Silage and grain yields and grain moisture (an indication of maturity at harvest) are given in Table 7. Significant differences (95%) in silage yields were not found at Lamberton or Waseca. Grain yield at Waseca was affected significantly with an apparent response to potassium. This was true even though soil test K was not influenced by fertilizer K. No reason can be given for the low yield obtained with treatment 4, however. The P treatments did not appear to effect the yield. Yields from both Lamberton and Morris were extremely low due to the lack of rainfall and inadequate subsoil moisture. Consequently, yield differences were not obtained. Grain moisture was affected slightly at Waseca but a relationship to P and K treatments was not evident.

Table 7. Corn yields and moisture at harvest as influenced by high P and K rates in Minnesota in 1976.

Treatment		Silage yield			Grain yield			Grain moisture		
No.	Description	La	Mo	Wa	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	T DM/A			------bu/A-------			------%-------		
1	0 + 0	1.8	1/	5.9	16.7	29.0	74.7	2/	27.8	21.5
2	0 + 100	1.4		5.7	8.9	23.4	97.9		29.4	21.9
3	50 + 100	1.5		5.9	16.8	26.4	101.9		24.4	23.0
4	100 + 100	1.4		5.3	15.2	35.8	86.4		22.9	21.0
5	0 + 100	1.2		6.1	14.3	31.0	105.5		25.2	21.4
6	100 + 0	1.8		6.2	15.1	33.4	93.7		21.0	21.1
7	100 + 50	1.6		6.0	17.5	33.6	118.0		23.8	20.0
8	100 + 0	1.6		6.2	11.6	24.3	98.6		22.8	21.6
9	0 + 0	1.2		5.6	12.6	32.6	98.5		24.5	19.8
10	0 + 0	1.4		5.7	11.2	30.6	91.7		24.8	19.2
Significance:		NS		NS	NS	NS	*		NS	+
BLSD (.05) :							24.8			
CV (%) :		26		13	39	28	15		16	7

1/ Yield not taken due to variable plant stands.

2/ Moisture not determined.

NITROGEN NEEDS FOR CORN AND ACCUMULATION OF NITRATES IN PROFILE, 1970 to 1976

W. E. Fenster and C. J. Overdahl

In the fall of 1969, nitrogen experiments were established with continuous corn on highly productive land to determine what rates of nitrogen would result in highest economic yields with a minimum of nitrate movement through the soil profile.

Two adjacent nitrogen experiments, one on continuous corn and one established to continuous corn on a virgin soil, were established in Martin County. The continuous corn experiment was established in the fall of 1969 and the one on the virgin soil was established one year later.

In 1976, drought conditions lowered yields and caused increased variation. As in previous years, the continuous corn area continued to respond to nitrogen, while the virgin area did not respond. Yield, tissue test and soil nitrate values for these experiments are given in tables 1, 2 and 3.

Table 1. Martin County corn yields as influenced by nitrogen treatments (8 replications).

N (lbs/A) annually	Yield (bu/A)												
	Continuous corn plots							Virgin plots					
	1970	1971	1972	1973	1974	1975	1976	1971	1972	1973	1974	1975	1976
0	120a	130a[1]	68[2]	112a	100a	77a	60a	179a	103	157	151	112	98
50	128ab	142b	78	115ab	126b	96ab	79b	190bc	107	151	155	128	104
100	140c	151b	68	136c	135bc	109ab	92b	187bc	88	149	157	118	99
150	132bc	144b	76	132bc	142c	100ab	80b	183b	103	150	154	120	109
200	131abc	147b	69	121abc	145c	117b	78ab	194c	96	145	153	126	103
400	135bc	153b	64	121abc	147c	132bc	89b	190bc	103	142	154	120	98
Sig.	5%	5%	ns	5%	5%	5%	5%	5%	ns	ns	ns	ns	ns

[1] Where letters differ for each experiment, yields are statistically different.

[2] A meaningful statistical analysis could not be run in 1972 because of severe hail damage.

All plots received a basic treatment of 0+150+200+20 Zn. The soil is classified as Nicollet silty clay loam.

Table 2. Percentage nitrogen in tissue* as related to nitrogen application on corn in Martin County.

N (lbs/A)	% Nitrogen in Tissue											
	Continuous Corn						Virgin plots					
	1971	1972	1973	1974	1975	1976	1971	1972	1973	1974	1975	1976
0	2.5	2.4	2.0	2.1	1.7	1.6	2.8	2.9	2.6	2.4	2.4	1.9
50	2.7	2.9	2.3	2.4	2.2	2.1	2.7	2.8	2.5	3.0	2.4	2.4
100	2.6	2.8	2.4	2.8	2.4	2.4	2.8	2.8	2.7	3.0	2.5	2.3
150	2.9	2.7	2.4	3.0	2.7	2.3	2.8	2.8	2.7	3.1	2.8	2.4
200	2.9	2.9	2.6	3.1	2.8	2.6	2.8	2.9	2.8	3.0	2.8	2.3
400	2.9	2.7	2.6	3.3	2.9	2.6	2.9	2.8	3.0	3.1	2.7	2.5
Date sampled	7/21	7/28	7/25	7/22	7/21	7/21	7/21	7/28	7/25	7/22	7/21	7/21

* sixth leaf at tasseling

Additional Observations

The average yield of all treated plots in bu/acre between the originally virgin plots above the long time continuously cultivated plots were:

1971	1972	1973	1974	1975	1976
41	29	26	21	16	22

It appears that the differences are narrowing somewhat each year.

Table 3a. Nitrate-nitrogen (ppm) in soil profile on long time continuous corn - Martin County - Thate Farm, 1976.

Soil Depth (ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
0-1	6	7	14	23	47	78
1-2	3	2	10	6	12	37
2-3	2	3	8	17	19	41
3-4	3	6	14	14	27	27
4-5	5	9	10	14	17	22
5-6	6	11	9	14	20	21

Table 3b. Amount of nitrate-nitrogen (ppm) in the soil profile on virgin plots - Martin County - Thate Farm, 1976.

Soil Depth (ft.)	Treatment - lbs. of N per acre applied annually					
	0	50	100	150	200	400
0-1	7	12	24	35	44	123
1-2	2	4	10	9	17	36
2-3	4	6	28	18	12	11
3-4	9	10	18	23	19	74
4-5	8	6	12	17	13	24
5-6	10	6	11	15	13	27

PASTURE FERTILIZATION TRIALS, GOODHUE COUNTY - 1976

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, hence no grazing was permitted.

Close evaluation of botanical composition has not been made as yet, but the Flueger farm has mostly bromegrass, with some legume remaining from a previous improvement. The Bryan pasture appears to have a predominance of bluegrass, resulting in short growth during July and a clipping at this time could not be made.

Data in the following tables are intended as a progress report only. Conclusions cannot be made on this one year's evidence.

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

N	+ P_2O_5	+ K_2O	Bryan* lbs/A	N response over check	Protein lbs/A
0	40	40	1642	-	229
30	40	40	2248	606	328
60	40	40	2685	1043	378
90	40	40	3775	2133	642
120	40	40	4054**	2412	680

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

N	+ P_2O_5	+ K_2O	Flueger* lbs/A	N response over check	Protein lbs/A
0	40	40	3646	-	440
30	40	40	4789	1143	660
60	40	40	5301	1655	843
90	40	40	7110**	3464	1250
120	40	40	6767	3121	1210

* 3 cuttings at Bryan's and 4 at Flueger's.
** best rate.

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 2. The P and K effect on pasture yield (lbs/A dry matter) - Goodhue County, 1976.

	Cuttings				
	1	2	3	4	Total
Bryan Farm					
P Effect					
90 (3)* + 0 + 40	255	1583	-	732	2570
90 (3) + 40 + 40	361	1677	-	970	3008
significance	ns	ns		ns	ns
K Effect					
90 (3)* + 40 + 0	392	1633	-	895	2920
90 (3) + 40 + 40	361	1677	-	970	3008
significance	ns	ns		ns	ns
Flueger Farm					
P Effect					
120 (4)* + 0 + 40	1071	3224	708	1832	6835
120 (4) + 40 + 40	1540	3449	985	1950	7924
significance	ns	ns	ns	ns	ns
K Effect					
120 (4)* + 40 + 0	1067	2930	824	1724	6545
120 (4) + 40 + 40	1540	3449	985	1950	7924
significance	ns	ns	ns	ns	ns

* number of 30 lb. applications of nitrogen.

Table 3. The effect of split applications of nitrogen on pasture yield (lbs/A dry matter) - Goodhue County, 1976.

N + P_2O_5 + K_2O	Cuttings 1	2	3	4	Total
Bryan Farm					
60 + 40 + 40	423	1154	-	608	2185
60 (1,3)* +40 + 40	199	872	-	724	1795
significance	ns	ns		ns	ns
120 + 40 + 40	1516	1786	-	752	4054
120 (1,3)+ 40 + 40	758	1314	-	1011	3038
significance	1%	ns		ns	5%
Flueger Farm					
60 + 40 + 40	1679	2432	504	686	5301
60 (1,3) 40 40	753	2273	603	569	4197
significance	.1%	ns	ns	ns	1%
120 + 40 + 40	2176	2962	515	1114	6767
120 (1,3)+ 40 + 40	1414	2512	879	1353	6158
120 (1,2,3,4)40+ 40	1540	3449	985	1950	7924
significance	ns	1%	ns	5%	ns

	Bryan	Flueger
Soil test P 0 - 6"	21 high	15 medium
Soil test K 0 - 6"	303 very high	241 high
Soil pH 0 - 6"	6.0	6.2

* application code:

1- early spring
2- following 1st cut
3- following 2nd cut
4- following 3rd cut

INFLUENCE OF NITROGEN RATE AND TIMING OF APPLICATION ON THE PRODUCTION AND QUALITY OF FORAGE GRASSES ON ORGANIC SOILS

G.L. Malzer, R.P. Schoper and J. Lensing

In 1975 three experiments were established on organic soils in Roseau County, Minnesota to evaluate the significance of timing and rate of nitrogen application on the production and quality of three grass species.

Three rates of nitrogen 0, 150, and 300 #/acre were applied as NH_4NO_3 to existing stands of orchardgrass, quackgrass, and reed canarygrass. The three grass experiments were separated, but were all contained within the same area of organic soil and were within reasonable proximity to each other. The 150 and 300 # N/A treatments were applied in four different manners: 1) the entire amount in one early spring application, 2) applied in two equal amounts one in early spring and the second after the first clipping, 3) applied in three equal portions including early application and after the first and second clipping, and 4) as four equal amounts applied early spring and then after the first, second and third clippings.

The experiments were set up to evaluate two management programs, a hay management with a two clipping sequence and pasture management with a four clipping sequence. Only the information obtained from the four clipping program will be included in this report. Clippings in 1976 were taken on June 1, June 28, August 2, and September 8. On these dates, all plots were cut back to about a 7 cm height.

Initial soil tests were taken, and to insure that P and K were not limiting all nitrogen treatments received 100 #/A of P_2O_5 and 100 #/A of K_2O applied as an early spring application. Two additional treatments were also included, a "true check" containing no N, P, and K and the high rate of nitrogen applied in four split applications with no phosphorus or potassium within the experimental areas.

Treatments were evaluated by determining dry matter production at each clipping (Table 1). Samples from each plot were obtained at harvest and analyzed for crude protein-Kjeldahl nitrogen (Table 2). These values allowed the calculation of total N removal (Table 3). Samples are also being analyzed for acid detergent fiber but results are not available at this time.

GENERAL RESULTS

Orchardgrass - Significant dry matter increases were found even at the higher rate of N application (300 #/A). Splitting of nitrogen application had no influence on total dry matter production. Splitting of N applications did significantly influence distribution of dry matter production and protein content between clippings. Applications of 150 #N/A when applied early had no influence on dry matter production on the

third and fourth clipping. The 300 #N/A treatment did result in a dry matter increase on the fourth clipping. Protein contents at each clipping were directly related to the amount and time of nitrogen application. Protein content in general for orchardgrass was lower than either quackgrass or reed canarygrass.

Quackgrass - Dry matter production of quackgrass in general followed the same trends as orchardgrass. Total yields were higher for quackgrass than orchardgrass and also had much higher crude protein contents. Quackgrass appeared to be much more efficient in obtaining nitrogen from the soil as can be seen in Table 3. When no nitrogen was applied, the quackgrass check plots utilized twice as much nitrogen from the soil than did either orchardgrass or reed canarygrass. This resulted in a much higher N uptake than either of the other grasses.

Reed canarygrass - Yield responses were similar to those of quackgrass with total production being very similar. Crude protein contents were higher for the reed canarygrass treatments than for orchardgrass resulting in larger amounts of total N being removed by reed canarygrass. Nitrogen removal by the three grass species at 300 #N/A was lowest for orchardgrass followed by reed canarygrass and was highest for quackgrass.

Table 1. Dry matter production of orchardgrass, quackgrass, and reed canarygrass as influenced by rate and time of nitrogen application (organic soil - Roseau County, Minnesota - 1976).

N applied (#/A)	Clipping 1	Clipping 2	Clipping 3	Clipping 4	Total
			Orchardgrass		
	----------lbs DM/A----------				
0	273	1794	508	304	2879
150 (1-150)	1037	2591	554	633	4815
150 (2-75)	787	3047	617	698	5149
150 (3-50)	649	2520	838	902	4909
150 (4-38)	658	2228	801	1135	4822
300 (1-300)	673	2925	1019	1388	6005
300 (2-150)	654	2783	955	1495	5887
300 (3-100)	800	2635	868	1542	5845
300 (4-75)	668	2652	846	1374	5540
+ 0	297	1281	421	308	2307
+300 (4-75)	372	1752	716	939	3778
Signif.	**	**	**	**	**
BLSD (.05)	180	456	239	300	671
CV, %	21.4	14.1	22.3	23.2	10.1
			Quackgrass		
	----------lbs DM/A----------				
0	1213	2454	733	670	5070
150 (1-150)	1958	2615	831	1119	6523
150 (2-75)	1725	2844	894	1113	6576
150 (3-50)	1564	2901	941	990	6396
150 (4-38)	1413	2496	1027	1358	6294
300 (1-300)	2228	2521	1130	1458	7337
300 (2-150)	2217	2725	1032	1385	7359
300 (3-100)	1996	2389	1038	1498	6921
300 (4-75)	1903	2648	913	1480	6944
+ 0	966	2087	636	776	4465
+300 (4-75)	1027	2201	593	1184	5001
Signif.	**	**	**	**	**
BLSD (.05)	369	528	303	241	606
CV, %	16.4	12.3	21.5	15.0	7.3
			Reed Canarygrass		
	----------lbs DM/A----------				
0	484	1932	688	285	3389
150 (1-150)	1361	2948	855	349	5513
150 (2-75)	1000	3120	1074	447	5641
150 (3-50)	775	3298	1552	515	6140
150 (4-38)	706	2772	1417	955	5850
300 (1-300)	2242	2699	1455	543	6939
300 (2-150)	1801	3087	1367	716	6971
300 (3-100)	1087	3346	1737	764	6934
300 (4-75)	992	3300	1575	963	6830
+ 0	332	1571	701	258	2862
+300 (4-75)	518	2578	1271	713	5080
Signif.	**	**	**	**	**
BLSD (.05)	501	663	417	393	1207
CV, %	20.0	9.7	13.7	7.1	8.7

+ No phosphorus and potassium applied.

Table 2. Crude protein content (%) of orchardgrass, quackgrass, and reed canarygrass as influenced by rate and time of nitrogen application (organic soil - Roseau County, Minnesota - 1976).

N applied (#/A)	Clipping 1	Clipping 2	Clipping 3	Clipping 4
Orchardgrass				
0	20.4	11.4	14.0	16.8
150 (1-150)	27.3	17.0	18.1	16.7
150 (2-75)	25.8	19.6	17.8	16.4
150 (3-50)	24.8	17.5	22.1	16.7
150 (4-38)	27.7	17.4	20.4	20.5
300 (1-300)	34.7	20.9	24.1	22.1
300 (2-150)	27.6	23.1	24.2	22.0
300 (3-100)	25.9	20.7	21.7	22.5
300 (4-75)	24.9	21.3	24.1	24.3
+ 0	20.8	12.6	15.0	16.8
+300 (4-75	28.7	21.3	24.6	23.9
Signif.	**	**	**	**
BLSD (.05)	7.0	2.6	3.9	1.4
CV, %	16.6	10.5	13.5	5.4
Quackgrass				
0	22.2	17.9	18.8	19.7
150 (1-150)	27.6	20.4	24.2	21.5
150 (2-75)	25.8	22.4	24.7	24.4
150 (3-50)	23.5	21.5	25.5	22.2
150 (4-38)	25.5	21.5	23.3	23.3
300 (1-300)	30.4	23.3	26.5	26.6
300 (2-150)	29.0	23.8	24.7	26.6
300 (3-100)	27.3	22.9	25.5	26.9
300 (4-75)	28.3	23.5	26.4	26.6
+ 0	26.3	17.5	19.8	20.3
+300 (4-75)	28.0	21.3	28.5	25.8
Signif.	**	**	**	**
BLSD (.05)	2.5	1.5	3.2	2.4
CV, %	6.3	5.2	9.3	7.4
Reed Canarygrass				
0	21.7	14.6	17.9	19.7
150 (1-150)	26.0	16.3	17.7	20.4
150 (2-75)	23.6	17.1	17.8	20.1
150 (3-50)	21.6	16.6	20.2	22.4
150 (4-38)	18.0	16.0	18.1	22.8
300 (1-300)	31.7	21.1	21.3	25.3
300 (2-150)	26.7	22.4	23.9	25.1
300 (3-100)	23.8	20.0	24.5	24.8
300 (4-75)	22.4	17.5	22.6	24.6
+ 0	21.8	14.5	16.0	20.4
+300 (4-75)	23.5	18.5	22.9	26.3
Signif.	**	**	**	**
BLSD (.05)	5.0	2.3	2.6	3.6
CV, %	8.6	5.4	5.2	6.4

+ No phosphorus and potassium applied.

Table 3. Total pounds of nitrogen removed by orchardgrass, quackgrass, and reed canarygrass as influenced by rate and time of nitrogen application (organic soil - Roseau County, Minnesota - 1976).

N applied (#/A)	Clipping 1	Clipping 2	Clipping 3	Clipping 4	Total
Orchardgrass					
0	9	33	12	8	62
150 (1-150)	46	69	16	17	148
150 (2-75)	33	96	18	18	165
150 (3-50)	26	70	29	24	149
150 (4-38)	29	61	26	37	153
300 (1-300)	37	98	39	49	223
300 (2-150)	29	102	37	53	221
300 (3-100)	33	88	30	55	206
300 (4-75)	25	91	32	53	201
+ 0	10	26	10	8	54
+300 (4-75)	18	59	28	35	140
Signif.	**	**	**	**	**
BLSD (.05)	11	15	10	9	27
CV, %	30.2	15.4	28.2	21.7	13.2
Quackgrass					
0	43	71	22	21	157
150 (1-150)	87	85	32	39	243
150 (2-75)	71	102	35	45	253
150 (3-50)	59	100	38	36	233
150 (4-38)	58	85	38	51	232
300 (1-300)	108	94	48	62	312
300 (2-150)	103	103	40	59	305
300 (3-100)	86	87	42	64	279
300 (4-75)	86	99	38	63	286
+ 0	40	58	20	26	144
+300 (4-75)	46	75	27	49	197
Signif.	**	**	**	**	**
BLSD (.05)	16	16	10	11	24
CV, %	16.8	12.7	20.2	17.1	7.7
Reed Canarygrass					
0	17	45	19	9	90
150 (1-150)	57	77	24	11	169
150 (2-75)	38	86	30	14	168
150 (3-50)	27	87	50	19	183
150 (4-38)	20	71	41	35	167
300 (1-300)	114	92	49	22	277
300 (2-150)	76	110	52	29	267
300 (3-100)	41	107	68	30	247
300 (4-75)	18	93	57	37	205
+ 0	12	36	18	8	74
+300 (4-75)	19	76	47	30	172
Signif.	**	**	**	**	**
BLSD (.05)	15	24	8	16	34
CV, %	24.0	12.0	12.6	28.8	12.0

+ No phosphorus and potassium applied.

FERTILIZATION OF GRASS PASTURES
Crookston, Minnesota - 1976

R. P. Schoper, C. A. Simkins, J. Lensing
R. K. Severson, G. W. Wallingford

This was the third and final year of the experiment described initially in the 1975 Blue Book. The same location with the same fertilizer treatments were used again in 1976. The full 20' x 20' plot area was used for pasture management simulation in 1976. The plots were clipped on June 10 and July 20 when the plants were approximately 8 to 10 inches high. Due to lack of rain, there was little plant growth after the July 20 clipping date. Due to the extremely dry spring, the earliest clipping date did not produce the highest yields as it did in 1975 and 1976. A rain in the middle of June provided the moisture to allow substantial growth in early summer which was reflected in the July 20 clipping. After July 20 there was little plant growth due to the continued drought.

Table 6. Dry matter yields of grass as influenced by clipping date and fertilizer treatment in 1976.

Treatment $N-P_2O_5-K_2O$ lbs/A	Dry Matter Yields lbs/A June 10	July 20	Total
0-0-0	125	477	602
0-60-0	321	1936	2257
0-0-60	125	541	666
0-60-60	450	2796	3246
30-60-60	426	2553	2979
60-60-60*	662	4046	4708
90-60-60*	662	4647	5309
120-60-60*	642	4717	5359
150-60-60*	560	5380	5940
150-0-0*	219	2532	2751
Significance	**	**	**
BLSD (.05)	212	807	805
CV (%)	36.1	20.7	18.2

* Plots received 30 lbs N/A of the nitrogen after the first cutting

GRASS SEED PRODUCTION AS INFLUENCED BY FERTILIZATION

John Grava
Department of Soil Science
University of Minnesota
St. Paul, Minnesota 55108

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 fertilizer 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.

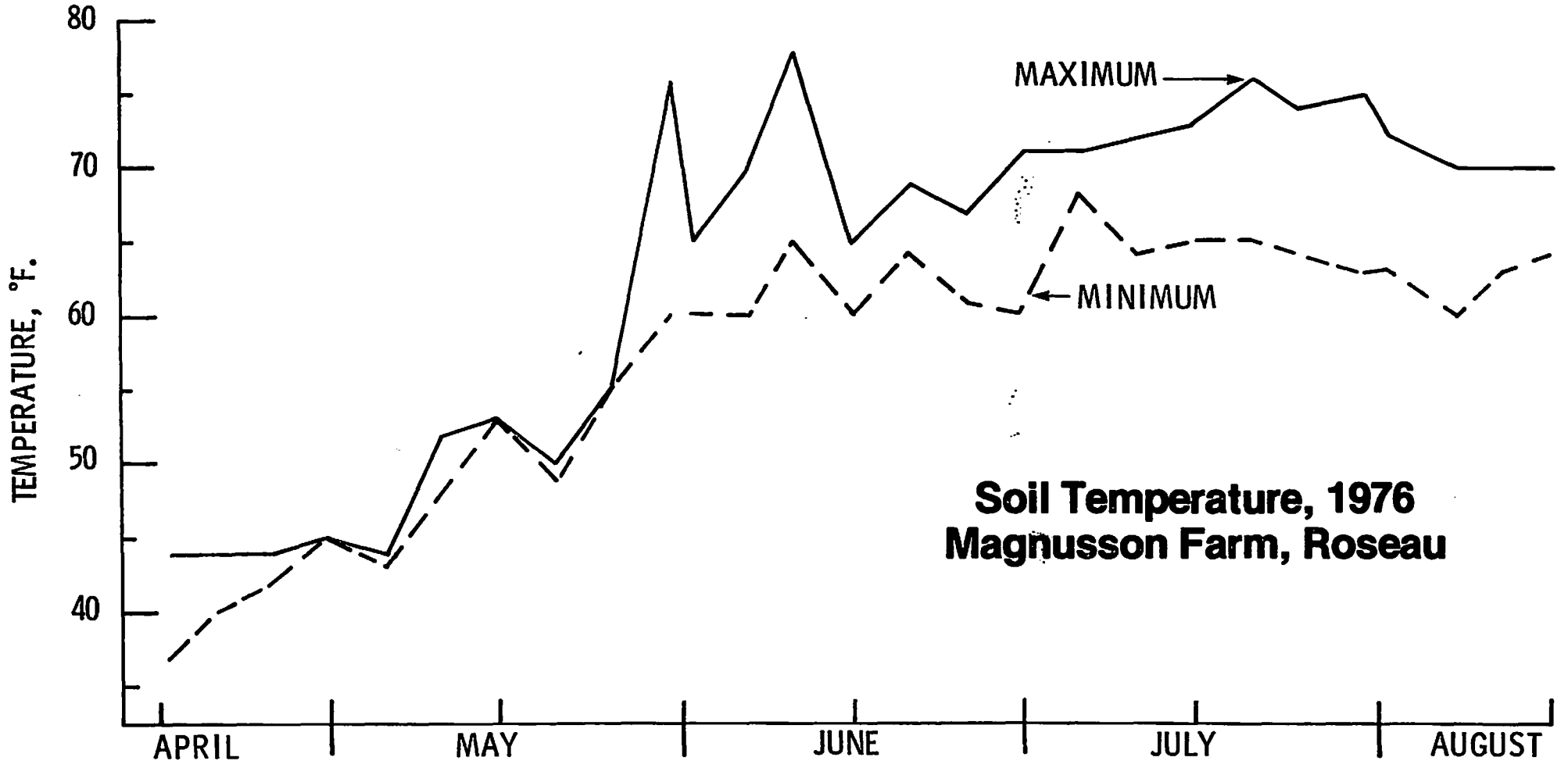
Research during 1976 consisted of (a) nitrogen source comparison, (b) nitrogen rate study on peat, and (c) copper study with Kentucky bluegrass on peat. Eight experiments with timothy and Kentucky bluegrass were conducted on growers' fields in Roseau and Lake of the Woods counties. Fertilizer effects were determined by yield measurements and plant analysis of grass tissue.

A. WEATHER CONDITIONS DURING 1975/76 GROWING SEASON

Comments on weather conditions are based on measurements of U.S. Weather Station at Roseau, observations and soil temperature determinations at the Magnusson farm at Roseau (table 1, fig. 1). August and September of 1975 were cool and relatively dry, with about 2 inches rainfall below normal. During October about 1.5 inch of rainfall was measured, about normal for the area. However, during an eight day period, from October 2 to 9, air temperature ranged from 67 to 78°F. Such high temperature may have affected N transformations in the nitrogen source experiments. November also was very dry and with the air temperature measuring about 3.5 degrees above normal. The area received about normal snowfall. April was warm with less than normal precipitation. May was very dry, with nearly 2 inches less rainfall than normal. During June 5.8 inches of rain were measured, but most of it fell during a six day period, from 6/7-6/13. Generally, during the period from August '75 to July '76, nearly 4 inches less precipitation than normal were received at Roseau while the average air temperature was about normal. Weather data of previous growing seasons indicate that during good seed production seasons (1964/65 and 1973/74) nearly 22 inches of precipitation are received at Roseau. Only 17 inches of precipitation were measured at Roseau during 1975/76 growing season. Rainfall in the area may have been spotty with some production fields receiving more rainfall than others.

Soil temperature (under sod at 3-inch depth) during May ranged from 45 to 55°F. Maximum soil temperature rose to 76-78° during first half of June. During the second half of June and during July, maximum temperature ranged from 71 to 76° while minimum temperature measured from 60 to 65°F.

Prepared for presentation at the Grass Seed Institute,
Baudette, March 24, 1977



Soil Temperature, 1976
Magnusson Farm, Roseau

Table 1. Precipitation and Temperature Data for the 1975/76 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
1975 Aug.	1.75	-1.47	61.1	-3.8	654
Sep.	1.79	-0.82	49.8	-4.8	294
Oct.	1.49	0.27	45.1	0.6	158
1975 Nov. to 1976 Apr.	4.30	-0.32	19.1	2.3	84
1976 May	0.54	-1.91	52.6	0.7	391
June	5.82	2.40	64.1	2.3	723
July	1.52	-1.93	64.8	-2.4	769
Total	17.21	-3.78			3073
Average			37.7	0.5	
Normal (1941-70)	20.99		37.2		3329

* Calculated from Climatological Data, Minnesota, Vol. 81 and 82, 1975 and 1976. U.S. Dept. of Commerce.

B. NITROGEN SOURCE COMPARISON

One of the most recent trends in fertilizer industry is the shift towards production of urea. In the grass seed producing area, urea has almost completely replaced ammonium phosphate and ammonium nitrate as source of nitrogen. This shift has occurred mainly because it's cheaper, easier and less hazardous to produce urea than other dry N fertilizers. For example, nitric acid, a highly corrosive material that must meet rigid pollution control standards, is required to produce ammonium nitrate. Also transportation and storage of ammonium nitrate is severely limited because of strict regulations.

As with any new material, questions have been raised about the effectiveness of urea as a N source for grass seed production. Growers also are concerned about possible N losses from urea when applied to soils under grass sod.

Research conducted elsewhere has shown that, in alkaline or calcareous soils, urea eventually is changed to ammonia gas (NH_3) which can escape into atmosphere when left on the soil surface. Urea losses can be cut down on cultivated land by incorporation into the soil. This, of course, is impossible with sod crops. Fortunately, moisture and low temperature greatly reduce urea losses. These losses can be minimized by applying urea when soil temperature is 50°F or below and when there is moisture from dew or rain that can wash urea into the soil. Such conditions normally exist around mid-October or May 1st - the usual dates for fertilizing grass seed production fields in NW Minnesota.

In a field experiment conducted in 1973 with Park Kentucky bluegrass on Helmstetter Bros. farm, urea was equally effective to ammonium nitrate as a N source. Both fertilizers were applied at rates to supply 40 or 100 lb/acre of N. Treatments were made on September 15 and April 25. Bluegrass seed yield and N concentration in grass tissue were affected to the same degree by ammonium nitrate and urea.

In fall of 1975, three field experiments were established on growers' fields. The soils contained 20-40 lb/acre of nitrate-N in the top two feet, considered to be relatively low (table 2). Nitrate-N concentration, in the main root zone (0-3 inches), was less than 3.4 pp2m. The timothy fields had fine textured silty clay loams and the bluegrass field had a sandy loam soil (table 3). The soils were calcareous with pH values near 8.

Table 2. Amount of Nitrate-N in the Soil Collected From 0-3, 3-6 and 6-24 Inch Depth on September 30, 1975

Location	Soil Texture	Sampling depth, inches 0-3	3-6	6-24	Total[1] NO_3-N in 0-24" Lbs/A
		NO_3-N pp2m			
Helmstetter Bros. Park K. bluegrass	Sandy loam	2.6	2.6	15.0	20
L. Knochenmus Kampe II timothy	Silty clay loam	3.0	3.0	33.6	40
D. Hedlund Timfor timothy	Silty clay loam	3.3	3.8	13.8	21
G. Kveen Park K. bluegrass	Peat	1.3	0.5	3.0	5
G. Kveen Newport K. bluegrass	Peat	0.5	0.5	3.0	4

1) By addition

Table 3. Soil Test Results of Samples Collected from 0-3, 3-6 and 6-24 Inch Depths on September 30, 1975

Location	Sampling depth, inches	Texture	pH	Extractable P pp2m	Exchangeable K pp2m
Helmstetter Bros.	0-3	SL	8.0	14	80
Park K. bluegrass	3-6	SL	8.2	20[1)]	50
	6-24	LS	8.2	7[1)]	30
L. Knochenmus	0-3	SICL	7.8	47[1)]	310
Kampe II timothy	3-6	SIL	8.0	13[1)]	100
	6-24	SIL	8.3	3[1)]	60
D. Hedlund	0-3	SICL	8.0	19	250
Timfor timothy	3-6	SICL	8.1	11[1)]	200
	6-24	SICL	8.5	2[1)]	140
G. Kveen	0-3	P	7.7	14	140
Park K. bluegrass	3-6	P	7.3	4	40
	6-24	P	7.0	4	20
G. Kveen	0-3	P	7.2	22	50
Newport K. bluegrass	3-6	P	6.4	3	10
	6-24	P	6.3	3	10

[1)] Bray P-1, 1:50 soil/solution ratio as reported to customer

Both nitrogen fertilizers were applied at rates of 50 and 100 lb of N per acre, either on September 30 or April 20. All plots received a 0+40+40 treatment. Fertilizer materials were applied with a 3-foot Gandy spreader.

Kampe II timothy yielded about 300 to 450 pounds of seed per acre (table 4). Sixty six pounds more seed were produced with ammonium nitrate than with urea. Optimum yield was produced with 100 lb/acre of nitrogen and spring fertilization was somewhat superior to fall. Ammonium nitrate treatments as well as the higher N rate and spring applications resulted in higher N concentration of tissue than other variables of this experiment.

Timfor timothy yield was not affected by the application of either N source when used at 100 lb per acre rate (table 5). The N100 treatments resulted in significantly higher N% of tissue than the check (N0).

Park Kentucky bluegrass yield (table 6) on sandy loam was relatively low, ranging from 200 to 250 pounds per acre. This probably was caused by draughty conditions. Fertilization with urea resulted in 37 pounds less seed per acre and a lower N concentration of tissue than obtained with comparable ammonium nitrate treatments. The rate or date of application had no effect on seed yield but the higher rate and spring treatments resulted in higher N concentration of tissue.

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 - 1976

Treatment	Seed yield lbs/acre	N percent in dry matter
(a) Source		
Urea	335 a	2.79 a
Ammonium nitrate	401 b	3.15 b
Significance	**	**
BLSD (0.05)	38	0.16
(b) Rate		
50 lbs/acre N	297 a	2.63 a
100 lbs/acre N	438 b	3.31 b
Significance	**	**
BLSD (0.05)	50	0.21
(c) Date		
Sept. 30	334 a	2.70 a
April 20	402 b	3.24 b
Significance	*	**
BLSD (0.05)	56	0.12
(d) Interaction		
Sept. 30 x 50 lbs/acre N	261	2.40 a
x 100 lbs/acre N	406	3.00 c
April 20 x 50 lbs/acre N	333	2.86 b
x 100 lbs/acre N	471	3.62 d
Significance	NS	*
BLSD (0.05)		0.09

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, 1973 Seeding. Dell Hedlund Farm, Roseau County - 1976

Treatment	Seed yield lbs/acre	N percent in dry matter
Check	418	3.10 a
Sept. 30		
Urea	421	3.92 c
Ammonium nitrate	417	3.84 bc
April 20		
Urea	517	3.57 b
Ammonium nitrate	475	3.69 bc
Significance	NS	**
BLSD (0.05)		0.33

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

All plots received 0+40+40 lbs/acre of P_2O_5 and K_2O. Urea and ammonium nitrate were applied at the rate of 100 lbs/acre of N.

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 - 1976

Treatment	Seed yield lbs/acre	N percent in dry matter
(a) Source		
Urea	207 a	2.40 a
Ammonium nitrate	244 b	2.75 b
Significance	*	**
BLSD (0.05)	33	0.16
(b) Rate		
50 lbs/acre N	212	2.33 a
100 lbs/acre N	239	2.82 b
Significance	NS	**
BLSD (0.05)		0.08
(c) Date		
Sept. 30	241	2.40 a
April 20	210	2.75 b
Significance	NS	**
BLSD (0.05)		0.12
(d) Interaction		
Sept. 30 x 50 lbs/acre N	233	2.22 a
x 100 lbs/acre N	249	2.58 c
April 20 x 50 lbs/acre N	191	2.44 b
x 100 lbs/acre N	229	3.06 d
Significance	NS	*
BLSD (0.05)		0.12

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

All plots received 0+40+40

C. FERTILIZER RATE STUDIES ON PEAT

In field experiments and growers' fields during 1960's, nitrogen rates of 20 to 30 pounds per acre often caused severe lodging of bluegrass on peat. Consequently, recommendations to growers called for an application of 10-15 lb/acre N. On the other hand, in experiments conducted during 1974 and '75, maximum seed 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 further investigate effectiveness of different N rates. Four nitrogen rates were used: 0, 20, 40, 80 lb/acre and the treatments were replicated four times. All plots received uniform 0+40+40 lb/acre phosphate and potash treatment. Twenty pounds of N were sufficient to produce optimum yield of 459 lb/acre (table 7). The 40-80 lb/acre N treatments, however, increased the nitrogen concentration of tissue.

Newport Kentucky bluegrass, in another experiment, produced relatively low seed yield (140-189 lb/acre), probably due to poor burn (table 8). Nitrogen concentration of tissue was increased by the use of the two highest nitrogen rates.

D. COPPER STUDY ON PEAT

The importance of copper fertilization in seed production of Kentucky bluegrass was investigated in three field experiments during 1976. Copper sulfate and copper chelate were dissolved in water and sprayed to 10 x 20 ft. plots on April 20. The treatments were replicated 6 times.

Copper concentration in tissue of Park and Newport varieties was relatively low, 2-4 ppm, while the Arista showed 31 ppm Cu concentration (table 9). Apparently the Arista field had been fertilized previously with copper. Copper concentration in the grass tissue was increased only by application of the sulfate form of copper. The seed yield of grass was not affected by fertilization with copper (table 10).

The lack of Kentucky bluegrass response to copper application is not surprising. Among several experiments conducted with grasses on peat during 1968-71, the seed yield was increased by copper application only in one trial. However, copper treatments, either the sulfate or chelate forms, have been effective in raising the copper concentration of grass tissue from 1-3 ppm to 6-10 ppm, considered to be sufficient. The concentration of over 200 ppm Cu, resulting from copper sulfate application, obtained in two experiments in 1976 is extremely high. It may be somewhat related to adverse weather conditions during growing season.

Table 7. Effect of Fertilization on the Seed Yield and N Concentration in Tissue of Park Kentucky Bluegrass on Peat, Gus Kveen Farm, Roseau County - 1976

Treatment[1)] N P_2O_5 K_2O lbs/acre	Seed yield lbs/acre	N percent in dry matter
Check	384 a	2.57 ab
0 + 40 + 40	354 a	2.36 a
20 + 40 + 40	459 bc	2.51 a
40 + 40 + 40	411 ab	2.77 ab
80 + 40 + 40	502 c	2.98 b
Significance	**	*
BLSD (0.05)	73	0.44

[1)]Fertilizer treatments were made on September 30, 1975.

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

Table 8. Effect of Fertilization on the Seed Yield and N Concentration in Tissue of Newport Kentucky Bluegrass on Peat, 1971 Seeding. Gus Kveen Farm, Roseau County - 1976

Treatment[1)] N P_2O_5 K_2O lbs/acre	Seed yield lbs/acre	N percent in dry matter
Check	156	3.38 a
0 + 40 + 40	162	3.42 a
20 + 40 + 40	140	3.45 a
40 + 40 + 40	162	3.72 b
80 + 40 + 40	189	3.87 b
Significance	NS	**
BLSD (0.05)		0.17

[1)]Fertilizer treatments were made on September 30, 1975.

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

Table 9. Copper Concentration of Kentucky Bluegrass Tissue on Peat as affected by Fertilization with Copper, Roseau County - 1976

Copper Treatment	Cooperator and variety		
	G. Kveen Park	G. Kveen Newport	Habstritt Arista
	Cu, ppm in dry matter		
None	2 a	4 a	31 a
50 lb/A Copper sulfate	17 b	217 b	202 b
2 lb/A Copper chelate	5 a	5 a	21 a
4 lb/A Copper chelate	6 a	16 a	48 a
Significance	**	**	**
BLSD (0.05)	4	152	56

Table 10. Effect of Copper Applications on the Seed Yield of Kentucky Bluegrass on Peat, Roseau County - 1976

Copper Treatment[1)]	Cooperator and variety		
	G. Kveen Park	G. Kveen Newport	Habstritt Arista
	Yield of seed, lbs/acre		
None	509[2)]	179	259
50 lbs/A Copper sulfate	523	196	264
2 lbs/A Copper chelate	564	188	261
4 lbs/A Copper chelate	547	200	243
Significance	NS	NS	NS
C.V. %	13	20	30

1) Copper treatments were made on April 20, 1976.

2) Average of 6 replications

SUMMARY AND CONCLUSIONS

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

Weather conditions during 1975/76 growing season were less than optimum. Nearly 4 inches of precipitation below normal were recorded at Roseau from August '75 to July '76. Relatively high air temperature, during October and November, may have affected nitrogen transformations in the N source experiments.

Fertilization with ammonium nitrate resulted in slightly higher seed yield and N concentration of tissue than from urea.

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

Fertilization with copper had no effect on the seed yield of Kentucky bluegrass on peat.

Acknowledgments

Grateful acknowledgments are made to the following cooperators and University personnel for their valuable assistance during 1976 in obtaining the information pertaining to grass seed production:

Messrs. Everett and George Helmstetter, Lake of the Woods county; Louis Knochenmus, Dell Hedlund, Habstritt Bros., Gustav Kveen, Roseau county; Dr. Laddie Elling, Messrs. Robert Schoper, Jerome Lensing, Tim Wagar, Mike O'Leary, Rick Quade, Donn Vellekson, University of Minnesota.

NAVY BEAN TRIALS - 1976

J.N. Lensing and G.E. Ham

Field experiments were established at Becker and Rosemount Experiment Stations to study the effect of nitrogen rates on yield of two varieties of navy beans. The two varieties used were Seafarer and Sanilac navy beans. The nitrogen source was urea. A randomized complete block design, replicated four times was used with each plot split with navy bean varieties.

Nitrogen fertilizer significantly increased bean yields with both varieties at Rosemount (Table 1), with highest yields at 120 lbs N/A. At Becker Seafarer beans increased from 1747 - 2264 lbs/A with highest yield at 90 lbs N/A. Sanilac beans increased from 1554 - 1933 lbs/A with highest yield at 60 lbs N/A.

Table 1. Yield of navy beans as affected by various rates of nitrogen.

Nitrogen Rate	Yields (lbs/A)			
	Rosemount		Becker	
lbs N/A applied	Seafarer	Sanilac	Seafarer	Sanilac
0	3115	3058	1747	1554
30	3227	3182	1788	1842
60	3434	3191	2046	1933
90	3748	3386	2264	1872
120	3847	3530	2009	1858
Significance	**	**	NS	NS
BLSD (.05)	210	253	--	--

POTATO TILLAGE,[1/]

Grand Forks, 1976

G.R. Blake
Professor, Department of Soil Science
University of Minnesota

Tillage System 2/	Total Weight lbs/A	Clods Removed lbs/A 3/	Culls Removed lbs/A	Net Weight cwt/A
Fall plowed	15018	678	26.0	143.1
Ditto	13425	283	36.2	131.1
Average				138.1
No fall tillage	14830	66	27.9	147.4
Ditto	14807	291	32.0	144.8
Average				146.1

1/ Harvested about two acres for each tillage treatment in two truck-loads from each. No difference found in potato specific gravity.

2/ Spring and summer tillage, fertilizer, spraying and vine killing were the same on both treatments. Prior to planting this consisted of field cultivating, marking rows, application of 20-20-12 and 30 lbs. of 10-G Thimet. Cultivations were blind with Lilliston and dragged with Melroe drag June 1 and 2; cultivated with Lilliston on June 17 and July 7. Sprayed 4 times plus vine killer.

3/ Weights approximate.

SOYBEAN NITROGEN FERTILIZER STUDIES

G.E. Ham and G.W. Randall

Ammonium nitrate and urea were compared at Waseca at the rate of 50 and 100 pounds N per acre when applied in the fall and spring. In addition, urea at the rate of 200 pounds N was applied in the fall. Fall applied-N was plowed-down and spring applied N was applied to the surface and disked in before planting. Corsoy and Hodgson varieties were planted on May 12th. Seed yields are shown in Table 1. Yields were lower than normal due to the extremely dry weather during the 1976 growing season. The seed yield of both varieties was increased significantly by the 200 pound rate of nitrogen. In addition, the seed yield of Hodgson was increased by the 100 pound rate of nitrogen as urea and ammonium nitrate with spring or fall application.

Several soybean genotypes were compared to common varieties for their response to 200 pounds of nitrogen per acre as urea. Planting was done on May 13 in 15-inch rows. The seed yield of 16 genotypes was increased significantly (Table 2). The other seven genotypes showed yield increases which were not significant. In no case did the fertilized yield less than the control. One genotype was destroyed by herbicide damage.

Table 1. Effect of nitrogen fertilizer on soybean seed yields at Waseca.

Fertilizer Treatment	Corsoy		Hodgson	
	15" rows	30" rows	15" rows	30"rows
lbs N/acre	bu/acre			
Control	33	34	33	34
50 urea, fall applied	34	35	35	36
50 urea, spring applied	34	37	37	37
100 urea, fall applied	35	35	37*	38*
100 urea, spring applied	33	34	37*	38*
200 urea, fall applied	37*	39*	40*	41*
50 amm. nitrate, fall applied	33	34	38*	36
50 amm. nitrate, spring applied	33	33	35	37
100 amm. nitrate, fall applied	33	36	38*	39*
100 amm. nitrate, spring applied	33	34	38*	38*

* Seed yield is significantly greater than the unfertilized control of the same variety and same row spacing.

Table 2. Effect of nitrogen fertilizer on soybean seed yield at Waseca.

Soybean Genotype**	Fertilizer N (urea) applied		Nitrogen Response
	0	200 lb N/A	
	bu/acre		
Corsoy	32	34	2
Hodgson	31	39*	8
Hark	29	35*	6
Grande	29	36*	7
M-67-68	33	37	4
M-68-48	31	37*	6
M-68-49	32	35	3
M-68-284	30	34	4
M-69-36	32	39*	7
Dt-2	25	32*	7
L-2	27	35*	8
12-055	29	38*	9
12-131	31	38*	7
A73D28	33	37	4
12-286	30	33	3
A73D8	31	37*	6
A73D22	31	38*	7
A74-102011	31	39*	8
A74-201006	31	39*	8
13-803	29	34*	5
13-825	29	38*	7
13-1030	30	35*	5
13-1035	27	34*	7

* Seed yield of fertilizer nitrogen treatment greater than control.

** 12- and 13- genotypes obtained from Dr. D.E. Green, Iowa State University; A- genotypes were obtained from Dr. W.E. Fehr, Iowa State University; M- genotypes obtained from Dr. J.W. Lambert, University of Minnesota.

SOYBEAN YIELD IMPROVEMENT WITH FOLIAR FERTILIZER

W.D. Poole[1], G.E. Ham[1] and G.W. Randall[2]

The recent soybean yield increases of 23 bushels per acre reported from foliar fertilization of soybeans has greatly increased interest in the subject. Dr. John Hanway of Iowa State University increased Corsoy soybean seed yields from 53 to 76 bushels per acre in tests in 1975.

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 (narrow rows, high-yielding varieties, etc.). 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.

According to previous Iowa State University research the suggested rate of application for an acre of soybeans is about 25 pounds of nitrogen, 3 pounds of phosphorus (6 pounds of P_2O_5), 7.5 pounds of potassium (9 pounds of K_2O) and 1.5 pounds of sulfur in 20 gallons of solution. 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. Using other sources of nutrients (commercially available liquid fertilizers) in the quantities mentioned above may "burn" the leaves and reduce yields.

In University of Minnesota studies in 1976 the lack of rainfall depressed all yields at Waseca while the plots at Rosemount were irrigated (Table 1). Soybean seed yields were not increased significantly by any foliar fertilizer treatment. The materials used in the Iowa State University studies (treatments A, B and C) were compared to conventional fertilizers (10-34-0 plus urea or 28% nitrogen solution and potassium sulfate in treatments D and E). The conventional fertilizers decreased

---

[1] Department of Soil Science, Univ. of Minnesota, St. Paul, MN 55108.

[2] Soil Scientist, Southern Expt. Sta., Univ. of Minn., Waseca, MN 56093.

yields and increased leaf burn significantly when UAN was used as the N source. This indicates the importance of using the proper source of nutrients.

The conventional fertilizers were included because they are cheaper and more readily available than the potassium polyphosphate. 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.

In another study at Rosemount in 1976, the seed yield of Evans variety soybeans was increased significantly (from 56 to 65 bushels per acre) by the treatment with the same materials used by Iowa State University. Adding phosphorus, potassium and sulfur from the same sources and changing the nitrogen source (calcium nitrate, ammonium sulfate or ammonium chloride) reduced yields very severely due to leaf burning. Adding nitrogen only as urea as a foliar or soil treatment did not increase yields.

Table 1. Influence of foliar fertilization on 1976 soybean seed yields in Minnesota.

Treatment*	Waseca		Rosemount	
	Corsoy	Hodgson	Evans	Hodgson
	bu/acre			
Control	25	28	47	50
Surfactant only	25	28	47	48
NPKS (3-4)[a]	26	27	46	49
NPKS (2-4)[b]	28	28	45	47
NPKS (1-4)[c]	26	28	45	48
10-34-0 + NKS[cd]	29	29	42	44
10-34-0 + NKS[ce]	23	26	38	43
NPKS (1-4)[f]	24	26	48	46
Benlate[g]	27	27	47	48
Benlate + NPKS (1-4)	27	29	47	49
Boron[h]	28	30	48	50
Boron + NPKS (1-4)	28	27	45	50

* 22.3 - 2.1 - 6.4 - 1.5 pounds NPKS/application in 26 gallons solution containing 0.1% tween 80 as surfactant.

[a] applied twice

[b] applied three times

[c] applied four times

[d] 10-34-0 + potassium sulfate + urea

[e] 10-34-0 + 28% N solution (UAN) + potassium sulfate)

[f] same as c except nitrogen supplied as ammonium thiosulfate

[g] applied at the rate of 1.0 pounds per acre

[h] applied at the rate of 0.4 pounds per acre

Table 2. Influence of foliar and soil fertilization on Evans soybean yields in 1976 at Rosemount, Minnesota.

Treatment	Seed Yield - bushels/acre
Control	56
Surfactant only[c]	57
NPKS foliar[a]	65
Urea only - foliar[b]	58
Urea only - soil	57
Calcium nitrate foliar[a]	44
Ammonium sulfate foliar[a]	43
Ammonium chloride foliar[a]	34

[a] Four applications of 18 - 1.7 - 5.2 - 1.2 pounds NPKS/application in 26 gallons solution containing 0.1% Tween 80 as surfactant.

[b] Four applications of 18 pounds N/application in 26 gallons solution containing 0.1% Tween 80 as surfactant.

[c] Four applications of 26 gallons solution containing 0.1% Tween 80.

REPORT ON SOYBEAN INOCULATION TRIALS

G.E. Ham, W.C. Lindemann, C.K. Kvien and G.W. Randall

Humus inoculants containing Rhizobium japonicum were applied to soybean seeds within 24 hours of planting and granular inoculants were applied with the seed at planting. All plots including the controls were hand planted into furrows opened with the planter and after planting the furrows were closed with a hand operated covering device. Emergence and germination of the plots were as good as the machine planted border rows. Plots were 16 feet long and 4 rows wide with a 15-inch row spacing. Weed control was excellent during the season. Rainfall was much less than normal and the drought during the pod-filling period was very severe. As a result, yields were about one-half of the normal yields obtained at Waseca. Also, the yield differential between the nodulating and the nonnodulating isoline was only 1.3 bu/acre which represents the yield contributed by nodulation.

Soybean seed yields were not increased significantly with inoculation with commercial humus or granular inoculants containing large numbers of Rhizobium japonicum (Table 1). Humus inoculants contained 4.9×10^5 to 1.3×10^8 rhizobia/gm inoculant and the granular inoculants contained 2.3×10^4 to 1.1×10^8/gm inoculant. Nodules are being serotyped to determine the recovery of added rhizobia.

Table 1. Influence of inoculating soybeans with *Rhizobium japonicum* on 1976 seed yields at Waseca, Minnesota.

Inoculant Treatment	Seed Yield bu/acre
Control	30.8
Ag Labs - humus - seed coated	29.0
Ag Labs - granular - soil - 5 lbs/acre	29.6
Ag Labs - granular - soil - 20 lbs/acre	28.4
Kalo - humus - seed coated	26.1
Kalo - granular - soil - 5 lbs/acre	30.0
Kalo - granular - soil - 20 lbs/acre	27.1
Nitragin - humus - seed coated	27.5
Nitragin - granular - soil - 5 lbs/acre	30.0
Nitragin - granular - soil - 20 lbs/acre	26.9
Nitragin - granular - soil - 40 lbs/acre	27.6
Olin - humus - seed coated	31.3
Olin - granular - soil - 5 lbs/acre	28.6
Olin - granular - soil - 20 lbs/acre	30.2
Research Seeds - humus - seed coated	28.2
Research Seeds - granular - 5 lbs/acre	28.6
Research Seeds - granular - 20 lbs/acre	28.1
Research Seeds - granular - 40 lbs/acre	28.6
University of Minnesota - SM31 granular - soil - 5 lbs/acre	28.5
University of Minnesota - SM31 granular - soil - 40 lbs/acre	27.2
University of Minnesota - SM35 granular - soil - 5 lbs/acre	27.2
University of Minnesota - SM35 granular - soil - 40 lbs/acre	27.7
University of Minnesota - USDA110 humus - seed coated	27.2
University of Minnesota - USDA110 granular - 20 lbs/acre	30.1
University of Minnesota - USDA110 granular - 40 lbs/acre	26.3
University of Minnesota - USDA142 humus - seed coated	29.2
University of Minnesota - USDA142 granular - 20 lbs/acre	29.8
University of Minnesota - USDA142 granular - 40 lbs/acre	29.0
Nodulating isoline	27.4
Nonnodulating isoline	23.9

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

W. E. Fenster and O. M. Gunderson

The main objective of this study is to determine the nitrogen needs of sugarbeets to the extent that recoverable sugar per acre can be increased and, hopefully, maximized in West-Central Minnesota. Unfortunately, 1976 was an extremely dry year and, as a result, the drought-stress on the sugarbeets masked nearly all of the fertilizer nitrogen treatments applied. Phosphorus and potassium experiments are also being conducted to ascertain what levels of these nutrients are needed for optimum sugar production.

Experimental procedure: Five locations were selected in West-Central Minnesota for the nitrogen correlation-calibration study. The sites represent the soil types on which most of the sugarbeets are grown. There was one nitrogen experiment in each of Traverse, Swift, and Chippewa counties and two in Renville County. The soils were Roliss Sicl in Traverse, Bearden Sicl in Swift, Tara sil in Chippewa, and Perella sil and Nicollet Sicl in Renville. One phosphorus and one potassium experiment was also established in Chippewa County on a Tara sil soil. Soil analyses were run on all experimental sites and fertilizers were added where necessary to insure adequate levels of nutrients.

A 5 x 5 Latin Square design was employed on all experiments. In addition, a starter-no starter split plot design was superimposed over the Latin Square in the phosphorus experiment.

Plant tissue analyses were run on young-mature petioles sampled at selected dates to check nitrate-nitrogen levels. Emission Spectrographic analyses were also run to ascertain nutrient levels in the plant tissue.

All plots were harvested with a one-row lifter and transported to North Dakota State University where the sugarbeets were immediately processed through the tare laboratory and the brei shipped to Rocky Ford for sodium, potassium, amino nitrogen and conductivity tests.

Statistical analyses were run on all data using a BLSD test.

Nitrogen investigation: Five soil profiles were taken to a depth of 5 ft. at each of the five locations. Depths of 0-6", 6-12", 12-24", 24-36", 36-48" and 48-60" were each analyzed for nitrate-nitrogen. These increments were each tested in an attempt to correlate depth and amount of nitrate with yield. Two of the five nitrogen trials, however, were affected by drought to the extent that they were abandoned and no yields were taken. The results from the remaining three trials are shown in tables 1-8. Based on the nitrate-nitrogen levels in the top two feet of soil at the start of the 1976 growing season (table 1), root yield increases would normally have been expected as a result of applying fertilizer nitrogen. Due to the extreme drought, however, no meaningful statistical differences in yields, percentage sugar, amino nitrogen, and recoverable sugar were noted as a

result of increasing rates of fertilizer nitrogen (tables 2-4). This was also apparent in the nitrate levels of the petioles which generally were not significantly different as a result of nitrogen applications (tables 5-7). It is obvious from table 8, however, that the nitrate soil tests did reflect the increased nitrogen applications at the end of the season.

Table 1. Nitrate-nitrogen levels at the experimental locations prior to planting in 1976.

Depth (in.)	Davison Farm (Traverse Co.)	W. Schwitters Farm (Chippewa Co.)	Frieberg Farm (Renville Co.)
	lbs. NO_3-N/A(1)		
0 - 6	32	17	11
6 - 12	24	19	18
12 - 24	30	43	22
24 - 36	30	51	15
36 - 48	23	26	15
48 - 60	15	12	22
Total	154	168	103

(1) All figures are an average of 5 soil probes.

Table 2. Effect of varying rates of fertilizer nitrogen on sugarbeet root yields, percentage sugar, amino nitrogen, impurity index and recoverable sugar on the Earl Davison farm in Traverse County, Minnesota, 1976.

Nitrogen Treatment[1] lbs/A	Roots T/A	Sugar %	Amino Nitrogen ppm	Impurity Index	Recoverable Sugar T/A
0	6.6	17.6	1165	1049	0.972
50	7.3	17.9	1174	1053	1.095
100	6.9	17.4	1091	1013	1.015
150	7.0	17.3	1139	1053	1.013
200	6.1	17.4	1137	1084	0.893
Sig.	ns	*	ns	ns	ns
BLSD (.05)		-			
(.10)		.4			

(1) 5x5 Latin square design.

Table 3. Effect of varying rates of fertilizer nitrogen on sugarbeet root yield, percentage sugar, amino nitrogen, impurity index and recoverable sugar on the Wayne Schwitters farm in Chippewa County, Minnesota, 1976.

Nitrogen Treatment[1] lbs/A	Roots T/A	Sugar %	Amino Nitrogen ppm	Impurity Index	Recoverable Sugar T/A
0	12.8	17.8	488	549	2.074
50	12.6	17.4	552	582	1.999
100	13.9	17.3	506	572	2.194
150	11.6	17.5	550	576	1.851
200	13.1	17.6	637	649	2.082
Sig.	**	ns	*	ns	ns
BLSD (.05)	1.6		91		

(1) 5x5 Latin square design.

Table 4. Effect of varying rates of fertilizer nitrogen on sugarbeet root yield, percentage sugar, amino nitrogen, impurity index and recoverable sugar on the Pete Frieberg farm in Renville County, Minnesota, 1976.

Nitrogen Treatment[1] lbs/A	Roots T/A	Sugar %	Amino Nitrogen ppm	Impurity Index	Recoverable Sugar T/A
0	18.7	16.3	427	735	2.607
50	19.4	16.6	433	735	2.866
100	20.5	16.5	479	739	3.020
150	18.8	16.5	514	793	2.724
200	18.2	16.6	530	810	2.666
Sig.	ns	ns	ns	ns	**
BLSD (.05)					.145

(1) 5x5 Latin square design.

Table 5. Effect of varying rates of fertilizer nitrogen on nitrate-nitrogen content of young-mature sugarbeet petioles taken at selected times on the Earl Davison farm located in Traverse County, Minnesota, 1976.

Nitrogen Treatment[1] lbs/A	Sampling Date July 19 ppm	August 2 ppm	August 16 ppm	August 30 ppm	September 13 ppm
0	7794	1605	2964	1941	1636
50	8750	2085	3502	1876	1918
100	8635	2270	3250	1712	1664
150	8343	2359	3167	1653	1900
200	10334	2573	3811	1987	2010
Sig.	ns	ns	ns	ns	ns
BLSD (.05)					

(1) 5 x 5 Latin square design.

Table 6. Effect of varying rates of fertilizer nitrogen on nitrate-nitrogen content of young-mature sugarbeet petioles taken at selected times on the Wayne Schwitters farm located in Chippewa County, Minnesota, 1976.

Nitrogen Treatment[1] lbs/A	Sampling Date July 19 ppm	August 2 ppm	August 16 ppm	August 30 ppm	September 13 ppm
0	4604	1605	1696	1353	782
50	5573	2085	2087	1786	837
100	5947	2270	2090	1533	677
150	4986	2359	2172	1868	974
200	8292	2573	2426	2355	1215
Sig.	ns	ns	ns	ns	ns
BLSD (.05)					

(1) 5 x 5 Latin square design.

Table 7. Effect of varying rates of fertilizer nitrogen on nitrate-nitrogen content of young-mature sugarbeet petioles taken at selected times on the Pete Frieberg farm located in Renville County, Minnesota, 1976.

Nitrogen Treatment[1] lbs/A	Sampling Date July 19 ppm	August 2 ppm	August 16 ppm	August 30 ppm	September 13 ppm
0	3370	2491	2282	1628	1268
50	3902	2451	2713	1741	1279
100	4119	3171	2746	1861	1378
150	4881	4289	4004	2531	1780
200	4143	3874	3800	2345	1648
Sig.	ns	ns	*	ns	ns
BLSD (.05)			1368		

(1) 5 x 5 Latin square design.

Table 8. Effect of varying rates of fertilizer nitrogen on soil nitrate-nitrogen levels taken to a depth of two feet after sugarbeet harvest, 1976.

Nitrogen Treatment[1] lbs/A	Nitrate-Nitrogen (0-24") Davison Farm Traverse Co. lbs/A	Schwitters Farm Chippewa Co. lbs/A	Frieberg Farm Renville Co. lbs/A
0	78	94	67
50	115	77	70
100	105	118	90
150	172	146	127
200	208	159	150
Sig.	*	ns	**
BLSD (.05)	101		34

(1) 5 x 5 Latin square design.

Phosphorus and Potassium Investigations

Five rates of phosphorus ranging from 0 to 100 lbs/acre phosphate were broadcast and each of the plots was then split to compare a 7-21-7 starter fertilizer applied at a rate of 5 gal/acre. Again, as with the nitrogen results, the extremely dry weather conditions played a major role in the experimental results. No significant differences in growth or yield criteria were realized as a result of the phosphorus treatments (table 9). It is interesting to note that the percentage phosphorus in the petiole (table 9) is very low, even where the higher rates of phosphate were applied. This would indicate that the sugarbeets probably were not taking up appreciable amounts of nutrients from the extremely dry plow layer, but rather from the subsoil which is characteristically low in available phosphorus.

The results of the potassium trial are given in table 10. Only two replicates out of five were harvestable as a result of poor stands due to the drought. No meaningful growth or yield differences were noted as a result of the potassium treatments.

ACKNOWLEDGEMENTS

Sincere appreciation is extended to the Sugarbeet Research and Education Board and to the University of Minnesota Agricultural Extension Service for financing and supporting this research project. It should also be recognized that American Crystal, Rocky Ford, conducted the analyses on the brei samples.

Special recognition should also be given to Robert Schoper and Jerome Lensing in the Soil Science Department, University of Minnesota, for their untiring efforts and attention to needed details on this project. Appreciation is also extended to Tim Wagar, Mike O'Leary and Richard Quade for their many hours of field work.