Table 2. Treatments used at the Waseca and Morris locations.

Treatment	Factor			
Number	Tillage	Rate[2]	Placement	Starter Use[3]
1	Ridge	--	--	No
2	Chisel	--	--	No
3	Ridge	--	--	Yes
4	Chisel	--	--	Yes
5	Ridge	X	Broadcast	No
6	Chisel	X	Broadcast	No
7	Ridge	X	Broadcast	Yes
8	Chisel	X	Broadcast	Yes
9	Ridge	1.5X	Broadcast	No
10	Chisel	1.5X	Broadcast	No
11	Ridge	1.5X	Broadcast	Yes
12	Chisel	1.5X	Broadcast	Yes
13	Ridge	X	Dribble	No
14	Chisel	X	Dribble	No
15	Ridge	X	Dribble	Yes
16	Chisel	X	Dribble	Yes
17	Ridge	1.5X	Dribble	No
18	Chisel	1.5X	Dribble	No
19	Ridge	1.5X	Dribble	Yes
20	Chisel	1.5X	Dribble	Yes
21	Ridge	X	Band	No
22	Chisel	X	Band	No
23	Ridge	X	Band	Yes
24	Chisel	X	Band	Yes
25	Ridge	1.5X	Band	No
26	Chisel	1.5X	Band	No
27	Ridge	1.5X	Band	Yes
28	Chisel	1.5X	Band	Yes
29	Ridge	X + 10X[4]	Band + Deep Band (M)[5]	Yes
30	Chisel	X + 10X	Band + Deep Band (M)	Yes
31	Ridge[6]	X + 10X	Band + Deep Band (BR)	Yes
32	Chisel[6]	X + 10X	Band + Deep Band (BR)	Yes
33	Ridge	10X	Deep Band	No
34	Chisel	10X	Deep Band	No
35	Ridge	10X	Deep Band	Yes
36	Ridge	10X	Deep Band	Yes

[1]Treatments applied to both high and low fertility sites at Waseca; treatments applied to high fertility site at Morris

[2]X - 44 lb. P_2O_5 + 87 lb. K_2O/acre; 1.5 X = 66 lb. P_2O_5 + 130.5 lb. K_2O/acre

[3]Starter rate was 100 lb. 7-21-7/acre at Waseca; 110 lb. 10-34-0/acre at Morris

[4]5 X rate was substituted for the 10 X rate at Morris

[5]M = deep band applied in the middle of the row; BR = deep band applied below the row

[6]Treatment not used at Morris location because ridges were built prior to the application of fertilizer

Table 3. Treatments used at the Lamberton location.

Treatment Number	Tillage	Factor Placement[2]	Starter Use[1]
1	Ridge	---	--
2	Ridge	Dribble	No
3	Ridge	Dribble	Yes
4	Ridge	Broadcast	No
5	Ridge	Broadcast	Yes
6	Ridge	Band	No
7	Ridge	Band	Yes
8	Chisel	---	--
9	Chisel	Dribble	No
10	Chisel	Dribble	Yes
11	Chisel	Broadcast	No
12	Chisel	Broadcast	Yes
13	Chisel	Band	No
14	Chisel	Band	Yes
15	Plow	Broadcast	No

[1]Starter used was 100 lb. 7-21-7/acre

[2]The P_2O_5 and K_2O were applied at the X rate; X = 44 lb. P_2O_5 and 87 lb. K_2O/acre

Table 4. The effect of tillage system, rate and placement of fertilizer and starter use on early growth and yield of corn at Waseca and Morris. 1984.

Treatment[1]				Early Growth			Yield		
Tillage	Rate	Placement	Starter	W (HF)	W (LF)	M (HF)[2]	W (HF)	W (LF)	M (HF)
				weight of 6 plants, g			-------bu./acre-------		
R	--	--	No	10.5	5.1	8.3	149.6	74.9	118.8
C	--	--	No	8.4	3.4	7.6	151.1	74.2	125.0
R	--	--	Yes	13.5	7.0	12.2	154.3	81.5	127.9
C	--	--	Yes	10.0	4.4	10.2	156.5	82.2	122.8
R	X	BD	No	12.0	5.2	8.4	155.2	81.6	119.2
C	X	BD	No	10.6	4.6	10.0	154.5	99.1	123.8
R	X	BD	Yes	14.1	6.8	12.4	159.3	90.3	123.1
C	X	BD	Yes	12.6	6.4	12.1	157.9	99.3	127.8
R	1.5X	BD	NO	13.6	7.5	7.9	150.0	84.2	123.5
C	1.5X	BD	No	11.8	4.0	10.8	151.9	96.5	128.0
R	1.5X	BD	Yes	13.9	6.5	13.4	146.4	85.7	130.0
C	1.5X	BD	Yes	12.9	4.7	10.8	150.0	99.2	128.8
R	X	D	No	12.1	5.4	9.1	149.1	99.9	121.3
C	X	D	No	9.7	5.9	8.9	157.8	101.6	124.8
R	X	D	Yes	12.0	6.6	12.1	148.1	97.6	123.0
C	X	D	Yes	10.9	4.5	11.2	166.2	107.0	128.9
R	1.5X	D	No	13.4	5.2	9.2	152.2	97.4	126.1
C	1.5X	D	No	9.4	4.5	7.0	148.8	97.4	125.4
R	1.5X	D	Yes	11.0	6.2	10.9	153.6	98.2	126.6
C	1.5X	D	Yes	11.1	5.9	12.6	150.6	106.1	128.3
R	X	B	No	12.1	6.0	9.6	150.2	105.3	120.0
C	X	B	No	9.5	4.8	10.6	154.0	110.6	124.3
R	X	B	Yes	11.8	7.0	11.6	149.5	106.6	120.4
C	X	B	Yes	10.9	4.5	14.3	157.8	101.3	124.9
R	1.5X	B	No	12.0	5.4	7.6	159.2	105.9	121.1
C	1.5X	B	No	8.6	4.1	9.3	157.2	106.5	125.0
R	1.5X	B	Yes	12.0	5.8	14.2	157.0	110.8	125.8
C	1.5X	B	Yes	7.7	4.4	10.5	156.4	107.7	129.2
			CV (%):	29.6	34.7	27.5	6.0	12.8	4.6

[1]R = ridge-till, C = chisel; BD = broadcast, D = dribble, B = band at 6-8 inches deep between rows.

[2]W (HF) = Waseca, high fertility; W (LF) = Waseca, low fertility; M (HF) - Morris, high fertility

These designations will be used in subsequent tables.

Table 5. The effect of tillage system, rate and placement of fertilizer and starter use on P and K concentration in young corn plants and ear leaf tissue as well as P and K uptake by young corn plants at the Waseca high fertility site. 1984.

Treatment				Young Plants				Ear Leaf	
Tillage	Rate	Placement	Starter	P	K	P uptake	K uptake	P	K
				-----%-----		mg/6 plants		-----%-----	
R	--	--	No	.428	4.00	44.6	422	.274	4.00
C	--	--	No	.469	3.93	36.2	330	.287	3.93
R	--	--	Yes	.442	4.09	59.8	555	.277	4.09
C	--	--	Yes	.471	4.25	44.2	423	.276	4.25
R	X	BD	No	.477	4.08	53.0	500	.279	4.08
C	X	BD	No	.440	3.85	45.4	412	.263	3.85
R	X	BD	Yes	.465	4.42	65.1	614	.292	4.42
C	X	BD	Yes	.493	4.19	57.5	539	.272	4.19
R	1.5X	BD	No	.465	4.09	61.4	559	.277	4.09
C	1.5X	BD	No	.453	4.40	50.9	514	.275	4.40
R	1.5X	BD	Yes	.511	4.39	64.8	609	.291	4.39
C	1.5X	BD	Yes	.476	4.41	57.7	559	.295	4.41
R	X	D	No	.474	4.26	52.0	513	.277	4.26
C	X	D	No	.491	4.16	42.1	404	.291	4.16
R	X	D	Yes	.493	4.05	52.8	485	.265	4.05
C	X	D	Yes	.501	4.03	47.8	443	.282	4.03
R	1.5X	D	No	.448	4.12	58.3	555	.269	4.12
C	1.5X	D	No	.454	3.92	40.2	366	.267	3.92
R	1.5X	D	Yes	.467	4.14	49.1	456	.265	4.14
C	1.5X	D	Yes	.489	4.12	51.3	453	.257	4.12
R	X	B	No	.475	3.90	55.0	468	.277	3.90
C	X	B	No	.472	4.24	41.4	409	.269	4.24
R	X	B	Yes	.440	4.22	52.0	500	.272	4.22
C	X	B	Yes	.505	4.60	50.0	507	.303	4.60
R	1.5X	B	No	.428	3.95	54.0	484	.264	3.95
C	1.5X	B	No	.473	4.16	37.6	361	.275	4.16
R	1.5X	B	Yes	.447	4.46	52.9	545	.271	4.46
C	1.5X	B	Yes	.487	4.04	34.6	313	.275	4.04
			CV (%):	6.4	8.4	33.5	31.4	3.6	8.0

Table 6. The effect of tillage system, rate and placement of fertilizer and starter use on P and K concentration is young corn plants and ear leaf tissue as well as P and K uptake by young corn plants at the Waseca low fertility site. 1984.

Treatment				Young Plants				Ear Leaf	
Tillage	Rate	Placement	Starter	P	K	P uptake	K uptake	P	K
				-----%-----		-----mg/6 plants---		-----%-----	
R	--	--	No	.380	1.22	19.8	65	.207	.58
C	--	--	No	.348	1.33	12.3	48	.202	.66
R	--	--	Yes	.406	1.31	28.8	94	.231	.62
C	--	--	Yes	.368	1.48	16.3	69	.218	.64
R	X	BD	No	.376	1.26	19.6	65	.172	.63
C	X	BD	No	.343	1.84	16.2	87	.238	.83
R	X	BD	Yes	.408	1.45	27.9	100	.203	.68
C	X	BD	Yes	.358	2.09	24.0	149	.236	.77
R	1.5X	BD	No	.383	1.47	29.1	121	.214	.70
C	1.5X	BD	No	.359	1.71	21.7	128	.231	.86
R	1.5X	BD	Yes	.406	1.57	26.9	114	.216	.79
C	1.5X	BD	Yes	.341	2.06	17.3	85	.231	.92
R	X	D	No	.399	1.93	21.5	107	.177	.73
C	X	D	No	.357	2.09	18.5	116	.223	.92
R	X	D	Yes	.422	1.32	27.9	87	.214	.79
C	X	D	Yes	.375	1.80	17.0	99	.227	.86
R	1.5X	D	No	.388	1.35	20.3	75	.196	.74
C	1.5X	D	No	.335	2.02	14.5	71	.231	1.07
R	1.5X	D	Yes	.409	1.35	25.2	87	.205	.83
C	1.5X	D	Yes	.374	2.93	16.4	97	.253	1.06
R	X	B	No	.377	2.05	22.5	123	.189	.97
C	X	B	No	.374	2.39	15.2	93	.226	1.16
R	X	B	Yes	.392	2.20	27.9	164	.199	1.03
C	X	B	Yes	.365	2.20	22.8	182	.231	1.14
R	1.5X	B	No	.385	1.97	20.7	109	.218	1.12
C	1.5X	B	No	.385	2.61	16.2	112	.227	1.22
R	1.5X	B	Yes	.401	1.87	23.2	111	.226	1.21
C	1.5X	B	Yes	.375	2.03	16.6	90	.235	1.33
			CV (%):	6.8	27.5	37.9	55.2	6.9	12.4

Table 7. The effect of tillage system, rate and placement of fertilizer and starter use on P and K concentration in young corn plants and ear leaf tissue as well as P and K uptake by young corn plants at the Morris high fertility site. 1984.

Treatment				Young Plants				Ear Leaf	
Tillage	Rate	Placement	Starter	P	K	P uptake	K uptake	P	K
				-----%-----		-----mg/6 plants---		-----%-----	
R	--	--	No	.411	3.26	34.1	268	.249	2.09
C	--	--	No	.385	3.14	30.8	243	.239	2.02
R	--	--	Yes	.432	2.88	55.4	371	.259	1.82
C	--	--	Yes	.389	2.69	36.5	252	.247	1.92
R	X	BD	No	.413	3.31	34.8	280	.258	2.09
C	X	BD	No	.421	3.60	42.5	363	.253	2.05
R	X	BD	Yes	.408	3.09	50.1	387	.250	2.01
C	X	BD	Yes	.412	3.22	51.2	412	.253	1.94
R	1.5X	BD	No	.416	3.46	33.2	277	.252	2.06
C	1.5X	BD	No	.418	3.74	46.0	403	.240	2.10
R	1.5X	BD	Yes	.428	3.18	57.5	419	.246	2.00
C	1.5X	BD	Yes	.407	3.34	45.2	370	.244	1.88
R	X	D	No	.417	3.32	39.7	316	.243	2.11
C	X	D	No	.398	3.45	35.7	306	.259	2.12
R	X	D	Yes	.429	2.94	52.2	364	.249	1.90
C	X	D	Yes	.445	3.35	50.2	377	.254	2.03
R	1.5X	D	No	.419	3.36	38.6	314	.247	2.08
C	1.5X	D	No	.399	2.95	27.8	208	.245	1.91
R	1.5X	D	Yes	.412	2.78	44.9	308	.242	1.94
C	1.5X	D	Yes	.442	3.15	55.7	405	.248	1.85
R	X	B	No	.421	3.34	40.3	321	.264	2.17
C	X	B	No	.416	3.42	44.1	365	.257	2.02
R	X	B	Yes	.424	2.92	49.2	342	.255	1.94
C	X	B	Yes	.420	3.50	60.6	507	.254	2.12
R	1.5X	B	No	.405	3.29	30.8	252	.251	2.16
C	1.5X	B	No	.400	3.52	37.9	330	.250	2.16
R	1.5X	B	Yes	.433	3.09	61.4	438	.260	2.12
C	1.5X	B	Yes	.422	2.74	44.8	296	.255	1.98
			CV (%):	7.1	10.9	31.6	35.1	4.7	6.4

Tillage system had a significant effect on some parameters measured at both Waseca and Morris (Table 8). Early plant growth as well as uptake of both P and K by these plants was greater when the ridge-till system was used at the high fertility site at Waseca. This may have been due to the more rapid emergence and subsequent expansion of the root system for this planting system. It's important to note that tillage system had no effect on yield at this high fertility site.

For the low fertility site at Waseca, early plant growth was higher, P concentration in the young plants was greater, and consequently P uptake by young plants was higher when the ridge-till system was used. On the other hand, yield, K concentration in the young plants as well as both the P and K concentration in the ear leaf tissue was higher when the chisel plow system was used (Table 8).

Tillage system had a significant effect on only two of the parameters measured at Morris (Table 8). Both grain yield and K concentration in the young plant tissue were higher when the chisel system was used.

The rate of fertilizer applied had no effect on grain production at both sites at Waseca (Table 9). The 1.5X rate did significantly increase the concentration of both P and K in the ear leaf tissue at the low fertility site. This increase in nutrient concentration, however, was not related to a significant increase in yield.

At Morris, grain yield was statistically higher when the 1.5X rate was used. This result is somewhat surprising in view of the high or very high soil test levels for P and K at this site. There is no apparent explanation for the apparent reduction in K in the ear leaf when the high rate of fertilizer was applied (Table 9).

When averaged over the other factors included in the study, placement of the fertilizer had a significant effect on yield only at the low fertility site at Waseca (Table 10). Statistical analysis shows that yield from the band application at a depth of 6-8 inches between rows was higher than the yield from the dribble application which, in turn, produced higher yields than those produced from the broadcast application.

Early growth and P as well as K uptake by the young plants at the Waseca high fertility site was highest when the fertilizer was broadcast (Table 9). Treatment means reported are averages for both tillage systems used. Placement had no significant effect on early plant growth at both the Waseca low fertility and Morris sites. The lack of significant differences for these parameters at these two sites may be due, in part, to the variability in the data recorded. The CV's are fairly high for these measured parameters (Tables 6 and 7).

The K concentration in the ear leaf tissue was highest at 2 of 3 sites when the fertilizer was placed in a band between the rows. Placement had a similar effect on the P concentration in the ear leaf at Morris but no significant effect on this parameter at both Waseca sites. The data resulting from the analyses of ear leaf tissue indicate that the fertilizer applied in the band between rows was readily available to the corn root system later in the growing season.

The use of a starter fertilizer in combination with some other method of fertilizer application had a significant effect on yield at the Morris location only (Table 11). This positive effect on yield at this site was accompanied by a positive effect on early plant growth. Early plant growth and yields at the Waseca sites were not affected by starter use in combination with the application of fertilizer in some other way.

For the most part, the plant analysis data show a positive effect for starter use. The lower values for K in the young plants and ear leaf tissue resulting from the use of starter cannot be completely explained at this time. Plant dilution due to higher dry matter production may be one possible explanation.

The use of starter fertilizer only had a significant effect on yield for both tillage systems at the low fertility site at Waseca and when corn was planted with the ridge-till system at Morris (Table 12). The results from the Morris location support earlier observations that starter fertilizer should be a management component for ridge-till and no-till planting systems at all soil test levels.

As would be expected, the use of starter only had a positive effect on early plant growth at the Waseca low fertility site. Again, K concentration in the corn tissue from Morris was lower when starter was used. Plant dilution provides the best possible explanation at this time.

The preceeding discussion has focused on the data collected from the Waseca and Morris locations. Results collected from the Lamberton location in 1984 were limited but do show some effects from treatment applied (Table 16). Early season stress contributed to a substantial amount of variability in the data. This variability may have some treatment effects.

Table 8. Effect of tillage system on early growth and yield, P and K concentration in young corn plants and ear leaf tissue and P and K uptake by young plants. 1984.

Tillage System	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
	bu./acre	6 plants, g	-----%-----		---mg./6 plants----		-----%-----	
Waseca - high fertility:								
Ridge-till	152.5	12.5	.443	4.17	55.9	524	.273	1.94
Chisel	155.3	10.5	.437	4.17	46.4	440	.274	1.99
		**			**	**		
Waseca - low fertility:								
Ridge-till	97.0	6.1	.395	1.65	24.4	105	.202	.85
Chisel	102.7	4.9	.362	2.15	18.0	109	.232	1.01
	*	**	**	**	**		**	**
Morris - high fertility:								
Ridge-till	123.4	10.6	.419	3.17	44.4	335	.251	2.04
Chisel	126.6	10.7	.416	3.33	45.2	362	.251	2.01
	**			**				

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 9. Effect of rate of fertilizer applied on early growth and yield, P and K concentration in young corn plants and ear leaf tissue and P and K uptake by young plants. 1984.

Fertilizer Applied P_2O_5	K_2O	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
lb./acre		bu./acre	6 plants, g	-----%-----		----mg/6 plants-----		-----%-----	
Waseca - high fertility:									
44	87	155.0	11.5	.442	4.17	51.2	483	.273	1.96
66	131	152.7	11.5	.439	4.18	51.1	481	.274	1.98
Waseca - low fertility									
44	87	100.0	5.7	.379	1.89	21.8	109	.211	.88
66	131	99.6	5.4	.378	1.91	20.6	105	.223	.99
								**	**
Morris - high fertility									
44	87	123.5	10.9	.419	3.29	45.9	362	.254	2.04
66	131	126.5	10.4	.417	3.22	43.7	335	.248	2.02
		**						**	

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 10. Effect of fertilizer placement on early growth and yield, P and K concentration in young corn plants and ear leaf tissue as well as P and K uptake by young plants. 1984.

Fertilizer Placement	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
	bu./acre	6 plants, g	-----%-----		----mg/6 plants----		-----%-----	
Waseca - high fertility								
Broadcast	153.2	12.7	.441	4.23	57.0	538	.274	1.97
Dribble	153.2	11.2	.435	4.10	49.2	459	.271	1.94
Band	155.2	10.6	.445	4.20	47.2	448	.275	1.99
		*			+	*		
BLSD (.05)		1.8			2.1	80		
Waseca - low fertility:								
Broadcast	92.0	5.7	.372	1.68	21.8	100	.218	.77
Dribble	100.6	5.6	.382	1.85	21.5	106	.216	.87
Band	106.8	5.3	.381	2.17	20.3	115	.219	1.15
	**			**				**
BLSD (.05)	5.9			.25				.05
Morris - high fertility:								
Broadcast	125.6	10.7	.415	3.37	45.1	364	.249	2.01
Dribble	125.6	10.2	.420	3.16	43.1	325	.248	1.99
Band	123.8	10.9	.417	3.23	46.1	356	.256	2.08
				+			*	*
BLSD (.05)				.19			.006	.07

**, *, + Treatment means are significantly different from one another at the .01, .05, and .10 confidence levels respectively.

Table 11. The effect of use of a starter fertilizer in combination with one additional application of P_2O_5 and K_2O on early growth and yield, P and K uptake by young plants. 1984.

Starter Use	Yield	Young Plants Weight	P	K	P uptake	K uptake	Ear Leaf P	K
	bu./acre	6 plants, g	-----%-----		----mg/6 plants----		-----%-----	
Waseca - high fertility:								
No	153.3	11.2	.433	4.09	49.3	462	.271	1.97
Yes	154.4	11.8	.448	4.26	53.0	502	.275	1.97
			**	**			*	
Waseca - low fertility:								
No	98.8	5.2	.371	1.89	19.7	101	.212	.91
Yes	100.0	5.8	.385	1.91	22.8	114	.223	.95
			**		+		**	+
Morris - high fertility:								
No	123.6	9.1	.412	3.40	37.6	311	.251	2.08
Yes	126.4	12.2	.423	3.11	51.9	385	.251	1.97
	*	**	+	**	**	**		**

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 12. The effect of tillage system and rate of fertilizer applied on the P concentration in the ear leaf tissue from the low fertility site at Waseca. 1984.

Fertilizer Applied		Tillage System	
P_2O_5	K_2O	Ridge-till	Chisel
lb./acre		----------%P---------	
44	87	.192	.230
66	131	.212	.235

Table 13. The effect of tillage system and placement of fertilizer on the P concentration in young corn plants at the low fertility site at Waseca. 1984.

Fertilizer Placement	Tillage System	
	Ridge-till	Chisel
	----------%P---------	
Broadcast	.393	.350
Dribble	.404	.360
Band	.387	.375

Table 14. The effect of the use of a starter fertilizer only compared to the control on early growth and yield, P and K concentration in young corn plants and ear leaf tissue and P and K uptake by young plants. 1984.

		Young Plants					Ear Leaf	
Treatment	Yield	Weight	P	K	P uptake	K uptake	P	K
	bu./acre	6 plants, g	-----%-----				-----%-----	
Waseca - high fertility: ridge-till								
Control	149.6	10.6	.422	4.00	44.6	422	.274	1.35
Starter only	154.3	13.5	.444	4.09	59.8	555	.269	1.89
			+					+
Waseca - high fertility: chisel								
Control	151.1	8.4	.432	3.94	36.2	330	.268	1.92
Starter only	156.5	10.0	.440	4.25	44.2	423	.267	1.95
Waseca - low fertility: ridge till								
Control	74.9	5.2	.380	1.22	19.8	65	.207	.58
Starter only	81.5	7.0	.406	1.31	28.8	94	.231	.62
	*	**	**				**	**
Waseca - low fertility: chisel								
Control	74.2	3.4	.348	1.33	12.3	48	.202	.66
Starter only	82.2	4.4	.368	1.48	16.3	69	.218	.64
	*	**						
Morris - high fertility: ridge till								
Control	118.8	8.3	.411	3.26	34.1	268	.249	2.09
Starter only	127.9	12.2	.432	2.88	55.4	371	.259	1.82
	*			+				*
Morris - high fertility: chisel								
Control	125.0	7.6	.385	3.14	30.8	243	.239	2.02
Starter only	122.8	10.2	.389	2.69	36.5	252	.247	1.92
				*				

**, *, + Treatment means are significantly different at the .01, .05, and .10 confidence levels respectively.

Table 15. The effect of application of fertilizer in a deep band on early growth and yield of corn. 1984.

Location	Tillage System	Deep Band Placement	Annual Fertilizer Used	Starter Used	Early Growth Weight 6 plants, g	Yield bu./acre
Waseca (HF)	ridge-till	below row	Yes	Yes	11.2	154.6
"	chisel	"	"	"	10.6	156.7
"	ridge-till	between row	No	No	11.4	153.4
"	chisel	"	"	"	10.4	163.4
"	ridge-till	"	"	Yes	10.3	158.0
"	chisel	"	"	"	12.1	158.3
"						
Waseca (LF)	ridge-till	below row	Yes	Yes	7.1	128.9
"	chisel	"	"	"	5.0	115.7
"	ridge-till	between row	"	"	7.3	125.5
"	chisel	"	"	"	4.9	120.1
"	ridge-till	"	No	No	7.1	116.4
"	chisel	"	"	"	6.4	125.0
"	ridge-till	"	"	Yes	7.3	114.7
"	chisel	"	"	"	6.1	124.5
Morris (HF)	chisel	below row	Yes	Yes	12.2	129.1
"	ridge-till	between row	"	"	11.1	126.1
"	chisel	"	"	"	11.0	132.1
"	ridge-till	"	No	No	9.1	121.7
"	chisel	"	"	"	9.0	122.8
"	ridge-till	"	"	Yes	11.9	123.6
"	chisel	"	"	"	13.4	127.9

Table 16. Effect of fertilizer treatment on early growth, yield, P and K concentration of young corn plants and P and K uptake by young corn plants at the Lamberton location when the fall chisel tillage system was used. 1984.

Treatment[1]	Yield	Weight	P	K	P uptake	K uptake
	bu./acre	6 plants, g	------%------		----mg/6 plants----	
Control	78.1	29.0	.236	3.69	68.8	1078
Dribble	66.4	25.8	.229	3.83	59.5	992
Dribble & Starter	78.3	35.5	.254	3.95	89.9	1400
Broadcast	71.9	30.2	.226	3.82	69.5	1165
Broadcast & Starter	75.5	35.2	.240	3.94	84.5	1386
Band	74.3	25.1	.262	3.59	64.9	915
Band & Starter	81.0	35.8	.285	3.78	101.6	1358
		*			*	*
BLSD (.05)	--	8.1	--	--	26.6	393
CV (%)	18.7	16.0	11.8	6.6	21.2	19.6

Table 17. The effect of the use of a starter fertilizer in combination with another fertilizer application on early growth and yield, P and K concentration in young plants and uptake of P and K by young plants at the high fertility site at Lamberton. 1984.

Variable	With Starter	Without Starter	Significance Level
Yield, bu./acre	78.3	70.3	*
Weight of young plants, g/6 plants	35.5	27.0	**
P conc. young plants, %	.260	.239	**
K conc. young plants, %	3.89	3.75	+
P uptake, young plants, mg/6 plants	92.0	64.6	**
K uptake, young plants, mg/6 plants	1381	1024	**

**, *, + Means are significantly different at the .01, .05, and .10 confidence levels.

EFFECT OF POTASSIUM PLACEMENT ON CORN PRODUCTION IN HIGH YIELD ENVIRONMENTS IN SOUTHEAST MINNESOTA

George Rehm, John Moncrief, Mike O'Leary and Greg Buzicky

There's no doubt that conservation tillage production systems are appropriate for use in southeastern Minnesota. However, if these systems are to be adopted by farmers, there are many questions that need to be answered. Because the K concentration in these soils is inherently low, there are several questions that relate to K fertilization and K management. This study is designed to evaluate the effect of rate and placement of fertilizer K with and without the use of K in a starter fertilizer on corn production with two tillage systems.

Experimental Procedures:

This study was initiated in the spring of 1984 in a farmer's field in Wabasha County. The soil is classified as a Fayette silt loam and is characteristic of soils in the region.

Prior to treatment application, 56 soil samples were collected from the experimental area to provide some measure of site uniformity. The results of this analysis showed the site to be quite uniform. The average pH was 6.5. The Bray and Kurtz #1 test showed 72 lb. P/acre while the 1 N NH_4 $C_2H_3O_2$ extraction showed 219 lb. K/acre.

The existing vegetation, sweetclover, was killed with Roundup (2 qt./acre) in late April. Treatments were applied in mid-May and corn was planted on May 18 with a Buffalo-Till planter adapted for planting in a no-till situation. Treatments used are listed in Table 1.

A fluid fertilizer (0-0-15) was used for the knife treatments. The broadcast K was supplied as 0-0-60. For the spring chisel tillage system, both broadcast and knife applications of K were made prior to the chisel operation.

The liquid starter, 7-21-7, was used at 125 lb./acre to supply K in the starter. Where no K was applied in the starter,10-34-0 was used at a rate to supply the amount of P_2O_5 provided by the 7-21-7.

A rotary hoe was used to enhance emergence in the chisel plow system. The corn planted in the chisel plow system was also cultivated once during the growing season.

Plant samples were collected from each plot at 3 times during the growing season (4-5 weeks after emergence, ear leaf at silking, whole plant at physiological maturity). These samples were dried, ground, and analyzed for K by routine procedures. Potassium uptake was computed for small plants and whole plants at physiological maturity.

Results and Discussion:

Statistical analysis of the data collected showed no significant interactions among the 4 factors used in this study. Therefore, main effects are discussed in the following paragraphs and summarized in the tables that follow.

Grain yield, silage yield, early plant growth, and total uptake of K by young plants were higher when corn was planted in the no-till system (Table 3). These measured differences were significant at the 99% confidence level. The concentration of K in the ear leaf at silking and the mature plant was significantly higher when the corn was planted in the chisel system (Table 3). These observations are consistent with those from other studies involving tillage systems in Minnesota.

The yield differences due to tillage could be related somewhat to a difference in plant population. The plant population at harvest was slightly lower in the chisel system. Nevertheless, grain and dry matter yields were certainly not reduced by the no-till planting. This is encouraging for farmers in southeast Minnesota.

Rate of applied K had no significant effect on any of the variables measured in this study (Table
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this publication for information regarding application and use of this article.

4). Since there were no significant interactions, the values reported in this table are averaged over both tillage systems, both methods of placement, with and without the use of a starter fertilizer.

When averaged over rate applied, tillage system, and starter use, early plant growth as well and K uptake by these early plants was high when K was knifed between the rows rather than broadcast (Table 5). Although the row spacing was 38 inches, the young plants were apparently able to use the knifed in K more easily than the broadcast K. The fact that placement of K had no effect on K concentration in the older tissue indicates that the broadcast K was utilized later in the growing season.

Considering all other factors, grain yields were higher when the starter fertilizer was used (Table 6). Total dry matter yield at physiological maturity and early plant growth, however, were significantly lower when starter was used. These observations are not consistent with grain yields and there is no ready explanation for these measured effects at this time. The use of a starter fertilizer when additional K was applied had no effect on the other variables measured.

Two treatments were included in the study which did not fit the complete factorial. These were: 1) complete control and 2) use of 125 lb. 7-21-7 only as a starter fertilizer. These treatments were included in both tillage systems so the effect of the use of a starter without additional K could be measured by the "t" test.

In the chisel system, the use of the starter only increased grain yield but had no significant effect on the other variables measured (Table 7). Starter use without additional K had no significant effect on any of the variables measured in the study (Table 8). These results are not consistent with results from other studies involving starter fertilizer use in Minnesota and cannot be readily explained at this time.

Table 1. The effect of tillage system, rate and placement of K and starter fertilizer use on early growth and yield of corn. Wabasha County 1984.

Tillage System	K Applied	Placement	Starter K Used	Early Growth	Yield	
					Grain	Silage
	lb./acre			weight of 6 plants,g	bu./acre	ton D.M./acre
No-till	---	---	No	18.0	171.0	6.88
"	---	---	Yes	17.9	172.0	6.51
"	40	Bdcst	No	18.8	166.8	7.03
"	40	Bdcst	Yes	17.1	169.9	6.88
"	40	Knife	No	19.5	166.5	7.43
"	40	Knife	Yes	18.6	171.8	7.11
"	80	Bdcst	No	17.8	156.0	6.93
"	80	Bdcst	Yes	15.1	166.0	7.12
"	80	Knife	No	17.4	160.1	7.07
"	80	Knife	Yes	17.8	169.8	7.20
"	120	Bdcst	No	17.7	165.8	7.31
"	120	Bdcst	Yes	16.7	172.9	6.76
"	120	Knife	No	18.7	164.5	7.05
"	120	Knife	Yes	18.1	168.9	7.06
Chisel	---	---	No	18.0	144.7	7.27
"	---	---	Yes	15.2	151.0	6.84
"	40	Bdcst	No	15.1	168.7	6.36
"	40	Bdcst	Yes	15.0	164.4	6.15
"	40	Knife	No	16.6	158.5	7.11
"	40	Knife	Yes	17.5	161.1	6.41
"	80	Bdcst	No	16.5	158.8	6.81
"	80	Bdcst	Yes	16.0	159.1	6.43
"	80	Knife	No	18.2	161.0	6.79
"	80	Knife	Yes	15.3	165.7	6.38
"	120	Bdcst	No	15.9	155.2	6.93
"	120	Bdcst	Yes	15.0	154.7	6.82
"	120	Knife	No	17.7	159.6	7.20
"	120	Knife	Yes	15.5	159.7	6.54
		CV = (%)		11.5	5.7	7.2

Table 2. The effect of tillage system, rate and placement of fertilizer K and starter fertilizer on K concentration in corn tissue and K uptake at 2 growth stages. Wabasha County, 1984.

Tillage System	K Applied	Placement	Starter K Used	K Concentration: Young Plant	K Concentration: Ear Leaf	K Concentration: Mature Plant	K Uptake: Young Plant	K Uptake: Mature Plant
	lb./acre			--------- %K	----------		mg/6 plants	lb./acre
No-till	---	-----	No	4.19	1.91	1.11	738	147.0
"	---	-----	Yes	4.30	1.81	1.10	768	148.0
"	40	Bdcst	No	4.43	1.79	1.00	829	138.8
"	40	Bdcst	Yes	4.49	1.84	1.15	768	152.7
"	40	Knife	No	4.48	1.87	.99	862	147.8
"	40	Knife	Yes	4.74	1.78	1.00	875	142.0
"	80	Bdcst	No	4.69	1.88	1.15	823	159.5
"	80	Bdcst	Yes	4.54	1.89	1.13	682	160.4
"	80	Knife	No	4.33	1.73	1.07	754	150.7
"	80	Knife	Yes	4.54	1.87	1.02	803	147.4
"	120	Bdcst	No	4.24	1.75	1.04	752	150.9
"	120	Bdcst	Yes	4.52	1.91	1.08	754	146.0
"	120	Knife	No	4.54	1.82	1.09	838	153.2
"	120	Knife	Yes	4.78	1.96	1.02	860	142.5
Chisel	---	-----	No	4.52	2.09	1.12	810	162.0
"	---	-----	Yes	4.32	2.06	1.23	660	168.0
"	40	Bdcst	No	4.59	2.02	1.17	696	148.5
"	40	Bdcst	Yes	4.72	1.96	1.18	712	146.1
"	40	Knife	No	4.53	1.99	1.04	747	146.8
"	40	Knife	Yes	4.40	2.02	1.13	766	144.9
"	80	Bdcst	No	4.51	1.98	1.04	746	141.8
"	80	Bdcst	Yes	4.62	2.01	1.22	735	157.1
"	80	Knife	No	4.43	2.12	1.08	808	146.3
"	80	Knife	Yes	4.36	2.08	1.13	665	143.2
"	120	Bdcst	No	4.67	2.11	1.15	741	160.3
"	120	Bdcst	Yes	4.54	2.04	1.15	682	155.8
"	120	Knife	No	4.45	1.99	1.10	794	157.6
"	120	Knife	Yes	4.59	1.99	1.29	708	168.3
			CV: (%)	9.0	9.8	14.8	13.0	14.6

Table 3. Effect of tillage system used on early growth, K uptake, and yield of corn. Wabasha County, 1984.

Tillage System	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No-till	17.8	4.53	1.84	1.06	166.6	7.08	800.0	149.3
Chisel	16.2	4.53	2.02	1.14	160.5	6.66	733.3	151.4
	**	**	**	**	**	**	**	

**, + Significant at the .01 and .10 confidence level respectively. This designation applies to all subsequent tables.

Table 4. Effect of rate of applied K on early growth, K uptake, and yield of corn. Wabasha County, 1984.

K Applied	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
lb./acre	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
40	17.3	4.55	1.91	1.08	166.0	6.81	781.8	146.0
80	16.8	4.50	1.95	1.10	162.1	6.84	752.0	150.8
120	16.9	4.54	1.94	1.11	162.6	6.96	766.1	154.3

Table 5. Effect of placement of K fertilizer on early growth, K uptake and yield of corn. Wabasha County, 1984.

Placement	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
Broadcast	16.4	4.55	1.93	1.12	163.2	6.79	743.3	151.5
Knife-In	17.6	4.51	1.93	1.08	163.9	6.95	790.0	149.2
	**						**	

Table 6. Effect of the use of a starter fertilizer in combination with application of either broadcast or knifed-in K on growth, K uptake and yield of corn. Wabasha County, 1984.

Starter used	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	----------%K----------			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No	17.5	4.49	1.92	1.08	161.8	7.00	782.5	150.2
Yes	16.5	4.57	1.95	1.12	165.3	6.74	750.7	150.5
	**				+	**		

Table 7. Effect of the use of a starter fertilizer without the application of additional K on growth, K uptake, and yield of corn in the chisel system. Wabasha County, 1984.

Starter used	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	%K			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No	18.0	4.52	2.09	1.12	144.7	7.27	810.0	162.0
Yes	15.2	4.32	2.06	1.23	151.0	6.84	660.0	168.0

Table 8. Effect of the use of a starter fertilizer without the application of additional K on growth, K uptake, and yield of corn in the no-till system. Wabasha county, 1984.

Starter used	Early Growth	K Concentration			Yield		K Uptake	
		Young plant	Ear leaf	Mature plant	Grain	Forage	Young plant	Maturity
	wt of 6 plants,g	%K			bu./acre	ton D.M./acre	mg/6 plants	lb./acre
No	18.0	4.19	1.91	1.11	171.0	6.88	738.0	147.0
Yes	17.9	4.30	1.81	1.10	172.0	6.51	768.0	148.0

THE PRESENCE OF "APPARENT" ATRAZINE IN GROUNDWATER OF SOUTHEAST MINNESOTA

R.S. Adams, Jr., Sheila Grow* and E.C. Alexander, Jr.*

For the past two years the authors have been conducting studies in the Karst area of southeast Minnesota. One of the measurements made has been to monitor atrazine in the water at four locations. The specific site is in Fillmore County. Water samples were collected at Fairview Sink and Mystery Cave: two sites where surface waters disappear into sink holes. Over a distance of 4 and 3 miles, respectively, these streams merge, converge, and emerge in two springs, Moth and Grabau that rise into Forestville Creek. Dye traces require three days to travel from the point of disappearance to the point of resurfacing.

Table 1 shows the concentration of "apparent" atrazine in the samples collected at these four sites from May 30, 1983 until January 12, 1985. The data show surges or peaks of "apparent" atrazine on July 5, 1983, followed by a gradual decline in concentration; and peaks on August 27, 1983, November 12, 1983 and April 29, 1984. Each of the samples were taken within a few days following a rainfall of two to three days duration. After a peak passed the quantities measured seemed to return to some equilibrium concentration which slowly declined with the approach of winter.

Using discharge flow rates from Moth and Grabau Springs the total delivery of "apparent" atrazine is plotted in Figure 1. These amounts total to approximately 10 pounds of "apparent" atrazine discharged to Forestville Creek over the period of a year's time. The estimated use of atrazine in the immediate watershed is 12,000 pounds or about .083% of the total used was discharged in these springs.

Why the designation "apparent" atrazine? A Hewlitt Packard gas chromatograph equipped with NP/FID detector and capillary columns was used in the analysis of these samples. Three liters of water per sample were extracted for atrazine by passing through an XAD-2 Amberlite resin. The atrazine was eluted with anhydrous ether. The ether evaporated to dryness and the residues dissolved in 2 milliliters hexane for analyses. The samples were analyzed in groups of four samples. With each group a deionized water control was passed through the entire analytical procedure. In the data reported here 46 controls were found to contain zero atrazine, in three controls the concentration was less than 10 nanograms per liter "apparent" atrazine and two controls had concentrations between 10 and 30 nanograms per liter "apparent" atrazine. One control was drawn while the deionizer was being recharged and gave extremely high readings and had to be discarded. All data given are minus the control concentrations. These precautions were taken and these procedures are shown because the gas chromatograph is a very sensitive <u>quantitative</u> instrument but not a <u>qualitative</u> instrument. Confirmation analyses must be performed. Such analyses are not sensitive at the nanograms per liter concentration reported here unless very large volumes of water are extracted. Intensive confirmation analyses are planned for the summer of 1985.

The data reported here are consistent with data reported from northeastern Iowa and Nebraska. We feel that peaks of "apparent" atrazine concentration probably do represent at least in part "true" atrazine. For example, with the April 29, 1984 peak, which occurred only at Mystery Cave, a heavy rainfall occurred April 27, 1984. Several farmers in the watershed planted corn early, just prior to that rainfall event. Water entering the sinks would not have had time to reach the springs from the April 27, 1984 rainfall on the sampling date. However, the fact that equilibrium levels were approached suggests that "noise" or atrazine mimics or "look alikes" may account for part of these results. Furthermore, in approximately 50% of wells (remote from the use of atrazine) tested by this laboratory "apparent" atrazine was measured. These findings make intensive confirmation analyses imperative before these data are accepted as atrazine.

Table 1. "Apparent Atrazine found in samples from four water sites in Fillmore County in nanograms per liter.

Date	Fairview Sink	Mystery Cave	Moth Spring	Grabau Spring
5-30-83	273	214	64	136
6-6-83	194	216	110	82
6-12-83	220	146	56	132
6-19-83	78	123	119	80
6-26-83	150	72	97	130

* Graduate Research Assistant and Associate Professor, respectively, Department of Geology & Geophysics,

Table 1. Continued.

Date	Fairview Sink	Mystery Cave	Moth Spring	Grabau Spring
7-5-83	1306	1462	1494	1333
7-10-83	565	388	360	511
7-17-83	227	203	193	237
7-31-83	57	73	185	139
8-7-83	87	113	76	102
8-17-83	54	120	84	89
8-21-83	51	217	101	115
8-27-83	217	551	449	530
9-4-83	117	155	146	222
9-11-83	108	129	129	154
9-18-83	55	96	75	93
9-25-83	165	201	175	198
10-5-83	154	152	89	146
10-9-83	94	176	173	155
10-16-83	150	144	138	124
10-23-83	222	334	274	154
11-6-83	63	121	105	111
11-12-83	104	285	117	139
11-20-83	152	170	121	134
11-27-83	93	148	146	132
12-4-83	88	119	114	90
12-11-83	94	60	109	130
12-18-83	88	0	53	96
1-1-84	--	--	27	31
1-8-84	--	29	--	23
1-15-84	79	103	96	86
1-22-84	37	113	93	98
1-29-84	23	34	29	8
2-5-84	25	--	39	60
2-11-84	37	121	79	35
2-19-84	115	247	115	--
2-23-84	122	172	152	147
3-4-84	142	128	206	145
3-11-84	128	124	111	112
3-18-84	78	138	104	116
3-25-84	78	295	128	145
4-1-84	108	203	189	171
4-8-84	39	57	42	72
4-22-84	35	28	10	6
4-29-84	6	1628	29	81
5-5-84	78	180	136	140
5-13-84	90	122	106	99
5-20-84	55	150	111	96
8-18-84	48	122	162	169
9-9-84	79	117	233	219
10-6-84	11	42	54	71
11-11-84	128	55	102	114
12-7-84	90	85	82	83
1-12-85	--	97	125	116

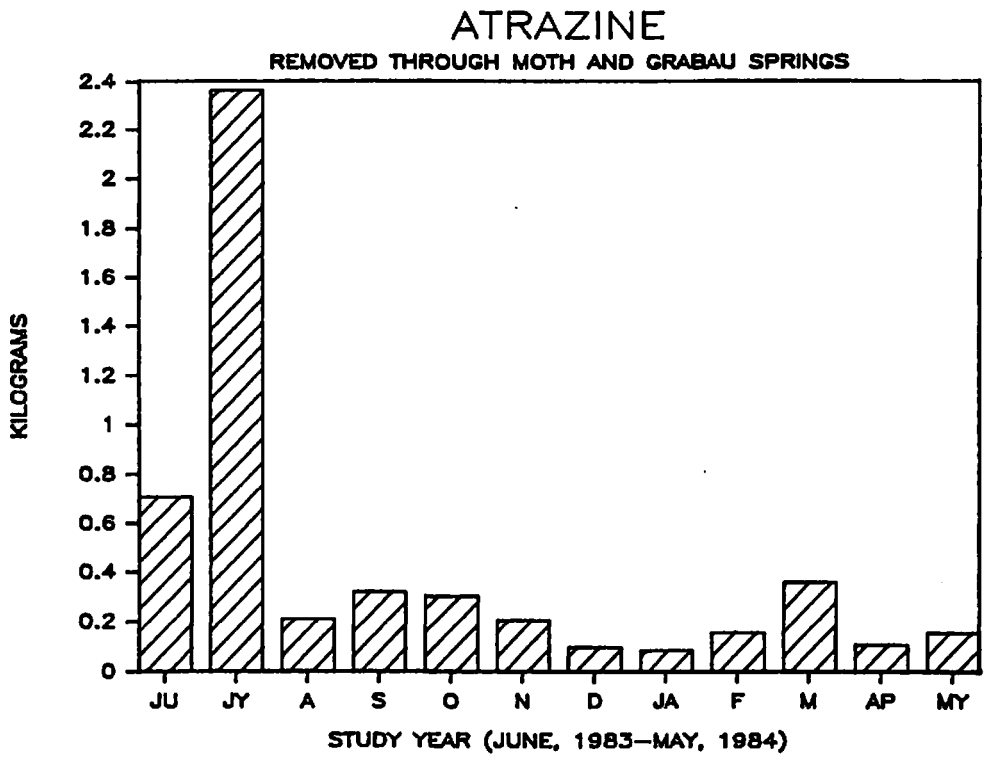

Figure 1. The discharge of "apparent" atrazine from springs in 1983-1984 study year.

CALCIUM AND MAGNESIUM AMENDMENT STUDIES ON POTATOES

C. J. Rosen and H. J. Buchite

Soil management practices for potato production differ from those used for most other agricultural crops in that liming of acid soils to a pH of 6.0 - 6.5 is avoided. The reason for not raising soil pH is due to the potential for increasing the incidence of common scab when the soil pH is above 5.2. Approximately 30% of potatoes grown in Minnesota are on irrigated coarse-textured soils. Because recommendations are not to lime, calcium and magnesium levels as well as soil pH are generally low. The potential for Al and Mn toxicity also exists due to the increase in solubilities of these elements with low soil pH. Yields of potatoes grown on many of these coarse-textured soils have generally declined over the past 10 years. Part of this problem may be due to lack of proper rotation coupled with an imbalanced soil fertility.

The objective of the present study was to determine the influence of Ca and Mg amendments on nutrition and production of potatoes grown on a soil with a history of continuous potatoes.

Materials and Methods:

The site was located in Cambridge, MN on an Anoka loamy sand. Potatoes had been grown on this site for the past 10 - 15 years. Treatments included:

1. Control
2. 0.4 T/A lime
3. 0.8 T/A lime
4. 1.2 T/A lime
5. 0.48 T/A gypsum + 0.56 T/A Epsom salts
6. 0.96 T/A gypsum + 1.12 T/A Epsom salts
7. 1.44 T/A gypsum + 1.68 T/A Epsom salts

All amendments were applied 8 November 1983 as a broadcast and disked in. The following spring the entire field was deep plowed to a depth of 8" - 10". The liming material used was a finely ground (200 mesh) dolomitic lime which enabled a relatively fast reaction with the soil. The gypsum/ Epsom salt combination was used to provide an equal amount of Ca and Mg as a non-lime source. Spacing used was 3' between row centers. Applications of N, P and K were made according to soil test recommendations. The cultivar used was 'Norland' planted on 23 April 1984. To monitor changes in soil pH, Ca and Mg levels, soil samples were collected on 7 November 1983, 4 April, 7 July, and 24 August 1984. Plant tissue samples consisting of the most recently matured whole leaf (blade and petiole) were collected 15 June, 6 July, and 24 July 1984 and subsequently analyzed for nutrient composition. Two center 15' rows of each plot were harvested on 28 August 1984 with the following measurements recorded: total yield, A-size, B-size and scab ratings. A randomized complete block design with 4 replications was used. Because this experiment was of a preliminary nature, non-orthogonal comparisons were used to determine the significance of trends observed throughout the experiment. This information will be used in the design of future experiments dealing with potatoes on acid soils.

Results and Discussion:

Soil Data -- Initial chemical properties of the soil before treatments were applied are provided in Table 1. Phosphorus levels were excessive while Ca and Mg levels were low. At the begining of the growing season fine dolomitic limestone increased soil pH slightly compared to a slight decrease with the gypsum and Epsom salts (Table 2). By the end of the season soil pH levels were low for all treatments. Soil Ca and Mg levels tended to be higher when amendments were added. As with pH, differences between the control and treated areas were minimal by the end of the season. Higher rates appear to be warranted in future studies.

Yield Data -- Regardless of source, there was a significant trend for plots receiving Ca and Mg to yield more A-size potatoes (Table 3). In general, potato yields were poor for the entire experiment regardless of treatment. This was probably due to die-back of the tops about two weeks earlier than expected. Symptoms of Verticillium wilt and Rhizoctonia were noted in the field. It appears that both of these factors, poor soil fertility and an increase in disease incidence are a consequence of continuous potatoes. In this study disease problems appeared to be the overriding factor. At the rates of amendments used, there was no effect on scab incidence.

Tissue Analysis -- Significant effects due to Ca and Mg amendments on leaf nutrient composition were apparent throughout the experiment (Tables 4 - 6). The most consistent reponses were high leaf Ca and Mg, and lower leaf K and Mn in the treated plots compared to the control plot. At the rates used, gypsum plus Epsom salts were more effective than dolomitic lime in depressing leaf Mn levels. It is conceivable that high tissue Mn coupled with low tissue Ca may increase susceptibility of these plants to disease.

The assistance of G. Buzicky, M. O'Leary and T. King during the course of this study is greatly appreciated.

Table 1. Initial soil chemical properties. Samples collected before treatment application. (Means of 4 samples.)

Soil Depth (inches)	pH	Buffer Index	P	K	Ca	Mg	O.M.	SO_4-S
			-------		lb/A	------	%	ppm
0-6	4.9	6.3	520	328	314	65	1.4	3
6-12	4.8	6.5	475	251	307	43	1.2	7
12-24	4.9	6.8	256	331	754	110	0.6	25

Table 2. Soil pH, calcium and magnesium levels during the course of the experiment. (Means of 2 replications.)

Soil Chemical Property	Treatment[1]	Date 4/84 Soil Depth (inches) 0-6	6-12	12-24	7/84 0-6	6-12	12-24	8/84 0-6	6-12	12-24
pH										
	1	4.8	4.7	4.9	4.2	4.5	4.6	4.5	4.3	4.5
	2	5.0	4.9	5.0	4.7	4.7	4.6	4.5	4.3	4.5
	3	5.0	4.8	5.1	4.5	4.8	4.6	4.5	4.6	4.5
	4	5.2	4.9	5.2	4.7	4.7	4.6	4.6	4.6	4.5
	5	4.7	4.7	4.7	4.5	4.6	4.6	4.7	4.4	4.6
	6	4.7	4.6	4.5	4.6	4.5	4.6	4.6	4.3	4.5
	7	4.6	4.5	4.6	4.6	4.5	4.6	4.6	4.3	4.5
Ca (lb/A)	1	184	189	530	169	147	484	178	195	409
	2	214	180	543	149	227	505	185	195	462
	3	221	204	553	203	219	595	184	266	463
	4	236	208	532	177	207	407	205	283	454
	5	184	179	491	185	246	561	173	233	500
	6	249	156	438	197	237	383	194	207	390
	7	444	163	470	197	266	420	168	308	428
Mg (lb/A)	1	52	46	100	37	31	99	47	56	104
	2	66	42	93	43	43	86	48	57	115
	3	72	51	96	40	58	107	41	93	111
	4	79	48	109	43	54	102	53	103	122
	5	75	77	146	47	65	152	59	73	165
	6	98	84	183	52	57	149	60	60	179
	7	85	102	239	48	49	156	60	71	166

[1]See Materials and Methods for treatment code.

Table 3. Total yield, A-size, B-size and scab rating as influenced by calcium and magnesium amendments.

Treatment[1]	B-size (cwt/A)	A-size (cwt/A)	Total (cwt/A)	Scab Rating[2]
1	51.8	38.7	90.5	1.75
2	51.4	63.9	115.7	1.58
3	47.3	70.7	118.1	1.48
4	66.1	62.4	128.5	1.65
5	61.6	67.0	128.6	1.67
6	44.0	73.6	117.7	1.68
7	49.9	88.1	137.9	1.75
CV (%)	22.9	35.4	25.3	13.7
Non-orthogonal Contrasts	Significance[3]			
Lin. Lime	-	-	-	-
Quad. Lime	-	-	-	-
Lin. G+E[4]	-	++	+	-
Quad. G+E	-	-	-	-
Lime vs G+E	-	-	-	-
Control vs lime+G+E	-	++	+	-

[1]See Materials and Method section for treatment code.
[2]Scale 0 - 5, 0 = no scab.
[3]++ = 5% level, + = 10% level.
[4]G+E = gypsum plus Epsom salts.

Table 4. Elemental concentrations in recently mature leaves 53 days after planting.

Treatment[1]	N	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	%					ppm					
1	5.20	0.63	6.74	0.33	0.30	235	219	614	39	5	46
2	5.40	0.64	6.55	0.37	0.33	239	214	547	41	5	41
3	5.29	0.70	7.52	0.42	0.38	239	211	506	48	7	42
4	5.13	0.64	6.83	0.36	0.38	224	196	502	40	6	41
5	5.01	0.64	6.70	0.44	0.36	250	192	436	44	6	40
6	5.39	0.69	6.63	0.40	0.36	252	188	380	49	7	40
7	5.36	0.68	6.71	0.40	0.38	250	180	373	52	5	39
CV(%)	2.8	6.4	7.3	13.1	11.8	11.2	9.4	10.3	13.1	34.5	11.3
Non-orthogonal Contrasts	Significance[2]										
Lin. Lime	-	-	-	++	++	-	-	++	-	-	-
Quad. Lime	++	-	-	-	-	-	-	-	+	-	-
Lin. G+E[3]	++	++	-	++	++	-	-	++	++	-	++
Quad. G+E	-	-	-	-	-	-	-	-	-	-	-
Lime vs G+E	-	-	-	-	-	-	-	++	+	-	-
Control vs Lime+G+E	-	-	-	++	++	-	-	++	++	-	++

[1]See Materials and Method section for treatment code.
[2]++ = 5% level, + = 10% level.
[3]G+E = gypsum plus Epsom salts.

Table 5. Elemental concentrations in recently mature leaves 74 days after planting.

Treament[1]	N	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	%					ppm					
1	4.26	0.41	7.86	0.74	0.44	540	365	1194	50	7	82
2	3.92	0.44	8.01	0.81	0.46	536	388	1144	43	6	93
3	4.07	0.39	7.61	0.85	0.47	387	320	883	37	5	64
4	4.05	0.41	7.45	0.96	0.53	476	354	943	39	8	84
5	4.32	0.42	7.73	0.77	0.47	519	384	918	49	6	80
6	4.26	0.42	7.21	0.81	0.46	560	375	850	47	6	73
7	4.34	0.41	6.76	0.85	0.47	585	320	821	49	5	69
CV(%)	6.3	7.6	8.2	11.5	13.6	21.6	16.0	9.0	14.5	28.6	27.1
Non-orthogonal Contrasts	Significance[2]										
Lin. Lime	-	-	-	++	++	-	-	++	++	-	-
Quad. Lime	-	-	-	-	-	-	-	-	-	+	-
Lin. G+E[3]	-	-	++	-	++	-	-	++	-	-	-
Quad. G+E	-	-	-	-	-	-	-	-	-	-	-
Lime vs G+E	++	-	+	+	-	-	-	++	++	-	-
Control vs Lime+G+E	-	-	-	+	++	-	-	++	-	-	-

[1]See Materials and Method section for treatment code.
[2]++ = 5% level, + = 10% level.
[3]G+E = gypsum plus Epsom salts.

Table 6. Elemental concentrations in recently mature leaves 92 days after planting.

Treatment[1]	N	P	K	Ca	Mg	Fe	Al	Mn	Zn	Cu	B
	%					ppm					
1	3.59	0.26	8.67	1.03	0.36	480	339	1702	54	107	107
2	3.72	0.27	8.33	1.07	0.47	435	282	1510	45	75	95
3	3.69	0.23	8.27	1.25	0.56	386	279	1307	43	84	69
4	3.70	0.25	8.35	1.29	0.55	393	324	1332	46	87	78
5	3.80	0.25	8.01	1.06	0.51	351	269	1299	43	66	95
6	3.78	0.25	7.90	1.17	0.53	475	294	1306	51	72	77
7	3.71	0.25	7.85	1.28	0.53	538	270	1230	60	66	75
CV(%)	4.8	12.3	5.1	8.8	12.5	27.9	16.3	8.2	20.2	27.6	21.0
Non-orthogonal Contrasts	Significance[2]										
Lin. Lime	-	-	-	++	++	-	-	++	-	-	++
Quad. Lime	-	-	-	-	-	-	++	+	-	-	-
Lin. G+E[3]	-	-	++	++	++	-	-	++	-	++	++
Quad. G+E	-	-	-	-	-	-	-	+	+	-	-
Lime vs G+E	-	-	++	-	-	-	-	+	-	-	-
Control vs Lime+G+E	-	-	++	++	++	-	+	++	-	++	++

[1]See Materials and Method section for treatment code.
[2]++ = 5% level, + = 10% level.
[3]G+E = gypsum plus Epsom salts.

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO CROP YIELDS AND PLANT ANALYSIS DATA

J. Grava, W. E. Fenster, S. D. Evans, J. A. Lamb,
M. O'Leary, G. Buzicky, and R. K. Severson

The objective of this study was to determine the relationship between crop yield and plant tissue phosphorus (P), and the amounts of phosphorus extracted by various soil testing methods. These experiments, to establish guidelines for making fertilizer recommendations from soil tests, have been conducted on private farms and at the Branch Experiment Stations since 1981.

EXPERIMENTAL PROCEDURE

Several field experiments were established on calcareous soils in western Minnesota in 1981 to evaluate three P soil tests and their relationship to crop response from P additions. The crops included spring wheat, barley, corn and soybeans. Information on location, soil type, crop and soil test levels of 1984 phosphorus trials is given in Table 1.

Table 1. Cooperator, county, soil type, crop, and soil test levels for 1984 phosphorus trials.

Cooperator:	Crookston Exp. Stn.	Morris Exp. Stn.	Dahl Farm
County:	W. Polk	Stevens	Norman
Soil Series:	Hegne	Doland	Vallers
Texture:	Sicl	Sil	Sil
Crop:	Wheat	Wheat	Barley
Soil pH:	8.0	7.8	8.3
Olsen P (lb/A):	15	6	12
Exch. K (lb/A):	314	263	302

The three soil tests compared were the Bray-1 method using 1:10 or 1:50 ratio of soil to extracting solution, and the Olsen sodium bicarbonate method. The Bray-1 method, used at a 1:10 soil/solution ratio, was adopted by the University of Minnesota Soil Testing Laboratory for routine analysis in 1954. This method is especially well suited for assessing P availability in acid to slightly alkaline soils. The reliability of the P soil test on calcareous soils was improved in 1975 by changing the soil/solution ratio from 1:10 to 1:50. In 1982, the Olsen method of extracting soil P was introduced for soils having pH over 7.4.

In the 1984 trials, only the 30 lb/A broadcast phosphate rate was applied, except at the Morris Station where the broadcast P effects were compared with and without the starter fertilizer.

RESULTS AND DISCUSSION

The yields of spring wheat for 1981, 1982, 1983, and 1984 are given in Tables 2 and 3, and Table 4 gives plant tissue and soil test results.

Wheat

Hegne sicl, Crookston Exp. Stn., Olsen P 15 lb/A (Fall 1983). Neither the yield nor the P concentration in plant tissue were affected by fertilization. Very high relative levels of P were indicated by the Bray-1 method (1:10 and 1:50) on this soil. Extractable P levels by all three methods were increased by broadcast fertilizer.

Wheatville sil, Crookston Exp. Stn., Olsen P 10 lb/A (Fall 1983). The yield was increased by 8 to 10 bu/A with 30 lb P_2O_5/A applied every year and from the carryover of 60 or 90 lb P_2O_5/A applied in 1982. On this soil which demonstrated relatively low P availability, tissue analysis and extractable P levels by three methods showed close relationship with the amounts of P applied.

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Doland sil, Morris Exp. Stn., Olsen P 6 lb/A (Fall 1983). Broadcast rates applied in 1983 and 1984 (30 lb P_2O_5/A) were reflected in increased percentage of P of plant tissue and higher soil test levels by all three methods. Increased yields were observed as a result of annual applications of phosphate fertilizer, either broadcast or banded, and from higher soil P levels, increased as a result of previous application of phosphate fertilizer.

Barley

Vallers sil, Dahl Farm, Olsen P 12 lb/A (Spring 1984). The yield was not determined because excessive rainfall in May and June resulted in heavy infestation with weeds and poor growth of barley. Gradual increases in plant tissue P and in extractable P by three methods resulted from broadcast phosphate applications.

Concentrations of eight plant nutrients in plant tissue are reported in Table 4. The concentration of zinc in tissue was decreased by fertilization with P in all experiments.

Table 2. Wheat yield at 13% moisture as affected by phosphorus fertilization in 1981, 1982, 1983 and 1984.

Treatment	Location									
Broadcast	Crookston Exp. Stn.						Morris Exp. Stn.			
P_2O_5	Hegne			Wheatville						
	1982	1983	1984	1982	1983	1984	1981	1982	1983	1984
Lb/acre	Bu/acre									
0	51	54	60	53	43	57	63	61	51	74
30	46	58	59	55	49	67	64	65	57	83
60	48	51	60	57	42	65	64	68	59	77
90	46	54	55	55	46	67	64	69	59	80
Significance	ns	+	ns	ns	ns	**	ns	*	**	+
BLSD (0.05)		5				7				
Starter	-	-	-	-	-	-	64	68	58	80
No Starter	-	-	-	-	-	-	64	64	54	77
Significance							ns	*	*	ns

Table 3. Wheat yield at 13% moisture as affected by broadcast and row applied phosphate fertilizer, Morris.

Treatment		Year			
Broadcast	Starter	1981	1982	1983[1/]	1984[1/]
P_2O_5 Lb/A		Bu/Acre			
0	-	63	56	44	68
0	+	64	67	57	80
30	-	62	64	56	81
30	+	65	67	58	85
60	-	65	68	58	77
60	+	63	68	59	75
90	-	64	69	58	80
90	+	64	68	59	79
Interaction					
Significance		*	*	**	*
C.V.%		2.5	5.7	3.9	3.2

1/ Only 30 Lb P_2O_5 rate applied in 1983 and 1984.

Table 4. Phosphorus concentration of entire wheat plant and barley plant at boot stage and relationship to P treatment and soil test.[1/]

Treatment	Location												
Broadcast	Crookston Exp. Stn.						Morris Exp. Stn.[2/]				Dahl Farm		
P_2O_5	Hegne Wheat			Wheatville Wheat			Wheat				Wheat	Barley	Barley
	1982	1983	1984	1982	1983	1984	1981	1982	1983	1984	1982	1983	1984
Lb/acre	Plant Tissue P %												
0	.30	.32	.28	.28	.30	.27	.16	.22	.27	.27	.27	.27	.20
30	.30	.33	.30	.26	.30	.29	.18	.26	.32	.32	.28	.31	.23
60	.30	.33	.29	.28	.32	.30	.18	.29	.32	.32	.29	.33	.24
90	.31	.34	.30	.28	.33	.32	.20	.31	.34	.34	.29	.36	.23
Significance	ns	*	ns	+	ns	**	ns	**	*	**	ns	*	**
BLSD (0.05)		.01				.01			.04			.06	.03
	Olsen P Lb/A												
0	20	16	15	15	10	10	11	6	5	6	17	14	12
30	-	22	21	-	10	12		13	9	10		15	16
60	-	24	27	-	16	25		15	12	11		19	21
90	-	30	34	-	18	26		23	15	16		21	34
	Bray-1 1:10 P Lb/A												
0	54	34	32	16	10	9	15	10	7	8	23	12	8
30	-	45	43	-	13	12		18	12	10	-	16	15
60	-	46	53	-	22	27		23	17	13	-	22	18
90	-	52	58	-	28	38		33	19	19	-	22	26
	Bray-1 1:50 P Lb/A												
0	84	81	71	60	54	45	21	12	38	30	57	45	62
30	-	96	86	-	54	48		23	34	34	-	46	70
60	-	101	104	-	72	84		25	42	40	-	64	86
90	-	111	112	-	70	82		33	48	55	-	66	102

1/ 1982 Crookston and Dahl trials were sampled in spring of 1982 prior to treatment, Morris trial was sampled in fall 1981.

1983 Crookston and Morris trials were sampled in fall of 1982, Dahl trial was sampled in spring of 1983. All 1984 trials were sampled in fall of 1983.

All soil test results are means of four replications.

2/ Plant and soil samples of Morris trial were collected from no starter plots.

Table 5. Plant nutrient concentration of wheat and barley at the boot stage, 1984.

Treatment Broadcast P_2O_5	Plant Nutrient							
	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Lb/A	----------%----------			----------ppm----------				
	Crookston Exp. Stn., Hegne, Wheat - whole plant at boot stage							
0	3.31	.33	.25	93	51	23	4	4
30	3.12	.30	.26	108	51	21	3	3
60	3.16	.31	.24	84	51	19	3	3
90	3.15	.29	.22	88	49	18	3	3
Significance						**		
BLSD (0.05)						4		
	Crookston Exp. Stn., Wheatville, Wheat - whole plant at boot stage							
0	3.63	.33	.26	100	59	31	5	4
30	3.62	.34	.28	89	61	27	5	4
60	3.39	.35	.30	171	63	29	6	4
90	3.37	.34	.26	147	58	27	4	4
Significance						*		
BLSD (0.05)						3		
	Morris Exp. Stn., Doland, Wheat - whole plant at boot stage							
0	3.49	.32	.24	85	42	25	4	4
30	3.51	.37	.26	97	43	20	4	4
60	3.54	.39	.26	89	42	19	3	4
90	3.53	.40	.26	86	40	18	3	4
Significance						**		
BLSD (0.05)						2		
	Dahl Farm, Vallers, Barley - whole plant at boot stage							
0	2.19	.45	.25	48	41	15	3	4.1
30	2.03	.45	.22	28	41	13	2	3.5
60	1.97	.38	.25	28	30	12	2	3.4
90	1.71	.44	.23	26	34	10	2	3.3
Significance				**		**	**	**
BLSD (0.05)				15		3	1	.6

All indicated P rates were broadcast in 1982; the 30 lb rate was also applied in 1983 and 1984.

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS. 1981 Through 1984.

W. E. Fenster and G. W. Rehm

Even though micronutrients for agriculture have been in use for a long time, little or no research has been done to relate soil tests of these elements to their response in the field. Sulfur and magnesium, even though not micronutrients, were also included as a variable.

The micronutrient study was initiated on corn in 1981. Three of the original 6 locations were discontinued for various reasons in 1982 and the three that were continued were planted to soybeans, in 1983 one of these was planted to snap beans, the other two were in corn. In 1984 the Goodhue plot was discontinued. Corn was grown at Dakota Co. site and soybeans at the Martin Co. plot.

The "missing element" technique was used whereby a series of plots each having one of the nutrients omitted were compared to a treatment with all elements included. This design prevented other nutrients from being limiting factors if there was possible interaction. Only one rate of each element was used. Since most of the added nutrients were in the sulfate form the sulfur comparisons were established by themselves on an adjacent area. A boron trial, in addition to being included in the main experiment, was established on an adjacent area in order to have four levels of boron compared. Nitrogen, phosphorus and potassium were applied at or above adequate amounts. All plots were replicated four times.

Yields and Plant Analysis

Tables 1 through 5 show the 1981, 1982, 1983 and 1984 results. No significant yield increases were obtained but it is apparent that nutrient content in the leaves for some elements are increased by treatments (Tables 1 and 3). Iron, manganese and copper analysis did not show increases from treatment but were usually in the high category.

Soil Testing

There has been fine cooperation of private laboratories in testing soils from these plots. The Harris Laboratory at Lincoln, Nebraska, the A & L Laboratories at Omaha, Nebraska and Minnesota Valley Testing at New Ulm, Minnesota, have run soil analysis from all plots which will in final summary contribute a large volume of useful data.

Soil tests taken in the fall of 1983 show relationships to treatment for magnesium, zinc, copper and at high rates for boron. No effect from treatment was observed by sulfur, iron and manganese tests. The one pound boron treatment that was included in a factorial with the other nutrients only on occasion showed some sensitivity to this treatment but the treatments up to four pounds of boron show the positive effect (tables 5a and 5b). These tables also show the downward boron movement to the 2 foot depth during these 4 years. Generally the 4 labs show similar relationships between soil test and treatment.

The recommended treatments by the various labs are reduced or omitted compared to check plots. This indicates that the lab tests are sensitive to treatment and reflected in recommendations accordingly.

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

Table 1. Corn, soybean and snap bean yields, plant boron, and soil test boron from four levels of boron applications. 1981, 1982, 1983 and 1984.

Kingston Farm - Dakota Co. - irrigated
loamy sand

lbs B/A	Yield 1/ Bu/A		lb/A	Bu/A	ppm B 1/ leaf				Soil test - ppm hot H_2O			
	1981 Corn	1982 Soybeans	1983 Snap beans	1984 Corn	1981 Corn	1982 Soybeans	1983 Snap beans	1984 Corn	1981	1982	1983	1984 3)
0	155	36	12,440	159	7	43	21	9	0.25	0.2	0.2	
1	159	34	13,855	169	8	52	48	10		0.3	0.3	
2	147	32	12,472	162	12	67	72	13		0.5	0.8	
4 2/	160	27	13,728	165	18	112	60	8 2/		0.9	1.4	
significance	ns	**	ns	ns	**							
BLSD (.05)		4			3.5							
C.V.	5.0	82	33	6.2	21.9							

1/ Average of 4 replications, where statistics are shown.

2/ Four lb. rate not applied 1983 or 1984.

3/ See table 5.

Table 2. Yields[1/] in three counties comparing complete treatments of micronutrients plus Magnesium to plots using missing element techniques. 1981, 1982, 1983.

Treatment[2/] omitted (-) added (+)	Martin[3)] Yield[4)]				Dakota[3/] Yield[4/]			
	1981	1982	1983	1984	1981	1982	1983	1984
None	179	56	143	48	156	33	12,185	167
-Mg	181	51	144	46	160	35	14,814	158
-Zn	181	52	145	46	159	33	16,044	155
-Fe	182	53	148	48	151	34	15,036	161
-Mn	180	54	148	49	159	34	12,814	163
-B	178	52	148	46	152	34	14,596	167
-Cu	178	52	146	47	157	33	16,676	158
+ complete includes S	184	54	141	49	156	33	16,246	164
Significance	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	4.9	5.0	6.7	7.3	5.6	7.8	27.2	7.1

1/ average of 4 replications.

2/ 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.

3/ soils are irrigated sandy loam at Dakota Co., clay loam, non-irrigated in Martin Co.

4/ Martin Co., corn 1981, 1983; soybeans 1982, 1984.
Dakota Co. corn 1981, 1984; soybeans 1982; snap beans 1983.
Snap beans yields in pounds per acre.

Table 3. Plant analysis[1/] from micronutrient and magnesium treatments in trials at three counties. 1981, 1982, 1983.

Treatment[2/] omitted (-) added (+)	Martin[3)]								Dakota[3)]							
	(-)				(+)				(-)				(+)			
	81	82	83	84	81	82	83	84	81	82	83	84	81	82	83	84
Mg (%)	.58	.48	.45	.47	.58	.42	.53	.48	.27	.43	.52	.37	.27	.49	.50	.36
Zn ppm	21	42	14	38	24	48	20	44	29	45	25	20	34	47	27	25
Fe ppm	93	113	100	116	97	131	99	111	120	84	94	105	117	92	94	98
Mn ppm	56	61	46	87	61	97	57	58	76	63	54	76	77	58	60	63
B ppm	5	50	8	46	5	50	7	48	5	39	24	6	9	54	40	8
Cu ppm	3	10	3	9	3	11	3	10	10	10	8	8	10	10	8	9

1/ average of 2 replications from leaf opposite and below ear at silking time.

2/ symbol + is from treatment of all nutrients. Pounds of nutrients added Mg=50, Zn=10, Mn=10, B=1, Cu=5, in 1981 and 1982. Residual in 1983.

3/ irrigated sandy loam at Dakota Co. site, clay loam non-irrigated site in Martin Co.

4/ Martin Co. corn 1981, 1983; soybeans 1982, 1984.
Dakota Co. corn 1981, 1984; soybeans 1982; snap beans 1983.

Table 4. Yields, [1/] plant sulfur and soil test sulfur with and without sulfur treatments in two counties. 1981, 1982, 1983, and 1984.

Sulfur Treatment	Yield (bu/A)				Leaf test (% S)				U of M Soil Test (PPM S)			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
						Martin Co.						
None	183	54	144	47	.23	.31	.20	.30	16	1	6	12
50#/A	180	53	152	48	.29	.31	.22	.32	--	--	5	11
Significance	ns	ns	ns	ns								
						Dakota [2/]						
None	151	33	15966	155	.24	.28	.21	.21	6	1	6	10
50#/A	154	34	14493	143	.25	.30	.21	.21	--	2	6	10
Significance	ns	ns	ns	*								

[1/] average of 4 replications, corn at both sites 1981, soybeans in 1982, corn in 1983 in Martin Co. and snap beans in Dakota Co.

[2/] irrigated sandy loam soil in Dakota Co., clay loam in Martin Co. (non irrigated).

Table 5a. Boron soil tests in one foot increments to 5 feet of depth. Kingston farm, Dakota Co. [1/] Fall 1983.

Depth, feet	Boron treatment, lb B/A 0	1	2	4
	lbs B/A ppm			
0 - 1	.3	.6	.8	.9
1 - 2	.2	.3	.4	.6
2 - 3	.1	.1	.2	.2
3 - 4	.1	.1	.1	.1
4 - 5	.1	.1	.1	.1

Table 5b. Boron soil test on Jokela farm. Goodhue Co., Fall 1983.

Depth, feet	Boron treatment, lb/A 0	1	2	4
	lbs B/A ppm			
0 - 1	.6	1.1	1.2	1.7
1 - 2	.4	.4	.4	.6
2 - 3	.3	.2	.3	.4
3 - 4	.2	.3	.3	.3
4 - 5	.2	.2	.1	.2

[1/] irrigated sandy loam, Kingston farm; silt loam soil, Jokela farm.

[2/] The 4 pounds rate was not applied in 1983 or 1984.

[3/] All B tests are averages of 2 reps.

Table 6a. Soil test means for micronutrients. University of Minnesota Lab. 1981, 1982, 1983 and 1984.

Treatment 1/ omitted (-) added (+)	Martin							Dakota						
	(ppm except Mg which is lbs/A)													
		(-)			(+)				(-)			(+)		
	1981	1982	1983	1984	1982	1983	1984	1981	1982	1983	1984	1982	1983	1984
Mg	881	990	1124	632	970	1096	1134	312	295	317	444	364	435	577
Zn	1.0	1.2	2.2	1.2	2.3	5.4	6.8	1.0	1.4	1.4	1.6	4.2	6.2	4.5
Fe	21	42	25	26	26	24	30	41	78	56	52	80	48	43
Mn	41	40	22	25	40	17	18	21	19	10	12	18	8	10
B	1.20	2.1	2.2	2.0	1.8	2.4	1.7	.25	2.2	0.4	0.8	2.4	0.9	0.8
Cu	1.28	1.8	1.7	1.8	2.5	3.0	3.7	0.48	0.6	0.9	0.5	3.1	3.4	2.1

1/ 1981 soil test results before treatment applied, 1982 from treatment plots in 1981 and 1983 from treatment plots in 1981 and 1982, 1984 from plots treated 1981, 1982 and 1983.

Table 6b. Soil test means for micronutrients. Minnesota Valley soil test lab. 1983 and 1984.

Treatment omitted (-) added (+)	Martin Co.				Dakota Co.			
	(ppm except Mg which is lbs/A)							
	(-)		(+)		(-)		(+)	
	1983	1984	1983	1984	1983	1984	1983	1984
Mg	1325	1350	1200	1675	400	500	525	625
Zn	2.1	2.0	4.0	6.7	1.8	2.2	4.0	4.8
Fe	8	18	8	12	8	12	8	12
Mn	2	10	2	8	2	10	2	10
B	3	3	4	3	1.4	0.5	2.4	0.8
Cu	0.4	1.9	0.4	3.6	0.4	1.5	0.4	2.5

Table 6c. Soil test means for micronutrients. Harris Lab. 1983 and 1984

Treatment omitted (-) added (+)	Martin Co.				Dakota Co.			
	(ppm)							
	(-)		(+)		(-)		(+)	
	1983	1984	1983	1984	1983	1984	1983	1984
Mg	629	585	567	567	143	164	227	206
Zn	2.0	1.2	4.7	6.6	1.4	1.5	5.8	4.8
Fe	22	21	20	26	43	41	36	35
Mn	14	15	12	13	9	14	7	11
B	1.9	1.5	2.0	1.6	0.5	0.8	0.7	0.8
Cu	1.5	1.3	2.6	3.0	0.8	0.6	3.3	2.2

Table 6d. Soil test means for micronutrients. A & L lab. Fall 1983 and 1984.

Treatment omitted (-) added (+)	Martin Co. (-) 1983	Martin Co. (-) 1984	Martin Co. (+) 1983	Martin Co. (+) 1984	Dakota Co. (-) 1983	Dakota Co. (-) 1984	Dakota Co. (+) 1983	Dakota Co. (+) 1984
	(ppm)							
Mg	549	592	525	582	171	193	223	212
Zn	1.7	1.2	4.7	6.7	1.8	1.8	5.2	5.2
Fe	19	23	19	27	46	46	49	46
Mn	15	13	11	12	10	13	7	12
B	2.8	1.5	3.0	1.4	0.9	0.8	0.8	0.8
Cu	1.4	1.4	2.4	3.0	1.5	0.8	2.9	2.2

CONCENTRATIONS OF P AND K IN THE RIDGE IN SELCTED RIDGE-TILL PLANTING SYSTEMS

George Rehm, Floyd Bellin, Jack Morris and Dave Hanson

Ridge-till planting systems for corn and soybean production have increased substantially in recent years. There is ample evidence that traditional management practices must be changed to match this conservation tillage production system. Many questions arise about soil sampling procedures needed for growers who use the ridge-till planting system. Before this question can be answered, it's important to know something about the concentration of plant nutrients in the ridge. Therefore, the purpose of the study was to monitor the concentration of P and K in the ridge in situations where ridge-till practices had been used for several years under widely different conditions in Minnesota.

Experimental Procedures

Ridge-till fields in 3 counties (Martin, Pope, and Dodge) were sampled in 1984. The sampling procedure varied with county.

Two fields were sampled in Martin County. One field was in corn in 1984 following a soybean crop in 1983. The second field was soybeans in 1984 following the 1983 corn crop. Row spacing was 30 inches in both fields. Soil cores were taken at 4, 8, and 15 inches from the row. These cores were sectioned into 0-3 and 3-6 inch increments.

These ridges were sampled at 4 times during the growing seson (early May, late May, late July, and late October). Samples were analyzed for pH, P, and K.

In Pope and Dodge Counties, soil cores were taken in the row, then at 3, 6, 9, 12, and 15 inches from the row. These cores were divided into 0-3, 3-6, 6-9, and 9-12 increments. Six cores were composited to form one sample. These samples were also analyzed for pH, P, and K by standard soil testing procedures.

Results and Discussion

The results from Martin County are summarized in Tables 1, 2, and 3. In general, the pH values were lower for the early May sampling date and increased during the growing season. There was no distinct change in pH with depths that were sampled.

Soil test values for P were quite variable--especially for the field that was in corn in 1984 (Table 2). Because of this variability it is difficult to make conclusions from the data taken from the field planted to corn in 1984. Except for the early May sampling, the P concentration in the soybean field was relatively uniform with respect to distance from the row and the depth sampled to 6 inches.

The potassium concentration was also quite variable with time of sampling and with depth. Therefore, no definite conclusions can be made from this data at the present time.

Results of the analysis of soil samples collected from the ridge-till field in Pope County are summarized in Table 4. The pH of the field was higher than 7.5. Therefore, both the Bray and Kurtz #1 and the Olsen procedures were used for P analysis.

As would be expected, the P concentration decreased with an increase in depth of sampling. This was true for cores taken at all distances from the row. Except for the 9-12 inch segment, the P concentration was fairly uniform up to 9 inches from the center of the ridge. The same general statements can be made for the concentration of K in the ridge.

This Pope County field had been in a ridge-till system for approximately 5 years. The grower routinely used a 9-18-9 liquid fertilizer applied at relatively low rates. Consequently, there were no small zones having high concentrations of P and K in the ridge.

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

The Dodge County field had been in a ridge-till system for 14 years. The standard fertilizer program consisted of a broadcast application of K with annual use of 10-34-0 applied with the seed at planting. The pH at this site was less than 7.0.

Using the Bray and Kurtz #1 P test values as a measure of P concentration in the center of the ridge was relatively high to a depth of 9 inches. This reflects the repeated use of 10-34-0 with the seed. The P concentration in the 9-12 inch segment was relatively uniform with distance from the center of the ridge.

Considering the other segments sampled, the P concentration was relatively uniform at 3, 6, 9, and 12 inches from the center of the ridge. In general, the P concentration at any depth was lower at 15 inches from the center of the ridge. The concentration of K was somewhat variable, but, in general, followed the same pattern as the P concentration.

The data generated from this study are, by no means, conclusive. They do indicate, however, that the concentration of P and K in the ridge where ridge-till planting systems have been used is relatively constant to a depth of 6 inches and at a distance of 8 to 9 inches from the center of the ridge. So, a preliminary suggestion for sampling a ridge-till system would be to take the sample to a depth of 6 inches at a distance of 6 to 8 inches from the center of the ridge. This sampling technique would avoid fertilizer bands created by repeated application of starter fertilizer.

Table 1. The pH in the ridge of 2 fields in Martin County. 1984.

		1984 Crop							
		Corn				Soybeans			
Sample depth	Distance from ridge center	Early May	Late May	Late July	Late October	Early May	Late May	Late July	Late October
in.	in.								
0-3	4	7.3	7.5	---	8.0	7.5	7.6	---	7.8
3-6	4	7.4	7.6	---	8.0	7.5	7.6	---	7.9
0-3	8	7.4	7.6	---	7.5	7.5	7.6	---	7.9
3-6	8	7.4	7.5	---	7.8	7.6	7.7	---	7.9
0-3	15	7.5	7.6	---	7.9	7.6	7.7	---	7.9
3-6	15	7.5	7.6	---	7.8	7.6	7.7	---	7.9

Table 2. Soil test P in the ridge of 2 fields in Martin County. 1984.

		1984 Crop							
		Corn				Soybeans			
Sample depth	Distance from ridge center	Early May	Late May	Late July	Late October	Early May	Late May	Late July	Late October
in.	in.	lb. P/acre (Olsen)							
0-3	4	32	41	44	64	29	14	16	12
3-6	4	25	45	33	56	14	14	14	10
0-3	8	32	47	39	82	20	22	14	15
3-6	8	21	32	35	53	8	20	13	17
0-3	15	19	46	36	66	37	27	17	17
3-6	15	17	40	35	71	14	25	18	13

Table 3. Soil test K in the ridge of 2 fields in Martin County. 1984.

		1984 Crop							
		Corn				Soybeans			
Sample depth	Distance from ridge center	Early May	Late May	Late July	Late October	Early May	Late May	Late July	Late October
In.	In.	lb. K/acre							
0-3	4	640	650	430	560	550	280	180	240
3-6	4	550	610	360	460	250	200	140	210
0-3	8	580	700	390	430	270	260	200	300
3-6	8	490	650	310	510	240	240	140	240
0-3	15	410	680	400	530	550	470	160	270
3-6	15	560	610	340	420	300	310	230	220

Table 4. Soil test values for P and K in a ridge planting system has been used for several years in Pope County.

	Distance From Row (in.)					
Depth	0	3	6	9	12	15
in.	lb. P/acre (Bray)					
0 - 3	75	71	73	71	68	62
3 - 6	56	63	59	55	39	31
6 - 9	56	56	66	47	48	36
9 - 12	21	25	28	21	18	14

	Distance From Row (in.)					
Depth	0	3	6	9	12	15
in.	lb. P/acre (Olsen)					
0 - 3	37	30	37	33	25	26
3 - 6	24	24	29	23	16	17
6 - 9	20	27	29	20	18	16
9 - 12	15	19	16	11	14	10

	Distance From Row (in.)					
Depth	0	3	6	9	12	15
in.	lb. K/acre					
0 - 3	495	455	470	440	390	360
3 - 6	205	250	220	255	180	185
6 - 9	310	255	275	280	300	235
9 - 12	160	175	175	170	180	175

Table 5. Soil test values for P and K in a ridge where ridge planting system has been used for several years in Dodge County.

Depth	Distance From Row (in.) 0	3	6	9	12	15
in.	lb. P/acre (Bray)					
0 - 3	213	164	180	147	155	180
3 - 6	162	87	73	90	90	75
6 - 9	117	107	74	91	80	55
9 - 12	48	47	37	36	40	26

Depth	Distance From Row (in.) 0	3	6	9	12	15
in.	lb. P/acre (Olsen)					
0 - 3	84	53	54	52	53	40
3 - 6	50	32	32	27	24	24
6 - 9	31	29	21	23	21	17
9 - 12	17	14	15	13	11	11

Depth	Distance From Row (in.) 0	3	6	9	12	15
in.	lb. K/acre					
0 - 3	605	585	545	570	530	570
3 - 6	250	265	240	290	255	250
6 - 9	305	185	250	265	285	275
9 - 12	185	165	160	160	190	195

EVALUATION OF FOLIAR FERTILIZERS FOR STRAWBERRY PRODUCTION

C. J. Rosen, E. E. Hoover, J. J. Luby and H. J. Buchite

The objectives of this experiment were to: 1) determine the influence of various rates and timings of foliar fertilizers (16-4-4, 9-18-9) on strawberry production; 2) increase the data base for strawberry leaf tissue analysis; and 3) determine nutrient removal by the strawberry crop.

Procedure:

Treatments were applied to a second year (first fruiting season) planting of 'Earliglow' strawberries on a Gotham loamy sand soil. A randomized complete block design was used with 5 replications. The planting system was a matted row with 4 feet between row centers. Each plot consisted of one 20 foot row. The treatments included:

1) control (soil applied previous season, U of M recommendations)
2) 1 gal/A 16-4-4 applied during flowering
3) 1 gal/A 16-4-4 applied during fruit maturation
4) 1 gal/A 16-4-4 split applied during flowering and fruit maturation
5) 2 gal/A 16-4-4 split applied during flowering and fruit maturation
6) 2 gal/A 16-4-4 soil applied during flowering and fruit maturation
7) 2 gal/A 9-18-9 split applied during flowering and fruit maturation
6) 4 gal/A 9-18-9 split applied during flowering and fruit maturation.

Treatments were applied 24 May 1984 and 8 June 1984. Except for treatment 6 which was soil applied, all others were applied with a CO_2 sprayer fitted with a fan type nozzle. The fertilizers were applied with 12 gal water/A at 40 psi. All treatments included WEX, a surfactant at the rate of 3 ml/gal.

Yield measurements were recorded for all treatments on the following harvest dates: 18, 21, 27 June and 7 July 1984. On 21 June, the most recently mature leaves were sampled for subsequent elemental analyses.

More detailed measurements were made for treatments 1, 5 and 8. A subsample of fruit was taken from these treatments to determine moisture content and number of berries per pound. Total N concentrations in lyophilized fruit tissue were determined conductimetrically and other elements were determined by ICP spectroscopy.

Results:

Neither of the foliar fertilizers, at the rates and timing used, significantly increased strawberry yields (Table 1). There was a significant decrease in yield when 2 gal/A 9-18-9 was split applied during flowering and fruit maturation. The reason for this yield decrease is not known. At higher rates of 9-18-9 (4 gal/A) applied at the same times, no yield de-crease was observed.

Elemental concentrations in leaves sampled on 21 June are presented in Table 2. Foliar fertilizers had no significant effect on leaf nutrient levels. It is possible that rates applied were too low to bring about a significant increase. Leaf burn was not observed from any of the treatments.

When the higher rates of 16-4-4 and 9-18-9 were compared with the control at the individual harvest dates, no significant differences in yield and number of berries per pound were observed (Tables 3 and 4).

Total nutrient removal by the strawberry crop is presented in Table 5. No differences due to foliar fertilizers were detected. In all cases, strawberry fruit appeared to remove relatively large amounts of potassium.

Table 1. Total yield of 'Earliglow' strawberries as influenced by foliar fertilizer (total from four harvest dates).

Treatment	Yield (T/A)
Control	8.07
1 gal/A 16-4-4 (fl)[1]	8.41
1 gal/A 16-4-4 (fr)[2]	8.76
1 gal/A 16-4-4 (fl + fr)	8.19
2 gal/A 16-4-4 (fl + fr)	7.97
2 gal/A 16-4-4 (soil)	8.60
2 gal/A 9-18-9 (fl + fr)	6.20
4 gal/A 9-18-9 (fl + fr)	8.36
Significance	**
BLSD (0.05)	1.34
CV (%)	11.6

[1]fl = applied during peak flowering
[2]fr = applied during fruit maturation

Table 2. Elemental concentrations in strawberry leaves (leaflets and petiole) sampled at peak harvest.

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Control	1.64	0.27	2.25	1.03	0.29	58	576	17	4	41
1 gal/A 16-4-4 (fl)[1]	1.70	0.28	2.36	0.95	0.29	52	625	18	4	39
1 gal/A 16-4-4 (fr)[2]	1.69	0.28	2.24	0.96	0.29	58	548	19	5	37
1 gal/A 16-4-4 (fl + fr)	1.66	0.28	2.28	0.96	0.29	53	639	19	5	40
2 gal/A 16-4-4 (fl + fr)	1.75	0.29	2.37	0.95	0.29	56	641	19	5	38
2 gal/A 16-4-4 (soil)	1.67	0.28	2.23	1.07	0.30	59	486	19	5	43
2 gal/A 9-18-9 (fl + fr)	1.65	0.30	2.43	0.88	0.29	55	631	20	5	37
4 gal/A 9-18-9 (fl + fr)	1.65	0.29	2.34	0.99	0.29	57	524	20	5	41
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	7.1	8.3	8.1	9.9	7.7	7.9	19.4	10.5	10.4	14.6

[1]fl = applied during peak flowering
[2]fr = applied during fruit maturation

Table 3. Strawberry yield at each harvest as influenced by 2 gal/A 16-4-4 and 4 gal/A 9-18-9.

Treatment	Harvest Date 6/18	6/21	6/27	7/3
	T/A			
Control	1.38	1.77	3.51	1.41
2 gal/A 16-4-4	1.47	1.92	3.42	1.16
4 gal/A 9-18-9	0.85	2.01	3.85	1.65
Significance	NS	NS	NS	NS
CV (%)	31.9	19.9	17.4	33.4

Table 4. Number of berries per pound at each harvest date as influenced by 2 gal/A 16-4-4 and 4 gal/A 9-18-9.

Treatment	Harvest Date 6/18	6/21	6/27	7/3
	berries /lb			
Control	20.8	28.2	41.6	81.8
2 gal/A 16-4-4	22.9	30.4	47.4	86.6
4 gal/A 9-18-9	20.2	29.7	43.2	73.8
Significance	NS	NS	NS	NS
CV (%)	14.4	12.7	18.6	16.3

Table 5. Total nutrient removal by strawberry fruits as influenced by 2 gal/A 16-4-4 and 4 gal/A 9-18-9 (total from four harvest dates)[1].

Treatment	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb/A					oz/A				
Control	13.9	4.2	35.3	4.3	3.0	1.17	4.42	0.34	0.15	0.39
2 gal/A 16-4-4	13.9	4.0	33.8	4.1	2.8	1.14	4.71	0.33	0.10	0.39
4 gal/A 9-18-9	14.3	4.3	35.6	4.5	3.1	1.19	4.67	0.35	0.14	0.41
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	12.0	11.6	11.2	16.1	15.1	20.8	27.3	27.3	31.9	12.2

[1]Yield for each treatment provided in Table 1.

FIELD TRIALS WITH "BASIC-H" 1983 and 1984

W. E. Fenster and G. W. Rehm

The effects of the wetting agent "Basic-H" were studied at several experimental farms and by growing various crops. This product is not marketed as a plant food but meant to improve water penetration and thus better water use efficiency.

Plots were established on fine textured, clay loam soils of high organic matter at Waseca, and Lamberton. The trials at the Morris station were on silt loam soils. The experiments conducted at Crookston were on high organic matter soils, the 1983 trial on a fine sandy loam, the 1984 trial on a loam soil. The trials at Becker were on very well drained loamy sands with low organic matter and were conducted under irrigation.

Under conditions of 1983 and 1984 no significant benefits were obtained by the use of the wetting agent except from one treatment on wheat at the Morris station.

Trials at the Waseca and Lamberton stations were conducted by G. W. Randall, W. W. Nelson respectively. The following tables present 1983 and 1984 results.

Table 1. Effects of Basic-H on corn yields, moisture at harvest and plant population at Waseca and Lamberton experiment stations 1983 and 1984.

	Yield (Bu/A)				Moist (%)				Pop. (x 1000)	
	Waseca		Lamberton		Waseca		Lamberton		Waseca	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
Control	56	68	62	94	21.6	21.5	23.2	31.5	27.1	26.6
Fertilizer (U of M recommendation)*	121	141	85	115	20.5	19.5	21.7	30.0	27.0	27.8
Fertilizer + Basic-H (1 gal./A)	111	141	87	116	20.4	19.3	22.1	31.5	27.6	28.2
Fertilizer + Basic-H (2 gal./A)	117	145	87	121	20.6	20.3	21.4	31.3	26.3	29.2
Basic-H only (1 gal./A)	53	58	54	95	21.8	22.6	23.1	31.8	26.8	26.1
Significance	**	**	**	**	**	**	ns	ns	ns	ns
BLSD (.05)	10	8	14	7	.6	2.5	--	--	--	--
C.V.	7.6	5.0	9.0	4.5	.8	7.3	4.2	2.9	4.9	6.8
*Fertilizer recommended	N		P_2O_5		K_2O					
Waseca lbs/A	175	170	50		150					
Lamberton lbs/A	150	150	60	60	60	60				

*This research partially funded by the Shaklee Corporation.

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In Table 1b results at Waseca of another wetting agent "Amway Spray Adjuvant" are shown.

Table 1b. Effects of Amway Spray Adjuvant on corn yield, moisture at harvest and plant population, Waseca, MN 1983 and 1984.

	Yield (Bu/A)		Moist (%)		Population (X 1000)	
	1983	1984	1983	1984	1983	1984
Control[1)]	56	68	21.6	21.5	27.1	26.6
Fertilizer (U of M recommendation)*	121	141	20.5	19.5	27.0	27.8
Fertilizer + Amway (1 gal./A)	115	142	20.4	18.7	27.2	28.7
Fertilizer + Amway (2 gal./A)	114	140	20.4	19.3	27.6	28.4
Amway only (1 gal./A)	50	71	21.8	22.2	26.6	26.5
Significance	**	**	**	**	ns	ns
BLSD (.05)	8.4	10	.8	2.6	--	--
C.V.	6.6	6.6	1.1	7.7	4.3	7.5
*Fertilizer recommended	N		P_2O_5		K_2O	
lbs./A	175	170	50	0	150	0

[1)] Soil test 1984, pH=6.8, P=30, K-345

Results from trials with "Basic-H" at the Morris station on wheat conducted by S. D. Evans and W. E. Fenster are shown in Table 2.

Table 2. Effects of Basic-H on wheat yields and moisture at harvest time. Morris, MN 1983 and 1984.

	Yield (Bu/A)		Moist (%)	
	1983	1984	1983	1984
Control[1)]	41	84	13.2	12.2
Fertilizer (U of M recommendation)*	55	75	12.2	12.6
Fertilizer + Basic-H (1 gal./A)	59	80	13.8	12.6
Fertilizer + Basic-H (2 gal./A)	56	81	13.9	12.6
Basic-H only (1 gal./A)	46	80	13.0	12.3
Significance	**	ns	ns	ns
BLSD (0.5)	4.5	--	--	--
C.V.	6.1	6.6	2.8	1.6

*Fertilizer recommended	N		P_2O_5	K_2O	
lbs/A	50	80	0 0	0	30

1) Soil test 1984, pH=7.2, P=46, K=278

Table 3. Effects of Basic-H on sunflower yield, annual oil content. Crookston, MN. 1983 and 1984.

	Seed Yield (lbs/A)				Oil %	
	1983	1984			1983	1984
Control	964	1743			37.5	42.6
Fertilizer (U of M recommendation)*	1180	1825			38.0	42.5
Fertilizer + Basic-H (1 gal/A)	1192	1949			37.4	42.5
Fertilizer + Basic-H (2 gal/A)	1169	1873			37.1	42.7
Basic-H only (1 gal/A)	996	1795			37.8	42.9
Significance	ns	ns			ns	ns
C. V.	11.4	8.9			3.4	1.5
*Fertilizer Recommendation	N		P_2O_5		K_2O	
lbs/A	90	18	50	46	100	0

1984 soil test - NO_3-N=86, P=13, K=260, O.M.+3.1%

Table 4. The effect of "Basic-H" on potato yield. Becker, MN. 1983 and 1984.

		Yield (Wt/A)		
		1983	1984	
Control		334	330	
Fertilizer (U of M recommendation)*		460	478	
Fertilizer + Basic-H (1 gal/A)		446	453	
Fertilizer + Basic-H (2 gal/A)		424	445	
Basic-H only (1 gal/A)		318	340	
Significance		**	**	
B.L.S. D. (.05)		98	37	
C. V.		11.0	6.3	
Fertilzer Applied	N	P_2O_5	K_2O	S
lbs/A - 1983	150[1/]	150	400	15
lbs/A - 1984	210[1/]	100	300	15

1984 soil test - pH=6.5, P=65, K=223, Mg=325, S=4, Zn=.8

[1/] 1983 N is applied in 3 different application times.
1984 N is applied in 4 different application times.

Field trials with "Reward" 1984

G. W. Rehm, W. E. Fenster, Sam Evans and John Lamb

Experiments with "Reward" were established on sunflowers at Crookston and on wheat at Morris, 1984. The product was used on plots where 75% of the recommended N was applied and compared to the 100% N applicaton. The Reward was foliar applied at the growth stage according to label instructions. Soils in these trials were Wheatville loam at Crookston and Tera silt loam at Morris. Reward contains no nutrients but is used on plants, soil or seeds to make more efficient use of nitrogen by the plant. The management practices at Morris were as follows: Era wheat was seeded at 1-1/3 bushels per acre on April 25. The fertilizer was broadcast and incorporated before planting. Harvest was in early August.

The management practices at Crookston were: Interstate 894 was the sunflower variety. The seeding rate was 21,550 seeds per acre. Planting was on May 30. The fertilizer was broadcast and incorporated before planting. Leaf application of Reward was made on July 6. The insecticide Pydrin at 1/3 pint per acre was applied July 20 for control of sunflower beetle and again on August 9 for control of the banded moth.

At Morris on wheat the 80 pounds of N per acre recommended was actually too high and caused reduction in yield due to lodging. The 75% N rate or 60 pounds of N resulted in a significantly higher wheat yield over the 80 pound rate. The addition of Reward at both 12 oz. and 24 oz. rate to the 75% N rate had no significant effect on yield.

At Crookston the recommended N rate for sunflowers was only 18 pounds of N per acre along with 46 pounds of P_2O_5. The 75% N treatment was therefore reduced to zero N since the difference between 13-1/2 and 18 pounds of N wouldn't be very meaningful. The treatments used had no significance on sunflower production at Crookston.

Results are shown in Table 1.

Table 1. The effects of "Reward" on sunflowers and wheat. 1984.

	Crookston Sunflowers		Morris Wheat		
Treatments	Yield lbs/A	oil %	Yield Bu/A	H_2O %	test Wt. lbs/bu
1. Check	1743	42.6	84	12.2	59.0
2. U.M. recommended	1825	42.5	75	12.6	58.9
3. *75% U.M. N rec. + 100% P and K	1787	42.9	84	12.1	60.0
4. *75% U.M. N rec. + 12 oz. Reward	1905	43.4	81	124	59
5. *75% U.M. N rec. + 24 oz. Reward	1791	41.0	81	126	60
Significance	ns	ns	**	ns	ns
BLSD (.05)	--	--	5.2	--	--
C.V.	10.5	3.0	4.0	2.5	2.8

*U.M. recommendation as follows: Sunflowers N=18 lbs/A, P_2O_5=46, K_2O=0
No. 3 treatment = 0, 46, 0

Wheat N=80 lbs/A, P_2O_5=0, K_2O=30
No. 3 treatment = 60 MO/A, P_2O_5=0, K_2O=30

Soil tests	pH	P	K	NO_3-N	O.M%
Sunflowers	7.8	13	260	86	3.1
Wheat	7.2	46	278	40	3.5+

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

EFFECT OF SULFUR FERTILIZATION ON YIELD AND QUALITY OF ALFALFA AND CORN IN MINNESOTA

George Rehm, Bill Fenster, Mike O'Leary and Greg Buzicky

The importance of S fertilizers for crop production on the sandy soils of Minnesota has been recognized for a number of years. To date most of the research has focused on the effect of S fertilizers on crop yield. Very little attention has been given to the effect of the use of S on the quality of the crops produced. Therefore, this study was designed to evaluate the effect of S additions to a fertilizer program on both yield and quality of corn and alfalfa on widely different soils in Minnesota.

Experimental Procedure:

Alfalfa studies--Studies with alfalfa were conducted at 2 locations (Staples, Winona County). Two sites were selected in Winona County. One site had no history of manure application in recent years. The second site had been manured heavily.

Gypsum was broadcast to the established stand at all sites in early April at rates to supply 0, 25, 50, 75, and 100 lb. S/acre. Adequate K_2O (supplied as 0-0-60) was also topdressed to all plots at this time.

The soil at the Staples site was classified as a Hubbard sandy loam. This site was irrigated as needed during the growing season. In Winona County, the soil was classified as a Fayette silt loam. Relevant soil properties for these experimental sites are listed in Table 1.

The first cutting was taken in late May at the Winona County site with subsequent cuttings at 30-35 day intervals. A total of 4 cuttings were taken from the manured site while excessive weed growth prevented a 4th cutting at the site which was not manured.

The first cutting at Staples was taken in early June with subsequent cuttings at 30-35 day intervals. A total of 3 cuttings were taken.

Whole plant samples were collected from each plot for each cutting. These samples were dried, ground and analyzed for S. In addition, forage quality was measured by using Near Infra Red (NIR) procedures.

Corn studies--Trials with corn were conducted at two locations (Staples, Goodhue County). The soil at the irrigated Staples site was classified as a Hubbard sandy loam. The soil at the Goodhue County site was classified as a Fayette silt loam. Appropriate soil properties for these two sites are summarized in Table 2.

For corn, 4 rates of N (0, 75, 150, 225 lb./acre) and 4 rates of S (0, 10, 20, 40 lb./acre) were combined in a complete factorial with 4 replications. Urea (46-0-0) was used as the N source while granular gypsum was used to supply the S. All plots received a broadcast application of 200 lb. 0-0-60/acre. At Staples, one half the N was applied before planting while the remainder was broadcast on the soil surface in early July. All fertilizer materials applied before planting were incorporated with a disk before planting.

Corn was planted in late April at Staples and early May at the Goodhue County location. Management practices appropriate for high yield production were used at both lcoations.

Samples of the leaves opposite and below the ear were collected from all plots at silking. These samples were dried, ground and analyzed for both N and S by standard laboratory procedures.

Total dry matter production (ear included) was measured at physiological maturity. Grain yields were recorded in October. Samples of chopped whole plant material taken at physiological maturity were collected from each plot. These samples will be analyzed for S by routine procedures and forage quality by NIR techniques.

Table 1. Selected soil properties (0-6 in.) for the alfalfa experimental sites. 1984.

Soil property	Site Description		
	Winona Co. manured	Winona Co. not-manured	Staples irrigated
pH	6.6	6.7	7.0
p (Bray + Kurtz #1) lb./acre	83	26	77
K (1N $NH_4C_2H_3O_2$) lb./acre	316	139	152
SO_4-S, ppm	8	7.5	5
organic, matter	low	low	medium
soil texture	silt loam	silt loam	sandy loam

Table 2. Selected soil properties (0-6 in.) for the corn experimental sites. 1984.

Soil Property	Location	
	Goodhue County	Staples
pH	6.6	7.1
P (Bray + Kurtz #1), lb./acre	56	91
K (1N $NH_4C_2H_3O_2$), lb./acre	231	178
SO_4-S, ppm	9	4
organic matter	1.6	medium
soil texture	silt loam	sandy loam

Results and Discussion: Alfalfa yields for the 3 sites are summarized in Table 3. The application of fertilizer S had no effect on yield at both Winona County sites. Although yields at both sites were lower than expected, there was no indication of any yield response due to the application of S.

The use of fertilizer S did increase yield of the 2nd and 3rd cuttings at the Staples location. The first cutting yields at this location were quite variable due to an unknown factor which caused the stunting of growth in some plots. This factor was not evident for the 2nd and 3rd cuttings. The application of 25 lb. S/acre was adequate to produce optimum yields in 1984. This observation is consistent with conclusions reached from other studies in the past.

At the time of this writing, plant samples collected from the Staples location had been analyzed for S while plant samples collected from the Winona County location had not been analyzed for S. As would be expected, the S concentration in the alfalfa tissue from Staples increased as rate of applied S increased. Except for the 3rd cutting, this increase was linear (Table 4). These results are consistent with conclusions reached from other studies in the past.

The effect of S fertilization on the quality of the forage produced was measured using NIR procedures. Results of this analysis are summarized in Tables 5, 6, 7, and 8. Rate of applied S had no significant effect on any of the forage quality parameters measured in 1984.

In 1984, corn grain yields at both locations were influenced by the application of both N and S (Table 9). Grain yield increased with rate of applied N at both locations with highest yields recorded from the use of 225 lb. N/acre. Grain yield was also significantly increased by the application of fertilizer S. At Goodhue County, the use of 10 lb. S/acre was adequate for maximum yield while 20 lb. S/acre was needed for maximum yield at the Staples site. It should be pointed out that this is the first reported response to S applied to a non-sandy soil in Minnesota.

Total dry matter yield measured at physiological maturity also increased as rate of N increased to 150 lb./acre. Additional N produced no additional dry matter (Table 10). In contrast to grain yield, application of fertilizer S had no significant effect on dry matter production measured at physiological maturity. Except for the problem of variability in this data, there is no ready explanation for this observation at this time.

There was no signfiicant NXS interaction for both grain and total dry matter yield at either location.

The results of the analysis of the ear leaf samples collected from the Staples location are summarized in Table 11. As would be expected the N concentration increased with rate of applied N while the use of S had no significant effect on the concentration of N in the ear leaf tissue.

The S concentration in the ear leaf tissue was increased by the application of both N and S. The concentration of S reached a maximum with the broadcast application of 20 lb. S|acre.

At the time of this writing, ear leaf samples collectedfrom the Goodhue County location had not been analyzed for N and S. In addition, there have been no measurements made of the quality of the samples collected at physiological maturity. The results of these analyses will be presented in future reports.

Table 3. Effect of rate of applied S on yield of alfalfa. 1984.

S Applied	Cutting 1	2	3	4	Total
lb./acre	---------- ton dry matter/acre ----------				
Winona Co. (manure):					
0	1.03	1.16	.90	.61	3.69
25	1.16	1.13	.97	.68	3.90
50	1.07	1.16	.85	.67	3.75
75	1.04	1.19	.92	.61	3.75
100	1.20	1.17	.84	.69	3.89
c.v.:%	7.2	11.5	14.9	11.1	6.4
Winona Co. (no manure):					
0	1.84	1.41	.90	---	4.15
25	1.90	1.28	.82	---	3.99
50	1.81	1.43	.85	---	4.08
75	1.96	1.32	.89	---	4.18
100	1.84	1.30	.88	---	4.02
c.v.:%	5.4	11.7	8.8		5.3
Staples:					
0	.92	1.36	.75	---	3.03
25	1.08	1.57	1.00	---	3.65
50	1.01	1.53	.94	---	3.48
75	1.04	1.52	1.01	---	3.57
100	1.06	1.47	.94	---	3.47
c.v.:%	8.3	13.5	8.8		8.2

Table 4. The effect of rate of applied S on the S concentration in alfalfa plants. 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
cv: %	7.7	6.8	7.9
BLSD (.05)	.03	.03	.03

Table 5. Effect of rate of applied S on the percentage of crude protein in alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb./acre	% protein			
Winona Co. (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
cv: %	3.7	5.6	4.4	4.1
Winona Co. (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	24.2	22.1	25.6	----
cv: %	3.3	3.9	3.1	
Staples				
0	20.9	19.7	20.1	----
25	21.9	20.3	20.1	----
50	21.6	20.6	20.3	----
75	21.9	20.7	20.1	----
100	21.9	20.3	20.4	----
cv: %	2.4	5.6	2.9	----

Table 6. Effect of rate of applied S on the ADF (acid detergent extractable fiber) content of alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb.|acre	---------- % protein ----------			
Winona Co. (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
cv: %	2.9	2.6	4.3	2.4
Winona Co. (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	----
cv: %	3.0	3.8	2.8	
Staples:				
0	32.2	33.0	32.0	----
25	31.9	33.1	32.8	----
50	31.7	32.0	32.0	----
75	31.8	32.2	32.2	----
100	32.6	31.9	32.4	----
cv: %	2.6	3.0	2.1	

Table 7. Effect of rate of applied S on the NDF (neutral detergent extractable fiber) content of alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb./acre	% NDF			
Winona Co. (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
cv: %	4.7	4.1	3.9	3.5
Winona Co. (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	----
cv: %	3.6	3.2	2.9	
Staples:				
0	47.2	49.3	47.9	----
25	46.1	48.6	47.9	----
50	46.1	48.2	47.5	----
75	45.2	47.6	47.4	----
100	46.2	48.4	47.6	----
cv: %	3.1	2.9	1.9	

Table 8. Effect of rate of applied S on the TDN (total digestible nutrient) content of alfalfa tissue. 1984.

S Applied	Cutting 1	2	3	4
lb./acre	% TDN			
Winona Co. (manure):				
0	63.3	61.9	62.0	65.9
25	63.8	61.4	60.6	65.2
50	63.2	61.2	62.3	65.7
75	63.4	61.0	60.7	64.4
100	63.1	60.9	61.8	65.8
cv: %	1.5	1.4	2.5	1.2
Winona Co. (no manure):				
0	61.4	61.2	59.3	----
25	62.4	61.8	60.5	----
50	61.7	60.8	59.9	----
75	62.2	61.7	59.0	----
100	62.7	62.5	59.4	----
cv: %	1.6	2.1	1.7	
Staples:				
0	59.3	58.7	59.6	----
25	59.8	58.4	58.7	----
50	59.9	59.7	59.6	----
75	59.9	59.4	59.4	----
100	59.0	59.7	59.2	----
cv: %	1.6	2.0	1.3	

Table 9. The effect of rate of applied N and S on grain yield of corn. 1984.

S Applied		N Applied (lb./acre) 0	75	150	225	Ave.
Goodhue Co.:		bu./acre				
0		102.7	162.1	163.8	190.0	154.7
10		122.8	171.4	185.1	187.4	168.9
20		120.8	181.2	174.8	184.3	165.3
40		126.7	174.2	186.2	188.4	168.9
	Ave.	118.2	172.2	177.5	187.5	
	BLSD (.05) for N = 6.7			BLSD (.05) for S = 5.8		
Staples:		0	75	150	225	Ave.
0		63.3	128.0	145.3	152.8	122.4
10		78.6	143.0	152.7	155.1	132.4
20		92.0	145.5	154.8	158.7	137.8
40		81.5	129.1	149.1	154.6	128.6
	Ave.	78.9	136.4	150.5	155.2	
	BLSD (.05) for N = 9.9			BLSD (.05) for S = 12.9		

Table 10. The effect of rate of applied N and S on the total dry matter yield measured at physiological maturity. 1984.

S Applied		N Applied (lb./acre) 0	75	150	225	Ave.
Goodhue Co.		ton dry matter/acre				
0		4.9	7.3	7.6	7.2	6.8
10		4.8	7.0	7.5	7.3	6.7
20		5.8	6.6	7.2	6.4	6.5
40		5.7	6.9	7.6	7.7	7.0
	Ave.	5.3	7.0	7.5	7.2	
	BLSD (.05) for N = .5					
Staples:		0	75	150	225	Ave.
		ton dry matter/acre				
0		3.9	5.7	6.2	5.8	5.4
10		4.2	6.0	6.6	6.3	5.8
20		4.4	6.0	6.9	6.1	5.9
40		4.5	6.2	6.2	6.3	5.8
	Ave.	4.3	6.0	6.5	6.1	
	BLSD (.05) for N = .4					

Table 11. The effect of rate of applied N and S on the concentration of N and S in the ear leaf collected at silking from the Staples location. 1984.

S Applied	N Applied (lb./acre) 0	75	150	225	Ave.
	% N				
0	1.49	2.72	2.76	2.55	2.38
10	1.72	2.76	2.76	2.99	2.56
20	1.92	2.88	2.66	2.89	2.59
40	1.79	2.60	2.92	2.93	2.56
Ave.	1.73	2.74	2.77	2.84	

BLSD (.05) for N = .17

S Applied	N Applied (lb./acre) 0	75	150	225	Ave.
	% S				
0	.119	.187	.174	.162	.161
10	.147	.181	.199	.210	.184
20	.152	.203	.220	.216	.198
40	.147	.192	.218	.219	.194
Ave.	.141	.191	.203	.201	

BLSD (.05) for N = .014 BLSD (.05) for S = .014

PLACEMENT OF NITROGEN SOLUTIONS UNDER DIFFERING TILLAGE SYSTEMS

G.L. Malzer, J.F. Moncrief, and G.W. Rehm

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 volitalization 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 - In 1984 experiments were conducted 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.

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	4/25		
	Chisel	4/26		5/28
	Ridge Till	6/24		6/29
	Culitivation	----		----
Planting Date[1]	No Till	5/2		
	Other Tillage	5/3		5/9
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		5/9		5/11 & 14
Starter Fertilizer	150#/A 8-10-30		14gal/A 7-21-7	
Other Fertilizer	300#/A 0-0-22	4/3		
Insecticide	Lorsban 15g 7#/A	5/2 & 3	Counter 15g 6#/A	
	Lorsban 4e 7#/A	7/11		
	Lorsban 4e 7#/A	8/20		
Herbicide[2]	Atrazine 2#/A	5/11	Lasso 2.5#/A	5/9
	Dual AE 1.5 pint/A	5/11	Bladex 1.5#/A	5/9
	Round Up 1 qt./A	5/11	Atrazine 2#/A + oil	6/11
	Atrazine 2#/A + oil	5/29	Banvel 1/8 #/A	6/13
Irrigation	5.85 inches	July		
	5.65 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 Excellent weed control was obtained at each location but giant foxtail was a problem on the no till plots at each location.

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 volitalization of urea as well as leaching and/or denitrification processes. Surface residue cover observed in 1984 were as follows:

		1984 cover *	
Location	Tillage	In Row	Between Rows
Becker (EC) (6/27)	Moldboard	3.5 (4.6)	2.5 (3.5)
	Chisel	25.0 (13.7)	41.3 (17.4)
	Ridge till	16.7 (12.4)	32.0 (14.5)
	No till	64.0 (17.9)	73.0 (14.6)
Goodhue Co. (SE) (6/19)	Chisel	16.8 (11.0)	23.8 (11.1)
	Ridge till	10.0 (7.9)	31.8 (14.3)
	No till	77.8 (17.2)	65.5 (15.3)

* 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 surfaces. The chisel plow treatment left 15-40% surface cover with the EC (Becker) location having slightly more residue cover. The ridge till systems were generally comparable in residue cover to the chisel plow treatments although the ridge till treatments tended to accumulate a larger proportion of the residue between the rows. As would be expected the no till areas had the highest residue cover ranging from 65-75% of the soil surface.

Grain yields and N utilization - Leaf samples from opposite and below the ear at mid-silking were collected on July 24 at the EC location and on July 27 at the SE location. All leaf samples were dried, ground, and analyzed for Kjeldahl N. Total dry matter production was determined on Sept. 19 and 20 at the EC location and on Sept. 26, 27, and 28th at the SE location. 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 including grain, stover, and total N are included in Table 2. Parameters used to evaluate N utilization characteristics including concentrations and total N removal are included in Table 3. Treatment varaibles 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 (.05) was computed to compare treatment means.

This location has a coarse textured soil with a low water holding capacity. With irrigation and proper N management these soils can be highly productive. The results obtained in 1984 at this location were excellent with treatment yields ranging from 41 bu/a to over 180 bu/a. The growing season, although excellent, was marked with a major rainfall event in mid June and a total monthly rainfall of over nine inches. It can be assumed that this precipitation resulted in substantial nitrate-N loss through leaching and probably had a profound effect on the yields obtained from the various treatments.

Nitrogen and management of UAN accounted for grain yield increases up to 140 bu/a (Table 3). Management of (placement) UAN across the different tillage systems was especially important in 1984 at this location. This can be demonstrated by examining the number of interactions that were obtained with UAN management across tillage systems (Tables 2 and 3, continued). A general view of the main effects would suggest that the highest yields were obtained when 300 #N/a was injected utilizing a moldboard plow system. All main effects (tillage, N rate, and placement) were important, but because of the significant interactions, placements and N rate did not react in a similar manner with all tillage systems and therefore require careful examination.

Grain yields were influenced by all main effects (tillage, N rate, placement) and each interacted with each other. The significant tillage by N rate interaction indicated that at the low N rate all tillage systems produced similar yields but at the higher N rates differences due to tillage were more apparent. In general no till was inferior to any of the other tillage systems at the higher N rates. The significant tillage by application method interaction indicated that the injection of UAN was superior to the other surface methods of application with all tillage systems except moldboard plow where methods of application were similar (one exception). This would suggest that if appreciable surface residue is present, injection of UAN would provide the best yield results.

Moisture content of the grain at harvest was influenced by all three main effects with no interaction. Grain produced from the no-till treatments had the highest moisture content followed by chisel and then ridge till and moldboard plow which were similar. The N rate and method of application that tended to have the highest yield (300 #N/a and injected) also tended to have a higher moisture content at harvest.

Stover and total yields tended to follow the same trend as that found with grain yield. The N rate by method of application interaction again supports the fact that injected applications gave the best results, but as the N rate increased (300 #N/a) results from the dribble application provided comparable results.

In general most of the results pertained to N concentrations, and N uptake followed the same trends as those that were observed with the various yield parameters.

GENERAL CONCLUSIONS (EC LOCATION)

The results from this location were excellent in 1984 and point out the importance of UAN placement with different tillage systems. In general, the injected placements were superior to either of the other surface applications when surface residue was present. The data collected this year also points out the complexity associated with N management and tillage on these types of soils. In many situations our concern with surface placement of UAN or other urea containing compounds would be associated with potential surface volitalization from the residue or immobiliation of N by the residue. The results from this experiment would suggest that other processes such as nitrification, leaching and/or denitrification should also be considered as factors that may interact with placement especially on soils which may be prone to leaching and/or denitrification problems.

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 4 and 5. The experimental design and treatments were identical in both experiments except only three tillage treatments were evaluated at this location.

Unlike the EC location, this experimental location consists primarily of a silt loam soil and yield reductions associated with N loss (leaching) were not evident at this location. This may partially explain why many of the treatment interaction obtained at the EC location were not observed at this location.

The yields obtained at this location in 1984 were well above average. Grain yields were increased up to the 150 #N/a application but not to the highest N rate. The chisel and ridge till treatments provided comparable grain yields while the grain yields associated with no till were significantly lower. Averaged over N rates and tillage treatments method of UAN application had no influence on grain yield. The relatively high P-value for the N rate by method of application interaction for grain yield, stover yield, and total dry matter yield would suggest that broadcast and dribble applications of UAN were inferior to injected application at the low N rates, but as N rates increased differences between methods of application were not observed. Reduced N availability or N loss may have occurred at all rates, but at the yield levels obtained the higher N rates masked the net effect and was therefore not reflected in the growth measurement.

Most of the N utilization data at this location tends to follow trends similar to the yield information. In general, however, N concentrations and N uptake tended to increase up through the highest rate of N application (300 #N/a). Likewise, even though no till was the lowest yielding, N concentrations in the plant tissue were normally highest with no till. Tillage did not influence total N removal, but total N found in the grain was lowest with no till and highest with chisel. This might suggest that the timing of N uptake by the crop may be effected by tillage. This may have

some influence on management in certain situations. The significant tillage by method interaction with leaf N suggested that injected application of UAN were superior on the no till and ridge till treatments while dribble was inferior to injected and broadcast treatments with the chisel tillage system.

GENERAL CONCLUSIONS

The results at this location in 1984 follow in a more traditional manner of what might be expected with UAN placement with different tillage systems. The injected applications, as would be expected, were generally better than the other methods. It is expected that the major reasons for reduced yields at this location with surface applications are related to surface volitalization and/or immobilization of N by the surface residue. By contrast the magnitude of yield reductions associated with placement at this location as compared to the EC location were much lower. This in turn brings out the complexity of N management and tillage systems on different soils. Although the final recommendation may be the same, the magnitude of the importance may be considerably different. Site specific recommendations based upon the major and dominant process in soils that may influence nitrogen management must be considered.

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

Treatments			Grain		Dry Matter Production		
N-Rate	Tillage System	Method Applied	Yields	DM	Grain	Stover	Total
#/A			Bu/A	%	---------T/A----------		
Control	No Till	---------	45.5	62.9	1.07	0.98	2.06
Control-Knife	No Till	---------	44.5	60.7	1.05	1.04	2.09
Control	Ridge Till	---------	50.9	65.1	1.20	0.91	2.11
Control-Knife	Ridge Till	---------	52.4	65.2	1.24	0.94	2.18
Control	Chisel	---------	55.2	65.8	1.30	1.05	2.35
Control-Knife	Chisel	---------	59.5	68.0	1.40	1.16	2.57
Control	Moldboard	---------	47.9	63.1	1.13	0.92	2.06
Control-Knife	Moldboard	---------	55.9	63.2	1.32	1.11	2.44
75	No Till	Broadcast	41.0	61.8	0.97	1.05	2.02
75	No Till	Injected	76.1	60.2	1.80	1.86	3.66
75	No Till	Dribble	49.9	61.9	1.18	1.28	2.46
75	Ridge Till	Broadcast	57.7	68.9	1.36	1.07	2.43
75	Ridge Till	Injected	80.6	66.4	1.90	1.68	3.59
75	Ridge Till	Dribble	64.6	69.2	1.53	1.15	2.68
75	Chisel	Broadcast	65.6	66.3	1.55	1.77	3.32
75	Chisel	Injected	83.3	67.3	1.97	2.11	4.08
75	chisel	Dribble	76.0	67.3	1.79	1.81	3.61
75	Moldboard	Broadcast	65.9	67.3	1.56	1.47	3.03
75	Moldboard	Injected	61.8	65.2	1.46	1.44	2.90
75	Moldboard	Dribble	69.4	66.8	1.64	1.51	3.15
150	No Till	Broadcast	42.7	59.3	1.01	1.24	2.25
150	No Till	Injected	109.5	60.5	2.59	2.27	4.86
150	No Till	Dribble	50.7	61.1	1.20	1.35	2.55
150	Ridge Till	Broadcast	74.6	67.6	1.76	1.64	3.40
150	Ridge Till	Injected	128.5	66.3	3.04	2.28	5.32
150	Ridge Till	Dribble	83.0	67.7	1.96	1.81	3.78
150	Chisel	Broadcast	90.9	65.3	2.15	2.26	4.42
150	Chisel	Injected	142.6	64.4	3.37	2.78	6.16
150	Chisel	Dribble	101.3	67.0	2.39	2.31	4.71
150	Moldboard	Broadcast	137.2	68.1	3.24	2.72	5.97
150	Moldboard	Injected	135.7	67.0	3.21	2.61	5.82
150	Moldboard	Dribble	105.8	68.2	2.50	2.27	4.78
300	No Till	Broadcast	53.0	59.4	1.25	1.81	3.06
300	No Till	Injected	154.9	59.3	3.66	2.80	6.46
300	No Till	Dribble	137.9	60.5	3.26	2.64	5.91
300	Ridge Till	Broadcast	125.5	65.7	2.96	2.48	5.45
300	Ridge Till	Injected	176.8	64.9	4.18	2.90	7.09
300	Ridge Till	Dribble	165.4	66.0	3.91	2.96	6.88
300	Chisel	Broadcast	134.8	64.3	3.19	2.69	5.88
300	Chisel	Injected	181.8	63.7	4.30	3.44	7.74
300	Chisel	Dribble	160.2	64.4	3.79	3.28	7.07
300	Moldboard	Broadcast	155.2	66.4	3.67	2.82	6.50
300	Moldboard	Injected	170.6	65.1	4.03	3.02	7.06
300	Moldboard	Dribble	173.3	60.7	4.10	3.08	7.18

Table 2. Continued

Treatments Tillage System	Grain Yield	Grain DM	Dry Matter Production Grain	Stover	Total
	Bu/A	%	--------T/A----------		
Factorial Arrangement (Excludes Controls)					
Tillage					
No Till	79.5	60.5	1.88	1.81	3.69
Ridge Till	106.3	67.0	2.51	2.00	4.51
Chisel	115.2	65.1	2.72	2.49	5.22
Moldboard	119.4	66.9	2.82	2.33	5.15
P-Value (%)	99	99	99	99	99
BLSD (.05)		1.6			
N-Rate					
75	66.0	65.7	1.56	1.52	3.08
150	100.2	65.2	2.37	2.13	4.50
300	149.1	64.0	3.52	2.83	6.36
P-Value (%)	99	99	99	99	99
BLSD (.05)		0.9			
Method Applied					
Broadcast	87.0	65.0	2.05	1.92	3.98
Injected	125.2	64.2	2.96	2.43	5.39
Dribble	103.1	65.6	2.44	2.12	4.56
P-Value (%)	99	99	99	99	99
BLSD (.05)		0.8			
Tillage X N-Rate	99	76	99	85	98
Tillage X Method	99	18	99	99	99
N-Rate X Method	99	7	99	99	99
Tillage X N-Rate X Method	94	10	99	17	57

Table 3. Continued

Treatments Tillage System	N-Concentration Leaf	Stover	Grain	N-Removal Grain	Stover	Total
	----------%----------			----------#/A---------		
Factorial Arrangement (Excludes Controls)						
Tillage						
No Till	1.77	0.47	1.20	48.0	18.2	66.3
Ridge Till	1.91	0.48	1.26	65.6	20.3	85.9
Chisel	1.98	0.44	1.22	68.7	22.7	91.4
Moldboard	1.97	0.46	1.29	75.1	22.3	97.5
P-Value (%)	99	98	99	99	99	99
BLSD (.05)			0.04			
N-Rate						
75	1.36	0.42	1.16	36.2	12.9	49.2
150	1.79	0.44	1.20	58.0	19.2	77.2
300	2.58	0.53	1.37	98.9	30.5	129.4
P-Value (%)	99	99	99	99	99	99
BLSD (.05)						
Method						
Broadcast	1.61	0.43	1.17	49.1	16.7	65.8
Injected	2.31	0.51	1.29	79.7	25.7	105.5
Dribble	1.80	0.46	1.26	64.3	20.2	84.5
P-Value (%)	99	99	99	99	99	99
BLSD (.05)						
Tillage X Rate	99	49	26	97	80	93
Tillage X Method	99	99	43	99	99	99
N-Rate X Method	99	99	99	99	99	99
Tillage X N-Rate X Method	99	99	70	62	66	58

Table 3. Influence of nitrogen rates, tillage systems and methods of 28% N application, on leaf N, grain N and nitrogen removal by irrigated corn. Becker, MN - 1984

Treatments			N-Concentration			N-Removal		
N-Rate	Tillage System	Method Applied	Leaf	Stover	Grain	Grain	Stover	Total
#/A			----------%----------			---------#/A----------		
Control	No Till	---------	1.38	0.47	1.03	21.9	9.2	31.2
Control-Knife	No Till	---------	1.26	0.44	1.14	23.0	9.2	32.3
Control	Ridge Till	---------	1.35	0.40	1.19	28.7	7.5	36.3
Control-Knife	Ridge Till	---------	1.32	0.43	1.14	28.4	7.9	36.4
Control	Chisel	---------	1.22	0.45	1.19	31.3	9.5	40.9
Control-Knife	Chisel	---------	1.15	0.44	1.12	30.7	10.2	41.0
Control	Moldboard	---------	1.22	0.45	1.11	25.4	8.4	33.8
Control-Knife	Moldboard	---------	1.18	0.42	1.12	29.5	9.1	38.7
75	No Till	Broadcast	1.23	0.42	1.10	21.8	9.1	31.0
75	No Till	Injected	1.78	0.46	1.05	38.2	17.1	55.3
75	No Till	Dribble	1.30	0.39	1.14	26.8	10.0	36.9
75	Ridge Till	Broadcast	1.24	0.36	1.23	33.7	7.8	41.5
75	Ridge Till	Injected	1.65	0.46	1.10	42.3	15.7	58.1
75	Ridge Till	Dribble	1.17	0.46	1.27	39.0	10.9	49.9
75	Chisel	Broadcast	1.29	0.41	1.07	32.9	14.4	47.3
75	Chisel	Injected	1.54	0.40	1.17	46.1	16.9	63.1
75	Chisel	Dribble	1.25	0.42	1.15	41.2	15.6	56.8
75	Moldboard	Broadcast	1.18	0.41	1.23	38.3	12.7	50.4
75	Moldboard	Injected	1.43	0.44	1.16	34.0	13.0	47.0
75	Moldboard	Dribble	1.26	0.39	1.23	40.6	12.0	52.6
150	No Till	Broadcast	1.18	0.44	1.13	23.1	10.9	34.1
150	No Till	Injected	2.35	0.47	1.22	63.6	21.6	85.2
150	No Till	Dribble	1.31	0.44	1.07	25.9	12.0	38.0
150	Ridge Till	Broadcast	1.34	0.48	1.15	40.6	15.7	56.3
150	Ridge Till	Injected	2.51	0.48	1.25	76.5	21.8	98.4
150	Ridge Till	Dribble	1.52	0.39	1.26	49.7	14.2	64.0
150	Chisel	Broadcast	1.47	0.38	1.11	48.2	17.1	65.3
150	Chisel	Injected	2.43	0.48	1.36	92.3	26.8	119.2
150	Chisel	Dribble	1.69	0.42	1.11	53.5	19.6	73.1
150	Moldboard	Broadcast	2.04	0.47	1.19	77.6	26.0	103.6
150	Moldboard	Injected	2.26	0.47	1.28	83.7	24.9	108.6
150	Moldboard	Dribble	1.36	0.43	1.22	60.8	19.8	80.7
300	No Till	Broadcast	1.46	0.45	1.18	29.3	16.8	46.2
300	No Till	Injected	3.00	0.72	1.55	114.0	40.5	154.6
300	No Till	Dribble	2.36	0.49	1.35	89.1	25.8	115.0
300	Ridge Till	Broadcast	1.96	0.38	1.19	71.0	19.2	90.2
300	Ridge Till	Injected	2.91	0.68	1.49	125.7	40.3	166.0
300	Ridge Till	Dribble	2.90	0.62	1.42	111.8	37.0	148.8
300	Chisel	Broadcast	2.42	0.44	1.25	80.4	23.8	104.3
300	Chisel	Injected	2.93	0.53	1.36	116.8	37.0	153.8
300	Chisel	Dribble	2.81	0.50	1.41	107.3	32.8	140.1
300	Moldboard	Broadcast	2.49	0.47	1.24	92.2	27.1	119.4
300	Moldboard	Injected	2.99	0.54	1.52	123.1	32.9	156.1
300	Moldboard	Dribble	2.69	0.52	1.53	125.8	32.7	158.5