General Results

The results from the 1977 cropping year are presented in Tables 2-5. Leaf nitrogen concentrations at silking (Table 2) indicate that only four locations out of twelve responsed to the application of nitrogen and only two or possibly three of these locations were low enough to anticipate reduced yields because of inadequate nitrogen.

Only two locations of the twelve established gave significant yield increases with the application of additional nitrogen (Table 3). In both cases these locations had the lowest leaf nitrogen concentrations earlier in the summer. Nitrogen removal in the grain generally followed grain yield, but grain protein normally increased in addition if a yield increase was obtained.

Yields and crop response to nitrogen application appeared to be highly correlated with soil nitrate nitrogen. No yield responses were obtained from any location when the average nitrate nitrogen concentration per foot of soil within the five foot profile was over eight parts per million (approx. 160 # NO_3-N/A on a five ft. basis). Both location showing a nitrogen response obtained yields in excess of 140 bu/A/ Other locations which had low soil nitrate concentrations but had no yield response to added nitrogen were much lower in yields and yield potentials were probably not obtained because of some other factor such as moisture, plant density, variety or numerous other factors.

As can be seen in Table 5 nitrate concentrations within the profile at each location changed between fall and spring sampling. In general many of the nitrates present in the surface in the fall had been moved down to depth of two to three feet by the following spring. The significance of nitrate nitrogen distribution within the soil profile and its effect on the depth to which sampling should be done remain to be investigated. Information obtained thus far would suggest that deep sampling of soils for residual nitrate could become a useful tool in predicting fertilizer nitrogen needs.

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

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	Morris Station "A"	Stevens
8	Morris Station "B"	Stevens
9	Lawrence Quade	Cottonwood
10	Paul Schoper	Cottonwood
11	Wayne Schwitter	Chippewa
12	Donald Werner	Pipestone

Table 2. Nitrogen concentration of the leaf opposite and below the ear at mid-silking at 12 locations in S.W. Minnesota as influenced by nitrogen treatment

Treatment		Leaf N Concentrations											
		Location No.											
N Applied	N Rate	1	2	3	4	5	6	7	8	9	10	11	12
	#/A	%											
fall	0	1.77	2.50	2.86	2.78	2.39	2.88	2.92	3.06	2.29	2.62	2.85	2.97
fall	40	2.38	2.70	3.08	2.78	2.39	2.84	3.03	2.94	2.47	2.86	2.88	2.96
fall	80	2.41	2.40	3.28	2.91	2.64	2.84	2.93	2.88	2.57	2.83	2.86	2.85
fall	120	2.60	2.56	3.15	2.75	2.81	2.91	2.98	3.04	2.69	2.80	3.00	3.08
spring	0	2.09	2.68	3.10	2.90	2.61	2.96	2.78	2.92	2.32	2.70	2.71	2.97
spring	40	2.16	2.42	2.94	2.77	2.76	2.80	2.80	2.91	2.50	2.78	2.79	3.06
spring	80	2.44	2.61	3.28	2.86	2.54	2.90	2.98	2.91	2.46	2.82	2.80	3.00
spring	120	2.54	2.78	2.98	2.98	2.91	2.84	3.20	3.09	2.94	2.90	3.02	3.20
signif.		**	+	NS	NS	NS	NS	NS	NS	*	NS	+	NS
BLSD .05		.25	.23							.40		.19	

Table 3. Grain yield at 12 locations in S.W. Minnesota as influenced by nitrogen treatment.

Treatment		Grain Yield -- 15.5% Moisture											
		Location No.											
N Applied	N Rate	1	2	3	4	5	6	7	8	9	10	11	12
	#/A	bu/A											
fall	0	108	109	105	135	144	143	102	130	139	116	124	125
fall	40	135	113	97	142	136	126	109	144	153	123	123	131
fall	80	138	115	100	138	131	125	101	148	174	117	116	124
fall	120	153	116	98	131	130	132	103	133	152	121	117	131
spring	0	101	109	97	137	157	132	102	123	141	126	119	123
spring	40	132	117	115	127	154	123	106	129	163	129	112	124
spring	80	132	121	109	129	120	135	109	133	159	124	105	115
spring	120	140	117	108	121	156	119	104	132	174	121	121	122
Signif.		*	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
BLSD .05		27								18			

Table 4. Nitrogen removal by the grain at 12 locations in S.W. Minnesota as influenced by nitrogen treatment.

Treatment		Grain Nitrogen Removal											
		Location No.											
N Applied	N Rate	1	2	3	4	5	6	7	8	9	10	11	12
	#/A	#N/A											
fall	0	54	87	89	100	99	109	83	112	86	102	93	93
fall	40	86	89	77	115	103	96	95	125	110	109	102	108
fall	80	82	89	84	116	100	97	85	125	126	101	88	100
fall	120	97	82	85	114	102	101	84	113	119	109	93	106
spring	0	48	82	76	109	112	102	84	108	104	107	92	98
spring	40	81	90	102	112	112	94	84	110	113	117	90	103
spring	80	82	92	87	106	94	110	93	111	104	107	81	92
spring	120	96	84	96	111	123	94	92	112	127	110	96	103
Signif.		*	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
BLSD .05		33								14			

Table 5. Soil nitrate concentrations by depth and previous cropping history of 12 locations in Southwestern Minnesota.

Depth	Nitrate Nitrogen Concentration											
	Location No.											
	1		2		3		4		5		6	
	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring
ft.	ppm											
0-.5	6	4	8	11	-	12	54	9	24	5	30	12
.5-1	3	4	10	13	-	20	34	23	20	13	29	49
1-2	1	5	6	10	-	20	17	32	8	19	15	45
2-3	1	2	6	9	-	27	20	34	4	17	13	28
3-4	1	2	6	7	-	23	16	17	4	9	14	15
4-5	1	1	5	5	-	17	6	6	4	8	14	11
Previous crop	soybeans		soybeans		oats		wheat		soybeans		corn	

	7		8		9		10		11		12	
0-.5	28	13	72	3	17	6	56	5	28	13	13	4
.5-1	17	16	27	14	11	6	40	11	7	12	13	21
1-2	4	16	4	19	4	11	14	32	3	10	14	14
2-3	4	7	5	14	4	10	13	18	4	6	9	15
3-4	3	3	8	8	5	6	14	13	2	6	3	5
4-5	3	3	7	7	6	4	13	11	2	2	3	4
Previous Crop	Corn		Corn		Soybeans		Wheat		Sugarbeets		Flax	

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 W. Wallingford

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, resulting in a loss of a portion of plant available nitrogen and, therefore, a potential for yield reductions. 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, and yield increases due to earlier planting dates with fall applications of nitrogen. This condition exists provided that nitrogen losses are not severe in the interum period. If nitrification inhibitors are capable of minimizing the production of nitrate 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, therefore, 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 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.

In order to follow the rate at which the ammonium nitrogen was converted to nitrate nitrogen soil samples were collected and analyzed from a 0-1 ft. depth over the anhydrous injection area at approximately one week intervals following nitrogen application. Soil samples were also collected and analyzed at monthly intervals to a depth of five feet in order to follow nitrate nitrogen accumulation within the soil profile (see supplement).

Treatment influences on nitrogen utilization by the crop evaluated in several manners. Corn leaf samples from opposite and below the ear at 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.

Results

In general relatively few major differences in yields and nitrogen utilization by the crops were encountered during the growing season in 1977. Most of the information would suggest that nitrogen was not the most limiting factor in production.

The nitrogen content of the leaf opposite and below the ear at silking was significantly influenced by timing and rate of nitrogen application at 2 out of 3 locations (Table 2). The spring nitrogen application was as good as any other time of application with one of the fall treatments not being as effective, but the earliest application not necessarily being the worst. N-Serve increased the nitrogen content of the 6th leaf at the Morris site but in all cases the nitrogen contents were above what would be considered limiting.

Grain yields (Table 3) were influenced very little by treatments. Only the experimental site at Waseca gave any significant yield increase with nitrogen and that was between the control and the first rate of nitrogen (75 # N/A). The early fall application of nitrogen at Waseca reduced corn grain yields. Nitrogen removal with the grain (Table 3) was influenced in a similar manner as yields.

Although N-Serve had very little influence in altering yields and plant utilization of nitrogen in 1977 it did have a considerable influence in keeping more of the applied nitrogen in the ammonium form (Table 5). In general the later nitrogen was applied in the fall the greater the ammonium concentration the following spring. The retension of nitrogen in the ammonium form in the spring following fall application without N-Serve, however, was not as large as anticipated. N-Serve was capable of keeping 10-40 percent more of the original nitrogen in the ammonium form than when no nitrification inhibitor was applied. Whether this influence will have any positive benefits on yield and nitrogen utilization by the crop depends on the environmental conditions encountered prior to and during the growing season which may result in nitrogen losses as well as crop demand and the expected response to applied fertilizer nitrogen.

Table 1. Experimental Treatments with fall vs. spring nitrogen applications and N-Serve.

Experimental Location	Nitrogen Rate[1]	Date of Appl.		N-Serve Rate	Test Crop
	#/A	1976-77		# AI/A	
Waseca	0	9/10	10/5	0, 1/2	Corn
	75	11/1	4/25		(Pioneer 3709)
	150				
Lamberton	0	9/15	10/1	0, 1/2	Corn
	50	11/1	4/29		(Pioneer 3780)
	100				
Morris	0	8/25	9/24	0, 1/2	Corn
	40	10/26	4/26		(Dekalk XL12)
	80				
Crookston	0	8/17	9/5	0, 1/2	Wheat
	40	10/19	5/3		(Era)
	80				

[1] applied as anhydrous ammonia

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.

Treatment[1]			6th Leaf N Content		
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris
		D.S. #ai/A	%		
Control	zero	no	2.42	2.72	2.86
Early Fall	Med	No	2.61	2.87	3.03
Early Fall	Med	Yes	2.59	2.89	3.28
Early Fall	High	No	2.67	3.00	2.96
Early Fall	High	Yes	2.65	2.93	3.16
Mid Fall	Med	No	2.60	2.90	2.77
Mid Fall	Med	Yes	2.53	2.95	2.95
Mid Fall	High	No	2.67	3.08	2.91
Mid Fall	High	Yes	2.64	3.05	3.01
Late Fall	Med	No	2.56	3.14	2.96
Late Fall	Med	Yes	2.59	2.94	2.98
Late Fall	High	No	2.77	3.34	3.08
Late Fall	High	Yes	2.68	3.09	2.95
Spring	Med	No	2.58	2.89	3.06
Spring	Med	Yes	2.56	3.06	3.12
Spring	High	No	2.64	3.13	3.00
Spring	High	Yes	2.65	3.19	2.94
Signif.			*	**	+
B.L.S.D. (.05)			.20	.24	.15
Factorial Arrangement					
Applicate Date					
Early Fall			2.63	2.92	3.11
Mid Fall			2.61	3.00	2.91
Late Fall			2.65	3.12	2.99
Spring			2.61	3.07	3.03
Signif.			NS	**	*
B.L.S.D. (.05)				.11	.13
Nitrate Rate					
Med			2.58	2.95	3.02
High			2.67	3.10	3.00
Signif.			**	**	NS
B.L.S.D. (.05)			.06	.08	
N-Serve					
No			2.64	3.04	2.97
Yes			2.61	3.01	3.05
Signif.			NS	NS	+
B.L.S.D. (.05)					.08

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--1977

Treatments[1]			Grain Yields			
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris	Crookston
		0.5 # ai/A	bu/A			
Control	zero	no	139.8	128.1	118.1	18.6
Early fall	med	no	144.2	128.5	117.8	22.2
Early fall	med	yes	148.2	129.0	108.2	19.4
Early fall	high	no	150.0	137.6	110.5	16.2
Early fall	high	yes	149.5	130.6	114.3	19.1
Mid fall	med	no	152.4	139.2	114.0	19.2
Mid fall	med	yes	156.0	131.2	116.4	18.9
Mid fall	high	no	154.5	133.6	114.2	19.7
Mid fall	high	yes	156.9	130.5	108.4	17.9
Late fall	med	no	145.0	129.8	112.4	20.1
Late fall	med	yes	147.5	141.2	108.6	20.4
Late fall	high	no	150.2	128.7	111.7	16.8
Late fall	high	yes	155.9	133.4	109.8	15.8
Spring	med	no	155.1	135.1	110.2	23.2
Spring	med	yes	155.1	132.1	118.8	22.0
Spring	high	no	152.0	132.0	114.3	20.2
spring	high	yes	154.5	139.2	112.4	18.7
Signif.			*	NS	NS	NS
B.L.S.D. (.05)			13.4			
Factorial Arrangement						
Application Date						
Early fall			148.0	131.4	112.7	19.2
Mid fall			154.9	133.8	113.3	18.9
Late fall			149.6	133.3	110.6	18.2
Spring			154.1	134.6	113.9	21.0
Signif.			*	NS	NS	NS
B.L.S.D. (.05)			5.4			
Nitrogen Rate						
Med			150.4	133.4	113.3	20.7
High			152.9	133.2	111.9	18.0
Signif.			NS	NS	NS	**
B.L.S.D. (.05)						1.6
N-Serve						
No			150.4	133.1	113.1	19.7
Yes			152.9	133.5	112.1	19.0
Signif.			NS	NS	NS	NS
B.L.S.D. (.05)						

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

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

Treatments			Grain N Removal			
Date of N Appl.	N Rate	N-Serve	Waseca	Lamberton	Morris	Crookston
		0.5 # AI/A	#/A			
Control	zero	no	92.0	100.1	88.5	34.7
Early fall	med	no	104.3	100.2	90.6	40.7
Early fall	med	yes	109.2	101.5	82.2	36.2
Early fall	high	no	109.3	100.6	84.3	31.1
Early fall	high	yes	106.0	110.1	86.8	36.6
Mid fall	med	no	106.3	113.3	84.4	37.3
Mid fall	med	yes	110.6	106.0	87.9	36.4
Mid fall	high	no	110.1	110.5	86.3	35.7
Mid fall	high	yes	116.4	109.2	81.7	33.2
Late fall	med	no	106.3	108.6	84.2	37.2
Late fall	med	yes	104.0	112.0	80.3	38.2
Late fall	high	no	112.2	105.0	86.4	32.6
Late fall	high	yes	111.8	107.5	85.3	31.3
Spring	med	no	113.9	112.5	84.8	43.5
Spring	med	yes	108.4	113.5	90.2	40.3
Spring	high	no	111.9	108.7	88.4	38.2
Spring	high	yes	116.1	120.9	88.5	37.7
Signif.			*	+	NS	NS
B.L.S.D. (.05)			13.0	13.6		
Factorial Arrangement						
Application Date						
Early fall			107.2	103.1	86.0	36.1
Mid fall			110.9	109.8	85.1	35.7
Late fall			108.6	108.3	84.1	34.8
Spring			112.6	113.9	88.0	40.0
Signif.			NS	*	NS	+
B.L.S.D. (.05)				6.2		3.7
Nitrogen Rate						
Med			107.9	108.4	85.6	38.7
High			111.7	109.1	86.0	34.5
Signif.			+	NS	NS	**
B.L.S.D. (.05)			3.3			2.8
N-Serve						
No			109.3	107.4	86.2	37.0
Yes			110.3	110.1	85.4	36.2
Signif.			NS	NS	NS	NS
B.L.S.D. (.05)						

Table 5. Influence of timing of nitrogen application and the use of N-Serve on the persistence of ammonium nitrogen within the soil at early spring.

Treatment		% of original NH_4^+-N			
Date of N Appl.	N-Serve	Waseca	Lamberton	Morris	Crookston
	0.5 # AI/A	May 19	June 1	May 18	May 14
		%			
Early fall	no	12	6	9	20
Early fall	yes	37	30	32	19
Mid fall	no	19	11	13	17
Mid fall	yes	40	51	24	36
Late fall	no	22	16	22	13
Late fall	yes	32	23	44	32
Spring	no	59	43	43	64
Spring	yes	38	80	58	80

PHOSPHORUS PLACEMENT ON CORN

G.L. Malzer, S. Evans, and W. Wallingford

Evidence from other states suggest that phosphorus fertilizer placement may be important in efficient phosphorus use, especially on soils which are known to have a high phosphorus "fixings" capacity. On these soils broadcast applications of phosphorus may be rendered unavailable to the present crop more rapidly than would a more concentrated application of the same amount of fertilizer in a smaller volume of soil. Trials were, therefore, established on two high pH soils in western Minnesota to investigate the influence of phosphorus placement and rate of phosphorus application on yield and phosphorus utilization of corn on soils already testing medium to high in phosphorus.

Experimental Procedures

Seven treatments including a check, two rates of phosphorus (30# and 60# P_2O_5/A) and three methods of application were established at West Central Experiment Station at Morris and the Northwest Experiment Station at Crookston. The three methods of application included a broadcast application, a "row" application in a small zone similar to a starter application, and a "band" application approximately 10-12 inches wide. Each method was applied at the two phosphorus rates and incorporated prior to planting. Corn was planted into 30 inch rows with the bands being in close proximity to the rows.

Influence of the treatments on phosphorus utilization were evaluated by collecting small plant samples (12" ht.) and leaf samples from opposite and below the ear at silking for elemental analysis. Yields were also obtained by hand harvesting known areas from each plot.

General Results

No significant yield responses were obtained with any of the phosphorus treatments. Dry weather at the Crookston location along with poor early growth of the crops at each location limited yields. The phosphorus concentration in the 6th leaf at silking (Table 1) would suggest that there is no advantage under the experimental conditions encountered at Morris and Crookston to wide band applications of phosphorus. The rates and methods of application also had an influence on the elemental concentrations of several other nutrients at Morris but the significance of this remains to be investigated.

Table 1. - Influence of phosphorus placement and rate on corn grain yield and elemental composition of the 6th leaf at silking

Treatment		Grain Yield		6th Leaf Composition											
				P		Mg		Fe		Zn		Cu		Mn	
P_2O_5	Method	Morr.	Crook	Morr.	Crook.	Morr.	Crook.	Morr.	Crook.	Morr.	Crook.	Morr.	Crook.	Morr.	Crook
#/A				%		%		ppm							
0	--	117.6	56.9	.35	.60	.61	.92	242	203	19	17	10	14	112	115
30	row	123.4	59.9	.39	.59	.64	.89	265	190	18	15	10	12	124	123
60	row	114.4	57.0	.38	.57	.76	.90	269	191	18	16	9	12	119	124
30	band	116.1	57.2	.33	.61	.61	.96	234	185	17	16	9	12	98	132
60	band	111.7	56.7	.36	.65	.70	.03	240	199	18	16	8	14	113	132
30	broadcast	117.1	57.1	.36	.59	.58	1.03	264	199	19	16	9	12	106	133
60	broadcast	119.6	56.6	.37	.64	.62	.96	241	211	18	17	8	12	106	123
Signif.		NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)						.12									
Factorial Arrangement															
Placement															
row		118.9	56.8	.38	.62	.70	.99	267	205	18	16	9	12	121	128
band		113.9	56.9	.34	.58	.66	.90	237	191	18	15	8	12	106	124
broadcast		118.4	57.0	.36	.63	.60	.95	253	192	18	16	9	13	106	132
Signif.		NS	NS	+	NS	*	NS	NS	NS	NS	NS	+	NS	*	NS
B.L.S.D. (.05)				.03		.08						1		13	
Rate															
30		118.9	57.1	.36	.60	.61	.96	255	192	18	16	9	12	109	129
60		115.2	56.7	.37	.62	.70	.93	250	200	18	16	8	12	113	126
Signif.		NS	NS	NS	NS	*	NS	NS	NS	NS	NS	*	NS	NS	NS
B.L.S.D. (.05)						.06						1			

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

Gyles W. Randall, Samuel D. Evans and Wallace 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. Treatments 5 and 8 will receive P and K, respectively, every third year for the duration of the experiment. Treatments 9 and 10, applied in the fall of 1973, will not receive P and K again until either P or K starts to become limiting (determined via soil test, tissue test or yield). All other treatments will be 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	1975	1976	1977
	lbs. P_2O_5 + K_2O				
1	0 + 0	0 + 0	0 + 0	0 + 0	0 + 0
2	0 + 100	0 + 100	0 + 100	0 + 100	0 + 100
3	50 + 100	50 + 100	50 + 100	50 + 100	50 + 100
4	100 + 100	100 + 100	100 + 100	100 + 100	100 + 100
5	150 + 100	0 + 100	0 + 100	150 + 100	0 + 100
6	100 + 0	100 + 0	100 + 0	100 + 0	100 + 0
7	100 + 50	100 + 50	100 + 50	100 + 50	100 + 50
8	100 + 150	100 + 0	100 + 0	100 + 150	100 + 0
9	150 + 100	0 + 0			
10	100 + 150	0 + 0			

Treatment numbers 2, 3, 4, 5, 6, 7, 8 were broadcast on cornstalks and plowed down at all locations in the fall of 1976. 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.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1977.

Variable	Lamberton	Morris	Waseca
Planting date	5/6	4/29	5/2
Row spacing	30"	30"	30"
Population	24,000	22,000	24,000
Hybrid	Pioneer 3780	DeKalb XL12	Pioneer 3710
Nitrogen rate	70# N	80# N	200# N
Herbicide	2½# Eradicane/A +1.5# Bladex(Bdct)	2# Lasso + 2# Bladex/A (Bdct)	3# Lasso + 2.5# Bladex/A (Bdct)
Insecticide	1# Counter/A	1# Furadan/A	1# Dyfonate/A
Harvest date	9/28	9/19	9/22

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1977 growing season. After four years of application, 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 only received an initial application in 1973. Intermediate P levels were found with treatment 5 (150 lb P_2O_5 every third year) at Morris and Waseca and at all locations with treatment 3 (50 lb P_2O_5 annually). 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 by the K treatments at Lamberton and Morris but not at Waseca (Table 3). These results are identical to 1976. As with P there appears to be somewhat of a linear response to the annual K applications but the relationship is not as exact. Soil pH differences were small and did not appear to be 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 growth (weight and height) was increased significantly (P=.01) by the P and K treatments at all three locations (Table 4). 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 haven't been applied since 1973 (nos. 9 and 10). The growth response at all locations was due primarily to P. Early weight was increased over the 0 P_2O_5 rate (no. 2) by the 50, 100 and 150 lb P_2O_5 rates by 6, 26 and 6% at Lamberton, 16, 38 and 39% at Morris, and 21, 40 and 36% at Waseca, respectively. No effect of K was noticed except at the Morris location.

Table 3. Soil test values as influenced by four year's application of the 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	5.9	7.7	5.8	38	15	37	20	195	320	210
2	0 + 100	5.8	7.7	5.8	31	15	38	22	240	445	225
3	50 + 100	6.3	7.6	5.7	42	33	76	32	235	385	230
4	100 + 100	5.8	7.7	5.9	55	52	116	39	225	395	245
5	150 + 100	6.0	7.6	5.8	54	36	83	32	235	385	225
6	100 + 0	5.8	7.7	5.9	54	50	116	34	180	315	200
7	100 + 50	5.9	7.7	5.8	50	48	110	37	205	375	215
8	100 + 150	5.9	7.5	5.7	54	63	134	37	225	375	215
9	0 + 0	6.2	7.6	5.8	38	25	61	21	205	330	205
10	0 + 0	5.9	7.8	6.0	44	18	48	21	210	350	220
Significance:[3]		NS	+	*	**	**	**	**	**	**	NS
BLSD (.05) :				0.2	13	9	20	6	30	55	
CV (%) :		5	3	2	19	18	18	16	8	10	9

1/ Samples were taken in October before the 1977 treatments were applied.
2/ Rates applied in fall of 1976 for 1977 crop.
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 1977.

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	9.0	5.1	10.2	21	22	29
2	0 + 100	8.5	5.6	9.6	21	24	30
3	50 + 100	9.0	6.5	11.6	21	25	32
4	100 + 100	10.7	7.7	13.4	22	26	34
5	150 + 100	9.0	7.8	13.1	22	26	34
6	100 + 0	10.2	7.6	12.2	22	25	32
7	100 + 50	9.8	7.0	12.2	22	25	33
8	100 + 150	10.9	8.2	12.8	22	27	33
9	0 + 0	8.4	6.1	9.3	21	24	29
10	0 + 0	9.0	5.7	8.9	22	24	30
Significance:		**	**	**	**	**	**
BLSD (.05) :		1.5	1.1	1.2	0.9	2.0	1.4
CV (%) :		10.	11.	8.	3.	5.	3.

Because of the sizable early plant growth effects at Waseca, the small plant samples were chemically analyzed. Concentrations of P and Mg were affected significantly (P=.01 and .05, respectively) by the P and K treatments (Table 5). Plant P appeared to increase linearly with P rate while plant Mg decreased with increasing K rate. Plant K was not influenced.

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at Waseca in 1977.

Treatment No.	Description lb P_2O_5+K_2O/A	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		---------%---------				--------ppm--------				
1	0 + 0	.41	3.47	.47	.39	480	82	47	8	11
2	0 + 100	.42	3.70	.43	.32	490	86	44	9	11
3	50 + 100	.46	4.01	.37	.28	480	81	42	8	12
4	100 + 100	.48	3.43	.38	.27	400	85	38	6	11
5	150 + 100	.51	4.03	.32	.26	370	65	39	5	10
6	100 + 0	.47	3.81	.46	.39	410	74	39	5	9
7	100 + 50	.48	3.50	.37	.29	420	73	41	6	12
8	100 + 150	.48	3.66	.38	.28	450	81	41	6	12
9	0 + 0	.43	3.10	.43	.35	470	88	41	8	16
10	0 + 0	.44	3.60	.42	.34	470	93	48	9	13
Significance:		**	NS	NS	*	+	NS	NS	**	+
BLSD (.05) :		.06			.10				2.6	
CV (%) :		9.	17.	27.	18.	13.	22.	14.	23.	20.

Uptake of P and K by the small plants was affected significantly (P=.01) by the treatments (Table 6). A linear response to P rate was obtained; whereas, K rate had little influence on K uptake. This would further indicate that early growth differences were due to phosphate application rather than potash.

Table 6. Effect of high P and K rates on the P and K uptake by small corn plants at Waseca in 1977.

Treatment No.	Description lb P_2O_5+K_2O/A	Uptake P	Uptake K
		--mg/plant---	
1	0 + 0	42	353
2	0 + 100	41	362
3	50 + 100	53	474
4	100 + 100	65	459
5	150 + 100	67	530
6	100 + 0	58	469
7	100 + 50	58	429
8	100 + 150	61	469
9	0 + 0	40	288
10	0 + 0	40	320
	Significance:	**	**
	BLSD (.05) :	8	116
	CV (%) :	11.	18.

Leaf analyses showed significant effects of the P and K treatments at the Morris and Waseca locations (Table 7). High variability in the analyses from Lamberton negated any significant effects. At Morris leaf P was increased with increasing P rate. Leaf K was related to K rate but did not correspond as closely to K rate as leaf P did to P rate. Leaf Mg was reduced by increasing K rate. At Waseca increasing K rate resulted in higher leaf K and lower leaf Mg. At all three locations leaf K was greater when no P was applied (trt. no. 1) than when the 100-lb P_2O_5 rate (trt. no. 6) was applied. Zinc concentrations at Lamberton and Morris were much lower than those found in 1976 and are now approaching deficiency levels. This may be due only to time of sampling or N nutrition. However, a broadcast Zn SO_4 treatment should be applied if these lower levels appear again in 1978.

No significant differences in final population were found among the 10 treatments at any of the locations (Table 8). The incidence of broken stalks was affected at Morris (Table 8). Those plots receiving higher rates of K had increased numbers of broken stalks at harvest. A disease which occurred rapidly within a few days in early September and caused premature death appeared to be the causal factor for the broken stalks.

Silage and grain yields and grain moisture (an indication of maturity at harvest) are given in Table 9. Silage yields at Lamberton and Waseca were not influenced significantly; however, a slight response to K (P=.10) was found at Morris. Grain yields after four years of treatment application were not affected significantly at any of the locations, although a trend was evident at Waseca. Yields at Morris may have been influenced slightly by the aforementioned disease problem. Grain moisture at harvest was affected by the treatments only at the Morris location, giving further indication of the premature death caused by disease.

Table 7. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1977. [1/]

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	---------%---------				--------ppm--------				
					Lamberton					
1	0 + 0	.23	1.93	.61	.38	185	63	24	6	6
2	0 + 100	.20	2.26	.50	.29	175	48	21	6	6
3	50 + 100	.24	2.45	.67	.37	160	48	18	6	8
4	100 + 100	.22	2.12	.54	.30	180	49	19	5	7
5	150 + 100	.21	2.10	.58	.32	155	53	19	6	6
6	100 + 0	.22	1.86	.61	.36	180	59	20	6	7
7	100 + 50	.21	2.15	.53	.31	185	49	19	5	6
8	100 + 150	.20	2.01	.54	.31	185	49	19	5	6
9	0 + 0	.22	2.03	.63	.37	180	54	19	6	7
10	0 + 0	.23	2.09	.62	.36	180	51	22	7	7
	Significance:	NS	NS	NS	NS	NS	NS	NS	NS	NS
	CV (%) :	19	17	20	18	11	18	13	19	18
					Morris					
1	0 + 0	.31	1.91	.56	.61	225	66	24	10	9
2	0 + 100	.31	2.05	.55	.56	235	59	24	9	9
3	50 + 100	.35	2.20	.60	.56	240	65	24	11	10
4	100 + 100	.34	2.12	.60	.58	240	70	19	10	11
5	150 + 100	.34	1.92	.58	.62	225	68	20	9	9
6	100 + 0	.35	1.79	.63	.68	230	68	18	9	11
7	100 + 50	.36	2.04	.62	.60	245	74	21	10	11
8	100 + 150	.36	1.89	.63	.55	235	62	19	9	9
9	0 + 0	.33	1.78	.58	.71	230	74	22	10	10
10	0 + 0	.32	1.92	.57	.63	230	65	24	10	10
	Significance:	**	**	NS	*	NS	*	*	NS	NS
	BLSD (.05) :	.02	.19		.10		10	5		
	CV (%) :	4	6	8	10	35	9	14	12	12
					Waseca					
1	0 + 0	.33	1.96	.63	.42	230	100	29	11	10
2	0 + 100	.33	2.08	.60	.34	220	103	32	9	12
3	50 + 100	.34	2.15	.60	.34	230	115	30	9	12
4	100 + 100	.34	1.94	.63	.34	215	108	24	9	12
5	150 + 100	.35	1.78	.69	.35	215	127	26	8	13
6	100 + 0	.35	1.61	.71	.42	220	116	24	8	11
7	100 + 50	.34	1.80	.66	.37	215	121	24	9	11
8	100 + 150	.36	2.21	.61	.36	250	106	30	8	12
9	0 + 0	.35	1.93	.66	.40	230	115	28	9	12
10	0 + 0	.34	1.94	.65	.41	230	102	29	10	12
	Significance:	NS	**	NS	**	NS	NS	NS	NS	NS
	BLSD (.05) :		.36		.05					
	CV (%) :	6	11	12	10	11	16	21	19	17

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

Table 8. Population and broken stalks at harvest as influenced by high P and K rates in 1977.

Treatment No.	Treatment Description	Final population La	Final population Mo	Final population Wa	Broken stalks La	Broken stalks Mo	Broken stalks Wa
	lb P_2O_5+K_2O/A	plants/A x 10^3			------%-------		
1	0 + 0	22.0	19.0	22.2	1/	16.6	1/
2	0 + 100	21.3	19.1	21.0		32.4	
3	50 + 100	20.0	19.0	20.9		35.4	
4	100 + 100	20.9	19.0	21.6		43.8	
5	150 + 100	21.6	19.1	22.5		32.7	
6	100 + 0	21.6	19.1	21.2		24.7	
7	100 + 50	20.2	19.0	22.1		34.5	
8	100 + 150	20.7	19.0	20.1		37.4	
9	0 + 0	20.9	19.1	22.0		21.7	
10	0 + 0	20.9	19.1	22.2		14.9	
	Significance:	NS	NS	NS		*	
	BLSD (.05) :					21.1	
	CV (%) :	8	1	8		40	

1/ Data not taken because stalk problems were not evident.

Table 9. Corn yields and moisture at harvest as influenced by high P and K rates in Minnesota in 1977.

Treatment No.	Treatment Description	Silage yield La	Silage yield Mo	Silage yield Wa	Grain yield La	Grain yield Mo	Grain yield Wa	Grain moisture La	Grain moisture Mo	Grain moisture Wa
	lb P_2O_5+K_2O/A	T DM/A			-------bu/A--------			-------%--------		
1	0 + 0	6.63	5.82	6.62	130.5	102.4	148.7	24.3	21.0	26.0
2	0 + 100	6.31	6.15	7.33	121.8	98.4	159.0	23.8	19.7	26.3
3	50 + 100	6.22	6.00	7.27	119.5	101.4	155.6	24.6	19.5	26.4
4	100 + 100	6.06	6.32	7.05	136.2	98.0	157.7	22.5	18.4	25.9
5	150 + 100	6.38	6.14	7.07	119.5	97.2	159.9	24.2	18.9	26.2
6	100 + 0	6.40	5.50	6.62	114.5	94.1	158.4	24.0	17.6	26.1
7	100 + 50	6.28	5.96	6.96	128.1	97.4	158.1	23.5	19.0	26.3
8	100 + 150	6.32	6.23	6.97	125.2	98.4	160.2	23.8	17.6	26.1
9	0 + 0	6.04	5.82	6.95	122.2	99.8	157.6	24.3	18.6	26.2
10	0 + 0	6.20	6.16	6.96	122.4	102.8	156.6	24.3	19.4	26.1
	Significance:	NS	+	NS	NS	NS	NS	NS	*	NS
	BLSD (.05) :								2.4	
	CV (%) :	7	6	6	11	6	5	7	7	1

PASTURE FERTILIZATION TRIALS, GOODHUE COUNTY - 1976 AND 1977

C. J. Overdahl

Pasture trials at two locations were initiated in Goodhue County in the spring of 1976. The plots were located on the Dale Flueger and Jim Bryan farms. The purpose of the study was to observe benefits from rates and application times for nitrogen. Also, a comparison between ammonium nitrate and urea was made, as well as a measure of P and K needs. Yields were evaluated by clipping four times during the summer. Plots were fenced and no grazing was permitted.

The Flueger farm has mostly bromegrass, with some legume remaining, apparently from a previous improvement. The Bryan pasture appears to have a predominance of bluegrass, resulting in short growth during July 1976 and a clipping at this time could not be made. In 1977, the lack of grazing on the Bryan farm seemed to give the alfalfa a chance for revival and a thin stand of alfalfa occurred in all plots.

Data in the following tables are a progress report for 1976 and 1977.

The fine cooperation of Jim Bryan and Dale Flueger are gratefully acknowledged. Also, the efforts of Bob Schoper, Jerome Lensing, research associates in the Soil Science Department, and Brian Schreiber, County Extension Agent in Goodhue County, are greatly appreciated. Without their help, the work wouldn't have been done.

This project was financed by the generous support of St. Paul Ammonia Products.

Table 1a. Relationship of nitrogen treatments to pasture yield at the Bryan farm, Goodhue Co., 1976 and 1977.

N	P_2O_5	K_2O	Bryan* lbs/A		N response over check		Protein lbs/A	
			1976	1977	1976	1977	1976	1977
0	40	40	1642	3071	-	-	229	466
30	40	40	2248	3542	606	471	328	545
60	40	40	2685	3284	1043	213	378	518
90	40	40	3775	4555	2133	1484	642	769
120	40	40	4054	5138	2412	2067	680	888

Table 1b. Relationship of nitrogen treatments to pasture yield at the Flueger farm, Goodhue Co., 1976 and 1977.

N	P_2O_5	K_2O	Flueger* lbs/A		N response over check		Protein** lbs/A	
			1976	1977	1976	1977	1976	1977
0	40	40	3646	2383	-	-	440	373
30	40	40	4789	3133	1143	750	660	483
60	40	40	5301	3926	1655	1543	843	690
90	40	40	7110	4868	3464	2485	1250	931
120	40	40	6767	4881	3121	2498	1210	988

* 3 cuttings at Bryan's and 4 at Flueger's, 1976; 4 cuttings at Bryan's and 3 at Flueger's, 1977.
** N removed times 6.25.

Discussion and summary

This was the last year for the Bryan plots, the Flueger plot will be continued one more year.

1. Significant increases in pasture yield were obtained from nitrogen additions. On the Bryan farm, the highest yield both years was from the 120 pounds of nitrogen per acre, but this was not significantly higher than 90 pounds per acre. On the Flueger farm, 90 pounds of nitrogen per acre gave approximately equal yields to 120 pounds. The same results occurred in 1976.

2. Protein yield increases follow the increases in grass yield and are directly in line with the nitrogen treatments.

3. Split applications did not yield higher than one application of the total amount in the spring.

   The large yields are usually in the first or second cutting which also gave the largest increases due to nitrogen treatment. Higher yields were obtained in midsummer from midsummer application, but the increases were not large enough to make up for the large early yields.

4. Soil tests of medium or high in P and high or very high in K resulted in no yield increases from additions of these two elements.

5. There was no significant difference in pasture yields where ammonium-nitrate and urea were compared. Sixty pounds per acre of nitrogen in two 30 pound applications were compared in this trial at both farms.

6. It would appear that approximately 90 to 100 pounds per acre of nitrogen, annually, along with a small amount of phosphorus and potassium for insurance, would be a highly satisfactory fertilizer program for grass pasture and best protein production.

GRASS SEED PRODUCTION AS INFLUENCED BY FERTILIZATION

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High production costs and concern for energy conservation and environmental quality make correct fertilizer use important. Therefore, it is most important that information on efficient use of commercial fertilizers is available.

Past research has supplied information on nutrient requirements of grasses, on soil fertility, and on rates and time of fertilizer application. But as new materials or new varieties become available or as new problems arise, additional investigations are needed.

Research during 1977 consisted of (a) nitrogen source comparison on mineral soils, (b) nitrogen rate study on peat, and (c) copper study with Kentucky bluegrass 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 measurements and chemical analysis of grass tissue.

A. WEATHER CONDITIONS DURING 1976/77 GROWING SEASON

Comments on weather conditions are based on measurements of the U. S. Weather Station at Roseau, observations and soil temperature determinations at the Magnusson farm at Roseau (table 1, fig. 1).

September and October of 1976 were cool and relatively dry, with about 3 inches of rainfall below normal. During a twelve day period, from October 16 to 27, air temperature ranged from 1° to 40° F. Also November through January the temperature was below normal. It ranged from 5 to 10 degrees below the normal temperature. During November the precipitation was about 1 inch below normal and the air temperature was 5 degrees below normal. The area received below normal snowfall. From February to July the temperature was either normal or above normal. May had about normal rainfall, with temperatures about 13 degrees above normal. During June 3.71 inches of rainfall were measured which is slightly above normal. Generally, during the period from August 1976 to July 1977 nearly 5 inches less precipitation than normal were received at Roseau while the average air temperature was about 6.5 degrees F. below normal. Weather data of previous growing seasons (1964/65 and 1973/74) indicate that during good seed production seasons nearly 22 inches of precipitation are received at Roseau. In contrast, about 16 inches of precipitation were measured at Roseau during 1976/77 growing season.

Soil temperature (under sod at 3-inch depth) during May ranged from 44 to 74° F. Maximum soil temperature rose to 84° F. during the middle of July. During the second half of July and during August, maximum temperature ranged from 66 to 83° F. while minimum temperature measured from 55 to 68° F.

Prepared for presentation at the Grass Seed Institute, Roseau, March 22, 1978.

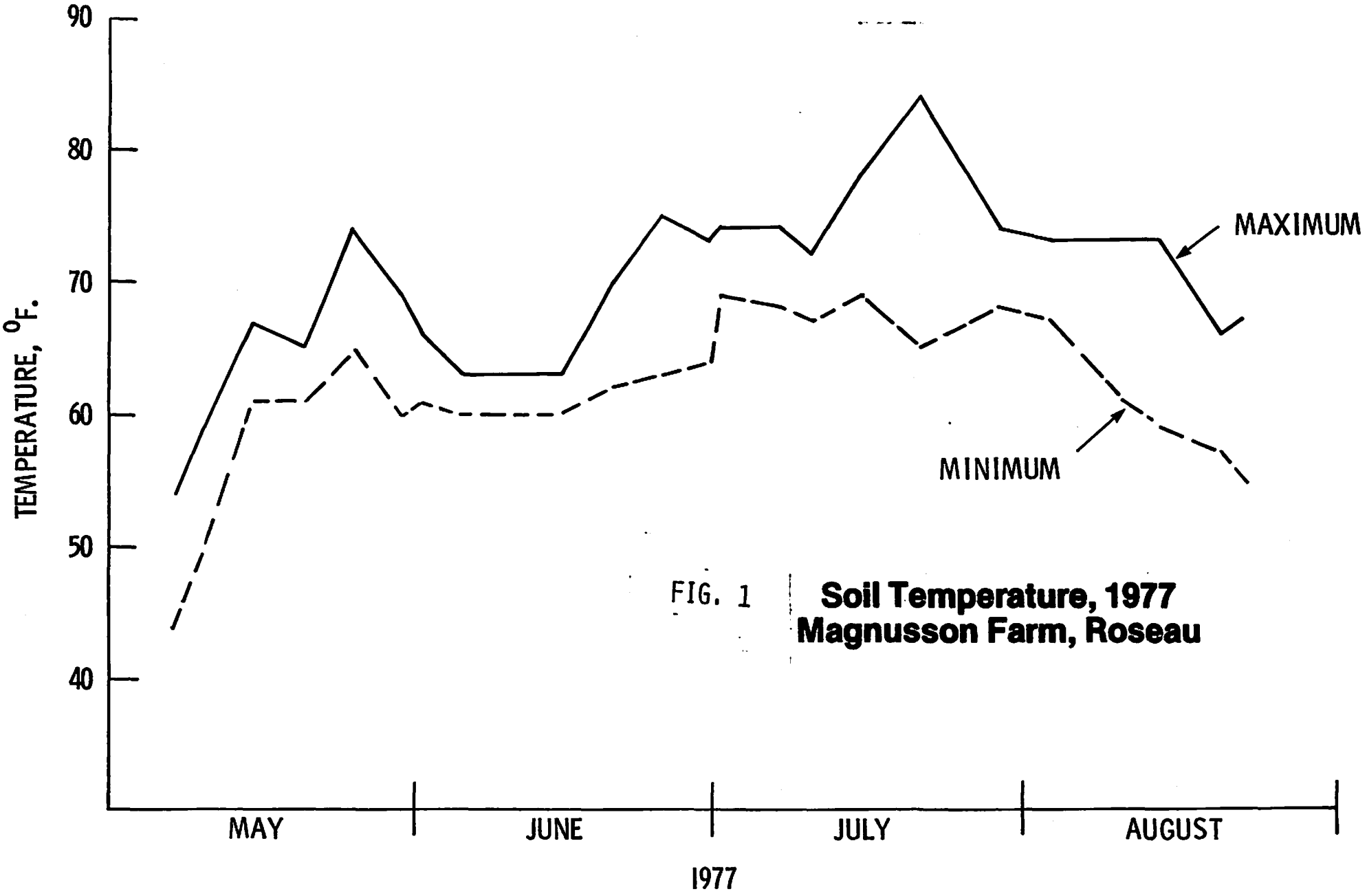

FIG. 1 **Soil Temperature, 1977 Magnusson Farm, Roseau**

B. NITROGEN SOURCE COMPARISON

Three field experiments, established in fall of 1975, were conducted on growers' fields. The soils contained 14-25 lb/acre of nitrate-N in the top two feet, considered to be a relatively low level (table 2). The nitrate-N concentration in the main root zone (0-3 inches) was less than 3.6 pp2m. The soils were calcareous with pH values near 8 (table 3).

Both nitrogen fertilizers were applied at rates of 50 or 100 lb of N per acre, either on October 12 or April 4. All plots received a 0+40+40 treatment. Fertilizer materials were applied with a 3-foot Gandy spreader.

Kampe II timothy yielded about 200 to 475 pounds of seed per acre (table 4). Ammonium nitrate gave a greater yield than urea by 44 pounds. Optimum yield was produced with 100 lb/acre of nitrogen and fall fertilization was superior to spring. There was a higher N concentration of tissue from 100 lb/acre N and spring application but no concentration differences were related to N source.

Timfor timothy seed yield ranged from about 300 to 700 lb/acre (table 5). Ammonium nitrate was slightly superior N source to urea. Optimum yield was produced with 100 lb/acre of nitrogen and spring fertilization was somewhat superior to fall. Nitrogen concentration of grass tissue was increased by the application of the higher rate of N and by fertilization in the spring.

Park Kentucky bluegrass yield (table 6) was extremely low, ranging from 40 to 150 pounds per acre, because of drought. Higher yields resulted from the use of the higher rate of N and fall fertilization but the form of fertilizer had no effect on seed yield. Increased N concentration in grass tissue resulted from ammonium nitrate, the use of higher rate and spring application compared to the respective treatment counterparts.

A field demonstration was conducted on the Erickson farm with S-51 timothy involving three N sources: anhydrous ammonia, ammonium nitrate and urea. Fertilizer materials were applied on October 13, 1976. Knives were set 12 inches apart for the anhydrous ammonia application.

All three nitrogen sources were equally effective in increasing either the seed yield or the N concentration in grass tissue when applied at the 100 lb/acre rate of N (table 7). Ripping-up of the sod with applicator knives did not affect the yield appreciably.

Table 1. Precipitation and Temperature Data for the 1976/77 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 $T_b = 40^oF$
1976 Aug.	3.72	.50	65.8	.9	733
Sept.	.34	-2.27	54.5	-.1	363
Oct.	.07	-1.15	37.0	-7.5	128
1976 Nov. to 1977 Apr.	3.24	-1.38	16.5	-.08	253
1977 May	2.43	-.02	64.7	12.8	764
June	3.71	.29	62.2	.4	666
July	2.28	-1.17	67.2	0	842
Total	15.79	-5.20			3749
Average			30.7	-6.5	
Normal (1941-70)	20.99		37.2		3329

*Calculated from Climatological Data, Minnesota, Vol. 82 and 83, 1976 and 1977, U.S. Dept. of Commerce.

NOTE: Data for January and February represent averages because precipitation 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 NO_3-N in 0-24"
		------NO_3-N pp2m--------			LBS/A
Knochenmus Kampe II timothy+	silty clay loam	3.5	3.9	17.3	24.7
G. Kveen Park K. bluegrass+	peat	2.5	2.1	15.0	19.6
Erickson S-51 timothy+	silt loam	2.8	2.8	12.8	18.4
Helmstetter Bros. Park K. bluegrass#	sandy loam	1.8	1.5	10.6	13.9
Hedlund Timfor timothy#	silty clay loam	2.0	2.1	10.2	14.3

+ Fall sampling - October 12, 1976

Spring sampling - April 27, 1977

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
Knochenmus	0-3	SICL	7.8	51	365
Kampe II timothy	3-6	SIL	8.0	17	215
	6-24	SIL	8.3	5#	95
Erickson	0-3	SIL	8.0	20	110
S-51 timothy	3-6	SIL	8.1	14	80
	6-24	SL	8.4	5#	50
Helmstetter Bros.	0-3	SL	7.9	60	339
Park K. bluegrass	3-6	SL	8.1	20	165
	6-24	LS	8.1	12#	118
Hedlund	0-3	SICL	8.1	12	223
Timfor timothy	3-6	SICL	8.2	11	144
	6-24	SICL	8.4	5#	85
Kveen	0-3	P	7.8	36	300
Park K. bluegrass	3-6	P	7.6	8#	43
Habstritt	0-3	P	6.7	14	200
Nugget K. bluegrass	3-6	P	6.5	4	31

Bray - 1 P, 1:50 soil/solution ratio.

Table 4. Effects of nitrogen source, rate and time of application on seed yield and N concentration in tissue of Kampe II timothy, Louis Knochenmus Farm, Roseau County, 1977

Treatment	Seed yield lbs/acre	N percent in dry matter
(a) Source		
Urea	274a	3.91
Ammonium nitrate	318b	3.88
Significance	*	NS
BLSD (0.05)	39	
(b) Rate		
50 lbs/acre N	258a	3.67a
100 lbs/acre N	334b	4.12b
Significance	*	**
BLSD (0.05)	62	.14
(c) Date		
October 12, 1976	348b	3.82a
April 4, 1977	245a	3.97b
Significance	**	**
BLSD (0.05)	79	.07
C.V.	17	3

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

Symbols indicating significance: NS Non significant
* Significant at 5% level
** Highly significant at 1% level.

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

Table 5. Effects of nitrogen source and time of application on seed yield and N concentration of Timfor timothy on a silt loam soil, Dell Hedlund Farm, Roseau County, 1977.

Treatment	Seed yield lbs/acre	N percent in dry matter
(a) Source		
Urea	454a	2.95
Ammonium nitrate	521b	3.03
Significance	**	NS
BLSD (0.05)	32	
(b) Rate		
50 lbs/acre N	339a	2.66a
100 lbs/acre N	636b	3.32b
Significance	**	**
BLSD (0.05)	73	.06
(c) Date		
October 12, 1976	445a	2.90a
April 4, 1977	529b	3.09b
Significance	*	*
BLSD (0.05)	53	.12
(d) Interaction		
October 12 x 50 lbs/acre N	317	2.61a
x 100 lbs/acre N	574	3.19c
April 4 x 50 lbs/acre N	361	2.72b
x 100 lbs/acre N	698	3.46d
Significance	NS	*
BLSD (0.05)		.09

Values having same letter are not significantly different (5% level).

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 Park Kentucky Bluegrass, Helmstetter Bros. Farm, Lake of the Woods County, 1977.

Treatment	Seed yield lbs/acre	N percent in dry matter
(a) Source		
Urea	86	1.93a
Ammonium nitrate	102	2.30b
Significance	NS	**
BLSD (0.05)		.12
(b) Rate		
50 lbs/acre N	70a	1.83a
100 lbs/acre N	118b	2.40b
Significance	**	**
BLSD (0.05)	13	.15
(c) Date		
Oct. 13, 1976	121b	2.04a
April 18, 1977	67a	2.19b
Significance	**	*
BLSD (0.05)	17	.13
C.V.	25	8

Values followed by different letter are significantly different at the 5% level.

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

Table 7. Effect of three nitrogen fertilizers on seed yield and N concentration in tissue of S-51 Timothy, Erickson Farm, 1977.

Treatment	Seed yield lb/acre	N percent in dry matter
Check	60a	2.19a
Check and knife	83a	2.34a
Anhydrous ammonia	317b	3.39b
Ammonium nitrate	348b	3.37b
Urea	298b	3.42b
Significance	**	**
BLSD (0.05)	97	0.26

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

All fertilizer materials were applied at 100 lb/acre N rate.

C. NITROGEN RATE STUDY ON PEAT

In field experiments conducted on growers' fields during 1960's, nitrogen rates of 20 to 30 pounds per acre often caused severe lodging of bluegrass on peat. Consequently, growers were advised not to exceed 15 lb/acre of N. In experiments conducted during 1974 and 1975, however, maximum yields were produced with 40-80 lb/acre of nitrogen.

A field experiment with Park Kentucky bluegrass on peat was established in fall of 1975 to futher investigate effectiveness of different N rates. Twenty pounds of N were sufficient to produce optimum yield of 459 lb/acre.

In fall of 1976, the experiment was shifted to a different area within the same field as used for 1975-76 experiment. Five nitrogen rates were used: 0, 20, 40, 60, 80 lb/acre and the treatments were replicated four times. All plots received uniform 0+40+40 lb/acre phosphate and potash treatment.

Relatively low seed yield was produced at this location, probably due to drought (table 8). Although fertilization with nitrogen did increase seed yield above the check, there was no advantage to apply more than 20 lb/acre of N. The N concentration in grass tissue increased according to the nitrogen rates.

Table 8. Effect of fertilization on the seed yield and N concentration in tissue of Park Kentucky Bluegrass on peat, Gus Kveen Farm, Roseau County, 1977.

N rate lb/acre	Seed yield lbs/acre	N percent in dry matter
0	75a	2.28a
20	139b	2.60b
40	130b	2.70b
60	157b	2.94c
80	141b	3.20d
Significance	**	**
BLSD (0.05)	32	.21

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

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

D. COPPER STUDY ON PEAT

The importance of copper fertilization in seed production of Kentucky bluegrass on peat was investigated in two field experiments during 1977. Copper sulfate and copper chelate were dissolved in water and sprayed to 10 x 20 ft. plots on April 19. The treatments were replicated 6 times.

Lack of moisture caused the seed yield to be very low at both locations. Park K. bluegrass on the Kveen farm yielded less than 120 lb/acre of seed, and the Nugget yield on Habstritt farm did not exceed 30 lb/acre. The seed yield of grass was not affected by fertilization with copper.

Copper concentration in tissue of Park K. bluegrass was as low as 2 ppm, but was increased by the application of either 50 lb/acre of Cu sulfate or 4 lb/acre of Cu chelate (table 9). Copper chelate applications to Nugget K. bluegrass did not increase the Cu concentration in tissue, but the Cu sulfate treatment increased the concentration from 3 to 29 ppm Cu.

Table 9. Copper concentration of Kentucky bluegrass tissue on peat as affected by fertilization with copper, Roseau County, 1977.

Copper Treatment	Cooperator and variety: G. Kveen Park	Cooperator and variety: Habstritt Nugget
	---------Cu, ppm in dry matter---------	
None	2a#	3a
50 lb/a copper sulfate	5b	29b
2 lb/a copper chelate	3a	5a
4 lb/a copper chelate	4b	7a
Significance	**	**
BLSD (0.05)	.8	8.5

Average of 6 replications.

Copper treatments were made on April 19, 1977.

SUMMARY AND CONCLUSIONS

Six field experiments with timothy and Kentucky bluegrass were conducted on growers' fields in northwestern Minnesota. The main objective of these studies was to determine the effects of urea, ammonium nitrate and anhydrous ammonia applications, nitrogen rate, and fertilization with copper on plant tissue and seed yield of grasses.

Weather conditions during 1976-77 growing season were less than optimum. Nearly 5 inches of precipitation below normal were recorded at Roseau from August 1976 to July 1977. Kentucky bluegrass seed yields were seriously affected by drought, particularly on mineral soils.

Ammonium nitrate was slightly superior to urea as a nitrogen source to timothy. Optimum seed yields were produced with 100 lb/acre of N with no clear cut advantage to either fall or spring application.

Optimum seed yield of Park Kentucky bluegrass on peat was produced with 20 pounds per acre of nitrogen.

The seed yield of K. bluegrass was not affected by copper additions.

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Potato Tillage
R. R. Valley Potato Research Farm
G. R. Blake and Dennis Askin
1977

	Conventional	No-till
	Potatoes, pounds 1/	
	15,770	13,310
	17,560	13,390
	13,390	14,430
	16,110	
	20,010	
Totals	82,840	41,130
Pounds/acre	19,145	19,011
	Clods, pounds	
	145	340
	225	260
	255	245
	260	
	240	
Totals	1,125	845
Pounds/acre	260	391

1/ 24 rows conventional, 12 rows no-till were harvested. Row spacing, 38 inches; row length, 2,480 feet.

INFLUENCE OF FOLIAR APPLICATIONS OF FERTILIZER NUTRIENTS AND FUNGICIDE ON THE YIELD AND PROTEIN CONTENT OF SMALL GRAINS

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Recent investigations of spray applications of N, P, K and S on soybeans by Dr. Hanway and others has renewed the interest in foliar feeding of crops.

A review of literature reveals that the foliar feeding of crops has been investigated by several scientists during the early 1950's. Most of the research, however, was limited to foliar applications of nitrogen and phosphorus.

Based on the quantity of plant nutrients required to increase a crop yield a given amount, it would appear that the greatest opportunity lies in foliar feeding of oil seed and other high protein crops. It may, however, be more economical to use foliar feeding on crops where the quantity of plant food nutrients needed to bring about an increase in yield requires significantly less N, P, K and S, i.e., soybeans versus rice or wheat; approximately 8 pounds N per 100 pounds soybeans, 1.5 pounds N per 100 pounds rice, 3 pounds N per 100 pounds wheat. This small quantity of spray would also allow for a larger acreage to be covered by the flight of an aircraft.

It is of particular interest to the researchers that investigations indicate that the application of fungicides on small grains often results in economical increases in yield when leaf rust, Septoria leaf blotch, and Helminthosporium are kept under control.

The timing of the application of fungicides for disease control would appear to nearly coincide with the recommended time for foliar applications of plant food nutrients for small grains. The combined application of plant nutrients and fungicides might prove to be additive in their ability to increase yields and quality of small grains.

STUDIES CONDUCTED

Trials were established at the experimental stations at Morris, Crookston, and Waseca. Treatments were as follows:

1. Control.

2. Foliar application of nutrients at flag leaf stage and 10 and 20 days later.

3. Fungicide applied at flag leaf stage and 10 and 20 days later.

4. Combinations of treatments 2 and 3.

SITE SELECTIONS

The sites for these studies were specifically selected to represent fields of high fertility. The NO_3-N level at all locations contained more than 100 pounds NO_3-N in the top 2 feet. Additionally, the P and K soil test levels were very high.

TREATMENT FORMULATION

Urea, potassium polyphosphate, and potassium sulfate were combined to develop a foliar spray which would contain plant nutrients similar to the small grain crops. The following quantities were used:

	Pounds per ton
Urea	260
Potassium polyphosphate	177
Potassium sulfate	58
Water	1,505

This formulation resulted in a ratio of the nutrient elements of 6-2.3 and 3.7 for N, P_2O_5 and K_2O. Additionally, the formula supplied .5 percent sulfur. The material was applied at the rate of 26.4 gallons per acre or 250 pounds per acre. The quantity of nitrogen, phosphorus, potassium, and sulfur applied per acre was 15, 6, 9, and 1.3, respectively.

A fungicide--Manzate 200--was applied at the rate of 2 pounds per acre alone and in combination with the fertilizer nutrients.

YIELDS OF SMALL GRAIN

Table 1 shows a summary of the yields of small grain. Yields at the Crookston experimental site are not shown because of the extreme variability of plant growth at the site.

Data from these trials show no increase in yield due to spray applications of plant nutrients. At the Waseca location, grain yields of wheat were significantly decreased by the application of 45 pounds of nitrogen per acre in combination with the other fertilizer nutrients.

Table 1. Yields of small grain as influenced by foliar applications--Minnesota--1977

Treatment lbs/A	Waseca Wheat	Morris Wheat	Morris Oats	Morris Barley
	Bu/A			
0	41	52	55	60
15	39	52	60	60
30	39	54	59	60
45	36	53	58	61
Sig.	**	ns	ns	ns
No Fungicide	39	51	53	60
Fungicide	38	55	63	59
Sig.	ns	**	**	ns

Table 2. Protein content of wheat as influenced by foliar application--Minnesota--1977

Treatment	% Protein--Wheat Waseca	% Protein--Wheat Morris
0	16.1	15.1
15	16.1	15.1
30	16.5	15.4
45	17.8	15.9
Sig.	**	*

The application of fungicide at the rate of 2 pounds per acre applied at the flag leaf stage and 10 and 20 days later resulted in significant increases in yield of wheat and oats at the Morris location. There was no significant interaction between the foliar nutrient spray and the fungicide.

PROTEIN CONTENT OF SMALL GRAIN

The protein content of wheat was significantly increased by the foliar application of plant nutrients at Waseca as well as Morris. The protein content of the barley and oats crop has not been determined at this date. It is anticipated that the nitrogen content of the wheat straw will also be determined.

RESPONSE OF SOYBEAN GENOTYPES TO FOLIAR FERTILIZATION

W.D. Poole, G.W. Randall and G.E. Ham

Foliar fertilization of soybeans has resulted in increased seed yields in some cases. However, lack of consistent yield increases is a concern shared by many. One of the factors that may be involved in the inconsistent yield increases is soybean genotype. This study was conducted to compare soybean genotypes for response to foliar fertilizer.

Foliar fertilization was conducted with the nitrogen supplied as urea; some potassium and the sulfur comes from potassium sulfate; and the phosphorus and additional potassium was supplied as potassium polyphosphate. The total quantity of nutrients supplied was 80+8+24+6 (N+P+K+S, respectively) in 4 applications.

Seed yields were not increased significantly in these studies which agrees with the lack of response in the other studies with these same fertilizer materials.

Table 1. Influence of foliar fertilization on soybean seed yield.

Soybean* genotype	Location					
	Waseca		Rosemount		Becker	
	No Foliar	Foliar	No Foliar	Foliar	No Foliar	Foliar
	bu/acre					
Hodgson	51	49	54	57	50	48
Hodgson M-75-1	53	50	58	60	--	--
Swift (Corsoy)**	46	46	56	57	--	--
Steele (Corsoy R-3)	45	48	48	42	--	--
12-22-1 (12-7-1)	47	49	49	53	--	--
12-22-2 (12-7-2)	45	45	43	48	--	--
13-3-1 (M-68-333)	51	50	46	46	--	--
13-3-2 (M-69-197)	44	46	47	47	--	--
13-40-1 (12-25-1)	48	48	44	42	--	--
13-40-2 (12-25-2)	43	43	43	44	--	--
13-61-1 (13-72-1)	45	45	46	51	--	--
13-61-2 (13-72-2)	43	43	44	47	--	--
13-84-1 (13-82-1)	46	49	47	47	--	--
13-84-2 (13-82-2)	39	43	43	41	--	--
M-68-49	44	44	53	49	--	--
M-68-176	--	--	--	--	56	51
M-68-213	--	--	--	--	45	44
M-69-36	44	46	42	41	--	--
M-69-124	--	--	--	--	54	47
M-69-128	--	--	--	--	51	50
M-69-129	--	--	--	--	58	56
M-69-264	--	--	--	--	55	53

* -M- genotypes obtained from J.W. Lambert, University of Minnesota; 12- and 13- genotypes obtained from D.E. Green, Iowa State University (-1 genotypes are semideterminate and -2 genotypes are indeterminate).
** Variety or genotype in parentheses grown at Waseca.

SOYBEAN YIELD IMPROVEMENT WITH FOLIAR FERTILIZER

W.D. Poole, G.E. Ham and G.W. Randall

Foliar fertilization is not a substitute for a good soil fertility program of soil applied fertilizers. Rather, foliar fertilization is in addition to soil applied fertilizers with other top management factors such as narrow rows and high-yielding varieties. If all other factors are optimum, foliar fertilization can result in increased yields.

The time of application is important and the best time to apply foliar fertilizers to soybean leaves is between the time when the top pods start filling and when about half of the leaves have turned yellow. Generally, 2-4 foliar fertilizer applications at least a week apart give the best results. One large application would probably "burn" the leaves severely and reduce the yield response to foliar fertilization. Research is continuing to evaluate single applications of nutrients compared to 2-4 applications.

The rate per application for an acre of soybeans is up to 20 pounds of nitrogen, 2 pounds of phosphorus (4 pounds of P_2O_5), 6 pounds of potassium (8 pounds of K_2O) and 1 pound of sulfur. Urea supplies the nitrogen; some potassium and the sulfur comes from potassium sulfate; and the phosphate and additional potassium comes from potassium polyphosphate. All four nutrients (nitrogen, phosphorus, potassium and sulfur) must be in the solution. Omitting any one of the nutrients decreases the yield response. In studies during 1977 these fertilizer materials were compared to conventional fertilizers that are cheaper and more readily available (10-34-0 and UAN or 28% N solution). In addition, B alone, benlate micronutrients, and the growth regulator TIBA were combined with N+P+K+S. The benlate was included since it had increased soybean yields in Illinois studies under conditions where pod and stem blight existed. Boron was included to determine the influence it may have on soybean seed yield. Several commercial products available for foliar fertilization of soybeans were applied according to the recommendations on the label (Na-Churs, Folian II, Bayfolan and Seaborne + F).

No fertilizer treatment increased soybean seed yields significantly across all locations and varieties. Folian II increased the seed yields of both varieties at Waseca and Hodgson variety at Becker and these were the only significant yield increases. The UAN or 28% N solution in place of urea resulted in severe leaf burn and reduced seed yields in all cases.

Each application should contain not more than 20 pounds of nitrogen in order to avoid leaf burn which results in yield reductions. A minimum of 12-15 pounds of nitrogen should be applied to increase soybean seed yields significantly since the smaller the quantity of nitrogen applied, the less likely are the chances of obtaining a yield response. A 60-bushel soybean crop contains about 300 pounds of nitrogen (240 pounds in the grain and 60 pounds in the leaves, stems and pods).

Foliar fertilization of soybeans should be conducted on an experimental basis until several questions have been answered. Evaluation in commercial soybean production on a limited scale is necessary since the experimental sites represent only a small sampling of environments. The yield responses obtained so far indicates that foliar fertilization has potential for increasing soybean seed yields. However, the yield increases are not consistent and dependable.

TABLE 1: Influence of various foliar fertilizers on 1977 soybean seed yields

Foliar Fertilizer Treatment	Number Applications	Fertilizer Applied N+P+K+S	Waseca		Becker		Rosemount	
			Corsoy	Hodgson	Evans	Hodgson	Evans	Hodgson
		lbs/acre	bu/acre					
Control	--	--	60	54	50	56	57	61
Surfactant	4	--	60	58	51	54	55	68
NPKS[a]	2	40-4-12-3	59	53	51	57	57	57
NPKS[a]	3	60-6-18-4.5	60	56	48	57	57	64
NPKS	4	80-8-24-6	61	57	48	53	54	63
10-34-0+urea+KS	4	80-8-24-6	59	55	45	52	55	65
10-34-0+UAN+KS	4	80-8-24-6	55	47	37	48	47	58
NPKS[a]+Benlate	4	80-8-24-6 +1.0 Benlate	64	53	45	56	58	60
NPKS[a]+Boron	4	80-8-24-6+0.4B	60	57	46	57	50	62
Ammonium sulfate+PK	4	80-8-24-6	60	57	47	56	55	64
Potassium sulfite+NP	4	80-8-24-6	62	57	46	53	56	68
NPKS[a]+micronutrients	4	80-8-24-6	58	50	41	48	47	64
NPKS[a]+TIBA	4	80-8-24-6	59	53	49	51	46	65
TIBA	1	--	55	51	47	57	49	63
Na-Churs[b]	4	9-8-7.5-0	59	55	48	55	58	63
Na-Churs+NKS	4	80-8-24-6	61	56	46	55	51	64
Folian II[c]	1	12-2.5-5-0.5	65	59	48	53	56	66
Folian II	1	24-5-10-1	59	57	46	55	54	61
Bayfolan[d]	2	--	59	55	50	54	57	65
Seaborne+F[e]	1	0.14-0.02-0.03 -0	60	55	49	54	55	64

[a]Iowa State formulation; [b]9-18-9; [c]12-6-6; [d]11-8-5; [e]6-3-3, $N-P_2O_5-K_2O$, respectively.

EVALUATION OF MAJOR NUTRIENT NEEDS OF SUGARBEETS IN WEST-CENTRAL MINNESOTA - 1977

R. P. Schoper, W. E. Fenster and O. M. Gunderson

Accurate prediction of nitrogen needs for optimum production of sugarbeets has been of prime importance in all sugarbeet producing areas. Sugarbeets do not have a built-in mechanism which automatically triggers sugar accumulation at a certain point in the growing season. Therefore, roots increase in sugar content only after a shortage of a primary growth factor exists such as heat units, water or essential nutrients. Of these growth factors, the control of an essential element such as nitrogen has proven to be the most effective.

In order to produce the highest possible yield of gross sugar per acre, nitrogen fertilizer is generally needed. However, if excess nitrogen is applied, it also increases the level of impurities, which decreases the processors extraction rate and lowers the percent sucrose in the root. It is generally agreed that in order to produce the highest possible sugar content only enough nitrogen fertilizer should be used so that a deficiency of nitrogen exists four to six weeks prior to harvest.

Presently two methods of predicting the proper rate of fertilizer nitrogen are available. The first is simply an estimate of the residual nitrogen level based on past cropping history. This method requires no soil sampling and thus holds the advantage of being easy to use. The main disadvantage is that it only provides a long-term estimate of residual nitrogen and, due to the dynamic nature of soil nitrogen, is probably not accurate more than 50 percent of the time. The second method is known as the nitrate-nitrogen soil test. It is obtained by taking 15 to 20 soil cores per field to a depth of two feet. This collection of soil can then be measured for residual nitrogen. This method has the advantage in prediction accuracy since it can measure the year to year variations in residual soil nitrogen.

Presently an on-going study is underway in west-central Minnesota working with the problem of predicting fertilizer nitrogen requirements for optimum yield and sugar content of sugarbeets. Specific objectives of this study are: a) to correlate residual soil nitrate levels to optimum fertilizer nitrogen rate, b) to determine the optimum sampling depth for correlation of the nitrate-nitrogen test to sugar yield, c) to demonstrate the relationship of soil nitrate-nitrogen levels and fertilizer nitrogen rates on sugar content and impurity index, and d) to observe the critical level of nitrate-nitrogen in sugarbeet petioles at various points in the growing season.

In addition to the nitrogen studies, work is also underway to determine the need for phosphorus and potassium fertilizers. Specific objectives of these studies are: a) to correlate and calibrate soil test phosphorus and potassium levels with the response of sugarbeets to phosphorus and potassium fertilizer and, b) to correlate tissue phosphorus and potassium concentration with soil test phosphorus and potassium levels.