Table 1. Influence of tillage treatments on continuous corn production at Waseca in 1979.

Tillage Treatments		Final	Grain		
Primary	Secondary	popl'n	Moisture	Yield	N
		x 10^{-3}	%	bu/A	%
Fall plow	Field cult.	24.0	37.2	176.8	1.33
Fall chisel	Field cult.	24.1	38.0	168.7	1.29
None	None	20.3	40.2	131.8	1.26
None	Disk	24.5	37.6	169.1	1.32
	Significance:[1/]	*	**	**	NS
	BLSD(.05) :	2.6	.7	12.8	
	CV(%) :	6.7	1.3	5.2	3.3

[1/] **, *, and + are significant at the 99, 95 and 90% levels, respectively. NS = not significant at the 90% level.

Marked differences in surface residue accumulation (mulch from the preceding corn crops) and early plant growth were found among the treatments (Table 2). Residue amounts of about 2 T/A with the chisel and spring disk treatments apparently reduced soil temperatures slightly resulting in somewhat slower early plant growth. With continuous no tillage, over 5 tons/A of residue covered the soil surface. Subsequently, early plant growth was reduced by 70%; probably a direct result of cooler soil temperatures. The correlation between grain yield and early plant growth was highly significant (r=.856**) and is shown by the following linear regression equation (Yield=120.9 + 10.594 EPG) where EPG = grams per plant.

Table 2. Effect of primary tillage treatments on the surface residue accumulation and early plant growth after ten years of continuous corn at Waseca.

Tillage Treatment		Surface residue	Early plant growth
Primary	Secondary	T/A (Dry Matter)	g/dry plant
Fall plow	Field cult.	Trace	5.3
Fall chisel	Field cult.	2.2	4.3
None	None	5.1	1.4
None	Disk	2.1	4.4
	Significance:	**	**
	BLSD(.05) :	1.2	.7
	CV(%) :	23.	11.

Plant emergence was affected greatly by the primary tillage treatments (Table 3). The first plants emerged 10 days after planting with the moldboard plow treatment showing the earliest emergence. Emergence was essentially completed within 3 days with the moldboard plow treatment. Emergence with the fall chisel and spring disk treatments was about 1 day later and was essentially complete within 4 days. With no tillage emergence was much slower and continued over an 8-day period. Surface residue accumulations shown in Table 2 more than likely reduced soil temperature sufficiently to result in the delayed emergence. In addition, the prolonged emergence period with no tillage was probably due to poor seed to moist soil contact even though fluted coulters were used with this system.

Table 3. Influence of primary tillage on the emergence rate of corn at Waseca in 1979.

Tillage Treatment	Days after planting							
	10	11	12	13	14	15	17	20
	% emerged							
Fall plow - field cult.	19	78	91	96	96	96	99	100
Fall chisel - field cult.	1	24	68	88	90	92	99	100
No Tillage	0	1	4	23	33	43	89	100
Spring disk only	1	30	79	92	94	94	100	100

Nutrient concentrations in the whole small plants (approximately 4 weeks after emergence) were influenced by tillage (Table 4). Phosphorus, Zn and Cu concentrations were highest with no tillage and lowest with fall plowing. These differences more than likely were due to the extreme differences in EPG among these treatments; hence, a dilution effect. The high Fe and Mn levels with the plots that received some form of tillage are probably due to contamination from soil splashing on the plants.

Table 4. Nutrient concentrations in the small whole plant as influenced by tillage methods at Waseca in 1979.

Tillage Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%				ppm				
Fall plow - field cult.	.38	4.35	.47	.35	746	53	39	7.4	8.2
Fall chisel - field cult.	.41	4.40	.48	.37	654	53	42	8.4	7.8
No Tillage	.43	4.10	.43	.34	293	45	47	10.5	7.6
Spring Disk only	.42	4.36	.46	.38	575	52	41	8.5	7.6
Significance:	*	NS	NS	NS	**	*	+	**	NS
BLSD(.05) :	.04				166	7		1.3	
CV(%) :	5.4	6.8	7.8	8.1	19	8.0	8.5	9.2	10

Nutrient uptake (the product of nutrient concentration times EPG) of all nutrients was influenced by the tillage treatments (Table 5). Uptake from the no tillage treatment was significantly less than from the other treatments and was primarily due to smaller EPG. Potassium, Ca, Mg, Fe, Mn and B uptake

was generally less with the chisel and disk treatments than with the moldboard plow.

Table 5. Nutrient uptake by small whole plants as influenced by tillage methods at Waseca in 1979.

Tillage Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	----g/10 plants-----				-----mg/10 plants------				
Fall plow - field cult.	.202	2.29	.25	.18	39	2.8	2.1	.39	.44
Fall chisel - field cult.	.175	1.88	.20	.16	28	2.2	1.8	.36	.33
No Tillage	.061	0.58	.06	.05	4	.6	.7	.15	.11
Spring Disk only	.186	1.92	.20	.17	26	2.3	1.8	.37	.34
Significance:	**	**	**	**	**	**	**	**	**
BLSD(.05) :	.034	.38	.04	.02	6	.4	.4	.08	.10
CV(%) :	15	15	16	12	17	14	15	17	20

With the exception of K, Mg and Mn, earleaf nutrient concentrations were not influenced by the tillage treatments (Table 6). Leaf K was significantly depressed by the reduced tillage treatments with concomittant increase in Mg. Concentrations of all nutrients, however, were sufficient for optimum crop production.

Table 6. Nutrient concentrations in the earleaf at silking as influenced by tillage methods at Waseca in 1979.

Tillage Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	---------%---------				----------ppm----------				
Fall plow - field cult.	.30	2.28	.45	.37	127	36	24	7.0	5.1
Fall chisel - field cult.	.29	1.93	.48	.47	122	34	22	7.4	5.0
No Tillage	.30	1.71	.48	.50	131	25	23	7.2	4.6
Spring Disk only	.30	1.97	.47	.50	130	28	23	7.2	5.0
Significance:	NS	**	NS	**	NS	*	NS	NS	NS
BLSD(.05) :		.25		.06		9			
CV(%) :	3.4	7.8	10	8.6	7.0	17	9.7	6.2	6.5

Soil NO_3-N levels from the 0-5' profile in April and the 0-10' profile were influenced significantly by the tillage treatments (Table 7). In April the fall chisel, spring disk and no tillage treatments contained 64, 77 and 54%, respectively, of the NO_3-N found in the 0-5' profile with the fall plow treatment. These proportions are slightly higher than shown in the fall of 1978. After the 1979 crop NO_3-N proportions in the 0-5' profile with the same three treatments were 70, 58 and 45%, respectively, of the moldboard plow. Sampling to 10' resulted in similar proportions of 74, 69 and 50%, respectively. Apparently, severe losses due to denitrification and/or leaching, reduced mineralization and/or immobilization of the fertilizer N are associated with these reduced tillage systems.

Distribution of NO_3-N in the top 5' varied with the time of sampling. In April, lowest concentrations were found in the 1-3' zone. By October concentrations were lowest in the top 3' with the moldboard plow and the top 4' with the other tillage systems.

Nitrate-N distribution in the 10' profile was not markedly affected by tillage. Over 57, 59, 61 and 64% of the NO_3-N was found below the 5' depth for the moldboard plow, chisel, spring disk and no tillage treatments, respectively. However, the absolute amounts of NO_3-N below 5' were almost doubled by tillage. Amounts remaining in the soil between 5' and 10' after the 1979 crop ranged from 166 lb NO_3-N/A with no tillage to 242 and 238 with disk and chisel, respectively, to 312 with the moldboard plow. These high levels of NO_3-N below the rooting depth of corn will more than likely be lost to the ground water.

Table 7. Nitrate-N distribution in the 0-5' soil profile in April and the 0-10' soil profile in October, 1979, as influenced by ten years of continuous tillage for corn at Waseca.

Depth	Fall plow-f. cult.		Fall chisel-f. cult.		No Tillage		None-Spr. Disk	
	Apr	Nov	Apr	Nov	Apr	Nov	Apr	Nov
ft.	ppm							
0-1	11.7	7.8	9.2	8.4	12.1	5.9	13.9	7.6
1-2	8.1	7.8	4.1	6.2	3.8	4.6	5.6	6.3
2-3	10.4	10.8	5.1	6.4	3.4	3.9	6.3	5.1
3-4	18.8	14.8	11.9	8.6	7.2	5.6	12.6	6.4
4-5	19.5	17.8	13.3	12.0	10.3	6.7	13.9	9.1
5-6		17.4		11.3		7.8		10.6
6-7		18.4		11.7		8.1		14.3
7-8		15.6		11.6		9.2		13.9
8-9		13.8		11.9		8.6		11.7
9-10		12.8		12.8		7.9		9.8
lb NO_3-N/A[1/] in profile								
(0-5')	274	236	174	166	147	107	210	138
(0-10')		548		404		273		380

[1/] Assuming 2 million lb soil/every 6" depth of soil.

The above data generally indicate that the efficiency of surface-applied fertilizer N tends to decrease as the intensity of the primary tillage is decreased. Annual applications of 175 lb N/A have resulted in substantial N accumulations throughout the 10' profile with moldboard plowing. This would suggest that this application rate is higher than needed especially considering the two very dry years (1975 and 1976) when crop removal was small. Nitrate accumulations with the chisel and disk systems range from 26 to 31% less and is largely concentrated below 5'.

These data also indicate that this N rate is too high when dry years are included, but is appropriate under normal growing conditions. The lower NO_3-N levels throughout the profile with continuous no tillage suggest poorer N efficiency compared to the other treatments and perhaps that the N rate may need to be increased under continued optimum growing conditions.

Soil samples to a depth of 6" were taken and separated into 0-1", 1-2", 2-3", 3-4" and 4-6" layers in October (Table 8). Soil pH of the surface soil was not influenced by the moldboard plow or chisel treatments but was reduced some with the light spring disk treatment. No tillage showed a substantial pH depression in the top 2 inches probably as a result of the nitrification of the surface-applied N. This continued pH depression could lead to substantial weed control problems with certain preemergence herbicides.

Table 8. Soil pH, P and K distribution in the 0-6" soil profile in October 1979 as influenced by ten years of continuous tillage for corn at Waseca.

Depth inches	Fall plow-f. cult.	Fall chisel-f. cult.	No Tillage	None-Spr. Disk
		Soil pH		
0-1	6.6	6.6	5.7	6.1
1-2	6.6	6.4	5.9	6.2
2-3	6.6	6.6	6.6	6.4
3-4	6.7	6.8	6.8	6.7
4-6	6.7	6.9	6.9	6.9
		Soil P (lb/A)		
0-1	66	90	108	114
1-2	62	90	94	99
2-3	57	76	59	71
3-4	60	72	31	52
4-6	56	56	27	34
		Soil K (lb/A)		
0-1	394	577	559	732
1-2	294	363	406	401
2-3	273	310	311	278
3-4	288	257	225	215
4-6	262	212	197	180

Soil P and K distribution throughout the 6-inch layer was relatively uniform with moldboard plowing. Stratification of both P and K was enhanced by reduced tillage with the disk = no tillage > chisel plow. In comparison to the moldboard plow, the chisel plow incorporated P to a depth of 6" and K to 4". With the disk and no tillage systems P and K were largely accumulated in the top 2 to 3 inches. Soil test P and K levels in the 0-1 inch layer were 2.5 to 3.4 times as high as in the 3-4" layer and 3 to 4 times as high in the 4-6" layer with these systems.

TEN-YEAR YIELD SUMMARY

Corn yields were affected significantly (P=.10 level) by the tillage treatments in 8 out of the 10 years (Table 9). In the first 5 years, climatological differences among growing seasons may have been largely responsible for the year to year inconsistency among treatments. For instance, 1971 was dry and highest yields were obtained from the fall plow and chisel treatments without any secondary tillage. In other years secondary tillage following chiseling generally increased yields. Five-year averages show highest yields with fall moldboard plowing or fall chiseling with secondary tillage. Spring chiseling and no tillage generally produced the lowest yields.

Results over the last 5 years were also affected by the climate during the growing season. Hot, dry conditions coupled with heavy amounts of road dust during pollination led to greater than 45% barrenness in the plants and extremely low yields in 1975. In 1976, extremely dry conditions along with 40 to 60% lodging due to rootworms resulted in very low yields. For these reasons the 1975 and 1976 yields were excluded from the 1970-79 averages. In the last three years yields from the plow, chisel and disk systems have been comparable and were significantly higher than with no tillage.

Average corn yields over the 10-year period indicate only a 2.7 bu/A advantage for moldboard plowing over chiseling and a 1.4 bu/A advantage for chiseling over spring disking. These differences were not significant at the P=.10 level. Yields with no tillage averaged 10% less and were significantly below (P=.01 level) the yields from the other treatments. These yield results may have been tempered somewhat due to the south facing slope and the good drainage. With poor drainage or a north facing slope the yield differences perhaps would have been greater and would have favored moldboard plowing.

Table 9. Yields from continuous corn tillage experiment at Waseca from 1970-1979.

Tillage Treatment		Year					5-Yr.	Year					10-Yr[2]
Primary	Secondary	1970	1971	1972	1973	1974	Avg	1975	1976	1977	1978	1979	Avg
		bu/A											
Fall plow	None	164.7	114.8	135.3	141.2	97.9	130.8						
" "	Conv.[1]	166.8	104.7	131.8	144.9	103.4	130.3						
" "	F. cult.	163.7	102.8	136.2	144.1	99.7	129.3	52.8	68.1	131.0	157.4	176.8	139.0
Spring plow	Conv.	161.5	100.6	134.9	140.5	90.4	125.6						
Fall chisel	"	164.2	106.6	130.8	155.1	99.2	131.2						
" "	F. cult.	156.7	110.5	133.1	145.7	92.1	127.6	48.7	66.6	128.0	155.3	168.7	136.3
" "	None	161.1	116.2	126.2	134.3	90.4	125.6						
Spring "	Conv.	150.2	100.1	139.9	138.4	92.1	124.1						
Spring "	Disk	159.5	110.2	133.6	131.5	95.7	126.1						
Zero	None	155.9	96.2	130.1	133.4	85.9	120.3	49.7	83.2	121.6	129.5	131.8	123.0
Zero	Disk	157.9	104.1	130.8	145.8	93.7	126.5	49.4	79.3	125.4	152.1	169.1	134.9
Significance:[3]		*	+	NS	**	**	*	NS	**	*	**	**	**
BLSD(.10)	:	8.3	9.7		7.7								5.8
(.05)	:	9.9			9.0	9.0	7.7		7.6	6.7	5.3	12.8	6.8
CV(%)	:	3.6	5.9	5.1	4.4	5.9	3.8	14.9	6.5	3.1	2.4	5.2	5.0

[1] Conventional = Disk and field cultivate.

[2] Excluding 1975 and 1976.

[3] **, *, + = significant at the 99, 95 and 90% levels; NS = not significant at the 90% level.

N RATE, SOURCE AND INCORPORATION STUDY-CORN

Gyles Randall and Harvey Meredith

Objective of Study: Determine the nitrogen uptake and corn yields when various sources of nitrogen are surface applied or soil incorporated. A secondary objective of the study is to correlate soil nitrate levels and corn yields.

Location: Waseca Experiment Station

N Source: Urea, Ammonium nitrate and 28 percent urea-ammonium nitrate.

N Rate: 50 and 100 pounds N per acre. Zero N plots deliniate N response.

Results: Rainfall was adequate to slightly excessive in 1979. A dramatic response to applied nitrogen was evident both in N uptake and yield. High yields in 1977 and 1978 tended to lower the level of soil nitrates although the soil nitrate levels in June indicated an average of 142 pounds of nitrogen in the top 60 inches. There were no significant differences between sources of N or incorporation.

Table 1. Yield of Corn Grain, Waseca Experiment Station in Response to Applied N, 1979. (bu/A).

Lbs-N/A	Yield - Bu/A					
	Am Nitrate		Urea		28% N Soln	
	I	N	I	N	I	N
75	129.1	128.8	133.0	128.2	122.4	127.8
150	146.8	148.8	148.6	149.5	141.2	143.4

NO N: 88.7 bu/A BLSD (.05)=7.2 bu/A

Table 2. Nitrogen Content of the 6th leaf of Corn as influenced by N source and rate, Waseca Experiment Station, 1979.

Lbs-N/A	N Content - Percent					
	Am Nitrate		Urea		28% N Soln	
	I	N	I	N	I	N
75	2.44	2.32	2.62	2.32	2.26	2.26
150	2.55	2.76	2.83	2.84	2.56	2.56

NO N: 1.84 BLSD (.05)=.17

Table 3. Soil pH of Zero N plots of N Source, Rate, Incorporation Study, Waseca Experiment Station, 1979.

	Soil pH					
Plot No.	111	207	308	404	510	610
Depth, In.						
0-12	7.4	7.4	6.8	7.6	7.1	6.9
12-24	7.6	7.6	7.4	7.8	7.4	7.5
24-36	7.7	7.8	7.5	7.8	7.5	7.7
36-48	7.7	7.8	7.6	7.9	7.4	7.8
48-60	7.7	7.7	7.7	7.8	7.6	7.9

Sampled June 1979.

Table 4. Soil Nitrate Values of Zero N Plots from N Source, Rate, Incorporation Study, Waseca Experiment Station, 1979.

	Lbs NO_3 - N/A					
Plot No.	111	207	308	404	510	610
Depth, In.						
0-12	59	62	44	55	60	20
12-24	20	18	18	16	23	11
24-36	17	18	16	17	22	16
36-48	24	26	25	27	29	26
48-60	27	28	33	29	33	32
	147	152	136	142	167	105

Average: 142

ROTATION NITROGEN STUDY

Waseca, 1977-1979

Gyles W. Randall

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 play a vital role in the conservation of N. The purpose of this study is to determine the N needs of corn following corn, soybeans, wheat and wheat interseeded with alfalfa in a crop sequence study.

EXPERIMENTAL PROCEDURES

The 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) were applied as anhydrous ammonia each in the spring. Wheat annually received 50 lb N/A as urea before planting. Broadcast P and K (averaging 0 + 80 + 140 lb P_2O_5 and K_2O/A) was applied annually to all plots. Row P and K (0 + 30 + 45 lb P_2O_5 and K_2O/A) was applied to the corn.

Corn was planted in 30" rows at 26,100 ppA in early May each year. The hybrid was Pioneer 3780 in 1978 and 1979 and Pioneer 3709 in 1977. Era wheat and Hodgson soybeans were planted in late April and/or in mid-May, respectively, each year. A non-winter hardy alfalfa was planted with the wheat in 1974 and 1975. Agate was the alfalfa variety used.

Each year weeds were chemically controlled along with one cultivation of the corn. A combination of 3 qt Lasso plus 2½ lb Bladex/A was applied preemergence each year for corn. Soybeans received 3 qt Lasso plus 5 qt Amiben/A applied preemergence. Broadleaf weeds in the wheat were controlled with ¼ lb MCPA plus ¼ lb Bromoxynil/A. Wheat + alfalfa received no herbicide.

All corn plots regardless of the preceding crop received a band-applied insecticide at planting. The insecticide rotation included Counter at 1 lb/A in 1977 and 1979 and Furadan at 1 lb/A in 1978.

Corn leaf samples were taken at silking from rows 2 and 5 of each six-row plot while rows 3 and 4 were mechanically harvested for yield. Grain moisture and protein data were obtained on the harvested samples.

Soil NO_3-N analyses were conducted on samples taken in increments of 1' to a depth of 5' each fall. The treatments sampled included all 0 and 160 lb N rates for corn plus random samples from the soybeans, wheat and wheat + alfalfa areas.

All plots were moldboard plowed in early November each year.

RESULTS

Corn yields with varying rates of N following the four previous crops are shown in Table 1. Yields in 1977 were high and reflected about a 20 to 30 bu/A advantage when following soybeans, wheat or wheat plus alfalfa. This advantage was greater at the lower N rates and somewhat narrower at the 200 lb rate. Yields were optimized with the 80-lb N rate except with continuous corn when 120 lb N/A was needed.

In 1978 and 1979 a significant response to N was obtained following all crops. Response was greatest for continuous corn and least with corn following wheat which had been interseeded with alfalfa. Corn yields were substantially higher when following soybeans and wheat. This was especially true at the low N rates. Even at the 200 lb N rate a 10-25 bu/A advantage was shown with soybeans or wheat.

Three-year yield averages (Table 1) over all N rates indicate an approximate 26 bu/A yield advantage for corn following soybeans, wheat, and wheat + alfalfa. Corn yields were optimized with 160 lb N/A following corn, 120 lb/A following soybeans and wheat + alfalfa, and 80 to 120 lb/A following wheat.

SUMMARY

These results indicate significant and economic yield depressions associated with continuous corn as compared to corn following soybeans, wheat or wheat plus alfalfa, regardless of N rate. Leaf and soil NO_3-N analysis (not included in this report) indicate slight affects of the previous crop. Hence, primary causative reasons or explanations must lie with factors other than soil fertility.

Table 1. Corn yields following various crops at Waseca in 1977, 1978 and 1979.

N rate		Corn yield following			
		Corn	Soybeans	Wheat	Wheat + Alfalfa
lb N/A		bu/A			
			1977		
0		96.8	145.6	147.3	120.2
40		124.2	158.4	158.6	140.4
80		129.5	165.0	167.0	161.2
120		143.4	168.3	171.6	161.4
160		147.3	174.3	168.3	168.2
200		151.1	171.1	171.2	163.0
	Avg.	132.0	163.8	164.0	152.4
			1978		
0		89.0	110.2	111.1	135.2
40		124.4	143.8	153.2	154.3
80		135.5	162.0	171.7	164.2
120		142.9	167.8	171.4	179.3
160		154.1	178.5	174.3	176.2
200		156.7	176.0	181.6	179.3
	Avg.	133.8	156.4	160.6	164.8
			1979		
0		88.1	129.8	119.8	147.5
40		122.9	146.5	151.9	158.6
80		141.9	169.4	165.6	167.8
120		156.7	180.8	164.6	173.6
160		167.2	178.5	178.8	183.5
200		170.0	186.4	182.0	171.7
	Avg.	141.1	165.2	160.4	167.1
			1977-79 AVG.		
0		91.3	128.5	126.1	134.3
40		123.8	149.6	154.6	151.1
80		135.6	165.5	168.1	164.4
120		147.7	172.3	169.2	171.4
160		156.2	177.1	173.8	176.0
200		159.3	177.8	178.3	171.3
	Avg.	135.6	161.8	161.7	161.4

USE OF TERRAZOLE (DWELL) AS A NITRIFICATION INHIBITOR IN FALL VS. SPRING NITROGEN APPLICATION PROGRAMS FOR CORN PRODUCTION IN SOUTHERN MINNESOTA

G.L. Malzer and G.W. Randall

The use of nitrification inhibitors on the heavy wet soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification, but there is only one currently on the market (N-Serve-Dow Chemical, U.S.A.). An experimental chemical Terrazole (Olin Corporation) has shown nitrificide characteristics and was evaluated under field conditions at the Southern Experiment Station at Waseca, MN in 1979. The objectives of the trial were to evaluate not only rate of nitrogen application but also timing of application and comparisons of different nitrogen forms with and without the use of Terrazole.

Experimental Procedures

Seventeen treatments including a control, two rates of nitrogen (75 and 150 #N/A), with two nitrogen forms (urea and anhydrous ammonia) were applied as fall (Oct. 30) or spring (May 7) treatments with or without Terrazole (0.5 #ai/A). Urea was broadcast and immediately incorporated after application with Terrazole (Dwell) treatments consisting of coatings on the urea fertilizer. The anhydrous ammonia treatments were injected at 30" knife spacings, and Terrazole applications were made simultaneously with the use of a dual-tube anhydrous shank and a separate pressurized system for application of the Terrazole. All treatments were replicated four times and arranged in a randomized complete block design. Corn (Pioneer 3732) was planted into the experimental area in 30" rows at a seeding rate of approximately 27,000 seeds/A.

Leaf samples were collected from opposite and below the ear at silking, dried, and Kjeldahl nitrogen determined. Dry matter production was determined by harvesting 15' of row from each plot at physiological maturity separating the sample into ears and stover and subsamples collected for moisture determination and Kjeldahl nitrogen analysis for calculation of nitrogen removal. Corn grain yields were collected by machine harvesting the center two rows from each plot and collecting subsamples for moisture determination and Kjeldahl nitrogen.

General Results

Grain yields were excellent in 1979 with yield responses to the application of nitrogen fertilizer up through the 150 #N/A rate. In general there was very little difference between times of fertilizer nitrogen application. Urea did not appear to perform as well as anhydrous ammonia. The nitrification inhibitor did not result in across-the-board yield increases, although significant yield advantages were obtained with the use of Terrazole when it was applied with fall urea. The difference obtained within yield on these treatments were, however, not reflected in corn forage production or total nitrogen removal. Care should therefore be exercised in evaluating those treatments.

Table 1. Influence of nitrogen form, rate of application, time of application, and use of Terrazole (Dwell) as a nitrification inhibitor on various yield components and nitrogen utilization characteristics of corn.

Treatments						Corn Forage Production							
						Stover			Grain			Total	
Date of Appl.	N Rate	N Form	Inhibitor	Leaf N	Yield Grain	Yield	N	N Removal	Yield	N	N Removal	Yield	N Removal
	#/A		0.5#ai/A	%	bu/A	T/A	%	#/A	T/A	%			
Control	-	-	-	2.06	124.4	4.43	0.43	37.9	3.05	1.10	67.2	7.48	105.1
Fall	75	Urea	No	2.74	161.2	4.91	0.53	51.5	3.96	1.23	97.2	8.87	148.7
Fall	75	Urea	Yes	2.70	173.3	4.97	0.57	57.1	4.07	1.23	100.6	9.03	157.7
Fall	75	A.A.	No	2.78	177.9	5.09	0.60	60.3	4.00	1.28	102.5	9.10	162.8
Fall	75	A.A.	Yes	2.74	176.3	4.68	0.54	50.7	3.94	1.25	98.3	8.62	149.0
Fall	150	Urea	No	2.88	173.4	5.16	0.60	62.1	4.35	1.26	109.4	9.51	171.5
Fall	150	Urea	Yes	2.87	187.2	5.08	0.59	59.9	4.22	1.28	107.9	9.30	167.8
Fall	150	A.A.	No	2.88	185.6	4.83	0.63	61.2	4.18	1.32	110.3	9.01	171.5
Fall	150	A.A.	Yes	2.86	178.4	5.44	0.58	63.2	4.43	1.25	111.2	9.87	174.4
Spring	75	Urea	No	2.68	166.6	4.87	0.56	55.6	3.99	1.19	94.9	8.86	150.5
Spring	75	Urea	Yes	2.71	167.8	4.59	0.50	46.5	3.75	1.16	87.0	8.35	133.5
Spring	75	A.A.	No	2.85	171.9	5.01	0.57	57.6	4.15	1.26	104.1	9.16	161.7
Spring	75	A.A.	Yes	2.86	172.6	5.01	0.64	64.1	4.15	1.26	104.6	9.16	168.7
Spring	150	Urea	No	2.98	180.6	4.97	0.71	70.5	4.05	1.25	101.5	9.02	172.0
Spring	150	Urea	Yes	2.84	176.3	5.16	0.63	64.5	4.14	1.25	103.4	9.30	167.9
Spring	150	A.A.	No	2.96	183.4	4.96	0.71	70.5	4.19	1.29	108.2	9.15	178.7
Spring	150	A.A.	Yes	2.93	184.5	5.03	0.71	71.4	4.00	1.30	103.8	9.03	175.2
Significance				**	**	*	**	**	**	**	**	**	**
BLSD(.05)				0.17	10.5	0.55	0.09	11.1	0.33	0.05	9.4	0.73	17.3

CORRECTING CHLOROSIS OF SOYBEANS BY FOLIAR APPLICATION OF IRON

Gyles W. Randall
Southern Experiment Station
University of Minnesota
Waseca, MN
1979

It has been estimated that about 400,000 acres in Minnesota have a sufficiently high pH to exhibit iron chlorosis symptoms. The major agronomic crop that is currently adversely affected by chlorosis induced Fe-deficiency is soybeans. Chlorotic soybeans are a common occurrence and in many instances major seed losses result.

The purpose of this study was to determine if the foliar application of some new iron compounds to the leaves of iron-chlorotic soybeans would correct the deficiency and result in significant yield improvement.

Experimental Procedures

Two experimental sites were selected in late June on farmers fields in Nicollet and Redwood Counties. After application of the iron materials to the Redwood County site (July 1), the farmer applied Basagran to the field and severely injured the plants in the chlorotic area. No visual response to the foliar-applied iron was observed three weeks after application. This could have been due to the late application at the 3rd to 4th trifoliate stage which is somewhat after the recommended 2nd trifoliate stage. Because of no response and the poor condition of the plants, yields were not taken and the site was abandoned.

At the Nicollet County site (John Bluhm) the iron materials were applied on July 6 to Corsoy soybeans in the 3rd trifoliate stage. Treatments were replicated 8 times in single-row plots measuring 20' long. Application was at 9:30-10:30 A.M. on a cloudy mild day. All materials were applied with a stainless steel hand sprayer at a gallonage rate of 50 gpa with X-77 at 0.25% v/v. The iron application rates (lb Fe/A) are shown in Table 1. Response notes (color and phytotoxicity) were taken on July 26. Yields were taken on October 10 by hand harvesting 16' of row per plot and threshing with a stationary soybean thresher.

Results

Visual color response three weeks after iron application was apparent with only two treatments. A healthy, dark-green color appeared with the 138-Fe treatment; whereas, only a slight improvement in the green color was noted with Hamp-Iron.

Although phytotoxicity symptoms were not severe, greatest wrinkling of the leaves and leaf loss occurred with Eagle Iron applied at the high rate. Only slight phytotoxicity was seen with the lower rates of Eagle Iron and with Hamp-Iron and KE-MIN.

Yield results shown in Table 1 indicate a significant response to both 138-Fe and Hamp-Iron. The 138-Fe treatment was clearly superior to all treatments. Variability within the site was extremely high (CV=61). The 138-Fe and Hamp-Iron materials were the only treatments which resulted in a consistent, harvestable yield from all replications. Plants were completely dead and yields were not taken from 16 of the plots which were treated with the other materials.

Table 1. Influence of various iron products applied to the foliage of chlorotic soybeans in Nicollet County in 1979.

Iron Treatment Material	Rate	Seed Yield
	lb Fe/A	bu/A
Check	0	6.6
EDDHA chelate	1/	8.8
Sequestrene 138-Fe	.15	25.0
Fe KE-MIN	1.0	7.8
Hamp-Iron	0.2	15.5
Eagle Iron	0.6	6.8
" "	1.2	7.7
" "	2.4	5.9
Significance:		**
BLSD(.05) :		6.6
CV(%) :		61.

1/ Applied at the same chelate rate as the 138-Fe treatment.

Summary

Soybean yields were improved 378 and 234% by 138-Fe and Hamp-Iron, respectively, applied to severely chlorotic foliage at the 3rd trifoliate stage. Yield responses were not shown with the foliar application of Fe KE-MIN or Eagle-Iron.

SOYBEAN TILLAGE-HERBICIDE STUDY*

Waseca, 1979

G. W. Randall and G. E. Ham

Concern for soil erosion has increased interest in tillage methods that leave residue on the soil surface. In addition, tillage methods which require lesser amounts of energy yet result in an acceptable seed bed are being considered. In south central Minnesota soybeans are generally grown in a corn-soybean sequence; hence, large amounts of corn residue are present. The objective of the study is to determine the effect of various tillage-herbicide systems (residue management) on soil parameters, weed control and soybean production.

EXPERIMENTAL PROCEDURES

To evaluate various tillage-herbicide systems on soybean production following corn, an experiment consisting of 8 tillage-herbicide treatments was established in the fall of 1978 on a Webster clay loam (2 reps) and Nicollet clay loam (4 reps) at the Southern Experiment Station. The primary tillage treatments include no tillage, fall moldboard plow, fall chisel plow, combined fall and spring disking and a double spring disking. The latter three treatments were split to also evaluate methods of herbicide application with minimum tillage. A preplant incorporate herbicide (Treflan) was compared to a preemergence herbicide (Lasso). All plots were 125' long and 20' wide (8-30" rows).

In the fall of 1978, fertilizer was broadcast at a rate of 0+100+200 ($N+P_2O_5+K_2O$/A) before any tillage was started. Row-placed fertilizer at planting was not used.

The no tillage, moldboard and chisel plow treatments were stalk chopped on October 27 and were immediately followed by the fall moldboard, chisel and disk tillage operations. Corn stalks on the spring disk treatments were allowed to stand throughout the winter. Secondary tillage was conducted on May 24. All chisel and disk treatments were disked with Treflan being applied at 1 qt/A to the PPI treatments. The fall plow and chisel treatments were field cultivated the same day.

Soybeans (Corsoy) were planted at 8.5 beans/foot on May 25. A John Deere Max-Emerge planter with 2" fluted coulters was used on all plots. On May 25 the preemergence herbicide treatment (Lasso, 3 qt/A) was applied. Amiben at a rate of 5 qt/A was superimposed over all plots on the same date. All plots were cultivated once on July 3.

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*This project was financed through support by Minnesota Soybean and Promotion Board.

Thermocouples were installed at the 4-inch depth directly below the soybean row on June 1. Surface residue amounts were measured on June 12. On July 11 population counts were taken and early plant growth was determined by harvesting and drying the above ground portion of 16 randomly selected plants from each plot. Nutrient composition of these samples was also determined. Uppermost, mature trifoliate samples were taken on August 3 for chemical analysis. Volunteer corn population counts were taken by counting the total number of single plants or clumps (if a large number of plants emerged from one ear) on July 11. Seed yields were determined by combine harvesting the center 4 rows from each plot on October 12.

RESULTS

Few differences in early plant nutrient concentrations were found (Table 1). Iron levels were lowest with no tillage due to reduced soil splash onto the tissue with the high level of surface residue present.

Table 1. Influence of primary tillage-herbicide combinations for soybeans following corn on the nutrient concentration of small whole soybean plants in 1979.

Treatment		Nutrient								
Tillage	Herbicide[1]	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage[2]	Pre	.32	2.38	1.56	.61	165	52	36	6.3	34
Fall plow[2]	Pre	.33	2.60	1.62	.57	237	59	36	6.4	31
Fall chisel[2]	Pre	.33	2.75	1.52	.54	205	54	34	6.6	31
Fall chisel[2]	PPI	.34	2.46	1.64	.59	228	54	39	6.6	33
Spr. disk (2x)	Pre	.32	2.57	1.56	.57	222	51	37	6.8	32
Spr. disk (2x)	PPI	.33	2.52	1.61	.59	254	52	40	6.6	33
Fall & Spr. disk	Pre	.33	2.67	1.50	.54	197	49	38	6.8	32
Fall & Spr. disk	PPI	.34	2.36	1.58	.59	222	48	39	7.4	33
Significance:		NS	NS	NS	NS	*	NS	NS	*	+
BLSD (.05) :						56			0.7	
CV (%) :		4.6	11.0	6.3	9.3	19.0	18.0	8.8	8.0	5.6

[1] Pre = Lasso (3 lb/A) PPI = Treflan (1 lb/A)

[2] These treatments were stalk chopped.

Dry matter per acre (product of DM/plant times plants/A) was affected significantly by the tillage treatments (Table 2). Dry matter accumulation five weeks after emergence was significantly less with no tillage compared to all other treatments. Differences among the moldboard plow, chisel or disk treatments were not significant.

These dry matter differences coupled with the associated nutrient concentration resulted in large tillage treatment differences in uptake of all nutrients (Table 2). No tillage showed significantly lower P, K, Ca, Fe, Cu and B uptake values than any other tillage treatment. Significant differences in uptake values were not found among the other tillage treatments.

Table 2. Influence of primary tillage-herbicide combinations for soybeans following corn on small plant dry matter accumulation and nutrient uptake in 1979.

Treatment			Nutrient								
Tillage	Herb.	DM	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		lb/A									
No tillage	Pre	625	2.03	14.7	9.8	3.83	.104	.032	.023	.0040	.021
Fall plow	Pre	911	2.98	23.8	14.7	5.21	.214	.053	.033	.0059	.028
Fall chisel	Pre	862	2.86	23.4	13.1	4.69	.178	.046	.030	.0057	.027
Fall chisel	PPI	823	2.77	20.6	13.3	4.87	.181	.044	.033	.0055	.027
Spr. disk (2x)	Pre	812	2.60	20.8	12.6	4.69	.184	.041	.030	.0056	.026
Spr. disk (2x)	PPI	887	2.96	22.4	14.3	5.26	.225	.047	.036	.0059	.030
Fall & Spr. disk	Pre	899	3.00	24.2	13.4	4.88	.174	.043	.034	.0061	.028
Fall & Spr. disk	PPI	884	3.00	21.0	13.9	5.26	.195	.043	.035	.0066	.029
Significance:		**	**	**	**	*	**	*	**	**	**
BLSD (.05)	:	116	0.44	5.0	2.1	0.93	.058	.012	.007	.0013	.004
CV (%)	:	11.7	13.1	18.3	13.2	14.3	25.3	20.3	17.1	17.7	12.7

At the mid-bloom stage (three weeks after the whole plants were sampled), differences in the nutrient concentrations of the plants were generally not found among the eight tillage treatments (Table 3). Only slight unexplainable differences in Ca and Mn were found.

Table 3. Influence of primary tillage-herbicide combinations for soybeans following corn on the leaf nutrient concentration of soybeans in 1979.

Treatment		Nutrient[1/]								
Tillage	Herbicide	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	Pre	.46	2.53	1.05	.39	92	74	35.7	7.0	51
Fall plow	Pre	.43	2.41	0.98	.39	93	57	34.9	6.4	50
Fall chisel	Pre	.44	2.40	0.96	.36	93	68	34.2	5.9	49
Fall chisel	PPI	.44	2.61	1.00	.37	92	70	35.2	5.9	51
Spr. disk (2x)	Pre	.43	2.61	1.01	.36	83	66	35.2	6.3	50
Spr. disk (2x)	PPI	.42	2.46	0.98	.35	95	64	35.7	6.3	50
Fall & Spr. disk	Pre	.42	2.35	1.00	.36	104	61	35.4	6.1	47
Fall & Spr. disk	PPI	.43	2.44	0.97	.35	92	60	35.3	6.8	49
Significance:		NS	+	**	NS	NS	**	NS	NS	NS
BLSD (.05)	:			0.04			7.4			
CV (%)	:	8.0	6.9	3.5	9.5	15.7	9.5	8.3	12.3	4.9

[1/] Uppermost, mature trifoliate leaf at mid-bloom.

Very high corn residue levels were found after the 1978 corn crop. However, about 70% of the surface residue was incorporated by chisel plowing (Table 4). Double spring disking incorporated approximately 44% of the residue. Slightly more residue (56%) was incorporated with the combined fall and spring disk treatment.

Soil temperatures at the 4-inch depth after planting were quite high and ranged from 64 to 72°F over the four-week period (Table 4). Fairly consistent temperature differences among tillage treatments were noticed. Moldboard plowing always resulted in the highest temperatures with lowest temperatures found under no tillage. Intermediate temperatures were associated with the disk and chisel treatments.

Table 4. Surface residue accumulation and average 4-inch soil temperature as influenced by tillage method for soybeans following corn in 1979.

Treatment		Surface residue	Soil temperature			
Tillage	Herb.	accumulation	6/4-8	6/11-15	6/18-22	6/25-29
		T DM/A	°F			
No tillage	Pre	5.9	68.1	65.8	63.7	70.3
Fall plow	"	0.6	70.0	67.7	64.1	72.2
Fall chisel	"	1.7	68.9	66.5	64.0	71.9
Spr. disk (2x)	"	3.3	68.3	66.2	64.1	71.1
Fall & Spr. disk	"	2.6	68.0	65.9	64.0	71.2
Significance:		**				
BLSD (.05) :		0.6				
CV (%) :		15.0				

Statistical differences in early plant growth were found among the tillage treatments in 1979 (Table 5); perhaps partly due to the soil temperature differences. Smallest plants were associated with no tillage. No differences were found among the other treatments.

Volunteer corn was not a problem at this site in 1979. Although a trend toward reduced volunteer corn population was evident with Treflan, these differences were not significant because of the high variability and low corn levels. Contrary to popular opinion, moldboard plow tillage did not reduce volunteer corn population and showed the highest level.

Nitrogen fixation values were obtained by Dr. Ham and students in July (Table 5). Highest N fixation was shown with the double spring disk treatment, intermediate values with the chisel and the fall and spring disk treatments and lowest values with no tillage and moldboard plowing.

Slight differences in the final bean population were shown in 1979 (Table 5). Highest population was obtained with moldboard plow tillage with slightly lower stands occurring with reduced tillage. In contrast to past years, Treflan did not reduce stand in comparison to Lasso. Stands were considered to be adequate for maximum yields in all cases.

Soybean yields were depressed considerably and statistically with no tillage (Table 5). Little difference in yields was found among the other treatments. The highest yield was obtained with the double spring disk treatment with Treflan. A trend toward slightly lower yields with the preemergence herbicide compared to the preplant incorporated herbicide was noticed. Similarily, weed control (primarily grass) was slightly better with the PPI herbicide in 1979; probably due to the higher surface residue levels which may have inactivated the preemergence herbicide somewhat.

Three-year averages show that optimum soybean yields can be obtained with reduced tillage following corn (Table 5). Marked yield reductions only occurred with no tillage.

Table 5. Influence of primary tillage-herbicide combinations for soybeans following corn on early growth, volunteer corn, population and soybean yield in 1979.

Treatment		Early plant growth	Volunteer[1/] corn	Nitrogen fixation index	Final population	Seed Yield	
							1977-79
Tillage	Herb.					1979	Avg.
		g/plant	plants/A	ul/plant /hr	beans/ft.	----bu/A----	
No tillage	Pre	2.3	0	6.4	7.0	30.8	41.1
Fall plow	Pre	3.1	38	6.2	7.6	46.1	51.4
Fall chisel	Pre	3.1	23	7.6	7.2	44.9	49.9
Fall chisel	PPI	3.1	6		7.0	46.8	51.2
Spr. disk (2x)	Pre	3.0	32	9.8	7.0	43.7	49.1
Spr. disk (2x)	PPI	3.4	6		6.7	47.9	49.9
Fall & Spr. disk	Pre	3.2	17	7.6	7.2	43.6	49.3
Fall & Spr. disk	PPI	3.3	9		7.1	46.7	49.9
Significance:		**	NS		*	**	
BLSD (.05) :		0.5			0.5	4.0	
CV (%) :		12.8	160.		5.0	7.5	

1/ Each clump of corn was counted as one plant.

SUMMARY

Optimum soybean yields were obtained in 1979 with reduced tillage systems. Surface residue accumulations of up to 5.9 T/A did influence soybean development somewhat and appeared to hinder weed control slightly. No tillage resulted in slightly cooler soils, smaller plants and in very poor weed control (primarily broadleaves and some grasses). Grass control was slightly better with Treflan with the disk and chisel systems. Volunteer corn populations were too small to evaluate the treatments thoroughly. These results indicate that soybean production following corn can be excellent with tillage systems that manage surface residue, thus, limiting soil erosion.

PLANTERRA AND SOIL INOCULANT

1979

Waseca, Minnesota

D.K. Langer, G.W. Randall & G.E. Ham

In 1978 World Agrisearch Corporation marketed a product called Planterra which contained non-symbiotic forms of N fixing bacteria and blue-green algae. With the change of supplier in 1979 the product was called Soil Inoculant which is basically the same product with one less bacteria species. That change also enabled Soil Inoculant to be combined with pesticides or liquid fertilizers for application. World Agrisearch claims that their product "decomposes crop residues, builds soil humus, and accelerates the nitrogen cycle". They state that this totally natural and safe product makes available the nitrogen, phosphorous, potassium, secondary and trace elements needed for crop production. Another claim is that a more stable form of "nitrogen is slowly released all through the growing season for even feeding of the growing crop". The purpose of this study was to evaluate Planterra on corn production and Soil Inoculant on soybean production in south-central Minnesota.

Experimental Procedures

Planterra-corn

The study was established on a Nicollet clay loam soil which had corn removed as silage the previous year. Fall P and K fertilizer was applied to the area at the 100 + 200 lb/A rate, respectively, (oxide basis). Treatments were arranged in a six-replicate, randomized, complete-block design and included a check, Planterra, 60 and 150-lb N treatments. The 60-lb N treatment was chosen as economically comparable in price to the Planterra treatment. After tillage Planterra was applied November 8, 1978 at the recommended rate of 0.1 gal Planterra + 30 gal H_2O/A. Corn (Pioneer 3732) was planted at a rate of 27,900 ppA in 30-inch rows on May 16 with 1 lb Counter/A and 140 lb 0-23-30 as starter fertilizer. Chemical weed control consisted of 3 lb Lasso and 2½ lb atrazine/A applied pre-emergence.

The leaf opposite and below the ear was sampled from 12 plants at silking and submitted for nitrogen analysis. Silage samples taken from 15 feet of row at physiological maturity (black layer stage) were measured for yield and submitted for nitrogen analysis. Grain yield, moisture and protein were determined on corn combine harvested from the center two rows of each 4-row plot. Grain yields were converted to 15.5% moisture.

Soil Inoculant-soybeans

Two different soybean lines (Hodgson 78 and 129-nonnod) were planted May 21 on a Nicollet clay loam soil at a rate of 5 beans/foot in 14-inch rows. This area received 100 + 200 lb P and K/A (oxide basis) the previous fall. Treatments were arranged in a six-replicate, randomized, complete-block design. The Soil Inoculant was soil-applied June 6 at the recommended rate of 0.1 gal Soil Inoculant + 30 gal H_2O/A. Chemical weed control consisted of 1 qt Treflan/A ppi and 5 qts Amiben/A postemergence. Seed yield was determined on soybeans combine harvested from the center four rows of each plot.

Results

Planterra-corn

Nitrogen concentration in the corn leaf was significantly higher in the 60 and 150-lb N treatments compared to the check and Planterra (Table 1). The fodder nitrogen content shows the 150-lb N treatment to be significantly better than all the other treatments and the 60-lb N superior to the check and Planterra. Grain and silage yields with the 150-lb N treatment were significantly better than all other treatments with the 60-lb N treatment superior to the check and Planterra treatments. Grain protein and moisture showed a significant advantage for the 60 and 150-lb N treatments over the check and Planterra. All of the above results would indicate no positive effect due to Planterra on corn production in south-central Minnesota.

Table 1. Influence of Planterra on the nitrogen concentrations in the corn leaf and fodder, silage yield, grain yield, moisture and protein content at Waseca in 1979.

Treatment	Nitrogen		Yield		Grain	
	Leaf	Fodder	Silage	Grain	Moisture	Protein
	-----%------		T DM/A	bu/A	--------%--------	
Check	1.74	.318	6.69	108.7	32.1	6.56
Planterra	1.60	.353	6.68	110.8	32.1	6.36
60 lb N	2.55	.456	8.54	159.6	30.2	7.69
150 lb N	2.68	.539	9.18	172.4	30.4	8.05
Signif:	**[1]	**	**	**	**	**
BLSD(.05):	.17	.068	.45	8.9	.6	.41
CV (%):	7.0	14	5.2	5.8	1.8	5.2

[1] ** designates significance at the 99% level.

Soil Inoculant-soybeans

The Soil Inoculant was applied on two different soybean lines. Hodgson 78 is a well adapted, widely grown variety that symbiotically fixes nitrogen. The 129-nonnod line is not capable of nodulation and thus does not fix nitrogen. One would expect that if Soil Inoculant non-symbiotically fixes N that it would be demonstrated by higher yields with the nonnod line receiving Soil Inoculant. Yields shown in Table 2 indicate no advantage for the use of Soil Inoculant with either line of soybeans. Thus, Soil Inoculant was not fixing or releasing sufficient N for improved soybean production.

Table 2. Influence of Soil Inoculant on soybean yield of two different lines at Waseca in 1979.

Line	Treatment	Yield
		bu/A
Hodgson 78	Control	36
Hodgson 78	Soil Inoculant	36
129-Nonnod	Control	14
129-Nonnod	Soil Inoculant	14

Summary

Corn leaf nitrogen, fodder nitrogen, silage yield, grain yield, grain moisture and grain protein were not affected positively by Planterra. Soil Inoculant, the World Agrisearch product that is similar to, and is being marketed in place of Planterra, showed no effect on soybean yield at Waseca in 1979.

SYMBEX

1978-79 Summary

Waseca, Minnesota

D.K. Langer and G.W. Randall

The Symbex system was developed and is being marketed by the Agro-K Corporation. The Symbex system includes three phases: (1) Symbex soil inoculant, (2) Sym-Coat seed treatment, and (3) Sym-Spray foliar spray. Symbex soil inoculant contains inactive ingredients of 41% water and 57% whey. The 2% active ingredients contain fungi, bacteria, yeasts, and according to Agro-K an enzyme system with activator which causes rapid breakdown of crop residue. Agro-K claims that this should release and make available the nitrogen, phosphorus, and potassium already in the soil so they can be utilized by the crop. Sym-Coat seed treatment increases and accelerates germination states Agro-K with resulting healthier stands. Sym-Spray foliar feeds micronutrients and is a growth regulator declares Agro-K. The purpose of this two-year study was to evaluate the effect of the Symbex system compared to conventional fertilizer and a check on continuous corn production on a medium fertility soil in south-central Minnesota.

Experimental Procedures

1978

The experiment was established in 1978 on a Nicollet clay loam soil which had not received fertilizer since 1974. Corn grown on the area the previous year was removed as silage. Treatments were arranged in a four-replicate, randomized, complete-block design and included a check, Symbex, Symbex + 30 lb N/A, and 175 lb N/A. The complete Symbex system was applied to the Symbex treatments at the recommended rates (Symbex:1 gal/A, Sym-Coat:10 g powder/10 lb seed, Sym-Spray: .05 gal + 9 lb N/A).

Symbex soil inoculant was applied May 1 and corn (Pioneer 3780) was planted at a rate of 26,100 ppA in 30-inch rows with 1 lb Furadan/A on May 15. The Symbex plots received Sym-Coated seed. Chemical weed control consisted of 3 lb Lasso/A plus 2½ lb Bladex/A applied preemergence. The nitrogen for the Symbex + 30 lb N/A treatment was sidedressed as feed-grade urea and the 175 lb N/A treatment was sidedressed as fertilizer-grade urea. The addition of 30-lb N/A to the Symbex treatment was done at the request of Agro-K because the Symbex soil inoculant was spring-applied rather than fall-applied. Both sidedressed treatments were cultivated in after application on June 17. Sym-Spray plus 9 lb N/A as feed-grade urea was applied to the Symbex treatments on July 24 just prior to tasseling. After the yields were determined the corn was removed as silage.

1979

The 1979 plots were superimposed over the 1978 plots to retain the accumulative effect of the treatments. Symbex plots thus received the soil inoculant in the spring of 1978 and again on November 7, 1978. In 1979 the Symbex plots also received the Sym-Coat and Sym-Spray treatments at the same rates as in 1978.

Soil samples taken after the 1978 crop indicated a NPK fertilizer recommendation of 160 + 80 + 100 lb/A (oxide basis). It was suggested by Agro-K to split the fertilizer treatment: (a) 100% NPK (160 + 80 + 100 lb/A) and (b) 50% NPK (80 + 40 + 50 lb/A). Each fertilizer rate was applied with and without the Symbex system and was superimposed by splitting the plots established in 1978 (the Symbex + 30 lb N and the 175 lb N treatments). The other treatments included in the experiment were the Symbex system alone and a check. Treatments were again arranged in a four-replicate, randomized, complete-block design. Corn (Pioneer 3780) was planted at a rate of 26,100 ppA in 30-inch rows with 1 lb Counter/A on May 18. Chemical weed control consisted of 3 lb Lasso plus 2½ lb atrazine/A applied pre-emergence. Sym-Spray plus 9 lb N/A as feed-grade urea was applied to the Symbex treatments on July 26.

In both years the leaf opposite and below the ear was sampled from 12 plants at silking and submitted for chemical analyses. Silage yields were obtained at physiological maturity (black layer stage) from 10 feet of row in 1978 and 20 feet of row in 1979. In both years corn grain yield, moisture and protein were determined on corn harvested from 40 feet of the center two rows. The grain data were collected at physiological maturity and yields were converted to 15.5% moisture because the corn in the plot area was to be removed as silage.

Results

1978

The nutrients N, P, Mg, Mn, Zn, and Cu were all increased significantly in the corn leaf with the addition of 175 lb N/A (Table 1). Symbex without the 30 lb N treatment had no effect on leaf nutrient concentration. Symbex + 30 lb N/A did tend to increase some of the nutrient concentrations probably due to the added nitrogen; however, none of these increases was statistically significant.

Table 1. Influence of Symbex on the nutrient concentrations in the corn leaf at Waseca in 1978.

Treatment	Nutrient[1] N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Check	1.79	.19	1.58	.62	.43	119	37	22	5.2	9
Symbex	1.91	.20	1.59	.57	.44	109	39	20	4.6	9
Symbex + 30 lb N/A	2.10	.21	1.60	.60	.45	120	40	25	5.7	9
175 lb N/A	2.58	.24	1.51	.64	.53	124	51	32	7.8	9
Signif. :	*[2]	+	NS	NS	**	NS	**	**	**	NS
BLSD(.05):	.58				.04		8	6	1.3	
CV (%) :	16.2	12.3	6.5	8.8	5.2	11.1	11.5	14.6	14.1	9.4

[1] Leaf opposite and below the earleaf was sampled at silking.

[2] **, *, + are significant at the 99, 95 and 90% levels, respectively. NS = not significant at the 90% level.

Silage yield, grain yield and grain protein with the 175 lb N/A treatment were significantly higher than with any of the other treatments (Table 2). The Symbex + 30 lb N/A treatment resulted in a significantly better grain yield than the check and significantly higher grain protein than the check and the Symbex treatment. This indicates that the additional 30 lb N/A with the Symbex caused the increase in protein percentage. These results show that Symbex did not enhance corn production in south-central Minnesota in 1978.

Table 2. Influence of Symbex on corn yields, protein, and moisture content at Waseca in 1978.

Treatment	Yield: Silage	Yield: Grain	Grain: Moisture	Grain: Protein
	T DM/A	bu/A	%	%
Check	3.85	73.6	43.1	5.88
Symbex	4.69	77.1	43.0	6.00
Symbex + 30 lb N/A	4.80	92.2	41.2	7.12
175 lb N/A	5.82	112.8	40.2	9.81
Significance:	**	**	NS	**
BLSD (.05) :	.96	16.7		.88
CV (%) :	12.3	11.8	4.3	8.6

After harvest soil samples were taken from each plot and submitted for a complete soil analysis by Harris Laboratories (Table 3). The resulting data indicate that the various treatments had little effect over the background level of the check treatment.

Table 3. Influence of Symbex on soil test results at Waseca in 1978.

Treatment	OM	pH	NO_3-N	P	K	Ca	Mg	Na	S	Fe	Mn	Zn	Cu	B
	%	ppm												
Check	3.2	6.2	4.0	16	100	2325	400	22	10	60.8	8.0	.9	.7	1.2
Symbex	4.1	6.2	2.5	11	98	2375	452	21	10	68.6	9.0	1.0	.7	1.0
Symbex + 30 lb N/A	3.2	6.2	2.2	13	112	2350	395	20	9	58.0	9.1	1.0	.8	1.0
175 lb N/A	3.4	6.0	5.0	13	98	2375	372	20	10	68.4	9.2	1.0	.7	1.0

1979

Nutrient concentrations of N, P, Ca, Mg, Fe, Zn and Cu in the corn leaf showed the check and Symbex treatments to be significantly inferior when compared to the fertilizer treatments either with or without Symbex (Table 4). The 100% NPK with or without Symbex was significantly better than the 50% NPK with or without Symbex with respect to N, P and K. The 100% NPK with or without Symbex and the 50% without Symbex treatments resulted in significantly more Mn than the other treatments. Nutrient concentrations of B in the corn leaf showed no significant differences among the treatments. These nutrient concentration data give no indication that the Symbex treatments result in consistent increases in nutrient uptake by corn.

Table 4. Influence of Symbex on the nutrient concentrations in the corn leaf at Waseca in 1979.

Treatment	Nutrient[1/] N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Check	1.26	.174	1.38	.53	.43	70	30	18	3.0	7
Symbex	1.42	.188	1.35	.55	.48	75	34	18	3.1	8
50% NPK(bdct)	2.61	.241	1.31	.72	.65	87	56	38	6.3	7
Symbex + 50% NPK(bdct)	2.44	.240	1.38	.71	.66	86	42	38	6.3	8
100% NPK(bdct)	2.78	.262	1.44	.72	.62	90	72	40	7.0	7
Symbex + 100% NPK(bdct)	2.84	.278	1.57	.67	.59	92	59	38	6.9	8
Significance:	**	**	**	**	**	**	**	**	**	NS
BLSD (.05) :	.17	.017	.13	.09	.05	7	14	5	.8	
CV (%) :	5.7	5.6	6.0	9.1	6.8	6.0	20	7.1	10	14

1/ Leaf opposite and below the earleaf was sampled at silking.

The nutrient concentrations in the fodder as affected by the treatments are somewhat difficult to interpret (Table 5). Significantly higher concentrations of P and Zn were found with the check and Symbex treatments. This may be explained as a concentration of these elements due to the very low dry matter accumulations shown with these two treatments (Table 6). The NPK treatments resulted in lower P and Zn levels with no difference shown for the addition of Symbex. Concentrations of N, K, Ca, Mg and Cu were generally increased by the NPK treatments with and without Symbex over the check and Symbex treatments. With the exception of K, the addition of the Symbex did not appear to increase nutrient levels in the corn fodder.

Table 5. Influence of Symbex on the nutrient concentrations in the corn fodder at Waseca in 1979.

Treatment	Nutrient[1/]									
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
Check	.36	.118	.61	.27	.26	58	47	24	1.1	6
Symbex	.42	.073	.64	.27	.26	50	51	26	1.2	5
50% NPK(bdct)	.48	.046	.67	.38	.38	51	51	14	1.5	5
Symbex + 50% NPK(bdct)	.51	.043	.74	.33	.33	42	43	16	1.6	5
100% NPK(bdct)	.66	.054	.80	.41	.37	58	60	19	1.9	5
Symbex + 100% NPK(bdct)	.51	.048	1.00	.35	.33	52	40	14	2.1	5
Significance:	**	**	**	**	**	NS	NS	**	**	NS
BLSD (.05) :	.13	.012	.10	.07	.07			4	.5	
CV (%) :	18	14	9.8	14	14	18	20	16	20	10

[1/] Corn silage minus the grain.

Grain yields showed the check to be inferior to all other treatments and the Symbex significantly inferior to all the NPK treatments (Table 6). The 100% NPK treatments were significantly better than the 50% with no significant advantage for the addition of Symbex. One possible explanation for the Symbex being superior to the check for grain yield could be the addition of the 9 lb N/A supplied in the Sym-Spray. This is theorized because of the greener color and increased vigor of the plants after the Sym-Spray + 9 lb N/A application. Silage yields show that the check and Symbex were inferior to the NPK treatments with the 100% significantly better than the 50% and no effect of Symbex. Protein was increased significantly by the NPK treatments over the check and Symbex treatments. The 100% NPK treatments contained more protein than the 50% treatments with no advantage from the addition of Symbex. For grain moisture the 100% NPK treatments and the Symbex + 50% NPK were significantly better than the check and Symbex alone.

Table 6. Influence of Symbex on corn yields and moisture and protein content at Waseca in 1979.

Treatment	Yield		Grain	
	Silage	Grain	Moisture	Protein
	T DM/A	bu/A	%	%
Check	3.87	67.8	47.6	5.38
Symbex	4.18	79.0	47.8	5.53
50% NPK (bdct)	6.98	139.7	45.4	7.42
Symbex + 50% NPK (bdct)	6.97	143.8	43.6	7.08
100% NPK (bdct)	7.60	152.1	43.5	8.24
Symbex + 100% NPK (bdct)	7.64	158.0	43.9	8.34
Significance:	**	**	*	**
BLSD (.05) :	.34	8.9	3.2	.68
CV (%) :	4.1	5.4	4.4	7.2

Summary

Nutrient concentrations in the corn leaf were not affected by Symbex in either year. The nutrient concentrations in the fodder were not increased with the addition of Symbex except for K in 1979. Thus nutrient uptake by corn does not appear to be consistently increased by Symbex. Silage yield was not affected by Symbex in 1978 or 1979. The only positive effect Symbex had on grain yield was an increase over the check treatment in 1979. This increase was possibly due to the 9 lb N/A supplied in the Sym-Spray treatment. Grain yields with the N or NPK treatments were vastly superior to those from the Symbex alone treatment. Symbex had no effect on protein in this two-year study. At this time we would not recommend the Symbex system for corn production in Minnesota.

DEEP SAMPLING OF SOILS FOR RESIDUAL NITRATES AND ITS POTENTIAL AS A DIAGNOSTIC TECHNIQUE FOR CORN PRODUCTION IN SOUTHWESTERN MINNESOTA

G.L. Malzer, G. Holcomb, W.W. Nelson, and S. Evans

The rates of fertilizer nitrogen recommended for corn production in Minnesota are currently based upon yield goal and previous cropping history. In many respects depending on the climatic conditions, these recommendations have the potential of being either too high or too low. Research experiments were therefore, established with the following objectives: 1) To determine if the residual nitrates within the top five feet of soil or to a lesser depth could be used in predicting nitrogen fertilizer requirements for corn; 2) To evaluate fall vs. spring soil sampling; 3) to ascertain the importance of nitrate accumulation and movement within the soil profile.

Experimental Procedures

Nine locations in southwestern Minnesota were established in the fall of 1978. One location was located on the Southwest Experiment Station-Lamberton, one at the West-Central Experiment Station-Morris, and seven locations on farmer cooperator fields (Table 1). At each location, four treatments were established with four replications. The four treatments were applied as fall applications of ammonium nitrate at rates of 0, 40, 80, and 120 #N/A. Soil samples were collected from each plot prior to fertilizer application in the fall and from the control plots (zero N/A) in the spring. Samples were collected to a depth of five feet in increments of one foot, except for the surface which was split into six inch increments. All samples were analyzed for nitrate nitrogen and soil moisture (Table 3). All cooperators were asked to follow normal management practices for the areas except for nitrogen fertilization or manure application. Treatments were evaluated by obtaining leaf samples from opposite and below the ear at silking for nitrogen analysis, grain yields and nitrogen utilization by the grain (Table 2).

Grain Results

Of the nine locations established for 1979, one location was lost due to hail (location 3); three locations showed significant positive yield increases due to nitrogen application, and five locations revealed no significant yield response to applied nitrogen. Other nitrogen utilization characteristics would suggest that location 1 which did not show a significant yield response should be included into the areas which responded favorably to nitrogen fertilization.

Nitrogen content in leaf tissue at silking time was influenced by the nitrogen treatments on seven out of eight locations. Three of these locations were, however, above the critical level (2.5-2.7%) even on the control so we would not expect a yield response. The four locations where nitrogen was limiting correspond to the same locations that provided yield responses. Nitrogen content in the grain and total nitrogen removal with grain, substantiate the fact that four locations did not respond to nitrogen fertilization while four locations responded to at least the first increment of nitrogen fertilization.

Yields and nitrogen utilization appeared to be highly correlated with soil nitrate nitrogen. The two foot nitrate nitrogen test currently used for small grains and sugarbeets in this area of the state did not do a satisfactory job in predicting nitrogen needs. Most locations ranged from 40-80 pounds of NO_3^--N in the top two feet, which would not provide the necessary flexibility for making fertilizer recommendations. Inclusion of the nitrate nitrogen to a depth of four feet did a much better job in predicting nitrogen responses. On seven out of eight locations, if the total nitrate nitrogen in the top four feet was greater than 150 #N/A yield responses were not obtained. In only one location (8) did the four foot sample nitrate soil sample not make an accurate prediction of nitrogen response.

The use of a nitrate test for making fertilizer recommendations for corn appears to be a promising technique. Additional research to verify the depth necessary for sampling and the availability of the deeper soil nitrates under varying climatic conditions appear to be warranted.

Table 1. Location number, cooperator and county of the experimental site.

Location No.	Cooperator	County
1	Charles Anderson	Yellow Medicine
2	Cornelius Boerboom	Lyon
3	Clarence Feste	Murray
4	Donald Lensing	Redwood
5	Lamberton Station	Redwood
6	Carsten Madsen	Lincoln
7 (8)	Morris Station	Stevens
8 (9)	Lawrence Quade	Cottonwood
9 (12)	Donald Werner	Pipestone

Table 2. Influence of nitrogen treatments on grain yield, leaf N at silking, grain N and grain nitrogen removal at eight locations in S.W. Minnesota.

Nitrogen Rate	Location No. 1	2	4	5	6	8	9	12
#/A	Yield-bu/A							
0	125.2	90.0	137.9	127.6	132.2	92.5	115.7	75.1
40	127.3	109.1	128.4	131.6	131.8	109.8	136.2	82.9
80	132.4	109.2	140.6	129.7	124.9	114.0	134.4	96.8
120	143.0	117.2	138.4	131.3	133.1	124.8	129.3	84.2
Signif.	NS	**	NS	NS	NS	*	**	NS
BLSD(.05)	-	14.6	-	-	-	21.1	7.2	-
	Leaf N-%							
0	2.06	2.18	2.93	2.63	2.67	2.21	2.54	2.41
40	2.46	2.26	2.68	2.61	2.78	2.52	2.88	2.59
80	2.74	2.30	2.73	2.76	3.00	2.62	2.95	2.37
120	2.24	2.60	3.06	2.78	2.97	2.64	2.98	2.63
Signif.	**	+	*	NS	**	*	**	*
BLSD(.05)	0.24	0.28	0.29	-	0.19	0.27	0.26	0.21
	Grain N %							
0	1.19	1.24	1.21	1.44	1.46	1.33	1.34	1.14
40	1.32	1.13	1.20	1.43	1.42	1.37	1.49	1.15
80	1.41	1.18	1.22	1.36	1.48	1.41	1.62	1.24
120	1.41	1.24	1.26	1.43	1.50	1.48	1.57	1.25
Signif.	**	+	NS	NS	NS	+	**	NS
BLSD(.05)	0.09	0.09	-	-	-	0.10	0.10	-
	N Removal with Grain-#/A							
0	70.6	52.7	78.7	87.1	91.1	58.3	73.7	40.8
40	79.4	58.3	72.8	89.1	88.8	71.4	96.1	46.2
80	88.5	60.8	80.9	83.7	87.4	76.2	103.2	56.6
120	95.5	68.8	82.7	89.1	94.1	87.1	96.1	50.5
Signif.	**	*	NS	NS	NS	**	**	NS
BLSD(.05)	13.3	8.8	-	-	-	14.2	9.7	-

Table 3. Residual nitrate nitrogen content by depth at nine experimental locations in S.W. Minnesota measured in the fall and spring before the growing season

depth -ft-	Nitrate Nitrogen - #/A depth increment					
	Loc. 1(Soybeans)		Loc. 2(Soybeans)		Loc. 3(Corn)	
	Fall	Spring	Fall	Spring	Fall	Spring
0-½	14	14	16	18	12	29
½-1	9	11	13	9	21	30
1-2	18	25	13	17	42	45
2-3	31	29	12	17	53	30
3-4	34	31	14	16	31	23
4-5	22	25	15	14	19	14
TOTAL	128	135	83	91	178	171

	Loc. 4(Soybeans)		Loc. 5(Sunflowers)		Loc. 6(Corn)	
	Fall	Spring	Fall	Spring	Fall	Spring
0-½	18	26	21	25	24	23
½-1	15	30	19	18	17	19
1-2	18	28	29	27	22	24
2-3	40	28	37	41	40	30
3-4	57	113	43	82	61	52
4-5	57	125	37	60	50	52
TOTAL	205	350	186	253	214	200

	Loc. 8(Corn)		Loc. 9(Soybeans)		Loc. 12(Corn)	
0-½	19	19	31	22	12	38
½-1	11	14	13	16	11	18
1-2	37	34	17	34	14	34
2-3	64	50	25	23	15	32
3-4	41	26	27	19	18	68
4-5	26	18	30	21	19	42
TOTAL	198	161	143	135	89	232

( ) = previous crop

ECO-GRO STUDIES ON CORN

Lamberton and Morris, 1979

S. D. Evans and W. W. Nelson

The product Eco-Gro is a low analysis liquid fertilizer manufactured mainly from liquid fish and seaweed. It contains 6 lbs of pure fish per gallon with 4% seaweed added. In addition it is fortified with urea, phosphoric acid and potassium hydroxide ending up with a product with an 8-4-4 (N-P_2O_5-K_2O) analysis. It is to be used on corn as a supplement to the standard fertilizer program. Instructions for corn were to make one application of 1 quart per acre as a foliar spray when the corn was 24-30 inches tall and 1 quart per acre 8-10 days before tasseling.

The objectives of the experiments were to measure the effect of Eco-Gro on corn yield and nutrient uptake and to compare this with conventional fertilizer materials.

Treatment Description - Lamberton

1. Check - No fertilizer material of any kind added.

2. 1 qt/A of Eco-Gro (8-4-4) applied as a foliar spray on July 16 (corn 20 inches tall) and 1 qt/A of Eco-Gro on August 1 (10 days prior to tasseling)--both applied with Wex, a wetting agent.
   Total plant food ($N + P_2O_5 + K_2O$) = 0.39 + 0.19 + 0.19.

3. 65.6 lbs/A of N as urea prior to planting plus 154 lbs/A of 10-26-26 starter. Total plant food = 80.00 + 40.00 + 40.00.

4. Combination of treatments 2 and 3, but corn 36 inches tall on July 16 and first tasseling on August 1.
   Total plant food = 80.39 + 40.19 + 40.19.

5. 103.3 gal/A of Eco-Gro applied prior to planting and worked into the soil. Total plant food = 80.00 + 40.00 + 40.00.

Treatment Description - Morris

1. Check - No fertilizer material of any kind added.

2. 1 qt/A of Eco-Gro (8-4-4) applied as a foliar spray on July 6 (corn 29 inches tall) and 1 qt/A of Eco-Gro on July 25 (corn tasseled on August 4)--both applied with Wex, a wetting agent.
   Total plant food ($N + P_2O_5 + K_2O$) = 0.39 + 0.19 +0.19.

3. 65.6 lbs/A of N as urea prior to planting plus 154 lbs/A of 10-26-26 starter. Total plant food = 80.00 + 40.04 + 40.04.

4. Combination of treatments 2 and 3, but corn was 43 inches tall on July 6 and tasseled on July 30. Total plant food = 80.39 + 40.23 + 40.23.

5. 103.3 gal/A of Eco-Gro applied prior to planting and worked into the soil. Total plant food = 80.00 + 40.00 + 40.00.

The yield data for the trials at Lamberton and Morris for 1979 are given in Table 1. At Lamberton there were highly significant (**) differences in both silage and grain yield with treatments 1 and 2 lower yielding than 3, 4, and 5. The Eco-Gro foliar treatments--2 and 4--did not increase yields significantly over treatments 1 and 3, respectively. Treatment 5 was not significantly different from the conventional treatment 3.

At Morris there were again highly significant differences in both silage and grain yields. Treatments 1 and 2 were lower yielding than all other treatments. The silage yield for treatment 5 was significantly lower in yield than the conventional treatment. The Eco-Gro foliar treatments--2 and 4--did not increase yields significantly over Treatments 1 and 3, respectively.

The economic analysis (Table 2) shows that the conventional treatment resulted in the highest return over the check at both Lamberton and Morris. In treatments 2 and 4 where Eco-Gro was used as a foliar spray, the return over the check was less than where Eco-Gro was not used. Treatment 5, the Eco-Gro soil treatment, resulted in a loss of over $2200/A because of the high cost of the Eco-Gro needed to provide sufficient nutrients for the corn. At both Lamberton and Morris, the lowest plant food cost was with the conventional treatment.

Table 1. Silage and Grain Yields in 1979.

	Silage Yield (Tons/A)		Grain Yield (Bu/A)	
Treatment	Lamberton	Morris	Lamberton	Morris
1. Check	3.6	3.2	37.6	38.2
2. Eco-Gro (foliar)	3.6	3.3	36.6	38.4
3. Conventional	4.6	6.2	82.8	83.8
4. Conventional + Eco-Gro (foliar)	5.3	5.6	86.6	73.9
5. Eco-Gro (soil)	4.6	5.1	79.5	73.8
Significance	**	**	**	**
Bayes LSD (5%)	0.8	0.8	8.4	11.9

Table 2. Economic Return* Based on Corn Grain Yield.

Treatment	Extra Corn over Check (Bu/A)	Value of Corn ($)	Total Fertilizer Cost ($)	Plant Food Cost ($/lb)	Return† over Check ($)
2. Eco-Gro (foliar)					
Lamberton	-1.0	-2.25	11.20	14.55	-13.45
Morris	+0.2	+ .45	11.20	14.55	-10.75
3. Conventional					
Lamberton	+45.2	+101.70	24.12	.15	+77.58
Morris	+45.6	+102.60	24.12	.15	+78.48
4. Conventional + Eco-Gro (foliar)					
Lamberton	+49.0	+110.25	35.32	.22	+74.93
Morris	+35.7	+80.33	35.32	.22	+45.01
5. Eco-Gro (soil)					
Lamberton	+41.9	+94.28	2314.95	14.47	-2220.67
Morris	+35.6	+80.10	2314.95	14.47	-2234.85

* Prices used: Eco-Gro - $22.41/gallon, urea - 20¢/lb of N, 10-26-26 - $144/ton, and corn - $2.25/bushel.

† If anhydrous ammonia @ 13¢/lb of N were used as the broadcast N source in treatments 2 and 3, increase return on these treatments by $4.59/acre.

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1979

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

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. Treatment 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 because P appeared to be limiting at Morris and Waseca. All other treatments have been applied annually.

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

Trt. No.	Application Year (Fall) 1973	1974,'75,'77	1976	1978
	----------lbs. P_2O_5 + K_2O/A----------			
1	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	150 + 100	0 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 150	100 + 0
9	150 + 100	0 + 0	0 + 0	150*+ 100
10	100 + 150	0 + 0	0 + 0	100 + 150*

* Was not applied at Lamberton.

Treatment numbers 2-10 were broadcast on cornstalks and plowed down at all locations in the fall of 1978. 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 at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location. Nitrogen rates were slightly higher than optimum. Plant populations were increased in 1979.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1979.

Variable	Lamberton	Morris	Waseca
Planting date	5/17	5/16	5/18
Row spacing	30"	30"	30"
Population	25,000	25,000	30,000
Hybrid	Pioneer 3780	Dekalb XL12	Pioneer 3732
Nitrogen rate	125#N	110#N	200#N
Herbicide	2½# Eradicane + 1½# Bladex/A (Bdct)	2½# Lasso + 2½# Bladex/A (Bdct)	3# Lasso + 2½# Atrazine/A (Bdct)
Insecticide	1# Counter/A	1.3# Lorsban/A	1# Furadan/A
Harvest date	10/25	10/17	10/20

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1979 growing season. Results obtained in 1979 were quite similar to those obtained in 1978. Soil test P was affected significantly at all three locations (Table 3). There appeared to be a linear response to annual P application. Soil test P was always lowest with treatments 1 and 2, which received no P, and treatments 9 and 10, which received an initial application in 1973 and again in 1978. 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. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio.

Soil test K was influenced (P=.05) for the first time by the K treatments at Lamberton and Morris but not at Waseca (Table 3). The response to the annual K applications was not as pronounced as with P. Soil pH was not related to the P and K treatments.

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant weight was increased significantly (P=.01) by the treatments at all three locations (Table 4). Plant height at Morris and Waseca were increased significantly but was not at Lamberton. Both plant weight and height were generally lowest with the check treatment (no. 1), the 0 P_2O_5 treatment (no. 2) and the two treatments which were not applied between 1973 and 1978 (nos. 9 and 10). The growth response was due primarily to P. Early weight was increased over the 0 P_2O_5 rate (no. 2) by the 50 and 100 lb P_2O_5 rates by 0 and 25% at Lamberton, 10 and 23% at Morris, and 35 and 56% at Waseca, respectively. No effect of K was noticed except at the Waseca location where a 26% weight increase was noted with the 100 lb K_2O treatment.

Table 3. Soil test values as influenced by six year's application of P and K treatments.[1]

Treatment No.	Description[2]	pH La	pH Mo	pH Wa	P La	P M_{10}	P M_{50}	P Wa	K La	K Mo	K Wa
	lb P_2O_5+K_2O/A				lb/A						
1	0 + 0	5.8	7.6	5.9	40	9	29	27	266	366	237
2	0 + 100	5.8	7.7	5.9	37	10	32	22	332	464	251
3	50 + 100	6.3	7.7	5.8	50	31	80	41	342	444	255
4	100 + 100	5.8	7.6	6.0	62	53	136	61	316	460	269
5	0 + 100	5.9	7.6	5.9	62	30	74	40	310	426	253
6	100 + 0	5.7	7.6	6.0	76	60	144	54	265	360	237
7	100 + 50	5.8	7.6	6.0	71	52	135	54	326	410	244
8	100 + 0	5.9	7.5	5.8	72	72	163	54	292	391	241
9	150 + 100	6.2	7.6	6.0	36	18	47	37	274	397	244
10	100 + 150	5.8	7.6	6.1	40	13	40	29	277	411	248
Significance:[3]		NS	NS	NS	**	**	**	**	**	**	NS
BLSD(.05)	:				14	9	19	16	39	46	
CV(%)	:	5.3	27	3.5	19	21	16	26	8.6	7.7	6.7

[1] Samples were taken in October before the 1979 treatments were applied.

[2] Rates applied in fall of 1978 for 1979 crop. Treatments 9 and 10 had received 0 + 0 lb P_2O_5 + K_2O/A since 1973.

[3] **, *, and + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level.

Table 4. Early plant growth characteristics as influenced by high P and K rates at the three experimental sites in 1979.

Treatment No.	Description	Weight La	Weight Mo	Weight Wa	Height La	Height Mo	Height Wa
	lb P_2O_5+K_2O/A	g/dry plant			---inches----		
1	0 + 0	2.9	6.4	4.6	16	24	24
2	0 + 100	3.2	6.1	4.3	16	26	24
3	50 + 100	3.1	6.7	5.8	16	28	26
4	100 + 100	4.0	7.5	6.7	17	30	27
5	0 + 100	3.3	6.6	4.5	16	29	24
6	100 + 0	4.2	7.2	5.3	16	28	25
7	100 + 50	4.4	7.1	5.9	18	29	26
8	100 + 0	4.0	7.6	5.5	17	30	26
9	150 + 100	2.9	5.9	5.2	17	26	24
10	100 + 150	3.4	6.5	5.1	17	26	24
Significance:		**	**	**	NS	**	**
BLSD(.05)	:	.8	.8	1.1		1.9	1.3
CV(%)	:	15	7.7	14	9.1	5.0	3.6

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the three experimental sites in 1979.

Treatment No.	Description (lb P_2O_5+K_2O/A)	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
						Lamberton				
1	0 + 0	.37	3.74	.58	.48	620	74	48	7.8	9.4
2	0 + 100	.40	4.48	.51	.39	655	69	43	8.1	9.8
3	50 + 100	.42	4.35	.54	.42	748	71	39	7.6	10.1
4	100 + 100	.43	4.52	.54	.40	606	71	38	6.5	9.4
5	0 + 100	.41	4.38	.56	.42	764	77	50	7.8	10.6
6	100 + 0	.42	3.85	.65	.50	689	84	43	6.5	9.9
7	100 + 50	.42	4.36	.54	.40	646	74	42	6.5	9.7
8	100 + 0	.44	3.91	.60	.44	654	75	39	6.8	10.2
9	0 + 100	.41	3.85	.60	.47	581	74	45	8.4	11.0
10	100 + 0	.40	4.18	.58	.45	673	76	47	7.7	9.6
	Significance:	**	**	**	**	NS	NS	NS	**	NS
	BLSD(.05) :	.02	.41	.04	.04				.8	
	CV(%) :	4.1	6.6	5.4	6.9	13	12	16	7.6	10
						Morris				
1	0 + 0	.36	3.51	.54	.47	1040	88	45	8.9	5.8
2	0 + 100	.35	4.06	.50	.45	969	87	48	8.8	5.9
3	50 + 100	.40	4.01	.54	.44	1098	87	39	8.6	5.7
4	100 + 100	.42	4.22	.55	.45	776	81	36	8.0	5.7
5	0 + 100	.39	4.21	.51	.46	889	83	43	8.1	5.6
6	100 + 0	.44	3.31	.64	.55	920	90	35	8.3	5.5
7	100 + 50	.43	3.70	.59	.48	856	82	34	8.0	5.4
8	100 + 0	.41	3.52	.64	.51	1169	96	36	8.0	6.0
9	150 + 100	.38	3.26	.60	.58	1104	95	44	8.9	5.8
10	100 + 150	.34	3.23	.60	.51	1296	100	44	9.3	6.2
	Significance:	**	**	*	**	NS	NS	*	**	NS
	BLSD(.05) :	.05	.42	.09	.07			7	.6	
	CV(%) :	8.1	7.9	10	9.1	38	18	11	4.6	9.6
						Waseca				
1	0 + 0	.34	3.23	.50	.40	659	55	40	7.2	8.8
2	0 + 100	.34	3.90	.42	.29	634	51	40	7.2	8.7
3	50 + 100	.35	4.03	.44	.31	749	52	39	7.0	8.0
4	100 + 100	.39	4.02	.45	.31	566	49	34	5.7	7.8
5	0 + 100	.34	3.80	.45	.33	597	51	39	7.2	8.8
6	100 + 0	.39	3.06	.52	.39	642	53	34	6.2	8.4
7	100 + 50	.36	3.44	.48	.34	768	53	36	5.9	8.2
8	100 + 0	.37	3.26	.50	.38	636	54	39	6.2	8.3
9	150 + 100	.36	3.54	.48	.35	560	50	35	6.6	8.4
10	100 + 150	.36	3.75	.47	.33	682	51	42	7.0	8.7
	Significance:	**	**	**	**	NS	NS	+	**	+
	BLSD(.05) :	.04	.41	.03	.05				.9	
	CV(%) :	6.0	7.9	5.1	10	20	12	9.8	8.8	5.6

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1979.[1]

Treatment No.	Description (lb P_2O_5+K_2O/A)	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
					Lamberton					
1	0 + 0	.24	1.68	.60	.42	87	53	22	3.2	9.0
2	0 + 100	.23	1.86	.54	.34	84	36	19	2.7	9.2
3	50 + 100	.23	1.82	.56	.36	78	37	16	2.8	10.1
4	100 + 100	.24	1.92	.56	.37	81	40	16	2.7	8.5
5	0 + 100	.23	1.88	.54	.35	83	40	18	2.9	9.1
6	100 + 0	.25	1.69	.63	.42	83	51	17	2.7	8.9
7	100 + 50	.25	1.90	.56	.36	83	44	18	3.2	8.9
8	100 + 0	.26	1.81	.61	.40	86	45	16	3.0	9.8
9	150 + 100	.24	1.81	.61	.40	86	44	20	3.5	9.3
10	100 + 150	.25	1.74	.60	.42	87	44	20	3.0	8.9
	Significance:	+	+	**	**	NS	NS	*	NS	+
	BLSD(.05) :			.05	.05			4		
	CV(%) :	5.4	6.5	5.5	8.1	6.7	19	14	16	7.3
					Morris					
1	0 + 0	.24	1.72	.55	.59	14	61	29	5.7	5.2
2	0 + 100	.23	1.93	.53	.53	14	56	28	5.0	4.9
3	50 + 100	.29	2.06	.60	.54	14	60	21	5.1	4.3
4	100 + 100	.32	2.06	.62	.58	16	67	20	5.3	5.1
5	0 + 100	.29	1.95	.56	.57	14	63	22	5.3	4.6
6	100 + 0	.33	1.77	.64	.68	15	76	18	5.0	5.0
7	100 + 50	.32	1.83	.60	.63	15	70	19	5.5	5.0
8	100 + 0	.31	1.88	.64	.61	15	69	21	5.0	4.5
9	150 + 100	.29	1.69	.61	.69	14	73	24	5.6	4.8
10	100 + 150	.27	1.76	.56	.63	14	66	25	5.4	4.5
	Significance:	**	**	*	**	**	**	**	NS	NS
	BLSD(.05) :	.03	.13	.07	.05	13	7	4		
	CV(%) :	8.6	4.8	7.7	6.2	5.7	7.7	12	13	11
					Waseca					
1	0 + 0	.28	1.58	.52	.44	101	74	29	7.8	5.5
2	0 + 100	.27	2.02	.46	.36	97	57	27	8.6	6.6
3	50 + 100	.28	1.95	.48	.36	100	70	26	7.6	6.4
4	100 + 100	.30	2.02	.48	.36	98	58	21	7.3	6.1
5	0 + 100	.28	1.93	.48	.39	99	62	25	7.7	6.6
6	100 + 0	.30	1.59	.54	.46	102	70	21	7.0	5.8
7	100 + 50	.29	1.77	.51	.40	99	70	22	6.8	5.6
8	100 + 0	.30	1.68	.52	.42	102	74	23	7.0	5.8
9	150 + 100	.28	1.82	.48	.42	97	63	24	7.3	6.0
10	100 + 150	.28	1.77	.51	.40	99	61	26	7.7	6.4
	Significance:	**	**	NS	**	NS	+	**	**	NS
	BLSD(.05) :	.01	.16		.04			3	.8	
	CV(%) :	3.4	6.4	8.2	7.4	5.0	13	9.3	6.6	16

[1] Leaf opposite and below the ear at silking.

The small plants were chemically analyzed with the results from all locations shown in Table 5. Concentrations of P, K, Ca, Mg and Cu were affected significantly by the treatments at all locations. Whole plant P and K were consistently increased by the P and K treatments while Ca and Mg were generally decreased by the K additions. The response to K rate was more linear than was the P response. Zinc concentrations were depressed by the 50 and 100 lb P_2O_5/A rates at Morris and to a lesser degree at Waseca.

Analysis of the leaf opposite and below the ear at silking indicated significant effects of the P and K treatments at all locations (Table 6). At Morris and Waseca, both leaf P and K were increased (P=.01) with increasing rates of P and K. At Waseca a linear response (P=.01) to applied K was noted with increased leaf K and decreased leaf Mg concentrations. A consistent effect of applied P or K on leaf P or K was not found (P=.05) at Lamberton. Leaf Zn concentrations were reduced by the P treatments at all sites.

Final populations were higher in 1979 than in previous years but significant differences were not found among the 10 treatments at all three sites (Table 7). Grain moisture an indication of maturity at harvest was affected inconsistently by both the treatments at Waseca (Table 7). At Morris grain moisture was reduced about 4 points by the P treatments but this difference was not significant (P=.10) due to the high variability.

The influence of the six years of P and K application on silage and grain yields for all three locations is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at Lamberton or Morris. At Waseca silage yields were improved significantly; primarily by the K treatments. For the first time in six years grain yield increases were significantly increased by the P treatments at Morris. The same trend was evident at Waseca but the 12 bu/A increase with the 50 and 100 lb P_2O_5 rates was not statistically significant at the 10% level even though the variability was quite low (CV=5.2). This quite vividly points out that even though yield increases are economical and may be highly profitable, statistical significance may not easily be shown at these <u>high</u> yield levels. Inconsistent significant yield differences were shown at Lamberton. However, yields were not increased over the check and did not appear to be related to either the P or the K treatments.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1979.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Grain Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb P_2O_5+K_2O/A	plants/A x 10^{-3}			-------%--------		
1	0 + 0	24.4	22.0	28.0	30.7	24.0	30.2
2	0 + 100	23.5	22.8	27.0	31.2	22.2	31.4
3	50 + 100	23.2	21.9	28.5	30.6	20.0	30.2
4	100 + 100	23.5	22.4	27.0	30.1	20.5	29.1
5	0 + 100	23.2	22.1	27.0	30.0	20.2	30.2
6	100 + 0	24.7	22.2	28.2	29.8	19.0	29.2
7	100 + 50	24.4	22.7	28.5	29.8	19.7	30.1
8	100 + 0	21.8	22.5	28.5	29.2	18.9	29.7
9	150 + 100	24.4	22.2	28.2	29.6	20.4	30.5
10	100 + 150	24.1	22.2	27.2	30.9	21.5	30.3
	Significance:	NS	NS	NS	NS	NS	**
	BLSD(.05) :						1.0
	CV(%) :	8.9	2.3	5.8	3.7	12	2.1

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1979.

Treatment No.	Treatment Description	Silage Yield La	Silage Yield Mo	Silage Yield Wa	Grain Yield La	Grain Yield Mo	Grain Yield Wa
	lb P_2O_5+K_2O/A	-----T DM/A-----			-------bu/A--------		
1	0 + 0	6.08	6.01	7.20	118.0	90.9	163.6
2	0 + 100	5.91	6.04	7.99	112.8	90.7	164.8
3	50 + 100	6.02	6.63	7.49	106.5	99.6	175.5
4	100 + 100	5.86	7.02	8.11	117.6	110.5	176.6
5	0 + 100	5.89	6.91	7.22	108.0	110.6	174.0
6	100 + 0	5.84	6.78	7.36	124.1	113.3	171.2
7	100 + 50	6.18	6.70	8.18	120.9	105.7	172.6
8	100 + 0	5.91	6.83	6.92	126.6	107.9	176.6
9	150 + 100	6.10	6.52	7.74	119.2	102.8	167.6
10	100 + 150	6.06	6.78	8.22	120.7	101.0	171.2
	Significance:	NS	NS	**	*	*	NS
	BLSD(.05) :			.79	13.8	17.5	
	CV(%) :	8.5	8.2	6.5	6.8	9.9	5.2

THE INFLUENCE OF NITRATE-NITROGEN IN THE SOIL PROFILE ON THE RESPONSE OF CORN TO NITROGEN FERTILIZER IN SOUTHEASTERN MINNESOTA - 1979 AND 1977-79 SUMMARY

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Nitrogen fertilizer recommendations for corn production in Minnesota are presently estimated on the basis of previous crop, yield goal, and soil organic matter level. These recommendations may be too high or too low in a given year depending on weather and other conditions. The purpose of this study is to evaluate use of a nitrate-nitrogen test to measure residual nitrogen in the soil profile as a means of refining nitrogen recommendations.

The 1979 study is a continuation of one started in 1977 in cooperation with farmers in 7 southeastern Minnesota counties - Dodge, Goodhue, Houston, Olmsted, Steele, Wabasha, and Winona. Soils range from the well-drained Fayette/Seaton and related silt loams in the hilly eastern part of the region to the level, poorly drained Skyberg, Floyd, and Webster soils in Dodge and Steele counties.

Experimental Procedures

On each farm a site was selected in a field to be planted to corn, avoiding fields where alfalfa was the preceding crop or where manure had been applied in the past year. Each site was sampled in the spring to a depth of 5 feet and samples were divided into the following increments for nitrate testing: 0-6", 6-12", 12-24", 24-36", 36-48", and 48-60". Farmers applied their normal rate of nitrogen on the field but left 3 or 4 alternating strips the width of their applicator without nitrogen. Grain yields and N content of the grain at harvest were determined for the nitrogen and no nitrogen treatments.

In 1979 N rates ranged from 100 to 170 pounds per acre with an average of 140. Liquid dairy manure at approximately 20 tons per acre was used in one case. In addition to this N rate a standard starter fertilizer rate supplying between 8 and 32 lbs. N per acre was applied on both N and no N strips.

The 0 to 6" surface soil samples were analyzed for pH, phosphorus, potassium, and organic matter. The average values and ranges are as follows:

pH	6.6 (5.9-7.9)	P	60 lbs/acre (23-151)
K	244 lbs/acre (160-360)		

Percent organic matter varied considerably from 2% to 8.5%. Actual values are shown in Table 2.

All but 2 of the 1979 sites were in corn the previous year, most for 2 or more years. One site was in soybeans (Hoschiet) and one in oats (Klemmenson).

1979 Results and Discussion

The amounts of nitrate-N found in different increments of the soil profile at each of the sites in spring of 1979 is shown in Table 1. All but 2 of the 14 sites tested between 40 and 120 lbs/acre in the top 2 feet. Nitrate-N in

Table 1. Nitrate-Nitrogen by Depth (Spring, 1979) and Soil Types at 14 Locations in Southeastern Minnesota.

Cooperator	Depth Increment 0-6"	6-12"	12-24"	24-36"	36-48"	48-60"	0-24"	0-36"	0-48"	0-60"	Soil Type*
	Nitrate-Nitrogen (lb/acre)										
Dodge County											
Moenning	35	30	39	34	30	20	104	138	168	188	Floyd si l
Rehwaldt	24	20	32	22	30	30	76	98	128	158	Skyberg/Kasson si l
Houston County											
Beranek	8	7	12	26	22	17	27	53	75	92	Rushford si l
Davison	16	18	30	29	28	49	64	93	121	170	not determined
Hempstead	25	28	39	34	25	36	92	126	151	187	Hokah l
Hoscheit	11	17	13	20	32	40	41	61	93	133	not determined
McCormick	32	24	47	49	68	68	183	232	300	368	Seaton si l
Olmsted County											
Pagel	16	12	12	8	10	21	40	48	58	79	Atkinson l
Randall	32	12	14	16	25	48	58	74	99	147	Port Byron si l
Steele County											
Abbe	36	28	56	65	30	20	120	185	215	235	Webster cl l
Klemmenson	28	15	10	8	10	9	53	61	71	80	Bixby l
Wabasha County											
Drysdale	16	14	25	26	28	26	55	81	109	135	Minnieska si l
Graner	14	12	19	14	12	13	45	59	71	84	Fayette si l
Winona County											
Redig	42	16	24	26	31	46	82	108	139	185	Fayette si l

*Determined from soil survey maps.

Table 2. N Rates, Grain Yields and % N, and Related Data for 14 Sites in Southeastern Minnesota. 1979.

Cooperator	N Rate* (lb/A)	Grain Yield (bu/A @15.5% M)		Yield Increase Due to N		Grain % N (D.W.)		Grain N Removal (lb/A)		Nitrate-N (lb/A, 0-2')	Soil %O.M.
		N	No N	bu/A	%	N	No N	N	No N		
Dodge County											
Moenning	150	150	149	1	1	1.51	1.46	107	103	104	8.3
Rehwaldt	165	166	140	26	19	1.69	1.52	133	101	76	4.3
Houston County											
Beranek	125	157	109	48	44	1.52	1.12	113	58	27	2.0
Davison	170	169	154	14	10	1.51	1.47	121	107	64	3.5
Hempstead	145	138	132	6	5	1.51	1.39	99	87	92	6.9
Hoschiet	130	136	117	19	16	1.60	1.46	103	81	41	3.9
McCormick	130	122	120	2	2	1.64	1.62	95	92	183	3.1
Olmsted County											
Pagel	150	138	109	19	17	1.78	1.40	116	72	40	3.7
Randall	150	122	108	14	13	1.57	1.44	91	74	58	4.4
Steele County											
Abbe	150	142	122	20	16	1.65	1.50	111	87	120	8.5
Klemmenson	135	147	122	25	20	1.69	1.32	118	76	53	4.0
Wabasha County											
Drysdale	100	153	126	27	21	1.74	1.42	126	85	55	3.0
Graner	125	125	115	10	9	1.47	1.42	87	77	45	2.2
Winona County											
Redig	20 tons manure	133	128	5	4	1.56	1.45	98	88	82	3.4

*An additional 8 to 32 lbs/A applied in starter on N and no N strips.

the 0 to 5' profile ranged from 79 to 368 lbs/acre. On the average 46% of this amount was found in the top 2 feet.

Yields with and without nitrogen and other related information are shown in Table 2. All yields were over 120 bu/acre with nitrogen. Average yields were 125 without and 143 with nitrogen for an 18 bu/acre response to N. In general yield response decreased with increasing nitrate-N. However, the Abbe site in Steele County showed a 20 bushel response to N even though nitrates were quite high, 120 lbs/acre in 0-2' and 235 in 0-5', and organic matter was 8.5%. The soil was a poorly drained Webster clay loam. Apparently the excessive rainfall this season caused a considerable amount of denitrification loss. At the Moenning site, which was also fairly high nitrates and a poorly drained Floyd soil, however, no N response occurred. But here the farmer-cooperator reported considerably lower rainfall in midsummer than much of the surrounding area.

Nitrogen content of the grain is reported in Table 2. In general where grain yields responsed well to nitrogen, percent N in the grain was also increased substantially by the addition of N. There was little effect on grain N where yields did not respond to N. Most of the N fertilized grain fell in the 1.5 to 1.7% range whereas those without N were 1.4 to 1.5% N. Substantial amounts of N were released by these soils, even without added N, as indicated by the amount of N removed in the grain.

Summary of 1977-1979 Results

Yield increases due to N application at various 2 ft. nitrate-N levels for the 50 site - years are summarized in Table 3. For sites with nitrate-N levels of 60 lbs/acre or less yield response to N was substantial, greater than 5 bu/acre in all cases. When nitrate-N was higher than 120, N responses were quite small, only one of 12 exceeding 5 bu/acre. In the intermediate range of 61 to 120 N response was variable, ranging from 0 to 27 bu/acre. About half of the sites in this range showed yield increases of greater than 5 bu/acre.

Table 4 shows average yield response and selected nitrate levels for each of the 3 years of the study. Average yield response to nitrogen was considerably greater in 1979 than in the 2 previous years. This corresponds to a lower average nitrate level in 1979 at both the 0 to 2 and 0 to 5 ft. depths.

Over the past 3 years 22 of the 50 sites, or 44%, showed a yield response of only 5 bu/acre or less. Most of these occurred in 1977. The dry weather and low yields of 1976 left higher than normal residual nitrogen, as measured by the high nitrate levels in spring of '77.

The percent increase in grain yield due to addition of nitrogen is correlated with the amount of nitrate-nitrogen (lbs/acre) in the top two feet prior to planting. The relationship for the 50 sites during the 3 years of trials is described by the following linear and quadratic equations:

$$y = 19.18 - .098\,x \qquad r = .566^{**}$$
$$y = 33.22 - .383\,x + .001\,x^2 \qquad r = .726^{**}$$

where y = % yield increase due to N fertilizer and x = lbs/acre nitrate-N in the 0 to 2 ft. depth.

Equations were developed for the 0-3', 0-4', and 0-5' nitrate-N values but r^2 values were lower than these for 0-2'. The linear and quadratic equations for percent yield increase vs. 0-2 ft. nitrate-N are graphed in Figure 1.

Table 3. Corn Grain Yield Increase Due to Nitrogen Fertilization at Various 0 to 2 ft. Nitrate-N Levels in Southwestern Minnesota. 1977-1979.[1/]

Nitrate N (lb/A, 0-2')	Number of Sites Total	Number of Sites N Response >5 bu/A	Yield Increase (bu/A)[2/] Average	Yield Increase (bu/A)[2/] Range
0-30	3	3	39	20-49
31-60	12	12	17	6-27
61-90	9	4	11	0-27
91-120	14	8	7	0-20
121-150	2	0	0	0-1
151-180	5	0	3	0-5
>180	5	1	4	1-8
TOTAL	50	28		

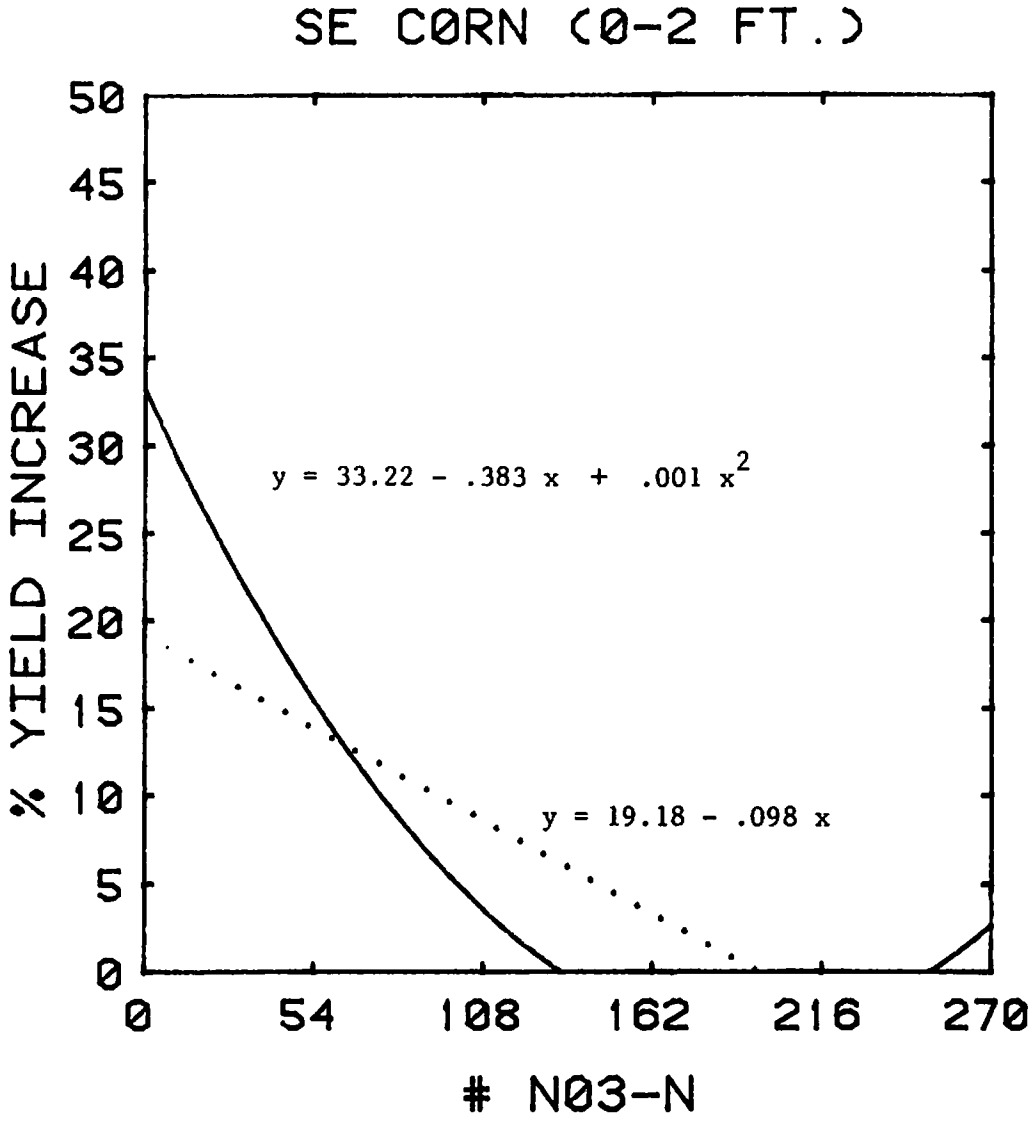
1/ Excludes Hempstead site in '78 which was flooded.
2/ Decreases are counted as 0.

Table 4. Corn Grain Yield Response to Fertilizer N and Average Nitrate-N Levels for Separate Years 1977, 1978, and 1979.

Year	Number of Sites Total	Number of Sites N Response >5 bu/A	Yield (bu/A) N	Yield (bu/A) No N	Yield Increases Due to N bu/A	Yield Increases Due to N %	Nitrate-N (lb/A) 0-2'	Nitrate-N (lb/A) 0-5'
1979	14	11	143	125	18	14	74	160
1978	16	10	140	129	11	9	105	260
1977	20	7	138	130	8	6	106	178

Results from the 3 years of this study indicate that the nitrate test can be a useful tool for predicting corn N response on well-drained soils in southeastern Minnesota. A 2 foot sample has been as reliable as deeper samples during these 3 years. Soils testing higher than 120 to 150 lb/acre nitrate-N in the top 2 feet showed little or no response to added N, whereas those testing less than 60 lb/acre showed large yield increases. The nitrate test is not well suited to fields where drainage is poor or where flooding may occur.

Figure 1. Percent Corn Grain Yield Increase as a Function of Nitrate-N (lb/acre) in 0 to 2' Depth. 50 Site-Years in Southeastern Minnesota. 1977-79.



USE OF N-SERVE IN FALL VS. SPRING NITROGEN APPLICATION PROGRAMS ON FINE TEXTURED SOILS OF MINNESOTA

G.L. Malzer, G.W. Randall, W.W. Nelson, S. Evans, and G. Varvel

A considerable interest has developed over the last several years concerning the use of N-Serve as a nitrification inhibitor with ammonium forming fertilizers on the fine textured soils of Minnesota. On many of these fine textured soils, depending on the climatic conditions encountered and internal soil drainage, losses of nitrate nitrogen may occur through denitrification. If this loss occurs, a portion of the plant available nitrogen is lost, and yield reductions may develop. With the normally cool wet spring conditions which are encountered on most of these soils, there may also be a considerable advantage in time management, associated with earlier nitrogen fertilization. This condition exists provided that nitrogen losses are not severe in the interim period. If nitrification inhibitors are capable of minimizing the production of nitrate nitrogen with fall nitrogen applications they may have the advantage of minimizing potential nitrate nitrogen losses as well as increasing the length of time that would be available in the fall to apply nitrogen (prior to 50-55° soil temperatures).

Experiments were established at four University of Minnesota Experiment Stations with the following objectives: 1) to evaluate the importance of timing of nitrogen application (fall vs. spring) on yield components and nitrogen utilization of corn and spring wheat; 2) to determine the importance of soil temperature on the rate of nitrification with early and late applied nitrogen; and 3) to examine the influence of N-Serve on yield components, nitrogen utilization by the crops, and its influence on the rate of nitrification within the soil.

Experimental Procedures

Four similar experiments were established one each at the Southern Experiment Station at Waseca, the Southwest Experiment Station at Lamberton, the West Central Experiment Station at Morris, and the Northwest Experiment Station at Crookston. Each experiment, (except for Lamberton), consisted of four times of nitrogen application (3 fall and 1 spring) two rates of nitrogen in addition to a check and all potential nitrogen treatments and times of application either had N-Serve at 0.5 # ai/A applied with it or contained no N-Serve. Times and rates of nitrogen application were adjusted for each experimental site to conform with the geographic area. The experimental treatments at each location are included in Table 1.

Each experimental site was fertilized with phosphorus and potassium according to soil test recommendations prior to establishment of treatments. All nitrogen applications were made with anhydrous ammonia with N-Serve injected into the tank for the appropriate treatments. Anhydrous knife spacings were 30" for corn production and approximately 15" for wheat. All primary tillage was done prior to the first nitrogen application with only secondary tillage prior to planting. Several areas within each plot received no tillage after nitrogen application for use in collection of soil samples from the anhydrous application zones.

Treatment influences on nitrogen utilization by the crop were evaluated in several manners. Corn leaf samples from opposite and below the ear at 50% silking were collected and analyzed for Kjeldahl nitrogen content. Forage dry matter production and nitrogen removal was measured by hand harvesting 15' of row from the corn plots, separation of samples into ear and stover components, field weights obtained and nitrogen content and moisture determined from subsamples. Grain yields were obtained by either hand harvesting or machine harvesting known areas from each plot and then determination of the nitrogen content (protein) by Kjeldahl analysis for calculation of nitrogen removal.

General Results

Positive yield responses were obtained at three of the four locations tested in 1979. Nitrogen response was, however, limited to the first level (Medium) of nitrogen application on two out of four locations. Only the Waseca location gave significant yield responses to the high level of nitrogen fertilization.

Yield responses in relationship to timing of nitrogen application were significant in two out of four locations. In general, early fall applications were inferior to later fall or spring application.

The use of N-Serve had relatively little influence on nitrogen utilization and grain yields at these four locations in 1979. The three locations in the western part of the state reflected essentially no advantage to the use of N-Serve. Although not significant at the 95% level of confidence, trends for yield increases due to N-Serve were found when applied with the nigh nitrogen rate with early fall nitrogen application and at the lower nitrogen rate with spring application. N-Serve has been found to be effective in delaying the conversion of ammonium nitrogen to nitrate nitrogen. The yield responses which have been obtained are related to the climatic and soil conditions which might influence the amount of nitrate nitrogen that might be lost by leaching or denitrification.

Table 1. Experimental Treatments with Fall vs. Spring Nitrogen Application with and Without N-Serve.

Experimental Location	Nitrogen Rate	Date of Application		N-Serve Rate	Test Crop
	#/A	1978-79		#ai/A	
Waseca	0	9/25	10/10	0, ½	Corn
	75	10/31	5/7		(Pioneer 3732)
	150				
Lamberton	0	10/1	11/1	0, ½	Corn
	50	5/5			(Pioneer 3780)
	100				
Morris	0	8/25	9/25	0, ½	Corn
	40	10/24	5/21		(Dekalk XL 12)
	80				
Crookston	0	8/29	9/28	0, ½	Wheat
	40	10/26	5/14		(Era)
	80				

Table 2. Nitrogen content of the leaf opposite and below the ear at silking as influenced by nitrogen rate, timing of nitrogen application and use of N-Serve.

Treatments 1/			Leaf N Content		
Date of Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris
		0.5#ai/A	----------	%	----------
Control	0	No	1.98	2.26	2.71
Early Fall	Med.	No	2.64		2.66
Early Fall	Med.	Yes	2.70		2.70
Early Fall	High	No	2.91		2.70
Early Fall	High	Yes	2.93		2.68
Mid Fall	Med.	No	3.03	2.82	2.80
Mid Fall	Med.	Yes	3.04	2.76	2.77
Mid Fall	High	No	2.92	2.84	2.78
Mid Fall	High	Yes	2.96	3.10	2.74
Late Fall	Med.	No	2.75	2.62	2.72
Late Fall	Med.	Yes	2.86	2.75	2.84
Late Fall	High	No	2.99	3.10	2.89
Late Fall	High	Yes	3.00	2.77	2.79
Spring	Med.	No	2.92	2.81	2.84
Spring	Med.	Yes	3.07	2.79	2.92
Spring	High	No	3.09	2.78	2.82
Spring	High	Yes	3.03	2.96	2.75
Significance			**	**	NS
BLSD(.05)			0.16	0.28	-
Factorial Arrangement					
Application Date					
Early Fall			2.80		2.68
Mid Fall			2.99	2.88	2.77
Late Fall			2.90	2.81	2.81
Spring			3.03	2.84	2.83
Significance			**	NS	*
BLSD(.05)			0.10	-	0.10
Nitrogen Rate					
Med.			2.88	2.76	2.78
High			2.98	2.92	2.77
Significance			**	**	NS
BLSD(.05)			0.07	0.12	
N-Serve					
No			2.91	2.83	2.76
Yes			2.95	2.85	2.77
Significance			NS	NS	NS
BLSD(.05)			-	-	-

[1]See table 1 for dates and rates of nitrogen application.

Table 3. Influence of nitrogen rate, timing of nitrogen application and N-Serve on grain yields - 1979.

Treatments 1/			Grain Yields			
Date of N Appl.	N Rate	N-Serve 0.5#ai/A	Waseca	Lamberton	Morris	Crookston
			bu/A			
Control	0	No	116.4	120.0	84.3	33.0
Early Fall	Med.	No	154.7		89.7	40.8
Early Fall	Med.	Yes	154.8		93.1	40.7
Early Fall	High	No	166.7		91.2	43.5
Early Fall	High	Yes	174.4		94.0	47.0
Mid Fall	Med.	No	173.6	128.2	100.0	41.2
Mid Fall	Med.	Yes	174.4	126.3	86.5	42.7
Mid Fall	High	No	172.9	125.4	96.6	41.5
Mid Fall	High	Yes	178.0	127.2	89.1	39.1
Late Fall	Med.	No	161.2	137.9	94.2	41.6
Late Fall	Med.	Yes	162.4	138.9	91.8	42.7
Late Fall	High	No	180.0	138.6	92.4	43.1
Late Fall	High	Yes	181.0	135.2	104.4	42.1
Spring	Med.	No	166.7	139.8	88.4	43.4
Spring	Med.	Yes	176.1	137.4	99.3	42.9
Spring	High	No	181.4	132.4	98.4	42.5
Spring	High	Yes	180.9	138.2	89.6	39.1
Significance			**	*	NS	**
BLSD(.05)			10.2	16.1	-	5.5
Factorial Arrangement						
Application date						
Early Fall			162.6		92.0	43.0
Mid Fall			174.7	126.8	93.1	41.1
Late Fall			171.1	137.6	95.7	42.4
Spring			176.3	136.9	93.9	42.0
Significance			**	**	NS	NS
BLSD(.05)			6.5	6.2	-	-
Nitrogen Rate						
Med.			165.5	134.7	92.9	42.0
High			176.9	132.8	94.5	42.2
Significance			**	NS	NS	NS
BLSD(.05)			4.9	-	-	-
N-Serve						
No			169.6	133.7	93.8	76.5
Yes			172.7	133.9	93.5	73.7
Significance			NS	NS	NS	NS
BLSD(.05)			-	-	-	-

1/ See table 1 for dates and rates of application.

Table 4. Influence of nitrogen rate, timing of nitrogen application and N-Serve on nitrogen removal with the grain.

Treatments [1/]			Grain N Removal			
Date of N Appl.	N Rate	N-Serve 0.5#ai/A	Waseca	Lamberton	Morris	Crookston
Control	0	No	64.6	68.1	63.4	38.3
Early Fall	Med.	No	96.8		72.2	50.1
Early Fall	Med.	Yes	97.4		71.7	51.3
Early Fall	High	No	98.6		73.8	59.8
Early Fall	High	Yes	106.4		76.1	65.3
Mid Fall	Med.	No	104.4	84.4	78.8	49.3
Mid Fall	Med.	Yes	110.2	80.6	67.6	54.2
Mid Fall	High	No	113.5	81.4	79.0	56.7
Mid Fall	High	Yes	112.3	83.0	72.0	54.1
Late Fall	Med.	No	93.1	87.1	76.4	52.3
Late Fall	Med.	Yes	97.7	84.0	73.7	52.9
Late Fall	High	No	107.5	90.6	77.2	59.9
Late Fall	High	Yes	111.7	84.6	81.0	59.0
Spring	Med.	No	101.8	87.1	70.3	54.8
Spring	Med.	Yes	104.9	86.6	76.0	53.4
Spring	High	No	111.8	83.4	84.4	61.5
Spring	High	Yes	110.5	86.6	71.2	54.7
Significance			**	+	NS	**
BLSD(.05)			9.5	12.6	-	7.1
Factorial Arrangement						
Application Date						
Early Fall			99.8		73.5	56.2
Mid Fall			110.1	82.2	74.4	53.6
Late Fall			102.5	86.6	77.1	56.0
Spring			107.2	85.9	75.5	56.1
Significance			**	NS	NS	NS
BLSD(.05)			6.0	-	-	-
Nitrogen Rate						
Med.			100.8	84.9	73.3	52.3
High			109.0	85.0	76.9	56.1
Significance			**	NS	NS	NS
BLSD(.05)			4.4	-	-	-
N-Serve						
No			103.4	85.6	93.8	76.5
Yes			106.4	84.2	93.5	73.7
Significance			NS	NS	NS	NS
BLSD(.05)			-	-	-	-

[1/] See table 1 for dates and rates of nitrogen application.

GRASS SEED PRODUCTION AS INFLUENCED BY FERTILIZATION

A PROGRESS REPORT
December 31, 1979

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Research during 1979 included: (a) nitrogen source comparison on mineral soils, (b) nitrogen rate study on peat, and (c) copper study on peat. Six trials with timothy and Kentucky bluegrass were conducted on growers' fields in Roseau and Lake of the Woods counties. Fertilizer effects were determined by yield measurement, chemical analysis of grass tissue and visual estimation of severity of lodging.

A. WEATHER CONDITIONS DURING 1978/79 GROWING SEASON

Comments on weather conditions are based on climatological data reported by the U. S. Weather Station at Roseau (Table 1).

Generally, during the period from August 1978 to July 1979, 22.5 inches of precipitation (1.5 inch above normal amount) was received at Roseau, while the average air temperature was 4.2°F below normal. During August and September, over 6.5 inches of rainfall was received, while October was very dry. From November to April, the temperature was about 7.3°F below normal and the precipitation was over 3 inches above normal. May was cool and somewhat drier than normal. During June, relatively cool weather prevailed and nearly 2 inches of rainfall was received, about 1.5 inch below the normal amount. Nearly 4 inches of rainfall was received during July with the average air temperature being 1.8°F below normal.

B. NITROGEN SOURCE COMPARISON

1. Anhydrous Ammonia vs. Urea vs. Ammonium Nitrate

Two field experiments were conducted with Heidemij timothy and Park Kentucky bluegrass on mineral soils. The soils contained 13-17 lb/A of nitrate-N in the top two feet (Table 2). This amount of nitrate is relatively low when compared to the levels commonly found after some cultivated crops or fallow. The main root zone (0-3 inches) contained only 1.5-1.7 pp2m nitrate-N. The soils were calcareous, with pH values near 8 (Table 3).

Table 1. Precipitation and temperature data for the 1978/79 growing season as measured at Roseau Weather Station (KRWB Radio)*.

Period	Precipitation (inches) Total	Precipitation (inches) Departure from Normal	Air Temperature (°F) Average	Air Temperature (°F) Departure from Normal	GDD T_b=40°F
1978 Aug.	3.25	.03	65.2	.3	781
Sept.	3.44	.83	58.7	4.1	561
Oct.	.23	-.99	45.0	.5	155
1978 Nov. to 1979 Apr.	8.07	3.14	9.5	-7.3	46
1979 May	1.89	-.56	45.9M	-6.0	183
June	1.91	-1.51	58.5	-3.3	555
July	3.70	.25	65.4	-1.8	787
Total	22.49	1.50			3068
Average			33.0	-4.2	
Normal (1941-1970)	20.99		37.2		3329

*Calculated from Climatological Data, Minnesota, Vol. 84 and 85, 1978 and 1979, U.S. Dept. of Commerce.

Note: Data for December, January, February and March represent averages for the Northwest Division because precipitation at Roseau was not recorded.

Table 2. Amount of nitrate-N in the soil collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Soil Texture	Sampling depth, inches 0-3	3-6	6-24	Total Nitrate-N in 0-24"
		----Nitrate-N pp2m----			
Kveen Heidemij timothy	CL	1.7	1.6	13.2	16.5
Helmstetter Bros. Park K. bluegrass	SL	1.5	1.6	9.6	12.7
Hedlund Timfor timothy	SICL	1.8	1.9	9.8	13.5
Kveen Park K. bluegrass	P	2.2	1.3	6.6	10.1

+ samples collected on October 9-11, 1978.

The objectives of this investigation were:

1) To determine effectiveness of nitrogen source,

2) To determine sod injury from anhydrous ammonia injection as measured in yield.

All fertilizer materials were applied during the first half of October 1978. Urea (46-0-0) and ammonium nitrate (34-0-0) were applied to 10 x 40 ft. plot areas with a 5-foot Gandy spreader. Anhydrous ammonia, AA (82-0-0) was applied with commercial applicators with the knives set 15 inches apart to 24 x 40 ft. plot areas. A 0+40+40 fertilizer treatment was made across all plots. Nitrogen treatments were replicated six times.

Heidemij Timothy showed good response to fertilization with nitrogen. Seed yield, N content of grass tissue and the lodging score all were increased by the application of 110 lb. N/acre (Table 4). All three nitrogen sources were equally effective. The knives of AA applicator caused some damage to timothy sod by ripping it. The damage, however, was not sufficiently serious as it did not affect the yield.

Park Kentucky Bluegrass produced high seed yield and showed remarkable response to the application of 120 lbs. of nitrogen per acre (Table 5). Vegetative growth had been stimulated by nitrogen to such an extent that considerable lodging was observed on June 27. Some lodging was noted for the AA treatment; urea showed very little to no lodging; grass receiving ammonium nitrate had lodged moderately to heavily. Ammonium nitrate also produced the highest yield, significantly higher than obtained with the two other nitrogen sources. Knifing did not significantly decrease the yield, as shown by the ammonium nitrate vs. ammonium nitrate + knife treatments (600 vs. 552 lb/acre).

2. Urea vs. Ammonium Nitrate

Several field trials were established in the fall of 1975 to compare the effectiveness of these two N sources when applied at two different times (fall vs. spring) and two different rates (50 vs. 100 lb. N/A). Only one of these experiments could be continued in 1979.

Timfor Timothy produced moderate seed yield, and therefore, the response to nitrogen fertilization was not spectacular. Extra plots receiving no nitrogen yielded 164 lb/acre of seed and produced grass tissue with 1.90% N. The N100 treatment increased N concentration of grass tissue and the seed yield above those produced with the N50 treatment (Table 6). Neither the N source nor the time of fertilization produced differences in yield or N concentration of grass.

Table 3. Soil test results of samples collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu+ ppm
Kveen	0-3	CL	8.2	23	167	
Heidemij Timothy	3-6	SL	8.4	7#	124	
	6-24	CL	8.6	3#	85	
Helmstetter Bros.	0-3	SL	8.1	22	101	
Park K. bluegrass	3-6	SL	8.3	10#	51	
	6-24	SL	8.5	8#	35	
Hedlund	0-3	SICL	8.4	27#	123	
Timfor timothy	3-6	SICL	8.5	11#	80	
	6-24	SICL	8.7	1#	35	
Kveen	0-3	P	8.3	24	90	
Park K. bluegrass	3-6	P	8.2	5#	29	
(N-Rate trial)	6-24	P	8.0	7#	31	
Kveen	0-3	P	8.2	45	129	1.45
Park K. bluegrass	3-6	P	8.0	8#	25	1.26
(copper trial)						
Kveen	0-3	P	6.6	19	176	1.18
Newport K.	3-6	P	6.6	30	53	1.02
bluegrass						
(copper trial)						

+ samples collected on October 9-11, 1978.

1:50 soil/solution ratio.

Table 4. Effect of four nitrogen treatments on seed yield, N concentration in tissue and lodging of Heidemij timothy, Gus Kveen farm, Roseau County, 1979.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter	Lodging Score #
Check	321a	2.88a	1.3
Ammonium Nitrate + Knife	458b	3.79b	3.5
Ammonium Nitrate	467b	3.78b	2.8
Anhydrous Ammonia	485b	4.05b	3.3
Urea	454b	3.92b	3.7
Significance	**	**	
BLSD (0.05)	66	0.31	
C.V.	14	8	

Values followed by different letters are significantly different (5% level); all results are averages of six replications.

Nitrogen materials were applied at a rate of 110 lb. N/acre; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Observations made on 8/21/79; 1 = standing erect, 5 = flat.

Table 5. Effect of four nitrogen treatments on seed yield, N concentration in tissue of Park Kentucky bluegrass, Helmstetter Bros. farm, Lake of the Woods County, 1979.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	166a	1.10a
Ammonium Nitrate + Knife	552cd	1.50b
Ammonium Nitrate	600d	1.56b
Anhydrous Ammonia	458b	1.95c
Urea	476bc	1.42b
Significance	**	**
BLSD (0.05)	83	0.18
C.V.	17	11

Values followed by different letters are significantly different (5% level); all results are averages of six replications.

Nitrogen materials were applied at a rate of 120 lb. N/acre; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Table 6. Effects of nitrogen source, rate, and time of application on seed yield and N concentration in tissue of Timfor timothy (1973 seeding), Dell Hedlund farm, Roseau County, 1979.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Source		
Urea	269	2.63
Ammonium Nitrate	287	2.68
Significance	ns	ns
BLSD (0.05)	-	-
Rate		
50 lb/acre N	229a	2.35a
100 lb/acre N	326b	2.96b
Significance	*	**
BLSD (0.05)	67	0.23
Date		
Fall	299	2.68
Spring	257	2.62
Significance	ns	ns
BLSD (0.05)	-	-
C.V.	17	5

Values followed by different letters are significantly different (5% level).

All plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

C. NITROGEN RATE STUDY ON PEAT

A field experiment with Park Kentucky bluegrass on peat was established in the fall of 1975 to investigate the effectiveness of different N rates. Five nitrogen rates were used: 0, 20, 40, 60, and 80 lbs/acre and the treatments were replicated four times. All plots received uniform 0+40+40 lbs/acre phosphate and potash treatments. Fertilizer materials were applied with a Gandy spreader on October 11.

Very high seed yield was produced at this location (Table 7). While nitrogen, applied at rates of 40 lb/acre and above, increased the N concentration of grass tissue, it had no beneficial effect on the yield.

Table 7. Effect of fertilization on seed yield and N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen farm, Roseau County, 1979.

N Rate lb/acre	Seed Yield lb/acre	N Percent in Dry Matter
0	570	2.04a
20	639	2.02a
40	614	2.16ab
60	526	2.29b
80	638	2.14ab
Significance	ns	*
BLSD (0.05)	-	0.20
C.V.	11	5

Values followed by different letters are significantly different (5% level).

All plots received 0+40+40 lbs/acre of P_2O_5 and K_2O.

D. COPPER STUDY ON PEAT

Two field experiments with Kentucky bluegrass on peat were established in the fall of 1978. The objectives of this study are:

1. To determine the need for copper by Kentucky bluegrass grown for seed production on peat.

2. To determine the effectiveness of copper sulfate and copper chelate as Cu source.

3. To determine the effectiveness of fall vs. spring application.

4. To evaluate the effectiveness of a single application (residual) vs. repeated annual applications of copper.

The soils contained 1.18 and 1.45 ppm DTPA extractable copper in the top 3 inches (Table 3), indicating a relatively low availability of this nutrient. Copper sulfate and copper chelate were dissolved in water and sprayed on 10 x 20 ft. plots on October 12 and May 8. The treatments were arranged in a split plot design with the time of application as main plots and the subplots consisting of residual and annual treatments. All treatments were replicated four times. During the first year of establishment, both residual and annual treatments actually represented an annual treatment. Therefore, results of treatments receiving copper applications represent averages of 8 subplots. The entire experimental area received 20+40+40 lb/acre of N, P_2O_5 and K_2O on October 12.

Park Kentucky bluegrass yield was not affected by fertilization with copper (Table 8). Copper concentration in tissue of bluegrass collected from check plots was 1.39 ppm, considered a very low level. Copper sulfate (12.75 lb. Cu/A) applied at 50 lb/acre rate, increased Cu concentration of tissue to nearly 11.0 ppm, with both fall and spring applications being equally effective. The application of 6 lb/acre of copper chelate (0.78 lb. Cu/A) did not significantly increase the copper concentration of grass tissue.

Newport Kentucky bluegrass yield was increased 48 lb/acre over the check by fall application of 50 lb/acre of copper sulfate. Copper concentration of grass tissue was increased by fertilization with copper sulfate to nearly 7 ppm, compared to 1.24 ppm Cu for tissue from check plots.

Table 8. Seed yield and Cu concentration of Park Kentucky bluegrass tissue as affected by fertilization with copper, Gus Kveen, Roseau Co., 1979.

Copper Treatment		Time of Application	Seed Yield lb/acre	Copper, ppm in Dry Matter
	None		593	1.39a
50 lb/acre	Copper Sulfate	Fall	600	11.57b
"	" "	Spring	617	10.45b
6 lb/acre	Copper Chelate	Fall	598	5.18a
"	" "	Spring	664	5.13a
Significance			ns	**
BLSD (0.05)			-	4.74
C.V.			14	70

Values followed by different letters are significantly different at 5% level.

Table 9. Seed yield and Cu concentration of Newport Kentucky bluegrass tissue as affected by fertilization with copper, Gus Kveen, Roseau Co., 1979.

Copper Treatment		Time of Application	Seed Yield lb/acre	Copper, ppm in Dry Matter
	None		254a	1.24a
50 lb/acre	Copper Sulfate	Fall	302b	7.66c
"	" "	Spring	256a	6.32bc
6 lb/acre	Copper Chelate	Fall	257a	4.07ab
"	" "	Spring	291ab	4.33abc
Significance			*	**
BLSD (0.05)			38	3.51
C.V.			13	70

Values followed by different letters are significantly different at 5% level.

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Navy Bean Inoculation Trials - 1979

S.D. Sparrow and G.E. Ham

Peat is generally used as a carrier of Rhizobium (or nodule bacteria) used for inoculation of legume crops. However, the properties of peat are highly variable (even if obtained from the same deposit) and survivability of Rhizobium in peat can therefore vary. Also, peat is not readily available in many parts of the world. In order to test the effectiveness, under field conditions, of several materials as carriers of Rhizobium phaseoli, Upland navy beans at Becker and Rosemount were inoculated at planting with nodule bacteria in the following carriers: mineral salts liquid media, milled peat and finely ground peanut hulls, corn cobs, vermiculite, and charcoal. Three R. phaseoli strains, 3644, CIAT 75, and 650 R, which were previously shown to be effective nitrogen fixers were used in the study.

Nodule bacteria were added, using either a concentrated (high rate) or a dilute (low rate) cell suspension, to the carriers two days before planting. Carriers were refrigerated until time of use. Plate counts of suspensions were done to determine cell numbers. Average cell numbers for the three strains are presented in Table 1.

Seed yields for each carrier and rate are presented in Table 1 for Becker and Table 2 for Rosemount. Yields are averaged over the three R. phaseoli strains. Yields at Rosemount (average yield 1729 lbs/ac) were considerably higher than at Becker (average yield, 789 lbs/ac). At Rosemount, inoculation did not result in significant yield increases over the control. At Becker on the other hand, liquid media and vermiculite at the high rate and peat and charcoal at both rates resulted in significant yield increases over the uninoculated control. Peanut hulls and corn cobs at either rate did not result in significant yield increases.

Studies are currently being done in the laboratory to determine the long-term effectiveness of these materials as carriers of nodule bacteria.

Table 1. Navy bean yield for various Rhizobium phaseoli carriers at Becker.

Carrier	Rate	Seed yield (lbs/ac)
Control	0	569[c+]
liquid	low*	683[bc]
liquid	high*	896[ab]
peat	low	1031[a]
peat	high	953[a]
peanut hulls	low	658[bc]
peanut hulls	high	670[bc]
corn cobs	low	653[bc]
corn cobs	high	564[c]
vermiculite	low	786[abc]
vermiculite	high	958[a]
charcoal	low	857[ab]
charcoal	high	981[a]

Average # cells for low rate = 2.5×10^4 cells per cm row
Average # cells for high rate = 5.0×10^6 cells per cm row
[+] yields followed by the same letter(s) are not significantly different at the 95% level.

Table 2. Navy bean yield for various Rhizobium phaseoli carriers at Rosemount

Carrier	Rate	Seed yield (lbs/ac)
Control	0	1768
liquid	low	1750
liquid	high	1589
peat	low	1645
peat	high	1724
peanut hulls	low	1799
peanut hulls	high	1773
corn cobs	low	1730
corn cobs	high	1824
vermiculite	low	1770
vermiculite	high	1778
charcoal	low	1601
charcoal	high	1721

PASTURE FERTILIZATION TRIALS

Washington Co., 1978 & 1979

Morris Station, 1979

C.J. Overdahl, Jerome Lensing and Michael O'Leary

A pasture trial was initiated at the Kelly farms in Washington County, managed by Morris Grogan. The objective of one trial was to document magnesium levels which might be related to grass tetany in cattle. Magnesium content and relationship to potash treatments, to added dolomitic lime and to magnesium sulfate applications were studied. A nitrogen trial was also conducted at this site and was adjacent to the magnesium plot. This plot had varying nitrogen treatments to 120 pounds and is a continuation of the nitrogen trials in Goodhue County. Plots were fenced to prevent grazing.

A bromegrass plot was established at the Morris Station in 1979 in cooperation with Dr. Sam Evans to observe urea benefits topdressed on a high pH soil. Urea and ammonium were applied to split plots.

Discussion and summary

Kelly farms

1. Applications of dolomitic lime in the spring of 1978 did not increase magnesium content of grass that year, but in 1979 magnesium significantly increased from the topdressed application in 2 of the 4 cuttings. Epsom salts also increased magnesium.

2. Potassium, at very high rates, decreased magnesium content but at recommended rates no apparent reduction occurred.

3. There were no grass yield benefits from liming, only magnesium quality benefits that could offset potential problems of grass tetany in cattle.

4. Soil pH, on the surface 3 inches, has increased from 5.2 to 6.4 from 4 tons of lime from April 1978 to October 1979.

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