhibitor)

	Yield Green	Yield Husked	Ear Length	Moisture	COC Eligible
Hybrid	*	ns	**	ns	ns
N rate	**	**	*	ns	*
Inhibitor	ns	ns	ns	ns	ns
Hybrid x N rate	ns	ns	ns	ns	ns
Hybrid x Inhibitor	ns	ns	ns	ns	ns
N rate x Inhibitor	ns	++	ns	+	ns
Hybrid x N rate x Inhibitor	ns	ns	ns	*	ns

Factorial Arrangement
(Hybrid x N rate x Split)

Hybrid	**	**	**	ns	+
N rate	**	**	*	*	*
Split	**	**	**	ns	**
Hybrid x N rate	*	+	ns	ns	ns
Hybrid x Split	*	*	ns	ns	ns
N rate x Split	ns	++	+	ns	ns
Hybrid x N rate x Split	*	*	++	*	ns

+ = .20, ++ = .10, * = .05, ** = .01

Table 6. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentration in various plant tissue during the growing season and on total nitrogen uptake. (Code 5). Waseca.

Treatment lb N/A	% N Whole Plant (6-8 leaf)	% N Leaf Above Ear (Silking)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear (lb N/A)	N Content Husk (lb N/A)	N Content Stover (lb N/A)	Total N Uptake lb N/A
0	2.62	1.43	1.39	0.54	0.75	7.2	1.0	27.8	35.9
50	3.28	1.87	1.36	0.56	0.85	14.7	2.4	39.1	56.1
100	3.32	2.02	1.41	0.62	1.03	25.5	4.5	46.3	76.3
150	3.24	2.23	1.50	0.68	1.15	40.1	4.6	52.1	96.9
200	3.42	2.56	1.46	0.71	1.28	32.9	5.2	54.4	92.6
100+NI	3.31	2.15	1.46	0.72	0.99	28.4	4.8	43.3	76.6
150+NI	3.53	2.15	1.44	0.69	1.16	29.2	5.3	49.6	84.2
100 Split	3.33	1.56	1.39	0.61	0.83	19.8	3.4	36.8	60.1
150 Split	3.09	1.89	1.53	0.64	0.91	18.1	3.2	37.3	58.6
Signif.	**	**	ns	**	**	**	**	**	**
BLSD (.05)	0.31	0.29	--	0.07	0.31	7.2	1.3	13.4	15.5

Table 7. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentration in various plant tissues during the growing season and on total nitrogen uptake (Jubilee). Waseca.

Treatment lb N/A	% N Whole Plant (6-8 leaf)	% N Leaf Above Ear (Silking)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear (lb N/A)	N Content Husk (lb N/A)	N Content Stover (lb N/A)	Total N Uptake lb N/A
0	2.61	1.32	1.62	0.58	0.73	14.1	2.1	23.2	29.4
50	3.44	1.37	1.41	0.57	0.79	22.1	2.9	29.5	54.5
100	3.26	1.76	1.57	0.67	1.17	27.9	4.6	47.1	79.7
150	3.23	2.10	1.71	0.69	1.44	43.1	5.4	62.2	110.6
200	3.42	2.27	1.82	0.77	1.34	43.5	6.9	65.5	115.9
100+NI	3.25	1.79	1.59	0.64	1.11	34.2	4.4	46.3	84.9
150+NI	3.66	1.90	1.58	0.69	1.23	34.6	5.1	51.4	91.1
100 Split	3.36	1.61	1.58	0.63	0.93	21.5	2.9	36.0	60.4
150 Split	3.13	1.53	1.46	0.64	1.01	34.8	5.0	38.9	78.7
Signif.	**	**	**	**	**	**	**	**	**
BLSD (.05)	0.38	0.23	0.21	0.10	0.17	8.4	1.5	12.3	20.1

Table 8. Influence of N-serve and N rate on an leaf elemental concentrations at mid-silking: Waseca, 1985.

Treatment lb N/A	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------%----------					----------ppm----------				
100	Code 5	2.02	0.28	2.32	0.71	0.35	91	47	15	8	11
150	Code 5	2.23	0.28	2.40	0.74	0.34	89	54	17	8	10
100+NI	Code 5	2.15	0.30	2.45	0.68	0.34	100	44	18	8	11
150+NI	Code 5	2.15	0.27	2.93	0.67	0.34	81	52	16	8	10
100	Jubilee	1.76	0.26	2.34	0.78	0.42	75	34	20	7	11
150	Jubilee	2.10	0.28	2.48	0.86	0.46	87	55	23	9	13
100+NI	Jubilee	1.79	0.27	2.49	0.72	0.40	83	41	21	7	11
150+NI	Jubilee	1.90	0.26	2.43	0.81	0.44	75	49	19	8	12
Statistics											
Hybrid		**	*	ns	**	**	*	ns	**	ns	++
N rate		+	ns	ns	ns	+	ns	*	ns	**	ns
Inhibitor		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Hybrid x N rate		ns	+	ns	ns	+	+	ns	ns	++	+
Hybrid x Inhibitor		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
N rate x Inhibitor		*	*	ns	+	ns	*	ns	*	+	ns
N rate x Hybrid x Inhibitor		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

+ = .20, ++ = .10, * = 0.5, ** = .01

FIELD TRIALS WITH "BASIC-H" IN 1983, 1984, AND 1985.

George Rehm and Bill Fenster

Procedure:

This study was initiated in 1983, continued in 1984, and terminated in 1985. Trials were conducted at the branch experiment stations at Waseca, Lamberton, Morris, and Crookston as well as the experimental field at Becker. The treatments used at each location are listed in Tables 1 through 6.

The "Basic-H" was applied according to label directions for all crops at all locations. Fertilizer recommendations were based on the results of the analysis of soil samples taken in the spring of 1983 and the fall of 1983, and the fall of 1984. The fertilizer needed to supply the recommended rate of N, P_2O_5, and K_2O was broadcast and incorporated before planting each year.

Specific management practices varied with crop and location. The management practices that were used for each crop were consistent with those needed for production of maximum yields of the specific crop.

Results and Discussion:

Corn grain yields recorded at the Waseca and Lamberton locations are summarized in Table 1. As would be expected, the use of recommended rates of N, P_2O_5, and K_2O produced significant increases in yield. The use of "Basic-H" alone or in conjunction with the recommended fertilizer program did not produce a significant yield increase at either location. The relatively low C.V. values provide evidence that the accuracy in measurement of yields was good.

The effect of "Basic-H" on the moisture content of corn at harvest is summarized in Table 2. Except for the Waseca location in 1985, the moisture content of corn was higher for the control treatment and the treatment where "Basic-H" only was applied at a rate of 1 gal./acre. Moisture content of the grain was not influenced by treatment at the Lamberton location in 1983 and 1984.

Wheat yields from the Morris location are summarized in Table 3. Treatment had no significant effect on grain yield in 1984. Effects of treatments used in 1983 and 1985 were similar to those recorded for corn at the Waseca and Lamberton locations. Wheat yields were increased by the use of fertilizer but the use of "Basic-H" either alone or with the recommended fertilizer program had no significant effect on yield. Treatment had no significant effect on the moisture content of the wheat crop at harvest.

Sunflower yields from the Crookston site are summarized in Table 4. Yields were quite variable and the C.V. was higher in all years. The treatment used had no significant effect on sunflower production in 1983 and 1984. The 1985 yields were severely reduced by an early frost and it is difficult to attach a large amount of importance to the yields measured.

Treatment used had no significant effect on the oil content of the sunflower seeds. Because of the low yield and poor seed quality in 1985, oil content was not measured in this year of the study.

The potato yields from the irrigated site at the Becker experimental field are summarized in Table 5. Yields were increased significantly by the use of fertilizer. The use of "Basic-H", however, either alone or with fertilizer had no positive effect on tuber yield.

The effect of the use of "Basic-H" on both yield and quality of sugarbeets was evaluated at the Crookston location. The treatment used had no significant effect on either yield or recoverable sugar in both 1983 and 1984. The 1985 yields were incrased by the use of fertilizer. The recoverable sugar was also increased by fertilizer use.

The use of "Basic-H" alone had no significant effect on yield in 1985. The use of 2 gal./acre of this material, when used with the recommended fertilizer instead of 1 gal./acre produced a significant increase in yield. The yield increase from the 2 gal./acre treatment compared to the fertilizer control was not significant. Therefore, very little importance can be attached to this

Please refer to title page of this publication for information regarding application and use of this article.

observation. The use of "Basic-H" had no significant effect on recoverable sugar.

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Table 1. Effect of Basic-H on corn yield.

	Location and Year					
	Waseca			Lamberton		
Treatment	1983	1984	1985	1983	1984	1985
	bu./acre					
control	56	68	61	62	94	38
Fertilizer* (U of M recommednations)	121	141	150	85	115	105
Fertilizer + Basic-H (1 gal./acre)	111	141	159	87	116	107
Fertilizer + Basic-H (2 gal./acre)	117	145	161	87	121	104
Basic-H (1 gal./acre)	53	58	66	54	95	42
Significance	**	**	**	**	**	**
BLSD (.05)	10	8	12	14	7	7
C.V.%:	7.6	5.0	6.4	9.0	4.5	6.5

*Recommended Fertilizer:

- Waseca (1983) 175N 50 P_2O_5 150 K_2O
- Waseca (1984) 170N -- --
- Waseca (1985) 170N 50 P_2O_5 150 K_2O
- Lamberton (1983) 150N 60 P_2O_5 60 K_2O
- Lamberton (1984) 150N 60 P_2O_5 60 K_2O
- Lamberton (1985) 150N 60 P_2O_5 60 K_2O

Table 2. Effect of Basic-H on the moisture content of corn grain at harvest.

	Location and Year					
	Waseca			Lamberton		
Treatment	1983	1984	1985	1983	1984	1985
	% H_2O					
control	21.6	21.5	26.2	23.2	31.5	47.3
Fertilizer (U of M recommendations)	20.5	19.5	27.5	21.7	30.0	38.6
Fertilizer + Basic-H (1 gal./acre)	20.4	19.3	26.0	22.1	31.5	38.4
Fertilizer + Basic-H (2 gal./acre)	20.6	20.3	26.5	21.4	31.3	39.3
Basic-H (1 gal./acre)	21.8	22.6	26.1	23.1	31.8	44.6
Significance	**	**	**	NS	NS	**
BLSD(.05)	.6	2.5	1.0	--	--	2.4
C.V. %	.8	7.3	2.2	4.2	2.9	4.0

Table 3. Effects of Basic-H on wheat yield and moisture content of the grain at harvest. Morris.

Treatment	Grain Yield 1983	1984	1985	Moisture Content 1983	1984	1985
	-------bu./acre-----			----------%--------		
control	41	84	31	13.2	12.2	17.1
Fertilizer* (U of M recommendations)	55	75	72	12.2	12.6	17.7
Fertilizer + Basic-H (1 gal./acre)	59	80	72	13.8	12.6	17.9
Fertilizer + Basic-H (2 gal./acre)	56	81	73	13.9	12.6	17.9
Basic-H (1 gal./acre)	46	80	30	13.0	12.3	17.5
Significance	**	NS	**	NS	NS	NS
BLSD(.05)	5	--	5	--	--	--
C.V.%	6.1	6.6	6.2	2.8	1.6	3.1

Fertilizer Recommended:

-1983 50N $0P_2O_5$ $0K_2O$
-1984 80N $0P_2O_5$ $30K_2O$
-1985 80N $0P_2O_5$ $0K_2O$

Table 4. Effect of Basic-H on yield of sunflower and oil content.

Treatment	Yield 1983	1984	1985	Oil Content 1983	1984
	-----lb./acre-----			--------%-------	
control	964	1743	445	37.5	42.6
Fertilizer* (U of M recommendations)	1180	1825	554	38.0	42.5
Fertilizer + Basic-H (1 gal./acre)	1192	1949	431	37.4	42.5
Fertilizer + Basic-H (2 gal./acre)	1169	1873	450	37.1	42.7
Basic-H (1 gal./acre)	996	1795	477	37.8	42.9
Significance	NS	NS	**	NS	NS
C.V.	11.4	8.9	11.8	3.4	1.5
LSD(.05)	--	--	86	--	--

*Fertilizer Recommended:

-1983 90N 50 P_2O_5 100 K_2O
-1984 18N 46 P_2O_5 0 K_2O
-1985 42N 40 P_2O_5 0 K_2O

Table 5. Effect of Basic-H on the yield of potatoes. Becker, MN.

Treatment	Yield 1983	1984	1985
	----------cwt/acre----------		
control	334	330	343
Fertilizer* (U of M recommendations)	460	478	583
Fertilizer + Basic-H (1 gal./acre)	446	453	584
Fertilizer + Basic-H (2 gal./acre)	424	445	600
Basic-H (1 gal./acre)	318	340	298
Significance	**	**	**
BLSD(.05)	98	37	60
C.V. %	11.0	6.3	8.7

Fertilizer Recommended:

-1983 150N 150 P_2O_5 400 K_2O 15S
-1984 210N 100 P_2O_5 300 K_2O 15S
-1985 210N 100 P_2O_5 300 K_2O 15S

Table 6. Effects of Basic-H on the yield and recoverable sugar in sugarbeets.

Treatment	Yield 1983	1984	1985	Recoverable Sugar 1983	1984	1985
	-----ton/acre-----			---------lb./acre-----		
control	21.5	17.9	15.3	5228	5409	4426
Fertilizer* (U of M recommendation)	23.1	19.7	21.3	5456	5740	6023
Fertilizer + Basic-H (1 gal./acre)	21.2	20.5	20.3	5255	5905	5737
Fertilizer + Basic-H (2 gal./acre)	23.2	19.3	21.9	5572	5770	6131
Basic-H (1 gal./acre)	23.2	17.9	15.7	5636	5150	4443
Significance	NS	NS	**	NS	NS	**
BLSD(.05)	--	--	1.5	--	--	537

*Fertilizer Recommended:
-1983 90N 80 P_2O_5 80 K_2O
-1984 70N 80 P_2O_5 80 K_2O
-1985 75N 80 P_2O_5 80 K_2O

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS, MARTIN CO. 1985

George Rehm, Bill Fenster, and Curtis Overdahl

Relationships between micronutrient recommendations and soil test are not well documented.

A study was initiated in 1981 at 5 locations in the state. All but one were discontinued in 1984. The following is a summary on the remaining site in Martin County.

Plot received treatments of all micronutrients minus one nutrient and each of these with the missing element are compared to the complete treatment of all micronutrients. Only one rate of each element was used. Adequate N, P, and K were added to all plots. Secondary nutrients, sulfur, and magnesium, were also included in the trial. Micronutrient additions were discontinued after the first 2 years but in 1985 were again applied.

Corn and soybeans were alternated over 5 years resulting in 3 crops of corn and 2 of soybeans.

The following tables show yields, plant analysis and the soil tests reported from 4 soil testing laboratories.

Table 1. Yield comparisons of complete treatment of micronutrients[1] plus magnesium with individual plots having a nutrient omitted. Martin[2] Co. 1981, 82, 83, 84, 85.

Treatment[2] omitted(-) added (+)	Yield 1981	1982	1983	1984	1985
	Corn	Bean	Corn	Bean	Corn
None	179	56	143	48	157
-Mg	181	51	144	46	130
-Zn	181	52	145	46	158
-Fe	182	53	148	48	153
-Mn	180	54	148	49	151
-B	178	52	148	46	159
-Cu	178	52	146	47	151
+complete includes S	184	54	141	49	149
Significance	ns	ns	ns	ns	ns
C.V.	4.9	5.0	6.7	7.3	3.9

1 average of 4 replications.
2 fine textured non-irrigated soil.
3 pounds per acre of nutrient added Mg=50, Zn=10, Fe=10, Mn=10, B=1, Cu=5 in 1981 and 1982, residual only in 1983, 1984. Nutrients added in spring 1985.

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Table 2. Plant analysis[1] from micronutrient and magnesium treatments in trials at Martin County, 1981, 1982, 1983, 1984.

Treatment omitted (-) added (+)	Martin (-) 81	82	83	84	(+) 81	82	83	84
Mg (%)	.58	.48	.45	.47	.58	.42	.53	.48
Zn ppm	21	42	14	38	24	48	20	44
Fe ppm	93	113	100	116	97	131	99	111
Mn ppm	56	61	46	87	61	97	57	58
B ppm	5	50	8	46	5	50	7	48
Cu ppm	3	10	3	9	3	11	3	10

1 average of 2 replications from leaf opposite and below ear at silking time. No analysis was made in 1985.
2 symbol (+) is from treatment of all nutrients and (-) is where nutrient was omitted. Pounds of nutrients added Mg=50, Zn=10, Mn=10, B=1, Cu=5, in 1981 and 1982. Residual in 1983, 1984.

Table 3. Yields,[1] plant sulfur and soil test sulfur with and without sulfur treatments, Martin County[2] 1981, 1982, 1983, 1984, and 1985.

Sulfur Treatment	Yield (bu/A) 81[3] C	82[3] B	83 C	84 B	85 C	Leaf test (% S) 81 C	82 B	83 C	84 B	U of M Soil Test (PPM S) 81 C	82 B	83 C	84 B
None	183	54	144	47	154	.23	.31	.20	.30	16	1	6	12
50#/A	180	53	152	48	153	.29	.31	.22	.32	--	--	5	11
Signif.	ns	ns	ns	ns	ns								

1 average of 4 replications.
2 non-irrigated clay loam soil.
3 C = Corn, B = Soybeans

Table 4a. Soil test means for micronutrients. University of Minnesota Lab. 1981, 1982, 1983, 1984, and 1985.

Treatment omitted (-) added (+)	(ppm except Mg which is lbs/A) (-) 81[1]	82	83	84	85	(+) 82	83	84	85	deficient level
Mg	881	990	1124	632	902	970	1096	1134	1049	NE[2]
Zn	1.0	1.2	2.2	1.2	1.1	2.3	5.4	6.8	6.0	0.5 ppm
Fe	21	42	25	26	43	26	24	30	35	NE[2]
Mn	41	40	22	25	11	40	17	18	9	NE[2]
B	1.20	2.1	2.2	2.0	1.6	1.8	2.4	1.7	2.0	1 ppm
Cu	1.28	1.8	1.7	1.8	1.2	2.5	3.0	3.7	2.7	2.5 ppm[3]

1 1981 soil test results before treatment applied.
2 NE indicates Not Established
3 for organic soils only, not established for mineral soils.

Table 4b. Soil test means for micronutrients. Minnesota Valley soil test lab. 1983 and 1984.

Treatment omitted (-) added (+)	(ppm except Mg which is lbs/A) (-) 1983	(-) 1984	(+) 1983	(+) 1984
Mg	1325	1350	1200	1675
Zn	2.1	2.0	4.0	6.7
Fe	8	18	8	12
Mn	2	10	2	8
B	3	3	4	3
Cu	0.4	1.9	0.4	3.6

Table 4c. Soil test means for micronutrients. Harris Lab. 1983 and 1984.

Treatment omitted (-) added (+)	(ppm except Mg) (-) 1983	(-) 1984	(+) 1983	(+) 1984
Mg	629	585	56	567
Zn	2.0	1.2	4.7	6.6
Fe	22	21	20	26
Mn	14	15	12	13
B	1.9	1.5	2.0	1.6
Cu	1.5	1.3	2.6	3.0

Table 4d. Soil tests means for micronutrients. A & L Lab. Fall 1983 & 1984.

Treatment omitted (-) added (+)	(ppm except Mg) (-) 1983	(-) 1984	(+) 1983	(+) 1984
Mg	549	592	525	582
Zn	1.7	1.2	4.7	6.7
Fe	19	23	19	27
Mn	15	13	11	12
B	2.8	1.5	3.0	1.4
Cu	1.4	1.4	2.4	3.0

Summary

No yield benefits were observed from sulfur, magnesium or the micronutrients in any of the 5 years of the study.

Soil tests were not below the deficient level (where these levels have been established). For the other nutrients not having established deficiency levels the deficiency levels are apparently lower than observed in this experiment. Some of the soil testing laboratories recommended nutrients at these levels and it is obvious that these were not satisfactory recommendations. Soil tests for magnesium, sulfur, zinc, boron, and copper all showed good sensitivity to treatment. Of the other nutrients studied, iron and manganese, this sensitivity was lacking. Frequently test readings were lower after treatment than without treatment. The micronutrient trial sites were originally chosen when established 5 years ago because several laboratories had recommended secondary and micronutrients for these specific sites.

CORRELATION OF SEVERAL TESTS FOR PHOSPHORUS WITH RESIN EXTRACTABLE PHOSPHORUS ON ALKALINE SOILS

P. Nesse and J. Grava

The University of Minnesota Soil Testing Laboratory uses the Olsen $NaHCO_3$ method to extract P from soils with pH levels exceeding 7.4. In 1983 a study was initiated on alkaline soils to correlate the Olsen method with resin extractable phosphorus, an indicator of phosphorus availability to the plant. Several other methods were also compared to resin extractable P, including the Bray-1 method that is used by the U of M to extract P from soils with pH less than 7.4.

Experimental Procedure. Thirty western Minnesota soils were sampled (0-6") in fall, 1983, and characterized in the laboratory. All were alkaline with an average pH of 8.1 and a range of 7.7 to 8.4. Free calcium carbonate ($CaCO_3$) averaged about 12 percent and ranged from 0 to 62 percent. Average clay percent was 27 with a low of 7 and a high of 55 percent. Organic matter averaged 7 percent and ranged from about 3 to 26 percent.

Phosphorus was determined by Olsen, Soltanpour AB-DTPA, Mehlich 2, Mehlich 3, and resin methods, and also by Bray-1 at 1:10, 1:50, and 1:100 soil to solution ratios. Soltanpour (1.0 N NH_4HCO_3--0.005 M DTPA), Mehlich 2 (0.2 N NH_4Cl--0.2 N HOAc--0.015 N NH_4F--0.012 N HCl), and Mehlich 3 (0.2 N HOAc--0.25 NH_4NO_3--0.015 N NH_4F--0.013 N HNO_3--0.001 M EDTA) are universal extractants designed to simultaneously extract a number of elements. Interest has been growing in their use. Increasing the soil to solution ratio (from 1:10 to 1:50 or 1:100) has generally improved the relationship between Bray-1 and P availability. Resin extractable phosphorus was obtained by shaking 0.5 g. of soil for 24 hours with 0.4 g of Dowex 1 x 8 resin (HCO_3). The resin was washed free of soil and P was extracted from the resin with 0.5 N HCl and shaken overnight. Phosphorus was read as percent absorbance on a colorimeter.

Soils were separated into groups on the basis of their reaction to dropwise addition of 10% HCl, a field test utilized by the National Cooperative Soil Survey to roughly assess the alkalinity of the soil. Fifteen soils that were neutral (no reaction with HCl), slightly effervescent (bubbles readily observable), or strongly effervescent (bubbles form a low foam) were found to have free calcium carbonate ($CaCO_3$) of less than 7 percent. Fifteen soils that were violently effervescent (thick foam jumps up) in reaction to HCl had $CaCO_3$ greater than 7 percent, with one exception.

Results. Means and ranges of P extracted by the various methods for all 30 soils is given in Table 1, as well as means for 15 soils with free calcium carbonate ($CaCO_3$) less than 7 percent (Low Group) and means for the remaining 15 soils that contained $CaCO_3$ greater than 7 percent (High Group). Low Bray-1 values for the high CCE soils is due to the neutralization of Bray-1 extractant by calcium carbonates.

The relationship between various soil tests and resin extractable P for all 30 soils is shown in Table 2. Olsen P values were most highly correlated with resin P values (r=0.943). The Soltanpour method was closely related to resin P after 9 clayey soils (> 35 percent clay) were removed from the study group. The relationship between $CaCO_3$% and effervescence is shown in Figure 2. All of the extractants were closely related (r > 0.9) to resin extractable P for the 15 low $CaCO_3$) soils. The Olsen extractant was the only extractant to have a close relationship (r=0.936) with resin P for the 15 high $CaCO_3$ soils. The Soltanpour extractant was closely related to resin P for high $CaCO_3$ soils after removal of the clayey soils from the study group.

The U of M Soil Testing Laboratory assumes that 1 mg kg^{-1} of Olsen P is equivalent to 1 mg kg^{-1} of Bray-1 (1:10) P when making fertilizer recommendations. This may be an oversimplification. The relationship of Bray-1 (1:10) to Olsen P (r=0.693) for 30 soils is shown in Figure 3. Mean values for Bray-1 (1:10) and Olsen are 13.2 and 14.6 mg kg^{-1}, respectively, for all 30 soils.

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The relationship of Bray-1 (1:10) to Olsen P for the high $CaCO_3$, violently effervescing soils (r=0.280) and for the low $CaCO_3$ soils is shown in Figures 3 and 4. The correlation coefficient for Bray-1 (1:10) and Olsen for the low $CaCO_3$ soils was r = 0.974 after the removal of one outlier, a sample that contained 26% organic matter. Mean values for Bray-1 (1:10) and Olsen P are 3.3 and 13.5 mg kg^{-1}, respectively, for the high $CaCO_3$ group. Mean values for the low $CaCO_3$ soils for Bray-1 (1:10) and Olsen P were 23.1 and 15.6 mg kg^{-1}.

Conclusions. Olsen P is closely related to resin extractable P, an indicator of available P, over all levels of free calcium carbonate ($CaCO_3$). Soltanpour P is closely related to resin P for high and low $CaCO_3$ groups when clayey soils (> 35% clay) are removed from the study group. Mehlich and Bray-1 extractants were closely related to resin P at low $CaCO_3$ but not at high $CaCO_3$. Bray-1 (1:10) and Olsen P do not appear to be equal. Bray-1 (1:10) values are higher than Olsen values at low $CaCO_3$ percentage and much lower than Olsen values at high $CaCO_3$. The effervescence test as used by the National Cooperative Soil Survey appears to be a fast, reliable method to separate problematic, high $CaCO_3$ soils from lower $CaCO_3$ soils.

Table 1. Means, minimum values, and maximum values of phosphorus extracted from 30 alkaline soils and means of phosphorus extracted from 15 low and high $CaCO_3$ soils by various extractants.

Method	Mean (n=30)	Minimum (n=30)	Maximum (n=30)	Free $CaCO_3$ Low Group (n=15)	Free $CaCO_3$ High Group (n=15)
	ppm			%	
Resin	26.8	5.0	62.0	27.0	26.7
Olsen	14.6	4.0	39.0	15.6	13.5
Soltanpour	8.0	1.0	22.0	22.0	7.8
Bray-1 (1:10)	13.2	1.0	55.0	23.1	3.3
Bray-1 (1:50)	36.4	5.0	117.0	45.2	27.5
Bray-1 (1:100)	52.4	6.0	155.0	55.0	49.9
Mehlich 2	29.3	1.0	78.0	27.0	30.9
Mehlich 3	32.7	1.0	86.0	31.9	33.4

Table 2. Correlation coefficients (r) for methods of phosphorus extraction for 30 alkaline soils.

	Resin	Olsen	Solt.	Bray-1 (1:10)	Bray-1 (1:50)	Bray-1 (1:100)	Mehl.2	Mehl.3
	r							
Resin	1.000							
Olsen	0.943	1.000						
Soltanpour	0.889	0.939	1.000					
Bray-1 (1:10)	0.617	0.693	0.606	1.000				
Bray-1 (1:50)	0.603	0.612	0.694	0.618	1.000			
Bray-1 (1:100)	0.659	0.587	0.710	0.315	0.806	1.000		
Mehlich 2	0.786	0.690	0.759	0.408	0.786	0.933	1.000	
Mehlich 3	0.809	0.723	0.768	0451	0.796	0.923	0.994	1.000

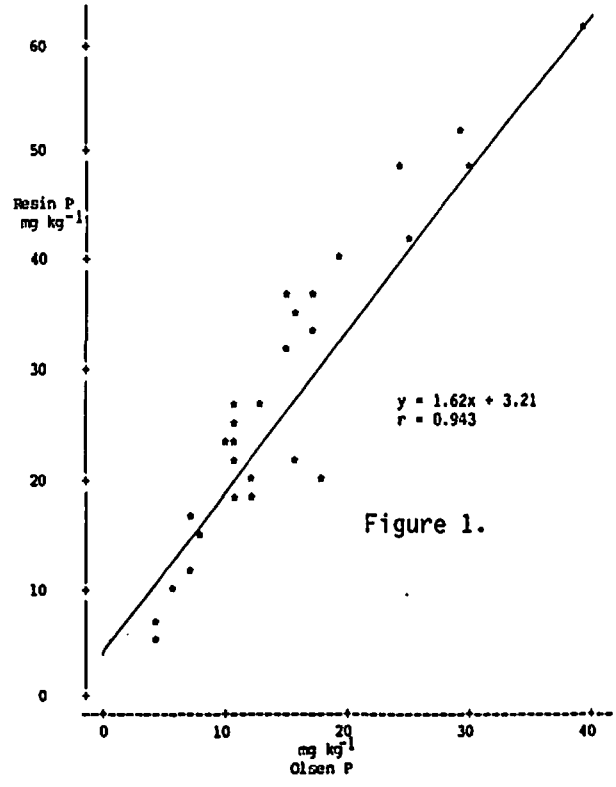

Figure 1.

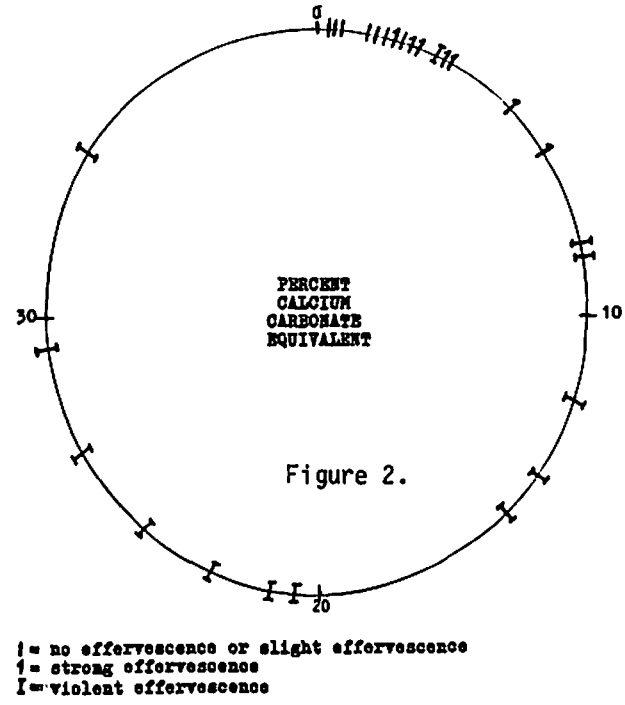

Figure 2.

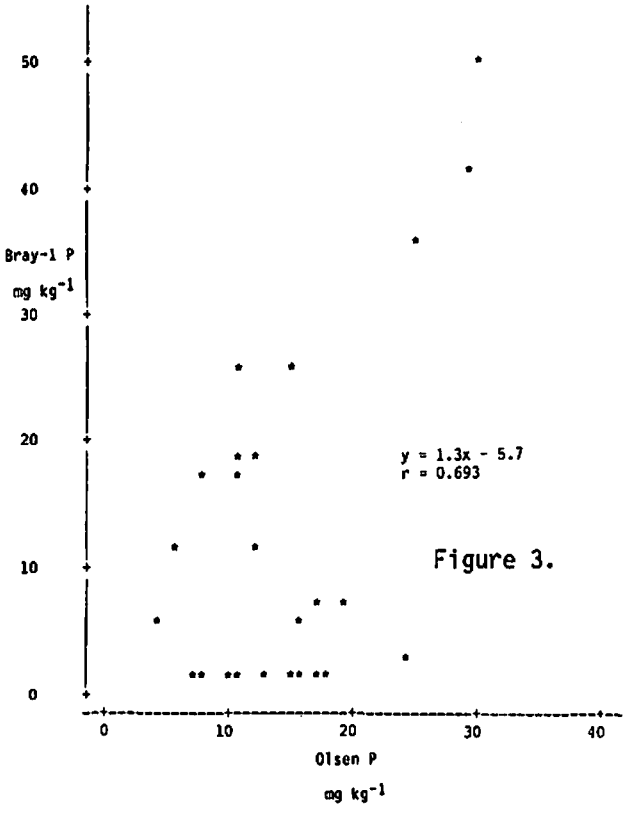

Figure 3.

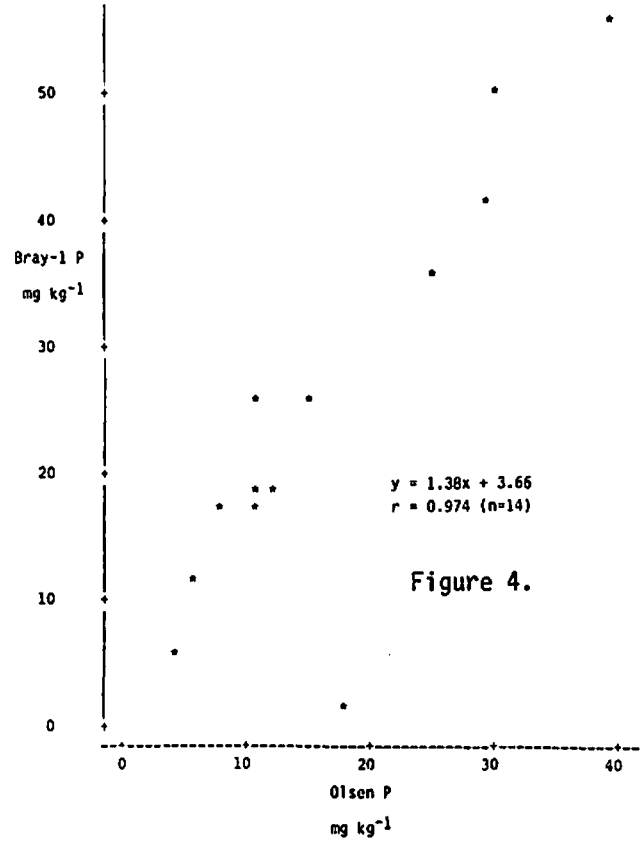

Figure 4.

Figures 1 - 4. The relationship between resin P and Olsen P, between calcium carbonate equivalent (CCE) and the effervescence test, and betweeen Bray-1 (1:10) and Olsen P for 30 alkaline soils; and the relationship between Bray-1 (1:10) and Olsen for 14 low CCE (CCE<7) soils.

PHOSPHORUS RETENTION IN CALCAREOUS SOIL

P. Nesse and J. Grava

It has been assumed that retention of added phosphorus increases with increasing amounts of free calcium carbonates, or calcium carbonate equivalent (CCE), in the soil. An objective of this research was to determine if this is true for western Minnesota soils.

Experimental Procedure. Twenty-four alkaline soils from western Minnesota and three neutral soils from south-central Minnesota were each incubated with 0 and 60 ppm of KH_2PO_4 for six weeks in 50 ml capped centrifuge tubes. Phosphorus was extracted using the Olsen method. Percent recovery was then estimated for each soil by subtracting the amount of extractable P in the check from the amount of extractable P in the 60 ppm added tube, and dividing the remainder by 60. Average recovery for the 24 alkaline soils was 34.3 percent with a minimum of 22.0 and a maximum of 46.0 percent. Recovery for the three neutral soils was 26.5, 33.2, 35.3 for an average of 31.7 percent. The range in pH for the three soils was 6.3 to 6.8. Calcium carbonate equivalent (CCE) is the same as free calcium carbonate and it was determined for all 27 soils by weight loss after addition of 6 N HCl. Average CCE for the 24 alkaline soils was 13.4 percent with a low of nearly 0 and a high of 62 percent. Thirteen of these soils had CCE greater than 7%. The range in pH for the 24 soils was 7.7-8.4. The three neutral soils had CCE of 0. Organic matter for the 24 alkaline soils ranged from 3.3 to 17.1 with an average of 6.7 percent. Organic matter for the three neutral soils was 6.8, 5.6 and 5.8 percent.

In a related study, a Calciaquoll soil and a Haplaquoll soil were sampled in each of two Red River Valley fields with the help of local Soil Survey personnel (M. Jacobsen and A. Gienke).Fargo and Hegne samples were taken about 75 feet apart from a Clay County field. A and B horizons were sampled. Both soils are poorly drained and had received similar management considerations prior to sampling. The major difference between these two soils is that Hegne is a Calciaquoll and it contains considerably more calcium carbonates than Fargo, a Haplaquoll. Perella and Colvin soils are from a Polk County field and they were sampled about 100 feet apart. A and B horizons were sampled. Both soils are poorly drained and had similar management. They are Haplaquolls and Calciaquolls, respectively. As before, the major difference between these soils is that the Colvin soil contains more calcium carbonates than Perella soils. Organic matter levels were visually estimated based on soil color for all four samples. CCE was determined by weight loss after addition of 6 N HCl to soil samples. Resin extractable phosphorus was determined after 0.5 g of soil was shaken for 24 hours with 0.4 g of Dowex 1 X 8 resin (HCO_3 form) in 30 ml of deionized water and subsequent extraction of the P from the resin by shaking with 0.5 N HCl.

Results. The relationship between calcium carbonate equivalent (CCE) and percent recovery of added P was found to be insignificant (r=-0.025) for 24 alkaline soils. Average percent recovery for the 24 alkaline soils was similar (34.3 %) to the average recovery for the three neutral soils (31.7 %). Recovery values would likely be lower for longer incubation times for both alkaline and neutral soils. There is presently no evidence to suggest that the ratio of the recovery of alkaline soils to the recovery of P in neutral soils would drastically vary with longer incubations that might better approximate field conditions.

Using Table 1, we can compare P retention in Calciaquoll soils to P retention in Haplaquolls. The amount of resin P extracted from the plow layers was greater for the two Calciaquolls than for their landscape associates. The relationship is reversed in Field No. 1 when comparing the amount of extractable P in the B horizon of the Calciaquoll, Hegne, to the B horizon of the noncalcareous Fargo. The B horizons are very low in organic matter. The situation in the B horizons of Field No. 2 is impossible to interpret due to the greater depth of the A horizon in the Perella soil.

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Conclusions. The results from this study indicates that phosphorus retention does not increase with the amount of calcium carbonates present in the soil for western Minnesota surface soils. These soils typically have high organic matter. A possible explanation is that organic matter is coating the carbonates, thereby reducing the adsorptivity of phosphates to the calcite crystals.

Table 1. A comparison of resin extractable phosphorus between Haplaquolls (low CCE) and Calciaquolls (high CCE) that have similar texture and management, Red River Valley.

Soil	Depth (cm)	Horizon	Resin P (ppm)	CCE (%)	OM	Soil	Depth (cm)	Horizon	Resin P (ppm)	CCE (%)	OM
			Field Number 1, Clay County, Minnesota								
Fargo	0-23	AP	110	0	High	Hegne	0-25	AP	115	5	High
sic	23-33	Bg1	23	0	Low	sic	25-33	Bk1	13	26	Low
	33-46	Bg2	12	0	Low		33-46	Bk2	4	28	Low
			Field Number 2, Polk County, Minnesota								
Perella	0-23	AP	23	6	High	Colvin	0-23	AP	37	16	High
sicl	23-35	A12	10	1	High	sicl	23-35	Bk	3	32	Low
	35-46	Bw	3	7	Low						

SULFUR MANAGEMENT FOR CORN PRODUCTION ON IRRIGATED SANDY SOILS

G.W. Rehm, M. O'Leary, G. Cremers, B. Anderson

The importance of sulfur (S) for corn production on sandy soils has been well documented over the past 15-25 years. Both sources and rates of S have been evaluated. In this past research, however, the S fertilizers have been either broadcast and incorporated or applied in the row as a starter fertilizer to the side of and below the seed at planting.

In addition to nitrogen (N), S is also mobile in soils. Considerable research with N has been conducted to define management practices such as frequency with timing of application which should reduce the loss of N due to leaching on sandy soils. Parallel studies to define the best management practices for the use of S fertilizers on these sandy soils have not been initiated.

In Minnesota as well as in other states, rainfall patterns during the early portion of the growing season are such that the potential for loss of both N and S to leaching is high. Research shows that split applications of N will reduce the amount of N lost from these soils. Logic also suggests that split applications of S might also be more beneficial for corn production on these sandy soils. Yet, few if any, studies have been initiated to evaluate the concept of split applications of S. The objective of this study is, therefore, to determine the effect of split applications of fertilizer S on the growth and production of irrigated corn on sandy soils.

Experimental Procedure:

This study was conducted in Benton County in north-central Minnesota. The soil at the experimental site is classified as a Hubbard sandy loam. Appropriate soil properties are listed in Table 1. All treatments received a broadcast application of 250 lb. 0-0-60 per acre which was incorporated before planting.

The S source was 21-0-0-24. Treatments used are listed in Table 2. Corn was planted on May 2. All treatments received a basic starter of 100 lb. of 9-23-30 per acre.

For the treatments involving the preemergence application of S, the 21-0-0-24 was broadcast on the soil surface after planting. The broadcast application was followed immediately by an irrigation to supply .5 in. of water per acre. The 21-0-0-24 was broadcast on the soil surface for the treatments which involved the application of S at the 8-leaf and tassel stages of corn development. These broadcast applications were also followed by an irrigation of .5 in. per acre.

A total of 200 lb. N per acre was applied to all treatments as 46-0-0. The amount of N as 46-0-0 was adjusted to compensate for the N supplied as 21-0-0-24. One half of the total N needed was broadcast immediately after planting. The remainder of the needed N was applied at the 8-leaf stage. Plots were irrigated immediately after these broadcast applications.

Ear leaf samples were collected when 50% of the silks had emerged and analyzed for S. Grain was harvested in mid-October and corrected to 15.5% moisture.

Results and Discussions:

Neither the rate of S applied nor the time of application had a significant effect on grain yield (Table 2). Considering the soil test for S (2.5 ppm) a response to applied S was expected. The 1985 corn crop, however, was apparently able to get adequate S from: 1) the irrigation water, 2) the rainfall, or 3) the release of S from the mineralization of the organic matter.

The yields were not as high as hoped for but 1985 yields were restricted by temperatures which were much below normal.

Both rate of applied S and time of application had a significant effect on the S concentration in the ear leaf tissue. There was no significant interaction between these two variables so main effects will be presented in this report. The S content of the control treatment was .185% and this value

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was significantly lower than the S concentration which resulted from the application of fertilizer S. When averaged over all times of application, the S concentration increased to .216%, .219%, and .224% with rates of 6, 12, and 24 lb.S per acre respectively. The S concentration from the control treatment is considered to be borderline between deficient and adequate. The other values indicate an adequate supply of S for the corn crop.

The effect of time of application on the S concentration in the ear leaf tissue is summarized in Table 3. When averaged over all rates, the lowest concentration resulted from the combination of a starter and tassel application. Split application did not produce a significant increase in the S concentration in the tissue. Although the results of the plant analysis indicate that there is no advantage to a split application, this should be confirmed in yields from a responsive site before a definite conclusion can be made.

Table 1. Selected soil properties for the experimental site.

pH	5.9
P (Bray & Kurtz #1, lb./acre	69
K (1N $NH_4C_2H_3O_2$), lb./acre	264
SO_4-S, ppm	2.5
organic matter, %	2.4
soil texture	sandy loam

Table 2. Effect of rate and time of S application on corn yield and S content of ear leaf tissue.

Treatment N	Total S Applied	Method of Application	Yield	S Content
	lb./acre		bu./acre	%
1	0	---	158.2	.185
2	6	starter	152.2	.213
3	12	starter	154.5	.217
4	24	starter	156.0	.225
5	6	1/2 starter, 1/2 preemerge	151.5	.223
6	12	1/2 starter, 1/2 preemerge	153.3	.226
7	24	1/2 starter, 1/2 preemerge	150.1	.220
8	6	1/2 starter, 1/2 8 leaf stage	151.3	.221
9	12	1/2 starter, 1/2 8 leaf stage	150.3	.228
10	24	1/2 starter, 1/2 8 leaf stage	146.4	.234
11	6	1/2 starter, 1/2 tassel	155.6	.203
12	12	1/2 starter, 1/2 tassel	153.7	.212
13	24	1/2 starter, 1/2 tassel	153.1	.220
14	6	1/3 starter, 1/3 preemerge, 1/3 tassel	152.1	.213
15	12	1/3 starter, 1/3 preemerge, 1/3 tassel	150.4	.223
16	24	1/3 starter, 1/3 preemerge, 1/3 tassel	147.6	.217
17	6	all preemerge	153.4	.225
18	12	all preemerge	157.5	.209
19	24	all preemerge	149.0	.231

THE EFFECT OF SULFUR FERTILIZATION ON YIELD AND QUALITY OF CORN AND ALFALFA

George Rehm, Mike O'Leary, and Neal Martin

The importance of sulfur (S) fertilizers for crop production in Minnesota has been recognized for several years. In past research, the use of S had increased crop production only on the sandy soils. Since the soil organic matter is a major reservior of S for plant use, there is always some question about the need for S in a fertilizer program where soils are not sandy but have a low organic matter content.

It is well known that S is an important component of some amino acids in plants and thus is important in the formation of plant proteins. The percentage of protein in plant material is one measure of the quality of that material for use as an animal feed. In Minnesota, both alfalfa and corn silage are important feed sources for the livestock industry. If the quality of this forage can be improved, this enhances the value of the forage and may result in improved profit from the livestock enterprise.

Although the effect of fertilizer S on the yield of corn and alfalfa has been studied in detail, very little attention has been devoted to the measure of the effect of fertilizer S on the quality of forage crops (alfalfa and corn silage). This report summarizes the initial results of a study designed to measure the effect of fertilizer S on both the yield and quality of corn and alfalfa.

Experimental Procedures:

This study was initialed in the spring of 1984 and continued in 1985. The overall objective was to evaluate the effect of S fertilization on the yield and quality of corn and alfalfa.

For alfalfa, fertilizer S at rates of 25, 50, 75, and 100 lb./acre were broadcast on established stands and these rates were compared to a control treatment. Each year, the study was conducted at a site with a sandy texture as well as a site where the soil had a silt loam texture. For the soils with a silt loam texture, the S was applied where the alfalfa had been manured heavily as well as where the alfalfa had received no manure.

In addition to the S, adequate P, K, and B were broadcast at rates needed to achieve maximum yield. Three cuttings were harvested at the Staples location in 1984. Four cuttings were taken from the Winona and Goodhue County locations. Severe winter kill eliminated harvest from the Staples location in 1985.

Whole plant samples were collected from each plot for each cutting. These samples were analyzed for S as well as quality. The standard NIR procedure was used for quality analysis.

For corn, the study was conducted at a site with a sandy texture as well as a site with a silt loam texture each year. With corn, various rates of S (0, 10, 20, 40 lb./acre) were combined with rates of N (0, 75,150, 225 lb./acre) in a complete factorial design. At the silt loam sites, the S, N, and adequate P and K were broadcast and incorporated before planting. For the sandy sites, the S, P, K and one half of the N were broadcast and incorporated before planting. The remainder of the N was applied at the 12-leaf stage. Management practices needed for production of maximum corn yields were used at all locations.

Ear leaf samples were collected from all plots at silking. These samples were dried, ground, and analyzed for N and S. Total dry weight of the corn was measured at physiological maturity. Samples collected at this growth stage were dried, ground and analyzed for N and S as well as Crude Protein (CP), Acid Detergent Fiber (ADF), and Neutral Detergent Fiber (NDF). Standard NIR procedures were used for measurement of CP, ADF, and NDF. Grain yields were also recorded and corrected to 15.5% moisture.

Soil samples were collected from all sites prior to establishment of the study. Results for the alfalfa and corn sites are summarized in Tables 1 and 2 respectively.

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Table 1. Soil properties (0-6 in.) for experimental sites where fertilizer S was applied to alfalfa.

Soil Property	Site and Year				
	Staples (84)	Winona (84) no manure	Winona (84) manure	Goodhue (85) no manure	Goodhue (85) manure
pH	7.0	6.7	6.6	6.7	6.5
P, lb./acre (Bray & Kurtz #1)	77	26	83	40	71
K, lb./acre (1N NH_4 $C_2H_3O_2$)	152	139	316	312	310
organic matter	med.	low	low	3.1	3.4
SO_4-S, ppm	5	7.5	8	7.5	8.5

Table 2. Soil properties (0-6 in.) for experimental sites where fertilizer S was applied to corn.

Soil Property	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
pH	7.1	6.6	6.5	7.0
P, lb./acre (Bray & Kurtz #1)	91	56	52	147
K, lb./acre (1N NH_4 $C_2H_3O_2$)	178	231	139	402
organic matter	med.	1.6	med.	3.6
SO_4-S, ppm	4	9	2	6

Results and Discussion:

The effects of S fertilization on yield of individual cuttings were similar to effects on total yield. Therefore, total yields are presented in this report (Table 3). Yield was significantly increased by S fertilization at the Staples site in 1984 with 25 lb.S/acre being adequate to produce maximum yield. These results are consistent with results of earlier research when S was applied to alfalfa grown on a sandy soil.

Use of fertilizer S had no significant effect on the yield of alfalfa in Winona County in 1984 and Goodhue County in 1985. It should be pointed out that a previous history of heavy manure use was not reflected in the amount of SO_4-S extracted from the soil by the calcium phosphate procedure (Table 2).

Table 3. Effect of application of fertilizer S on total yield of alfalfa.

S Applied	Site and Year				
	Staples (84)	Winona (84) no manure	Winona (84) manure	Goodhue (85) no manure	Goodhue (84) manure
lb./acre	ton dry matter/acre				
0	3.0	4.2	3.7	5.2	4.9
25	3.7	4.0	3.9	5.4	5.1
50	3.5	4.1	3.8	5.0	5.0
75	3.6	4.2	3.8	5.5	5.0
100	3.5	4.0	3.9	5.3	5.1

Samples collected from each cutting were analyzed for S. The results of this analysis are summarized in Tables 4, 5, and 6. As would be expected, the use of fertilizer S increased the S concentration in the alfalfa tissue at the Staples location (Table 4). In general, the S concentration increased with a S rate of up to 50 lb./acre. Except for the first cutting, the S concentration in alfalfa that received no S was less than .200%. A response to the use of fertilizer S would be expected in this situation.

The use of fertilizer S increased the S concentration in the alfalfa tissue at the Winona County site which received no manure (Table 5). When manure was applied, S concentration in the tissue was not affected by S fertilization. The S concentration in the control treatment, however, was above the critical level for S in alfalfa tissue and no response to fertilizer S would be expected.

Except for the second cutting at the site which was not manured, use of fertilizer S increased the S concentration in the tissue for all cuttings at the Goodhue County site in 1985 (Table 6). The S concentration of the alfalfa taken from the control treatment, however, was not near the critical level. Therefore, no response to fertilizer S would be expected. These data do show that applied S is being absorbed by the alfalfa plant.

Whole plant samples collected from each plot were also analyzed for crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) using standard NIR (Near Infra Red) analytical techniques. These three measurements provide a good estimate of the quality of the forage produced.

The use of fertilizer S did produce a significant increase in the protein content of the first cutting at Staples in 1984. Applied S had no effect on the protein content of tissue taken from the other two cuttings.

The percentage of ADF and NDF was not affected by S fertilization in 1984. It should be noted that the crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) values remained fairly close together for the major portion of the growing season.

Use of fertilizer S had no significant effect on the three quality measurements of alfalfa grown in Winona County in 1984 (Tables 8, 9, 10). Likewise, application of fertilizer S had no effect on the quality of the alfalfa produced at the Goodhue County sites in 1985 (Tables 11, 12, 13). In general, the quality of the 4th cutting was superior to the quality of hay taken from the other three cuttings.

In the 2 years of the study, corn grain yields have been measured at 4 sites (Tables 14, 15). As would be expected, yields increased with rate of applied N. The N rate of 150 lb./acre was satisfactory for highest yield at Staples in both years. Yields at the Goodhue County site in 1984 increased linearly with N rate. In 1985, a rate of 75 lb. N/acre was satisfactory for optimum production. The lower N requirement in 1985 may be attributed to the lower yield caused by drought as well as the release of N from the soil organic matter (3.6%).

Application of fertilizer S increased grain yield at Staples in both 1984 and 1985 (Table 15). A rate of 20 lb. S/acre was needed for maximum production in 1984 while highest yields were produced by the use of 40 lb. S/acre in 1985. The higher rate needed in 1985 can be attributed to heavy rains in late May and early June which may have leached applied S below the root zone. In general, 1985 yields at Staples were reduced by a cool growing season.

Use of fertilizer S had no effect on grain yield at the Goodhue County site in 1985. By contrast, maximum yields were produced by the use of 10 lb.S/acre at the 1984 Goodhue County site. The response of corn to S when grown on sandy soils is consistent with other research; the response on the silt loam soil is not. The response to S at the Goodhue County site in 1984 can be attributed to 1) high yields, 2) the low organic matter content of the soil (1.6%), and 3) heavy rains in late May and early June of 1984.

It is important to note that there was no significant interaction between N and S at all sites. The effects of fertilizer N were independent of the effects of fertilizer S.

Total dry matter production, as would be expected, was influenced by rate of applied N (Table 16). Except for the Staples site in 1985, the use of 150 lb. N/acre produced the highest yield. The 225 lb. N/acre produced the highest yield at the Staples site in 1985.

In contrast to grain yield, use of fertilizer S had no significant effect on total dry matter production measured at physiological maturity (Table 17). As was the case for grain production, there was no significant N by S interaction.

Ear leaf samples were collected from each plot at silking. These tissue samples were analyzed for N and S by standard laboratory procedures and the N/S ratio was computed. As would be expected, the N concentration in the ear leaf tissue was increased by the use of N fertilizer (Table 18). This is consistent with results of previous research.

Except for the Staples location in 1985, the S concentration in the ear leaf tissue was increased by the application of both N and S (Table 19). In general, the highest S concentration was associated with the application of 150 lb. N/acre. The use of 20 lb. S/acre appeared to be adequate in producing the highest S concentration in the tissue.

The S concentration in the ear leaf tissue varied with year and location. It is not possible to define a "critical" value for S in the ear leaf tissue from the data gathered from this study to date.

The N/S ratio was affected by N rate at 3 of the 4 locations (Table 20). Use of fertilizer S significantly reduced the ratio at 2 of the 4 locations. There is some thinking that the N/S ratio should be closely related to yield. In this study, there has been no significant relationship between grain yield and the N/S ratio in the ear leaf at silking (data not shown). Since both N and S are components of protein, it seems logical that the N/S ratio should remain relatively constant. In this study, the ratio varied over a rather wide range for any site.

Whole plant samples were collected when dry matter yields were measured at physiological maturity. These samples were dried, ground, and analyzed for CP, ADF, and NDF by the NIR techniques. The protein content was increased by the use of fertilizer N but the addition of S had no significant effect (Table 21). Except for the Goodhue County site in 1985, the protein content increased as rate of N was increased.

The percentage of ADF was significantly reduced (digestibility increased) by N at 2 of the 4 sites (Table 22). The use of fertilizer S reduced the percentage of ADF at the Goodhue County site in 1984. The importance of this observation must be weighed against similar data which will be collected from other sites in future years.

The percentage of NDF was significantly reduced (intake increased) by fertilizer N at 2 of the 4 sites (Table 23). The application of S reduced this percentage at the Goodhue County site in 1985. This is consistent with the observations for the percentage of ADF and the importance must await similar data collected from additional sites in future years.

Summary:

It is not possible to make concrete conclusions from field data collected in 2 years of research. Nevertheless, there are some general statements that can be made. These are:

1. Use of fertilizer S improved yield of alfalfa grown on a sandy soil but had no significant effect on yield when alfalfa is grown on fine textured soils.

2. The S concentration of the alfalfa tissue increased with rate of applied S. Where there is no response to fertilizer S, the S concentration in the tissue from the control treatment is greater than .200%.

3. Application of S had no consistent effect on the percentage of CP, ADF, and NDF in alfalfa tissue for all cuttings recorded.

4. Use of S increased grain yield of corn. The response at the Goodhue County site in 1984 is of special importance. However, S fertilization had no significant effect on total dry matter produced.

5. The concentration of N in the ear leaf tissue was affected by applied N but not by the rate of S used.

6. The S concentration in the ear leaf tissue was increased by the use of both N and S.

7. The N/S ratio in the ear leaf tissue was not consistently influenced by applied N and S. There was no apparent relationship between N/S ratio and corn yield.

8. The percentage of crude protein in corn tissue at physiological maturity was improved with N but not S fertilization.

9. Neither applied N nor S had a consistent effect on the percentage of both ADF and NDF in the tissue of corn at physiological maturity.

Table 4. Effect of rate of applied S on the S concentration in alfalfa tissue. Staples. 1984.

S Applied	Cutting 1	2	3
lb./acre		% S	
0	.227	.182	.193
25	.279	.268	.260
50	.310	.300	.287
75	.316	.308	.305
100	.328	.327	.297
PR>F	.01	.01	.01
BLSD (.05)	.03	.03	.03
C.V.:	7.7	6.8	7.9

Table 5. Effect of applied S on the S concentration in alfalfa tissue. Winona County, 1984.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	% S			
no manure	0	.244	.266	.306	--
	25	.292	.327	.352	--
	50	.314	.311	.394	--
	75	.336	.330	.404	--
	100	.328	.318	.398	--
	PR>F	.013	.034	.001	--
	BLSD (.05)	.044	.041	.024	--
	C.V.	9.3	8.1	4.5	--
manure	0	.393	.323	.355	.387
	25	.431	.340	.374	.419
	50	.423	.342	.397	.427
	75	.411	.364	.386	.435
	100	.429	.360	.377	.412
	PR>F	.298	.171	.375	.394
	BLSD (.05)	--	--	--	--
	C.V.	5.9	5.3	7.7	7.1

Table 6. Effect of applied S on the S concentration in alfalfa tissue. Goodhue County. 1985.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	% S			
no manure	0	.236	.286	.285	.355
	25	.265	.296	.295	.415
	50	.303	.308	.322	.433
	75	.307	.301	.321	.440
	100	.312	.304	.339	.446
	PR>F	.01	.50	.05	.01
	BLSD (.05)	.028	--	.043	.041
	C.V. %	6.7	5.9	8.0	6.4
manure	0	.261	.277	.278	.363
	25	.315	.301	.285	.421
	50	.342	.317	.322	.442
	75	.337	.313	.329	.429
	100	.349	.328	.313	.449
	PR>F	.01	.01	.07	.04
	BLSD (.05)	.028	.027	.047	.062
	C.V.	6.0	5.6	8.9	8.7

Table 7. Effect of S fertilization on the quality of alfalfa, Staples. 1984.

Component	S Applied	Cutting 1	2	3
	lb./acre		%	
Crude protein	0	20.9	19.7	20.1
Crude protein	25	21.9	20.3	20.1
Crude protein	50	21.6	20.6	20.3
Crude protein	75	21.9	20.7	20.1
Crude protein	100	21.9	20.3	20.4
	PR>F	.08	.76	.88
	BLSD (.05)	.9	--	--
	C.V. %	2.4	5.6	2.9
			%	
ADF	0	32.2	33.0	32.0
ADF	25	31.9	33.1	32.8
ADF	50	31.7	32.0	32.0
ADF	75	31.8	32.2	32.2
ADF	100	32.6	31.9	32.4
	PR>F	.59	.29	.48
	BLSD (.05)	--	--	--
	C.V. %	2.6	3.0	2.1
			%	
NDF	0	47.2	49.3	47.9
NDF	25	46.1	48.6	47.9
NDF	50	46.1	48.2	47.5
NDF	75	45.2	47.6	47.4
NDF	100	46.5	47.6	47.6
	PR>F	.42	.41	.91
	BLSD (.05)	--	--	--
	C.V. %	3.1	2.9	1.9

Table 8. Effect of S fertilization on the crude protein content of alfalfa. Winona County. 1984.

Site	S Applied	Cutting 1	2	3	4
	lb./acre		%		
no manure	0	24.4	21.4	26.3	--
	25	24.2	21.6	25.9	--
	50	24.0	21.1	26.4	--
	75	24.1	21.6	25.7	--
	100	24.1	22.1	25.6	--
	PR>F	.96	.56	.55	--
	BLSD (.05)	--	--	--	--
	C.V.	3.3	3.9	3.1	--
manure	0	24.9	22.0	25.8	26.9
	25	25.7	21.6	25.5	26.8
	50	25.2	22.9	25.7	26.3
	75	25.7	21.9	26.2	26.8
	100	25.8	21.6	26.0	26.9
	PR>F	.73	.70	.94	.94
	BLSD (.05)	--	--	--	--
	C.V.	3.7	5.6	4.4	4.1

Table 9. Effect of S fertilization on the percent ADF for alfalfa. Winona County. 1984.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	% ADF			
no manure	0	30.4	30.6	32.3	--
	25	29.6	30.1	31.3	--
	50	30.2	31.0	31.8	--
	75	29.8	30.2	32.5	--
	100	29.3	29.4	32.2	--
	PR>F	.37	.43	.36	--
	BLSD (.05)	--	--	--	--
	C.V.	3.0	3.8	2.8	--
manure	0	28.8	30.0	29.9	26.5
	25	28.3	30.4	31.2	27.1
	50	28.8	30.6	29.6	26.7
	75	28.7	30.7	31.0	27.8
	100	29.0	30.8	30.0	26.6
	PR>F	.90	.71	.53	.21
	BLSD (.05)	--	--	--	--
	C.V.	2.9	2.6	4.3	2.4

Table 10. Effect of S fertilization on the percent NDF for alfalfa. Winona County. 1984.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	% NDF			
no manure	0	42.1	45.3	43.0	--
	25	42.1	45.5	42.8	--
	50	41.7	46.1	42.4	--
	75	41.2	44.7	43.9	--
	100	41.0	44.0	42.8	--
	PR>F	.77	.35	.37	--
	BLSD (.05)	--	--	--	--
	C.V.	3.6	3.2	2.4	--
manure	0	40.9	43.3	41.6	37.0
	25	40.5	44.8	42.6	37.5
	50	40.6	43.5	40.7	37.1
	75	41.2	45.1	42.3	38.3
	100	40.9	45.3	40.5	36.6
	PR>F	.99	.54	.48	.61
	BLSD (.05)	--	--	--	--
	C.V.	4.7	4.1	3.9	3.5

Table 11. Effect of S fertilization on the crude protein content of alfalfa. Goodhue County. 1985.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	%			
no manure	0	19.6	22.1	21.8	28.3
	25	20.1	21.0	21.9	28.8
	50	20.9	21.8	22.4	28.6
	75	20.8	21.1	22.3	29.5
	100	20.4	21.6	22.2	28.6
	PR>F	.27	.36	.40	.38
	BLSD (.05)	--	--	--	--
	C.V.	3.9	3.3	2.3	3.4
manure	0	21.0	23.1	21.1	28.2
	25	21.5	22.9	21.4	28.9
	50	21.9	22.7	21.5	29.4
	75	21.8	22.8	21.3	28.5
	100	22.0	22.9	21.1	29.1
	PR>F	.67	.99	.99	.63
	BLSD (.05)	--	--	--	--
	C.V.	2.9	4.3	3.5	4.1

Table 12. Effect of S fertilization on the percent ADF for alfalfa. Goodhue County. 1985.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	% ADF			
no manure	0	31.6	31.6	30.7	24.0
	25	31.8	31.9	30.3	22.7
	50	30.0	30.6	28.4	24.2
	75	30.1	32.6	29.3	22.8
	100	31.7	31.9	29.7	23.6
	PR>F	.20	.59	.27	.53
	BLSD (.05)	--	--	--	--
	C.V.	4.1	4.1	4.0	7.1
manure	0	29.9	28.8	31.1	24.5
	25	29.1	28.6	30.4	23.9
	50	29.1	29.6	30.9	23.4
	75	28.9	29.2	30.2	24.3
	100	28.3	29.3	31.5	23.6
	PR>F	.23	.86	.51	.85
	BLSD (.05)	--	--	--	--
	C.V.	4.2	4.6	3.1	5.9

Table 13. Effect of S fertilization on the percent NDF for alfalfa. Goodhue County. 1985.

Site	S Applied	Cutting 1	2	3	4
	lb./acre	% NDF			
no manure	0	42.2	40.4	39.2	32.6
	25	41.6	40.9	38.5	31.7
	50	39.4	39.6	37.0	32.7
	75	39.7	41.5	37.3	30.7
	100	40.7	41.1	38.0	32.3
	PR>F	.13	.43	.37	.75
	BLSD (.05)	--	--	--	--
	C.V.	3.7	3.6	4.0	6.2
manure	0	38.6	36.1	38.8	32.3
	25	37.4	36.2	38.7	31.0
	50	37.1	36.7	38.8	31.1
	75	37.0	37.6	39.4	31.8
	100	36.8	36.7	39.7	32.1
	PR>F	.01	.93	.91	.90
	BLSD (.05)	--	--	--	--
	C.V.	3.4	5.3	3.7	6.5

Table 14. Effect of rate of applied N on grain yield of corn.

N Applied	Site and Year Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
lb./acre	bu./acre			
0	78.9	118.2	45.4	108.9
75	136.4	172.2	87.8	125.5
150	150.5	177.5	121.2	127.8
225	155.3	187.5	118.9	128.2
PR>F	.01	.01	.01	.99
BLSD (.05)	10.0	6.7	10.4	6.7
C.V., %	12.1	6.5	11.1	8.3

Table 15. Effect of rate of applied S on grain yield of corn.

N Applied	Site and Year Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
lb./acre	bu./acre			
0	122.4	154.7	89.9	119.9
10	132.4	166.7	89.8	120.6
20	137.8	165.3	91.6	126.6
40	128.6	168.9	102.0	123.3
PR>F	.06	.01	.11	.26
BLSD (.05)	12.7	7.5	13.3	--
C.V., %	12.1	6.5	11.1	8.3

Table 16. Effect of rate of applied N on the dry matter produced by corn.

N Applied	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
lb./acre	ton D.M./acre			
0	4.24	5.28	2.38	5.16
75	5.95	6.94	4.69	4.89
150	6.48	7.46	5.14	6.26
225	6.13	7.14	5.58	6.18
PR>F	.01	.01	.01	.01
BLSD (.05)	.38	.45	.51	.29
C.V., %	10.6	10.4	11.8	7.7

Table 17. Effect of rate of applied S on the dry matter produced by corn.

S Applied	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
lb./acre	ton D.M./acre			
0	5.38	6.73	4.19	5.84
10	5.80	6.64	4.58	5.90
20	5.83	6.49	4.44	5.83
40	5.78	6.96	4.57	5.92
PR>F	.13	.31	.44	.93
BLSD (.05)	--	--	--	--
C.V., %	10.6	10.4	11.8	7.7

Table 18. Effect of rate of applied N and S on the N concentration in the ear leaf at silking.

N Applied	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
lb./acre	% N			
0	1.73	2.14	1.72	2.07
75	2.74	2.72	2.57	2.38
150	2.77	2.93	3.21	2.38
225	2.84	2.95	3.37	2.23
PR>F	.01	.01	.01	.01
BLSD (.05)	.17	.12	.46	.15
S Applied:				
lb./acre	% N			
0	2.38	2.66	2.61	2.18
10	2.56	2.63	2.75	2.31
20	2.59	2.68	2.70	2.26
40	2.56	2.77	2.80	2.32
PR>F	.13	.21	.86	.30
BLSD (.05)	--	--	--	--
C.V., %	10.8	7.2	17.0	9.9

Table 19. Effect of rate of applied N and S on the S concentration in the ear leaf at silking.

N Applied	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
Lb./acre	% S			
0	.141	.171	.162	.167
75	.191	.211	.225	.186
150	.203	.235	.250	.193
225	.202	.229	.278	.197
PR>F	.01	.01	.01	.01
BLSD (.05)	.01	.01	.02	.006
S Applied:				
Lb./acre	% S			
0	.161	.202	.232	.180
10	.184	.203	.217	.188
20	.198	.215	.228	.186
40	.194	.226	.237	.188
PR>F	.01	.01	.32	.07
BLSD (.05)	.014	.010	--	.007
C.V., %	11.4	7.4	9.0	4.8

Table 20. Effect of rate of applied N and S on the N/S ratio in the ear leaf at silking.

N Applied	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
Lb./acre	N/S Ratio			
0	12.2	12.6	10.5	12.4
75	14.4	12.9	11.4	12.8
150	13.8	12.5	12.9	12.4
225	14.2	13.0	12.2	11.4
PR>F	.01	.34	.07	.01
BLSD (.05)	.7	--	2.0	.9
S Applied:				
Lb./acre	N/S Ratio			
0	14.7	13.3	11.1	12.1
10	13.8	13.0	12.5	12.3
20	13.1	12.4	11.8	12.1
40	13.0	12.3	11.6	12.4
PR>F	.01	.02	.45	.90
BLSD (.05)	.8	.7	--	--
C.V., %	8.2	7.3	14.2	10.0

Table 21. Effect of rate of applied N and S on the percentage of crude protein in corn at physiological maturity.

N Applied	Staples (84)	Goodhue (84)	Site and Year Staples (85)	Goodhue (85)
lb./acre	% CP			
0	5.58	6.26	7.56	7.78
75	6.88	7.29	7.74	9.44
150	7.87	7.80	8.58	9.46
225	8.05	8.21	9.32	9.42
PR>F	.01	.01	.01	.01
BLSD (.05)	.37	.27	.58	.47
S Applied:				
lb./acre	% CP			
0	7.05	7.38	8.72	8.97
10	7.10	7.25	8.40	9.18
20	7.23	7.53	8.15	8.95
40	7.00	7.40	7.93	9.00
PR>F	.81	.34	.08	.81
BLSD (.05)	--	--	--	--
C.V., %	8.3	5.8	6.9	8.1

Table 22. Effect of rate of applied N and S on the ADF percentage in corn at physiological maturity.

N Applied	Staples (84)	Goodhue (84)	Site and Year Staples (85)	Goodhue (85)
lb./acre	% ADF			
0	31.2	28.5	30.2	25.8
75	28.3	26.5	28.5	21.5
150	27.9	27.5	27.3	23.0
225	26.7	26.1	26.3	24.8
PR>F	.01	.19	.29	.04
BLSD (.05)	1.7	--	--	3.5
S Applied:				
lb./acre	% ADF			
0	27.4	28.0	27.0	24.8
10	28.8	28.3	27.1	23.4
20	28.3	25.2	28.1	23.7
40	29.5	27.1	30.1	23.3
PR>F	.12	.05	.42	.76
BLSD (.05)	--	2.6	--	--
C.V., %	8.8	12.3	14.4	18.6

Table 23. Effect of rate of applied N and S on the NDF percentage in corn at physiological maturity.

N Applied	Site and Year			
	Staples (84)	Goodhue (84)	Staples (85)	Goodhue (85)
Lb./acre	% NDF			
0	48.9	42.1	45.1	40.8
75	45.6	40.4	44.9	36.0
150	45.3	41.9	43.5	38.0
225	44.1	40.0	42.2	39.9
PR>F	.01	.37	.61	.07
BLSD (.05)	2.2	--	--	4.4
S Applied:				
Lb./acre	% NDF			
0	44.5	42.0	42.5	39.8
10	46.3	42.5	43.1	38.3
20	46.2	38.7	43.8	38.6
40	47.1	41.2	46.2	38.0
PR>F	.14	.05	.46	.80
BLSD (.05)	--	3.2	--	--
C.V., %	6.9	9.7	43.9	13.8

PLACEMENT OF NITROGEN SOLUTIONS UNDER DIFFERING TILLAGE SYSTEMS

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The use of 28% N solution (UAN) for corn production has increased over the last several years in Minnesota. The popularity of this product stems at least partially because of its handling characteristics and its convenience as a carrier for herbicide applications. With the increasing emphasis on conservation tillage increased concerns are being expressed related to placement and/or management of UAN. These concerns are related to the potential volatilization losses or immobilization of N that may take place if applied to soils with high surface residues (conservation tillage). The objectives of these experiments were therefore to: (1) evaluate surface vs. injected applications of UAN under different tillage systems, and (2) with surface applications of UAN compare uniform broadcast applications to surface dribble applications under different tillage systems.

MATERIALS, METHODS, AND OBSERVATIONS

Experimental sites - Experiments were conducted in 1984 and 1985 at two locations. One location was in East Central (EC) Minnesota at the University of Minnesota Sand Plains Research Farm near Becker, Minnesota. The second location was in South Eastern (SE) Minnesota on a producers field in Goodhue County. The soils at the EC location are formed from glacial outwash and are deep, coarse textured, and contain medium to high levels of organic matter. The soils are classified as a Hubbard loamy sand (Udorthentic Haploboroll) and because of their coarse texture and low water holding capacity must be irrigated to attain high production levels. The soils at the SE location are loess derived silt loam soils classified as either Seaton (Typic Hapludalfs) or Mt. Carroll (Mollic Hapludalfs).

Experimental treatments - The treatment combinations at each location were a complete factorial arrangement of either four (EC) or three (SE) tillage treatments at three nitrogen (75, 150 and 300 # N/A), with three method of UAN application (broadcast, injected, or surface dribble). The 44 treatments established at the EC location consisted of four tillage systems (no till, ridge till, chisel, and moldboard plow) with all three methods of UAN application, plus two control treatments (zero N) for each tillage system. The two control treatments were included to determine the effect of the injection procedure across tillage systems. The 33 treatments established at the SE location were set up in an identical manner except that only three tillage systems were investigated. No moldboard plow treatment was included because this is no longer a recommended tillage practice in this area. All treatments were replicated four times utilizing a split-split plot design. The main plots were tillage with the first sub-plots being nitrogen rate and the second sub-plot being method of application. The smallest experimental sub-units were 14.7 ft. (4 rows) wide 50 ft. long.

Cultural practices - A summary of the management practices utilized at each location are summarized in Table 1.

Surface residue cover - Tillage practices can have a considerable impact on the amount of crop residue remaining on the soil surface. The amount of residue on the surface may likewise influence many other parameters and processes including soil temperature, soil moisture, mineralization rate, nitrification rate, potential for surface volatilization of urea as well as leaching and/or denitrification processes. Surface residue cover observed in 1984 and 1985.

Please refer to title page of this publication for information regarding application and use of this article.

1984 and 1985 cover*

Location	Tillage	In Row 1984	In Row 1985	Between Rows 1984	Between Rows 1985
Becker (EC)	Moldboard	3.5 (4.6)	1.5 (2.47)	2.5 (3.5)	1.0 (1.79)
(6/27/84)	Chisel	25.0 (13.7)	18.0 (13.3)	41.3 (17.4)	21.2 (11.7)
(5/30/85)	Ridge till	16.7 (12.4)	10.5 (6.0)	32.0 (14.5)	28.2 (11.5)
	No till	64.0 (17.9)	53.7 (20.0)	73.0 (14.6)	53.7 (12.7)
Goodhue Co. (SE)	Chisel	16.8 (11.0)	29.2 (17.8)	23.8 (11.1)	28.2 (19.1)
(6/19/84)	Ridge till	10.0 (7.9)	11.7 (8.6)	31.8 (14.3)	53.7 (6.3)
(6/4/85)	No till	77.8 (17.2)	71.7 (21.2)	65.5 (15.3)	76.0 (9.8)

* In the row = an 8 inch area centered over the row and between is the remainder. The number in parentheses is the standard deviation.

With moldboard tillage there was very little residue remaining on the soil surface in 1984 and 1985. The chisel plow treatment left 15-41% surface cover with the EC (Becker) location having slightly more residue cover. The ridge till was almost the same at both locations but there was more cover at the (SE) Goodhue location between rows in 1985 than 1984. As would be expected the no till areas had the highest residue cover ranging from 53-78% of the soil surface.

Grain yields and N utilization - Leaf samples from opposite and below the ear at mid-silking were collected on July 23 at the EC location and on July 26 at the SE location. All leaf samples were dried, ground, and analyzed for Kjeldahl N. Total dry matter production was determined on Sept. 24 and 25 at the EC location and at the SE location on Oct. 2, 3, and 7. At each location ears were separated from 40 ft. of row, field weights obtained, and subsamples collected for moisture analysis and N determination. Grain yields were adjusted to 15.5% moisture. Stover yields were obtained by removing the above ground plant material in the same 40 ft. row. Subsamples were also collected for moisture determination and N analysis.

RESULTS AND DISCUSSION - EC LOCATION - BECKER, MN

A summary of the crop yield components and N utilization components for 1984, 1985 and a two year average are presented in Tables 2 - 5. Treatment variables were evaluated utilizing analysis of variance. Treatment means are reported for individual treatments and statistically analyzed as factorial combinations in a split-split block design. Where appropriate a BLSD (0.5) was computed to compare treatment means. Analysis of variance was also computed for the two year average. Since the year term was expected to be significant with most observations, but in general meaningless for treatment comparisons, the probability levels for year terms have not been reported.

The grain yields obtained and response to nitrogen/tillage treatments were excellent in both 1984 and 1985. Yields obtained in 1985 from the better treatments (185 bu/A) and low yielding treatments (35 bu/A) were similar to those obtained in 1984. Significant leaching losses of nitrate-N was experienced in 1984, while minimal leaching was experienced in 1985. This led to treatment means and main effects that were higher in 1985 than in 1984. Although the grain yields from specific treatments were higher in 1985 than 1984, the relative differences between treatments (tillage, method of placement, and N rate) followed the same general trends as those observed in 1984.

Grain yields were significantly influenced by all main treatment effects (tillage, N rate, and method of application). Significant two-way interactions obtained in both years suggest that method and rate of N application did not provide similar responses under different tillage systems. Since the trends for 1984 and 1985 were similar, discussion will be concentrated with the two-year average.

The N-rate x tillage interaction indicated that at the lowest N-rate (75 # N/A) only modest differences were observed between tillage systems (although no till had the lowest yield). As N-rate increased differences in N response across tillage systems became more apparent. At the highest N rate (300 # N/A) no till was clearly inferior to the other tillage systems, while moldboard plow provided the highest yields. Averaged over two years at the highest N rate, moldboard plow was 53 bu/A better than no till, 18 bu/A better than ridge till, and 10 bu/A better than chisel plow.

The most efficient method of UAN placement was highly dependent on tillage system (tillage x method interaction). On moldboard plow treatment where residue cover was minimal, method of placement had no influence on yield. Method of UAN placement had similar effects on the chisel and ridge-till tillage systems. Injected treatments were 10-14 bu/A higher than dribble which were in turn 10-14 bu/A better than broadcast treatments. Injected treatments were clearly superior with no till (high residue cover). Surface dribble treatments on no till were intermediated, but 29 bu/A lower than injected while broadcast treatments were 25 bu/A lower than dribble treatments. This would suggest that as surface residue covers increase, injection of UAN would become the most efficient method of application. Although a significant N-rate x method of application interaction existed, the practical significance would suggest that as N-rate increased to higher than "adequate" levels, differences between methods of application were not as clearly defined.

Stover yields and N utilization characteristics followed the same trends as those that were observed with grain yield.

RESULTS AND DISCUSSION - SE LOCATION - GOODHUE CO.

A summary of the crop yield components, and nitrogen utilization characteristics similar to the previous experiments are presented in Tables 6-9. The experimental design and treatments were identical in both experiments except only three tillage treatments were evaluated at this location.

The yields obtained in 1985 were slightly below those that were obtained in 1984, but were good considering the extremely dry conditions that were experienced early in the growing season at this location. The dry conditions also magnified problems with plant population, weed control, and cut worms, especially on the no till treatments. Because of these confounding factors, no till treatments performed very poorly compared to other treatments and several treatments were discarded.

Although yields from the no till treatments were considerably lower than the other tillage systems, overall trends in 1985 were similar to those established in 1984. Yields from the two-year average indicated that ridge till and chisel produced similar yields while no till had significantly lower yield during both years. Optimum nitrogen rate was around 150 # N/A, but method of application interacted with N rate. This interaction indicated that at the low N rates when surface residue was present, surface applications of UAN were inferior to injected treatments. As nitrogen rates increased or as surface residue decreased, differences between methods of application narrowed.

GENERAL CONCLUSIONS

The results at this location in 1984 and 1985 followed the same general trends. These general trends would suggest that as surface residue cover increases, surface applications become less efficient. Although concentrating the surface application into a dribble application improved the efficiency over broadcasting, it was never as efficient as injection. If surface residue was not present there was little difference between methods of application.

Although the trends were the same at both locations, the magnitude of differences were substantial across locations. The coarse textured irrigated soil exhibited relatively large differences between treatments while the non-irrigated silt loam soil had relatively modest differences. Part of this may be explained on the basis that the coarse textured soil, because of the soil and irrigation, is much more responsive to N fertilizer (140-150 Bu/A) than the silt loam soil (60-70 Bu/A). This may tend to magnify differences. The corn residue (stover) at the Becker location (coarse textured soil) had a much lower concentration of N than the stover samples at the site with the silt loam soil. Although this aspect was not investigated in depth, immobilization of nitrogen by the residue at the site with the coarse-textures soil may have been a more dominant factor than at the silt loam location thus magnifying differences especially with surface applications.

Table 1. Management practices utilized at the Becker (EC) and Goodhue (SE) experimental locations.

Management Practice	EC (Becker)	Date	SE (Goodhue)	Date
Tillage	Moldboad plow & plowpacker	4/5		
	Chisel	4/29		5/7
	Ridge Till	6/24		6/29
	Culitivation	----		----
Planting Date[1]	No Till	5/7		5/7
Corn Variety	Pionner 3906		Pionner 3906	
Seeding Rates	29,580 seeds/A		28,000 seeds/A	
Row spacing	30 inches		38 inches	
Fertilizer treatments application		5/7		5/9
Starter Fertilizer	150#/A 8-10-30		14gal/A 7-21-7	
Other Fertilizer	235#/A 0-0-22	4/1		
	250#/A 1-14-42	4/1		
Insecticide			Counter 15g 6#/A	
Herbicide[2]	Atrazine 2#/A	5/3	Lasso 2.5#/A	5/7
	Dual AE 1.5 pint/A	5/3	Round Up 1 qt/A	5/7
	Round Up 1 qt./A	5/3	Atrazine 2#/A	5/7
	Atrazine 2#/A + oil	5/30	Butril 1 pint/A	6/14
Irrigation	0.90 inches	June		
	5.90 inches	July		
	0.60 inches	August		

1 At the EC location the ridge till treatments were planted with a Buffalo till planter (disc trash cleaners) and a white (12 inch fluted coulter). At the SE location a Hiniker planter was used for all treatments (trash discs were raised for no till and chisel treatments).

2 Weed control was obtained at each location but giant foxtail was a problem on the no till plots at each location we had to throw some treatments out at the SE location because the weeds were so bad in 1985.

Table 2. Influence of nitrogen rates, tillage systems, and methods of 28% N application on grain yields and % dry matter of the grain for 1984 and 1985 on irrigated corn. Becker, MN 84-85.

Treatments			Grain Yields			Dry Matter Grain		
N-Rate	Tillage System	Method Applied	1984	1985	Ave.	1984	1985	Ave.
#/A				Bu/A			%	
Control	No Till	---------	45.5	35.6	40.6	62.9	65.0	64.0
Control-Knife	No Till	---------	44.5	35.1	39.8	60.7	64.0	62.4
Control	Ridge Till	---------	50.9	34.6	42.7	65.1	66.0	65.6
Control-Knife	Ridge Till	---------	52.4	36.2	44.3	65.2	67.0	66.1
HHLtrol	Chisel	---------	55.2	46.0	50.6	65.8	64.0	64.9
Control-Knife	Chisel	---------	59.5	41.2	50.3	68.0	62.0	65.0
Control	Moldboard	---------	47.9	36.1	42.0	63.1	63.0	63.1
Control-Knife	Moldboard	---------	55.9	47.0	51.5	63.2	62.0	62.6
75	No Till	Broadcast	41.0	47.9	44.5	61.8	63.0	62.4
75	No Till	Injected	76.1	77.8	77.0	60.2	61.0	60.6
75	No Till	Dribble	49.9	57.7	53.8	61.9	63.0	62.5
75	Ridge Till	Broadcast	57.7	69.0	63.4	68.9	65.0	67.0
75	Ridge Till	Injected	80.6	68.0	74.3	66.4	63.0	64.7
75	Ridge Till	Dribble	64.6	74.1	69.4	69.2	63.0	66.1
75	Chisel	Broadcast	65.6	90.9	78.3	66.3	63.0	64.7
75	Chisel	Injected	83.3	98.3	90.8	67.3	64.0	65.7
75	chisel	Dribble	76.0	96.5	86.3	67.3	62.0	64.7
75	Moldboard	Broadcast	65.9	81.4	73.9	67.3	63.0	65.2
75	Moldboard	Injected	61.8	75.7	68.8	65.2	62.0	63.6
75	Moldboard	Dribble	69.4	70.1	69.8	66.8	63.0	64.9
150	No Till	Broadcast	42.7	91.8	67.3	59.3	60.0	59.7
150	No Till	Injected	109.5	125.4	117.4	60.5	58.0	59.3
150	No Till	Dribble	50.7	80.1	65.4	61.1	61.1	61.1
150	Ridge Till	Broadcast	74.6	134.3	104.5	67.6	62.0	64.8
150	Ridge Till	Injected	128.5	144.6	136.6	66.3	62.0	64.2
150	Ridge Till	Dribble	83.0	126.5	104.8	67.7	62.0	64.9
150	Chisel	Broadcast	90.9	123.3	107.1	65.3	60.0	62.7
150	Chisel	Injected	142.6	144.0	143.3	64.4	60.2	62.2
150	Chisel	Dribble	101.3	135.2	118.3	67.0	61.0	64.0
150	Moldboard	Broadcast	137.2	149.9	143.6	68.1	62.0	65.1
150	Moldboard	Injected	135.7	150.6	143.2	67.0	63.0	65.0
150	Moldboard	Dribble	105.8	156.3	131.1	68.2	63.0	65.6
300	No Till	Broadcast	53.0	94.0	73.5	59.4	57.0	58.2
300	No Till	Injected	154.9	148.1	151.5	59.3	57.0	58.2
300	No Till	Dribble	137.9	139.8	138.9	60.5	58.0	59.3
300	Ridge Till	Broadcast	125.5	146.9	136.2	65.7	59.0	62.4
300	Ridge Till	Injected	176.8	158.8	167.8	64.9	60.0	62.5
300	Ridge Till	Dribble	165.4	160.1	162.8	66.0	61.0	63.5
300	Chisel	Broadcast	134.8	159.4	147.1	64.3	61.0	62.7
300	Chisel	Injected	181.8	168.2	175.0	63.7	61.0	62.4
300	Chisel	Dribble	160.2	178.1	169.2	64.4	61.0	62.7
300	Moldboard	Broadcast	155.2	178.2	166.7	66.4	62.0	64.2
300	Moldboard	Injected	170.6	183.5	175.8	65.1	62.0	63.6
300	Moldboard	Dribble	173.3	185.6	179.5	60.7	63.0	61.9

Table 3. Influence of nitrogen rates, tillage systems, and methods of 28% N application on dry matter production on irrigated corn. Becker, MN - 1984 and 1985.

Treatments			Dry Matter Production								
	Tillage	Method	Grain			Stover			Total		
N-Rate	System	Applied	1984	1985	Ave.	1984	1985	Ave.	1984	1985	Ave.
#/A			T/A								
Control	No Till	---------	1.07	0.84	0.96	0.98	1.15	1.07	2.06	2.00	2.03
Control-Knife	No Till	---------	1.05	0.83	0.94	1.04	1.27	1.16	2.09	2.11	2.10
Control	Ridge Till	---------	1.20	0.82	1.01	0.91	1.24	1.08	2.11	2.06	2.09
Control-Knife	Ridge Till	---------	1.24	0.86	1.05	0.94	1.23	1.09	2.18	2.09	2.14
Control	Chisel	---------	1.30	1.09	1.02	1.05	1.41	1.23	2.35	2.50	2.43
Control-Knife	Chisel	---------	1.40	0.98	1.19	1.16	1.62	1.39	2.57	2.60	2.59
Control	Moldboard	---------	1.13	0.86	1.00	0.92	1.19	1.06	2.06	2.05	2.06
Control-Knife	Moldboard	---------	1.32	1.11	1.22	1.11	1.48	1.30	2.44	2.59	2.52
75	No Till	Broadcast	0.97	1.13	1.05	1.05	1.84	1.45	2.02	2.97	2.50
75	No Till	Injected	1.80	1.84	1.82	1.86	2.21	2.04	3.66	4.05	3.86
75	No Till	Dribble	1.18	1.37	1.28	1.28	1.69	1.49	2.46	3.06	2.76
75	Ridge Till	Broadcast	1.36	1.63	1.50	1.07	2.00	1.54	2.43	3.63	3.03
75	Ridge Till	Injected	1.90	1.61	1.76	1.68	1.89	1.79	3.59	3.50	3.55
75	Ridge Till	Dribble	1.53	1.75	1.64	1.15	2.07	1.61	2.68	3.82	3.25
75	Chisel	Broadcast	1.55	2.15	1.85	1.77	2.75	2.26	3.32	4.90	4.11
75	Chisel	Injected	1.97	2.33	2.15	2.11	2.47	2.29	4.08	4.79	4.44
75	chisel	Dribble	1.79	2.28	2.04	1.81	2.53	2.17	3.61	4.81	4.21
75	Moldboard	Broadcast	1.56	1.94	1.75	1.47	2.38	1.93	3.03	4.31	3.67
75	Moldboard	Injected	1.46	1.79	1.63	1.44	2.25	1.85	2.90	4.04	3.47
75	Moldboard	Dribble	1.64	1.66	1.65	1.51	2.33	1.92	3.15	3.99	3.57
150	No Till	Broadcast	1.01	2.17	1.59	1.24	2.28	1.76	2.25	4.45	3.35
150	No Till	Injected	2.59	2.97	2.78	2.27	2.61	2.44	4.86	5.58	5.22
150	No Till	Dribble	1.20	1.90	1.55	1.35	1.93	1.64	2.55	3.83	3.19
150	Ridge Till	Broadcast	1.76	3.18	2.47	1.64	3.05	2.35	3.40	6.23	4.82
150	Ridge Till	Injected	3.04	3.42	3.23	2.28	3.14	2.71	5.32	6.56	5.94
150	Ridge Till	Dribble	1.96	3.00	2.48	1.81	2.99	2.40	3.78	5.99	4.89
150	Chisel	Broadcast	2.15	2.92	2.54	2.26	2.95	2.61	4.42	5.87	5.15
150	Chisel	Injected	3.37	3.41	3.39	2.78	3.05	2.92	6.16	6.45	6.31
150	Chisel	Dribble	2.39	3.20	2.80	2.31	3.09	2.70	4.71	6.29	5.50
150	Moldboard	Broadcast	3.24	3.55	3.40	2.72	3.22	2.97	5.97	6.76	6.37
150	Moldboard	Injected	3.21	3.56	3.39	2.61	3.20	2.91	5.82	6.76	6.29
150	Moldboard	Dribble	2.50	3.70	3.10	2.27	3.13	2.70	4.78	6.83	5.81
300	No Till	Broadcast	1.25	2.22	1.74	1.81	2.55	2.18	3.06	4.77	3.92
300	No Till	Injected	3.66	3.51	3.59	2.80	2.82	2.81	6.46	6.32	6.39
300	No Till	Dribble	3.26	3.31	3.29	2.64	2.74	2.69	5.91	6.05	5.98
300	Ridge Till	Broadcast	2.96	3.48	3.22	2.48	2.77	2.63	5.45	6.25	5.85
300	Ridge Till	Injected	4.18	3.76	3.97	2.90	2.91	2.91	7.09	6.67	6.88
300	Ridge Till	Dribble	3.91	3.79	3.85	2.96	3.05	3.01	6.88	6.84	6.86
300	Chisel	Broadcast	3.19	3.77	3.48	2.69	3.21	2.95	5.88	6.98	6.43
300	Chisel	Injected	4.30	3.98	4.14	3.44	3.49	3.47	7.74	7.47	7.61
300	Chisel	Dribble	3.79	4.21	4.00	3.28	3.35	3.32	7.07	7.57	7.32
300	Moldboard	Broadcast	3.67	4.22	3.95	2.82	3.74	3.28	6.50	7.96	7.23
300	Moldboard	Injected	4.03	4.34	4.19	3.02	3.61	3.32	7.06	7.95	7.51
300	Moldboard	Dribble	4.10	4.39	4.25	3.08	3.69	3.39	7.18	8.08	7.63

Table 2. Continued

Treatments Tillage System	Grain Yields 1984	1985	Ave.	Dry Matter Grain 1984	1985	Ave.
		Bu/A			-%-	
Factorial Arrangement (Excludes Controls)						
Tillage						
No Till	79.5	95.8	87.6	60.5	59.0	59.7
Ridge Till	106.3	120.3	113.3	67.0	61.0	64.0
Chisel	115.2	132.6	123.9	65.1	61.0	63.0
Moldboard	119.4	136.8	128.1	66.9	62.0	64.4
P-Value (%)	99	99	99	99	99	99
BLSD (.05)				1.6		
N-Rate						
75	66.0	75.6	70.8	65.7	62.0	63.8
150	100.2	130.2	115.2	65.2	61.0	63.1
300	149.1	158.4	153.7	64.0	60.0	62.0
P-Value (%)	99	99	99	99	99	99
BLSD (.05)				0.9		
Method Applied						
Broadcast	87.0	113.9	100.4	65.0	61.0	63.0
Injected	125.2	128.6	126.9	64.2	61.0	62.6
Dribble	103.1	121.7	112.4	65.6	61.0	63.3
P-Value (%)	99	99	99	99	89	99
BLSD (.05)				0.8		
Tillage X N-Rate	99	99	99	76	99	94
Tillage X Method	99	99	99	18	25	3
N-Rate X Method	99	99	99	7	47	25
Tillage X N-Rate X Method	94	62	87	10	13	13

Table 3. Continued

Treatments Tillage System	Grain 1984	1985	Ave.	Dry Matter Production Stover 1984	1985	Ave.	Total 1984	1985	Ave.
					T/A				
Factorial Arrangement (Excludes Controls)									
Tillage									
No Till	1.88	2.26	2.07	1.81	2.29	20.5	3.69	4.56	4.12
Ridge Till	2.51	2.84	2.67	2.00	2.65	2.32	4.51	5.49	5.00
Chisel	2.72	3.13	2.92	2.49	2.98	2.73	5.22	6.12	5.67
Moldboard	2.82	3.23	3.02	2.33	3.06	2.69	5.15	6.29	5.72
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)									
N-Rate									
75	1.56	1.79	1.69	1.52	2.19	1.85	3.08	3.98	3.53
150	2.37	3.08	2.72	2.13	2.88	2.50	4.50	5.96	5.23
300	3.52	3.74	3.63	2.83	3.16	2.99	6.36	6.90	6.63
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)									
Method									
Broadcast	2.05	2.69	2.37	1.92	2.72	2.32	3.98	5.42	4.70
Injected	2.96	3.04	3.00	2.43	2.88	2.65	5.39	5.84	5.61
Dribble	2.44	2.87	2.65	2.12	2.71	2.41	4.56	5.59	5.07
P-Value (%)	99	99	99	99	59	99	99	99	99
BLSD (.05)									
Tillage X Rate	99	99	99	85	99	98	98	99	99
Tillage X Method	99	99	99	99	85	99	99	99	99
N-Rate X Method	99	98	99	99	55	98	99	93	99
Tillage X N-Rate X Method	99	62	84	17	9	7	57	31	25

Table 4. Influence of nitrogen rates, tillage systems and methods of 28% N application, on leaf, stover and grain N concentration on irrigated corn. Becker, MN - 1984 and 1985.

Treatments			N-Concentration								
	Tillage	Method	Leaf			Stover			Grain		
N-Rate	System	Applied	1984	1985	Ave.	1984	1985	Ave.	1984	1985	Ave.
#/A			%								
Control	No Till	---------	1.38	1.11	1.25	0.47	0.42	0.45	1.03	0.84	0.94
Control-Knife	No Till	---------	1.26	1.10	1.18	0.44	0.37	0.41	1.14	0.95	1.05
Control	Ridge Till	---------	1.35	1.01	1.18	0.40	0.39	0.40	1.19	0.93	1.06
Control-Knife	Ridge Till	---------	1.32	1.05	1.19	0.43	0.41	0.42	1.14	0.99	1.07
Control	Chisel	---------	1.22	1.09	1.16	0.45	0.47	0.46	1.19	0.90	1.05
Control-Knife	Chisel	---------	1.15	1.30	1.23	0.44	0.48	0.46	1.12	1.10	1.11
Control	Moldboard	---------	1.22	1.06	1.14	0.45	0.43	0.44	1.11	0.92	1.02
Control-Knife	Moldboard	---------	1.18	1.10	1.14	0.42	0.42	0.42	1.12	0.89	1.10
75	No Till	Broadcast	1.23	1.39	1.31	0.42	0.43	0.43	1.10	0.88	0.99
75	No Till	Injected	1.78	1.81	1.80	0.46	0.50	0.48	1.05	0.84	0.95
75	No Till	Dribble	1.30	1.51	1.41	0.39	0.44	0.42	1.14	0.79	0.97
75	Ridge Till	Broadcast	1.24	1.59	1.42	0.36	0.45	0.41	1.23	0.96	1.10
75	Ridge Till	Injected	1.65	1.59	1.62	0.46	0.39	0.43	1.10	0.90	1.00
75	Ridge Till	Dribble	1.17	1.68	1.43	0.46	0.47	0.47	1.27	0.96	1.12
75	Chisel	Broadcast	1.29	1.89	1.59	0.41	0.45	0.43	1.07	0.91	0.99
75	Chisel	Injected	1.54	2.06	1.80	0.40	0.47	0.44	1.17	0.87	1.02
75	Chisel	Dribble	1.25	2.01	1.63	0.42	0.46	0.44	1.15	0.93	1.04
75	Moldboard	Broadcast	1.18	1.80	1.49	0.41	0.48	0.45	1.23	1.08	1.16
75	Moldboard	Injected	1.43	1.62	1.53	0.44	0.46	0.45	1.16	0.96	1.06
75	Moldboard	Dribble	1.26	1.84	1.55	0.39	0.46	0.43	1.23	0.95	1.09
150	No Till	Broadcast	1.18	2.15	1.67	0.44	0.50	0.47	1.13	1.09	1.11
150	No Till	Injected	2.35	2.80	2.58	0.47	0.59	0.53	1.22	0.96	1.09
150	No Till	Dribble	1.31	1.65	1.48	0.44	0.46	0.45	1.07	0.87	0.97
150	Ridge Till	Broadcast	1.34	2.62	1.98	0.48	0.61	0.55	1.15	1.08	1.12
150	Ridge Till	Injected	2.51	2.73	2.62	0.48	0.59	0.54	1.25	1.11	1.18
150	Ridge Till	Dribble	1.52	2.43	1.98	0.39	0.55	0.47	1.26	0.93	1.10
150	Chisel	Broadcast	1.47	2.54	2.01	0.38	0.56	0.47	1.11	1.06	1.09
150	Chisel	Injected	2.43	2.80	2.62	0.48	0.64	0.56	1.36	1.05	1.21
150	Chisel	Dribble	1.69	2.74	2.22	0.42	0.61	0.52	1.11	1.12	1.12
150	Moldboard	Broadcast	2.04	2.58	2.31	0.47	0.57	0.52	1.19	1.17	1.18
150	Moldboard	Injected	2.26	2.74	2.50	0.47	0.60	0.54	1.28	1.19	1.24
150	Moldboard	Dribble	1.36	2.66	2.01	0.43	0.64	0.54	1.22	1.15	1.19
300	No Till	Broadcast	1.46	2.26	1.86	0.45	0.51	0.48	1.18	0.94	1.06
300	No Till	Injected	3.00	3.14	3.07	0.72	0.86	0.79	1.55	1.15	1.35
300	No Till	Dribble	2.36	3.29	2.83	0.49	0.65	0.57	1.35	1.04	1.20
300	Ridge Till	Broadcast	1.96	3.02	2.49	0.38	0.58	0.48	1.19	1.17	1.18
300	Ridge Till	Injected	2.91	2.87	2.89	0.68	0.68	0.68	1.49	1.37	1.43
300	Ridge Till	Dribble	2.90	3.03	2.97	0.62	0.68	0.65	1.42	1.28	1.35
300	Chisel	Broadcast	2.42	3.05	2.74	0.44	0.67	0.56	1.25	1.22	1.24
300	Chisel	Injected	2.93	3.30	3.12	0.53	0.77	0.65	1.36	1.31	1.34
300	Chisel	Dribble	2.81	3.01	2.91	0.50	0.78	0.64	1.41	1.20	1.31
300	Moldboard	Broadcast	2.49	3.04	2.77	0.47	0.80	0.64	1.24	1.01	1.13
300	Moldboard	Injected	2.99	3.09	3.04	0.54	0.83	0.69	1.52	0.95	1.24
300	Moldboard	Dribble	2.69	2.96	2.83	0.52	0.82	0.67	1.53	1.08	1.31

Table 5. Influence of nitrogen rates, tillage systems and methods of 28% N application, on stover and grain nitrogen removal by irrigated corn. Becker, MN - 1984 and 1985.

Treatments			N-Removal								
	Tillage	Method	Grain			Stover			Total		
N-Rate	System	Applied	1984	1985	Ave.	1984	1985	Ave.	1984	1985	Ave.
#/A			#/A								
Control	No Till	---------	21.9	14.1	18.0	9.2	9.7	9.4	31.2	23.8	27.5
Control-Knife	No Till	---------	23.0	15.8	19.4	9.2	9.4	9.3	32.3	25.2	28.7
Control	Ridge Till	---------	28.7	15.3	22.0	7.5	9.7	8.6	36.3	25.0	30.6
Control-Knife	Ridge Till	---------	28.4	17.0	22.7	7.9	10.1	9.0	36.4	27.1	31.7
Control	Chisel	---------	31.3	19.6	22.5	9.5	13.2	11.4	40.9	32.8	36.8
Control-Knife	Chisel	---------	30.7	21.6	26.1	10.2	15.6	11.4	41.0	37.2	39.1
Control	Moldboard	---------	25.4	15.8	20.6	8.4	10.4	9.3	33.8	26.0	29.9
Control-Knife	Moldboard	---------	29.5	19.7	24.6	9.1	12.4	10.8	38.7	32.1	35.4
75	No Till	Broadcast	21.8	19.8	20.8	9.1	15.6	12.4	31.0	35.5	33.3
75	No Till	Injected	38.2	31.5	34.9	17.1	22.0	19.6	55.3	53.5	54.4
75	No Till	Dribble	26.8	21.4	24.1	10.0	15.1	12.6	36.9	36.5	36.7
75	Ridge Till	Broadcast	33.7	31.5	32.6	7.8	18.1	13.0	41.5	49.7	45.6
75	Ridge Till	Injected	42.3	28.2	35.3	15.7	14.7	15.2	58.1	42.8	50.5
75	Ridge Till	Dribble	39.0	33.4	36.2	10.9	19.7	15.3	49.9	53.2	51.6
75	Chisel	Broadcast	32.9	38.9	35.9	14.4	24.6	19.5	47.3	63.6	55.5
75	Chisel	Injected	46.1	39.6	42.9	16.9	23.1	20.0	63.1	62.7	62.9
75	Chisel	Dribble	41.2	42.0	41.6	15.6	23.4	19.5	56.8	65.4	61.1
75	Moldboard	Broadcast	38.3	41.9	40.1	12.7	22.5	17.6	50.4	64.4	57.4
75	Moldboard	Injected	34.0	34.1	34.1	13.0	20.5	16.8	47.0	54.6	50.8
75	Moldboard	Dribble	40.6	31.6	36.1	12.0	21.8	16.9	52.6	53.4	53.0
150	No Till	Broadcast	23.1	47.5	35.3	10.9	22.8	16.9	34.1	70.3	52.2
150	No Till	Injected	63.6	57.8	60.7	21.6	31.3	26.5	85.2	89.1	87.2
150	No Till	Dribble	25.9	33.4	29.7	12.0	18.0	15.0	38.0	51.4	44.7
150	Ridge Till	Broadcast	40.6	69.4	55.0	15.7	37.2	26.5	56.3	106.7	81.5
150	Ridge Till	Injected	76.5	76.1	76.3	21.8	36.9	29.4	98.4	113.1	105.8
150	Ridge Till	Dribble	49.7	56.1	52.9	14.2	32.7	23.5	64.0	88.9	76.5
150	Chisel	Broadcast	48.2	61.4	54.8	17.1	33.0	25.1	65.3	94.5	79.9
150	Chisel	Injected	92.3	72.2	82.3	26.8	39.1	33.0	119.2	111.3	115.3
150	Chisel	Dribble	53.5	72.0	62.8	19.6	37.9	28.8	73.1	110.0	91.6
150	Moldboard	Broadcast	77.6	82.5	80.1	26.0	36.4	31.2	103.6	119.0	111.3
150	Moldboard	Injected	83.7	86.0	84.9	24.9	37.9	31.4	108.6	123.9	116.3
150	Moldboard	Dribble	60.8	85.4	73.1	19.8	39.6	29.7	80.7	125.1	102.9
300	No Till	Broadcast	29.3	41.7	35.5	16.8	26.0	21.4	46.2	67.7	57.0
300	No Till	Injected	114.0	79.9	97.0	40.5	48.2	44.4	154.6	128.2	141.4
300	No Till	Dribble	89.1	68.2	78.7	25.8	35.8	30.8	115.0	104.1	109.6
300	Ridge Till	Broadcast	71.0	82.8	76.9	19.2	32.0	25.6	90.2	114.8	102.5
300	Ridge Till	Injected	125.7	102.6	114.2	40.3	39.6	40.0	166.0	142.3	154.2
300	Ridge Till	Dribble	111.8	98.0	104.9	37.0	42.1	39.6	148.8	140.1	144.5
300	Chisel	Broadcast	80.4	91.9	86.2	23.8	42.4	33.1	104.3	134.4	119.4
300	Chisel	Injected	116.8	104.2	110.5	37.0	53.7	45.4	153.8	157.9	155.9
300	Chisel	Dribble	107.3	100.5	103.9	32.8	52.3	42.6	140.1	152.8	146.5
300	Moldboard	Broadcast	92.2	85.8	89.0	27.1	59.6	43.4	119.4	145.4	132.4
300	Moldboard	Injected	123.1	83.0	103.1	32.9	59.5	46.2	156.1	142.5	149.3
300	Moldboard	Dribble	125.8	94.6	110.2	32.7	60.3	46.5	158.5	155.0	156.8

Table 4. Continued

Treatments Tillage System	N-Concentration Leaf 1984	Leaf 1985	Leaf Ave.	Stover 1984	Stover 1985	Stover Ave.	Grain 1984	Grain 1985	Grain Ave.
	%								
Factorial Arrangement (Excludes Controls)									
Tillage									
No Till	1.77	2.22	1.99	0.47	0.54	0.50	1.20	0.95	1.07
Ridge Till	1.91	2.39	2.15	0.48	0.55	0.51	1.26	1.08	1.17
Chisel	1.98	2.60	2.29	0.44	0.60	0.52	1.22	1.07	1.14
Moldboard	1.97	2.48	2.22	0.46	0.62	0.54	1.29	1.06	1.14
P-Value (%)	99	99	99	98	99	90	99	99	99
BLSD (.05)							0.04		
N-Rate									
75	1.36	1.73	1.54	0.42	0.45	0.43	1.16	0.91	1.03
150	1.79	2.53	2.16	0.44	0.57	0.50	1.20	1.06	1.13
300	2.58	3.00	2.79	0.53	0.71	0.62	1.37	1.14	1.25
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)									
Method Applied									
Broadcast	1.61	2.32	1.96	0.43	0.55	0.49	1.17	1.04	1.10
Injected	2.31	2.54	2.42	0.51	0.61	0.56	1.29	1.05	1.17
Dribble	1.80	2.39	2.09	0.46	0.58	0.52	1.26	1.02	1.14
P-Value (%)	99	99	99	99	99	99	99	46	99
BLSD (.05)									
Tillage X N-Rate	99	82	97	49	99	68	26	99	79
Tillage X Method	99	99	99	99	99	99	43	30	48
N-Rate X Method	99	97	99	99	99	99	99	92	99
Tillage X N-Rate X Method	99	99	99	99	93	99	70	48	69

Table 5. Continued

Treatments Tillage System	N-Removal Grain 1984	Grain 1985	Grain Ave.	Stover 1984	Stover 1985	Stover Ave.	Total 1984	Total 1985	Total Ave.
	#/A								
Factorial Arrangement (Excludes Controls)									
Tillage									
No Till	48.0	45.6	46.8	18.2	26.1	22.1	66.3	70.7	68.5
Ridge Till	65.6	64.2	64.9	20.3	30.3	25.3	85.9	94.6	90.2
Chisel	68.7	69.2	68.9	22.7	36.6	29.6	91.4	105.8	98.6
Moldboard	75.1	69.4	72.2	22.3	39.8	31.0	97.5	109.3	103.4
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)									
N-Rate									
75	36.2	32.8	34.5	12.9	20.1	16.5	49.2	53.0	51.1
150	58.0	66.7	62.3	19.2	33.6	26.4	77.2	100.3	88.7
300	98.9	86.1	92.5	30.5	46.0	38.2	129.4	132.1	130.7
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)									
Method									
Broadcast	49.1	57.9	53.5	16.7	30.8	23.7	65.8	88.8	77.3
Injected	79.7	66.2	72.9	25.7	35.5	30.6	105.5	101.8	103.6
Dribble	64.3	61.4	62.8	20.2	33.2	26.7	84.5	94.7	89.6
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)									
Tillage X Rate	97	99	94	80	99	98	93	99	92
Tillage X Method	99	96	99	99	99	99	99	99	99
N-Rate X Method	99	99	99	99	99	99	99	99	99
Tillage X N-Rate X Method	62	65	78	66	44	66	58	65	72

Table 6. Influence of nitrogen rates, tillage sytems and methods of 28% N application on grain yield and % dry matter of the grain on corn. Goodhue Co. MN - 1984 and 1985.

	Treatments		Grain Yields			Dry Matter Grain		
N-Rate	Tillage System	Method Applied	1984	1985	Ave.	1984	1985	Ave.
#/A			------Bu/A--------			----------%----------		
Control	No Till	--------	82.8	82.8*	82.8	60.8	60.0*	60.8
Control-Knife	No Till	---------	84.7	84.7*	84.7	61.0	61.0*	61.0
Control	Ridge Till	---------	70.8	66.6	68.7	65.0	55.0	60.0
Control-Knife	Ridge Till	---------	73.4	68.1	70.8	63.9	57.0	60.5
Control	Chisel	---------	91.3	66.3	78.8	66.1	54.0	60.1
Control-Knife	Chisel	---------	93.2	84.9	89.1	64.0	57.0	60.5
75	No Till	Broadcast	127.8	90.2	109.0	63.1	59.0	61.1
75	No Till	Injected	145.7	111.5	128.6	63.8	58.0	60.9
75	No Till	Dribble	140.9	82.5	111.7	63.2	57.0	60.1
75	Ridge Till	Broadcast	143.6	128.1	135.9	64.6	60.0	62.3
75	Ridge Till	Injected	152.4	135.1	143.8	63.6	60.0	61.8
75	Ridge Till	Dribble	145.9	124.2	135.1	65.1	59.0	62.1
75	Chisel	Broadcast	144.1	138.8	141.5	66.0	61.0	63.5
75	Chisel	Injected	148.9	133.8	141.4	65.9	60.0	63.0
75	Chisel	Dribble	140.8	135.2	138.0	65.8	60.0	63.0
150	No Till	Broadcast	148.2	108.6	128.4	63.1	59.0	61.1
150	No Till	Injected	154.4	122.6*	138.5	62.9	55.9*	59.4
150	No Till	Dribble	159.1	115.1	137.1	63.4	58.0	60.7
150	Ridge Till	Broadcast	154.6	139.1	146.9	64.8	59.0	61.9
150	Ridge Till	Injected	168.0	153.1	160.6	64.6	60.0	62.3
150	Ridge Till	Dribble	165.3	138.6	152.0	64.4	59.0	61.7
150	Chisel	Broadcast	164.0	145.2	154.6	64.8	62.0	63.4
150	Chisel	Injected	158.8	152.2	155.5	63.8	60.0	61.9
150	Chisel	Dribble	167.0	154.0	160.5	66.4	61.0	63.7
300	No Till	Broadcast	161.1	114.8	138.0	62.6	57.0	59.8
300	No Till	Injected	158.2	108.2	133.2	62.8	58.0	60.4
300	No Till	Dribble	151.1	109.4	130.3	62.9	57.0	60.0
300	Ridge Till	Broadcast	167.1	150.9	159.0	64.1	60.0	62.1
300	Ridge Till	Injected	158.8	149.0	153.9	64.1	61.0	62.6
300	Ridge Till	Dribble	169.0	148.4	158.7	66.7	61.0	63.9
300	Chisel	Broadcast	161.3	157.2	159.3	64.7	58.0	61.4
300	Chisel	Injected	165.7	134.6	150.2	64.6	59.0	61.8
300	Chisel	Dribble	165.1	157.1	161.1	65.9	60.0	63.0

* After the number means that sum of the 1985 plots were thrown out because of low plant population or weed problems. Then either the 1984 ave. was used or a value that would best fit that treatment was assigned to it.

Table 7. Influence of nitrogen rates, tillage sytems and methods of 28% N application on grain dry matter production on corn. Goodhue Co. MN - 1984 and 1985.

Treatments			Dry Matter Production								
	Tillage	Method	Grain			Stover			Total		
N-Rate	System	Applied	1984	1985	Ave.	1984	1985	Ave.	1984	1985	Ave.
#/A			T/A								
Control	No Till	---------	1.96	1.96*	1.96	1.85	1.85*	1.85	3.81	3.81*	3.81
Control-Knife	No Till	---------	2.00	2.00*	2.00	1.87	1.87*	1.87	3.88	3.88*	3.88
Control	Ridge Till	---------	1.67	1.58	1.63	1.59	1.33	1.46	3.26	2.91	3.09
Control-Knife	Ridge Till	---------	1.73	1.61	1.67	1.63	1.35	1.49	3.37	2.96	3.17
Control	Chisel	---------	2.16	1.57	1.87	1.61	1.77	1.69	3.77	3.34	3.56
Control-Knife	Chisel	---------	2.20	2.01	2.11	1.86	1.82	1.84	4.07	3.83	3.95
75	No Till	Broadcast	3.02	2.14	2.58	2.34	20.3	2.19	5.37	4.16	4.77
75	No Till	Injected	3.44	2.64	3.04	2.68	2.51	2.60	6.13	5.15	5.64
75	No Till	Dribble	3.33	1.95	2.64	2.65	1.97	2.31	5.98	3.92	4.95
75	Ridge Till	Broadcast	3.39	30.3	3.21	2.46	2.30	2.38	5.86	5.33	5.60
75	Ridge Till	Injected	3.60	3.20	3.40	2.78	2.64	2.71	6.39	5.84	6.12
75	Ridge Till	Dribble	3.45	2.94	3.20	2.65	2.21	2.43	6.11	5.15	5.63
75	Chisel	Broadcast	3.41	3.29	3.35	2.70	2.58	2.64	6.11	5.87	5.99
75	Chisel	Injected	3.52	3.17	3.35	2.80	2.83	2.82	6.33	5.99	6.16
75	Chisel	Dribble	3.33	3.20	3.27	2.69	2.47	2.58	6.02	5.67	5.85
150	No Till	Broadcast	3.50	2.57	3.04	2.93	2.29	2.61	6.43	4.86	5.65
150	No Till	Injected	3.65	2.69*	3.17	3.03	2.21*	2.62	6.68	4.90*	5.79
150	No Till	Dribble	3.76	2.72	3.24	2.98	2.36	2.67	6.74	5.08	5.91
150	Ridge Till	Broadcast	3.65	3.29	3.47	2.63	2.57	2.60	6.29	5.86	6.08
150	Ridge Till	Injected	3.97	3.62	3.80	3.16	2.82	2.99	7.13	6.44	6.79
150	Ridge Till	Dribble	3.91	3.28	3.60	2.87	2.52	2.70	6.78	5.80	6.29
150	Chisel	Broadcast	3.88	3.44	3.66	2.96	2.91	2.94	6.84	6.43	6.59
150	Chisel	Injected	3.75	3.60	3.68	30.2	3.12	3.07	6.78	6.72	6.75
150	Chisel	Dribble	3.95	3.65	3.80	3.19	2.93	3.06	7.14	6.58	6.86
300	No Till	Broadcast	3.81	2.72	3.27	3.08	3.04	3.06	6.89	5.76	6.33
300	No Till	Injected	3.74	2.56	3.15	3.08	2.68	2.88	6.82	5.24	6.03
300	No Till	Dribble	3.57	2.59	3.08	3.08	2.50	2.79	6.66	5.09	5.88
300	Ridge Till	Broadcast	3.95	3.57	3.76	2.97	2.79	2.88	6.92	6.36	6.64
300	Ridge Till	Injected	3.75	3.53	3.64	2.97	2.66	2.82	6.73	6.19	6.46
300	Ridge Till	Dribble	3.99	3.51	3.75	2.88	2.66	2.77	6.88	6.17	5.53
300	Chisel	Broadcast	3.81	3.72	3.77	3.23	3.07	3.15	7.05	6.79	6.92
300	Chisel	Injected	3.92	3.19	3.56	2.98	2.82	2.90	6.90	6.00	6.45
300	Chisel	Dribble	3.90	3.72	3.81	2.89	2.85	2.87	6.80	6.57	6.69

Table 6. Continued

Treatments Tillage System	Grain Yields 1984	1985	Ave.	Dry Matter Grain 1984	1985	Ave.
		Bu/A			---%---	
Factorial Arrangement (Excludes controls)						
Tillage						
No Till	149.7	107.0	128.3	63.1	44.8	53.9
Ridge Till	158.3	140.7	149.5	64.7	44.6	54.6
Chisel	157.3	145.3	151.3	65.3	44.6	54.9
P-Value (%)	99	99	99	98	92	97
BLSD (.05)	2.7			1.5		
N-Rate						
75	143.3	119.9	131.6	64.6	46.5	55.5
150	159.9	136.5	148.2	64.2	44.4	53.4
300	161.9	136.6	149.2	64.3	45.1	54.7
P-Value (%)	99	99	99	31	4	16
BLSD (.05)	6.6					
Method						
Broadcast	152.4	130.3	141.3	64.2	45.4	54.8
Injected	156.8	133.3	145.0	64.0	45.4	54.5
Dribble	156.0	129.4	142.7	64.9	45.1	55.0
P-Value (%)	84	67	82	99	39	76
BLSD (.05)				0.6		
Tillage X N-Rate	1	67	9	39	77	70
Tillage X Method	11	98	88	58	52	55
N-Rate X Method	85	99	99	56	93	97
Tillage X N-Rate X Method	71	14	22	73	26	52

Table 7. continued

Treatments Tillage System	Dry Matter Production Grain 1984	1985	Ave.	Stover 1984	1985	Ave.	Total 1984	1985	Ave.
					T/A				
Factorial Arrangement (Excludes controls)									
Tillage									
No Till	3.54	2.50	3.02	2.87	2.39	2.63	6.41	4.75	5.58
Ridge Till	3.74	3.33	3.35	2.82	2.57	2.69	6.75	5.90	6.32
Chisel	3.72	3.43	3.57	2.94	2.84	2.89	6.66	6.28	6.47
P-Value (%)	99	99	99	56	99	99	89	99	99
BLSD (.05)	0.06								
N-Rate									
75	3.39	2.83	3.11	2.64	2.39	2.51	6.03	5.23	5.63
150	3.78	3.20	3.49	2.97	2.63	2.80	6.67	5.69	6.18
300	3.83	3.23	3.53	3.02	2.78	2.90	6.85	6.01	6.43
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)	0.16						0.23		
Method									
Broadcast	3.60	3.08	3.34	2.81	2.61	2.71	6.42	5.70	6.06
Injected	3.71	3.13	3.42	2.94	2.69	2.81	6.65	5.68	6.16
Dribble	3.69	3.06	3.37	2.88	2.49	2.68	6.57	5.55	6.06
P-Value (%)	99	49	72	84	99	99	94	65	65
BLSD (.05)									
Tillage X N-Rate	1	40	4	58	99	99	10	99	87
Tillage X Method	11	96	80	80	14	57	46	85	69
N-Rate X Method	85	99	99	96	99	99	94	99	99
Tillage X N-Rate X Method	71	47	39	32	52	28	37	99	96

Table 8 Influence of nitrogen rates, tillage systems and methods of 28% N application, on leaf stover and grain N concentration by corn. Goodhue Co. MN - 1984 and 1985.

	Treatments		N-Concentration								
	Tillage	Method	Leaf			Stover			Grain		
N-Rate	System	Applied	1984	1985	Ave.	1984	1985	Ave.	1984	1985	Ave.
#/A			%								
Control	No Till	---------	1.91	1.60	1.76	0.52	0.58	0.55	1.12	1.14	1.16
Control-Knife	No Till	---------	1.93	1.57	1.75	0.44	0.61	0.53	1.11	1.08	1.08
Control	Ridge Till	---------	1.70	1.32	1.51	0.41	0.56	0.49	1.10	1.10	1.10
Control-Knife	Ridge Till	---------	1.79	1.27	1.53	0.40	0.56	0.48	1.06	1.11	1.09
Control	Chisel	---------	1.85	1.42	1.64	0.46	0.49	0.48	1.06	1.08	1.07
Control-Knife	Chisel	---------	1.90	1.43	1.67	0.47	0.54	0.51	1.05	1.09	1.07
75	No Till	Broadcast	2.67	2.22	2.45	0.69	0.74	0.72	1.24	1.08	1.16
75	No Till	Injected	2.93	2.79	2.86	0.67	0.78	0.73	1.29	1.20	1.25
75	No Till	Dribble	2.60	1.98	2.29	0.60	0.71	0.66	1.28	1.30	1.29
75	Ridge Till	Broadcast	2.53	2.21	2.37	0.61	0.63	0.62	1.15	1.38	1.27
75	Ridge Till	Injected	2.89	3.05	2.97	0.52	0.78	0.65	1.32	1.23	1.28
75	Ridge Till	Dribble	2.66	2.09	2.38	0.53	0.80	0.67	1.24	1.34	1.29
75	Chisel	Broadcast	2.69	2.04	2.37	0.54	0.60	0.57	1.26	1.30	1.28
75	Chisel	Injected	2.85	2.59	2.72	0.55	0.63	0.59	1.36	1.27	1.32
75	Chisel	Dribble	2.40	1.95	2.18	0.45	0.64	0.55	1.28	1.32	1.30
150	No Till	Broadcast	3.02	2.69	2.86	0.58	0.85	0.72	1.44	1.46	1.45
150	No Till	Injected	3.03	3.04	3.03	0.85	0.97	0.92	1.46	1.24	1.35
150	No Till	Dribble	3.01	2.44	2.73	0.82	0.97	0.90	1.40	1.13	1.27
150	Ridge Till	Broadcast	2.96	2.54	2.75	0.68	0.75	0.72	1.40	1.44	1.42
150	Ridge Till	Injected	2.98	3.21	3.10	0.77	0.95	0.86	1.37	1.49	1.43
150	Ridge Till	Dribble	2.84	2.59	2.72	0.56	0.85	0.71	1.27	1.43	1.35
150	Chisel	Broadcast	2.84	2.50	2.67	0.75	0.88	0.82	1.40	1.40	1.40
150	Chisel	Injected	2.83	3.06	2.95	0.67	0.86	0.77	1.46	1.38	1.42
150	Chisel	Dribble	2.61	2.44	2.53	0.68	0.74	0.71	1.43	1.37	1.40
300	No Till	Broadcast	3.10	3.17	3.14	0.79	1.09	0.94	1.46	1.48	1.47
300	No Till	Injected	3.17	2.91	3.04	0.76	1.14	0.95	1.51	1.43	1.47
300	No Till	Dribble	3.15	2.83	2.99	0.75	0.90	0.83	1.46	1.45	1.46
300	Ridge Till	Broadcast	2.98	3.00	2.99	0.77	0.91	0.84	1.42	1.44	1.43
300	Ridge Till	Injected	2.92	2.90	2.91	0.91	0.85	0.88	1.46	1.20	1.33
300	Ridge Till	Dribble	3.05	2.95	3.00	0.78	0.79	0.79	1.44	1.30	1.37
300	Chisel	Broadcast	3.08	3.04	3.06	0.80	0.89	0.85	1.43	1.59	1.51
300	Chisel	Injected	3.01	3.07	3.04	0.64	0.96	0.80	1.45	1.61	1.53
300	Chisel	Dribble	2.77	3.00	2.89	0.76	0.83	0.80	1.44	1.47	1.46

Table 9. Influence of nitrogen rates, tillage systems and methods of 28% N application, on grain and stover nitrogen removal by corn. Goodhue Co. MN - 1984 and 1985.

	Treatments		N-Removal								
	Tillage	Method	Grain			Stover			Total		
N-Rate	System	Applied	1984	1985	Ave.	1984	1985	Ave	1984	1985	Ave.
#/A			#/A								
Control	No Till	---------	43.9	43.9*	43.9	19.3	19.3*	19.3	63.2	63.2*	63.2
Control-Knife	No Till	---------	44.8	44.8*	44.8	16.6	16.6*	16.6	61.4	61.4*	61.4
Control	Ridge Till	---------	37.1	34.8	35.9	13.0	14.9	13.9	50.2	49.8	50.0
Control-Knife	Ridge Till	---------	36.8	35.7	36.2	13.3	15.1	14.2	50.2	50.4	50.3
Control	Chisel	---------	45.9	33.9	39.9	14.9	17.3	16.1	60.9	56.0	58.4
Control-Knife	Chisel	---------	46.3	43.8	45.0	17.6	19.7	18.3	64.0	63.3	58.4
75	No Till	Broadcast	75.5	46.0	60.7	33.4	30.1	31.7	109.0	76.2	92.6
75	No Till	Injected	89.3	63.0	76.1	36.2	39.3	37.7	125.5	102.3	113.9
75	No Till	Dribble	85.6	51.3	68.4	32.2	27.9	30.0	117.8	79.3	98.0
75	Ridge Till	Broadcast	78.0	84.5	81.2	30.8	28.6	29.7	108.8	113.1	110.9
75	Ridge Till	Injected	95.0	78.0	86.5	29.1	41.0	30.5	124.1	119.1	121.6
75	Ridge Till	Dribble	86.1	79.0	82.5	28.5	35.5	32.0	114.7	114.5	114.6
75	Chisel	Broadcast	86.6	85.2	85.9	30.2	31.5	30.8	116.9	116.8	116.8
75	Chisel	Injected	96.2	81.2	88.7	31.1	35.6	33.3	127.3	116.9	122.1
75	Chisel	Dribble	86.0	85.0	85.5	24.2	31.4	27.8	110.2	116.5	113.3
150	No Till	Broadcast	100.8	74.7	87.7	34.1	38.9	36.5	134.9	113.7	124.3
150	No Till	Injected	106.5	67.1*	86.8	51.2	42.9*	47.0	157.8	109.9*	133.8
150	No Till	Dribble	105.1	61.6	83.3	48.5	45.9	47.2	153.7	107.5	130.6
150	Ridge Till	Broadcast	103.0	94.9	98.9	36.0	38.5	37.2	139.0	133.4	136.2
150	Ridge Till	Injected	109.5	108.4	108.9	48.7	53.2	50.9	158.3	161.6	159.9
150	Ridge Till	Dribble	99.7	93.8	96.7	32.6	42.7	37.6	132.4	136.6	134.5
150	Chisel	Broadcast	108.9	95.6	102.2	45.3	51.3	48.3	154.2	147.0	150.6
150	Chisel	Injected	109.8	98.8	104.3	40.7	54.2	47.4	150.6	153.1	151.8
150	Chisel	Dribble	113.6	99.8	106.7	43.8	43.8	43.8	157.4	143.7	150.5
300	No Till	Broadcast	111.8	79.9	95.8	49.0	65.8	57.4	160.8	145.8	153.3
300	No Till	Injected	113.1	73.0	93.0	47.3	60.7	54.0	160.4	133.8	147.1
300	No Till	Dribble	104.4	74.5	89.4	46.9	44.9	47.2	151.3	119.5	135.4
300	Ridge Till	Broadcast	112.2	102.9	107.5	46.0	50.9	48.4	158.3	153.8	156.0
300	Ridge Till	Injected	110.2	84.7	97.4	54.7	45.6	50.1	165.0	130.4	147.7
300	Ridge Till	Dribble	115.3	92.1	103.7	45.5	41.7	43.6	160.9	133.8	147.3
300	Chisel	Broadcast	109.5	118.7	114.1	51.9	54.8	53.3	161.4	173.6	167.5
300	Chisel	Injected	114.0	102.5	108.2	38.4	53.6	46.0	152.5	156.2	154.3
300	Chisel	Dribble	113.1	109.2	111.1	44.1	47.0	45.5	157.3	156.2	156.7

Table 8. Continued

Treatments Tillage System	N-Concentration Leaf 1984	Leaf 1985	Leaf Ave	Stover 1984	Stover 1985	Stover Ave.	Grain 1984	Grain 1985	Grain Ave.
	%								
Factorial Arrangement (Excludes controls)									
Tillage									
No Till	2.96	2.67	2.81	0.72	0.90	0.81	1.39	1.31	1.35
Ridge Till	2.87	2.72	2.79	0.68	0.81	0.74	1.34	1.36	1.35
Chisel	2.78	2.63	2.70	0.65	0.78	0.71	1.39	1.41	1.40
P-Value (%)	96	32	82	62	99	97	96	99	99
BLSD (.05)							0.04		
N-Rate									
75	2.69	2.32	2.50	0.57	0.70	0.63	1.27	1.27	1.27
150	2.90	2.72	2.81	0.71	0.86	0.78	1.40	1.37	1.38
300	3.02	2.98	3.00	0.77	0.92	0.84	1.45	1.44	1.44
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)							0.04		
Method									
Broadcast	2.87	2.59	2.73	0.69	0.81	0.75	1.35	1.39	1.37
Injected	2.95	2.95	2.95	0.70	0.88	0.79	1.41	1.34	1.37
Dribble	2.79	2.47	2.63	0.66	0.80	0.73	1.36	1.34	1.35
P-Value (%)	99	99	99	80	99	99	99	88	60
BLSD (.05)							0.04		
Tillage X N-Rate	39	65	48	71	96	46	54	99	98
Tillage X Method	98	65	61	93	39	82	8	32	15
N-Rate X Method	99	99	99	78	92	87	82	95	98
Tillage X N-Rate X Method	15	6	6	98	73	96	40	99	85

Table 9. continued

Treatments Tillage System	N-Removal Grain 1984	Grain 1985	Grain Ave.	Stover 1984	Stover 1985	Stover ave.	Total 1984	Total 1985	Total Ave.
	#/A								
Factorial Arrangement (Excludes controls)									
Tillage									
No Till	99.1	65.7	82.4	42.1	44.1	43.1	141.2	109.8	125.5
Ridge Till	101.0	90.9	95.9	39.1	42.0	40.5	140.2	132.9	136.5
Chisel	104.2	97.4	100.8	38.8	44.8	41.8	143.1	142.2	142.6
P-Value (%)	98	99	99	39	50	48	22	99	99
BLSD (.05)	3.2								
N-Rate									
75	86.5	72.6	79.5	30.6	33.4	32.0	117.1	106.1	111.6
150	106.3	88.3	97.3	42.3	45.7	44.0	148.7	134.1	141.4
300	111.5	93.1	102.3	47.1	51.7	49.4	158.7	144.8	151.7
P-Value (%)	99	99	99	99	99	99	99	99	99
BLSD (.05)	5.5			4.1			8.3		
Method									
Broadcast	98.5	86.9	92.7	39.6	43.4	41.5	138.1	130.4	134.2
Injected	104.8	84.1	94.4	41.9	47.4	44.6	146.8	131.5	139.1
Dribble	101.0	82.9	91.9	38.5	40.1	39.3	139.5	123.1	131.3
P-Value (%)	99	77	67	84	99	99	99	97	99
BLSD (.05)	3.8						6.3		
Tillage X N-Rate	11	89	15	47	99	80	28	99	34
Tillage X Method	1	41	28	98	39	88	74	25	61
N-Rate X Method	87	97	97	83	99	99	71	99	99
Tillage X N-Rate X Method	65	82	63	84	77	77	60	70	54

CORN TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1985

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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 region such as Fayett-Dubuque, Seaton, and associated soils, are highly erodible, form dense crust 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; 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 mulched plots of the same tillage treatment. On mulched subtreatments of the moldboard, chisel and paraplow treatments, 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 1985. In 1984 corn (Pioneer 3747) was planted (at 29,000 seeds/acre) on April 25. The conventional (moldboard) treatment was plowed about April 22 and secondary tillage with a disk was done on April 23 on the conventional and chisel treatments. The fall chisel and paraplow treatments were carried out in early November of 1984. All plots were planted with a 4-row John Deere 7000 Max-Emerge planter equipped with fluted coulters on one side and "trash whipunits" on the other side which removed residue from an 8 to 9 inch area over the row.

Nitrogen (250 lb/AC as 28% solution) was applied on April 15 prior to spring tillage. The starter fertilizer at planting was 200 lbs of 6-24-24. The insecticide was counter at 10 lb/ac. Preemergence chemical weed control was Bladex at 2 1/2 qts/ac and Dual at 2 pints/ac applied May 2. On May 20 Banvel was applied at 1 pint/ac (post emergence).

Percent cover was determined from slides made on May 21. Planting depth, rate of emergence, silking date and soil moisture and bulk density measurements were made on designated portions of each plot. Hourly spring soil temperatures, leaf number, soil moisture and bulk density 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, 50, and 100 cm. Yields were determined by hand harvesting 60 foot samples (two 30-ft subsamples) from each plot in mid-October, 1985.

Ten plot frames (45 3/4 x 45 3/4 inches) were implaced 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. Random roughness was measured before and after each run. Residue amounts were measured on each treatment. Tensiometer measurements were made during infiltration runs on conventional and no-till bare treatments.

Results - Corn Yields

In 1985, water stress, due to drought prior to and during pollenation, reduced corn yields; only 1.59 inches of precipitation occurred between May 28 and July 25, a period of 57 days. Total precipitation for June, July, and August was only 6.77 inches with approximately 1/2 that occurring

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