CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

S. D. Evans

I. Experimental Description

In 1965 an experiment was initiated on McIntoch silt loam to determine the effect of removal of continuous corn silage and fertilizer on corn grain and corn silage yields and on soil properties. Rates of fertilizer used were 74 + 48 + 48 (N + P_2O_5 + K_2O) and 148 + 96 + 96. All plots received a broadcast application of 10 lbs/acre of zinc as zinc sulfate in the fall of 1965.

II. 1984 Operations

In 1984 the variety was Dekalb-Pfizer T950 and was planted @ 24,300 seeds/acre. Counter was applied @ 1 lb/acre (active ingredient) at planting on May 23. Lasso @ 3 lbs/acre and Bladex @ 2.2 lbs/acre were applied broadcast on May 24. Silage yields were taken on September 28 and grain yields on November 2 and 5.

III. Silage Yields - Dry matter; tons/acre

Treatment	1984 yield	1966-84 yield
Silage, low fertility	5.47	5.67
Silage, high fertility	6.44	6.15
Grain, low fertility	5.90	5.71
Grain, high fertility	6.72	5.99

IV. Grain Yields - Bushels/acre @ 15.5% M.

	1984 yield	1966-84 yield
Grain, low fertility	91.8	90.5
Grain, high fertility	103.0	94.0

V. Check Yields

Yields on an additional unfertilized, unreplicated check adjacent to the experimental area:

	1984 yield	1966-84 yield
Grain (0 + 0 + 0)	20.8	46.5
Silage (0 + 0 + 0)	2.99	3.68

VI. Discussion

A. In 1984 the grain high fertility silage yields were significantly higher than the grain low fertility or silage low fertility treatments. The silage high fertility plots had significantly higher silage yields than did the silage low fertility plots.

B. The 19-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

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ALFALFA FERTILITY--MANAGEMENT STUDY

West Central Experiment Station - Morris
S. D. Evans and C. C. Sheaffer

With the newer alfalfa management procedures, higher yields have resulted. In many cases this might put the plant under greater stress, so it is important to investigate the effect of P and K fertilization on alfalfa yield and stand longevity. Therefore, a study was set up at Morris in 1983 to investigate the effect of (1) P and K fertilization, (2) alfalfa cutting schedule and (3) variety on alfalfa.

Experimental Procedures

The experiment was set up in 1983 on a Tara silt loam site that tested medium in Bray P (19 lbs/acre) and high in exchangeable K (234 lbs/acre). The experiment was direct seeded on May 23-24, 1983. The design was four replications of a split-split plot. The main plots were cutting schedule. The first split was P and K fertilizer and the second split was variety. In 1983 the area was harvested but no yields were taken and no fertilizer applied. In 1984 the cuttings were taken as scheduled. Fertilizer was applied by hand after the first cutting except for the 300- and 400-lb K rates where 200 lbs/acre was applied after the first cutting and the remainder after the second cutting. The 4-cut schedule was harvested on May 30, June 28, July 30 and August 29. The 3-cut schedule was harvested on June 13, July 13 and August 16. Yields were taken with a small flail chopper, weighed and a moisture sample collected from each plot. Samples of the Answer variety were saved for chemical analysis. Soil samples were taken of the 0 to 2-inch and 2- to 8-inch zones in early September.

Results and Discussion

Total seasonal yields (Tables 1 and 2) were not significantly affected by any treatment (Table 3). Significant treatment effects were found when the data was analyzed by individual cuttings. With the 3-cut schedule, variety (Table 4) was significant on both the 2nd and 3rd cuttings (P=94%). With the 4-cut schedule only the PK treatment was significant (P=98%). The effect is due to P fertilization with No-P yielding 1798 lbs/acre, 50-P @ 2086 lbs/acre and 100-P @ 2182 lbs/acre.

Dry matter percentage (Table 5) was significantly affected by PK treatment in 5 of 7 cuttings. In all cases the No-P treatment was drier than the 50-P and 100-P treatments.

Statistical analysis of the soil tests show many significant fertilizer effects on the 0 to 2-inch soil zone (Table 6). In all cases increasing either P or K fertilizer increased the P soil test and K soil test, respectively (Tables 7 and 8). Fertilizer did not affect soil tests in the 2- to 8-inch zone.

Table 1. Effect of cutting schedules, P and K fertilization and varieties on alfalfa yields at Morris in 1984.

Fertilizer Rate		1/2 Bud (4 cuttings)			1/10 Bloom (3 cuttings)			Average over Fertilizer
		Variety			Variety			
P_2O_5	K_2O	Vernal	Answer	Average	Vernal	Answer	Average	
- - lb/A - -		- - - - - - - - - - - -			Dry Matter (T/A) - - - - - - - - - - - -			
0	200	5.32	5.33	5.33	4.82	4.95	4.88	5.10
50	200	5.46	5.44	5.45	5.24	5.40	5.32	5.38
100	200	5.23	5.31	5.27	5.30	5.29	5.29	5.28
50	0	5.13	5.33	5.23	5.21	5.29	5.25	5.24
50	100	5.48	5.39	5.44	5.14	5.09	5.12	5.28
50	200	5.30	5.29	5.30	5.22	5.08	5.15	5.22
50	300	5.60	5.64	5.62	5.35	5.45	5.40	5.51
50	400	4.84	5.47	5.16	5.40	5.47	5.43	5.30
Average		5.29	5.40	5.35	5.21	5.25	5.23	5.29
CV = 5.8%								

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Table 2. Effect of P and K fertilization and variety on alfalfa yields at Morris in 1984.

Fertilizer Rate		Varieties	
P_2O_5	K_2O	Vernal	Answer
- - lb/A - -		- Dry Matter (T/A) -	
0	200	5.07	5.14
50	200	5.35	5.42
100	200	5.26	5.30
50	0	5.17	5.31
50	100	5.31	5.24
50	200	5.26	5.18
50	300	5.47	5.54
50	400	5.12	5.47
Average		5.25	5.33
CV = 5.8%			

Table 3. Effect of cutting schedule, P and K fertilization and variety on alfalfa yields.

Variable	Std. Error	Signif. Level[1]
	- T/acre -	- - % - -
Cutting Schedule (CS)	.22	37
PK Treatment (PK)	1.13	50
CS x PK	.25	43
Variety (V)	.05	83
CS x V	.08	42
PK x V	.15	39
CS x PK x V	.22	21

[1]Probability that differences are not due to chance.

Table 4. Effect of P and K fertilization and variety on alfalfa yields by individual cuttings.

	3-cut Schedule			4-cut Schedule			
Variable	1st	2nd	3rd	1st	2nd	3rd	4th
	- - - - - - - Signif. Level (%)[1] - - - - - - -						
PK Treatment (PK)	68	12	51	33	80	48	98
Variety (V)	60	94	94	6	51	84	76
PK x V	72	52	81	25	40	1	27

[1]Probability that differences are not due to chance.

Table 5. Effect of P and K fertilization and variety on alfalfa dry matter percentage by individual cuttings.

	3-cut Schedule			4-cut Schedule			
Variable	1st	2nd	3rd	1st	2nd	3rd	4th
	- - - - - - - Signif. Level (%)[1] - - - - - - -						
PK Treatment (PK)	14	98	40	90	90	96	> 99
Variety (V)	42	15	51	38	11	31	27
PK x V	79	65	74	10	19	45	86

[1]Probability that differences are not due to chance.

Table 6. Effect of cutting schedule and P and K fertilization on Answer only on soil test levels in September 1984.

Variable	Soil Tests (lbs/acre)					
	Bray P		Olsen P		Exch. K	
	0-2"	2-8"	0-2"	2-8"	0-2"	2-8"
	- - - - - - - Probability[1] (%) - - - - - - -					
Cutting Schedule (CS)	87	21	87	83	29	29
PK Treatment (PK)	> 99	79	> 99	68	> 99	50
CS x PK	17	92	17	83	70	10

[1]Probability that differences are not due to chance.

Table 7. Effect of P rate on Answer only on soil test P of the 0 to 2-inch soil zone (September 1984).

Fertilizer Rate			
P_2O_5	K_2O	Bray P	Olsen P
- lbs/acre -		- - - - lbs/acre - - - -	
0	200	13	10
50	200	27	22
100	200	53	49

Table 8. Effect of K rate on Answer only on soil test K of the 0 to 2-inch soil zone (September 1984).

Fertilizer Rate		
P_2O_5	K_2O	Exch. K
- lbs/acre -		lbs/acre
50	0	311
50	100	354
50	200	405
50	300	452
50	400	540

EFFECT OF LIQUID STARTER RATE AND ANALYSIS ON CORN GROWTH AND YIELD

West Central Experiment Station - Morris
S. D. Evans

With the increase in reduced tillage systems, many new types of fertilizer placement devices have been developed. One of these is a knife which is mounted inside the double disk openers on minimum row crop tillage planters. This device supposedly places the liquid fertilizer 1/2 to 3/4 inch to the side and 1/2 to 1 inch below the seed. This study was set up to examine the effect of two liquid fertilizers, 10-34-0 and 0-12-12, at two rates, 10 and 20 gal/acre, on corn growth and yield, when applied with this device.

Experimental Procedures

The study was set up on a Hidewood silty clay loam with a Bray P soil test of 15 lbs/acre and a K soil test of 288 lbs/acre. The liquid starters used were standard 10-34-0 and an 0-12-12 made from phosphoric acid (0-52-0) and pure KCl (0-0-62). The treatments were (1) 10-34-0 @ 10 gal/acre, (2) 10-34-0 @ 20 gal/acre, (3) 0-12-12 @ 10 gal/acre and (4) 0-12-12 @ 20 gal/acre. The variety was Pioneer 3906 planted at 24,300 seeds/acre on May 30-31. Nitrogen was applied sidedressed on July 9 to provide 120 lbs N/acre. Bladex was applied @ 2 1/2 lbs/acre on July 10 just as the corn was emerging. The treatments were replicated six times. Stand counts were taken on July 25 and height measurements were made on July 10. The plots were harvested on November 5 with a plot combine.

Results and Discussion

The stand counts (Table 1) were not significantly affected by treatment. The height measurements show an increase in height as the 10-34-0 rate was increased, but a drop in height when the 0-12-12 rate was increased. Yields show no significant effect of rates of 10-34-0 or between 10-34-0 and 0-12-12 at the low rate. With 0-12-12, the higher rate was significantly lower yielding than the low rate. Grain moisture on the 0-12-12 material @ 20 gal/acre was significantly higher than all other treatments.

The results of this study in 1984 show some detrimental effects of placing liquid 0-12-12 @ 20 gal/acre near the seed with this fertilizer knife. There was no effect on early stand. This type of device works well, but needs further research to determine rates and materials that may be safely used with it.

Table 1. Effect of 2 liquid starter fertilizers at 2 rates on corn at Morris in 1984.

Material	Rate	Stand (6-25-84)	Plant Height (7-10-84)	Grain Yield	Grain Moisture
	gal/acre	- plant/A -	- inches -	- Bu/A -	- % -
10-34-0	10	23,087	23.9	76.5	32.8
10-34-0	20	22,555	33.5	84.2	30.2
0-12-12	10	23,523	30.5	80.6	31.8
0-12-12	20	23,232	27.1	69.6	36.6
Signif. Level (%)		66	96.5	94.5	98
BLSD(.05)		-	4.4	11.9	9.3
C.V. (%)		4	11	11	10

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Problems with Irrigated Corn 1982, 1983, 1984

W. E. Fenster, Mike O'Leary and Greg Buzicky

The two experiments in the Staples area established in 1982, were again conducted in 1984 at both farms. These were located on the Staples experimental farm and on the Roth farm northeast of Staples. Both areas have sandy textured soils and are irrigated. The objective of these trials was to probe possible causes for apparent corn yield restrictions.

County Agricultural Agents and irrigator farmers in recent years have reported corn production problems where corn yields appear to be on the decline. In 1979 two farmers in Morrison County complained that yields dropped by two-thirds from the year before. In 1980 and 1981 the Wadena County Agricultural Agent reported similar problems.

Treatments of the experiment are shown in Table 1 along with corn yield data and leaf tests. The Roth farm site was not in corn in 1983.

1982 results

Yield data in 1982 from the Roth farm indicated a significant response to nitrogen, and a significant benefit from the use of the inhibitor "N-Serve" but no benefit from boron even though plant analysis of the corn leaf at silking time showed below sufficient levels of boron. The Staples site showed no benefit from the inhibitor, the sulfur, the boron, or from split application of N in 1982.

1983 results

Data from the Staples farm in 1983 showed a significant response to nitrogen. The 80 pounds per acre N treatment (treatment 2) at the eight leaf stage plus inhibitor provided significantly higher yield than 160 pounds (treatment 3) of N per acre added preplant, at the Staples farm. With no inhibitor the treatment of 160 pounds in split applications added at eight leaf, 12 leaf and tasselling stages gave yields as high as any. The 200 pound N with inhibitor treatment gave no further yield increase over the 160 pound treatment with inhibitor. There was no significant increase in yield from magnesium or sulfur when used as starter with NPK fertilizer.

1984 results

In 1984 at the Staples farm there was a significant response to nitrogen. The 160 pounds of N preplant without inhibitor yielded no better than 80 pounds of N at the 8 leaf stage with inhibitor, as on other years the 200 pounds of N gave no higher yields than the 160 pounds treatment. There appeared to be a great benefit by adding N at the 8 leaf stage over the preplant treatment time, since the inhibitor on the 160 pounds treatment at preplant was no better than the 160 pounds preplant without inhibitor. There was no benefit from magnesium or sulfur at the Staples farm.

In 1984 at the Roth farm there was a significant nitrogen response. The 80 pounds of N per acre with inhibitor at the 8 leaf stage was significantly higher than 160 pounds of N preplant without inhibitor. The 200 pound treatment preplant without inhibitor was significantly lower than 200 pounds with the inhibitor but this treatment effect was significantly lower than 160 pounds per acre with inhibitor when N was applied at 8 leaf stage. Split applications of 160 pounds of N gave highest yields either with or without inhibitor. There was a significant drop in yield when sulfur was omitted (treatment 13 compared to treatment 12). There was no apparent magnesium benefit.

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

Table 1. Nutrient treatments on corn at various growth stages at the Staples and Roth irrigated farms. 1983, 1984.

Trt	Total[2/] #N/A	Broadcast Nitrogen: Amount and time of application: ppl[1/]	8 leaf[1/]	12 leaf	Tassel	Starter[2/]: N	P	K	S	Mg	1984 Roth	Yield Bu/A: 1983 Staples	1984 Staples
1	20	--	--	--	--	+	+	+	+	+	56	66	70
2	100		80+			+	+	+	+	+	133	124	130
3	180	160				+	+	+	+	+	100	91	122
4	180	160+				+	+	+	+	+	121	136	116
5	180		160+			+	+	+	+	+	152	149	131
6	180	80+	80			+	+	+	+	+	142	146	143
7	180		80	40	40	+	+	+	+	+	162	145	150
8	180		80+	40	40	+	+	+	+	+	156	137	142
9	220	200				+	+	+	+	+	101	139	145
10	220	200+				+	+	+	+	+	135	138	123
11	220		80	80	40	+	+	+	+	+	154	141	139
12	220		80+	80	40	+	+	+	+	+	158	141	147
13	220		80+	80	40	+	+	+	-	+	143	143	148
14	220		80+	80	40	+	+	+	+	-	153	147	135
15	220		80+	80	40	+	+	+	-	-	144	134	137
16	220		80+	80	40	-	-	-	-	-	142	132	139

Trts	CMIDRF (1984 1-12	12-16	Roth (1984) 1-12	12-16
Significant	**	ns	**	**
BLSD (.05)	16	--	15	9
C.V. %	9.3	7.3	8.8	3.9

1984 Soil test averages: Staples pH - 6.2, P - 59 lb/A, K - 252 lb/A, Mg - 233 lb/A, S - 4 ppm, Zn - 4 ppm.

Roth pH - 5.7, P - 115 lb/A, K - 242 lb/A, Mg - 145 lb/A, S - 1 ppm, Zn - 1 ppm.

1/ + associated with N rate indicates use of N-Serve (1/2 lb/A a.i.)

2/ 20 #N, 20 #P_2O_5, 40 #K_2O, 10# S and 10 #Mg applied per acre as starter if used. Both farms received 120 #K_2O over all plots.

Table 2. Plant analysis of corn of the 6th leaf. Staples (C) and Roth (R) farms 1984.

Treatment	N (%)		P (%)		K (%)		S (%)		Mg (%)		Zn (ppm)	
	R	C	R	C	R	C	R	C	R	C	R	C
12	3.0	3.1	.27	.27	2.75	2.81	.23	.22	.20	.23	6	6
13			.27	.26	2.78	2.74	.25	.22	.18	.24	6	6
14			.28	.27	2.80	2.84	.24	.21	.20	.21	5	6
15			.27	.29	2.69	2.75	.25	.21	.18	.23	6	7
16			.28	.28	2.78	2.81	.26	.22	.18	.23	5	5
Adequate levels			.25		1.75		.20		.16		6	

Table 3. Nitrogen content in 6th leaf at tasselling time from various nitrogen treatment rates and methods. Staples (CMIDRF) and Roth farms 1982, 1983, 1984.

Treatment		CMIDRF			Roth	
Treatment	N rate lb./A	1982	1983	1984	1982	1984
1	0	2.08	1.67	1.32	2.31	1.50
2	80	2.48	2.68	2.41	2.84	2.91
3	160	2.93	1.99	2.13	2.80	2.20
4	160+	3.06	2.74	2.67	3.15	2.53
5	160+	2.97	2.81	3.07	3.26	3.09
6	80+ + 80	3.29	2.70	2.89	2.96	2.87
7	80 + 40 + 40	3.03	3.04	2.90	2.98	2.88
10	200+	3.39	3.18	2.70	3.00	2.70
Adequate			2.70		2.70	

+means inhibitor added

CORN - SOYBEAN ROTATION

H. Meredith, Melvin Wiens and Greg Buzicky

A corn-soybean experiment initiated in 1981 at the Staples Station to evaluate corn yields under a regime of continuous corn and corn following soybeans continues.

Pioneer 3978 (85-day) and 3906 (95-day) relative maturity hybrids and clay soybeans are utilized as the test crops in the experiment.

Purpose of Study: This study was initiated following complaints from farmers and extension personnel of the inability to meet corn yield expectations under irrigation on the sand plain . It is recognized that consistently high yields result from the best combination of management and climate. Temperatures ranging from excessively low spring and early fall to high summer offer adequate opportunities for havoc. Rainfall, both too little and too much on these coarse textured soils creates severe management problems. Typically farmers are ill prepared to supply sufficient irrigation water during periods of severe heat stress. Excess precipitation, especially following irrigation, may result in removal of nitrate nitrogen and possibly other vital soluble nutrients as sulfur from the rooting zone.

This study attempts to apply the best cultural management practices coupled with emphasis on timely irrigation and nutrition adequacy.

Table 1. Yield and Corresponding Information.

Treatment	Bu/A	Harvest Population (x 1000)	% Moisture	Grain Yield T/A	Stover Yield T/A	Grain/Stover Ratio	Total Tons
(1) C-C 3978	116.4	26.7	29.2	2.70	2.42	1.11	5.12
(2) C-C 3906	112.7	31.4	37.5	2.79	3.37	.84	6.16
(5) SB-C 3978	124.0	27.1	28.6	2.82	2.70	1.05	5.52
(6) SB-C 3906	121.7	31.9	36.2	2.86	3.54	.81	6.40
(7) CC + Zn 3978*	117.6	26.5	29.2	2.63	2.42	1.08	5.05
BLSD (.05)	85	99	99	20	99	99	99
Sig level	--	.27	1.9	--	.42	.17	.74
C.V. %	5.3	6.2	4.2	10.8	9.8	11.3	8.4

*Received zinc in '81, '82, '83, and '84. All other plots received zinc only in '83.

CC Continuous corn
C-SB Corn-soybeans

Table 2. Fertilizer Applied to Corn Plots

	Broadcast	Row or Starter	Total
	- - - - - - - -	Lbs/A - - - - - -	
*N	180	10	190
P_2O_5		10	10
K_2O	225	20	245
S		10	10
Mg		5	5

*60#/A applied 6/15, 7/3, and 7/26

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Table 3. Supplemental Information Corn

Date of Planting: 4/25
Herbicide: 2.5#AI/A Lasso 5/4/84
3/4 pt 2,4-D 6/2/84
Emergence Date: 5/16
Tassel Began: 7/19
Seeding Note Corn: 32,000 plants/A

Harvest: 10/4 corn
Irrigation: 13.5 in.
Rainfall (May-Sep): 12.5 in.
Row Width: 30 in.

Table 4. Additional Information on Nutrient Removal

Total Nutrients Removed (Grain + Forage)

	Lbs/A								
Treatment	N	P	K	Ca	Mg	MN	Zn	Cu	B
1	118.5	17.3	120.4	30.5	18.3	.37	.20	.036	.047
2	156.0	20.9	160.8	45.6	23.5	.53	.23	.034	.074
5	131.7	19.1	136.2	35.1	20.9	.44	.21	.025	.052
6	165.0	23.5	174.4	47.3	25.1	.57	.24	.033	.077
7	117.6	16.1	123.8	30.4	18.1	.37	.23	.025	.049
Sig level	99	99	99	99	99	99	96	99	99
BLSD (.05)	17.7	2.8	21.1	9.1	3.5	.10	.03	.004	.01
C.V. %	88.7	9.6	9.9	15.6	10.7	14.0	8.2	9.5	11.4

Table 5. Nutrient Content of Corn Grain

Treatment	N	P	K	Ca	Mg	Zn	Cu	B	Mn
	Percent					PPM			
1	1.21	.23	.44	.005	.10	20.8	1.1	2.4	4.0
2	1.48	.24	.43	.006	.12	20.8	1.4	3.5	5.6
5	1.27	.24	.46	.004	.11	21.2	.8	2.5	4.1
6	1.50	.27	.45	.006	.13	21.5	1.3	3.6	6.1
7	1.25	.22	.42	.004	.10	21.6	1.1	2.6	3.9
Sig level	99	99	83	99	99	.07	99	99	99
BLSD (.05)	.10	.02	--	.001	.008	--	.31	.19	.45
C.V. %	5.2	4.5	5.4	15.4	4.9	8.2	17.1	4.5	6.7

Table 6. Nutrient Content of Corn Stover

Treatment	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	Lbs/A					PPM			
1	1.10	.104	2.00	.621	.263	71.1	18.2	4.11	7.03
2	1.09	.107	2.03	.664	.247	73.1	17.0	3.93	8.05
5	1.11	.103	2.05	.644	.272	76.5	16.5	3.92	6.94
6	1.13	.113	2.09	.658	.247	75.2	16.2	3.66	7.93
7	1.08	.096	2.10	.621	.263	72.0	23.5	4.10	7.19
Sig level	14	98	15	38	85	55	99	32	99
BLSD (.05)		.009					4.2		.58
C.V. %	6.8	5.4	7.1	7.7	6.1	6.1	14.2	12.1	5.0

Table 7. Leaf Tissue Analyses at Silking

Treatment	N	P	K	Ca	Mg	Mn	Zn	Cu	B
	- - - - - - - - -		Lbs/A	- - - - - - - - - -		- - - - - - - -	PPM	- - - - - - - -	
1	2.96	.287	2.72	.78	.26	77.2	23.6	4.97	5.41
2	3.02	.292	2.35	.84	.31	82.1	26.8	5.24	6.18
5	2.89	.286	2.78	.84	.28	81.0	23.2	4.61	5.43
6	3.10	.303	2.56	.86	.32	86.9	24.2	4.98	5.85
7	2.96	.286	2.76	.79	.27	73.3	28.6	5.10	5.56
Sig level	99	99	83	99	99	99	.07	99	99
BLSD (.05)	.10	.02		.001	.008	.45		.31	.19
C.V. %	5.2	4.5	5.4	15.4	4.9	6.7	8.2	17.1	4.5

Table 8. Leaf Sulfur and Nitrogen-Sulfur Ratios of Corn Leaf Samples at Silking, Staples

Treatment	N %	S %	N/S
Cont. corn (3978) 1/	2.96	.215	13.8
Cont. corn (3906)	3.02	.232	13.1
Rot. corn (3978) 2/	2.89	.220	13.2
Rot. corn (3906)	3.10	.236	13.2
High Zn (3978) 3/	2.96	.214	13.1
Sig level	88	97	78
BLSD (.05)	--	.017	--
C.V. %	3.4	4.5	4.4

1/ Continuous corn

2/ Corn-soybean rotation

3/ 10 pounds Zn broadcast

SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1984

Month	Period	Precipitation 1984	Precipitation Normal 1/	Avg. Air Temp. 1984	Avg. Air Temp. Normal 1/	Growing Degree Days 1984	Growing Degree Days Normal 1/
		----inches-----		-------°F-------			
January	1-31	0.35	0.84	11.4	10.0		
February	1-29	2.00	0.99	25.0	16.4		
March	1-31	2.79	1.99	22.1	27.6		
April	1-30	4.99	2.64	45.6	44.7		
May	1-10	0.75		45.8		30.0	
	11-20	0.66		59.5		113.5	
	21-31	1.56		58.4		116.0	
	Total	2.97	3.76	54.7	57.7	259.5	334
June	1-10	2.13		70.1		200.0	
	11-20	1.94		66.6		155.5	
	21-30	1.04		69.6		196.0	
	Total	5.11	4.48	68.9	67.1	561.5	518
July	1-10	1.60		67.8		182.5	
	11-20	1.63		67.9		185.5	
	21-31	0.20		71.0		229.0	
	Total	3.43	4.02	69.2	71.2	597.0	641
August	1-10	1.30		75.5		248.0	
	11-20	0.11		72.3		220.5	
	21-31	0.03		69.5		204.0	
	Total	1.44	3.99	72.3	68.8	672.5	579
September	1-30	2.42	3.36	57.1	59.8	309.5	311
October	1-31	4.63	2.08	50.0	48.9	0.0	38
November	1-30	2.21	1.43	32.5	32.5		
December	1-31	3.08	1.02	18.8	18.0		
Year	Jan-Dec	35.42	30.60	44.0	43.6	2400.0	2421
Growing Season	May-Sep	15.37	19.61	64.4	64.9	2400.0	2383

Notes:

1) 30-year normal from 1951-1980.
2) Highest temp. on Aug. 28 -- 96°.
3) Highest 24-hour precipitation on Apr. 30 -- 1.92".
4) Available soil moisture in 0-5' profile was 40% of field capacity in late August and was non-existent in the 0-2' layer.
5) Last spring frost -- May 8.
6) Frost on September 26.

ROTATION NITROGEN STUDY

Waseca, 1984

G. W. Randall, D. T. Walters, and M. P. Russelle

Increasing the efficiency of fertilizer N along with reducing fertilizer N recommendations by improved diagnostic techniques, symbiotic N fixation, crop rotation, etc. are goals which are gaining widespread research support throughout the United States. The adoption of crop rotations or sequences may plan a vital role in the conservation of N. The purpose of this study is to determine the N needs of continuous corn (removed for grain), corn removed for silage, second year corn following soybeans, corn following soybeans and corn following wheat.

EXPERIMENTAL PROCEDURES

Four crop sequences (continuous corn, corn-soybean, corn-wheat and corn-wheat + alfalfa) were begun in 1974 on a Webster clay loam. Each N plot within each crop sequence is 15' wide (6 rows) by 50' long. Rates of N (0, 40, 80, 120, 160 and 200 lb N/A) have been applied annually to corn.

The corn-wheat + alfalfa sequence was dropped in 1981 in favor of a continuous corn system where all of the corn was removed as silage the preceding year. This gives us a comparison of the N needs between grain removal only compared to total above-ground biomass removal. In 1982, a C-C-Sb rotation was introduced to examine the N needs of second-year corn following soybeans.

In 1984, anhydrous ammonia was applied on April 19 to all corn plots. Wheat received 50 lb N/A as urea before planting. All plots were moldboard plowed in the fall of 1983. Because of high soil test P and K values, broadcast P and K or starter fertilizer was not used.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3906) were planted in 30" rows at 27700 ppA on May 12. Counter was applied to all corn plots at 1 lb/A to control rootworms. Butte wheat was planted on April 25. Hardin soybeans were planted on May 15.

Weeds were chemically controlled along with one cultivartion of the corn. A combination of 4 qt Lasso plus 3½ lb Bladex/A was applied preemergence to corn. Soybeans received 4 qt Lasso plus 6 qt Amiben/A applied preemergence.

Corn leaf samples were taken at silking from rows 2 and 3 (Hybrid A) and from rows 4 and 5 (Hybrid B) of each 6-row plot. Corn yields were taken by mechanically harvesting the same rows. Grain moisture and grain N data were obtained on the harvested samples.

After the 1983 harvest, soil samples were taken in the fall to a depth of 5' from the 0 and 160-lb N treatments which were applied to the continuous corn (grain) and continuous corn (silage) rotations in 1982. Soil samples were also taken from the 0-lb N treatments in the plots where soybeans, wheat, and corn following soybeans were the 1983 crops. Two cores were taken/plot, divided into 1-foot increments, composited/ rep, dried, crushed and analyzed for NO_3-N by the Soil Testing Laboratory.

RESULTS

Nitrate-N remaining in the soil profile after the 1983 crop which was available to the 1984 corn, is presented in Table 1. When no fertilizer N was applied in 1983 (except the blanket 50-lb rate to wheat) very little difference in residual NO_3-N appeared among the five crop sequences. For the second year in a row, levels were lowest following wheat. Approximately 50% of the residual NO_3-N was found in the top foot of the 5-foot profile with all five crop sequences. Very small amounts of NO_3-N were found below 2'. When 160 lb of N was applied to continuous corn (grain and silage) some residual N was found. About 30% of the carryover was located in the top foot with a uniform distribution throughout the rest of the 5-foot profile.

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

Table 1. Effect of crop and N rate applied to corn in the crop sequence on residual NO_3-N remaining in the 0-5' profile at the end of the 1983 growing season.

	1983 Crop				
Profile depth	Corn (grain)	Corn (silage)	Corn Fol. Soybeans	Soybeans	Wheat
feet	lb NO_3-N/foot				
			0 lb N/A		
0-1	33	37	31	35	28
1-2	13	13	12	17	10
2-3	9	8	5	13	7
3-4	8	7	7	7	6
4-5	8	13	11	11	9
Total (lb NO_3-N/5')	71	78	66	83	60
			160 lb N/A		
0-1	53	38			
1-2	28	24			
2-3	27	34			
3-4	27	33			
4-5	20	25			
Total (lb NO_3-N/5')	155	154			

Corn yield, leaf N, grain N, grain N removed, and grain moisture at harvest are shown for each of the treatments in Table 2. All data are an average of the five replications. Averages for each of the main factors and the two-way interactions along with the statistical interpretations are shown in Table 3.

Grain yield

Corn yields were suboptimal in 1984 due to the moisture stress conditions from late July through early September. As in previous years crop sequence had a substantial effect on corn yield. Yields following soybeans or wheat were significantly higher (15 to 28 bu/A) than when following corn (either for grain, silage, or first year corn after soybeans) when averaged over N rates and hybrids. Yields were economically maximized with the 120-lb N rate when averaged over crop sequences and hybrids. As in 1983, there was no difference in grain yield between P3906 and P3732 when averaged over sequences and N rates.

Closer examination of the interactions reveals additional information. Surprisingly, the sequence x N rate interaction was not significant when averaged across hybrids (P = 76% level) even though the yield response to the 200-lb rate over the 0-lb rate was 46.3, 60.3, 59.2, 64.1 and 49.1 bu/A for the CC (grain), CC (silage), C-Sb, C-Wht, and second year corn after soybeans sequences, respectively. The sequence x hybrid interaction showed slightly higher yields for P3906 when corn followed corn. However, when corn followed either soybeans or wheat, yields from P3732 were slightly better. In contrast to 1983, there was no N rate by hybrid interaction.

The three-factor interaction between sequence x N rate x hybrid (significant at the 92% level) shows that yields were generally higher with P3906 than with P3732 at the higher N rates when the sequence was CC (grain) or CC (silage). When corn followed either wheat or first year corn after soybeans, there generally was no difference between P3906 and P3732 as N rate was increased. However, when corn followed soybeans yields from P3732 were higher than P3906 at N rates greater than 80 lb/A.

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. Perhaps the NO_3-N differences among the sequences were too small, the absolute amounts too little, and/or losses between the fall of 1983 and summer of 1984 too great.

In summary, corn yields (averaged over hybrids) from the 200-lb rate were 11, 26, 30 and 5 bu/A higher when following corn removed for silage, soybeans, wheat or first year corn after soybeans, respectively, compared to continuous corn. This attests to the advantage for crop rotation in a dry (stress) year and gives further proof that yield differences due to previous crop cannot be overcome by high N rates alone.

Table 2. Corn grain yield, leaf N, grain N, grain N removed and grain moisture as influenced by previous crop, N-rate and hybrid at Waseca, 1984.

Previous Crop	Hybrid	N-rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. Corn (grain)	3906	72.5	97.5	101.7	118.4	116.6	125.1
	3732	77.7	89.2	101.1	111.8	114.4	117.6
Cont. Corn (silage)	3906	78.8	94.3	117.4	127.1	121.0	127.9
	3732	74.6	96.4	112.4	122.1	113.9	123.8
Soybeans	3906	88.5	122.2	131.8	143.9	143.0	145.0
	3732	87.6	127.0	131.2	148.9	157.5	149.5
Wheat	3906	88.3	104.6	133.7	142.4	142.1	152.4
	3732	85.7	119.7	136.4	144.4	141.6	149.9
Corn after soybeans	3906	73.4	98.0	118.9	129.8	131.9	133.3
	3732	71.4	103.0	112.5	128.3	125.3	132.1
		Leaf N %)					
Cont. Corn (grain)	3906	1.84	1.99	2.33	2.58	2.79	2.95
	3732	1.70	1.90	2.14	2.45	2.67	2.96
Cont. Corn (silage)	3906	1.70	2.01	2.53	2.65	2.78	2.90
	3732	1.54	1.91	2.35	2.40	2.77	2.78
Soybeans	3906	1.70	2.16	2.71	2.71	2.96	3.01
	3732	1.55	2.33	2.60	2.79	2.84	2.92
Wheat	3906	1.82	2.08	2.54	2.76	2.83	2.91
	3732	1.69	2.10	2.51	2.79	2.87	2.91
Corn after soybeans	3906	1.61	1.84	2.29	2.65	2.67	2.90
	3732	1.50	1.84	2.35	2.63	2.67	2.79
		Grain N (%)					
Cont. Corn (grain)	3906	1.34	1.23	1.35	1.60	1.67	1.66
	3732	1.15	1.10	1.24	1.45	1.49	1.55
Cont. Corn (silage)	3906	1.25	1.27	1.41	1.50	1.52	1.67
	3732	1.03	1.09	1.22	1.31	1.41	1.53
Soybeans	3906	1.19	1.28	1.42	1.47	1.61	1.66
	3732	1.05	1.12	1.26	1.38	1.44	1.46
Wheat	3906	1.33	1.25	1.36	1.55	1.62	1.58
	3732	.98	1.06	1.22	1.38	1.40	1.43
Corn after soybeans	3906	1.27	1.15	1.40	1.53	1.61	1.64
	3732	1.11	1.11	1.13	1.36	1.46	1.52
		Grain N Removed (lb/A)					
Cont. Corn (grain)	3906	46.1	56.7	65.4	89.5	91.5	98.1
	3732	42.7	46.0	59.5	76.4	80.4	85.5
Cont. Corn (silage)	3906	46.6	56.9	78.1	90.6	87.7	101.0
	3732	36.3	49.9	64.8	76.2	75.7	89.4
Soybeans	3906	49.7	74.7	88.9	99.9	108.9	113.2
	3732	43.6	67.8	78.1	96.5	106.6	102.8
Wheat	3906	56.4	62.4	87.0	104.7	108.4	113.6
	3732	40.0	60.0	78.8	94.0	94.2	100.9
Corn after soybeans	3906	44.0	54.2	79.0	93.9	100.3	102.8
	3732	37.0	54.2	60.3	82.6	86.6	94.3
		Grain Moisture (%)					
Cont. Corn (grain)	3906	16.6	15.9	16.5	14.3	14.2	14.1
	3732	23.2	20.4	18.1	16.5	16.3	16.1
Cont. Corn (silage)	3906	16.9	15.9	15.3	15.3	13.7	14.3
	3732	22.6	19.4	18.6	18.0	15.5	16.0
Soybeans	3906	18.1	18.1	17.0	16.8	16.6	16.1
	3732	22.7	21.0	20.0	19.2	19.5	18.6
Wheat	3906	19.0	18.6	17.6	17.3	16.5	17.7
	3732	25.4	22.2	20.1	20.1	19.1	19.3
Corn after soybeans	3906	17.1	17.2	16.4	15.5	15.6	15.8
	3732	23.4	20.5	19.8	18.8	18.3	17.7

Table 3. Main factor and two-factor interaction averages for corn grain yield, moisture, N, and grain N removal and leaf N in 1984.

Source	Grain Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
	bu/A	------- %	-------	lb/A	%
MAIN FACTORS					
Sequence					
Cont. corn (grain)	103.6	16.8	1.40	69.8	2.36
Cont. corn (silage)	113.1	18.0	1.36	74.1	2.31
Sb-C	131.1	18.6	1.36	85.9	2.52
Wht-C	128.4	19.4	1.35	83.4	2.48
Sb-C-C*	109.1	16.8	1.35	71.1	2.36
Signif. Level (%):	99	99	66	99	99
BLSD(.10) :	8.8	1.2	-	6.4	.08
BLSD(.05) :	10.3	1.4	-	7.5	.10
N Rate (lb/A)					
0	79.9	20.5	1.17	44.3	1.66
40	105.2	18.9	1.17	58.3	2.02
80	119.7	17.9	1.30	74.0	2.44
120	131.7	17.2	1.45	90.4	2.64
160	130.7	16.5	1.52	94.0	2.78
200	135.6	16.6	1.57	100.2	2.90
Signif. Level (%):	99	99	99	99	99
BLSD(.10) :	3.7	0.4	.04	3.2	.09
BLSD(.05) :	4.3	0.5	.05	3.7	.10
Hybrid					
P 3906	117.4	16.3	1.45	81.7	2.44
P 3732	116.9	19.5	1.28	72.0	2.38
Signif. Level (%):	46	99	99	99	99
INTERACTIONS					
Sequence x N Rate					
CC(g) 0	75.1	19.9	1.24	44.4	1.77
40	93.3	18.1	1.16	51.3	1.95
80	101.4	17.3	1.30	62.5	2.23
120	115.1	15.4	1.52	83.0	2.51
160	115.5	15.3	1.58	85.9	2.73
200	121.4	15.1	1.61	91.8	2.96
CC(s) 0	72.4	20.3	1.19	40.6	1.56
40	100.5	18.8	1.13	54.2	1.84
80	115.7	18.1	1.27	69.7	2.32
120	129.0	17.1	1.44	88.2	2.64
160	128.6	16.9	1.54	93.5	2.67
200	132.7	16.7	1.58	98.6	2.85
Sb-C 0	88.0	20.4	1.12	46.6	1.63
40	124.6	19.5	1.20	71.2	2.24
80	131.5	18.5	1.34	83.5	2.66
120	146.4	18.0	1.42	98.2	2.75
160	150.3	18.1	1.52	107.8	2.90
200	147.2	17.3	1.56	108.0	2.97
Wht-C 0	87.0	22.2	1.16	48.2	1.76
40	112.2	20.4	1.16	61.2	2.09
80	135.1	18.8	1.29	82.9	2.52
120	143.4	18.7	1.47	99.3	2.78
160	141.8	17.8	1.51	101.3	2.85
200	151.1	18.5	1.51	107.3	2.91

Table 3. (Continued)

Source		Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
		bu/A	------ %	--------	lb/A	%
Sb-C-C*	0	76.7	19.8	1.14	41.5	1.62
	40	95.4	17.6	1.18	53.4	1.96
	80	114.9	16.9	1.32	71.5	2.44
	120	124.6	16.6	1.40	83.4	2.52
	160	117.4	14.6	1.46	81.7	2.78
	200	125.8	15.1	1.60	95.2	2.84
Signif. Level (%):		76	79	28	70	44
Sequence x Hybrid						
CC(g)	3906	105.3	15.3	1.47	74.6	2.41
	3732	102.0	18.4	1.33	65.1	2.30
CC(s)	3906	114.2	16.3	1.43	79.0	2.33
	3732	112.1	19.7	1.28	69.2	2.30
Sb-C	3906	129.1	17.1	1.44	89.2	2.54
	3732	133.6	20.2	1.29	82.6	2.51
Wht-C	3906	127.2	17.8	1.45	88.7	2.49
	3732	129.6	21.0	1.25	78.0	2.48
Sb-C-C*	3906	111.1	15.2	1.44	76.8	2.43
	3732	107.2	18.3	1.26	65.4	2.29
Signif. Level (%):		99	10	60	66	81
BLSD(.10)	:	2.9				
BLSD(.05)	:	3.4				
N rate x Hybrid						
0	3906	80.3	17.5	1.27	48.6	1.73
	3732	79.4	23.4	1.07	39.9	1.60
40	3906	103.3	17.1	1.24	61.0	2.02
	3732	107.1	20.7	1.10	55.6	2.02
80	3906	120.7	16.6	1.39	79.7	2.48
	3732	118.7	19.3	1.22	68.3	2.39
120	3906	132.3	15.8	1.53	95.7	2.67
	3732	131.1	18.5	1.37	85.2	2.61
160	3906	130.9	15.7	1.60	99.4	2.80
	3732	130.6	17.7	1.44	88.7	2.76
200	3906	136.7	15.6	1.64	105.7	2.93
	3732	134.6	17.5	1.50	94.6	2.87
Signif. Level (%):		76	99	53	78	50
BLSD(.10)	:		0.5			
BLSD(.05)	:		0.6			
Seq. x N rate x Hybrid						
Signif. Level (%):		92	20	37	51	6
CV(%)	:	5.6	6.4	6.8	8.9	7.2

* = Position in sequence for which measurements taken.

Grain moisture

The CC (grain) and second year corn after soybeans sequences, which had lower yields, also had lower grain moisture at harvest compared to the C-Sb and C-Wht sequences. Grain moisture was reduced significantly by each additional 40-lb increment of N through 160 lb/A when averaged over sequences and hybrids. P3906 consistently showed lower moisture levels at harvest. This was especially true at the 0-lb N rate when a 5.9 percentage point difference existed between the two hybrids. At the 200-lb rate, only a 1.9 point difference was shown between the two hybrids; thus, the significant N rate by hybrid interaction.

Grain N

When averaged over N rates and hybrids, grain N was not influenced by crop sequence. Grain N was increased significantly from 1.17% with 40 lb N/A to 1.57% with 200 lb/A when averaged over sequences and hybrids. P3906 averaged 1.45% N compared to 1.28% for P3732 when averaged over sequences and N rates. Protein levels at the optimum N rates averaged about 9.8 (1.56% N) and 8.8 (1.40% N) for the two hybrids, respectively. In contrast to 1983, a sequence x hybrid interaction was not present.

Grain N removed

N removed in the grain crop was closely associated with both grain yield and grain N concentration. Highest grain N removal occurred when soybeans or wheat were the previous crop, when 200 lb N/A was applied, and when P3906 was grown.

N efficiency, as measured by grain N removed fertilizer N application rate, ranged from 24% to 31% at the 200-lb rate and from 32% to 43% at the 120-lb rate for the CC (g) and C-Sb sequences, respectively, when averaged over hybrids. When averaged over crop sequences there was no difference between P3906 and P3732 at either of these N rates.

Leaf N

N concentrations in the earleaf at silking were significantly higher when corn followed either soybeans or wheat compared to followiong corn when averaged over N rates and hybrids. When averaged over crop sequences and hybrids, leaf N was increased significantly by each increment of fertilizer N through 200 lb/A. Significantly more leaf N was found in P3906 than P3732 when averaged over sequences and N rates. No interactions were found.

Silage production

Measurements were taken from the CC (silage) 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 160 lb/A on fodder yield. Fodder yield of P3732 was significantly greater than P3906. The highly significant (P = 98%) interaction for fodder N concentration between N rate and hybrid indicates that fodder N in P3732 was increased to significantly higher levels by the higher fertilizer N rates compared to P3906. The highly significant interaction for fodder N uptake (P = 97%) also indicates that N contained in the fodder of P3732 was increased with increasing rate of N application whereas with P3906 it plateaued.

Silage yields were also increased significantly by N rates up to 160 lb/A and by the P3732 hybrid. No N rate x hybrid interaction existed. Total N removed in the silage was increased with increasing N rates up through 160 lb/A. There was no difference in total N uptake between the two hybrids and no N rate x hybrid interaction.

Soybean production

To determine if N from the 1983 application to corn influenced the 1984 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.

Nitrogen Uptake Investigation

Because highly significant interactions were found in 1983 between the grain yields of the two hybrids with N rates and sequences and between the grain N concentrations of the hybrids with the sequences, an additional investigation was conducted by Drs. Russelle and Walters in 1984. The purpose of this study was to determine the N uptake patterns of the two hybrids at three times during the season (12-leaf stage, blister stage (BL), and physiological maturity (PM)) as influenced by N rate and crop sequence.

Plants from three N rates (0, 80, and 160 lb N/A) were taken from all crop sequences, from both hybrids, and from three of the replications. In order to not interfere with the main objectives of the rotation study, only two carefully selected plants were taken from each plot at each growth stage. The plants were cut at the ground level, chopped, dried, and weighed for dry matter. At physiological maturity, the ears were separated, the grain shelled from the cob, and the cob returned and weighed with the stover. The dried plant parts were then ground and submitted for total Kjeldahl

Table 4. Silage production as influenced by N rate and hybrid in a silage corn rotation at Waseca, 1984.

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	1.47	.41	12.1	3.52	55.4
	3732	1.51	.38	11.7	3.51	51.4
40	3906	2.05	.39	15.8	4.70	72.7
	3732	2.49	.39	19.2	5.22	71.9
80	3906	2.33	.41	18.9	5.46	89.7
	3732	2.88	.40	23.3	6.17	97.8
120	3906	2.35	.40	18.8	5.53	102.9
	3732	2.57	.49	26.1	5.58	101.9
160	3906	2.67	.52	27.6	6.49	132.9
	3732	2.98	.61	36.1	6.52	129.7
200	3906	2.27	.48	21.9	5.69	116.5
	3732	2.68	.70	37.4	5.96	128.8
Individual Factors						
N rate (lb/A)						
0		1.49	.40	11.9	3.52	53.4
40		2.27	.39	17.5	4.96	72.3
80		2.60	.40	21.1	5.81	93.8
120		2.46	.45	22.4	5.56	102.4
160		2.83	.56	31.8	6.51	131.3
200		2.48	.59	29.6	5.83	122.6
Signif. Level (%): 1/		99	99	99	99	99
BLSD (.05) :		.34	.06	4.2	.54	10.4
Hybrid						
3906		2.19	.43	19.2	5.23	95.3
3732		2.52	.50	25.6	5.49	96.9
Signif. Level (%): 1/		99	99	99	95	44
N rate x Hybrid IA: 1/		29	98	97	54	29
CV (%) :		16.	17.	25.	9.0	9.6

1/ Probability level of significance

Table 5. Soybean yield and moisture as influenced by N applied to corn in 1983.

N rate	Seed Yield	Seed Moisture
(lb/A)	bu/A	%
0	55.6	9.4
200	54.2	9.3
Signif. Level (%):	73	37
CV (%) :	3.3	5.2

N analysis. All values shown in Table 6 were obtained by converting the N concentrations and DM accumulation on the 2-plant samples to an area basis by adjusting with the final plant population of each of the plots. Statistical analysis of the population data showed no significant differences in final plant population. Only data from the BL and PM stages are presented.

Nitrogen in the stover at the BL stage was not influenced by crop sequence or hybrid (Table 6). N rate and the interaction between N rate and hybrid were both highly significant. The significant interaction is shown by the lower N yields with P3732 at the low N rates but the higher N yield with P3732 at the high N rate. Interactions between crop sequence and N rate or hybrid were not significant.

Stover N yield at PM presented slightly different results. Significantly more N was found in the corn following soybeans and wheat than when following CC for grain or silage or first year corn after soybeans. N rate again increased stover N. Similar to the BL stage, there was no effect of hybrid on stover N at PM. All interactions were not significant.

Total N in the grain at PM was affected significantly by crop sequence, N rate, and hybrid (Table 6). These results are similar to those presented in Table 3. Highest amounts of grain N were found when corn followed either soybeans or wheat and with the P3906 hybrid.

To try and determine when P3906 accumulated more N than P3732, the investigators assumed that the difference in stover N between the BL and PM stage (always less stover N at PM compared to BL) must be due to translocation of this N to the grain during earfill. This N which had already been taken up by the plant at the BL stage was termed "OLD N" (Table 6). "OLD N" was not affected by crop sequence when averaged over N rate and hybrid and was not affected by hybrid when averaged over sequence and N rate. However, the highly significant N rate by hybrid interaction is very similar to that found with stover N at the BL stage. Again, it appears as though P3732 was capable of taking up more N than P3906 by the blister stage and that much of this was translocated to the grain.

By subtracting the translocated "OLD N" in the grain from the total N in the grain, we can calculate the amount of N that must have been taken up after the blister stage. This N, termed "NEW N" may have come from late-season absorption of N from the soil by the roots or from N which may have been stored in the roots at the BL stage. The "NEW N" was affected significantly by the crop sequence, N rate, and hybrid (Table 6). More "NEW N" was found when corn followed either soybeans or wheat. The apparent difference between CC for grain or for silage is not explainable at this time. As expected Higher N rates increased "NEW N" in the grain. A two-fold increase in "NEW N" occurred with P3906 compared to P3732 when averaged over sequence and N rate. The highly significant interaction between N rate and hybrid shows substantially more "NEW N" accumulated in the grain with P3906 at the high N rate compared to P3732.

Total N in the plants at PM was also affected by crop sequence, N rate, and hybrid. Highest total N uptake occurred with the corn-soybean and corn-wheat sequences, at the 160-lb N rate, and with the P3906 hybrid.

In summary, these data indicate that P3732 is capable of taking up more N from the soil before the blister stage with higher rates of N application than is P3906. A large portion of this N appears to be translocated to the developing grain. However, P3906 at these N rates showed a tremendous ability to take up late-season N (either from the soil or from the roots) and translocate it to the grain. This uptake of late-season N more than accounts for any apparent early-season N uptake shortcomings and results in high grain N concentrations, excellent yields and excellent stress tolerance. The mechanism or reason for this late season advantage is not known at this time and needs further research. Perhaps it could be due to a larger more active root system capable of taking up and translocating N late in the season or an exudate relationship in the rhizosphere which increases N availability to the plant. On the other hand the uptake of late-season N could be related to soil moisture. If the ET demand of P3906 is not as high as with P3732, there could be more moisture available for late season uptake of both water and N with P3906.

Table 6. N uptake as influenced by rotation, N rate and hybrid in 1984.

Source	Stover N Yield[1/] BL	Stover N Yield[1/] PM	Grain N Yield at PM Total	Grain N Yield at PM OLD[2/]	Grain N Yield at PM NEW[3/]	Total Plant N at PM
	kg N/ha					
MAIN FACTORS						
Sequence						
CC (grain)	114	39	104	75	30	144
CC (silage)	120	35	94	85	10	130
Sb-C	126	48	115	77	38	163
Wht-C	120	49	113	70	42	162
Sb-C-C*	116	35	97	81	16	132
Signif. Level (%):	61	99	97	67	97	99
N Rate (lb/A)						
0	77	27	70	50	20	97
80	122	39	106	83	23	145
160	158	58	138	100	38	196
Signif. Level (%):	99	99	99	99	98	99
Hybrid						
P 3906	119	41	113	78	35	154
P 3732	119	42	96	77	19	138
Signif. Level (%):	9	26	99	23	99	99
INTERACTIONS						
N Rate x Hybrid						
0 3906	81	28	78	54	24	106
0 3732	73	26	63	47	16	89
80 3906	130	39	113	91	22	152
80 3732	114	40	98	74	24	138
160 3906	147	57	148	89	58	204
160 3732	170	59	128	110	17	187
Signif. Level (%):	99	33	17	99	99	4
Sequence x N Rate						
Signif. Level (%):	85	73	94	97	97	89
Sequence x Hybrid						
Signif. Level (%):	12	56	6	38	19	13
CV (%):	15.	21	17.	22.	72.	16.

1/ BL = blister stage, PM = physiological maturity
2/ OLD N = N in stover at BL - N in stover at PM, the difference is assumed to be translocated to the grain
3/ NEW N = Total N in grain - OLD N, the difference is assumed to be absorbed from the soil after blister stage and/or translocated from the roots.
* Position in sequence for which measurements taken

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1984

G. W. Randall and D. T. Walters

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' fepth. 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 croops. 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 and 1983. Percent surface residue was measured on April 18, 1984 and averaged 8 and 93% for the moldboard plow and no tillage systems, respectively.

On April 23, 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 10 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. Counter 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 12. Control was excellent.

Early plant growth was determined by harvesting the above ground portion of 10 plants/plot 42 days after planting. The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking (Moldboard plow = July 23, No tillage = July 25) 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 mid February, 1984 and continued to flow intermittently until mid July. Conditions were extremely dry in late July, August and September and no tile flow was recorded during this period. Tile lines commenced flowing again in November for 8 days. 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 October 26, 1984.

RESULTS

Early plant growth with moldboard plow tillage was significantly greater than with no tillage (Table 1). This was probably due to cooler soil temperatures and slower emergence rates under no tillage. Leaf N was also signficantly greater with moldboard plow tillage. Final population was not affected by tillage. Corn silking was delayed 2 to 3 days with no tillage.

Silage and grain yields and grain N removal were significantly higher (P = 95% level) with moldboard plow tillage compared to no tillage (Table 1). This is in contrast to 1982 and 1983 when differences between the two systems were not found. Although silage N uptake and grain N tended to be higher with moldboard plow tillage, these differences were not statistically significant.

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 1984.

Tillage system	Early plant growth	Final population	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	g/plant	x10^3	%	T DM/A	lb N/A	bu/A	%	lb N/A
Mb. Plow	11.0	24.6	2.73	6.22	128.8	118.3	1.57	87.7
No Tillage	7.3	25.3	2.30	5.65	120.5	106.1	1.49	74.9
Signif. Level(%):[1/]	99	77	98	99	84	99	79	98
CV (%)	: 7.6	2.7	5.5	1.8	5.1	7.2	4.6	5.0

[1/] Probability level of significance.

Precipitation for the February-June period was 4" above normal. Most of the tile flow shown in Table 2 occurred during that period. Total tile flow, flow-weighted NO_3-N concentration, and NO_3-N lost thru the tile lines were not different between the two tillage treatments. Average NO_3-N concentrations rose from about 8 mg/L in 1983 to slightly above 11 mg/L in 1984.

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss at Waseca in 1984.

Tillage system	Tile flow	Nitrate-N Concentration[1/]	Nitrate-N Loss
	acre-inches	mg/L	
Mb. Plow	13.89	11.2	35.1
No Tillage	12.75	11.4	32.9

[1/] Flow-weighted

Soil moisture measurements were taken from the 0-5' profile in each plot via neutron attenuation at weekly intervals. Differences in available water between the two tillage systems were minimal throughout 1984 (Table 3). However, there appeared to be a slight but consistent advantage for the no-tillage system during the dry July-September period. In addition, the only tile lines which flowed in November were from the no-tillage system.

Table 3. Influence of tillage system on available moisture in the 0-5' soil profile for corn at Waseca in 1984.

Tillage	Date 5/31	6/7	6/14	6/21	6/28	7/6	7/12	7/19	7/26
	inches available moisture[1/]								
Moldboard plow	7.16	9.16	9.21	8.68	8.92	6.73	7.08	7.47	6.23
No tillage	7.48	9.07	9.03	8.67	8.70	6.86	7.10	7.61	6.83

	8/2	8/9	8/16	8/23	8/30	9/7	9/21
	inches available moisture						
	5.43	5.02	3.88	3.92	3.85	4.17	4.71
	5.50	5.53	4.00	4.00	3.86	4.25	5.01

[1/] Determined through the use of a neutron probe.

Residual NO_3-N in the 0-8' profile after harvest was substantially higher than in 1983 when approximately 80 lb/A remained in the 0-6' layer (Table 4). Differences between the tillage systems existed with an additional 90 lb/A found in the profile under moldboard plowing. Although it was not surprising to find greater quantities of NO_3-N with the plow system, it was suprising to see the relatively high concentrations of NO_3-N (about 10 ppm) in the 6-8' zone of both tillage systems.

Table 4. Influence of tillage systems on residual NO_3-N in the soil profile in October, 1984.

Profile depth	Tillage System	
	Mb. Plow	No Tillage
feet	------ NO_3-N (lb/A) -------	
0-1	42.8	32.6
1-2	52.7	33.1
2-3	82.5	52.1
3-4	56.3	46.2
4-5	45.7	37.7
5-6	39.0	32.2
6-7	42.6	39.1
7-8	41.2	40.2
Total (lb NO_3-N/A 0-8')	403	313

THREE YEAR SUMMARY

The cumulative totals for the 3-year period (1982-1984) are shown in Table 5. Corn yields over this period have averaged 6 bu/A better with moldboard plow tillage, although the difference between the two systems has widened each year. Approximately 8% 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 (45% vs 41% for plow vs no tillage, respectively). Total tile flow was almost identical between the two systems. Even though about 9% 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 3-year period.

Table 5. Cumulative effects of the two tillage systems over the 3-year period.

Parameter	Tillage System	
	Mb plow	No tillage
Fert. N applied (lb/A)	540	540
Corn grain removed (bu/A)	370	352
N removed in grain (lb/A)	242	223
Percent of applied N removed in grain (%)	45	41
Tile flow (acre inches)	35.5	36.9
Nitrate-N lost in tile (lb/A)	73.0	79.6

SOIL TEST COMPARISON STUDY

Waseca, 1984

G. W. Randall, D. T. Walters, 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. Both sites have been cropped to continuous corn. 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. 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 allows us to follow the buildup or decline of nutrients in the soil as affected by the recommendations of a particular laboratory over a continuous, long period of time.

Soybeans were initiated into this study in 1982 after nine years 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 1983 samples were applied November 1 to the appropriate plots and plowed down. The fertilizer recommendations were based on a yield goal of 55 bu/A of soybeans. Soybeans (Hardin) were planted at the rate of 4.5 beans/foot in 15" rows on May 15. Chemical weed control consisted of 4 qt. Lasso and 6 qt. Amiben/A applied preemergence to all plots.

On July 9 (R1 stage) leaf samples were taken from each plot by sampling fifteen random, most recently mature trifoliate leaves. Seed yield was determined on soybeans harvested from the center eight rows of each plot with a modified JD 3300 plot combine. Seed yields were converted to 13.5% moisture.

In August, 1984, 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 1985 growing season.

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, sulfur, and lime were recommended by the private labs. Two of the four labs recommended nitrogen for soybeans.

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

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1984.

Test	Soil Test Results[1/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.0	6.0	6.0	6.5	5.8
pH (buffer)	6.7	6.8	6.6	6.9	6.3
Phosphorus	35 VH	23 L	22 VH	39 H	17 H
Potassium	194 H	154 L	120 MH	157 H	138 H
Organic matter (%)	4.3 H	2.8 A	3.8 M	3.5	M
Calcium	2050 M	1975 E	3500	4560 H	---
Magnesium	496 VH	375 E	500	686 M	---
Sulfur	5 L	6 L	7 M	14 H	7 MH
Iron	89 VH	73 E	12 S	5.6 VH	---
Manganese	30 VH	21 E	10 S	2.1 VH	---
Zinc	3.3 H	1.5 E	1.8 VH	2.2 H	1.3 H
Copper	1.2 M	.7 A	.6 S	---	---
Boron	1.1 M	.8 E	1.0 S	0.0 VL	---
ENR (lb/A)	92	---	---	80	---
C.E.C. (meq/100g)	17.5	16.4	22.3	30.3	---

1/ All soil test results are stated in ppm unless noted otherwise.

Nutrient	Recommended Fertilizer Program[2/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	25	30	0	0	0
Phosphorus (P_2O_5)	30	50	0	35	30
Potassium (K_2O)	80	147[3/]	50	78	40
Sulfur	15	10	20[4/]	--	--
Iron	--	--	--	.2[5/]	--
Manganese	--	--	--	.5[5/]	--
Zinc	--	--	--	.3[5/]	--
Lime (T/A)	1.5	.5	1.2	--	--

2/ All values indicate pounds of nutrients recommended per acre for a yield goal of 55 bushels of soybeans per acre.

3/ Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

4/ Sulfur to be applied on a trial basis only.

5/ As 6.7 qt/A of a material weighing 10 lb/gal and containing 2% Zn, 1% Fe and 3% Mn.

Seed yields were not affected significantly by the fertilizer treatments (Table 2). The maximum difference between treatments including the check amounted to only 1.5 bu/A.

Leaf P, Ca, Fe and B concentrations among the five laboratories were not significantly different ($P = .05$ level) (Table 3). Higher K recommendations by Labs A and B resulted in higher leaf K and lower leaf Mg than the other treatments. The Fe + Mn + Zn recommended by Lab D resulted in higher leaf Mn than other labs but Fe and Zn were unaffected. Leaf Cu was reduced by the fertilizer applications. Leaf nutrient concentrations except Cu appeared to be adequate for optimum plant growth.

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 sometimes similar the corresponding interpretations (whether the soil tests high, low, medium,

Table 2. Effect of fertilizer recommendations on soybean seed yield on the very high testing site at Waseca in 1984.

Lab	Fertilizer Recommendations lb/A[1/]	Grain Yield bu/A
A	25N + 30P + 80K + 15S	47.7
B	30N + 50P + 147K + 10S	48.5
C	50K	48.4
D	35P + 78K + .2 Fe + .5 Mn + .3 Zn	47.0
E (UM)	30P + 40K	47.4
Check		47.3
	Signif. Level (%):[2/]	16
	CV (%) :	4.8

1/ P and K expressed on oxide basis.

2/ Probability level of significance.

Table 3. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the very high testing site at Waseca in 1984.

Lab	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
A	.44	2.44	1.16	.44	141	56	46	8.3	50.0
B	.45	2.41	1.12	.43	134	55	45	7.3	48.1
C	.45	2.31	1.19	.47	136	55	46	8.2	50.2
D	.45	2.32	1.16	.45	134	60	43	7.5	49.1
E (UM)	.47	2.32	1.12	.47	131	54	42	8.2	48.1
Check	.46	2.28	1.16	.48	135	50	43	9.4	50.8
Signif. Level (%):	73	98	73	99	42	99	99	99	91
BLSD (.05) :		.11		.02		3	2	.5	
CV (%) :	5.6	3.5	5.1	3.8	6.8	4.8	4.3	5.3	3.8

deficient, etc.) varied substantially. As a result P and K recommendations among the laboratories were markedly different. Various micronutrients and sulfur were recommended by the four private labs. Nitrogen was recommended by two of the four private labs.

At this medium-high testing site the treatments that received fertilizer generally yielded significantly more than the check (Table 5). There were no significant yield differences among the fertilizer treatments (recommendations).

There was no significant difference among the five laboratories for leaf nutrients P, Ca and Fe (P = .05 level) (Table 6). As fertilizer K rates increased, leaf K increased and leaf Mg decreased. All K recommendations resulted in higher leaf K levels than the check. Leaf Cu was reduced by the fertilizer applications. The Fe + Mn + Zn recommended by lab D did not result in higher leaf concentrations of these micronutrients. Leaf nutrient concentrations appeared to be adequate for optimum growth except for Cu.

SUMMARY - 1984

There were substantial differences among the laboratories' fertilizer recommendations for soybeans at both sites. Two of the five laboratories recommended N. Phosphorus and K recommendations among the labs differed by over three-fold. One private lab recommended micronutrients while three recommended sulfur. With the exception of K and Mn at the very high testing site, the fertilizer rates recommended and applied did not influence the leaf nutrient concentrations. Soybean yields were not influenced significantly by the large differences in fertilizer amounts nor was there a significant difference between fertilizer treatments and the check for the very high testing site.

Table 4. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1984.

Test	Soil Test Results 1/ Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.9	7.0	6.6	6.3	6.5
pH (buffer)	---	---	7.0	6.7	---
Phosphorus	19 M	13 L	13 M	25 M	18 H
Potassium	215 H	165 L	125 H	183 H	138 H
Organic matter (%)	5.9 H	3.5 A	5.1 H	4.2	M
Calcium	3610 H	4026 E	6000	7125 VH	---
Magnesium	554 VH	554 E	700	797 M	---
Sulfur	5 L	4 L	5 L	14.0 H	5 LM
Iron	48 VH	26 E	12 S	5.6 VH	---
Manganese	22 H	14 E	10 S	2.1 VH	---
Zinc	2.1 M	1.4 E	2.1 VH	2.9 H	1.4 H
Copper	1.2 M	.9 M	1.1 S	---	---
Boron	1.3 H	1.3 E	1.1 S	0.0 VL	---
ENR (lb/A)	107	---	---	110	---
C.E.C. (meq/100g)	23.2	25.2	36.1	47.0	---

1/ All soil test results are stated in ppm unless noted otherwise.

Nutrient	Recommended Fertilizer Program 2/ Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	20	25 3/	0	0	0
Phosphorus (P_2O_5)	60	100 3/	38	50	30
Potassium (K_2O)	55	178 3/	48	80	40
Sulfur	15	15	20 4/	--	--
Iron	--	---	--	.2 5/	--
Manganese	--	---	--	.5 5/	--
Zinc	--	---	--	.3 5/	--

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 55 bushels of soybeans per acre.

3/ Value includes maintenance recommendation plus 50% of the buildup recommendation which was to be applied over a two-year period.

4/ Sulfur to be applied on a trial basis only.

5/ As 6.7 qt/A of a material weighing 10 lb/gal. and containing 2% Zn, 1% Fe and 3% Mn.

Table 5. Effect of fertilizer recommendations on soybean seed yield on the medium-high testing site in 1984.

Lab	Fertilizer Recommendations lb/A 1/	Seed Yield bu/A
A	20 N + 60 P + 55 K + 15 S	49.9
B	25 N + 100 P + 178 K + 15 S	50.5
C	38 P + 48 K	49.9
D	50 P + 80 K + .2 Fe + .5 Mn + 3 Zn	50.4
E (UM)	30 P + 40 K	51.3
Check		46.1
	Signif. Level (%):	95
	BLSD (.05) :	3.9
	CV (%) :	5.6

1/ P and K expressed on oxide basis.

Table 6. Effect of fertilizer recommendations on soybean leaf nutrient concentrations on the medium-high testing site at Waseca in 1984.

Lab	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
A	.43	2.35	1.28	.45	124	65	41	6.8	52.0
B	.43	2.33	1.27	.44	127	67	37	7.1	50.3
C	.43	2.20	1.30	.48	127	63	39	7.5	53.8
D	.43	2.27	1.25	.45	122	68	39	6.9	53.2
E (UM)	.43	2.14	1.27	.48	126	62	37	7.5	54.1
Check	.42	1.83	1.32	.56	129	60	45	10.3	58.6
Signif. Level (%):	20	99	92	99	45	99	99	99	99
BLSD (.05) :		.09		.19		4	2	.9	1.7
CV (%) :	3.7	3.7	3.2	3.7	5.6	5.3	5.4	5.8	2.9

Table 7. Effect of fertilizer recommendations on yield, value, fertilizer cost and the resulting economic return on both the very high testing site and medium-high testing site at Waseca in 1984.

Lab	Very High Testing Site Yield	Value @6.00/bu	Fert. Cost[1/]	Return[2/]	Medium-High Testing Site Yield	Value @6.00/bu	Fert. Cost[1/]	Return[2/]
	bu/A	$/A			bu/A	$/A		
A	47.7	286	26	-24	49.9	299	29	- 7
B	48.5	291	38	-31	50.5	303	54	-28
C	48.4	290	6	0	49.9	299	15	7
D	47.0	282	25	-27	50.4	302	29	- 4
E (UM)	47.4	284	12	-12	51.3	308	12	19
Check	47.3	284	--	---	46.1	277	--	---

1/ Using April, 1984 prices for each nutrient expressed as dollars/lb as follows: N, .26; P_2O_5, 25; K_2O, .11; S, .20; Zn, .95.

2/ Return yield value @6.00/bu - fertilizer cost - value of check trt.

Table 8. Effect of fertilizer recommendations on total yield, total fertilizer cost and the resulting economics on both the very high and medium-high testing site at Waseca from 1980-1984.

Lab	Very High Testing Site 5-Year Total Crop Value[1/]	Fert. Cost	Return[2/]	Medium-High Testing Site 5-Year Total Crop Value[1/]	Fert. Cost	Return[2/]
	$/A			$/A		
A	1599	265	-100	1803	303	+ 94
B	1628	283	- 89	1792	353	+ 33
C	1665	189	+ 42	1803	223	+174
D	1658	311	- 87	1795	333	+ 56
E (UM)	1626	152	+ 40	1814	197	+211
Check	1434	0	----	1406	0	----

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

2/ Return over 5-year period = crop value - fertilizer cost - value of check treatment.

Economic returns from the fertilizer recommendations for soybeans in 1984 are given in Table 7. On the very high testing site fertilizer costs ranged from $6 with Lab C to $38/A with Lab B. Positive economic return to fertilizer programs was not obtained with any of the five labs. On the medium-high site fertilizer costs ranged from $12 (Lab E) to $54/A (Lab B). Positive economic return to the laboratories' fertilizer recommendations was only obtained with two labs (C and E). Net returns ranged from $19 to -$28/A.

Conclusions from the 1984 study can be summarized as follows:

1. Application of high rates of P and K to soils already testing high to very high is not practical.

2. No direct benefit on soybean yield response was obtained with the addition of N, S or the micronutrients even though they were recommended by some of the laboratories.

FIVE-YEAR SUMMARY

Economic returns from the very high testing site showed little benefit to fertilization (Table 8). Net return from 1980-1984 period ranged from $40/A to $42/A with Labs C and E which had the lowest fertilizer costs, to -$100/A with Lab A. Recommendations from Lab D resulted in the highest fertilizer cost. Part of the low overall return on this site was due to fertilizer recommendations for a yield goal of 180 bu/A in 1980 while the yields obtained barely exceeded 100 bu/A due to drought-stress conditions.

On the medium-high site yield responses paid for the fertilizer recommendations by all five laboratories (Table 8). However, net return ranged from $33/A with Lab B, whose recommendation resulted in the highest fertilizer cost, to $211 with Lab E which recommended the least amount of fertilizer.

NITROGEN AND SULFUR APPLICATIONS TO CORN IN SOUTHERN MINNESOTA

1984

G. W. Randall, D. T. Walters, and P. L. Kelly

Corn yield response to varying N rates and application times in Southern Minnesota have been documented frequently. However, response by corn to sulfur (S) on these soils has not been frequently and consistently reported. Recently, ammonium sulfate as a source of both N and S has become more common as a fertilizer material in the northern Corn Belt. The purpose of this study was to evaluate preplant vs split applications of ammonium sulfate compared to preplant application of urea on corn production on two soils of Southern Minnesota.

EXPERIMENTAL PROCEDURES

Two sites which had been planted to corn in 1983 were selected for this study. One location was on a Seaton silt loam (Alfisol) on the Charles McNamara 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 soil 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 County site consisted of fall chisel plowing and then spring disking and field cultivating prior to planting. The site in Waseca County was fall moldboard plowed and spring field cultivated. Soil tests for the Goodhue and Waseca sites follow: pH = 7.3 and 6.5; Bray extractable P_1 = 101 and 46 lb/A (both Very High); exchangeable K = 237 and 465 lb/A (Medium High and Very High); and extractable SO_4-S = 7 and 8 ppm, respectively, for the two locations.

Eight N and S treatments were replicated four times at the Goodhue site and 6 times at the Waseca site in a randomized, complete-block design. Each plot measured 15' wide (6-30" rows) x 30' long in Goodhue County and 10' wide (4-30" rows) x 55' long in Waseca County.

Corn was planted with a John Deere Max-Emerge planter at a population of 27700 plants/acre at both sites. Pioneer 3901 was planted on May 16 in Goodhue County while Pioneer 3906 was planted on May 9 in Waseca County. Weeds were chemically controlled with Lasso + atrazine at Waseca and Lasso + Bladex at Goodhue. Counter was applied with the planter to control rootworms at both locations.

The preplant applications of both N sources were applied and incorporated by secondary tillage on May 10 and April 25 at the Goodhue and Waseca sites, respectively. The split application treatments were applied ½ preplant and ½ sidedressed at the 8-leaf stage on June 29 and June 19 at the Goodhue and Waseca locations, repsectively. Application rates of N and S for the Goodhue and Waseca locations are shown in Tables 1 and 4, respectively.

Ten randomly selected leaves opposite and below the ear were taken at silking for total 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 fodder and grain analyses were conducted on samples gathered at harvest. Chemical analyses were performed by the Research Analytical Laboratory, University of Minnesota.

RESULTS AND DISCUSSION

Goodhue County: Leaf N was increased significantly (P = 94% level) over the check by the urea and AS treatments (Table 1). Differences among the urea with and without S treatments and AS were not statistically significant for any of these parameters.

When examining the effect of N rate averaged over N source and time of application, leaf N and fodder yield were greater with the higher N rate (Table 1). Fodder N, silage yield, total N uptake and final population were not influenced by N rate. The N source-method of application, when averaged over N rates, had no effect on any of the above parameters. Moreover, there was no interaction between N rate and N source-time of application.

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

Grain N concentration was significantly improved by the urea and AS treatments over the check (Table 2). Grain yield, N removed by the grain and ear moisture at harvest were not affected by the N and S treatments. Factorial examination of the main effects showed no effect of either N rate or N source-time of application on any of the grain yield parameters. In addition, no interaction between N rate and N source-application time was noted.

Leaf, grain, and fodder samples from the three high N rate treatments were additionally analyzed for total S. Results shown in Table 3 indicate no significant (90% level) effect of S applied to this low OM soil on leaf, grain and fodder S concentrations, total S uptake in the silage, and grain S removal (product of grain yield times grain S concentration). In contrast to 1983, N:S ratios were not reduced by the AS treatments. N:S ratios were 13.0, 10.1 and 14.8 with urea and 12.7, 10.1 and 15.3 with the PP application of AS for leaf, fodder and grain, respectively.

In summary, this experimental site did not provide much valuable data to evaluate the treatments. Only leaf N and grain N were improved by the N treatments. The highest N rate (134 lb/A) resulted in higher leaf N compared to the 67 lb/A rate but did not influence any of the other parameters. Even though yields were high, they were not increased over the check by any of the N and S treatments. Apparently, the residual NO_3-N (124 lb/A in the 0-5' profile) plus mineralizable N was sufficient to sustain the crop. In addition, SO_4-S (7 ppm), although not high for this low OM soil, plus mineralizable organic S must have been sufficient for optimum corn production.

Table 1. Influence of rate, source and time of application of N and S on leaf N, fodder N, fodder yield, silage yield, total N uptake and final population at GOODHUE in 1984.

N Rate	N Source[1/]	S Rate	S Source	Applcn method[2/]	Leaf N	Fodder N	Fodder yield	Silage yield	Total N uptake	Final population
lb/A		lb/A			%	%	---T DM/A ----		lb N/A	ppA x 10^3
Check					2.69	.62	3.20	7.52	139	24.5
67	Urea	-	-	PP	2.94	.67	3.13	7.68	154	24.4
67	Urea	79	Gypsum	PP	2.87	.67	3.05	7.56	153	24.1
67	AS	79	AS	PP	2.91	.67	2.81	7.28	150	24.8
67	AS	79	AS	Split	2.92	.73	3.08	7.67	159	24.2
134	Urea	-	-	PP	2.92	.73	3.38	7.85	160	23.8
134	AS	158	AS	PP	3.02	.66	3.01	7.35	151	23.2
134	AS	158	AS	Split	3.07	.72	3.29	7.62	158	23.1
Significance Level (%):[3/]					94	44	66	18	63	14
BLSD(.10) :					.26					
CV(%) :					5.1	12.	10.	6.8	7.9	7.7
Individual Factors										
N rate (lb/A)										
67					2.90	.69	2.98	7.50	154	24.4
134					3.00	.70	3.23	7.60	156	23.4
Significance Level (%):[3/]					97	49	92	36	45	84
N source-time of application										
Urea - PP					2.89	.70	3.21	7.70	157	23.9
AS - PP					2.96	.66	2.91	7.32	151	24.0
AS - Split					2.99	.73	3.18	7.65	158	23.7
Significance Level (%):[3/]					82	82	84	70	80	9
Interactions										
N rate x N source-time										
Significance Level (%):[3/]					35	58	9	19	33	27

1/ AS = ammonium sulfate
2/ PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
3/ Probability level of significant difference among treatment means

Table 2. Influence of rate, source and time of application of N and S on ear moisture, grain yield, N and N removal at GOODHUE in 1984.

N Rate	N Source[1]	S Rate	S Source	Applcn method[2]	Ear moisture	Grain Yield	Grain N	Grain N removal
lb/A		lb/A			%	bu/A	%	lb/A
Check					41.2	158.0	1.32	99
67	Urea	-	-	PP	40.9	167.3	1.42	112
67	Urea	79	Gypsum	PP	41.1	165.7	1.44	113
67	AS	79	AS	PP	41.4	164.5	1.45	113
67	AS	79	AS	Split	40.9	166.6	1.45	114
134	Urea	-	-	PP	40.5	163.3	1.42	110
134	AS	158	AS	PP	41.2	157.4	1.50	112
134	AS	158	AS	Split	41.4	158.3	1.48	110
	Significance Level (%):[3]				44	11	97	56
	BLSD (.05)		:				.10	
	CV (%)		:		1.6	8.0	4.4	8.5
Individual factors								
N rate (lb/A)								
67					41.2	165.6	1.45	113
134					41.0	159.7	1.47	111
	Significance Level (%):[3]				35	75	57	58
N source - time of application								
Urea - PP					40.8	164.5	1.43	111
AS - PP					41.3	161.0	1.48	112
AS - Split					41.2	162.5	1.47	112
	Significance Level (%):[3]				72	15	72	15
Interactions								
N rate x N source-time								
	Significance Level (%):[3]				72	13	46	6

Table 3. Influence of N source and time of ammonium sulfate application on leaf S, grain S, fodder S, total S uptake and grain S removal at GOODHUE in 1984.

N Source[1]	Application method[2]	Leaf S	Grain S	Fodder S	Total S uptake	Grain S removal
		%	%	%	lb/A	lb/A
Urea	PP	.225	.096	.072	12.3	7.4
AS	PP	.237	.098	.065	11.2	7.3
AS	Split	.232	.098	.070	11.8	7.3
Signif. Level(%):		77	29	39	71	22
CV (%)	:	3.7	3.2	16.	8.1	4.6

1/ AS = ammonium sulfate; Both N sources applied at rate of 134 lb/A
2/ PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
3/ Probability level of significant difference among the treatment means

Waseca County: Similar to 1983, results from the study in Waseca County were considerably different than from Goodhue County. This was primarily due to the dry conditions which began in mid-July and continued through early September. Rainfall totaled only 1.90" over the 8-week period from July 18 through September 11, with a highest 1-day occurrence of 0.48 inches.

Leaf N concentration, fodder and silage yield, and total N uptake in the silage were increased over the check by all of the urea and AS treatments (Table 4). Fodder N was increased over the check by only the 178-lb N/A treatments. At the low rate of N, leaf N and fodder yield were both increased by

Table 4. Influence of rate, source and time of application of N and S on leaf N, fodder N, fodder yield, silage yield, total N uptake and final population at WASECA in 1984.

N Rate	N Source[1/]	S Rate	S Source	Applcn method[2/]	Leaf N	Fodder N	Fodder yield	Silage yield	Total N uptake	Final population
lb/A		lb/A			%	%	--- T DM/A --		lb/A	ppA x 10^3
Check					1.37	.33	1.42	3.18	41.9	23.5
89	Urea	-	-	PP	2.23	.32	2.31	5.48	83.7	25.1
89	Urea	105	Gypsum	PP	2.53	.34	2.59	5.90	89.6	26.1
89	AS	105	AS	PP	2.44	.33	2.54	5.95	87.1	25.6
89	AS	105	AS	Split	2.43	.33	2.36	5.77	81.7	24.8
178	Urea	-	-	PP	2.76	.48	2.88	6.88	128.6	25.1
178	AS	210	AS	PP	2.91	.49	2.92	6.73	127.1	26.2
178	AS	210	AS	Split	2.80	.48	2.46	6.09	119.9	25.2
	Significance Level (%):				99	99	99	99	99	97
	BLSD (.05)		:		.18	.05	.25	.52	8.0	1.8
	CV (%)		:		7.2	12.	9.6	8.6	8.0	5.1
Individual Factors										
N Rate (lb/A)										
89					2.47	.34	2.50	5.87	86.1	25.5
178					2.82	.49	2.75	6.56	125.2	25.5
	Significance Level (%):				99	99	99	99	99	01
N source-time of application										
Urea - PP					2.65	.41	2.74	6.39	109.1	25.6
AS - PP					2.68	.41	2.73	6.34	107.1	25.9
AS - Split					2.62	.41	2.41	5.93	100.8	25.0
	Significance Level (%):				31	02	99	92	97	73
	BLSD (.05)		:				.22		6.3	
Interactions										
N rate x N source-time										
	Significance Level (%):				80	10	56	69	04	70

1/ AS = ammonium sulfate

2/ PP = preplant, Split = ½ at PP and ½ at 8-leaf stage

3/ Probability level of significant difference among treatment means

the urea + gypsum and AS treatments over the urea alone treatment. Silage yield was increased 0.42 to 0.47 T DM/A by the S treatments, but this difference was only significant at the 90% level (BLSD = 0.45). These effects were not found at the high rate of N. No explanation can be given for the slightly lower final population in the check treatment.

Examination of the main effect of N rate averaged over N source-time of application indicates that leaf and fodder N, fodder and silage yield, and total N uptake were increased significantly (99% level) by the high N rate (Table 4). The N source-time of application had an effect on fodder and silage yield, and total N uptake when averaged over N rates. Results from the PP application of urea and AS were almost identical. However, splitting the AS application into ½ at the 8-leaf stage produced significantly lower fodder and silage yield and total N uptake. Apparently the sidedress portion of the split application remained near the soil surface and was never moved down into the root system where it could have been utilized by the plants. A significant interaction between N rate and N source-time of application was not found for these parameters.

Grain yield, grain N and grain N removal were increased substantially and grain moisture reduced significantly by all of the urea and AS treatments compared to the check (Table 5). The urea + gypsum treatment and the PP appliled AS treatments did not improve yield, N concentration, moisture content and N removal of the grain over the standard urea treatments.

Factorial examination of the main effects showed a highly significant improvement in all of the grain parameters with the high N rate when averaged over N source-time of application (Table 5). Differences among the N source-time application treatments were only significant (P = 95% level) for grain N removal when averaged over N rates. Corn grain yield, moisture content, N concentration and N removal were almost identical with the PP urea and AS treatments. However, the split application of AS gave significantly lower grain N removal than the PP application of AS. Positional unavailability of the sidedress portion applied at the 8-leaf stage was thought to be the primary reason for the somewhat poorer performance of the split AS treatments.

Sulfur analysis conducted on the plant tissue from the 178-lb N treatments showed highly significant increases in leaf, fodder and grain S with both of the AS treatments compared to urea (Table 6). This resulted in significantly higher total S uptake and grain S removal with both AS applications. Ratios of N:S for leaf, fodder, and grain were reduced from 16.0, 11.7 and 15.3 with urea to 12.5, 54.4 and 11.9 with the PP application of AS, respectively. As in 1983, these results were somewhat surprising on this high organic matter soil which had a moderate extractable SO_4-S level (8 ppm).

In summary, grain and silage yields, N concentration in the plant parts, and N and S uptake were improved by the urea and AS treatments. The highest N rate (178 lb N/A) produced the highest yields and N concentrations and was judged to be an optimum N rate under the growing conditions in 1984. The split application of AS consistently did not improve yields and N uptake when compared to the PP aplication in early May. This was primarily due to positional unavailability of the mid-June N application which apparently was not moved down into the zone of root activity during the dry 8-week period in July, August and September. Significant and consistent differences between the urea treatment and the urea + gypsum and AS treatments occurred for leaf N, fodder yield and silage yield when a low rate of N was applied but did not occur for the grain yield parameters. Even though S concentrations in the plant parts were significantly improved, yield response to the added S was not obtained.

CONCLUSION

Under the good growing conditions at the Goodhue County location in 1984, corn yields, plant N and S concentrations, and plant N and S uptake were generally not affected by any of the N and S treatments. This was apparently due to sufficient residual NO_3-N and mineralizable organic N and S which sustained optimum corn growth. At Waseca where dry conditions limited corn yields, highly significant and consistent effects of the N and S treatments were found for 14 of the 15 parameters measured. Yields and plant N concentration and uptake were highest with the 178-lb N rate. Split application of the AS treatments did not improve yields or nutrient uptake; probably due to positional unavailability of the sidedress-applied material. Application of S as AS or with urea increased leaf N, leaf, fodder and grain S, fodder yield, and silage yield but did not improve grain yield when applied at the low rate.

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Table 5. Influence of rate, source and time of application of N and S on grain yield, moisture, N and N removal at WASECA in 1984.

N Rate	N Source[1]	S Rate	S Source	Applcn method[2]	Grain Yield	Grain Moisture	Grain N	Grain N removal
lb/A		lb/A			bu/A	------ %	-----	lb/A
Check					53.3	20.2	1.28	32.5
89	Urea	-	-	PP	103.8	18.8	1.39	68.6
89	Urea	105	Gypsum	PP	106.9	18.6	1.42	71.7
89	AS	105	AS	PP	105.6	18.6	1.41	70.3
89	AS	105	AS	Split	96.9	18.2	1.43	65.8
178	Urea	-	-	PP	122.8	18.1	1.73	100.5
178	AS	210	AS	PP	121.8	18.1	1.71	98.2
178	AS	210	AS	Split	121.7	17.7	1.66	95.7
	Significance Level (%):[3]				99	99	99	99
	BLSD (.05)		:		8.1	.9	.07	6.3
	CV (%)		:		7.4	4.4	4.7	7.9
Individual Factors								
N rate (lb/A)								
89					103.2	18.5	1.42	69.3
178					122.1	18.0	1.70	98.1
	Significance Level (%):[3]				99	97	99	99
N source-time of application								
Urea - PP					114.8	18.3	1.57	86.1
AS - PP					113.7	18.4	1.56	84.2
AS - Split					109.3	18.0	1.55	80.8
	Significance Level (%):[3]				87	72	36	95
	BLSD (.05)		:					4.6
Interactions								
N rate x N source-time								
	Significance Level (%):[3]				78	03	72	11

[1] AS = ammonium sulfate
[2] PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
[3] Probability level of significant difference among treatment means

Table 6. Influence of N source and time of ammonium sulfate application on leaf S, grain S, fodder S, total S uptake and grain S removal at WASECA in 1984.

N source[1]	Application method[2]	Leaf S	Grain S	Fodder S	Total S uptake	Grain S removal
		%	%	%	lb/A	lb/A
Urea	PP	.172	.113	.041	8.9	6.6
AS	PP	.233	.144	.090	13.5	8.3
AS	Split	.246	.142	.091	12.6	8.1
Signif. Level (%):[3]		99	99	99	99	99
BLSD (.05)	:	.032	.008	.009	1.1	.5
CV (%)	:	12.	4.8	10.4	7.9	6.0

[1] AS = ammonium sulfate; Both N sources applied at rate of 178 lb N/A
[2] PP = preplant, Split = ½ at PP and ½ at 8-leaf stage
[3] Probability level of significant difference among treatment means

LONG-TERM CARRYOVER FROM HIGH RATES OF MANURE

Waseca, 1984

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.

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/] 1758 T/A on a wet basis

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.

Table 2. Corn grain yields from 1974-1983 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		

Some of the data shown in Table 3 indicate that the residual effect of the manure may be waning in the 11th year of the study. Leaf and fodder concentrations and total N uptake were significantly lower for both of the manure treatments compared to the annual fertilizer N treatment. However, grain yields from the manure treatments were significantly higher than from the N treatment. Silage yields showed the same trend but were not significantly different.

Reasons for this apparent discrepancy can probably be attributed to the weather conditions in 1984. Conditions thru July were excellent for corn growth. At the end of July corn growing on the N treatment looked much better (larger, more vigorous and darker green) than on the manure treatments. Less than 1.5" of rain fell between the end of July and September 12. This dry period coupled with a few hot days provided a severe stress on the corn. This was especially true on the larger, more vigorous corn with higher ET needs. Consequently, final yields of grain and silage (primarily because of grain) were lower with the fertilizer treatment.

Table 3. Influence of manure and fertilizer application on corn production and N utilization at Waseca in 1984.

Treatment	Final popl'n	Leaf N	Fodder N	Silage Yield	Silage N Uptake	Grain Yield	Grain N	Grain N removal	Ear Moisture
	$ppA \times 10^{-3}$	%	%	T DM/A	lb N/A	bu/A	%	lb N/A	%
Manure-(345 T/A)	25.9	2.70	.55	6.32	114.3	114.6	1.47	79.8	39.6
" -(200 T/A)	29.1	2.25	.48	6.18	106.0	112.8	1.43	76.4	38.1
Fert. N (150 lb/A)	29.1	3.06	.87	5.80	125.0	96.3	1.53	70.3	37.4
Signif. Level (%):	99	99	99	75	99	98	61	79	87
BLSD (.05) :	1.1	.18	.18		10.9	13.3			
CV (%) :	2.4	4.1	16.	6.7	5.4	6.9	6.8	8.8	3.4

Nitrate-N concentrations within the 0-10' soil profile show substantially more NO_3-N in the top 2' with the fertilizer N treatment (Table 4). Much of this could have come from the nitrified anhydrous ammonia that was applied in late April. At depths below 2' very little difference in NO_3-N concentration was found among the manure and fertilizer treatments. Consequently, total nitrate-N accumulation in the top 10' was higher with the fertilizer treatment as shown by 332 and 454 lb NO_3-N in the top 5' and 10', respectively. Accumulation between 5' and 10' ranged from 99 to 122 lb NO_3-N/A and these differences among treatments were considered to be insignificant.

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, 1984.

Profile depth	Treatment		
	345 T/A	200 T/A	150 lb N/A
feet	ppm		
0-1	2.9	8.8	55.1
1-2	4.2	5.6	11.2
2-3	3.8	4.7	5.4
3-4	3.9	5.4	5.5
4-5	4.4	6.0	6.0
5-6	4.6	5.6	5.7
6-7	5.0	5.4	6.6
7-8	4.8	5.6	7.3
8-9	5.1	4.9	5.6
9-10	5.3	4.6	5.2
lb NO_3-N in top			
0-5' =	77	122	332
5-10' =	99	104	122
0-10' =	176	226	454

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 1974-1983. Nitrogen uptake by the corn and soil NO_3-N levels in 1984 indicated that the carryover effect from the previous manure treatments has begun to wane. Corn yields, however, were significantly higher with the manure treatments. This was due to the adverse effects of the August weather conditions on the annually fertilized corn.

CONSERVATION TILLAGE STUDY

Waseca, 1984

G. W. Randall, D. T. Walters, 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 1984 were built in July, 1983. The fall moldboard and chisel tillage operations were also done in early November, 1983. Secondary tillage conducted on April 24 consisted of field cultivating the moldboard and chisel treatments and the spring disking. Ammonium nitrate was broadcast-applied at a rate of 150 lb N/A immediately before the secondary tillage. Ridges for the 1985 soybeans were built on June 28.

Corn (Pioneer 3732) was planted in 30" rows at a rate of 29,900 plants/A on May 10. All treatments 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. Ten gallons/A of 7-23-5 was used as the starter treatment.

Broadcast P and K were not applied for the 1984 corn crop because of very high soil tests. Soil tests on this site averaged: pH=6.7, Bray 1 extractable P=60 lb/A and exchangeable K=424 lb/A. Chemical weed control consisted of 3½ lb Lasso and 3½ lb Bladex/A applied preemergence. In order to evaluate the effectiveness of the preemergence herbicide application on weed control, a plastic sheet 2' wide and 5' long was placed between the 4th and 5th rows of each tillage plot during herbicide spraying to prevent the application of herbicide onto the soil surface. Weed counts (grass and broadleaf) were taken on June 5 from sprayed and unsprayed areas. All treatments except no tillage were cultivated on June 19. Weed control was excellent on all cultivated plots.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each tillage plot 30 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 33 days after planting. On June 25 soil samples were taken to a 9" depth from the ridge-planted plots which had starter fertilizer for the last ten years. These plots were sampled in 3 positions: directly down the center of the ridge, at 6" to the side of the 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.

Yields were taken by combine harvesting the center two rows from each plot. Grain moisture and N concentrations were determined on each of these samples.

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

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 our of 20 due to chance. A significance level below 50 would indicate less than 50:50 odds of being real.

RESULTS

Since the 2-way and 3-way interactions shown at the bottom of Table 1 are generally non-significant, the comparison of main effects (tillage, starter fertilizer, and previous Poast treatment) is appropriate.

Significant differences in plant height, final population, grain moisture and grain yield were found among the tillage treatments when averaged over starter fertilizer and previous Poast treatments (Table 1). Plant heights taken after silking showed somewhat shorter plants with the ridge-plant (RP) system. This 4 to 6" difference could have been due largely to the presence of the ridge around the base of the plant. Plant height was increased slightly with starter fertilizer but was not affected by the previous Poast treatment.

Final population of the no tillage (NT) plots ranged between 1000 to 1500 plants fewer than with the other treatments. Differences in final stand did not exist among the moldboard plow (MP), chisel plow (CP), RP, and spring disk (SD) treatments. Final population was not affected by starter fertilizer or the previous Poast treatments.

Grain moisture, an indication of maturity, was significantly higher with the NT treatment (Table 1). This was consistent with previous years when continuous corn was grown. Grain moisture for the MP, CP, RP and SD systems was not significantly different. Neither starter fertilizer nor the previous Poast treatments affected grain moisture.

Grain yields were highest with the MP and SD systems, intermediate with the CP and RP systems, and significantly lower with the NT system when averaged over starter fertilizer and previous Poast treatments (Table 1). The 4.4 bu/A response to starter fertilizer averaged across tillage systems was only significant at the 90% level. Even though a statistically significant interaction between tillage system and starter fertilizer did not exist (81% level), it did appear that the largest responses to starter fertilizer were obtained with the NT (11.9 bu/A) and RP (11.0 bu/A) treatments. Yield responses to starter fertilizer were less than 4 bu/A with the MP, CP and SD treatments. The previous Poast treatment did not influence corn yields.

Early plant growth was significantly greater for the MP, CP and SD tillage systems than for the RP and NT systems (Table 2). Plants in the NT system were only 50% as large as with the MP, CP and SD systems. Starter fertilizer also increased early plant weight by 20% when averaged across tillage systems. The interaction between tillage system and starter fertilizer was not significant (38% level). The correlation between EPG and grain yield was not significant when starter fertilizer was used ($r = +.299$) but was significant at the 97% level when no starter was used ($r = +.486$). A linear rather than a curvilinear relationship was best for each.

Grain N (protein) was not influenced by tillage or starter fertlizer (Table 2). However, N removal in the grain (product of grain N concentration and grain yield) was significantly affected by both tillage and starter fertilizer. This effect was due largely to the yield difference among the treatments.

Residue measurements taken prior to planting showed significant differences among the treatments for percent of the soil surface covered with residue from the previous crops (Table 3). The treatments ranked NT > RP = SD > CP > MP. After planting, surface residue measurements were taken both within the row and randomly across the plot area. All tillage treatments showed significantly more residue than the MP treatment. However, only the RP and NT systems exceeded 30% and therefore met the definition of "conservation tillage". Within the row measurements showed slightly less residue than random across the plot measurements for both the RP and NT systems.

Planting depth averaged significantly deeper with the MP and CP systems compared to the NT system. This was consistent with previous years (Table 3). Planting depth was not different between the MP, CP and RP systems which is in contrast to previous years with continuous corn when the RP system usually showed a shallower planting depth. The variability in the seeding depth as measured by standard deviation and range in depths indicates least variability with the CP, MP and SD systems and greatest variability with the RP and NT systems. This is consistent with previous years. Seed placement ranged between 2.2" and 3.0" with the CP system and between 1.8" and 3.2" with the RP

Table 1. Influence of tillage methods, starter fertilizer and previous Poast herbicide treatment on corn production at Waseca in 1984.

Treatment						
Tillage	Starter fert.[1/]	Poast herb.[2/]	Plant height	Final population	Grain Moisture	Grain Yield
			cm	x 10^3	%	bu/A
No tillage	S	P	275	26.3	25.7	136.4
"	S	NP	271	25.7	28.0	138.0
"	NS	P	269	25.6	28.1	127.7
"	NS	NP	265	24.5	28.8	123.0
Fall plow, f. cult.	S	P	274	26.3	24.8	157.9
" "	S	NP	269	26.1	24.5	152.0
" "	NS	P	274	27.0	24.1	157.6
" "	NS	NP	271	26.5	24.0	165.7
Fall chisel, f. cult.	S	P	271	26.3	22.3	146.4
" "	S	NP	271	26.6	22.9	150.9
" "	NS	P	268	27.1	22.2	146.3
" "	NS	NP	272	27.2	22.7	143.1
Ridge plant	S	P	261	27.0	23.0	150.4
"	S	NP	260	26.9	23.1	145.9
"	NS	P	257	26.8	23.1	131.9
"	NS	NP	258	26.7	21.9	142.5
Spring disk	S	P	276	27.1	23.4	158.2
"	S	NP	276	26.1	23.9	154.3
"	NS	P	272	27.7	23.7	152.8
"	NS	NP	271	27.7	22.7	155.5
Individual Factors						
Tillage						
No tillage			270	25.5	27.7	131.3
Fall plow			272	26.5	24.4	158.3
Fall chisel			270	26.8	22.5	146.7
Ridge plant			259	26.8	22.8	142.6
Spring disk			274	27.2	23.4	155.2
Significance Level (%):			99	99	99	99
BLSD (.05) :			6	.8	2.0	10.7
Starter Fertilizer						
Starter			271	26.4	24.2	149.0
No starter			268	26.7	24.1	144.6
Significance Level (%):			99	63	6	90
Poast Herbicide						
Poast			270	26.7	24.0	146.6
No Poast			268	26.4	24.2	147.1
Significance Level (%):			85	85	12	8
Interactions						
Tillage x SF			91	86	83	81
Tillage x Poast			69	18	49	2
SF x Poast			71	2	92	66
Tillage x SF x Poast			32	13	53	66
CV (%)			1.3	4.3	8.3	8.0

1/ S = starter fertilizer used and NS = no starter fertilizer used.
2/ P = Poast herbicide used and NP = no Poast herbicide used in 1983.

Table 2. Influence of tillage methods and starter fertilizer on corn production at Waseca in 1984.

Treatment		Early	Grain		
Tillage	Starter fert.[1/]	plant growth	N	Protein	N Removal
		g/plant	------- % -------		lb/A
No tillage	S	5.4	1.40	8.7	84.4
No tillage	NS	3.8	1.48	9.2	95.5
Fall plow, f. cult.	S	11.0	1.43	8.9	106.4
Fall plow, f. cult.	NS	8.7	1.43	8.9	107.1
Fall chisel, f. cult.	S	10.1	1.46	9.1	100.6
Fall chisel, f. cult.	NS	8.9	1.51	9.4	104.4
Ridge plant	S	8.4	1.44	9.0	89.7
Ridge plant	NS	6.7	1.47	9.2	104.7
Spr. disk	S	9.5	1.50	9.3	107.7
Spr. disk	NS	8.9	1.45	9.1	108.5
Individual Factors					
Tillage					
No tillage		4.6	1.44	9.0	89.9
Fall plow		9.9	1.43	8.9	106.8
Fall chisel		9.5	1.48	9.3	102.5
Ridge plant		7.5	1.46	9.1	97.2
Spr. disk		9.2	1.47	9.2	108.1
Signif. Level (%):		99	42	42	99
BLSD (.05) :		1.2			7.0
Starter fertilizer					
Starter		8.9	1.47	9.2	104.0
No starter		7.4	1.44	9.0	97.8
Signif. Level (%):		99	74	74	98
Till x SF IA					
Signif. Level (%):		38	62	62	69
CV (%) :		14.	4.5	4.5	7.9

1/ S = starter fertilizer used and NS = no starter fertilizer

system. Even though these differences are less than in previous years with continuous corn, they do point out the need for careful adjustment of the planter even when following soybeans.

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 100-feet of row/plot from the 11th to the 25th day after planting. Emergence, as a percent of final stand, shown in Table 4 indicates most rapid emergence with the MP, CP, RP and SD systems. Plants emerged 2 to 3 days later with the NT system.

Leaf samples were taken from the leaf opposite and below the ear at silking. When averaged over starter fertilizer treatments, only leaf Fe was affected (P = ≥ 95% level) by tillage (Table 5). The reason for higher Fe concentrations with the RP system compared to the MP and CP systems is unexplainable and not consistent with previous years. When averaged over tillage systems, the starter fertilizer treatment showed slightly higher leaf K and Mg concentrations and lower Zn, Cu, and Mg concentrations. The highly significant interactions between tillage and starter fertilizer for Mn, Zn, and Cu was generally due to lower concentrations of these nutrients when starter fertilizer was used with moldboard tillage compared to the other tillage systems. Reasons for this phenonenon are not evident at this time. All nutrient concentrations in the leaves were considered to be adequate for optimum yields.

Table 3. Influence of tillage methods for corn following soybeans on surface residue and seeding depth at Waseca in 1984.

Treatment	Surface Residence: Before planting	After Planting: Across plot	After Planting: Within row	Planting Depth: Average	Planting Depth: S	Planting Depth: Range
	%			mm		
No tillage	93	70	61	65	9.0	51-80
Fall plow	2	3	3	74	6.6	60-90
Fall chisel	25	13	17	71	4.8	57-75
Ridge plant	61	41	32	69	8.7	45-82
Spr. disk	60	18	23	66	7.2	52-74
Signif. Level (%):	99	99	99	98		
BLSD (.05) :	12	11	13	6		
CV (%) :	17	18	30	5.0		

Table 4. Influence of tillage methods on the emergence progress of corn following soybeans at Waseca in 1984.

Treatment	Days Post Planting: 11	12	13	14	15	16	17	18	19	20	21	25
	% emerged											
No tillage	1	23	47	67	92	95	97	98	98	98	98	100
Fall plow	45	91	97	98	100							
Fall chisel	44	91	95	97	98	98	99	99	100			
Ridge plant	36	81	91	96	97	98	99	99	99	100		
Spring disk	44	93	96	98	100							

Weed counts (broadleaf and grass) were taken between the 4th and 5th rows from randomly placed 1 ft^2 sections/plot 24 days after preemergence herbicide application. Weed pressure from broadleaf weeds was not great, as counts were low from both herbicide treated and untreated areas (Table 6). Grasses were controlled extremely well in the MP, CP, RP and SD systems. It should be noted that the RP system had the fewest grass weeds when no herbicide was applied and showed no weeds after herbicide application. Grass control was inadequate in the NT system because of at least two reasons. Weed pressure without herbicides was extremely high and probably the greater surface residue accumulation prevented the preemergence herbicides from fully contacting the soil.

Soil samples taken from the RP treatment after planting showed that regardless of the sampling position, pH, P and K levels were fairly uniform when compared within each depth (Table 7.) From this we can conclude that soil samples can be taken randomly from a ridge-planted system that is relatively flat <u>after</u> planting but <u>before</u> ridging.

Table 5. Influence of tillage methods and starter fertilizer on the leaf nutrient concentration in the corn earleaf at Waseca in 1984.

Treatment		Nutrient									
Tillage	Starter fert.	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.72	.29	2.02	.45	.34	115	34	28	9.1	6.4
" "	NS	2.62	.28	1.90	.44	.33	108	30	26	8.5	6.5
Fall plow	S	2.80	.29	2.09	.47	.31	112	46	23	8.5	6.4
" "	NS	2.89	.28	2.10	.47	.33	115	57	31	9.8	6.8
Fall chisel	S	2.83	.29	2.00	.50	.40	112	48	26	8.7	6.2
" "	NS	2.91	.30	1.97	.47	.36	119	44	28	9.3	6.8
Ridge plant	S	2.84	.29	1.90	.49	.43	135	39	25	8.7	6.8
" "	NS	2.74	.30	1.82	.48	.39	126	37	27	8.8	6.8
Spring disk	S	2.92	.28	1.97	.47	.45	123	43	30	9.2	6.8
" "	NS	2.91	.29	1.94	.47	.39	117	45	30	9.5	6.9
Individual Factors											
Tillage											
No tillage		2.67	.29	1.96	.44	.34	111	32	27	8.8	6.5
Fall plow		2.84	.29	2.09	.47	.32	114	52	27	9.1	6.6
Fall chisel		2.87	.29	1.99	.48	.38	116	46	27	9.0	6.5
Ridge plant		2.79	.30	1.89	.49	.41	131	38	26	8.7	6.8
Spring disk		2.91	.29	1.96	.47	.42	120	44	30	9.3	6.9
Signif. Level (%):		89	2	51	47	92	97	93	40	19	24
BLSD (.05) :							13				
Starter fertilizer											
Starter		2.82	.29	2.00	.48	.39	119	42	27	8.8	6.5
No starter		2.81	.29	1.95	.47	.36	117	43	28	9.1	6.8
Signif. Level (%):		13	11	93	71	99	76	38	99	95	97
Interactions											
Tillage x SF											
Signif. Level (%):		31	19	50	13	88	92	99	99	98	62
CV (%) :		6.0	8.1	3.9	6.2	7.6	5.2	9.6	6.1	5.2	5.0

Table 6. Weed populations on June 5th as affected by tillage and herbicide for corn following soybeans as Waseca in 1984.

Treatment	Herbicide[1/]		No Herbicide	
	Grasses	Broadleaves	Grasses	Broadleaves
	plants/10 sq. ft.[2/]			
No tillage	85	1	1107	7
Fall plow	1	2	16	4
Fall chisel	3	1	123	4
Ridge plant	0	0	4	6
Spring disk	1	1	155	1

1/ 3 lb Lasso and 3 lb Bladex/A, preemergence

2/ Average over 4 replications

Table 7. Soil test pH, P and K after corn planting and before ridging after 10 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	6.5	6.4	6.2
2-4	6.7	6.8	6.6
4-6	7.0	7.1	6.8
6-9	7.1	7.1	6.7
	Soil P (ppm)		
0-2	54	49	39
2-4	26	28	25
4-6	12	16	19
6-9	9	10	14
	Soil K (ppm)		
0-2	277	287	286
2-4	183	191	203
4-6	149	163	166
6-9	139	143	157

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

SUMMARY

After 8 years of continuous corn this experiment was changed in 1983 to evaluate five tillage systems in a long-term corn-soybean rotation. Yield results from this study in 1984 differ from previous studies where corn yields were generally not influenced by various tillage systems when following soybeans in a corn-soybean rotation as long as weeds were controlled. Over the 8-year period with continuous corn a substantial amount of corn residue had accumulated on the soil surface with NT. Even with one crop of soybeans in 1983, a large amount of residue still remained (93% surface coverage) at the beginning of the 1984 season. This accumulation of residue resulted in a 2-3 day delay in corn emergence, retarded early plant growth, and higher grass weed populations. These factors more than likely contributed to the 15% yield reduction with no tillage compared to the higher yielding tillage treatments. Starter fertilizer improved the NT and RP yields by about 11 bu/A with less than 4 bu/A responses with the other tillage systems. Yields were not influenced by the previous Poast treatments. Large differences in nutrient concentrations in the earleaf at silking were not found among the tillage treatments or between the starter fertilizer treatments. Soil samples taken in the ridge, 6" to the side of the ridge, or midway between the ridges did not show apparent pH, P or K differences within depths when taken after planting but before ridging.

Weed pressure without herbicides was lowest for the RP system; however, the herbicides provided excellent control with all tillage systems except NT. Only the NT and RP tillage systems had greater than 30% surface residue coverage after planting, and thus met the SCS definition of "conservation tillage".

SOYBEAN ROW WIDTH IN A RIDGE-PLANT TILLAGE SYSTEM

Waseca, 1984

G. W. Randall, D. T. Walters, and P. L. Kelly

One of the tillage systems that is rapidly gaining popularity is the ridge-plant system (sometimes referred to as till planting). With this system no primary tillage is done. Ridges are built sometime during the previous year and the crop is merely planted on the ridge. Since most Corn Belt farmers are growing corn in 30" rows prior to soybeans in the crop sequence, ridges are built in a 30" row-width. Most recent studies, however, have indicated soybean yield responses of 0-20% by using 15" and narrower rows compared to 30" rows. Thus, the objective of this study was to evaluate 30" soybean rows planted on ridges compared to 30" and 10" rows planted on previously ridged areas that had been tilled lightly before planting.

Experimental Procedures

An area of Webster clay loam which was planted to corn in 30" rows and ridged in July, 1983, was the site for the study. A split-plot design consisting of three row width-ridge treatments (30" row on ridges, 30" row with ridge disked, and 10" row with ridge disked) and split into two varieties (Corsoy 79 and Hodgson 78) was used. Each individual plot measured 60' long by 10' wide and was replicated six times. A light 20" diameter blade tandem disk was used to disk the tops off of the ridges immediately prior to planting the flat treatments. A John Deere 7100 Max-Emerge with B & H ridge cleaners was used to plant the 30" ridge treatment and the 30" flat treatment. An Almaco experimental planter was used for the 10" rows. Soybeans were planted on May 16 at a rate of about 160,000 seeds/A. Starter fertilizer was not used because of high soil tests. Weeds were controlled chemically with Lasso + Amiben.

Emergence rates were taken from May 23 thru June 13 by counting plants in either two 30-inch rows or four 10 -inch rows per plot. Surface residue accumulation was measured with the line transect method. Plant height was taken September 21 when greater than 75% of the pods were brown. All yields were determined by combine harvesting the entire plot.

Results and Discussion

Emergence rate of the soybeans was affected by the row width-ridge treatments but was only slightly affected by soybean variety (Table 1). Planting in 30" rows either directly into the ridges or where the ridge tops had been disked resulted in soybean emergence 8 days after planting with 50% of the beans emerged by 10 days. Rate of emergence was slowest with the 10" rows planted on the disked ridges. The first plants emerged 8 days after planting, but emergence continued to lag two days behind the 30" rows with 50% of the plants emerged by 12 days. Emergence was slightly earlier with the Hodgson 78 variety.

The reason for this delayed emergence can be attributed to (1) disking which tends to dry the surface soil especially when little rain occurs during the first 5 days after planting and (2) the Almaco experimental planter did not place the seed as deep in 10" rows as when planted in 30" rows. Consequently, emergence was delayed significantly by the combination of drier surface soil and shallower planting. In all row width-ridge treatments, 95% of the seedlings had emerged 20 days following planting.

Date of canopy closure estimated subjectively showed a large difference between row width but essentially no difference between ridge treatment or soybean varieties. The date of closure was July 1 with the 10" rows while the 30" rows did not close until July 22.

Surface residue measurements taken prior to disking of the ridges indicated that 70% of the soil surface was covered by residue from the previous corn crop. After planting, surface residues covered approximately 16% of the soil surface with the ridges that had been disked lightly compared to 23% with the conventional ridge-plant system (Table 2).

Surface residue measurements taken post-harvest revealed no difference between varieties but slightly more residue with the 10" row width-ridge treatment (Table 2).

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

Table 1. Influence of row width-ridge treatment and soybean variety on rate of emergence.

Treatment		Days after planting																
Row width-ridge	Variety	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	28
		% emerged																
30", ridge	Corsoy 79	0	10	34	45	49	63	83	89	89	89	90	92	94	94	97	98	100
30", ridge	Hodgson 78	0	21	42	58	60	69	85	87	87	89	89	92	92	93	95	97	100
30", flat	Corsoy 79	0	21	46	55	58	65	80	82	85	89	90	91	92	95	97	100	100
30", flat	Hodgson 78	0	25	45	59	60	68	80	84	84	88	89	93	94	95	97	98	100
10", flat	Corsoy 79	0	3	11	32	35	43	66	76	80	85	88	93	95	95	96	99	100
10", flat	Hodgson 78	0	5	16	26	49	59	66	79	80	87	88	93	94	95	95	98	100

Table 2. Influence of row width-ridge treatment and soybean variety on surface residues, plant height and seed yields.

Treatment		Surface residue		Plant height	Seed	Seed
Row width-ridge	Variety	after pltng.	after harvest	at maturity	moisture	Yield
		%	%	in.	%	bu/A
30", ridge	Corsoy 79	26	22	32	8.9	46.0
30", ridge	Hodgson 78	19	22	32	8.3	43.7
30", flat	Corsoy 79	16	23	31	8.7	45.3
30", flat	Hodgson 78	15	22	31	8.3	44.6
10", flat	Corsoy 79	21	24	33	9.0	49.0
10", flat	Hodgson 78	17	23	35	8.3	46.4
Individual Factors						
Row width-ridge						
30", ridge		23	22	32	8.6	44.9
30", flat		16	23	31	8.5	44.9
10", flat		19	24	34	8.6	47.7
Signif. Level (%):[1/]		99	94	99	80	99
BLSD (.05):		5		2		1.1
Variety						
Corsoy 79		21	23	32	8.8	46.7
Hodgson 78		17	23	33	8.3	44.9
Signif. Level (%):[1/]		93	86	35	99	99
Row width-ridge x variety interaction						
Signif. Level (%):[1/]		56	32	17	82	83
CV (%):		28.	6.4	8.5	1.7	2.8

[1/] Probability of a significant difference among the treatment means.

Plant height measured at maturity indicated that the soybeans planted in the 10" row flat treatment were taller than the 30" row flat treatment. Unexpectedly, there was no plant height difference between the two varieties.

As expected, seed moisture differed significantly among the two varieties (Table 2). The earlier maturing Hodgson 78 was .5% drier at harvest than the later maturing Corsoy 79.

Soybean yields were also affected significantly by the treatments (Table 2). Yields from the 10" rows surpassed the 30" rows by about 3 bu/A. No significant difference occurred between the ridge-planted and flat planted treatments in 30" rows. The Corsoy 79 variety outyielded the Hodgson 78 variety by 1.8 bu/A. There was no interaction between variety and row width-ridge treatment.

Summary

Data from the third year of the three-year study indicated that light disking of ridges could be performed easily and satisfactorily to enable narrow row planting of soybeans in a ridge-plant corn-soybean sequence. Surface residue amounts can be maintained at satisfactory levels and yields increased withthe 10" row soybeans planted in this manner. This, of course, necessitates building the ridges for corn (if one desires to do so) after the soybean crop is harvested.

THREE YEAR SUMMARY

Table 3. Influence of row width-ridge treatment and soybean variety on 3-yr average surface residues and seed yields.

Treatment		Surface residue after planting	Seed yield
Row width-ridge	Variety	%	bu/A
30", ridge	Corsoy 79	27	43.7
30", ridge	Hodgson 78	25	45.3
30", flat	Corsoy 79	29	43.2
30", flat	Hodgson 78	32	43.2
10", flat	Corsoy 79	33	50.1
10", flat	Hodgson 78	30	49.1
Individual Factors			
Row width-ridge			
30", ridge		26	44.5
30", flat		30	43.2
10", flat		32	49.6
Variety			
Corsoy 79		30	45.7
Hodgson 78		29	45.9

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EFFECT OF TIME OF RIDGING SOYBEANS ON SOYBEAN PRODUCTION IN A RIDGE-PLANT SYSTEM

Waseca. 1984

G. W. Randall, D. T. Walters and P. L. Kelly

The ridges in a ridge-plant system are usually considered one of the keys in making the system work. This is especially important in wet, poorly-drained soils planted to corn which is sensitive to cold soil temperatures. The ridge warms up and dries more quickly, thus allowing earlier planting.

Construction of the ridges in soybeans for corn the next year poses some potential problems. If the ridging is done during the growing season, are the soybeans damaged to the point of yield reduction? Is pod height lowered so as to increase harvest losses? On the other hand, if narrow-row soybeans are planted, is it possible to build the ridges post-harvest? What are the effects of this late ridging treatment on surface residue cover?

The purpose of this study was to evaluate three times of building ridges in soybeans on soybean production.

EXPERIMENTAL PROCEDURES

The experimental site (Webster clay loam) was planted to corn in 30" rows and ridged in 1983. Two varieties of soybeans (Corsoy 79 and Hodgson 78) were planted with a John Deere 7100 Max-Emerge planter with B & H ridge cleaners in 30" rows on May 16 at a rate of 160,000 seeds/A. No starter fertilizer was used. Weeds were controlled chemically with Lasso and Amiben. The ridging treatments were superimposed over varieties at three stages of soybean growth (early bloom (R1), mid-bloom (R2.5), and post-harvest). A Hiniker cultivator was used to build the ridges. This split-plot design with ridge treatments as the main plot was replicated six times.

Plant height at maturity and the height of the lowest pod above the soil surface were measured from 5 randomly selected plants/plot just prior to harvest. Harvest loss was determined by counting the soybean seeds present in 10 random one-foot square areas/plot. All yields were obtained by harvesting with a modified JD3300 plot combine.

RESULTS AND DISCUSSION

In 1982 and 1983 problems arose in that some plants ridged at the R1 stage were knocked over by the dry, hard soil slabs of ridging. To alleviate this damage, a Hiniker cultivator in the non-ridge mode was used to breakup the soil two weeks prior to the 1984 ridging. The ridging operation at the R1 stage (July 9) did appear to ridge more smoothly than in the two previous years. Yet speed and depth of cultivation had to be carefully watched. At the mid-bloom stage (R2.5) on July 16th, the plants were bigger and did not appear to be quite as sensitive to cultivation speed. Ridge height at the end of the July treatments was estimated to be about 5 to 6" (amplitude). Soil moisture conditions were at field capacity in the 0-6" depth during each of these operations.

Plant height at maturity from the early bloom (R1) ridging treatment averaged 3" higher than the mid-bloom (R2.5) and 2" higher than the post-harvest ridging treatments (Table 1). Corsoy 79 soybeans were 5" taller than the Hodgson 78 variety. A time of ridging by variety interaction was found indicating a positive growth response with Corsoy 79 with the early bloom ridging treatment.

The height of the lowest pod above the soil surface was shortest with the R2.5 stage of ridging (Table 1). There was no significant difference between early bloom (R1) and post-harvest ridging treatments. The pod height of the Group I variety (Hodgson 78) was significantly lower than the Group II variety (Corsoy 79). A time of ridging x variety interaction indicates a greater pod height with Corsoy 79 with the early and mid-bloom ridging treatments compared to the post-harvest treatment when no difference between varieties was noted.

Seed moisture at harvest was influenced by the variety but was not affected by the time of ridging (Table 1).

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

Table 1. Influence of time of ridging on soybean plant height, pod height, seed moisture and seed yield.

Treatment		Plant height at maturity	Height of lowest pod	Seed	
Ridging time [1]	Variety			Moisture	Yield
		inches	cm	%	bu/A
July 9	Corsoy 79	41	13.9	8.7	46.5
"	Hodgson 78	33	9.9	8.2	44.3
July 16	Corsoy 79	36	11.5	8.6	41.7
"	Hodgson 78	32	10.0	8.2	41.7
Post Harvest	Corsoy 79	37	11.5	8.6	45.6
" "	Hodgson 78	33	11.6	8.2	45.3
Individual Factors					
Ridging time					
July 9		37	11.9	8.5	45.4
July 16		34	10.7	8.4	41.7
Post Harvest		35	11.6	8.4	45.5
Signif. Level (%): [2]		99	92	68	99
BLSD (.05):		1			1.2
Variety					
Corsoy 79		38	12.3	8.7	44.6
Hodgson 78		33	10.5	8.2	43.8
Signif. Level (%): [2]		99	99	99	88
Ridge time x variety interaction					
Signif. Level (%): [2]		99	99	10	81
CV (%):		4.8	11.	1.2	3.5

[1] Corresponds to R1 (July 9) and R2.5 (July 16) stages.

[2] Probability of a significant difference among treatment means.

Soybean yields when averaged over the two varieties were significantly reduced about 4 bu/A by ridging at the R2.5 soybean stage (Table 1). It does appear that some of the yield reduction may have been partially the result of higher harvest losses. Harvest difficulty was encountered because of the lower pod height associated with the mid-bloom (R2.5) stage of ridging. Ridge cultivation at this time may have also pruned roots and/or increased soil water loss during the very dry late July and August months. Yield differences between the varieties were not obtained nor was there a significant interaction between time of ridging and variety.

Harvest losses were 0.4 bu/A greater with the mid-bloom (R2.5) stage of ridging than the early bloom (R1) and post-harvest ridging treatments (Table 2). Losses were greater for the Hodgson 78 variety; perhaps due to lower seed moisture and lower pod height.

Ridge heights were measured shortly after the fall post-harvest ridging operation was conducted. At that time the post-harvest ridges were approximately 1" higher than the ridges formed in July (Table 2). The percent surface covered by the residue after harvest was decreased to 42% with post-harvest ridging compared to approximately 77% with the July ridge treatments when measured by the line-intercept method. As expected, no difference in residue was observed between the varieties.

Table 2. Influence of time of ridging and soybean variety on harvest loss, ridge height and surface residue cover.

Treatment		Harvest	Post Harvest		Spring'84
Ridging time [1]	Variety	loss	Ridge ht.	Residue	ridge ht.
		bu/A	cm	%	cm
July 9	Corsoy 79	.5	14.1	76	13.2
"	Hodgson 78	1.2	14.5	77	12.6
July 16	Corsoy 79	1.0	13.2	77	11.9
"	Hodgson 78	1.4	13.7	77	11.8
Post-Harvest	Corsoy 79	.6	17.1	42	14.7
" "	Hodgson 78	1.0	17.1	42	14.0
Individual Factors					
Ridging time					
July 9		.8	14.3	77	12.9
July 16		1.2	13.4	77	11.8
Post-Harvest		.8	17.1	42	14.3
Signif. Level (%): [2]		99	99	99	99
BLSD (.05):		.2	.8	4	.7
Variety					
Corsoy 79		.7	14.8	65	13.3
Hodgson 78		1.2	15.1	65	12.8
Signif. Level (%): [2]		99	59	11	87
Ridge time x variety interaction					
Signif. Level (%): [2]		84	19	01	28
CV (%):		23.	6.9	8.4	6.4

[1] Corresponds to R1 (July 9) and R2.5 (July 16) stages.

[2] Probability of a significant difference among treatment means.

Ridge heights from the 1983 experiment were measured on April 17, 1984 and are shown in Table 2. Ridge heights ranged between 4½ and 5". Significant differences among the time of ridging treatments were apparent with the largest ridges resulting from the post-harvest treatment.

SUMMARY

Results from the third year of this study indicate that soybeans were depressed approximately 4.0 bu/A when ridging was done at the R2.5 stage compared to the R1 and post-harvest stages of ridging. Soil cultivation prior to the early bloom (R1) ridging treatment reduced damage from soil slabs hitting the plants. These data agree fairly well with the 1982 and 1983 data and suggest a consistent yield advantage for post-harvest ridging in the fall for the next year's crop.

THREE-YEAR SUMMARY

Table 3. Influence of time of ridging and soybean variety on the 3-yr average height of lowest pod and seed yield.

Treatment		Height of lowest pod	Seed Yield
Ridging time	Variety	cm	bu/A
R1	Corsoy 79	10.1	47.5
"	Hodgson 78	8.1	43.3
R2.5	Corsoy 79	9.7	44.7
"	Hodgson 78	8.2	42.3
Post Harvest	Corsoy 79	11.1	47.7
" "	Hodgson 78	10.7	45.4
Individual Factors			
Ridging time			
R1		9.1	45.4
R2		9.0	43.5
Post Harvest		10.9	46.6
Variety			
Corsoy 79		10.3	46.6
Hodgson 78		9.0	43.7

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NITROGEN FERTILIZATION FOR PROCESSING SWEET CORN ON A FINE-TEXTURED SOIL: INFLUENCE OF RATES, TIMING AND A NITRITICATION INHIBITOR -- 1984

C. J. Rosen, H. J. Buchite and J. B. Hebel

The majority of the acreage used for processing sweet corn in Minnesota is on nonirrigated fine-textured soils. Because of potential nitrogen losses due to denitrification and/or leaching the practice of sidedressing or use of nitrification inhibitors in a nitrogen management program have become issues of interest for many growers. The objectives of this study were to 1) determine optimum rates and timing of nitrogen fertilizer for sweet corn on fine-textured soils, and 2) evaluate the effectiveness of N-Serve, a nitrification inhibitor, for sweet corn production.

Experimental Procedures:

The experimental site was located at the Southern Experiment Station in Waseca, Minnesota on a Webster clay loam (4.0 % organic matter). Phosphorus and potassium were broadcast according to soil test recommendations the previous fall. Treatments included a control, 4 nitrogen rates (50, 100, 150, 200 lb N/A), 100 lb N/A plus N serve (0.5 lb ai/A), 150 lb N/A plus N-Serve (0.5 lb ai/A), 100 lb N/A split (1/2 preplant, 1/2 6-8 leaf stage), 150 lb N/A split (1/3 preplant, 1/3 6-8 leaf stage, 1/3 12 leaf stage). All preplant nitrogen was with anhydrous ammonia. For the split treatments, ammonium nitrate was used as the nitrogen source. Each treatment was replicated 4 times in a randomized complete block design. Two varieties, Code 5 (early maturing) and Jubilee (midseason maturing), were planted on 11 May 1984 at a population of approximately 22,000/A. Each plot consisted of 6 - 30 ft rows with 2.5 ft between the rows.

Whole plant samples collected at the 6-8 leaf stage (before any sidedress application) and leaf samples from opposite and above the ear collected at mid-silking were dried, ground and analyzed for total nitrogen content. Leaf samples from the 100 and 150 lb N/A treatment with and without inhibitor were analyzed for P, K, Ca, Mg, Fe, Mn, Zn, Cu, and B using an inductively coupled plasma emission spectrometer.

Total yield (ear and husk), husked yield, and stover yield were obtained by harvesting 2 - 15 ft rows within each plot. Subsamples of ears, husk and stover were taken to determine % moisture for nitrogen uptake calculations. The following quality measurements were also made: ear length, % moisture in kernels, and % usable ears (5.5 inches or greater with tip removed).

Code 5 was harvested 6 August 1984 and Jubilee was harvested 10 August 1984. Rainfall data reported from the Southern Experiment Station is as follows: May, 2.22"; June 5.11"; July 3.43"; August (until Jubilee harvest) 1.3". The total rainfall was 12.06".

Results:

Rainfall at Waseca was very localized. During the month of July very little rain fell on the experimental plot. Additionally, root growth was extremely shallow, which may have been due to soil compaction. All plants including those that received 200 lb N/A showed signs of scorching on the older leaves. Scorching was most severe on the low nitrogen plots.

Sweet corn repsonded to nitrogen applications up to 100 lb N/A (Tables 1 and 3). Yields from plants receiving the 150 and 200 lb N/A rates were significantly greater than those in the 0 and 50 lb N/A plots but not the 100 lb N/A plot. Split applications or the addition of N-Serve at either the 100 or 150 lb N/A rates did not offer any advantage in terms of yield increase over the corresponding preplant rates. For Code 5, plants that received the split application at 100 lb N/A yielded significantly less than the corresponding preplant and preplant plus N-Serve treatment. Ear length and % COC eligible were similar for all 100 lb N/A treatments or more regardless of whether applications were preplant, split, or with N-Serve.

Whole plant nitrogen concentrations at the 6-8 leaf stage were generally lowest for plants in the check plots and those receiving 50 lb N/A (Tables 2 and 4). Except for plants in the check plots, nitrogen concentrations in whole plants at the 6-8 leaf stage were poor predictors of leaf nitrogen status at silking. Leaf nitrogen at silking tended to be greater when N-serve was added compared to preplant without N-Serve and split applications. Even at the high N rate treatments, leaf concentrations were relatively low (< 3.0% for Jubilee). It is possible that environmental factors such as low rainfall and/or soil compaction restricted nitrogen availability. These factors make it

difficult to interpret leaf analysis data. Concentrations of nitrogen in ear, husk or stover were generally not sensitive indicators of plant nitrogen status. Total nitrogen uptake generally increased with increasing nitrogen rates. For Jubilee, there were no significant differences in nitrogen uptake for plants receiving preplant, split or N-Serve treatments. For Code 5, nitrogen uptake by plants receiving the sidedress application and preplant plus N-Serve at 100 lb N/A were significantly lower than preplant applications. At 150 lb N/A, N uptake was the same regardless of treatment.

Preplant applications plus N-Serve had no consistent significant effect on leaf elemental concentrations compared to preplant applications without N-serve (Tables 5 and 6).

General Comments:

Maximum yields and quality for processing sweet corn were obtained with a preplant application of 100 lb N/A. N-Serve and sidedress treatments did not significantly increase yields or quality compared to corresponding preplant treatments. These data are based on one year of research. Further experiments are warranted on these fine-textured soils in order to better understand sweet corn response to nitrogen fertilization and management.

Table 1. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on Code 5 sweet corn yield and quality.

Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length inches	% Moisture in Kernels	% COC Eligible
0	2.97	2.20	5.9	69.7	41.2
50	5.40	3.65	7.2	68.7	72.0
100	7.30	4.81	7.9	69.8	85.9
150	6.75	4.54	8.0	69.2	88.1
200	7.28	4.89	7.8	67.6	86.1
100+N-Serve	7.24	4.97	8.2	68.2	92.2
150+N-Serve	5.80	4.01	7.7	68.8	86.4
100 2 splits	4.79	3.48	7.2	69.3	80.1
150 3 splits	6.80	4.70	7.7	70.5	84.0
Significance	**	**	**	NS	**
BLSD (.05)	1.57	1.01	0.4	--	10.8

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

Treatment lb N/A	% N Whole Plant (6-8 Leaf)	% N Leaf Above Ear (Silking)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear lb N/A	N Content Husk lb N/A	N Content Stover lb N/A	Total N Uptake lb N/A
0	3.14	2.06	1.68	0.54	1.04	14.2	1.4	24.5	40.1
50	3.49	2.65	1.65	0.54	1.13	29.3	3.3	45.6	78.2
100	3.78	2.91	1.77	0.73	1.42	41.9	6.6	67.4	115.9
150	3.95	3.01	1.83	0.71	1.53	39.3	5.7	65.2	110.1
200	3.96	3.17	1.79	0.75	1.59	40.6	6.4	71.3	118.3
100+N-Serve	3.75	3.03	1.79	0.69	1.08	41.7	5.4	43.6	90.7
150+N-Serve	3.94	3.12	1.74	0.76	1.44	29.2	4.5	61.7	95.4
100 2 splits	3.47	2.73	1.72	0.72	1.29	26.4	4.0	44.4	74.8
150 3 splits	3.43	3.00	1.79	0.74	1.74	36.3	5.3	66.0	107.7
Significance	**	**	NS	**	**	**	**	**	**
BLSD (.05)	0.21	0.19	—	0.13	0.30	10.3	1.8	14.6	17.1

Table 3. Effect of nitrogren rate, nitrification inhibitor and sidedress applications on Jubilee sweet corn yield and quality.

Treatment lb N/A	Yield (T/A) Green	Yield (T/A) Husked	Ear Length inches	% Moisture in Kernels	% COC Eligible
0	4.17	2.73	6.7	80.1	37.0
50	6.75	4.60	7.4	78.8	76.3
100	8.10	5.13	7.3	78.9	74.3
150	7.79	5.12	7.4	77.9	79.4
200	8.31	5.48	7.3	77.9	78.8
100+N-Serve	7.09	4.73	7.4	77.3	80.6
150+N-Serve	8.16	5.23	7.5	78.8	82.6
100 2 splits	7.56	4.70	7.5	77.4	78.4
150 3 splits	8.07	5.27	7.5	79.1	76.8
Significance	**	**	**	NS	**
BLSD (.05)	1.46	0.86	0.3	--	11.2

Table 4. Effect of nitrogen rate, nitrification inhibitor and sidedress applications on nitrogen concentrations in various plant tissues during the growing season and total nitrogen uptake (Jubilee).

Treatment lb N/A	% N Whole Plant (6-8 Leaf)	% N Leaf Above Ear (Silking)	% N Ear (Harvest)	% N Husk (Harvest)	% N Stover (Harvest)	N Content Ear lb N/A	N Content Husk lb N/A	N Content Stover lb N/A	Total N Uptake lb N/A
0	3.29	2.03	1.96	0.68	1.28	16.6	4.8	31.6	53.0
50	3.77	2.47	1.88	0.62	1.25	32.9	5.3	55.6	93.9
100	3.96	2.78	1.95	0.74	1.09	37.1	8.5	48.5	94.0
150	3.91	2.88	2.10	0.84	1.14	41.3	8.2	61.1	110.6
200	3.87	2.96	2.12	0.88	1.41	42.5	8.6	70.3	121.4
100+N-Serve	3.97	2.81	2.05	0.81	1.10	36.4	7.2	49.1	92.7
150+N-Serve	3.98	2.93	2.16	0.88	1.35	44.1	9.4	74.2	127.8
100 2 splits	3.55	2.64	1.96	0.71	1.13	37.2	8.3	64.2	91.7
150 3 splits	3.45	2.87	2.08	0.81	1.40	42.3	8.5	65.1	115.9
Significance	**	**	NS	NS	NS	**	NS	**	**
BLSD (.05)	0.26	0.19	--	--	--	9.6	--	15.7	17.7

Table 5. Influence of N-Serve and N rate on leaf elemental concentrations at mid-silking: Code 5.

Treatment lb N/A	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
100	2.91	0.32	2.39	0.68	0.28	125	103	24	5	6
150	3.01	0.31	2.39	0.66	0.24	128	110	23	6	6
100+N-Serve	3.03	0.32	2.33	0.66	0.27	132	101	23	5	6
150+N-Serve	3.12	0.31	2.42	0.61	0.24	130	114	24	7	7
N rate effect	NS	NS	NS	NS	*	NS	NS	NS	**	NS
N-Serve effect	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
N rate X N-Serve	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Influence of N-Serve and N rate on leaf elemental concentrations at mid-silking: Jubilee.

Treatment lb N/A	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
100	2.78	0.29	2.47	0.58	0.27	114	117	37	7	10
150	2.88	0.29	2.45	0.59	0.27	116	123	38	7	10
100+N-Serve	2.81	0.30	2.39	0.58	0.28	109	105	35	6	8
150+N-Serve	2.93	0.30	2.42	0.61	0.27	106	123	39	6	9
N rate effect	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
N-Serve effect	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
N rate X N-Serve	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SULFUR, BORON, COPPER AND MAGNESIUM TRIALS ON A PROBLEM ALFALFA FIELD 1982, 1983, 1984

W. E. Fenster, M. O'Leary and G. Buzicky

Yields of irrigated alfalfa on sandy loam soils have been unsatisfactory at some locations in Stearns County. This led to the establishment of a trial with sulfur, boron and magnesium where phosphorus and potassium were maintained at very high levels. These trials were on the Eugene Heinen farm. The 1983 and 1984 plots were in the same place but different from the 1982 location.

Tables 1 through 4 show alfalfa yields, related soil tests and plant analysis resulting from sulfur, boron, copper, and magnesium treatments.

Since copper appeared to be low in the plant analysis in 1982 it was added as a variable along with magnesium, sulfur and boron in 1983 and 1984.

Yields were low in 1982 because no irrigation water was added during first growth. Yields in 1983 and 1984 were reasonably good. No effect on yield due to treatments have been observed any of the three years.

Plant analysis shows highly adequate levels of all nutrients except copper. Copper treatments have failed to bring this element to an adequate level according to plant analyses.

Although very high in boron, added boron is reflected in an even higher level in the plant. Magnesium and copper sometimes show an increase in plant tissue of these elements from treatment. The magnesium soil test is increased by added magnesium, from 210 lb/A to 290 lb/N and copper is increased from 8 ppm to 1.1 ppm from copper treatment.

Table 1 shows treatments, alfalfa yields and check plot soil tests. Tables 2, 3 and 4 show 1982, 1983 and 1984 plant analyses results.

Table 1. Alfalfa yields relationship to sulfur, boron, copper and magnesium treatments. Stearns County 1982, 1983.

	Treatment lbs/A			Alfalfa yields Tons/acre (15% moisture)			Soil Test (Check plot)			
Treatment	1982	1983	1984	1982	1983	1984		1982	1983	1984
Check				3.62	5.35	4.90	Text	SL	SL	SL
S	100	50	50	3.85	5.27	5.16	O.M.	M	M	M
B	3	3	3	3.71	5.11	5.10	pH	7.3	7.2	7.1
Mg	300	300	300	3.94	5.04	5.05	P lb/A	200+	200+	200+
Cu	---	6	6	---	5.47	4.99	K lb/A	443	410	298
Significance				ns	ns	ns	Mg lb/A	204	201	210
C.V.				4.4	4.4	7.2	S ppm	5	2	7
							Cu ppm	---	0.6	8
							B ppm	---	0.5	---
							Zn ppm	---	4.5	5.2

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Table 2. Plant analysis of alfalfa for 3 individual cuttings according to sulfur, boron and magnesium treatments 1982.

		Tissue Analysis									
1st cut		%					ppm				
treatment	lbs/A*	S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.41	.44	3.28	1.67	.25	119	55	30	3	43
S	100	.44	.44	3.40	1.63	.25	110	52	31	3	40
B	3		.43	3.17	1.75	.25	116	55	30	3	43
Mg	300		.43	3.19	1.81	.26	116	57	29	3	36
adequate levels		.30	.25	2.40	1.70	.30	30	30	30	10	30
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		--	2.0	5.5	1.7	9.5	5.3	9.4	3.7	9.7	18.6
2nd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.32	.44	2.81	1.96	.29	115	69	32	5	47
S	100	.35	.47	2.75	2.05	.28	118	72	33	5	45
B	3		.45	2.80	2.04	.27	110	65	31	6	42
Mg	300		.47	2.72	2.04	.27	111	65	33	5	38
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		*	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		--	3.6	2.2	2.5	7.7	6.4	14.4	4.2	4.1	17.7
3rd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.33	.37	2.65	2.12	.26	104	75	26	4	55
S	100	.34	.37	2.49	2.25	.26	104	76	26	4	51
B	3		.35	2.58	2.14	.24	99	70	26	5	50
Mg	300		.36	2.61	2.26	.26	104	78	27	5	45
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		*	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		--	3.1	3.0	3.6	9.3	4.3	11.6	5.8	9.7	20.6

* Treatment once annually

Table 3. Plant analysis of alfalfa for three individual cuttings related to S, B, Mg and Cu treatments 1983.

First Cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Trt.	lbs/A*	%					ppm				
Check		.34	.46	2.58	2.15	.24	144	72	35	4	36
S	50	.41	.46	2.62	2.22	.25	144	76	38	4	38
B	3		.47	2.59	2.13	.25	143	72	36	4	70
Mg	300		.46	2.62	2.24	.26	150	84	36	4	38
Cu	6		.47	2.62	2.12	.24	148	73	37	4	40
Adequate levels		.30	.25	.240	1.70	.30	30	30	20	10	30
Significance		*	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)			--	--	--	--	--	--	--	--	6
C.V.			3.1	6.5	3.6	3.9	9.0	10.9	5.4	9.8	8.8
Second Cut											
Check		.35	.41	3.00	1.60	.25	111	46	26	4	43
S	50	.41	.42	3.15	1.65	.26	103	45	28	4	42
B	3		.42	3.03	1.68	.25	110	51	27	4	62
Mg	300		.41	2.88	1.68	.27	111	50	28	4	44
Cu	6		.42	3.00	1.62	.26	110	46	28	4	46
Adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	--	--	--	--	3
C.V.			2.8	4.5	3.8	3.6	4.8	7.2	3.3	9.3	5.2
Third Cut											
Check		.30	.36	2.74	1.65	.20	64	35	22	4	40
S	50	.29	.38	2.72	1.70	.20	67	37	22	4	40
B	3		.38	2.76	1.68	.19	64	35	22	4	53
Mg	300		.38	2.81	1.68	.20	64	35	22	4	41
Cu	6		.38	2.79	1.67	.19	68	36	23	4	44
Adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		ns	ns	ns	ns	ns	**	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	3	--	--	--	2
C.V.			5.1	4.6	2.9	5.2	2.5	5.2	7.2	15.2	3.9

* Treatment once annually

Table 4. Plant analysis of alfalfa for three individual cuttings related to S, B, Mg and Cu treatments. 1984.

First Cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Treatment*	lbs/A	%					ppm				
check	---	.32	.47	2.91	2.06	.29	104	60	32	3	37
S	50	.43	.49	2.90	2.15	.29	95	55	36	3	36
B	3		.47	2.93	2.09	.30	111	63	33	3	61
Mg	300		.47	2.90	2.13	.34	116	62	33	3	40
Cu	6		.49	2.94	2.11	.30	115	65	36	4	38
Significance		**	**	ns	ns	**	ns	ns	*	*	**
BLSD (.04)			.01			.02			3	1	6
C.V.		--	2.1	4.9	7.2	4.4	9.3	12.1	5.2	14.7	9.9
Second Cut											
Treatment*	lbs/A										
check	---	.36	.40	2.96	1.84	.27	90	50	28	3	36
S	50	.40	.41	3.00	1.86	.26	88	53	29	3	38
B	3		.40	2.95	1.86	.27	90	55	28	3	60
Mg	300		.40	3.06	1.70	.28	86	44	27	3	35
Cu	6		.42	2.87	1.72	.26	93	55	29	4	38
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	--	--	--	--	5
C.V.		--	3.0	4.9	5.4	5.7	7.6	11.4	5.1	15.1	7.7
Third Cut											
Treatment*	lbs/A										
check	---	.33	.34	2.64	1.77	.19	105	40	21	3	42
S	50	.32	.34	2.57	1.80	.19	107	40	21	3	43
B	3		.34	2.53	1.83	.19	105	43	22	3	71
Mg	300		.33	2.61	1.66	.21	106	37	20	3	43
Cu	6		.32	2.48	1.76	.19	108	41	20	4	44
Significance		ns	ns	ns	ns	ns	ns	ns	ns	**	**
BLSD		--	--	--	--	--	--	--	--	.6	7
C.V.		--	5.4	3.9	6.9	7.7	5.5	9.3	4.5	13.0	10.9
adequate levels			.25	2.40	1.70	.30	30	30	20	10	30

* Treatment once annually

LIMING ACID SOILS FOR CAULIFLOWER PRODUCTION

C. J. Rosen, H. J. Buchite and R. C. Munter

Many of the coarse-textured soils in north central Minnesota tend to be acidic. This tendancy is accentuated in soils that have been farmed for a number of years without liming. In these situations, soil pH values of 5.0 and below are common. In recent years, interest in growing fresh market vegetable crops in north central Minnesota has increased. At these pH levels, nutritional imbalance in vegetable crops may occur. The objective of the present study was to determine the influence of various liming rates on cauliflower production and nutrition.

Materials and Methods:

In November 1983, 200 mesh dolomitic limestone was broadcast on and disked in a Hubbard loamy sand located in Princeton, MN. The treatments included a control and three rates of lime (0.75, 1.5 and 2.25 T/A). After an initial crop of broccoli was harvested, cauliflower transplants were planted on 12 July 1984 and fertilized with 50 lb/A N, 50 lb/A P_2O_5, 150 lb/A K_2O, 1/2 lb/A B, 30 lb/A S and 40 lb/A Mg. At planting, all fertilizer was banded 3 inches to the side and 5 inches below the transplants. There was an additional 50 lb N/A supplied through the irrigation system at four different times to provide a total of 250 lb N/A for the crop. Plant spacing was 15 inches within the row and 40 inches between row centers. A randomized complete block design was used with three replications. Soil samples were collected 25 September 1984. The most recently mature leaves were sampled 29, 48 and 62 days after transplanting. Nutrient composition of ashed samples was determined using an inductively coupled plasma (ICP) spectrometer. Because molybdenum availability is reduced under acid conditions, this element was also included in the ICP determinations.

Four center 15' rows of each plot were harvested on six dates from 12 September - 9 October 1984. Plants were cut and trimmed to a market ready stage before weighing. Measurements included total fresh weight, head diameter, and number of harvested heads per plot. To determine the nature of the response to lime rates, data were statistically analyzed using orthogonal comparisons.

Results and Discussion:

As expected, soil levels of Ca and Mg increased with increasing lime rates (Table 1). The soil pH increased from 5.3 in the check plot to 5.9 where 2.25 T/A lime was applied. Because of shallow incorporation by disking, soil chemical properties were affected only at the 0-6 inch depth. Subsoil (6-24 inch) pH levels were all less than 4.8 regardless of the liming rate.

There was a significant trend for increasing yield with increasing lime rate. Although head diamter and percent harvestable heads were not significantly affected by lime applications, there was a trend for an increase in these measurements with increasing lime rate. The greatest benefit of lime additions seemed to occur when the soil pH was raised to 5.7.

Tissue analysis did not appear to correlate well with liming treatments. Levels of leaf Ca and Mg were not significantly affected by dolomitic lime. Additionally, Ca concentrations, which generally increase in plant tissue with age, tended to decrease in cauliflower leaves with age. Levels of Ca in leaves at the third sampling date appeared to be in a low range. This low tissue Ca in later samples may be due to a relatively fast growth rate along with a limited capacity of the root system to absorb Ca. Throughout the field symptoms of tip-burn appeared on recently mature leaves. This symptom was not correlated with liming treatments. The exact causes of this tip-burn are not know but may be related to the low tissue Ca. In general, Mo levels in the leaf tissue tended to be lowest in untreated plots; however, a statistically significant effect was not detected. By the final tissue sampling date, Mo tissue levels were all in a range considered to be sufficient. A significant trend was observed with increasing tissue P with increasing lime rates. This suggests a greater availability of soil P with increasing pH.

In summary, lime applications appeared to have a significant effect on cauliflower yield. If soil pH is below 5.5, then a lime application would be beneficial.

Table 1. Influence of dolomitic lime on soil pH, calcium and magnesium. Samples taken 9 months after initial application.

Lime Treatments (Tons/A)	Ca (lb/A) 0-6	Ca (lb/A) 6-12	Ca (lb/A) 12-24	Mg (lb/A) 0-6	Mg (lb/A) 6-12	Mg (lb/A) 12-24	pH 0-6	pH 6-12	pH 12-24
0	396	175	506	160	47	72	5.3	4.5	4.6
0.75	439	197	378	184	80	72	5.3	4.4	4.5
1.50	500	186	462	220	48	68	5.7	4.5	4.6
2.25	613	225	584	279	58	88	5.9	4.5	4.7
Regression	Significance*								
Lin.	-	-	-	-	+	-	-	-	-
Quad.	++	-	-	++	-	-	++	-	-

* + = 10% level, ++ = 5% level

Table 2. Influence of dolomitic lime on cauliflower yield, head diameter and % harvestable heads.

Lime Treatments (Tons/A)	Yield (T/A)	Diameter (inches)	% Harvestable Heads
0	4.33	5.3	68.4
0.75	4.73	5.6	64.1
1.50	5.24	5.7	70.3
2.25	5.28	5.7	71.4
Regression	Significance*		
Lin.	-	-	-
Quad.	+	-	-

* + = 10% level, ++ = 5% level

Table 3. Nutrient concentrations in recently mature cauliflower leaves as affected by dolomitic lime.

Days After Planting	Lime Treatments (Tons/A)	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B	Mo
		%				ppm						
29	0	0.28	3.59	1.99	1.00	38	82	219	21	4	24	0.4
	0.75	0.30	3.90	2.15	1.05	34	81	227	23	4	26	0.9
	1.50	0.31	3.97	2.09	1.13	33	85	233	22	5	30	0.7
	2.25	0.31	4.07	1.94	1.03	38	88	228	24	4	26	0.9
	Regression	Significance*										
	Lin.	-	-	-	-	-	-	-	-	-	-	-
	Quad.	++	-	-	-	-	++	-	-	-	-	-
48	0	0.41	2.71	0.96	0.46	24	82	237	34	27	47	1.16
	0.75	0.44	2.87	1.16	0.49	28	93	267	34	39	40	0.97
	1.50	0.50	2.95	0.85	0.47	22	81	235	37	21	46	0.82
	2.25	0.48	2.98	1.04	0.54	21	82	254	38	17	45	1.21
	Regression	Significance*										
	Lin.	-	-	-	-	-	-	-	-	-	-	-
	Quad.	+	-	-	-	-	-	-	-	-	-	-
68	0	0.41	2.64	0.75	0.37	23	71	191	35	40	29	1.18
	0.75	0.44	2.71	0.62	0.36	21	75	173	38	62	30	1.21
	1.50	0.40	2.50	0.62	0.38	21	71	180	33	64	29	1.60
	2.25	0.51	2.59	0.69	0.38	21	86	228	39	76	30	1.50
	Regression	Significance*										
	Lin.	-	-	-	-	-	-	-	-	-	-	-
	Quad.	-	-	-	-	-	-	-	-	-	-	-

* + = 10% level, ++ = 5% level

HIGH PHOSPHORUS AND POTASSIUM RATES IN A CORN-SOYBEAN ROTATION

Waseca, 1984

G. W. Randall, S. D. Evans, W. W. Nelson and D. T. Walters

EXPERIMENTAL PROCEDURES

Ten P and K treatments (Table 1) were applied at three branch experiment stations (Southern Experiment Station, Waseca; Southwest Experiment Station, Lamberton; and West Central Experiment Station, Morris) in Minnesota. A randomized, complete-block design with four replications was used. The 50-pound rates were estimated to be "maintenance" rates, and the 0, 100 and 150-pound rates provide the response curves for each element. Treatments 5 and 8 receive P and K, respectively, every third year for the duration of the experiment. Treatments 9 and 10, applied in the fall of 1973, did not receive P and K again until the fall of 1978 when the treatments were resumed at Waseca because P appeared to be limiting. These two treatments were resumed at Morris in 1979 for the same reason. All other treatments have been applied annually. In 1982, soybeans were planted at Morris and Waseca after 8 years of continuous corn to begin a long-term corn-soybean rotation phase of this experiment.

Table 1. Phosphorus and potassium treatments applied in the high P and K rate study.

Trt. No.	Application Year (Fall) 1973,'76,'79,'82	1974,'75,'77,'78,80,'81,'83
	----------lb P_2O_5 + K_2O/A----------	
1	0 + 0	0 + 0
2	0 + 100	0 + 100
3	50 + 100	50 + 100
4	100 + 100	100 + 100
5	150 + 100	0 + 100
6	100 + 0	100 + 0
7	100 + 50	100 + 50
8	100 + 150	100 + 0
9 1/	150 2/ + 100	0 + 100 3/ 5/
10 1/	100 + 150 2/	100 + 0 4/ 6/

1/ Neither P nor K was applied in 1976.

2/ The 150-lb rate was not applied at Lamberton or Waseca in 1979 but was applied at Morris.

3/ 150 + 100 applied at Waseca in 1978.

4/ 100 + 150 applied at Waseca in 1978.

5/ 0 + 100 was applied at all locations from 1980 through 1983.

6/ 100 + 0 was applied at all locations from 1980 through 1983.

The P and K materials were broadcast on corn residue and plowed down at all locations in the fall of 1984. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

Specific experimental procedures used for soybeans at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location.

At Lamberton each of the plots was split with the west half planted to soybeans and the east half to corn. Corn (Pioneer 3732) was planted in 30" rows at a population of 26000 plants/A on May 18. Weeds were controlled with a ppi application of Lasso (3 lb) and Bladex (1½ lb). Plant tissue samples were not taken. Corn was harvested October 21.

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Planting in 1984 was delayed by late snow at Lamberton and Waseca in April. Yields at Waseca were reduced by a hot and dry August. Grain yields at Lamberton were reduced somewhat probably due to an excessively wet June.

Table 2. Experimental procedures for soybeans on the high P and K rate study at the three branch stations in 1984.

Variable	Lamberton	Morris	Waseca
Planting date	5/19	5/24	5/15
Row spacing	30"	6"	15"
Planting rate	10 beans/foot	3 beans/foot	4½ beans/foot
Variety	Corsoy	Evans	Hardin
Herbicide	2½# Amiben + 3# Lasso/A (Bdct)	2½# Amiben + 3# Lasso/A (Bdct)	3½# Amiben + 3½# Lasso/A (Bdct)
Harvest date	10/1	10/1	9/20

RESULTS AND DISCUSSION

Soil samples taken at the end of the 1984 growing season indicate significant differences in Bray P1 and Olsen's extractable P at all locations (Table 3). There appeared to be a good linear response between extractable P and P application rate. Soil test P was always lowest with treatments 1 and 2, which received no P. Intermediate P levels were found with treatment 3 (50-lb P_2O_5 annually) and treatment 5 (150-lb P_2O_5 every third year). Highest soil test P values were associated with the annual 100-lb P_2O_5 treatments at all locations. Soil test P values at Waseca were quite similar to those obtained in 1983. Soil test P values at Morris, however, averaged approximately 25 percent lower than 1983 while at Lamberton soil P was approximately 20% higher than 1983.

Table 3. Soil test values as influenced by 11 year's application of P and K treatments at Lamberton, Morris and Waseca.[1/]

Treatment No.[2/]	pH			P							K		
	La	Mo	Wa	L_{10}	L_{50}	L_{0L}	M_{10}	M_{50}	M_{0L}	Wa	La	Mo	Wa
				lb/A									
1	5.6	7.8	6.4	57	117	36	7	23	5	24	347	337	227
2	5.7	7.8	6.4	45	92	32	7	23	6	17	464	478	295
3	6.3	7.8	6.2	65	130	52	39	93	34	47	445	442	305
4	5.6	7.7	6.4	118	197	76	72	154	66	89	413	433	326
5	5.9	7.8	6.4	84	156	56	31	74	28	53	446	411	322
6	5.7	7.6	6.6	128	216	79	72	161	63	85	342	331	255
7	5.6	7.9	6.4	114	206	76	55	148	54	79	395	365	263
8	5.8	7.6	6.4	107	192	77	74	163	71	80	373	365	269
9	6.1	7.7	6.6	57	111	38	19	49	15	26	426	359	310
10	5.7	7.8	6.5	104	185	69	15	44	12	79	371	337	292
Signif.Level(%):	94	96	78	99	99	99	99	99	99	99	99	99	99
BLSD (.05) :		.2		20	31	13	15	29	13	17	49	53	41
CV (%) :	5.4	2.7	2.5	17.	14.	16.	22.	18.	22.	18.	8.5	8.2	7.5

1/ Samples were taken in August, October and September for Lamberton, Morris and Waseca, respectively, before the 1984 treatments were applied.

2/ Treatments applied in fall of 1983 for 1984 crop.

Use of the 1:50 soil to Bray P1 solution ratio on the calcareous Aastad soil at Morris indicated slightly more than twice as much extractable P in the soil as with the 1:10 ratio at higher levels of application and about 3 times as much when no P was applied. Soil P values obtained with Olsen's $NaHCO_3$ test on the calcareous soil at Morris were slightly but consistently lower than values from the Bray P1 test (1:10 ratio).

The 1:50 soil to Bray P 1 solution ratio extracted slightly more than twice as much P when no P was applied at Lamberton while slightly less than twice as much P was extracted when the 100-lb P_2O_5 rate was applied. Soil P values obtained with the Olsen's $NaHCO_3$ test on the acid soil at Lamberton were about 30% lower than with the Bray P1 (1:10) extractant.

Soil test K was influenced by K applications at all locations in 1984 (Table 3). The response to annual K applications was not as pronounced as with P. Highest soil test K levels were associated with the annual application of 100-lb K_2O/A. Soil pH was not related to P and K treatments.

Analysis of the uppermost mature trifoliate leaf samples taken at the R2 (mid-to-late bloom stage) indicated significant effects of the P and K treatments on leaf P, K, Ca, Mg, Zn and Cu at Lamberton and on leaf K, Fe, Zn, Cu and B at Waseca (Table 4). Leaf K was improved significantly by the K treatments at both locations while leaf P was increased by the P treatments only at Lamberton. Leaf Ca and Mg were reduced by the K treatments at both locations while leaf B was reduced at Waseca. Leaf Zn and Cu were reduced by the P treatments at both locations.

Table 4. Effect of high P and K rates on the nutrient concentrations in the soybean leaves at the Lamberton and Waseca experimental sites in 1984.

Treatment No.	Treatment Description	Nutrient Concentration[1/] P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
					Lamberton					
1	0 + 0	.40	2.13	1.24	.67	139	60	39	8.6	74
2	0 + 100	.39	2.64	1.14	.55	141	52	37	8.6	68
3	50 + 100	.41	2.63	1.19	.56	138	51	35	7.0	72
4	100 + 100	.42	2.51	1.14	.58	139	57	36	5.9	69
5	0 + 100	.39	2.48	1.15	.56	143	54	35	7.6	70
6	100 + 0	.45	2.18	1.23	.67	132	62	36	5.2	79
7	100 + 50	.42	2.49	1.17	.59	130	57	35	6.1	74
8	100 + 0	.44	2.41	1.21	.61	136	53	33	5.3	71
9	0 + 100	.38	2.56	1.15	.56	138	51	36	8.5	76
10	100 + 0	.43	2.37	1.22	.64	138	55	33	5.6	74
	Signif. Level (%):	99	99	96	99	37	79	95	99	82
	BLSD (.05) :	.02	.10	.09	.02			4	1.0	
	CV (%) :	3.1	3.2	4.4	2.5	6.3	11	6.8	10	7.5
					Waseca					
1	0 + 0	.45	1.79	1.32	.67	142	52	51	11.0	59
2	0 + 100	.47	2.30	1.17	.48	128	51	49	10.5	51
3	50 + 100	.46	2.23	1.22	.50	135	57	46	8.9	54
4	100 + 100	.49	2.37	1.17	.49	125	55	42	6.9	53
5	0 + 100	.46	2.25	1.20	.49	123	57	46	8.2	53
6	100 + 0	.49	1.88	1.33	.65	125	57	43	6.9	62
7	100 + 50	.50	2.10	1.18	.53	122	53	42	6.7	54
8	100 + 0	.50	2.05	1.19	.57	125	51	44	7.4	56
9	0 + 100	.44	2.20	1.24	.52	133	57	48	9.6	53
10	100 + 0	.50	1.96	1.21	.60	121	52	43	6.8	57
	Signif. Level (%):	82	99	92	99	99	71	99	99	99
	BLSD (.05) :		.21		.06	11		3	1.0	6
	CV (%) :	6.5	5.8	5.8	6.3	4.6	7.5	4.5	7.4	5.8

[1/] Uppermost, mature trifoliate at the R2 stage.

The influence of 11 years of P and K applications on soybean yields is shown in Table 5. Soybean yields were not affected by the P and K treatments at Lamberton and Waseca although a trend toward a P response was noted at Waseca. At Morris yields were improved significantly with the 50-lb P_2O_5 rate with no additional response to the 100-lb rate. A response to K was not obtained.

Table 5. Soybean yields at the three sites as influenced by high P and K rates in 1984.

Treatment No.	Description	Lamberton	Morris	Waseca
	lb P_2O_5+K_2O/A	bu/A		
1	0 + 0	39.8	38.3	44.2
2	0 + 100	43.1	36.3	44.3
3	50 + 100	45.8	44.6	47.1
4	100 + 100	41.0	45.3	47.5
5	0 + 100	43.5	43.2	49.5
6	100 + 0	41.7	46.1	46.9
7	100 + 50	42.9	46.8	47.8
8	100 + 0	45.4	45.0	48.0
9	0 + 100	42.4	45.1	44.9
10	100 + 0	40.5	45.4	44.2
	Signif. Level (%):	48	99	76
	BLSD (.05) :		4.2	
	CV (%) :	9.7	6.6	5.9

Small corn plant weight and height, final population, and corn yield were not influenced by the P or K treatments at Lamberton (Table 6).

Table 6. Early plant growth, plant population, and grain yield as influenced by high P and K rates at the Lamberton site in 1984.

Treatmemt No.	Description	Early plant Weight	Early plant Height	Final popl'n	Grain Yield
	lb P_2O_5+K_2O/A	g/dry plant	cm	ppA x 10^3	bu/A
1	0 + 0	36	56	22.3	132.8
2	0 + 100	56	56	23.7	138.9
3	50 + 100	40	58	23.7	131.4
4	100 + 100	64	64	23.3	140.6
5	0 + 100	60	56	22.2	122.0
6	100 + 0	59	58	23.6	134.1
7	100 + 50	38	58	22.6	130.0
8	100 + 0	49	59	23.6	144.6
9	0 + 100	40	52	22.5	136.8
10	100 + 0	57	59	23.6	137.2
	Signif. Level (%):	81	63	54	82
	CV (%) :	34	9.6	5.2	7.5

SUMMARY

These 1984 data are quite similar to past years in that yield responses to K have not been obtained at any of the sites. Yield responses to applied P have been very consistent at Morris, have occurred in some years at Waseca and have not occurred at Lamberton. Triennial applications of the 150-lb rates of P and K appear to be equal to annual applications at the 50-lb rate.

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PLACEMENT OF P AND K FOR CORN AND SOYBEAN PRODUCTION IN THE NORTH CENTRAL REGION

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Background and Objectives:

Until recently, farmers had few choices with respect to placement of P and/or K for corn and soybean production. They could either broadcast and incorporate the fertilizer before planting, apply it in a band to the side of and below the seed at planting (starter fertilizer) or use a combination of both of these methods.

Our thinking about placement of P and/or K has changed substantially in recent years. Two factors are primarily responsible for this change. One factor is the increased popularity of the adoption of conservation tillage production systems. Without some form of primary tillage, P and K (both immobile nutrients) remain relatively close to the soil surface if broadcast applications are used. This may or may not be a disadvantage for broadcast application. Secondly, research at Purdue University demonstrated that fertilizer banded on the soil surface and plowed under produced corn yields that were higher than yields produced by the broadcast application of similar rates.

Thus, new methods of fertilizer placement have been developed and promoted in recent years. Terms such as "deep banding" and "surface bands" have entered our vocabulary. With these new ideas, however, come new questions. These questions had not been answered in previous research dealing with fertilizer placement.

Therefore, this study was initiated to evaluate the effect of placement of P and K on corn and soybean production planted with two tillage systems where the soil test levels for P and K vary over a wide range.

Procedure Used:

This study was initiated at the Waseca, Lamberton and Morris experiment stations in the fall of 1983. Appropriate site characterization data are listed in Table 1.

The treatments used at the Waseca and Morris locations are listed in Table 2. Space limitations dictated that fewer treatments be used at the Lamberton location and the treatments used at this location are listed in Table 3.

Some explanation should be provided for treatments 29 through 36 at the Waseca and Morris locations. The term "Deep Band" describes the placement of the N-P-K suspension used at a depth of 10-12 inches. In treatments 29 and 30, the 10X rate was applied so that it would be in the middle (M) of future corn rows. In treatments 31 and 32, the "Deep Band" was placed so that it would be dirctly below the rows (BR) of future crops. The annual rate of P_2O_5 and K_2O will be applied in the middle of existing rows in a band at a depth of 6-8 inches in treatments 29 through 32. The appropriate starter wil also be used each year in treatments 29 through 32. In treatments 33 through 36, the deep band was applied so that it would be in the middle of future crop rows. No addition N-P-K suspension will be applied in treatments 33 through 36 but the appropriate starter will be used for the designated treatments.

The fall chisel operation was completed after the application of fertilizer. Depth of chiseling was 6-8 inches. A secondary tillage operation was used in the spring prior to planting in this tillage system. With the ridge-till system, all fertilizer was applied after the ridges had been established.

Accepted production practices conducive to attaining high yields were used at all locations.

Whole plant samples (6 plants/plot) were collected from all locations at 4 to 5 weeks after emergence. These whole plants were dried, weighed, ground and analyzed for P and K by ICP (Induction Coupled Plasma) procedures. Uptake of P and K by these young plants was computed from plant weight and concentration data. The ear leaf at silking was also collected at all locations. These samples were dried and analyzed for P and K by the standard ICP procedure. Grain yields were

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measured with plot combines at all locations and are corrected to a 15.5% moisture basis.

Standard analysis of variance procedures were used for separation of treatment means.

Results and Discussion:

The data collected in this study are summarized in various ways in this report. The data for all treatments, except those involving the use of the deep band, are presented in Tables 4, 5, 6, and 7. Very little emphasis will be placed on the 1984 data gathered from treatments involving the use of the deep band. There is a logical explanation for this. The implement used to apply the fertilizer at a depth of 10-12 inches (either between or below future corn rows) caused a great deal of soil disturbance. Soil disturbance in itself could have an impact on the measurements taken. Therefore, any differences observed for the deep band treatments could be due to either the fertilizer applied or the soil disturbance created in the application process. More attention will be given to a discussion of data from these treatments in future years.

The main effects of the four variables used in this study on the parameters measured are listed in Tables 8, 9, 10, and 11. There were no significant interactions at the Morris location. Some significant 2-way interactions between or among variables were recorded at the low fertility site at Waseca. Two such interactions are summarized in Tables 12 and 13.

The control and the starter only treatments cannot be included in the statistical analysis of the complete factorial. The effect of the starter only treatment can be compared to the control for both tillage systems by using "t" test. This comparison for the parameters measured is summarized in Table 15.

As mentioned, data collected from treatments involving the use of the deep band were not analiyzed statistically. For those interested, the early growth and yield data are summarized in Table 15.

Because of space limitations at the Lamberton location, the treatments used are not as extensive as at Waseca and Morris. In addition, two factors severely limited the collection of data from this location. To begin with, an erratic stand emerged from the ridge-till system. The variability was such that it limited the collection of meaningful data from this tillage system. In addition, there was excessive rainfall during the month of June. This excessive moisture severely restricted early growth and development of the corn. This was especially true for the low fertility site. Therefore, data were gathered from the chisel system at the high fertility site at Lamberton. The data gathered are summarized in Table 16.

Table 1. Selected soil properties for the experimental sites.

	Location and Fertility Level				
	Waseca		Lamberton		Morris
Soil property	High fertility	Low fertility	High fertility	Low fertility	High fertility
pH	6.6	6.0	5.8	6.0	7.5
P (Bray + Kurtz #1) lb./acre	48	15	33	14	39
K (1N $NH_4C_2H_3O_2$) lb./acre	433	270	305	222	259
organic matter, %	3.5	3.5+	3.0	3.0	3.5+
soil texture:	silty clay loam	silty clay loam	silty clay loam	silty clay loam	silt loam