Source		Grain Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
		bu/A	------- %	-------	lb/A	%
Sb-C-C*	0	80.3	27.8	1.13	43.0	1.27
	40	118.7	26.5	1.13	63.3	1.54
	80	150.7	26.7	1.28	91.1	2.11
	120	161.6	26.5	1.39	105.8	2.35
	160	172.9	26.6	1.46	118.8	2.64
	200	165.6	27.0	1.49	116.4	2.64
Signif. Level (%):		99	08	99	99	99
BLSD(.05) :		9.0		0.05	5.8	0.14
Sequence x Hybrid						
CC(g)	3906	128.1	24.7	1.45	89.3	2.18
	3732	140.2	29.8	1.23	83.3	2.07
CC(s)	3906	133.2	24.7	1.46	93.4	2.16
	3732	144.4	30.0	1.27	87.6	2.14
Sb-C	3906	141.6	24.5	1.43	97.2	2.27
	3732	156.3	29.5	1.22	91.7	2.26
Wht-C	3906	153.2	25.0	1.49	108.4	2.36
	3732	163.0	29.6	1.27	98.6	2.45
Sb-C-C*	3906	136.0	24.5	1.42	93.6	2.08
	3732	147.2	29.2	1.20	85.9	2.10
Signif. Level (%):		49	94	25	77	99
BLSD(.10) :		---	.4	---	---	.06
BLSD(.05) :		---	---	---	---	.08
N rate x Hybrid						
0	3906	97.5	25.1	1.26	58.3	1.48
	3732	101.4	30.7	1.09	52.6	1.45
40	3906	125.8	24.2	1.31	78.5	1.86
	3732	135.0	29.5	1.11	71.4	1.82
80	3906	146.7	24.5	1.43	99.3	2.25
	3732	157.8	29.2	1.21	90.6	2.21
120	3906	150.5	24.9	1.55	110.0	2.41
	3732	165.6	29.5	1.32	103.1	2.47
160	3906	155.7	24.8	1.57	115.3	2.60
	3732	171.2	29.3	1.35	109.3	2.62
200	3906	154.3	24.8	1.60	116.7	2.66
	3732	170.5	29.5	1.36	109.4	2.64
Signif. Level (%):		99	99	99	15	50
BLSD(.10) :		3.3	.3	.02	---	---
BLSD(.05) :		3.9	.4	.03	---	---
Seq. x N rate x Hybrid						
Signif. Level (%):		78	08	03	23	27
CV(%) :		5.4	2.8	3.9	6.4	6.7

* = Position in sequence for which measurements taken.

Contrary to 1984, the sequence x hybrid interaction was not significant indicating that the two hybrids behaved identically across all sequences. On the other hand, a highly significant N rate x hybrid interaction was found. At the 0-lb N rate only a 3.9 bu/A advantage was shown for P3732. As the N rates increased, yield advantages for P3732 increased up to a maximum of 16.2 bu/A at the 200-lb rate when averaged over sequences. No three-factor interaction was found.

Corn yield responses to N with each of the sequences did not appear to show any consistent relationship to the residual soil NO_3-N levels shown in Table 1. This is consistent with past years.

In summary, corn yields (averaged over hybrids) from the 160-lb rate were approximately 8% higher when following either soybeans or wheat compared to continuous corn (grain or silage). This advantage was slightly below the advantages shown in previous dry years. Also, contrary to reports from Purdue University, P3732 continued to respond to increasing N rates up to 160 lb N/A. This same N rate also maximized the P3906 yield when averaged over sequences.

Grain Moisture

Grain moisture at harvest was unaffected by crop sequence but was reduced from the 0-lb rate by all rates $\geq$ 40 lb N/A. The shorter season hybrid (P3906) had significantly less moisture.

Interactions between crop sequence and N rate or hybrid were not significant at the 95% level. The highly significant interaction between N rate and hybrid was due to the greater difference in grain moisture between the two hybrids at the 0-lb rate (5.6%) compared to differences (<4.7%) at N rates of 80-lb or more.

Grain N

Grain N concentrations were not influenced by the crop sequence when averaged over N rates and hybrids, but were increased signficantly by N rates up through 160 lb/A when averaged over sequences and hybrids. The P3906 hybrid averaged 0.21% higher grain N or 1.3% higher protein than P3732 when averaged over sequence and N rate. The significant sequence x N rate interaction was due to the higher N rate (160-lb) required to optimize grain N with the Sb-C-C rotation compared to the other sequences where 120 lb N/A was adequate. Also, grain N was lowest with the 0-lb N rate when in the Sb-C-C rotation. The N response curve was least when corn followed wheat. No sequence x hybrid interation was found. The significant N rate x hybrid interaction was due to the greater difference in grain N concentrations between the two hybrids as the N rate increased.

Grain N removed

Nitrogen removed in the grain crop was closely associated with both grain yield and grain N concentration. Highest grain N removal was when wheat was the previous crop, when the 160-lb N rate was applied, and when P3906 was grown even though grain yields were higher with P3732.

Nitrogen efficiency, as measured by grain N removed divided by fertilizer application rate, averaged 45, 38, 43, 52, and 47% for the N rates giving the highest yields (statistically) for the CC(g), CC(s), C-Sb, C-W, and Sb-C-C sequences, respectively. At the N rates where yields were maximized economically, the efficiency values were 36, 31, 34, 52, and 47%, respectively. Efficiency was consistently maximized at 60, 52, and 47% for the 80, 120, and 160-lb N rates, respectively, with the Sb-C-C rotation.

Leaf N

Concentrations in the earleaf at silking were significantly higher when corn followed either soybeans or wheat compared to following corn when averaged over N rates and hybrids. Contrary to 1984, leaf N was not different between the two hybrids when averaged over sequences + N rates. The significant interaction between sequence and N rate was due to the much higher N concentration with the 0-lb N rate in the C-W sequence compared to the other sequences. The 160-lb N rate maximized leaf N concentration at between 2.54% and 2.73% N for all crop sequences. When averaged over N rates, leaf N of P3732 was lower when grown in the CC(g) sequence but was higher than P3906 when grown in the C-W sequence; hence, the significant interaction. A difference between the two hybrids was not found when grown in the CC(s), C-Sb, and Sb-C-C sequences. No N rate x hybrid interaction was found.

Silage production

Measurements were taken from the CC(s) crop sequence to determine fodder yield, fodder N concentration, fodder N uptake, silage yield, and total N uptake. Data shown in Table 4 indicate a significant effect of N up to the 120-lb rate on fodder yield. Similar to 1984, fodder yield of P3732 was significantly greater than P3906. Fodder N concentration was maximized at the 160-lb rate and contrary to 1984 was signficantly higher for P3906. Fodder N uptake was highest at the 160-lb N rate with no difference between hybrids.

Silage yields were increased significantly by N rates up to 120 lb/A and by the P3732 hybrid (similar to 1984). Total N removed in the silage was increased with increasing N rates up through 160 lb/A. More N was removed by the P3906 hybrid than by P3732. N efficiency with P3906 fertilized at the 160-lb rate was 58%.

Table 4. Silage production as influenced by N rate and hybrid in a silage corn rotation at Waseca, 1985.

N rate	Hybrid	Fodder Yield	Fodder N	Fodder N Uptake	Silage Yield	Silage N Removal
lb/A		T DM/A	%	lb N/A	T DM/A	lb N/A
0	3906	1.82	.41	14.9	4.38	65.1
	3732	2.05	.33	13.7	4.53	55.3
40	3906	1.91	.40	15.3	4.90	76.6
	3732	2.48	.33	16.9	5.52	70.6
80	3906	2.65	.43	22.7	6.53	111.5
	3732	2.84	.42	24.1	6.93	101.3
120	3906	2.74	.58	31.4	7.05	141.4
	3732	3.12	.54	33.2	7.64	133.2
160	3906	2.63	.72	37.9	6.90	157.4
	3732	2.91	.66	38.3	7.41	146.1
200	3906	2.57	.67	33.8	6.86	156.2
	3732	3.02	.62	37.5	7.62	145.8
Individual Factors						
N rate (lb/A)						
0		1.93	.37	14.3	4.46	60.2
40		2.20	.37	16.1	5.21	73.6
80		2.75	.43	23.4	6.73	106.4
120		2.93	.56	32.3	7.34	137.3
160		2.77	.69	38.1	7.15	151.7
200		2.80	.64	35.6	7.24	151.0
Signif. Level(%)1/:		99	99	99	99	99
BLSD(.05) :		.20	.06	3.8	.60	12.1
Hybrid						
3906		2.39	.53	26.0	6.10	118.0
3732		2.74	.48	27.3	6.61	108.7
Signif. Level(%)1/:		99	97	79	99	99
N rate x Hybrid IA:1/		60	06		44	03
CV (%) :		8.7	16.	14.	5.8	6.4

1/ Probability level of significance

Soybean production

To determine if N from the 1984 application to corn influenced the 1985 soybean yields, soybeans from the 0-and 200-lb N treatments were harvested. The data in Table 5 indicate no effect from the previous year's N treatment on either soybean yield or seed moisture at harvest.

Table 5. Soybean yield and moisture as influenced by N applied to corn in 1984.

N rate	Seed Yield	Seed Moisture
(lb/A)	bu/A	%
0	52.2	13.9
200	51.7	14.0
Signif. Level (%):	57	63
CV (%) :	1.8	1.1

Summary - 1985

Corn grain yields averaged about 8% higher when corn followed either soybeans or wheat compared to continuous corn (grain or silage). Highest yields with minimum N input were found when corn followed wheat and were maximized at the 80-lb N rate. Yields with both P3732 and P3906 were maximized at the 160-lb N rate with the CC(g), CC(s), C-Sb, and Sb-C-C crop sequences. Grain N concentrations and grain N removal were significantly higher with the P3906 hybrid. Leaf N at silking was maximized at between 2.54% and 2.73% with the 160-lb rate for all crop sequences. Soybean production was not affected by N application to the previous corn crop.

ELEVEN-YEAR YIELD SUMMARY

Average corn yields over this 11-year period have been optimized with 175, 140, and 120 lb N/A for the continuous corn, corn-soybean, and corn wheat sequences, respectively. At these N rates, yields for corn following soybeans and wheat were 17 and 14% higher than for continuous corn.

Table 6. Effect of previous crop on corn response to N from 1975-1985 at Waseca.

	Previous Crop		
N rate	Corn(g)	Soybeans	Wheat
lb N/A	----------	bu/A	----------
0	76	110	106
40	100	134	132
80	115	146	147
120	124	152	150
160	131	157	152
200	134	157	154

SPLIT APPLICATION OF N FOR CORN ON A WEBSTER SOIL

Waseca, 1985

G. W. Randall and P. L. Kelly

Improved nitrogen (N) efficiency is a goal of many corn producers because of the enhanced economic return to their fertilizer dollar. One potential method of improving the efficiency of N is to apply it closer to the period of greatest demand by the plant. For corn this is the period from three weeks prior to three weeks after tasseling. Applying N closer to this period limits the potential for N loss due to leaching or denitrification. Split applications of N have been shown to be quite beneficial on coarse-textured soils where leaching losses are common. The primary purpose of this study was to evaluate split applications of N to a naturally, poorly drained Webster clay loam where leaching is thought not to be a problem. A secondary objective was to evaluate two sources/application methods for split application.

EXPERIMENTAL PROCEDURES

A poorly drained Webster clay loam soil with lateral tile lines at 75-foot spacings was the experimental site. Corn, which had been fall moldboard plowed, was the previous crop. Soil tests of the site showed a pH = 6.7, OM = High, Bray P_1 = 52 lb/A (VH), and exchangeable K = 416 lb/A (VH).

Ten N treatments were applied in a randomized, complete-block design with six replications (Table 1). Each plot measured 10' wide (4-30" rows) by 60' long. Split treatments consisted of a 1/3-rate applied preplant with the remaining 2/3 sidedressed. The preplant treatments were applied on May 9. Anhydrous ammonia (AA) was injected while the urea-ammonium nitrate (UAN) was broadcast applied on the soil surface. Immediately afterwards the entire experimental area was field cultivated.

Corn (Pioneer 3906) was planted at 29900 ppA on May 10. No starter fertilizer was used. Furadan was used at a rate of 1 lb(a.i.)/A to control rootworms. Weeds were chemically controlled with a preemergence application of Lasso (3½ qt./A) plus Bladex (3½ qt./A). Rootworm and weed control was excellent.

The sidedress portions of the split treatments were applied at the 8-leaf stage (June 21). The AA was injected while the UAN was applied in bands to the soil surface using a bicycle sprayer with no. 55 orfices. Both materials were applied mid-way between the rows. The UAN was not incorporated. No rain occurred in the next 4 days, but was followed by 0.55" on the fifth day after application.

Ten randomly selected leaves opposite and below the ear were taken at silking (July 25). Stover and silage yields were obtained at physiological maturity by hand harvesting 15' of row. Grain yields were determined on October 16 by harvesting the center two rows with a modified JD 3300 plot combine. Chemical analyses on the leaves, stover, and grain were performed by the Research Analytical Laboratory, University of Minnesota.

RESULTS

Leaf N

Severe N deficiency symptoms were very apparent for the lower N rates and the sidedress UAN treatments at the tasseling stage. Leaf N concentrations given in Table 1 show all N treatments with significantly more N than the control. Factorial comparisons of the treatments show a linear response to N rate when averaged over source-time of application. When averaged over N rates significantly less leaf N was found with split applications (especially with UAN) compared to the single preplant application. The highly significant interaction between N rate and N time-source (P = 99% level) is shown by the lack of response with the 180 lb AA sidedress treatement. The severe N deficiency as shown by the split-applied UAN treatments was caused by the dry conditions between the June 21 application and tasseling. Only 0.87" of rain fell during this period and apparently was not sufficient to move the surface-applied N down into the active root zone. This positional unavailability was much less evident with the split-applied AA which was injected about 7" deep. Apparently this N was nitrified and moved into the root system.

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

Table 1. Leaf N, stover N, stover yield, and final population as influenced by split N application.

Nitrogen[1/] Rate	Time	Source	Leaf N	Stover N	Stover Yield	Final population
lbN/A			%	%	TDM/A	ppA x 10^{-3}
0	--	CHECK --	1.22	.38	1.74	28.9
60	PP	AA	1.92	.42	2.61	29.3
120	"	"	2.24	.42	2.71	30.2
180	"	"	2.57	.58	3.12	28.8
60	1/3PP+2/3SD	UAN(PP)+AA(SD)	1.92	.40	2.50	28.8
120	"	"	2.32	.50	2.68	29.3
180	"	"	2.25	.51	2.81	29.2
60	"	UAN	1.46	.41	2.51	28.7
120	"	"	1.61	.50	2.69	29.2
180	"	"	1.88	.52	2.69	28.7
Signif. Level (%):			99	99	99	42
BLSD (.05) :			.14	.06	.28	
CV (%) :			6.9	12.	9.8	4.2
FACTORIAL COMPARISONS						
Main Factors						
N Rate (lb/A)						
60			1.77	.41	2.54	28.9
120			2.06	.48	2.69	29.6
180			2.24	.54	2.87	28.9
Signif. Level (%):			99	99	99	79
BLSD (.05) :			.08	.04	.17	
N Time-Source (Method)						
PP - AA			2.24	.48	2.82	29.5
PP/SD - UAN/AA			2.16	.47	2.66	29.1
PP/SD - AA			1.65	.48	2.63	28.8
Signif. Level (%):			99	7	92	67
BLSD (.05) :			.08			
Interaction						
				Significance Level (%)		
N Rate x N Time-Source			99	98	64	23

[1/] PP = preplant, SD = sidedress applied at the 8-leaf stage.

Stover N

Nitrogen concentrations in the stover at physiological maturity were increased linearly by the N rates but were not different between the single and split applications (Table 1). The highly significant interaction between N rate and N time-source (P = 98% level) was due to the single preplant application at the 120-lb rate which for some unexplainable reason did not respond over the 60-lb rate. These results indicate that the sidedress application of UAN became available to the plants after silking due to the above normal rainfall during August and September.

Stover Yield

Stover yield was increased significantly over the check by all of the N treatments (Table 1). Highest stover yields were obtained at the 180-lb rate regardless of source or time of application. Slightly higher yields were found with the single preplant application than with the split applications (P = 92% level). No difference was observed between the sidedress applied AA vs UAN.

Final Population

None of the treatments affected the final population (Table 1).

Grain Yield

Grain yields were increased significantly over the control by all N treatments (Table 2). Highest yields were obtained at the 180-lb rate for all application methods. When averaged over N rates, there was no difference between the single preplant and the split application when AA was the sidedressed material. However, at the 120-lb rate the split application with AA gave a significantly higher yield than the single preplant application. Yields were approximately 10% lower when UAN was the sidedressed material. This more than likely was due to the dry weather causing the positional unavailability described under Leaf N.

Grain Moisture

Grain moisture at harvest was reduced by all N treatments and was lowest with the 120- and 180-lb N rates (Table 2). Moisture differences were not found among the N source-time of application treatments.

Grain N

Grain N was increased significantly by all N treatments except the 60-lb single preplant application (Table 2). A linear grain N response was obtained with increasing N rate when averaged over methods of application. Split application of both N sources resulted in significantly higher levels of N in the grain than the single preplant application. The significant interaction between N rate x method of application was due to the 120-lb split application using AA which showed a grain N level higher than the other 120-lb treatments and not less than the 180-lb treatments.

Grain N removal

Grain N removal (product of grain yield times grain N concentration was increased significantly by all N treatments (Table 2). Highest grain N removals were associated with the 180-lb rate with the single application and with the 120 and 180-lb rates with the split application when AA was the sidedressed material. When averaged over N rates, highest N removal was found with the spilt application using AA.

Nitrogen efficiency based on grain N removal minus that removed by the check averaged 60, 49, and 40% for the 60, 120, and 180-lb rates, respectively. When averaged over N rates, methods of application ranked according to highest efficiency were: split with AA (51%) > single (45%) = split with UAN (43%).

Silage Yield

Similar to grain yields, silage yields were increased significantly by all N treatments (Table 2). Highest silage yields were obtained with the 180-lb rate and with the single preplant application. Silage yields were significantly lower with the split application when UAN was sidedressed.

Total N Uptake

Total N uptake by the corn can be calculated from multiplying the stover N concentration times stover yield and adding it to grain N removal. Similar to grain N removal total N uptake was highest when the 180-lb rate was applied as either a single preplant application or as a split application using AA. When averaged over N rates, total N uptake was highest with the spilt application using sidedressed AA.

Nitrogen efficiency based on total N uptake minus that removed in the check averaged 73, 59, and 50% for the 60, 120, and 180-lb rates, respectively. When averaged over N rates, efficiency was 61, 57, and 53% for the split application with AA, single application, and split application with UAN, respectively.

Table 2. Corn grain and silage production as influenced by split N applications.

Nitrogen			Grain				Silage	Total N
Rate	Time	Source	Yield	H_2O	N	N Removal	Yield	Uptake
lb/A			bu/A	---- % ----		lb/A	TDM/A	lb/A
0	--- CHECK ---		66.2	30.7	1.18	36.6	3.73	49.9
60	PP	AA	119.6	29.2	1.24	70.5	6.32	92.5
120	"	"	144.5	28.4	1.32	90.1	6.95	113.2
180	"	"	157.0	28.2	1.50	111.9	7.81	148.1
60	1/3PP+2/3SD	UAN+AA	119.9	29.4	1.32	75.0	6.20	95.1
120	"	"	152.0	28.1	1.50	107.5	7.04	134.0
180	"	"	157.0	28.2	1.50	111.8	7.27	140.4
60	"	UAN	113.5	29.2	1.34	72.2	6.00	93.0
120	"	"	132.2	28.2	1.43	89.4	6.66	116.4
180	"	"	144.9	29.0	1.52	104.2	6.86	132.2
Signif. Level (%):			99	99	99	99	99	99
BLSD (.05) :			6.8	0.8	0.07	7.0	0.50	8.9
CV (%) :			5.0	2.6	5.1	7.7	7.3	7.7
FACTORIAL COMPARISONS								
Main Factors								
N Rate (lb/A)								
60			117.7	29.3	1.30	72.6	6.17	93.5
120			142.9	28.2	1.41	95.7	6.89	121.2
180			153.0	28.5	1.51	109.3	7.31	140.2
Signif. Level (%):			99	99	99	99	99	99
BLSD (.05) :			4.0	0.5	0.04	4.1	0.30	5.3
N Time - Source (Method)								
PP - AA			140.4	28.6	1.36	90.8	7.03	117.9
PP/SD - UAN/AA			143.0	28.6	1.44	98.1	6.84	123.2
PP/SD - UAN			130.2	28.8	1.43	88.6	6.51	113.9
Signif. Level (%):			99	37	99	99	99	99
BLSD (.05) :			4.1		0.04	4.4	0.33	6.0
Interaction					Significance Level (%)			
N Rate x N Time-Source			83	50	99	99	63	99

CONCLUSIONS

Based on this 1-yrs data corn yields were not improved significantly by split applications of N on this Webster soil. Split applications with 2/3 of the N applied at the 8-leaf stage showed decreased leaf N concentrations at silking but resulted in higher grain N concentrations than the single preplant application. Grain and silage yields were consistently lower with the split applications of UAN. The abnormally dry period from May thru late July undoubtedly affected these results and pointed to the need for injecting sidedress applications of N.

NITROGEN SOURCES FOR CORN WITH CONSERVATION TILLAGE IN SOUTHERN MINNESOTA

1985

G. W. Randall and C. Zadak

Conservation tillage, which leaves plant residues on the soil surface, is frequently being practiced in southern Minnesota. These residues have been shown to affect N losses. Hence, best management practices, including proper N sources, are necessary to minimize loss of N and maximize economic return. The purpose of this study was to evaluate various N sources for corn production with conservation tillage on two contrasting soils in southern Minnesota.

EXPERIMENTAL PROCEDURES

Two sites which had been planted to corn in 1984 were selected for this study. One location was on a Mount Carroll silt loam (Mollic Hapludalf) on the Roger Kleese farm in Goodhue County. This soil represents a large acreage of well-drained, low organic matter, loessial soils cropped to corn in southeastern Minnesota. The other location was at the Southern Experiment Station, University of Minnesota in Waseca County. This Webster clay loam (Typic Haplaquoll) has inherently poor drainage, high organic matter content, and is extensively cropped to corn and soybeans. It represents a large acreage of soils in Southern Minnesota and Northern Iowa.

Tillage at the Goodhue Co. site consisted of fall chisel plowing and then spring field cultivating prior to planting. The site in Waseca Co. was ridge-planted in both 1984 and 1985. Soil tests for the Goodhue and Waseca sites follow: pH = 6.2 and 7.1; Bray extractable P_1 = 48 and 42 lb/A (both Very High); exchangeable K = 374 and 427 lb/A (both Very High); and extractable SO_4 - S = 7 and 8 ppm (both Medium), respectively, for the two locations. Nitrate-N totaled 130 lb/A in the 0-5' profile (83 lb NO_3 - N/A in 0-3' profile) at the Goodhue Co. site. Surface coverage by plant residues averaged 30 and 38% at the two sites, respectively. Ridge height averaged 5.2 inches at the Waseca site.

Sixteen N treatments were replicated three times at the Goodhue site while 13 treatments were replicated five times at the Waseca site. A randomized, complete-block design was used at each site. Each plot measured 10' wide (4-30" rows) x 35' long in Goodhue County and 10' wide x 60' long in Waseca County.

Corn (Pioneer 3737) was planted with a John Deere Max-Emerge planter at a population of 27700 plants/acre on May 2 in Goodhue Co. and on May 8 in Waseca Co. Excellent weed and corn rootworm control was obtained with proper chemicals at both sites.

Nitrogen treatments were broadcast applied on the soil surface on May 6 in Goodhue Co. and on May 8 in Waseca Co. Rainfall in the 10-day period following N application in Goodhue Co. totaled 0.48 inch with 0.08" on the 5th day and 0.23" on the 8th day following application. At Waseca, 1.01" rain occurred in the 10-day period with .06" on the 3rd day, .07" on the 4th, .26" on the 6th, and .50" on the 8th day following application. Three quarters of the N (90 lb/A) for the split application was sidedress applied on the soil surface at the 7-leaf state (June 12) at Goodhue Co. Two days later 0.38" of rain fell to dissolve the AN into the surface soil.

Ten randomly selected leaves opposite and below the ear were taken at silking for N and S analyses. Fodder and grain yields were obtained at physiological maturity by hand harvest techniques at the Goodhue location while plots were combine harvested at Waseca. All stover and grain analyses were conducted on samples gathered at harvest. Chemical analyses were performed by the Research Analytical Laboratory, University of Minnesota.

Soil samples were taken at 1-foot increments to a depth of 8' from the 0, 60, 120, 180, and 240-lb AN treatments on November 12 at the Goodhue Co. site. These samples were dried, ground, and analyzed for NO_3 - N to determine the carryover and accumulations of NO_3^- in the soil profile.

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

RESULTS AND DISCUSSION

Rainfall during the 1985 growing season was considerably below normal in Goodhue Co. and slightly below normal in Waseca Co. (Table 1). Conditions were exceptionally dry during May, June, and July; rain did not occur in sufficient amounts immediately after application to leach the surface applied N into the soil profile. Thus, some volatilization could have occurred in the first 5 days at both locations.

Table 1. Rainfall during the May thru October growing season in Goodhue and Waseca Counties.

Month	Location	
	Goodhue	Waseca
	inches	
May	1.58	1.81 (-1.95)[1/]
June	1.32	2.56 (-1.92)
July	1.64	2.51 (-1.51)
August	4.35	5.21 (+1.22)
September	3.09	5.40 (+2.04)
October	1.17	2.71 (+0.63)
TOTAL	13.15	20.20 (-1.49)

1/ Departure from 30-year normal.

Goodhue County

Because of the moderate levels of NO_3^- in the soil profile and the adverse growing conditions during the season, corn response to the N treatments was minimal (Tables 2 and 3). These small differences made it difficult to clearly establish the effects of the N sources and their interaction with rate of N application.

Nitrogen Concentrations

Leaf, stover, and grain N concentrations were generally increased over the control by the 120-lb N/A application rate but not by the 60-lb rate (Table 2). When averaged over N rate, differences among the N source were not significant at the P=95% level. At the 60-lb rate leaf and grain N were lowest with the urea + AS treatment. The 120-lb N rate averaged over the six sources increased leaf N and grain N significantly (P=99% level). Increasing the application rate of AN to 240-lb N/A increased leaf, stover, and grain N significantly. However, the split application of AN did not improve the N concentrations in the plant tissure over the single, preemergence application.

Significant (P = > 94% level) interactions between N source and N rate were found for leaf N, stover N, and grain N. The 120-lb rate resulted in a large increase in leaf N when the N source was urea + AS, modest increases with AN, AS, UAN + S, and urea, and no increase when UAN was used. Stover N was increased with the higher N rate when AS, UAN + S, and urea + AS were used but was unchanged when UAN or urea were used. Grain N was also increased substantially by the 120-lb rate of urea + AS, but was unaffected by N rate when UAN, UAN + S, or urea were used. Explanations for these significant interactions are not readily apparent at this time.

Yields

Although significant differences (P = 95% level) in stover, silage, and grain yields occurred among the 16 treatments, few yields were increased significantly over the check (Table 3). When averaged over N rates, highly significant differences were found among the N sources. Silage yields were lowest with the AS and urea treatments while grain yields were significantly lower with the AS and urea + AS treatments. For some unknown reason the yields from these treatements did not differ from the check. The 120-lb N rate significantly increased silage and grain yield over the 60-lb rate. Additional yield increases with the 180 and 240-lb rates were not found.

Significant (P = > 93% level) interactions between N source and rate of application were also found for stover, silage, and grain yields (Table 3). These were primarily due to the large yield increases with the 120-lb N rate of urea or urea + AS over the 60-lb rate while yield differences between the two N rates were minimal when using AN, AS, or UAN.

Table 2. Nitrogen concentration in corn tissue and final population as affected by N source and rate of application in Goodhue Co.

N Treatment		N concentration in			Final
Source[1/]	Rate	Leaf	Stover	Grain	population
	lb N/A	%			ppA x 10^{-3}
CHECK	0	1.95	.60	1.32	24.0
AN	60	2.28	.83	1.37	24.5
"	120	2.35	.72	1.44	24.9
"	180	2.40	.91	1.47	24.4
"	240	2.65	.90	1.54	22.3
"	120 split	2.50	.82	1.44	23.1
AS	60	2.03	.63	1.36	23.9
"	120	2.26	.76	1.42	22.4
UAN	60	2.23	.76	1.43	23.8
"	120	2.29	.77	1.42	23.8
UAN+S	60	2.01	.67	1.40	24.0
"	120	2.25	.78	1.41	24.0
Urea	60	1.97	.81	1.38	24.3
"	120	2.20	.80	1.38	25.2
½UR+½AS	60	1.70	.73	1.33	25.0
"	120	2.38	.85	1.47	23.2
Signif. Level (%):		99	99	99	42
BLSD (.05)	:	0.29	.11	0.10	
CV (%)	:	7.8	8.4	3.8	6.3
INDIVIDUAL FACTORS					
N Source (60+120 lb)					
AN		2.32	.78	1.41	24.7
AS		2.14	.69	1.39	23.2
UAN		2.26	.76	1.42	23.8
UAN+S		2.13	.72	1.41	24.0
Urea		2.09	.80	1.38	24.7
½UR+½AS		2.04	.79	1.40	24.1
Signif. Level (%):		91	94	50	53
BLSD (.10)	:	0.21	.08		
N Rate (lb/A)					
60		2.04	.74	1.38	24.2
120		2.29	.78	1.43	23.9
Signif. Level (%):		99	93	99	48
Interaction			Significance Level (%)		
Source x Rate		94	98	97	43

1/ AN = ammonium nitrate, AS = ammonium sulfate, UAN = urea-ammonium nitrate, UAN + S = UAN + 3% S as AS(25-0-0-3), and UR = urea.

2/ 30 lb at preemergence (May 6) and 90 lb at 7-leaf stage (June 12).

Table 3. Corn yields and N uptake as influenced by N source and rate of application in Goodhue Co.

N Treatment		Yields			Ear	N Uptake	
Source	Rate	Stover	Silage	Grain	Moisture	Grain	Total[1/]
	lb N/A	----- TDM/A ----		bu/A	%	--- lb N/A ---	
CHECK	0	1.98	5.62	137.0	40.7	86.0	109.7
AN	60	2.17	6.26	152.9	41.3	99.3	135.5
"	120	2.13	6.08	147.8	41.7	100.9	131.6
"	180	2.26	6.41	154.8	41.0	108.0	149.4
"	240	2.26	6.28	149.3	41.0	108.7	149.7
"	120 split	2.26	5.90	136.2	42.7	92.5	129.3
AS	60	2.03	5.62	134.8	40.7	86.4	112.0
"	120	2.16	5.83	137.2	41.3	92.4	125.2
UAN	60	2.34	6.23	145.2	41.0	98.3	134.1
"	120	2.08	6.16	151.7	40.3	102.0	134.0
UAN+S	60	2.16	5.98	143.0	40.3	95.1	124.0
"	120	2.24	6.32	152.7	40.7	102.2	137.0
Urea	60	1.79	5.48	137.8	41.7	89.8	118.6
"	120	2.19	6.33	155.1	40.3	101.6	136.5
½UR+½AS	60	2.04	5.34	123.9	41.7	78.1	107.8
"	120	2.10	6.04	147.3	42.0	102.7	138.3
Signif. Level (%):		96	99	99	97	99	99
BLSD (.05)	:	0.35	0.58	15.7	1.6	14.0	17.4
CV (%)	:	7.6	5.3	5.9	1.3	8.0	7.9
INDIVIDUAL FACTORS							
N Source (60+120 lb)							
AN		2.15	6.17	150.3	41.5	100.1	133.6
AS		2.10	5.72	136.0	41.0	89.4	118.6
UAN		2.21	6.19	148.4	40.7	100.1	134.1
UAN+S		2.20	6.15	147.8	40.5	98.6	130.5
Urea		1.99	5.90	146.4	41.0	95.7	127.6
½UR+½AS		2.07	5.69	135.6	41.8	90.4	123.1
Signif. Level (%):		80	98	99	95	98	95
BLSD (.05)	:		0.40	10.2	1.0	8.4	12.7
N Rate (lb/A)							
60		2.09	5.82	139.6	41.1	91.2	122.0
120		2.15	6.13	148.6	41.1	100.3	133.8
Signif. Level (%):		72	99	99	17	99	99
Interaction				Significance Level(%)			
Source x Rate		95	96	93	79	94	96

[1/] Grain + stover

N Uptake

Uptake of N (product of N concentration times either the grain or grain + stover dry matter yield) was increased significantly over the check by most of the 120-lb treatments (Table 3). Grain and total plant uptake of N was highest with the AN and UAN sources and lowest with the AS source when averaged over N rates. Again, the reason for this is not clear. Both grain and total plant uptake were increased by the 120-lb rate over the 60-lb rate. Grain N uptake was not increased by the AN rates greater than 120-lb N/A, whereas, total plant uptake was highest with the 180-lb rate. The significant N source by N rate interaction was due to higher grain and total plant uptake at the 120-lb rate with the AS, UAN + S, urea, and urea + AS sources, while with AN and UAN, uptake was not affected by rate. Reasons for this interaction are not known at this time, but may merely reflect the variability in the data.

Sulfur Concentrations

Even though S applications totaled 138, 69, and 14.4 lb S/A with the AS, UAN + S, and urea + AS treatments, leaf and stover S concentrations were not affected (Table 4). Due to the extremely low variability grain S was increased slightly but significantly by the 69 and 138-lb AS treatments. Sulfur uptake in the grain and the whole plant were not affected by the S treatments. Nitrogen:S ratios ranged from 13.8 to 15.8 for leaves, 10.6 to 11.8 for stover, and from 14.8 to 15.8 for the grain. In all cases, the lowest N:S ratio was with the 138-lb S treatment as AS.

Table 4. Sulfur concentrations and uptake by corn as influenced by N sources in Goodhue Co.

N Source[1/]	Leaf S	Stover S	Grain S	Sulfur Uptake Grain	Sulfur Uptake Total
	%			lb S/A	
AN	.149	.063	.091	6.37	9.05
AS	.164	.072	.096	6.25	9.35
UAN	.155	.069	.091	6.55	9.44
UAN+S	.159	.071	.093	6.69	9.86
Urea	.155	.070	.088	6.46	9.52
½UR+½AS	.159	.072	.094	6.52	9.55
Signif. Level (%):	17	41	98	26	27
BLSD (.05) :			.004		
CV (%) :	8.4	9.9	2.5	5.6	6.5

1/ 120 lb N/A

Residual Nitrate - N

Samples taken to an 8-foot depth after harvest showed a linear increase corresponding to N application rate in NO_3^- remaining in the soil profile (Table 5). In the 0-8' profile an increase of 189 lb NO_3-N was noted with the 240-lb rate over the control The majority of the NO_3^- accumulated in the top 3' with some evidence of movement to 6' with rates of 120-lb and greater.

Table 5. Residual soil NO_3-N in the soil profile in November as influenced by N rate in Goodhue Co.

Profile depth	N Application Rate (lb/A) 0	60	120	180	240
feet	lb NO_3-N/foot				
0-1	14	22	27	52	55
1-2	11	19	43	61	90
2-3	4	18	31	31	47
3-4	12	18	19	16	26
4-5	14	18	22	20	22
5-6	15	16	23	24	20
6-7	16	13	18	18	16
7-8	14	12	14	14	13
Totals					
0-5'	55	95	142	170	240
5-8'	45	41	55	56	49
0-8'	100	136	197	226	289

Nitrogen Budget

A N budget can be obtained by adding the total N uptake shown in Table 4 to the residual NO_3-N shown in Table 5 for each treatment, and then subtracting out the uptake plus residual from the check treatment. From this one can calculate the precent recovery by dividing by the respective N application rate. Using this method, % recovery totaled 103, 99, 92 and 95% for the 60, 120, 180, and 240-lb N rates, respectively. These high recovery rates indicate that very little fertilizer N was lost from the soil or immobilized into the soil organic matter during the 1985 season.

Waseca County

Nitrogen Concentrations

Leaf N was increased significantly over the check by all N treatments except UAN at the 75-lb N rate (Table 6). Grain N was increased significantly by all of the 150-lb treatments and with the AA, AS, and urea sources at the 75-lb N rate. Stover N concentrations were not increased over the check by any of the N treatments due to the high variabililty (CV = 14.0). However, stover N concentrations averaged 40% lower at this site than at the Goodhue site.

When averaged over N rates, leaf N was significantly higher with the AA and AS treatments compared to the UAN and UAN + S treatments with the urea treatments being intermediate. Stover N was not influenced (P = 90% level) while grain N was highest with the AA and AS treatments (P = 92% level). When averaged over the six N sources, leaf and grain N were both increased significantly by the 120-lb N rate. Interactions between N source and N rate were not significant for either leaf or grain N.

Table 6. Nitrogen concentration in corn tissue and final population as affected by N source and rate of application in Waseca Co.

N Treatment		N concentration in			Final
Source[1/]	Rate	Leaf	Stover	Grain	population
	lb N/A	---------- %	----------		ppA x 10^{-3}
CHECK	0	1.68	.39	1.08	26.3
AA	75	2.47	.50	1.24	26.4
"	150	2.62	.42	1.38	26.5
AS	75	2.36	.50	1.28	26.6
"	150	2.54	.48	1.34	26.0
UAN	75	1.92	.40	1.13	27.2
"	150	2.37	.50	1.33	26.5
UAN+S	75	2.04	.41	1.14	26.8
"	150	2.29	.38	1.27	27.2
Urea	75	2.22	.42	1.25	27.2
"	150	2.52	.49	1.32	26.5
½UR+½AS	75	2.16	.46	1.13	26.8
"	150	2.38	.43	1.30	27.2
Signif. Level (%):		99	95	99	3
BLSD (.05)	:	0.30	.12	0.13	
CV (%)	:	9.3	14.	7.1	5.1
INDIVIDUAL FACTORS					
N Source					
AA		2.54	.46	1.31	26.4
AS		2.45	.49	1.31	26.3
UAN		2.14	.45	1.23	26.0
UAN+S		2.16	.39	1.21	27.0
Urea		2.37	.46	1.28	26.8
½UR+½AS		2.27	.45	1.21	27.0
Signif. Level (%):		99	88	92	18
BLSD (.05)	:	0.21			
N Rate (lb/A)					
75		2.20	.45	1.19	26.8
150		2.45	.45	1.32	26.6
Signif. Level (%):		99	19	99	34
Interaction		Significance Level (%)			
Source x Rate		25	91	37	14

[1/] AA = anhydrous ammonia, AS = ammonium sulfate, UAN = urea-ammonium nitrate, UAN + S = UAN + 3% S as AS(25-0-0-3), and UR = urea.

Yields

Grain and silage yields were increased over the check by all of the N treatments (Table 7). Grain moisture at harvest was also decreased significantly by the N treatments. Stover yields were not affected by the treatments.

Table 7. Corn yields and N uptake as influenced by N source and rate of application in Waseca Co.

N Treatment		Yields			Grain	N Uptake	
Source	Rate	Stover	Silage	Grain	Moisture	Grain	Total[1/]
	lb N/A	----- TDM/A ----		bu/A	%	lb N/A	
CHECK	0	1.79	4.80	106.9	25.6	55.1	69.2
AA	75	2.29	6.61	147.9	23.0	87.0	109.9
"	150	2.14	6.61	149.9	22.4	97.6	115.7
AS	75	2.17	6.50	146.5	23.9	88.6	110.1
"	150	2.17	6.56	152.2	24.0	96.6	117.7
UAN	75	2.18	5.82	128.1	24.2	68.9	86.1
"	150	2.26	6.51	148.8	22.8	94.0	116.7
UAN+S	75	2.19	6.35	131.3	24.2	71.0	89.2
"	150	2.29	6.58	145.3	23.8	87.9	105.3
Urea	75	2.14	6.62	140.5	23.4	83.3	101.5
"	150	2.31	6.70	144.8	23.7	90.2	112.7
½UR+½AS	75	2.22	6.34	141.1	24.2	75.7	96.6
"	150	2.19	6.55	143.1	23.4	87.8	106.7
Signif. Level (%):		83	99	99	99	99	99
BLSD (.05) :			0.70	17.7	1.4	15.6	19.5
CV (%) :		9.8	7.5	8.5	3.8	13.	13.
INDIVIDUAL FACTORS							
N Source							
AA		2.21	6.62	148.9	22.7	92.3	112.8
AS		2.17	6.53	149.3	24.0	92.6	113.9
UAN		2.22	6.16	138.4	23.5	81.4	101.4
UAN+S		2.24	6.47	138.3	24.0	79.5	97.2
Urea		2.23	6.66	142.6	23.5	86.7	107.1
½UR+½AS		2.21	6.44	142.1	23.8	81.8	101.6
Signif. Level (%):		1	60	80	93	92	90
BLSD (.10) :					1.0	11.3	14.2
N Rate (lb/A)							
75		2.20	6.37	139.2	23.8	79.1	98.9
150		2.23	6.58	147.3	23.4	92.4	112.5
Signif. Level (%):		33	86	99	90	99	99
Interaction				Significance Level (%)			
Source x Rate		27	27	54	56	42	52

[1/] Grain + stover

When averaged over N rate, significant differences (P = 90% level) in stover, silage, or grain yield were not found among the N source treatments. However, grain yields were 10% lower with the two UAN treatments compared to the AA and AS treatments. Grain yields were increased significantly by the 150-lb N rate over the 75-lb rate. Interactions between N source and N rate were not apparent.

N Uptake

Nitrogen uptake in both the grain and total plant (grain + stover) was increased (P = 95% level) over the check by all treatments except UAN at the 75-lb N rate (Table 7). When averaged over N rates, highest N uptake was achieved with the AA and AS sources while UAN + S resulted in lowest uptake. Uptake of N was significantly (P = 99% level) increased by the 150-lb N rate over the 75-lb rate when averaged over N sources. There was no N source by N rate interaction.

Sulfur Concentrations

Sulfur application rates with the AS, UAN + S, and urea + AS treatments totaled 170, 18, and 85 lb S/A, respectively. The 170-lb S rate consistently resulted in highest leaf, stover, and grain S (Table 8). Grain S was also increased with the 85-lb rate. The 18-lb rate applied with UAN did not affect leaf, stover, or grain S concentrations. Sulfur uptake in the grain and the total plant was only increased with the AS treatment (170 lb S/A). Nitrogen:S ratios ranged from 14.3 to 16.1 for leaves, 8.3 to 10.4 for stover, and 13.5 to 15.7 for grain. In all cases lowest N:S ratios were found with the 85 and 170-lb S rates as AS. Slight reductions in the N:S ratio were noted with the UAN + S treatment.

Table 8. Sulfur concentrations and uptake by corn as influenced by N sources in Waseca Co.

N Source[1/]	Leaf S	Stover S	Grain S	Sulfur Uptake Grain	Sulfur Uptake Total
	---------- %	----------		---- lb S/A	----
AA	.163	.046	.088	6.23	8.22
AS	.178	.058	.098	7.10	9.61
UAN	.150	.048	.086	6.10	8.30
UAN+S	.144	.044	.088	6.04	8.08
Urea	.157	.049	.087	5.93	8.20
½UR+½AS	.154	.052	.096	6.50	8.77
Signif. Level (%):	94	99	99	91	92
BLSD (.10) :	.021	.006	.004	0.82	1.11
CV (%) :	9.2	9.0	3.8	8.8	8.8

[1/] 150 lb N/A

SUMMARY

Although differences did exist among the N sources when averaged over N rates, these differences did not show a consistent advantage for any one particular source. In Goodhue Co. slight advantages appeared with AN and UAN, while AS resulted in the poorest yields. In Waseca Co., highest yields and N uptake were obtained with AA and AS while UAN resulted in the lowest yields. Corn production was maximized by the 120-lb rate in Goodhue Co. and by the 150-lb rate in Waseca Co.

Corn production was not enhanced by the sulfur in the N sources although S uptake was increased at Waseca. A nitrogen budget calculated from the plant N uptake and residual soil NO_3^- data in Goodhue Co. indicated N recovery to range from 92 to 103%, indicating little N loss in 1985.

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UAN AND S PLACEMENT FOR CORN WITH RIDGE TILLAGE IN SOUTHERN MINNESOTA

1985

G. W. Randall and C. Zadak

Ridge tillage is a conservation tillage method which is gaining popularity in the Corn Belt. With this system corn is planted on a previously built ridge which has had the residue removed by the planting operation. Thus, most of the plant residue remains in the valleys between the rows or on the ridge edges. Urea-ammonium nitrate (UAN) is also becoming a popular source of N in southern Minnesota. However, volatilization losses of N from surface-applied UAN to residue covered soils have frequently been reported in the literature. Recently North Dakota State University scientists reported that additions of ATS (ammonium thiosulfate) with UAN have reduced volatilization losses from surface-applied UAN. The purpose of this study was to determine the effect of placement of UAN (28% N) with and without sulfur (S) in a ridge tillage system in two southern Minnesota soils.

EXPERIMENTAL PROCEDURES

Two sites which had been ridge-planted to corn in 1984 were selected for this study. One location was on a Mount Carroll silt loam (Mollic Hapludalf) on the Paul Nesseth farm in Goodhue County. This soil represents a large acreage of well-drained, low organic matter, loessial soils cropped to corn in southeastern Minnesota. The other location was at the Southern Experiment Station, University of Minnesota in Waseca County. This Webster clay loam (Typic Haplaquoll) has inherently poor drainage, high organic matter content, and is extensively cropped to corn and soybeans. It represents a large acreage of soils in Southern Minnesota and Northern Iowa.

Soil tests for the Goodhue and Waseca sites follow: pH = 6.0 and 7.9; OM = Med. and High; Bray 1 extractable P = 78 lb/A (VH) and Olsen's extractable P = 27 lb/A (H); exchangeable K = 297 lb/A(H) and 241 lb/A(MH); and extractable SO_4-S = 7 and 7 ppm (both medium), respectively, for the two locations. Nitrate-N totaled 83 lb/A (Low) in the 0-5' profile (54 lb NO_3-N/A in the 0-3' profile) at the Goodhue Co. site. Surface coverage by plant residues perpendicular to the rows averaged 48 and 33% at the two sites, respectively. Coverage on the ridges averaged 22 and 11% at the two sites, respectively. Ridge height averaged 4.2" at the Waseca site.

Ten N treatments were replicated four times at the Goodhue site and five times at the Waseca site. A randomized, complete-block design was used at each site. Each plot measured 10' wide (4-30") rows x 40' long in Goodhue County and 10' wide x 60' long in Waseca County.

Corn (Pioneer 3737) was planted with a John Deere Max-Emerge planter at a population of 26100 plants/acre on May 1 in Goodhue Co. and at 27700 on May 8 in Waseca Co. Excellent weed and corn rootworm control was obtained with proper chemicals at both sites.

Nitrogen treatments were applied on the soil surface on May 6 in Goodhue Co. and on May 8 in Waseca Co. The broadcast treatments were applied using 8006E nozzles. The 2-cm wide band application to the ridge-top was accomplished using no. 93 orfices. Rainfall in the 10-day period following N application in Goodhue Co. totaled 0.48 inch with 0.08" on the 5th day and 0.23" on the 8th day following application. At Waseca, 1.01" rain occurred in the 10-day period with .06" on the 3rd day, .07" on the 4th, .26" on the 6th, and .50" on the 8th day following application. The sidedress portion of the split application was applied in a band 6" to the side of the row at the 6-leaf stage on June 12 at the Goodhue Co. site and on June 17 at the Waseca Co. site.

Rain (0.36") occurred 2 days later in Goodhue Co. to move the UAN into the soil. The sidedress application was followed immediately by cultivation in Waseca Co.

Ten randomly selected leaves opposite and below the ear were taken at silking for N and S analyses. Fodder and grain yields were obtained at physiological maturity by hand-harvest techniques at the Goodhue location while grain yields were obtained by combine harvesting at Waseca. All stover and grain analyses were conducted on samples gathered at harvest. Chemical analyses were performed by the Research Analytical Laboratory, University of Minnesota.

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

RESULTS AND DISCUSSION

Rainfall during the 1985 growing season was considerably below normal at both locations. Conditions were exceptionally dry during May, June, and July. Only five 24-hr rainfall events greater than 0.10" occurred during this period in Goodhue Co. while 13 occurred in Waseca Co. Rain did not occur in sufficient amounts immediately after application to leach the surface-applied N into the soil profile. Thus, some volatilization could have occurred in the first 5 days at both locations.

Goodhue County

Due to the dry weather and the apparent carryover of residual N, crop response to the N treatments was limited. Check plot yields surpassed expectations. Moreover, yield response to the N treatments was marginal and was quite variable.

Nitrogen Concentrations

Leaf and stover N concentrations were not affected significantly (P=90% level) from the check by the N treatments (Table 1). Neither N source nor placement affected leaf and stover N concentrations. The significant interaction between N source and placement (P=92% level) was due to the large depression in leaf N (0.40% N) and stover N (0.13% N) when the UAN + ATS treatment was broadcast applied compared to ridge-top applied. The effect of placement was minimal when either UAN or UAN + AS were applied. Leaf N was below the sufficiency level for all N treatments.

Grain N concentrations were higher, probably due to the late season rainfall, and were increased over the check by some of the N treatments. The source of N had no effect on grain N. Although grain N was slightly lower with the broadcast placement and specifically the broadcast UAN + ATS treatment, these differences were not significant at the 90% probability level. Final population was not affected by any of the treatments.

Yields

Stover yields were increased significantly over the check by 4 of the 9 treatments (P=95% level) while silage yields were increased by 5 of the 9 treatments (P=90% level) (Table 2). Grain yields were variable and, thus, were not significantly improved by the N treatments. Neither N source when averaged over placement methods nor placement method when averaged over N sources affected stover, silage or grain yields. The significant (P>90% level) interaction between N source and N rate was due to the increase in stover, silage, and grain yield when UAN was broadcast compared to banded on the ridge-top; whereas, when either AS or ATS was added to the UAN, broadcast application resulted in slightly decreased yields. Because plant population was not affected and phytotoxic symptoms did not appear with the banded ridge-top placement, no explanation for this apparent advantage for broadcast UAN placement can be given.

N Uptake

Uptake of N into the grain (product of N concentration times grain yield) was not influenced significantly by any of the N treatments because of the high variability (CV=12%) (Table 2). Although uptake of N into the total plant (grain + stover) was not increased significantly over the check by any of the N treatments, a significant (P=94% level) N source x placement method interaction did exist. Broadcast application of UAN increased total N uptake over the ridge-top band application, whereas when ATS was added to UAN the broadcast application markedly reduced N uptake. Placement method did not affect N uptake when AS was added to the UAN. Again, the reasons for this are not clear at this time.

Table 1. Nitrogen concentrations in corn tissue and final plant population as affected by placement method of UAN with and without S in Goodhue Co.

N Treatment			N Concentration in			Final
No.	Material[1]	Placement[2]	Leaf	Stover	Grain	population
			%			ppA x 10^{-3}
1	CHECK	----	1.92	.57	1.26	24.5
2	Am. Nitrate	Bdct.	2.20	.64	1.39	22.8
3	UAN	Ridge top	2.10	.59	1.40	23.2
4	"	Between rows	2.06	.61	1.34	23.1
5	"	Bdct.	2.11	.65	1.36	25.0
6	"	Split[3]	2.10	.57	1.35	24.6
7	UAN+AS	Ridge top	2.07	.60	1.40	24.5
8	"	Bdct.	2.19	.66	1.38	23.2
9	UAN+ATS	Ridge top	2.34	.70	1.44	24.7
10	"	Bdct.	1.94	.57	1.34	26.0
Signif. Level (%):			58	58	95	63
BLSD (.05) :					0.12	
CV (%) :			12.	14.	4.8	8.0
ORTHOGONAL COMPARISONS						
N Source						
UAN (trts 3&5)			2.10	.62	1.38	24.1
UAN+AS			2.13	.63	1.39	23.8
UAN+ATS			2.14	.63	1.40	25.4
Signif. Level (%):			5	5	11	64
Placement						
Ridge top			2.17	.63	1.41	24.1
Broadcast			2.07	.63	1.36	24.7
Signif. Level (%):			67	4	89	48
Interaction				Significance Level (%)		
Source x Placement			92	95	48	65

1/ UAN = 28-0-0; UAN + AS = 25-0-0-3 w/S as ammonium sulfate; UAN + ATS = 25-0-0-3 w/S as ammonium thiosulfate.
2/ All materials applied at 120 lb N/A.
3/ 40% on ridge top preemergence + 60% sidedressed in a band 6-8" from row at 6-leaf stage.

Nitrogen efficiency determined by subtracting the grain and total N uptake of the check plots ranged from 10 to 20% for grain N uptake and from 12 to 28% for the total plant N uptake.

Sulfur Concentrations

The addition of 14.4 lb S/A as AS did not increase the S concentrations in the leaf, stover, or grain or S uptake in the grain or in the whole plant (Table 3). Placement of the UAN + ATS in a band on the ridge-top significantly increased leaf S and grain S uptake but did not affect stover or grain S concentration or S uptake by the whole plant. Between 2 and 5% of the applied S was taken up by the plants.

Waseca County

Even though conditions were dry until late July, a good response to the N treatments was found.

Table 2. Corn yields and N uptake as influenced by placement method of UAN with and without S in Goodhue Co.

N Treatment			Ear	Yields			N Uptake	
No.	Material	Placement	moisture	Stover	Silage	Grain	Grain	Total[1/]
			%	---- T DM/A ----		bu/A	---- lb N/A ---	
1	CHECK	----	33.1	1.42	4.92	132.8	79.4	95.7
2	Am. Nitrate	Bdct.	32.2	1.71	5.49	142.4	94.1	116.2
3	UAN	Ridge top	32.6	1.57	5.16	137.8	91.1	109.6
4	"	Between rows	32.6	1.83	5.85	151.5	95.9	118.3
5	"	Bdct.	33.3	1.78	5.88	154.7	99.6	122.9
6	"	Split	32.8	1.92	5.95	153.3	98.2	120.4
7	UAN+AS	Ridge top	33.7	1.93	5.84	147.0	96.9	120.1
8	"	Bdct.	32.8	1.60	5.46	145.9	95.3	116.3
9	UAN+ATS	Ridge top	32.6	1.85	5.88	151.8	104.1	129.7
10	"	Bdct.	32.0	1.72	5.51	143.8	91.5	111.3
	Signif. Level (%):		72	95	94	69	75	88
	BLSD (.05), (.10)*:			0.38	0.73*			
	CV (%) :		2.7	12.	8.6	8.7	12.	12.
	ORTHOGONAL COMPARISONS							
	N Source							
	UAN (trts 3&5)		33.0	1.68	5.52	146.3	95.3	116.2
	UAN+AS		33.3	1.77	5.65	146.4	96.1	118.1
	UAN+ATS		32.3	1.79	5.70	147.8	97.8	120.5
	Signif. Level (%):		91	46	37	7	14	22
	Placement							
	Ridge top		33.0	1.78	5.63	145.5	97.4	119.8
	Broadcast		32.7	1.70	5.61	148.1	95.4	116.8
	Signif. Level (%):		50	65	07	50	37	45
	Interaction				Significance Level (%)			
	Source x Placement		86	94	99	96	89	94

1/ Grain + stover

Plant Height

Because visual phytotoxicity symptoms were apparent with the UAN and UAN + ATS treatments when banded on the ridge, extended leaf heights were measured on 10 random plants per plot on July 2. Plant height was increased significantly (P=95% level) by all of the treatments except UAN + ATS banded on the ridge (Table 4). When averaged over N sources, ridge-top placement significantly reduced plant height compared to broadcast placement.

Nitrogen Concentrations

Leaf and grain N concentrations were increased over the check by all of the N treatments (Table 4). Stover N was increased over the check by 5 of the 9 treatments. Leaf and grain N concentrations were highest with UAN and lowest with UAN + AS when averaged over placement method. Broadcast placement of all three N sources significantly reduced leaf, stover, and grain N concentrations compared to banding the N on the ridge-top. Nitrogen deficiency symptoms were readily evident on the broadcast, between the ridge, and split application treatments at the silking stage. These results suggest that N losses occurred, perhaps through volatilization, with the broadcast and between the row applications. The addition of S as either AS or ATS appeared to enhance the N losses from the UAN.

Table 3. Sulfur concentrations in plant tissue and S uptake as influenced by S source and placement method in Goodhue Co.

N + S Treatment			S Concentration in			S Uptake	
No.	Material[1/]	Placement	Leaf	Stover	Grain	Grain	Total[2/]
			%			lb S/A	
3	UAN	Ridge top	.149	.059	.084	5.46	7.31
5	"	Bdct.	.150	.060	.085	6.20	8.35
7	UAN+AS	Ridge top	.156	.061	.084	5.88	8.22
8	"	Bdct.	.151	.068	.085	5.87	8.03
9	UAN+ATS	Ridge top	.174	.071	.088	6.36	9.00
10	"	Bdct.	.142	.065	.086	5.88	8.13
FACTORIAL ANALYSIS							
N Source							
UAN			.150	.606	.084	5.83	7.83
UAN+AS			.153	.064	.085	5.87	8.12
UAN+ATS			.158	.068	.088	6.12	8.55
Signif. Level (%):			63	70	65	53	72
BLSD (.05) :							
Placement							
Ridge top			.160	.064	.086	5.90	8.17
Broadcast			.148	.064	.085	5.98	8.17
Signif. Level (%):			98	11	7	33	1
Interaction					Significance Level (%)		
Source x Placement			98	52	21	93	88
CV (%):			7.2	16.	5.4	8.3	11.

1/ N applied at 120 lb N/A; S applied at 14.4 lb S/A (25-0-0-3)
2/ Grain + stover

Final Population

Plant population was reduced significantly (5%) by the band application of UAN and UAN + ATS on the ridge (Table 4). Apparently, these applications were concentrated too close to the germinating seedling.

Grain Moisture

Grain moisture at harvest, an indication of plant maturity, was decreased significantly by all of the N treatments (Table 5).

Yields

Stover, silage, and grain yields were increased significantly (P=95% level) over the check by all of the N treatments (Table 5). Compared to the highest yielding AA treatment, grain yields were reduced about 10% and significantly (P=95% level) by the broadcast UAN + AS treatment and both UAN + ATS treatments. Although not as statistically clear as the N concentration data, the yield data show a slight trend toward lower yields with the surface applications of UAN regardless of placement method. The inclusion of S, especially ATS, tended to further decrease yields. These data suggest that N losses occurred, probably from volatilization or immobilization of N.

N Uptake

Both grain and total plant uptake of N were increased by all of the N treatments (Table 5). Uptake of N was significantly reduced when either AS or ATS was added to the UAN when averaged over placement methods. Band application of all three N sources significantly increased N uptake over broadcast application.

Table 4. Plant height, N concentrations in plant tissue, and final plant population as affected by placement method of UAN with and without S in Waseca Co.

N Treatment			Plant	N Concentration in			Final
No.	Material[1]	Placement[2]	height	Leaf	Stover	Grain	population
			cm	---------- %		----------	ppA x 10^3
1	CHECK	----	89	1.69	.35	1.07	26.1
2	An. ammonia	preplant	98	2.57	.51	1.41	26.8
3	UAN	Ridge top	97	2.70	.48	1.43	24.6
4	"	Between rows	100	2.35	.40	1.32	27.0
5	"	Bdct.	105	2.36	.40	1.30	27.1
6	"	Split[3]	103	2.35	.42	1.37	26.0
7	UAN+AS	Ridge top	100	2.44	.48	1.35	26.7
8	"	Bdct.	103	2.14	.39	1.19	26.8
9	UAN+ATS	Ridge top	95	2.63	.45	1.37	25.3
10	"	Bdct.	101	2.19	.37	1.21	26.6
Signif. Level (%):			99	99	99	99	99
BLSD (.05)		:	7	.18	.06	.06	1.5
CV (%)		:	5.2	6.5	11	3.9	4.0
ORTHOGONAL COMPARISONS							
N Source							
UAN (trts 3&5)			101	2.53	.44	1.36	25.8
UAN+AS			102	2.29	.44	1.27	26.8
UAN+ATS			98	2.41	.41	1.29	25.9
Signif. Level (%):			67	99	75	99	78
BLSD (.05)		:		.13		.05	
Placement							
Ridge top			97	2.59	.47	1.38	25.5
Broadcast			103	2.23	.39	1.23	26.8
Signif. Level (%):			99	99	99	99	99
Interaction					Significance Level (%)		
Source x Placement			38	47	11	25	86

1/ UAN = 28-0-0; UAN+AS = 25-0-0-3 w/S as ammonium sulfate; UAN+ATS = 25-0-0-3 w/S as ammonium thiosulfate.

2/ All materials applied at 150 lb N/A.

3/ 40% on ridge top preemergence + 60% sidedressed in a 6-8" from row at 6-leaf stage.

Nitrogen efficiency measured by the difference method was 36 and 42% for the AA treatment for grain and total plant uptake, respectively. This was reduced to 30 and 35% by the UAN treatments, to 25 and 30% by the UAN + AS treatments, and to 24 and 28% by the UAN + ATS treatments, respectively. Ridge-top, band applications showed efficiency values of 30 and 35% while broadcast applications reduced N efficiency to 23 and 26%. Application of UAN between the rows gave efficiency values similar to broadcast applications, while the split application was similar to the band, ridge-top application.

These results further confirm that N losses must have occurred, especially with the broadcast applications containing either AS or ATS.

Sulfur Concentrations

Leaf and grain S concentrations were affected slightly and inconsistently by the 18 lb S/A N + S treatments (Table 6). However, S concentrations in all three plant parts were increased consistently by the band application of N on the ridge-top compared to the broadcast application. Sulfur uptake in the grain and the whole plant was also increased with the band application on the ridge. Sulfur uptake values showed that between 1 and 2% of the applied S was taken up by the plants.

Table 5. Grain yeilds and N uptake as influenced by placement method of UAN with and without S in Waseca Co.

N Treatment			Grain	Yields			N Uptake	
No.	Material[1/]	Placement[2/]	Moisture	Stover	Silage	Grain	Grain	Total[1/]
			%	-------- T DM/A --------			---- lb N/A ----	
1	CHECK	----	25.7	1.45	4.05	86.2	44.0	54.1
2	An. ammonia	preplant	22.1	1.94	6.31	146.2	97.8	117.6
3	UAN	Ridge top	22.8	1.82	5.90	135.8	91.6	109.1
4	"	Between rows	22.9	1.93	6.03	137.5	86.2	101.5
5	"	Bdct.	22.3	2.04	6.31	141.5	86.9	103.3
6	"	Split	22.8	1.99	6.17	139.7	90.6	107.4
7	UAN+AS	Ridge top	22.1	2.03	6.10	139.3	88.9	108.6
8	"	Bdct.	23.3	1.92	5.90	131.7	74.0	88.8
9	UAN+ATS	Ridge top	22.8	1.96	5.83	131.0	84.7	102.1
10	"	Bdct.	23.0	1.79	5.75	131.2	75.5	88.7
	Signif. Level (%):		99	99	99	99	99	99
	BLSD (.05)	:	.8	.32	.65	10.5	7.5	9.4
	CV (%)	:	2.9	12.	9.1	6.8	7.9	8.2
	ORTHOGONAL COMPARISONS							
	N Source							
	UAN (trts 3&5)		22.5	1.93	6.10	138.6	89.3	106.2
	UAN+AS		22.7	1.97	6.00	135.5	81.4	98.7
	UAN+ATS		22.9	1.87	5.79	131.1	80.1	95.4
	Signif. Level (%):		62	43	61	79	99	99
	BLSD (.05)	:					6.1	7.0
	Placement							
	Ridge top		22.6	1.94	5.94	135.3	88.4	106.6
	Broadcast		22.9	1.91	5.99	134.8	78.8	93.6
	Signif. Level (%):		80	21	19	13	99	99
	Interaction				Significance Level (%)			
	Source x Placement		98	90	62	71	76	87

1/ Grain + Stover

SUMMARY

Results from the study conducted at the Goodhue County site were quite inconclusive due to the high check plot yields, lack of N response, and high variability. However, the addition of S as ATS to the broadcast UAN solution quite consistently reduced N concentrations in the plant and plant yield. At the Waseca site response to the N treatments was excellent. Yields and N uptake were generally highest with the preplant anhydrous ammonia treatment. The UAN treatments usually resulted in lower N concentrations, slightly lower yields, and lower N uptake values, especially when the UAN contained S and was broadcast on the soil surface. Nitrogen was apparently being lost thru either volatilization or immobilization. Band application of UAN to the ridge top, especially with ATS, showed some early season phytotoxicity. Split application of UAN did not improve N uptake or yield over the single preemergence applications. Addition of S to the UAN did not improve corn production at either site. Based on these first-year data, the addition of S to UAN could not be recommended. Moreover, surface application of UAN showed slightly lower N efficiencies especially when broadcast applied.

Table 6. Sulfur concentrations in plant tissue and S uptake as influenced by S source and placement method in Waseca Co.

N + S Treatment			S Concentration in			S Uptake	
No.	Material[1/]	Placement	Leaf	Stover	Grain	Grain	Total[2/]
			%			lb S/A	
3	UAN	Ridge top	.175	.049	.087	5.62	7.41
5	"	Bdct.	.153	.044	.085	5.70	7.51
7	UAN+AS	Ridge top	.169	.053	.093	6.14	8.29
8	"	Bdct.	.146	.049	.089	5.52	7.38
9	UAN+ATS	Ridge top	.179	.052	.094	5.79	7.80
10	"	Bdct.	.152	.043	.084	5.25	6.79
FACTORIAL ANALYSIS							
N Source							
UAN			.164	.046	.086	5.66	7.46
UAN+AS			.157	.051	.091	5.83	7.84
UAN+ATS			.165	.047	.089	5.52	7.29
Signif. Level (%):			97	88	98	64	89
BLSD (.05) :			.007		.003		
Placement							
Ridge top			.174	.051	.091	5.85	7.83
Broadcast			.150	.045	.086	5.49	7.23
Signif. Level (%):			99	99	99	95	99
Interaction							
Source x Placement			21	48	93	79	93
CV (%) :			4.3	10.	3.7	8.3	7.5

1/ N applied at 150 lb N/A; S applied at 18 16 S/A (25-0-0-3).

2/ Grain + Stover

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NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1985

G. W. Randall and P. L. Kelly

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

EXPERIMENTAL PROCEDURES

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N into a tile line installed in each of 12 plots measuring 45' x 50'. Each plot is enclosed with plastic sheeting to a 6' depth. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. Residual N from N applied over the 7-year period (75-79) was utilized by the 1980 and 1981 corn crops. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. Corn was grown on these plots in 1982 through 1984. The stalks were chopped in October, 1984 and moldboard plots plowed.

On May 7, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 7 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with 2" fluted coulters. Starter fertilizer was not used because of the high soil tests. Furadan was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½#) and atrazine (3#/A) applied May 7. Weed and insect control was excellent.

The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (Moldboard plow = July 24, No tillage = July 29) and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 30 and 60' of row, respectively, from each plot.

Tile lines began flowing in late March 1985 and continued to flow intermittently until mid-May. Conditions were extremely dry in June and July and no tile flow was recorded during this period. Tile lines commenced flowing again in late September and flowed throughout October. When tile lines were flowing, flow rates were measured daily and samples taken on a Monday, Friday, Wednesday two-week rotation for NO_3-N analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-8' profile was determined from two cores/plot taken in 1-foot increments on April 29 and November 1, 1985.

RESULTS

Grain yield, N removed in the grain, and N uptake in the silage were significantly higher (P=95% level) with moldboard plow tillage compared to no tillage (Table 1). Silage yields were significantly improved with moldboard plowing (P=90% level). Leaf and grain N and final population were not influenced by the tillage system.

Precipitation for the March and April period was 4.2" above normal while rainfall was 4.0" above normal for the August and September period. Thus, most of the tile flow shown in Table 2 occurred in April and October. Total tile flow, flow-weighted NO_3-N concentration, and NO_3-N lost thru the tile lines were not markedly different between the two tillage systems. Nitrate-N concentrations averaged about 12 mg/L in comparison to 11 mg/L in 1984.

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

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1985.

Tillage system	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	$x10^{-3}$	%	T DM/A	lb N/A	bu/A	%	lb N/A
Mb. Plow	27.1	2.35	6.89	133.4	160.3	1.37	103.6
No Tillage	27.3	2.26	6.29	124.5	145.1	1.34	92.4
Signif. Level (%):1/	33	79	90	98	99	40	98
CV (%) :	2.2	3.5	5.5	2.2	2.5	4.0	3.3

1/ Probabililty level of significance.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss in 1985.

Tillage system	Tile flow	Nitrate-N Concentration1/	Nitrate-N Loss
	acre-inches	mg/L	
Mb. Plow	5.63	12.1	15.4
No Tillage	6.82	11.6	17.9

1/ Flow-weighted

Residual NO_3-N remaining in the 0-8' soil profile were not different between the two tillage systems when measured prior to N application (Table 3). After harvest slightly more residual NO_3^- remained in the no tillage system. The NO_3-N concentrations were surprisingly uniform throughout the profile of both tillage systems. No accumulation zone was apparent except for the slight increase in the surface 0-2' with no tillage.

Table 3. Influence of tillage systems on residual NO_3-N in the soil profile in 1985.

Profile depth	April Mb. Plow	April No Tillage	November Mb. Plow	November No Tillage
feet	NO_3-N (lb/A)			
0-1	19.2	14.9	12.5	23.6
1-2	15.3	10.7	12.8	19.7
2-3	14.0	10.1	14.0	15.7
3-4	14.6	14.4	13.3	13.3
4-5	13.8	14.3	13.3	18.2
5-6	10.0	13.4	12.8	14.2
6-7	9.0	11.1	10.8	14.8
7-8	10.0	9.9	9.9	13.2
Total (lb NO_3-N/A 0-8')	105.9	98.8	99.4	132.7

FOUR-YEAR SUMMARY

The cumulative totals for the 4-year period (1982-1985) are shown in Table 4. Corn yields over this period have averaged 8 bu/A better with moldboard plow tillage, although the difference between the two systems has widened each year. Approximately 10% more N has been removed in the grain with moldboard plow tillage. This has been due to both higher yields and slightly higher grain N concentrations with the moldboard tillage system some years. Even so, very little difference in applied N removed in the grain exists between the two treatments (48% vs 44% for plow vs no tillage, respectively). Total tile flow has been almost identical between the two systems. Even though about 10% more NO_3-N was lost through the tile lines with no tillage, this small difference is considered to be insignificant when considering tile flow variability among the eight plots over this 4-year period.

Table 4. Cumulative effects of the two tillage systems over the 4-year period.

Parameter	Tillage System	
	Mb. plow	No tillage
Fert. N applied (lb/A)	720	720
Corn grain removed (bu/A)	530	497
N removed in grain (lb/A)	346	315
Percent of applied N removed in grain (%)	48	44
Tile flow (acre inches)	41.1	43.7
Nitrate-N lost in tile (lb/A)	88.4	97.5
Percent of applied N lost via tile lines (%)	12	14

STARTER FERTILIZER PLACEMENT EFFECTS ON CORN PRODUCTION

Waseca, 1985

G. W. Randall and P. L. Kelly

Starter fertilizers will increase in popularity as farmers attempt to maximize return from their fertilizer dollar and as reduced tillage becomes more popular. However, with less spring secondary tillage, farmers somtimes encounter problems with the conventional disk opener systems when moist soil is dislodged by them and then sticks to the depth bands on the planter. The result can be uneven seeding depth. To correct this problem, farmers would like to remove the disk opener fertilizer attachment and instead place the starter fertilizer directly with the seed rather than in the conventional 2 x 2" placement. The purpose of this study was to evaluate seed placement versus 2 x 2" placement of two liquid fertilizers on the early growth, final stand, and yield of corn.

Experimental Procedures

A Webster clay loam soil planted to soybeans in 1984, chisel plowed in the fall, and field cultivated in the spring was the experimental site. The soil tests were: pH = 7.0, OM = High, Bray P_1 = 15 lb/A (M), and exchangeable K = 280 lb/A (H).

A randomized, complete block design with four replications was used. Factorial treatments consisting of two liquid starter fertilizers (10-34-0 and 7-21-7), three rates (5, 10, and 15 gal/A), and two placement methods (directly with the seed and 2" to the side and below) plus a no starter fertilizer check were applied.

Corn (Pioneer 3732) was planted in 30" rows with a JD Max-Emerge planter at 27,700 plants per acre on May 3. The liquid materials were applied either directly on the seed by running the delivery tube between the double disk openers on the planter or in the 2 x 2" position with the starter fertilizer disk opener. No insecticide was used. Chemical weed control consisted of 3½ qt. Lasso and 3½ qt. Bladex/A applied preemergence.

Table 1. Daily precipitation and average soil temperatures (2" depth) in the 2-week period following planting.

Days after planting	Avg. Soil temperature (2")	Precipitation
	°F	inches
1	69	0
2	60	.20
3	66	0
4	69	0
5	71	0
6	76	0
7	75	.06
8	68	.07
9	58	0
10	64	.26
11	60	.07
12	56	.50
13	52	.05
14	59	0

Plant counts to obtain emergence rate and final stand were then taken daily from two rows each 55' long for 12 days beginning on the 10th day after planting. Grain yield was determined by harvesting each plot with a modified JD 3300 plot combine.

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

Results and Discussion

Growing conditions following planting were excellent for corn germination and emergence. Soil temperature at the 2" depth averaged well above 50°F (Table 1). Soil moisture in the seed zone was slightly dry at planting and remained on the dry side for 11 days. On the 12th day 0.50" rain thoroughly wet the seed zone.

The salt rate ($N+K_2O$) of fertilizers has been shown to be important when applying fertilizer with the seed. Ammonia toxicity and/or salt burn can affect the germination of seedlings. A rule of thumb in Minnesota based on older research is not to apply more than 15 lb of $N+K_2O$/A. The $N+K_2O$ application rates with the various treatments are shown in Table 2. Salt levels are higher for 7-21-7 than for 10-34-0 because of the K component. Fifteen gallons of either material clearly exceeded the 15 lb/A threshold.

Table 2. Salt rate as influenced by starter fertilizer material and rate of application.

Application rate	Liquid fertilizer 10-34-0	7-21-7
gal/A	--- lb $N+K_2O$/A ---	
5	6	7.5
10	12	15.0
15	18	22.5

Emergence rate was affected significantly by the seed-placed fertilizers (Table 3). Application of 15 gal/A of both fertilizer materials with the seed resulted in less than 50% of the plants emerged on the 10th day following planting compared to about 80% with the 2 x 2" placement. At the high application rate 90% emergence was delayed by 5 to 6 days with seed-placement. Emergence was delayed slightly more with the 7-21-7 material because of the higher salt rate.

Table 3. Influence of liquid starter fertilizer material, application rate, and placement on emergence rate of corn.

Treatment			Days after planting									
Material	Rate	Placement	10	11	12	13	14	15	16	17	19	21
	gal/A		% of final stand									
None	0	CHECK	80	87	91	94	95	96	96	97	97	100
10-34-0	5	Seed	86	84	94	97	97	98	98	99	100	100
"	"	2 x 2	89	91	93	95	95	96	97	99	99	100
"	10	Seed	75	86	91	94	95	96	97	98	99	100
"	"	2 x 2	87	90	94	95	94	96	97	97	100	100
"	15	Seed	48	61	73	79	81	84	87	91	96	100
"	"	2 x 2	85	87	92	95	96	96	97	98	99	100
7-21-7	5	Seed	78	82	87	93	93	95	95	96	98	100
"	"	2 x 2	82	86	93	93	98	95	97	97	100	100
"	10	Seed	63	70	78	86	88	91	93	95	97	100
"	"	2 x 2	73	76	87	92	93	93	94	95	98	100
"	15	Seed	38	54	65	75	77	81	86	88	94	100
"	"	2 x 2	71	76	84	88	88	90	94	95	96	100

Final population was not effected by any of the treatments except with the seed-placed, high rate of both materials which reduced stand by almost 10% (Table 4). Factorial analyses (Table 5) showed no difference between 10-34-0 and 7-21-7 when seed-placed at the 15 gal/A rate. Application of 10 gal/A, although close to the 15 lb $N+K_2O$/A threshold, did not influence final population.

Seeds were excavated from the gaps where plants were missing. In almost all cases the seed had started to germinate as evidenced by the the emerged radicle (root). This radicle was usually from 1/4 to 3/4" long and was dark brown, indicating that it had been killed by salt burn and/or ammonia toxicity.

Grain moisture was reduced slightly by selected treatments (Table 4) and by 10-34-0 when averaged over rate and placement.

Grain yields were quite variable and thus were not effected statistically by the treatments (Table 4). When averaged over fertilizer materials and placement methods, higher yields were found with the 10 and 15 gal/A treatments compared to the 5 gal/A. This would be expected on this medium P testing soil. The delayed emergence and reduced stand did not effect the yield or moisture of the grain at harvest.

Table 4. Influence of liquid starter fertilizer material, application rate and placement on plant population, grain moisture, and corn grain yield.

Treatment			Final	Corn grain	
Material	Rate	Placement	population	Moisture	Yield
	gal/A		ppA x 10^{-3}	%	bu/A
None	0	Check	26.1	24.3	130.8
10-34-0	5	Seed	26.2	25.2	128.3
"	"	2 x 2	26.5	25.2	130.6
"	10	Seed	26.3	25.4	140.7
"	"	2 x 2	27.2	24.8	141.2
"	15	Seed	24.1	25.1	149.1
"	"	2 x 2	26.5	23.2	152.1
7-21-7	5	Seed	26.8	25.5	135.3
"	"	2 x 2	25.5	25.5	143.6
"	10	Seed	25.6	25.1	145.5
"	"	2 x 2	27.4	25.6	146.0
"	15	Seed	24.7	26.1	140.9
"	"	2 x 2	25.6	25.6	141.3
Signif. Level (%):[1/]			98	95	48
BLSD (.05):			2.1	1.9	--
CV (%):			4.7	4.0	10.7

[1/] Probability level of significance.

Conclusion

In this 1-yr study application of 10-34-0 or 7-21-7 at 15 gal/A with the seed resulted in delayed emergence and reduced stand but did not effect yield. To be on the safe side, however, we cannot recommend rates greater than 10 gal/A with either of these materials when applied with the seed. Rates should be reduced further if soil conditions are very dry at planting and/or soils are lower in organic matter and coarse to medium textured.

Table 5. Factorial analyses of the effect of liquid starter fertilizer material, rate, and placement on corn production parameters.

Factors	Final population	Corn grain Moisture	Corn grain Yield
MAIN FACTORS	ppA x 10^{-3}	%	bu/A
Material			
10-34-0	26.1	24.8	140.3
7-21-7	26.0	25.6	142.1
Signif. level (%):	37	98	31
Rate (gal/A)			
5	26.3	25.4	134.4
10	26.6	25.2	143.3
15	25.2	25.0	145.8
Signif. level (%):	99	40	90
BLSD (.05):	0.9	--	--
Placement			
Seed	25.6	25.4	139.9
2 x 2	26.4	25.0	142.4
Signif. level (%):	97	87	43
INTERACTIONS			
Material x Rate			
10-34-0 5	26.4	25.2	129.4
" 10	26.7	25.1	140.9
" 15	25.3	24.2	150.6
7-21-7 5	26.2	25.5	139.4
" 10	26.5	25.3	145.7
" 15	25.2	25.8	141.1
Signif. level (%):	1	90	82
Material x Placement			
10-34-0 Seed	25.6	25.3	139.3
" 2 x 2	26.7	24.4	141.3
7-21-7 Seed	25.7	25.6	140.5
" 2 x 2	26.2	25.5	143.6
Signif. level (%):	66	87	10
Rate x Placement			
5 Seed	26.5	25.4	131.8
" 2 x 2	26.0	25.4	137.1
10 Seed	26.0	25.3	143.1
" 2 x 2	27.3	25.2	143.5
15 Seed	24.4	25.6	145.0
" 2 x 2	26.0	24.4	146.7
Signif. level (%):	96	80	11
	Significance level (%)		
Material x Rate x Placement	72	44	8

STARTER FERTILIZER N, P, AND S FOR RIDGE-PLANTED CORN

Waseca, 1985

G. W. Randall

Many soils test high in phosphorus (P) in Southern Minnesota where corn is intensively grown. However, an early growth response to starter fertilizer containing NPK or just NP is frequently observed. Is that response due to the P as is commonly thought or is it due to the closely placed N? The purpose of this study was to determine the effect of N in starter fertilizer applied to corn grown with ridge tillage on a high P testing soil. An additional objective was to evaluate the addition of P and S to the high N analysis starter fertilizer.

Experimental Procedures

The site selected at the Southern Experiment Station was a tile drained Nicollet clay loam which had been ridge-planted to corn in 1984. Ridges were rebuilt just prior to layby. Following harvest all stalks were chopped. Soil test results from a spring 1985 sample indicated pH = 6.5, OM = High, Bray P_1 = 64 lb/A (VH), exchangeable K = 320 lb/A (VH), and SO_4-S = 4 ppm (L). Six treatments were applied using a randomized, complete-block design with six replications. Each plot measured 4 rows wide (10') by 55' long. Nitrogen was applied to all plots as anhydrous ammonia at a rate of 135 lb N/A on April 30.

Five liquid starter fertilizer treatments were applied 2" to the side and 2" below the seed using a JD Max-Emerge planter equipped with B & H ridge cleaning units and Acra-Plant Nutri-Till liquid fertilizer attachments (Table 1). No starter fertilizer was used in the sixth treatment. Corn (Pioneer 3732) was planted in 30" rows at 27700 plants per acre on May 3. Furadan was applied at 1 lb a.i./A to control corn rootworms. A Lasso (3½ qt./A) plus Bladex (3½ qt./A) tank-mix combination was applied preemergence to all plots to control weeds. Rootworm and weed control were excellent. Surface residue coverage after planting averaged 32 percent.

Early plant growth measurements were taken on June 11 at the 6-leaf stage by cutting 10 random plants (5 each from rows 1 and 4) and oven dried. After weighing and grinding, the plant tissue was chemically analyzed by the U of M Research Analytical Laboratory.

Final population was taken on August 19 by counting the plants from 25' of row in each of the center two rows. Grain yields were determined on October 16 by harvesting the two center rows with a modified JD 3300 plot combine.

Table 1. Treatment identification in starter fertilizer material study.

Treatment code	Fertilizer analysis	Application rate	Nutrients applied
		gal/A	lb N + P_2O_5 + K_2O + S/A
CHECK	0	0	0
APP	10-34-0	12.5	15 + 51 + 0 + 0
UAN	28-0-0	5.0	15 + 0 + 0 + 0
N+P	25-5-0-0	5.6	15 + 3 + 0 + 0
N+P+S	20-5-0-3	6.5	15 + 4 + 0 + 2.2
N+S	20-0-0-4	6.5	15 + 0 + 0 + 3.6

Results and Discussion

Temperatures during May were quite warm with growing degree days for the month averaging 27% above normal. Consequently, early plant growth was rapid on this very high testing soil. Visual differences in early growth were not visible.

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

Dry matter measurements taken on June 11 showed a slight (approx. 15%) growth advantage over the check with 4 of the 5 starter fertilizer treatments (Table 2). No explanation can be given at this time for the lack of early growth response with the APP treatment. With the exception of Mg, none of the nutrient concentrations were affected by the starter fertilizer treatments (Table 2).

Table 2. Early plant growth and nutrient concentrations as influenced by starter fertilizer material.

Treatment	EPG	Nutrient[1/] N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plant	%						ppm				
CHECK	4.1	3.70	.43	3.71	.236	.55	.47	281	51	42	9.3	8.5
APP	4.2	3.66	.42	3.49	.232	.57	.50	297	53	42	9.4	8.9
UAN	4.8	3.66	.41	3.43	.233	.56	.54	284	57	43	9.3	9.1
N+P	4.8	3.77	.42	3.50	.228	.54	.51	264	53	43	9.2	8.7
N+P+S	4.7	3.62	.41	3.51	.236	.57	.53	278	53	43	9.2	8.6
N+S	4.8	3.71	.41	3.65	.235	.55	.51	274	56	45	9.4	8.8
Signif. Level(%):	99	31	89	67	37	82	99	79	82	74	1	74
BLSD(.05):	0.4						.04					
CV(%):	7.0	4.4	3.6	6.8	4.0	4.2	5.9	7.8	7.5	5.0	5.7	4.5

[1/] Whole plant at 6-leaf stage.

Nutrient uptake at the 6-leaf stage (product of dry matter yield times nutrient concentration) was generally increased over the control by four of the starter treatments (Table 3). This increased uptake was due directly to the increase in early DM accumulation.

Table 3. Nutrient uptake by the small plants as influenced by starter fertilizer material.

Treatment	Nutrient uptake[1/] N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu	B
	mg/plant						mg/10 plants				
CHECK	152.	17.8	153.	9.7	22.6	19.2	11.5	2.1	1.7	.38	.35
APP	154.	17.8	146.	9.7	24.1	20.9	12.5	2.2	1.8	.40	.37
UAN	177.	20.0	166.	11.3	26.9	26.0	13.7	2.7	2.1	.45	.44
N+P	182.	20.2	171.	11.0	26.1	24.5	12.8	2.6	2.1	.44	.42
N+P+S	171.	19.3	165.	11.1	26.9	25.0	13.2	2.5	2.0	.43	.41
N+S	178.	19.7	175.	11.2	26.1	24.3	13.1	2.7	2.2	.45	.42
Signif. Level(%):	99	99	87	99	99	99	71	99	99	99	99
BLSD(.05):	16.	1.8		0.9	2.0	1.9		0.4	0.2	.04	.04
CV(%):	7.9	7.3	12.	7.3	6.6	7.3	13.	12.	9.4	8.0	8.4

[1/] Whole plant at 6-leaf stage.

Corn grain yield, grain moisture at harvest, and final population were not affected by any of the starter fertilizer treatments (Table 4).

Table 4. Corn yield, moisture, and population as affected by starter fertilizer material.

Treatment	Final population	Corn grain Moisture	Yield
	ppA x 10^{-3}	%	bu/A
CHECK	26.6	29.3	157.1
APP	27.1	27.8	155.8
UAN	27.4	29.6	157.8
N+P	26.5	29.8	155.0
N+P+S	27.7	29.4	163.2
N+S	28.2	30.2	152.2
Signif. Level(%):	86	78	60
CV(%):	4.2	2.2	5.6

Summary

Data obtained from this high testing site with warm spring conditions showed a slight early growth response with some of the treatments, no effect on small plant nutrient concentrations, and no effect on grain yield. The individual effects of the N, P, and S components in the starter materials was inconclusive. Under these conditions, starter fertilizer could not be recommended to increase the economic return to farmers growing corn in a ridge plant system.

Acknowledgement

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LONG-TERM CARRYOVER FROM HIGH RATES OF MANURE

Waseca, 1985

G. W. Randall and R. H. Anderson

Conditions sometime exist in livestock operations where acreage, time and/or labor may not be sufficient to permit the application of manure to land just prior to planting or at conventional rates. In addition, the monetary value of the nutrients contained in the manure in relation to prices for inorganic fertilizers sometimes is relatively low. As a result of these factors, heavy rates of manure have been applied or disposed of in localized areas; often close to the livestock facility.

With these conditions in mind an experiment was established to determine the maximum quantity of manure that can be applied and incorporated in a limited non-crop area. Primary objectives were to investigate: (a) the capacity of land to serve as a disposal medium for excessive rates of manure, (b) the accumulation and movement of nutrients in the soil profile and (c) the response of future crops to these high rates.

Experimental Procedures

During 1971, 1972 and 1973, beginning in mid-May and ending in mid-September, dairy cattle manure taken directly from the barn was applied to the surface of a Webster clay loam soil. Manure was applied to the same 0.5-acre area in both 1971 and 1972. In 1973, this area was split and manure was applied to one of the 0.25-acre areas. The manure was allowed to dry for 1 to 7 days before incorporating by disking, field cultivating or periodic plowing by either moldboard or chisel plow. Dry matter determined at 105 C and nutruent application rates were calculated by weighing each load of manure and by gathering random manure samples throughout the season for chemical analysis. Total N, organic N, inorganic N, total P and total K applied in the manure treatments are shown in Table 1.

To evaluate the carryover from the manure treatments a 0.25-acre section has received an annual application of N (approximately 150 lb N/A) as anhydrous ammonia each year. Supplemental P and K or starter fertilizers have not been used on the whole experimental site due to very high soil test levels.

Corn has been planted annually beginning in 1974. Excellent weed control has been obtained with preemergence herbicides. Corn root worms have been controlled with a rotation of Furadan and Counter. Soil samples have been taken in 1-foot increments to a depth of 10' each spring. Leaf nutrient concentrations at silking, fodder N and grain N have been determined annually. Corn silage and grain yields have been obtained by hand harvesting four replicated sections within each of the treatments each fall.

Results

The manure application rates and amount of nutrients applied in the manure are shown in Table 1. These extremely high manure rates resulted in approximately 10, 3 and 5 tons of N, P, and K/A, respectively, applied over the 3-year period with slightly less over the 2-year application period. Approximately 75% of the N was in the organic form with the remainder as NH_4-N.

Soil and plant samples taken annually (data not shown) and corn yields show that there has been a long-term effect of these manure rates on corn production (Table 2). Yield differences among the treatments have not been significant (P = 90% level) in 6 of the 10 years. Significant yield advantages were obtained with at least one of the manure treatments in 1976 and 1978. Yields in 1979 showed an advantage for the fertilizer N and high rate of manure treatments. Although significant yield differences were found in 1982, no consistent advantage was seen for either manure or fertilizer.

Some of the data shown in Table 3 indicate that the residual effect of the manure is waning in the 12th year of the study. Leaf and grain N concentrations were significantly lower for both of the manure treatments compared to the annual fertilizer N treatment. However, silage and grain yields along with N uptake did not show consistent advantages for the fertilizer treatment over the manure treatments.

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Table 1. Nutrient amounts applied with the manure treatments in 1971-73.

	Period	
	1971-72	1971-73
Manure rate (T/A, dry basis)	200[1/]	345[2/]
Nutrients (lb/A)		
Total N	11800	20150
Org. N	8980	15320
NH_4-N	2820	4820
NO_3-N	3	5
P	3220	5840
K	6210	10780

1/ 1040 T/A on a wet basis.
2/ 1785 T/A on a wet basis.

Table 2. Corn grain yields from 1974-1984 as influenced by previous manure application rates at Waseca.

	Treatment					
	Manure		Fertilizer	Signif.	BLSD	
Year	345 T/A	200 T/A	150 lb N/A	level	.05	(.10)
	bu/A			%		
1974	117.1	119.9	117.0	NS		
1975	99.2	93.2	105.3	NS		
1976	98.7	88.0	86.4	99	7.5	
1977	148.0	158.0	161.8	84		
1978	152.9	148.3	138.0	96	11.7	
1979	179.6	161.4	183.5	99	11.8	
1980	103.1	111.0	111.1	33		
1981	183.3	177.3	177.3	54		
1982	148.3	165.2	158.9	93		(12.4)
1983	85.4	77.6	93.2	78		
1984	114.6	112.8	96.3	98	13.3	

Reasons for these inconclusive data can probably be attributed to the weather. Conditions from May thru most of July were extremely dry. At the end of July when the leaf samples were taken, corn growing on the two manure treatments looked extremely N deficient while on the fertilizer N treatment corn was taller and was not N deficient. After rain started on July 25 and continued above normal throughout August, the corn on the manure plots improved tremendously. Growth was improved and N deficiency symptoms were not nearly as prevalent. Apparently, substantial amounts of N were released by mineralization from the manure treatments after the soils were sufficiently wetted. Consequently final yields and N uptake were not significantly different (P = 95% level) from the fertilized treatment.

Table 3. Influence of manure and fertilizer application on corn production and N utilization at Waseca in 1985.

Treatment	Final popl'n	Leaf N	Fodder N	Silage Yield	Silage N Uptake	Grain Yield	Grain N	Grain N removal	Ear Moisture
	$ppAx10^{-3}$	%	%	T DM/A	lb N/A	bu/A	%	lb N/A	%
Manure-(345 T/A)	27.1	2.11	.68	6.87	138.4	148.1	1.42	99.3	38.9
" -(200 T/A)	28.1	2.10	.54	7.45	145.5	168.3	1.42	113.6	37.2
Fert. N (150 lb/A)	26.6	2.68	.71	6.80	149.0	150.2	1.54	109.6	38.2
Signif. Level (%):	94	99	99	90	66	93	97	91	90
BLSD (.05),(.10)*:	1.1*	.13	.10	.57*		15.9*	.10	11.3*	1.3*
CV (%) :	2.7	3.5	8.9	5.4	6.6	6.9	3.9	7.0	2.3

Nitrate-N concentrations taken in early June within the 0-10' soil profile show substantially more NO_3-N in the top 1-foot with the fertilizer N treatment (Table 4). Much of this could have come from the nitrified anhydrous ammonia that was applied on April 26. At depths below 1' there was slightly but consistently more NO_3-N with the fertilizer N treatment. Consequently, total NO_3-N accumulation in the top 10' was almost twice as high with the fertilizer treatment as with the manure treatments.

Table 4. Influence of past manure treatments and annual N applications of NO_3-N in the 0-10' soil profile at Waseca in June, 1985.

Profile depth	Treatment		
	345 T/A	200 T/A	150 lb N/A
feet	ppm		
0-1	14.4	12.5	40.9
1-2	7.0	8.3	8.3
2-3	4.7	5.6	7.7
3-4	4.4	5.0	6.9
4-5	4.5	5.5	8.2
5-6	4.1	5.5	7.5
6-7	2.5	5.2	9.4
7-8	3.1	5.1	7.5
8-9	2.9	5.8	7.9
9-10	2.6	6.2	7.4
lb NO_3-N in top			
0-5' =	140	148	288
5-10' =	76	112	159
0-10' =	216	260	447

Summary

High rates of manure resulted in large quantities of nutrients applied to a Webster clay loam soil in 1971-73. Carryover from these manure treatments without additional fertilizer applications sustained corn production from 1974-1984. Nitrogen concentrations in the corn and soil NO_3-N levels in 1985 indicated that the carryover effect from the previous manure treatments has begun to wane. Corn yields from the manure treatments, however, were not consistently and significantly different (P = 95% level) from the fertilized treatment. Even though NO_3-N levels within the 10-foot profile were 50% lower with the manure treatments, sufficient N was apparently released from the soil organic matter thru mineralization to sustain corn production in 1985. This was true even though severe N deficiency symptoms were present at the silking stage. Apparently mineralization and subsequent N uptake were enhanced by the above normal August and September rainfall.

SOIL TEST COMPARISON STUDY

Waseca, 1985

G. W. Randall and P. L. Kelly

Soil testing is one of the best and most economical methods of ascertaining the nutrient status of the soil. The test then serves as the basis for fertilizer recommendations for crops. Many private and public laboratories provide that service to Corn Belt farmers. The purpose of this study is to compare the soil analyses and fertilizer recommendations given by five regional laboratories for corn production in Southern Minnesota. Working with the laboratories in this comparison study we should be able to improve and standardize fertilizer recommendations for corn and soybean production.

PROCEDURES

Two experimental sites measuring 150' by approximately 300' were selected for sampling in October, 1979. One of the sites had a history of high P and K fertilization while the other had not received P or K since 1974. The soil type in the former is a Nicollet clay loam while that in the latter is primarily Webster clay loam with some Nicollet clay loam. Tile lines spaced at 75' intervals provide excellent drainage at both sites. Neither site can be irrigated.

Four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. The laboratories were: A & L Agricultural Laboratories, Inc., Omaha, NE; Harris Laboratories, Inc., Lincoln, NE; Minnesota Valley Testing Laboratories, Inc., New Ulm, MN; AMOCO/Cropmate Co., Reinbeck, IA; and University of Minnesota Soil Testing Laboratory, St. Paul, MN. Soil analyses requested consisted of pH, OM, extractable P, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. Based on the results from the U of M laboratory these two sites were then classified as being initially "very high" and "medium-high". The fertilizer recommendations given by the five laboratories were then applied as five treatments in the spring of 1980 for corn. An additional check (no fertilizer) treatment was included in the randomized, complete-block design with six replications. Each plot measures 15' wide and 55' long.

After the 1980 crop, soil samples (5 cores/plot times 6 replications yielding 30 cores per treatment) were taken yearly from each treatment and sent to the respective laboratory. This allowed us to follow the buildup or decline of nutrients in the soil as affected by the recommendations of a particular laboratory over this 6-year period.

Soybeans were planted in this study in 1982 after nine years of continuous corn at the very high testing site and after seven years at the medium-high testing site.

Fertilizer amounts based on the analyses and recommendations from the summer 1984 samples were applied October 24 to the appropriate plots and chisel plowed in. Nitrogen as urea was spread the following spring (April 18) and field cultivated in. These fertilizer recommendations were based on a yield goal of 160 bu/A corn following soybeans. Corn (Pioneer 3732) was planted at 27,700 ppA in 30" rows on April 30 with neither starter fertilizer or insecticide. Chemical weed control consisted of 3½ qt. Lasso and 3½ qt. Bladex/A applied preemergence to all plots.

On July 22 the leaf opposite and below the ear at 50% silking was randomly sampled from 10 plants and was submitted for analyses. Final populations were determined from 50' of row. Grain yield and moisture were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine. Grain yields were converted to 15.5% moisture.

In August, 1985, 0-7" soil samples were taken from each treatment at each of the two sites and were sent to the laboratory of the respective treatment. The recommendations obtained from these samples will be used for the 1986 growing season.

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RESULTS

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. While the numeric values of the five laboratories were sometimes similar, the interpretations (whether the soil tests high, low, medium, deficient, etc.) varied substantially. As a result P and K recommendations among the laboratories were substantially different. Various micronutrients and sulfur were recommended by three of the four private labs. Lime was recommended by all four private labs.

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1985.

Test[1/]	Laboratory				
	A&L	Harris	MVTL	Cropmate	U of Mn.
	Soil test results				
pH	6.1	6.1	6.1	5.6	6.1
pH buffer	6.7	6.5	6.6	6.5	---
Phosphorus	27 H	33 D	22 VH	33 M	18 H
Potassium	174 H	221 L	130 H	218 H	141 H
Organic Matter (%)	3.9 H	3.6 A	3.8 M	4.1	M
Calcium	1660 M	3350 A	3550	3735 M	---
Magnesium	449 VH	468 A	515	565 M	476 A
Sulfur	6 L	4 L	11 L	15 H	4 LM
Iron	121 VH	87.2 E	11.8 S	5.6 H	---
Manganese	24 H	21.6 E	13.7 S	2.1 H	---
Zinc	2.1 M	1.5 E	1.5 VH	2.7 H	.9 M
Copper	1.3 H	.9 A	1.0 S	---	.8 A
Boron	1.3 H	1.0 A	1.0 L	---	---
ENR (lb/A)	87	---	---	105 H	---
C.E.C. (meq/100g)	15.0	27.3	26.3	31.1	---
Nutrient	Recommended fertilizer program [2/]				
Nitrogen	190	175	167	237	160
Phosphorus (P_2O_5)	50	65	60	91	50[6/]
Potassium (K_2O)	125	105[3/]	65[4/]	112	50[6/]
Sulfur	16	15	---	---	---
Iron	---	---	---	.12[5/]	---
Manganese	---	---	---	.12[5/]	---
Zinc	2.0	---	---	.62[5/]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.5	3.0	1.0	2.9	---

1/ All soil test results are stated in ppm unless otherwise noted.
2/ All values are pounds of nutrient recommended per acre for a corn yield goal of 160 bu/A.
3/ Value includes maintenance recommendation, plus 50% of the build up recommendation was to be applied over a two-year period.
4/ Value includes standard recommendation plus 50% of the maintenance recommendation to be applied over a 2-year period.
5/ As 5 qt/A of a material weighing 9.9 lb/gal and containing 5% Zn, 1% Fe, and 1% Mn.
6/ Rate for broadcast application.

Grain yields were increased significantly over the unfertilized check by all five fertilizer treatments (Table 2). However, the yield with the Harris recommendation was significantly lower (P = 95% level) than with the MVTL or Cropmate recommendations. The reason for this is unknown. Grain moisture and final population were not affected by the fertilizer treatments.

Fertilizer recommendations from all five laboratories influenced all leaf nutrient concentrations except Ca over the unfertilized check and resulted in sufficient nutrient levels for optimum yields (Table 3). Leaf N and Fe concentrations did not vary among the labs. Slight differences in leaf P, Cu and B concentrations did exist among the laboratories. The higher 1985 K recommendations and soil test K levels with the long-term A&L, Harris, and Cropmate recommendations resulted in significantly

higher leaf K and lower leaf Mg concentrations. The small amount of micronutrients recommended by Cropmate appeared to increase leaf Mn but had no effect on leaf Fe or Zn. Leaf Zn was increased by the A&L recommendation of two pounds Zn/A.

Table 2. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the very high testing site in 1985.

Lab	Fertilizer Recommendations	Final Population	Grain Yield	Grain H_2O
	lb/A[1/]	$x10^3$	bu/A	%
A&L	190N + 50P + 125K + 16S + 2 Zn	26.2	158.0	29.5
Harris	175N + 65P + 105K + 15S	26.9	153.7	29.4
MVTL	167N + 60P + 65K	26.6	166.0	29.1
Cropmate	237N + 91P + 112K + .12 Fe + .12 Mn + .62 Zn	26.4	165.1	29.1
U of Mn.	160N + 50P + 50K	26.8	162.5	29.2
Check	Unfertilized	26.6	123.6	28.8
	Significance Level (%):	13	99	28
	BLSD (.05) :	--	10.7	--
	CV (%) :	4.1	6.3	2.4

1/ P and K expressed on oxide basis.

Table 3. Effect of fertilizer recommendations on corn leaf nutrient concentrations on the very high testing site in 1985.

Lab	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A&L	2.50	.25	2.00	.51	.42	132	48	41	6.8	11.5
Harris	2.47	.26	2.15	.50	.40	136	46	36	6.5	11.0
MVTL	2.45	.24	1.81	.51	.46	137	43	37	6.6	10.2
Cropmate	2.50	.26	2.07	.50	.42	134	53	34	6.2	10.3
U of Mn.	2.48	.24	1.88	.50	.46	137	44	30	7.0	10.2
Check	1.76	.18	1.70	.54	.46	126	32	24	5.3	9.4
Signif.(%):	99	99	99	93	99	95	99	99	99	99
BLSD (.05):	.11	.01	.12	-	.03	9	5	2	.6	.9
CV (%) :	4.4	3.8	5.8	4.8	5.8	4.8	11.	5.0	7.8	7.0

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 4 for the medium-high testing site. While the numeric values of the five laboratories were generally similar the corresponding interpretation (whether the soil tests high, low, medium, deficient etc.) varied substantially. Nitrogen, P and K recommendations among the labs were quite different. Also, various micronutrients and sulfur were recommended by three of the four private labs. Only one of the four private labs recommended liming the soil.

The treatments that received fertilizer yielded significantly more than the unfertilized check (Table 5). However, there were no significant yield differences among the fertilizer treatments. Grain moisture was reduced significantly from the control by all of the fertilizer treatments with no differences among the five laboratories. Final population was not different among the treatments.

Fertilizer recommendations from all five laboratories influenced all leaf nutrient concentrations over the unfertilized check and resulted in sufficient levels to optimize yields (Table 6). No difference was found in the leaf P and B concentrations among the laboratory treatments. Slight differences existed among the labs for the leaf N, Ca, Fe, Mn and Cu concentrations. Even though an extra 90 lb N/A was applied with the Cropmate recommendation, leaf N was not increased over that with the MVTL recommendation. The higher K recommendations in 1985 from the A&L, Harris and Cropmate labs along with the long-term high K recommendation from Harris resulted in substantially higher soil test K and greater amounts of leaf K than with the MVTL or U of Minnesota recommendations. The

micronutrients recommended by Cropmate did not increase leaf Fe or Mn significantly but appeared to give a slightly higher leaf Zn concentration. Leaf Zn was also increased by the A&L recommendation.

Table 4. Soil test results and the recommended fertilizer programs on the medium-high testing site in 1985.

Test[1/]	Laboratory				
	A&L	Harris	MVTL	Cropmate	U of Mn.
	Soil test results				
pH	6.6	7.0	6.5	6.1	6.3
pH buffer	6.8	---	6.9	6.8	---
Phosphorus	23 H	24 D	15 M	13 L	14 MH
Potassium	198 H	240 L	135 H	221 H	147 H
Organic Matter (%)	4.7 H	4.6 A	4.9 H	4.8	M
Calcium	2650 M	6551 A	4950	5940 H	---
Magnesium	616 VH	543 A	570	661 M	582 A
Sulfur	6 L	4 L	10 H	16 H	4 LM
Iron	55 VH	42.9 E	11.8 S	5.6 H	---
Manganese	21 H	17.7 E	12.6 S	2.1 H	---
Zinc	2.4 M	1.5 E	1.1 H	1.6 M	1.2 H
Copper	1.5 H	1.2 A	1.4 S	---	1.1 A
Boron	1.8 H	1.4 A	1.2 S	---	---
ENR (lb/A)	96	---	---	120 H	---
C.E.C. (meq/100g)	20.1	38.0	30.8	38.6	---
Nutrient	Recommended fertillizer program [2/]				
Nitrogen	180	170	147	237	160
Phosphorus (P_2O_5)	50	120	88	105	70[6/]
Potassium (K_2O)	105	132[3/]	58[4/]	112	50[6/]
Sulfur	16	15	---	---	---
Iron	---	---	---	.12[5/]	---
Manganese	---	---	---	.12[5/]	---
Zinc	2.0	---	---	.62[5/]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.0	---	---	---	---

1/ All soil test results are stated in ppm unless otherwise noted.
2/ All values are pounds of nutrient recommended per acre for a corn yield goal of 160 bu/A.
3/ Value includes maintenance recommendation, plus 50% of the build up recommendation was to be applied over a two-year period.
4/ Value includes standard recommendation plus 50% of the maintenance recommendation to be applied over a 2-year period.
5/ As 5 qt/A of a material weighing 9.9 lb/gal and containing 5% Zn, 1% Fe, and 1% Mn.
6/ Rate for broadcast application.

Table 5. Effect of fertilizer recommendations on corn final population, grain yield and moisture on the medium-high testing site in 1985.

Lab	Fertilizer Recommendations lb/A[1/]	Final Population $x10^{-3}$	Grain Yield bu/A	Grain H_2O %
A&L	180N + 50P + 105K + 16S + 2 Zn	26.3	169.8	26.4
Harris	170N + 120P + 132K + 15S	26.4	177.3	26.0
MVTL	147N + 88P + 58K	27.3	171.8	25.4
Cropmate	237N + 105P + 112K + .12 Fe + .12 Mn + .62 Zn	26.5	175.7	26.0
U of Mn.	160N + 70P + 50K	26.7	169.9	25.6
Check	Unfertilized	26.1	95.3	27.6
	Significance Level (%):	55	99	99
	BLSD (.05) :	--	10.1	.9
	CV (%) :	4.2	5.9	3.0

1/ P and K expressed on oxide basis.

Table 6. Effect of fertilizer recommendations on corn leaf nutrient concentrations on the medium-high testing site in 1985.

Lab	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A&L	2.63	.24	1.38	.56	.52	111	45	33	4.4	9.1
Harris	2.67	.25	1.72	.53	.43	113	50	26	4.6	8.8
MVTL	2.71	.24	1.29	.55	.54	116	48	28	4.7	8.7
Cropmate	2.70	.25	1.46	.54	.51	115	52	32	4.2	9.0
U of Mn.	2.73	.24	1.23	.56	.57	122	49	28	4.7	8.6
Check	1.66	.16	.87	.59	.58	94	34	23	3.6	7.5
Signif.(%):	99	99	99	99	99	99	99	99	99	98
BLSD (.05):	.09	.02	.15	.03	.05	10	4	4	.4	1.1
CV (%) :	3.4	8.4	10.	4.1	7.8	8.1	8.6	12.	8.5	9.5

SUMMARY - 1985

Substantial differences again existed among the laboratories fertilizer recommendations at both sites. Excessive N was recommended by the Cropmate laboratory even though corn followed soybeans at both sites. High amounts of P were recommended by the Harris and Cropmate labs at the medium-high testing site and by Cropmate at the very high testing site. High amounts of K were recommended by the A&L, Harris and Cropmate Labs at both sites. Micronutrients and sulfur were recommended by three of the four private labs for both sites. The fertilizer recommendations influenced nutrient concentrations in the corn earleaf compared to the unfertilized check. However, only slight differences in leaf nutrient concentrations were found among the laboratories. The exception was leaf K and Zn.

Differences in grain yield, grain moisture, and final population were not observed among the five laboratories' recommendations at the medium-high site while only a slight yield difference was found at the very high site. Yields were excellent at both sites.

Fertilization resulted in only two (MVTL and U of Mn) of the five labs showing any profit on the very high testing site (Table 7). Fertilizer costs ranged from $54/A with the U of Mn recommendation to $96/A with the Cropmate recommendation. On the medium-high testing site a positive return was gained from fertilizer recommended by all laboratories. Greatest returns were again found with the MVTL and U of Mn recommendations while the least return was found with the Cropmate recommendation, which was also the most expensive recommendation. Fertilizer costs ranged from $58/A with the U of Mn recommendation to $99/A with Cropmate's recommendation.

Table 7. Effect of fertilizer recommendations on yield, value, fertilizer, cost and economic return on both the very high and medium-high testing sites at Waseca in 1985.

	Very High Testing Site				Medium-High Testing Site			
Lab	Yield	Value @2.07/bu	Fert. cost 1/	Return 2/	Yield	Value @2.07/bu	Fert. cost 1/	Return 2/
	bu/A	$/A			bu/A	$/A		
A&L	158.0	327	72	- 1	169.8	351	68	+86
Harris	153.7	318	69	- 7	177.3	367	82	+88
MVTL	166.0	344	59	+29	171.8	356	60	+99
Cropmate	165.0	341	96	-11	175.7	364	99	+68
U of M	162.5	336	54	+26	169.8	351	58	+96
Check	123.6	256	--	--	95.3	197	--	--

1/ Using May, 1985 prices for each nutrient expressed as dollars/lb as follows: N, .24; P_2O_5, .21; K_2O, .10; S, .21; Zn, .40.

2/ Return yield value @2.07/bu - (fertilizer cost & value of check trt).

Conclusions from the 1985 study can be summarized as follows:

1. Although soil test P and K values were sometimes similar, interpretation ranged from deficient to very high and suggests that some laboratories calibration curves do not fit these soils.

2. Excessive and economically unprofitable rates of N were recommended by Cropmate while little difference existed among the other laboratories.

3. Application of high rates of P and K to soils already testing high to very high did not improve yields and, thus, was not profitable.

4. No yield response was obtained with the addition of S or micronutrients recommended by three of the four private laboratories.

5. Highest economic return was obtained with the fertilizer recommendations provided by MVTL and the U of Mn for both of the sites.

Table 8. Effect of fertilizer recommendations on total crop value, total fertilizer cost and the resulting economics on both very high and medium-high testing sites at Waseca from 1980-85.

	Very High Testing Site			Medium-High Testing Site		
	6-Yr Total			6-Yr Total		
Lab	Crop value[1/]	Fert. cost	Return[2/]	Crop value[1/]	Fert. cost	Return[2/]
	$/A					
A&L	1926	337	-101	2154	371	+180
Harris	1946	352	- 96	2159	435	+121
MVTL	2009	248	+ 71	2159	283	+273
Cropmate	1999	407	- 98	2159	432	+124
U of M	1962	206	+ 66	2165	255	+307
Check	1690	0	---	1603	0	---

1/ 3.00, 2.40, 3.00 and 2.07/bu used for corn in 1980, 1981, 1983 amd 1985 respectively and 5.50/bu and 6.00/bu used for soybeans in 1982 and 1984, respectively, for a six-year total crop value.

2/ Return over 6-year period = crop value - (fertilizer cost & value of check treatment).

SIX-YEAR SUMMARY

Economic returns to the fertilizer recommended at the very high testing site ranged from sizable losses to modest gains (Table 8). Net return over the 1980-85 period was highest with the MVTL ($71/A) and U of Mn ($66/A) recommendations. Negative returns ranging from -$96/A to -$101/A were found with the higher cost recommendations provided by A&L, Harris and Cropmate. Part of the low overall return on this site was due to fertilizer recommendations for a yield goal of 180 bu/A of corn in 1980 while the yields obtained barely exceeded 100 bu/A due to drought stress conditions.

On the medium-high testing site yield responses paid for the fertilizer recommendations made by all five laboratories (Table 8). However, net return was highest with the lowest cost fertilizer recommendations. The higher cost recommendations given by A&L, Harris, and Cropmate resulted in lowest economic return. It is interesting to note the very narrow range in crop value among the five laboratories over this 6-year period (a low of $2154/A to a high of $2165/A).

Soil samples from the 0-7" layer were taken in August 1985 from all plots, composited according to the respective laboratory, and sent to the U of Mn lab. The purpose of this was to determine the effect of the various amounts of fertilizer on the soil test levels after the six years of application. Soil test values shown in Table 9 indicate substantial differences in soil pH, P, K and Zn between the unfertilized check and the fertilized treatments. Soil pH was lowered by as much as 0.7 pH unit with the N applications. Soil test P and K were maintained in the high to very high ranges with all fertilizer recommendations. In addition, the magnitude of the soil P & K values was closely related to the amount of P and K applied. Slightly higher soil SO_4-S and Zn levels were found with the laboratories that recommended these nutrients.

Figure 1 shows the relationship between the amount of P_2O_5 applied with each of the laboratories and the soil test P level. At the medium-high soil test P increased linearly at a rate of 1 lb P/A for each 19 lb P_2O_5 applied/A. Soil test P declined very little over the 6-yr period at this site when

no fertilizer P was added. At the very high testing site soil test P dropped from 56 to 32 lb P/A or on the average 4 lb P/year when no fertilizer P was applied. Addition of P with the five long-term laboratory recommendations resulted in a gain of 1 lb soil test P for every 9 lb P_2O_5 applied. In addition, fertilizer P recommended by Harris and Cropmate raised the soil test considerably over the initial very high tests found in 1980.

In summary, maintenance and buildup fertilization philosophies, which continue to recommend fertilizer P and K and sometimes S and micronutrients regardless of soil test level, clearly result in high fertilizer costs and poor economic return to the farmer. Soil testing should be used to determine what and how much fertilizer should be applied so as to maximize the farmers' profits.

Table 9. Soil test results after 6 years of fertilizer with the five laboratories recommendations.

Laboratory	Soil pH	Bray Ext. P	Exch. K	Ext. SO_4-S	Zn
		----- lb/A ------		------ ppm ------	
	---------- Very high testing site[1/] ----------				
A&L	5.7	59	384	10	3.0
Harris	5.6	71	400	10	2.0
MVTL	5.9	59	320	5	2.1
Cropmate	5.8	76	356	6	1.8
U of Mn.	5.9	50	340	7	1.1
Check (No fert.)	6.3	32	275	6	1.2
	---------- Medium high testing site[2/] ----------				
A&L	6.5	39	334	7	3.1
Harris	6.6	44	342	7	2.3
MVTL	6.5	39	308	5	1.5
Cropmate	6.6	44	332	3	2.0
U of Mn.	6.8	35	290	4	1.3
Check (No fert.)	6.9	15	282	6	1.4

1/ Initial tests in 1980 were pH = 5.4, P = 56, K = 318.
2/ Initial tests in 1980 were pH = 6.4, P = 18, K = 294.

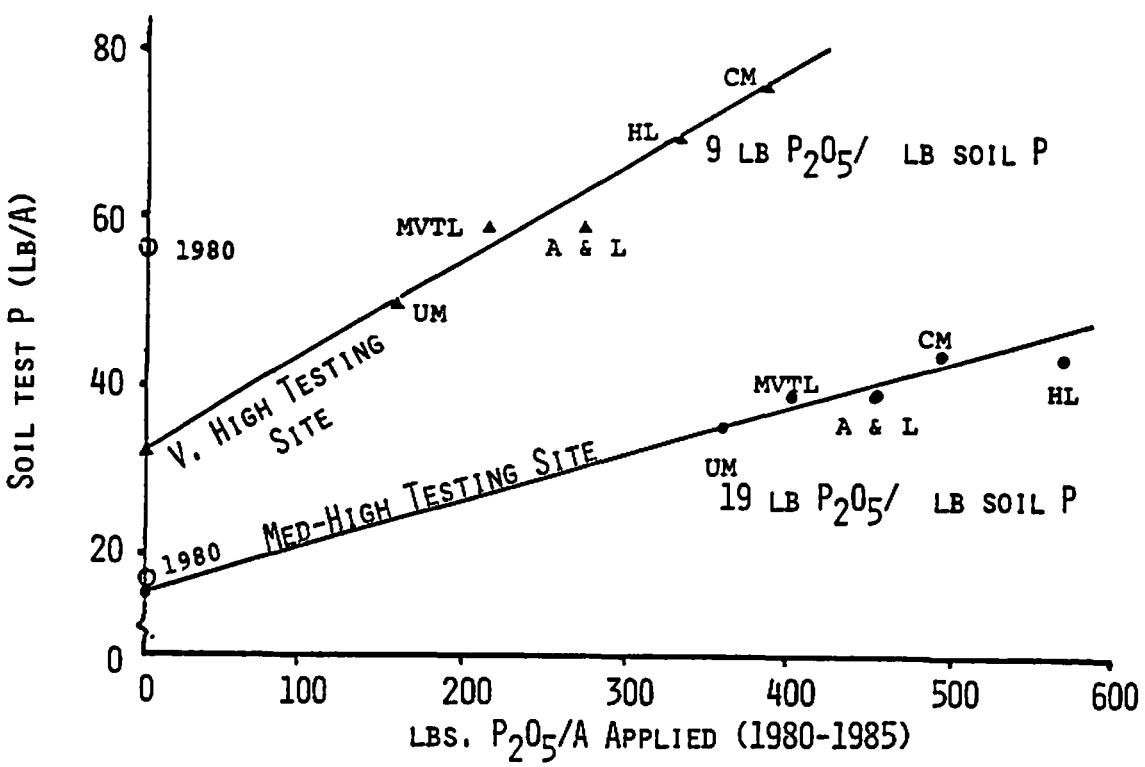

FIG. 1. RELATIONSHIP BETWEEN AMOUNT OF P APPLIED AND SOIL TEST P.

CONSERVATION TILLAGE FOR CORN AND SOYBEAN PRODUCTION

Waseca, 1985

G. W. Randall and J. B. Swan

With increasing emphasis on controlling erosion and minimizing energy requirements (time, labor, and fuel), tillage practices have changed markedly over the last decade. Many of tillage practices have come to be known as "conservation tillage". To fit this definition, a tillage practice must leave 30% of the soil surface covered with residue after planting.

EXPERIMENTAL PROCEDURES

To evaluate some of these conservation tillage practices an experiment was started in 1975 with continuous corn grown on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (no tillage, fall moldboard plow, fall chisel plow, ridge-plant and till-plant (flat)) were replicated four times. Each plot was 20' wide by 125' long. Tile lines spaced 75' apart run perpendicular to the rows in all plots. Beginning in 1979 all plots were split into two, 4-row plots -- one with starter fertilizer and the other without.

After 8 years of continuous corn, soybeans were planted in 1983 to begin a long-term corn-soybean rotation. Tillage and starter fertilizer treatments remained the same except the till-plant (flat) treatment was changed to a spring-disk (20" disk blade) treatment (Table 1). Because of increased pressure of the grass weeds in the no tillage treatment, all plots were split so that either the front or rear half received a postemergence application of Poast at a rate of ¼ lb/A with 1 qt of oil concentrate.

Ridges for the ridge plant treatment in 1985 were built in June, 1984. After the 1984 corn harvest stalks were chopped and the moldboard and chisel plow treatments were performed. On May 9 the moldboard and chisel plow treatments were field cultivated once with the chiseled plots receiving a prior disking. The spring disk treatment was disked twice on this same date. Ridges for 1986 corn were prepared in July.

Soybeans (Hardin) were planted in 30" rows at a rate of 200,000 plants/A on May 18. All treatments except no-till were planted with a John Deere 7100 planter equipped with 2" fluted coulters. B&H ridge cleaners were attached to the planter for the ridge-plant treatment. Because of high surface soil density with no tillage, seeding depth was not adequate with this planter. Thus, a JD 7000 planter was used to get better seeding depth on this tillage treatment. Ten gallons/A of 7-21-7 was used as the starter treatment.

Broadcast P and K were not applied for the 1985 soybean crop because of very high soil tests. Soil tests on this site in 1984 averaged: pH=6.7, Bray $_1$ extractable P=60 lb/A and exchangeable K=424 lb/A. Chemical weed control consisted of 3 lb Amiben and 3½ lb Lasso/A applied preemergence. Due to the heavy early-season weed pressure, tillage treatments that did not receive spring secondary tillage (ridge plant and no tillage) were treated with a "burndown" treatment of 1 qt Roundup/A on May 21. In order to evaluate the effectiveness of the preemergence herbicide application on weed control, a plastic sheet 18" wide and 6' long was placed between the 4th and 5th rows of each plot during herbicide spraying to prevent the application of herbicide onto the soil surface. Weed counts (grass and broadleaf) were taken on June 4 from sprayed and unsprayed areas. On July 15, one-half of each replicate was treated with a postemergence application of Poast at a rate of ¼ lb/A with 1 qt of oil concentrate for grass control. Treatments 2, 3, 4, and 5 were cultivated on June 17.

Surface residue coverage was measured by the line-transect method on April 15 prior to spring tillage and on May 22 after planting. Soybean leaf samples were taken on July 26 (R1 stage) by randomly sampling the uppermost fully mature trifoliate from each of the starter treatments within each tillage treatment. Yields were taken by combine harvesting the center two rows from each plot.

On May 3 prior to disturbance of the ridge, soil samples were taken to a 9" depth from the ridge-planted plots which had starter fertilizer for the last nine years. These plots were sampled in 3 positions: directly down the center of the ridge, at 6" to the side and at an angle into to the

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

Table 1. Influence of tillage methods, starter fertilizer and Poast herbicide on soybean production at Waseca in 1985.

Treatment				Seed	
Tillage	Starter[1/] fertilizer	Poast[2/] herbicide	Population	Moisture	Yield
			ppA x 10^{-3}	%	bu/A
No tillage	S	P		14.8	40.8
"	S	NP	126	14.6	40.8
"	NS	P		14.9	39.4
"	NS	NP	100	14.6	41.0
Fall plow, f. cult.	S	P		14.7	51.7
" "	S	NP	202	14.7	53.0
" "	NS	P		14.6	50.3
" "	NS	NP	196	14.7	50.6
Fall chisel, d., f. cult.	S	P		14.6	48.8
" "	S	NP	189	14.6	50.8
" "	NS	P		14.6	47.0
" "	NS	NP	201	14.4	46.6
Ridge Plant	S	P		15.1	46.4
"	S	NP	196	14.9	48.8
"	NS	P		15.0	49.1
"	NS	NP	195	15.0	48.6
Spring disk (2x)	S	P		14.8	49.2
"	S	NP	174	14.6	47.6
"	NS	P		14.7	48.3
"	NS	NP	183	14.6	46.8
Individual Factors					
Tillage					
No tillage			113	14.7	40.5
Fall plow			199	14.7	51.4
Fall chisel			195	14.5	48.3
Ridge plant			196	15.0	48.2
Spring disk (2x)			179	14.7	48.0
Significance Level (%):[3/]			99	97	99
BLSD (.05) :			23	.3	3.0
Starter Fertilizer					
Starter			177	14.7	47.8
No starter			175	14.7	46.8
Significance Level (%):[3/]			24	37	88
Poast Herbicide					
Poast				14.8	47.1
No Poast				14.7	47.5
Significance Level (%):[3/]				91	43
Interactions				Significance Levels(%)[3/]	
Tillage x SF			59	05	66
Tillage x Poast				26	30
SF x Poast				04	52
Tillage x SF x Poast				13	20
CV(%)			11.6	1.7	6.2

1/ S = starter fertilizer used: NS = no starter fertilizer used.

2/ P = Poast herbicide used: NP = no Poast herbicide used.

3/ Probability level of significant difference between means.

ridge, and midway between the ridges. Before compositing the 8 cores/plot they were separated into 0-2", 2-4", 4-6", and 6-9" increments. After drying at 100°F they were submitted to the University of Minnesota Soil Testing Lab for pH, Bray $_1$ extractable P, and exchangeable K analyses.

Statistical interpretation of the data throughout this report is based on the percent probability (significance levels) of obtaining a response. A significance level of 95 indicates that we could expect a real difference to occur 19 times out of 20 and only 1 time out of 20 due to chance. A significance level below 50 would indicate less than 50:50 odds of being real.

RESULTS

Significant differences in population, seed moisture at harvest, and soybean yields were found among the tillage treatments (Table 1). Due to the density of the surface soil and the dry conditions following planting, plant population with the no tillage (NT) treatment was significantly lower than with the other tillage treatments. Even though a heavier planter was used, seeding depth was rather shallow and germination was poor. Starter fertilizer had no effect on plant population, seed moisture, and seed yield.

Seed moisture at harvest was slightly higher with the ridge-plant (RP) treatment and lowest with the fall chisel (CP) system. These differences were slight and are statistically significant only because of the low variability (CV=1.7). The Poast treatments had no effect on seed moisture.

Yields were significantly higher for the moldboard plow (MP) treatment compared to the CP, RP, and spring disk (SD) treatments. Identical yields were found with the CP, RP, and SD tillage systems. Yields with NT were approximately 20% lower than the other tillage systems. Because there was no effect of the Poast treatments on yield and no interactions with tillage, the impact of weed competition was judged to be minimal this year. Thus, the primary reason for the reduced yields with NT appears to be largely due to lower plant population and slightly slower emergence.

Percent surface residue cover measured before spring tillage showed highest amounts with the NT (96%) and SD (92%) systems. The RP system also had a high level of coverage (76%) and an intermediate level with CP (41%). Almost no residue was left on the surface with the moldboard plow (8%). After planting, residue coverage decreased substantially with the RP and SD systems. Only the NT, CP, and RP systems met the strict conservation tillage definition of 30% residue coverage.

Table 2. Influence of tillage methods for soybeans after corn on surface residue before spring tillage and after planting at Waseca in 1985.

Treatment	Surface Residue	
	Before spr. tillage	After planting
	%	%
No tillage	96	93
Fall plow	8	5
Fall chisel	41	30
Ridge plant	76	38
Spring disk (2x)	92	23
Significance Level (%):	99	99
BLSD (.05) :	6	13
CV (%) :	6.6	24.

The rate of seedling emergence was determined by counting the number of plants whose cotyledons had emerged in 40' of row/plot/day from the 7th through the 18th day following planting. Emergence as a percent of final stand, shown in Table 3, indicates rapid and uniform emergence among the MP, CP, RP, and SD tillage systems. Emergence was delayed approximately 4 days with NT. Ninety percent emergence was reached 9 days after planting with MP & CP systems, 10 days after planting with the RP system, 11 days with the SD system, and 13 days with the NT system.

Leaf samples taken at the R1 stage show no effect of tillage on any of the nutrient concentrations (P=90% level) except for Mg and Fe (Table 4). For some unexplainable reason Mg was slightly higher with the two most reduced systems (NT and RP). The slightly higher Fe concentrations with MP tillage may have been due to soil contamination associated with rain splashing soil onto the plants. Starter fertilizer significantly increased the leaf P, K, Ca, and Mn concentrations. For the most part these differences were very small. There was no interaction between starter fertilizer and tillage system on the nutrient concentrations.

Weed counts (broadleaf and grass) were taken between the 4th and 5th rows from 4 randomly placed 10 ft^2 sections/plot 17 days after preemergence herbicide application (Table 5). Weed pressure from broadleaf weeds was not great, as broadleaf weed counts were low from both herbicide treated and untreated areas. Grasses were controlled extremely well in the MP and RP systems and to a lesser degree with CP tillage. Considering the extremely high population of grasses with NT when no herbicide was used, weed counts were reduced by 94% with the Lasso & Amiben combination and the Roundup burndown program. Grass weed control was least adequate with the SD tillage system.

Table 3. Influence of tillage methods on the emergence progress of soybeans following corn at Waseca in 1985.

Treatment	Days Post Planting 7	8	9	10	11	12	13	16	18
	% emerged								
No tillage	0	22	48	52	70	84	91	99	100
Fall plow	1	84	93	94	98	99	99	100	100
Fall chisel	1	80	90	92	97	98	99	100	100
Ridge plant	2	76	88	91	97	99	100	100	100
Spring disk (2x)	0	75	85	87	93	96	100	100	100

Table 4. Influence of tillage methods and starter fertilizer for soybeans on leaf nutrient concentration at the R1 stage at Waseca in 1985.

Treatment: Tillage	Starter fert.	Nutrient: P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	S	.38	2.01	1.08	.40	70	37	38	9.2	42
"	NS	.36	1.88	1.05	.40	68	35	38	9.5	41
Fall plow	S	.35	2.02	1.09	.35	78	35	38	8.2	41
"	NS	.31	1.89	1.11	.36	74	34	36	8.4	39
Fall chisel	S	.32	1.94	1.17	.38	70	40	37	8.4	42
"	NS	.30	1.80	1.11	.37	73	37	37	8.7	40
Ridge plant	S	.35	1.92	1.17	.41	75	37	38	8.9	42
" "	NS	.35	1.87	1.11	.40	71	35	38	9.2	42
Spring disk (2x)	S	.34	1.91	1.11	.39	73	39	39	8.8	42
" "	NS	.31	1.84	1.09	.37	71	38	38	8.7	41
Individual Factors										
Tillage										
No tillage		.37	1.95	1.07	.40	69	36	38	9.4	42
Fall plow		.33	1.96	1.10	.36	76	35	37	8.3	40
Fall chisel		.31	1.87	1.14	.38	72	38	37	8.5	41
Ridge plant		.35	1.90	1.14	.41	73	36	38	9.1	42
Spring disk (2x)		.33	1.88	1.10	.38	72	39	38	8.8	41
Significance Level (%):		71	77	62	99	92	59	33	80	53
BLSD (.05)(.10)* :					.02	4.2*				
Starter fertilizer										
Starter		.35	1.96	1.12	.39	73	38	38	8.7	42
No starter		.33	1.86	1.09	.38	71	36	37	8.9	41
Significance Level (%):		99	99	96	53	82	98	86	96	99
Interactions										
Tillage x SF										
Significance Level (%):		48	27	56	42	73	23	62	32	99
CV (%) :		6.6	3.7	3.9	4.4	4.9	5.6	4.4	3.6	1.9

Postemergence application of Poast herbicide 58 days after planting provided additional weed control but, because of the lower weed pressure across all tillage systems, did not affect soybean yields (Table 1).

Table 5. Weed populations on June 4 as affected by tillage and herbicide for soybeans following corn at Waseca in 1985.

Treatment	Herbicide 1/		No Herbicide	
	Grasses	Broadleaves	Grasses	Broadleaves
	plants/10 sq. ft. 2/			
No tillage	46	1	816	2
Fall plow	7	2	7	1
Fall chisel	16	1	33	1
Ridge plant	1	1	12	3
Spring disk (2x)	85	1	88	2

1/ 3 lb Amiben and 3½ lb Lasso/A preemergence. No tillage and ridge-plant trts received 1 qt/acre Roundup preemergence.

2/ Average over 4 replications.

Soil samples taken from three different positions from the row in the RP system prior to planting showed slightly more acidic conditions in the ridge than in the valley area (Table 6). Soil test P in the top 4" was considerably higher when the samples were taken at an angle under the row starting from 6" to the side of the row. Perhaps some old starter fertilizer bonds were hit when obtaining these samples. Soil P was consistently higher at each depth with the ridge samples compared to the 15" (valley) sample. Phosphorus accumulated at very high levels in the top 4" of the ridge samples and in the top 2" of the valley sample. Soil test K accumulated at very high levels in the top 2" regardless of sampling position. At lower depths soil K was slightly higher when samples were taken in the ridge area. In summary, it appears that after 11 years of ridge tillage, soil test P and K are very high throughout the ridged area and that soil sampling position in this area is not important.

Table 6. Soil test pH, P and K after soybean planting and before ridging after 11 years continuous ridge planting at Waseca.

Profile depth	Position of ridge sample 1/		
	In row	6" to side of row	15" between row
inches	Soil pH		
0-2	6.3	6.4	6.6
2-4	6.4	6.4	6.8
4-6	6.6	6.8	6.9
6-9	6.8	6.9	7.0
	Soil P (lb/A)		
0-2	93	151	76
2-4	69	126	36
4-6	32	33	22
6-9	22	28	16
	Soil K (lb/A)		
0-2	665	660	665
2-4	530	515	425
4-6	395	360	345
6-9	335	300	280

1/ Average over 4 replications; 8 cores composited/replication.

SUMMARY - 1985

This was the second crop of soybeans grown in this long-term study with continuous corn from 1975 through 1982, soybeans in 1983, and corn in 1984. Surface residues prior to planting were greater than 70% with NT, RP, and SD tillage and remained at 30% or greater after planting with NT, CP, and RP tillage. Plant emergence was approximately 4 days slower with NT compared to the other tillage

systems. Weed pressure was reduced considerably with the Lasso + Amiben preemergence application and the Roundup burndown treatment. Lowest weed pressure was noted with the RP and MP tillage systems. Highest weed counts were with the NT and SD systems. Leaf nutrient concentrations were generally unaffected by the tillage and starter fertilizer treatments. Yields averaged about 3 bu/A higher with MP tillage compared to the CP, RP, and SD systems. Yields were reduced about 20% with NT. This decrease was most likely due to the significantly lower plant population, resulting from the dense surface soil and shallow planting depth. Soil samples taken both in the top and into the side of the ridge showed very high levels of P and K and indicated that the entry position of the soil tube into the ridge when taking samples makes little difference. The accumulation of P and K appeared to be fairly uniform at each depth within the ridge and higher than from samples taken midway between the ridges.

ELEVEN-YEAR YIELD SUMMARY

Grain yields were obtained from the five tillage systems where starter fertilizer was used from 1975-1982 (Table 7). The 8-year average yield shows a 5.3 bu/A yield advantage for the moldboard plow over the ridge-plant system. Some of this difference can be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control was excellent in all treatments except no tillage. Postemergence herbicides were applied to no tillage in 1979 and 1980 and did provide better weed control.

Four-year data (1979-82) indicate some advantage for the use of starter fertilizer with the chisel plow (6 bu/A), ridge-plant (5 bu/A) and no tillage systems (5 bu/A). No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Yields with no tillage continue to be significantly below the other tillage systems since converting to a corn/soybean sequence (Table 7). Both corn and soybean yields in this sequence averaged about 6% higher with the moldboard plow system compared to the chisel plow, ridge plant, or spring disk systems with virtually no difference among the latter three systems.

Table 7. Influence of tillage methods and starter fertilizer on long-term corn and soybean at Waseca.

Treatment		Cont. Corn Yield		Soybeans	Corn
Tillage	Starter	1975-82	1979-82	1983 & 85	1984
		bu/A			
No tillage	Yes	129.2	140.6	36.6	137.2
"	No		136.0	35.4	125.4
Fall plow	Yes	154.5	170.9	48.4	155.0
"	No		170.8	47.8	161.6
Fall chisel	Yes	144.4	161.8	46.1	148.6
"	No		155.5	43.8	144.7
Ridge plant	Yes	149.2	161.5	45.8	148.2
"	No		156.4	45.0	137.2
Till plant (flat)1/	Yes	144.9	154.8	45.3	156.2
"	No		157.4	45.6	154.2

1/ This treatment was converted to a spring disk(2x) beginning with the 1983 crop.

PRELIMINARY EVALUATION OF THE EFFECT OF SUBSOIL K LEVEL ON RESPONSE OF CORN TO K FERTILIZATION

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Background:

Except for nitrogen, fertilizer recommendations are based on the analysis of soil samples collected from the plow layer, usually the top 6 to 8 inches of soil. Very little attention has been devoted to the effect of subsoil levels of major nutrients on fertilizer requirements for those nutrients. Past glacial activity in Stearns County provides a unique opportunity to study the effect of potassium (K) concentration in the subsoil on the response of corn to K fertilization.

The red glacial till in the county has a K concentration that is classified as low or very low. The gray glacial till has a K concentration that is classified as being in the medium to medium high range.

Experimental Procedure:

Four sites were selected for this study in Stearns County in 1985. The parent material at two sites was red till while the parent material at the other two was gray till. Relevant soil properties for the sites are listed in Table 1.

Three rates of K (50, 100, 150 lb./acre) supplied as 0-0-60 were combined with a control treatment in a randomized block design with four replications at each site. All treatments received 100 lb. 18-46-0 and 200 lb. gypsum per acre to supply P_2O_5 and S. Urea was used to supply 30 lb. N per acre before planting. All of these materials were broadcast and incorporated before planting. A second application of urea was made at the 8-leaf stage to supply 70 lb. N per acre. Ear leaf samples were collected at silking. Yields and grain moisture values were recorded in mid-October.

Results and Discussion:

The effect of rate of applied K on grain yield, grain moisture at harvest and concentration of K in the ear leaf tissue at silking in summarized in Table 2. Data were collected from 3 of the 4 original sites. Erratic stand at the 4th site prevented collection of meaningful data.

Neither rate of applied K nor level of subsoil K had a significant effect on grain yield in 1985. Except for the Dobis location, neither variable had any effect on the grain moisture at harvest. Grain moisture did vary with location, but this was due to variability in hybrid and planting date used at each location. The cooperating farmers were responsible for planting (without starter fertilizer) and cultivation of the plots.

The concentration of K in the ear leaf tissue was not influenced rate of applied K. The average K concentration did increase at the Dobis location as rate of fertilizer K was increased. These increases, however, were not highly significant.

The results of this study raised more questions than were answered. Considering the combination of levels of K in the plow layer as well as the subsoil, a yield response to fertilizer K was not expectd at the Pratt and Elfering locations (Table 1). The K content of the soil at the Dobis location, however, was low. Yet there was no response to added K. Based on the current standards used, there is no apparent explanation for this lack of response. Perhaps there is a real need to evaluate the usefulness of the current soil test procedure used to extract K from sandy soils.

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

Table 1. Relevant soil properties of the experimental sites in Stearns County, 1985.

Name	Property	Depth (in) 0-6	6-12	12-24	24-36
Dobis	pH	6.4	6.4	6.1	5.4
Dobis	Bray & Kurtz #1 P,lb/acre	50	37	40	58
Dobis	Extractable K, lb/acre	51	42	52	97
Pratt	pH	5.8	6.1	6.2	7.2
Pratt	Bray & Kurtz #1 P,lb/acre	95	38	28	15
Pratt	Extractable K, lb/acre	200	247	221	208
Elfering*	pH	6.8	7.0	6.9	7.0
Elfering	Bray & Kurtz #1 P,lb/acre	72	30	27	17
Elfering	Extractable K, lb/acre	300	144	138	110

*History of heavy manure use at this location. No manure used at other locations.

Table 2. Effect of rate of applied K on grain yield, grain moisture at harvest and concentration of K in ear leaf at silking.

K Applied	Dobis Yield	Dobis Grain Moisture	Dobis Ear Leaf K	Pratt Yield	Pratt Grain Moisture	Pratt Ear Leaf K	Elfering Yield	Elfering Grain Moisture	Elfering Ear Leaf K
lb/acre	bu/acre	-------%------		bu/acre	-------%------		bu/acre	-------%-----	
0	123.6	29.1	1.58	118.9	35.2	2.02	124.4	27.2	2.46
50	109.6	30.0	1.71	131.2	34.9	1.95	124.6	25.7	2.58
100	116.3	30.9	1.87	124.9	34.8	2.06	121.5	28.6	2.54
150	116.5	30.8	1.82	138.3	34.5	2.06	127.4	28.5	2.55
PR>F(%)	63	99	79	80	10	24	30	66	45
BLSD(.05)	---	0.9	---	---	---	---	---	---	---
C.V.(%)	9.1	1.8	10.8	9.4	4.0	8.7	5.6	4.4	4.8