D. COPPER STUDY ON PEAT

The importance of copper fertilization in seed production of Kentucky bluegrass on peat was investigated in a field experiment during 1978. Copper sulfate and copper chelate were dissolved in water and sprayed to 10 x 20 ft. plots on April 25. The treatments were replicated six times. The field was renovated by plowing and disking in 1977. The entire plot area received 20+40+40 lb/acre of N, P_2O_5 and K_2O on October 5. Low copper availability was indicated by the soil test. The DTPA-extractable copper content ranged from 1.2 - 1.5 ppm in the top 3 inches of soil, and 1.0 - 1.3 ppm Cu at 3-6 inch depth.

The seed yield was not affected by fertilization with copper (Table 8). Copper concentration in tissue of Newport K. bluegrass collected from check plots was 1.5 ppm, considered a very low level. Copper sulfate (25.5% Cu) applied at 50 lb/acre rate, increased Cu concentration to 8.1 ppm. The application of copper chelate (13% Cu) increased Cu concentration in grass tissue only slightly above the values of check plots.

Table 8. Seed yield and copper concentration of Newport Kentucky bluegrass tissue as affected by fertilization with copper, Gustav Kveen Farm, Roseau County, 1978.

Copper Treatment	Seed Yield lb/acre	Copper, ppm in dry matter
None	163	1.5a
50 lb/acre copper sulfate	201	8.1b
2 lb/acre copper chelate	224	2.9a
4 lb/acre copper chelate	183	3.8a
Significance	ns	*
BLSD (0.05)	-	3.7
C.V.	26	73

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

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the following cooperators and University personnel for their valuable assistance during 1978 in obtaining the information pertaining to grass seed production:

Messrs. Douglas Erickson, Dell Hedlund, Luis Knochenmus, Gustav Kveen, Roseau County; Everett and George Helmstetter, Lake of the Woods County; Dr. Laddie Elling, Messrs. Jerome Lensing, Mike O'Leary, Donn Vellekson, Owney Koski, Russel Severson, University of Minnesota.

PASTURE FERTILIZATION TRIALS, GOODHUE CO., 1976, 1977 and 1978 WASHINGTON CO., Kelly farms, 1978

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, 1977 and 1978.

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

The fine cooperation of Jim Bryan, Dale Flueger and Morris Grogan are gratefully acknowledged. Also, the efforts of Bob Schoper, Jerome Lensing and Mike O'Leary, 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 in 1976 and 1977; and supported by the Cenex Foundation in 1978.

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, 1977, and 1978.

N	P_2O_5	K_2O	Flueger* lbs/A			N response over check			Protein** lbs/A		
			1976	1977	1978	1976	1977	1978	1976	1977	1978
0	40	40	3646	2383	3738	-	-	-	440	373	671
30	40	40	4789	3133	4701	1143	750	963	660	483	846
60	40	40	5301	3926	5580	1655	1543	1852	843	690	1033
90	40	40	7110	4868	5856	3464	2485	2018	1250	931	1123
120	40	40	6767	4881	6480	3121	2498	2742	1210	988	1289

* 3 cuttings at Bryan's and 4 at Flueger's, 1976; 4 cuttings at Bryan's and 3 at Flueger's, 1977; 4 cuttings at Flueger's, 1978.

** N removed times 6.25.

Table 2. The effect of split applications of nitrogen on pasture yield (lbs/acre dry matter). Goodhue Co. 1978.

Flueger Farm

N + P_2O_5 + K_2O	Cuttings 1	2	3	4	Total
60 + 40 + 40	1371	2119	1111	978	5579
60(1,3)* + 40 + 40	896	1218	1573	765	4452
significance (t test)	10%	1%	ns	10%	ns
120 + 40 + 40	1817	1984	1772	907	6480
120(1,3)* + 40 + 40	1378	1304	2131	641	5454
120(1,2,3,4)*+40 + 40	1450	2086	2060	1003	6599
significance					
60(1,3)* + 40 + 40	896	1218	1573	765	4452
60(1,3) + 40 + 40 (urea)	925	1369	1526	950	4470
significance	ns	ns	ns	**	ns

* application code

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

Table 3 The effect of potash, magnesium and dolomitic limestone on dry matter yield of grass pasture. Kelly farms. 1978.

	pounds dry grass/acre				
	Cuttings				
	1	2	3	4	Total
Lime 4 T/A	1690	2772	1226	939	6627
No lime	1803	2362	1336	1026	6527
Significance	ns	*	ns	ns	ns
BLSD (05)	-	353			
Lbs K_2O/A					
0	1850	2528	1230	911	6518
160	1716	2473	1113	886	6187
320	1767	2677	1228	928	6800
640	1624	2512	1545	1284	6964
1000	1803	2537	1313	942	6595
1000+100# Mg/A	1719	2674	1256	948	6596
Significance	ns	ns	ns	*	ns
BLSD (05)	-	-	-	184	-

All plots received 120# N/A and 40# P_2O_5/A

Table 4a. Emission spectrograph analysis 1st cutting, Kelly farm, Washington Co. 1978.

	%				ppm				
Treatment	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
No lime	.31	4.10	.30	.16	155	137	34	8	5
Lime 4 T/A	.31	4.48	.27	.14	155	149	35	8	5
Significance	ns	ns	+	*	ns	ns	ns	ns	ns
BLSD (5%)	-	-	.02	.01	-	-	-	-	-
lbs K_2O/A									
0	.35	4.16	.30	.16	153	133	36	8	5
160	.28	3.87	.29	.14	143	129	33	8	6
320	.33	4.47	.29	.14	162	153	35	8	6
640	.30	4.38	.29	.15	158	145	34	8	4
1000	.32	4.56	.28	.16	154	152	35	8	5
1000 + 100# Mg	.28	4.30	.28	.15	159	147	34	8	7
Significance	*	*	ns	ns	ns	+	ns	ns	ns
BLSD (5%)	.04	.44	-	-	-	18	-	-	-

Table 4b. 2nd Cutting

No lime	.32	3.32	.30	.16	71	159	30	8	5
Lime 4 T/A	.34	3.56	.27	.15	70	204	30	8	6
Significance	ns	*	ns	ns	ns	ns	ns	ns	ns
BLSD (5%)	-	.23	-	-	-	-	-	-	-
lbs K_2O/A									
0	.34	3.20	.29	.16	66	169	30	8	6
160	.33	3.42	.30	.15	72	161	31	8	5
320	.31	3.41	.26	.13	66	190	30	8	5
640	.33	3.57	.28	.16	71	189	30	8	5
1000	.35	3.43	.32	.17	78	202	30	8	6
1000 + 100# Mg	.32	3.62	.27	.16	71	176	31	9	5
Significance	ns	ns	ns	+	ns	ns	ns	ns	ns
BLSD (5%)	-	-	-	.02	-	-	-	-	-

Table 5. The effect of varying nitrogen treatments on grass yield (dry matter). pounds per acre of nitrogen removed and percent.

Treatment N	P_2O_5	K_2O	lbs D.M./A 1	2	3	4	Total	%N 1	2	3	4
0	0	0	969	2066	1040	871	4946	2.75	2.32	2.73	3.20
0	40	40	1098	2129	1093	1018	5340	2.96	2.07	2.68	3.23
30	40	40	1314	2364	1038	1042	5759	3.05	2.29	2.69	3.11
60	40	40	1750	1978	1145	890	5763	3.70	2.71	2.66	3.39
*120(60+60)	40	40	1567	2295	1756	950	6568	3.72	2.48	3.37	3.43
Significance			**	ns	**	ns	**	**	**	**	ns
BLSD (05)			174	-	246	-	796	.41	.27	.35	-
C.V.			9.1	12.6	13.7	25.5	8.9	8.5	7.2	8.0	6.7

*60# N/A spring +
60# N/A after second cutting

Table 6. Soil tests average of 2 samples per plot at 0 to 3 and 3 to 6 inch depths, according to lime and potash treatments. Kelly farms, Washington Co. 1978.

0 to 3 inch depth

potash treatment per acre 1978

	0			160			320			640			1000			1000 + Mg		
	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K
no lime	5.2	24	192	5.2	39	270	5.2	21	314	5.4	42	548	5.4	26	580	5.4	31	600+
lime	6.2	28	263	6.3	28	207	6.1	28	340	6.2	23	490	6.0	27	555	6.2	23	600+
3 to 6 inch depth																		
no lime	5.4	16	155	5.4	26	195	5.4	13	160	5.4	28	314	5.4	18	426	5.3	16	360
lime	5.6	22	201	5.6	15	129	5.4	16	236	5.5	15	264	5.5	21	375	5.5	16	479
Ave P & K 0-6"		23	203		27	200		20	263		27	404		23	484		22	510

Discussion and summary

Bryan and Flueger farms

This was the last year for the Goodhue County plots.

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 in 1976 and 1977. When alfalfa was killed by 2,4D in 1978, the 120 pound treatment in the spring gave highest yield.

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 100 to 120 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.

7. Soil tests shown in Table 6 reveal that most of the phosphorus and potassium are in the top 3 inches of the soil.

Kelly farms

1. Lime, magnesium and potash additions did not affect grass yield, either upward or downward.

2. Generally, plant analysis showed that treatments had no significant effect upward or downward on magnesium content. Magnesium levels were the same even with 100 pounds of added magnesium for the first two cuttings, but the 3rd cutting showed .02 percent more magnesium from the added magnesium.

3. The 4 tons per acre lime treatment increased soil pH about 1 full pH unit in just 6 months.

4. Potash treatments increased the K test from 200 pounds of exchangeable K to nearly 600 pounds when treatment was 1000 pounds of K_2O per acre.

INFLUENCE OF FOLIAR APPLICATIONS OF FERTILIZER NUTRIENTS AND FUNGICIDE ON THE YIELD AND PROTEIN CONTENT OF SMALL GRAINS - 1978

C.A. Simkins, G.W. Randall, S.D. Evans, Gary Varvel, and H.L. Bissonnette

The foliar feeding of crops has been investigated by several scientists during the early 1950's. The yield and percent protein of several crops was increased by the spray application of nitrogen fertilizer (urea and ammonium nitrate). These increases were obtained on soils deficient in available nitrogen.

Foliar fertilization was reported to increase seed yields of soybeans in field experiments in Iowa. Researchers in other states have not obtained consistent increases in yield.

Several researchers have shown that the application of fungicides on small grains often results in economical increases in yield due to control of certain leaf diseases. The influence of the combined application of plant nutrients and fungicides on the yield and quality of small grains was of particular interest to the investigators.

Materials and Methods

These studies were conducted at 3 locations in Minnesota; Waseca, Morris and Crookston. The sites at these locations were selected to represent soils in a high state of fertility. The NO_3N level at the 3 locations contained more than 100 lbs. of NO_3N in the top 2 feet. The P and K soil test levels were also well above the critical levels normally associeted with response to additions of phosphorus and potassium fertilizer.

	Lbs/Acre		
SITE	NO_3N-2'	P	K
Crookston	130	28	290
Morris	110	31	300+
Waseca	118	32	300+

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.

Trials were established on wheat and oats at the Morris location and wheat at the Crookston and Waseca locations.

Treatments were as follows:

1. Control.
2. Foliar application of nutrients at flag leaf stage and 10 to 20 days later.
3. Fungicide applied at flag leaf stage and 10 and 20 days later.
4. Combinations of treatments 2 and 3.

Treatments were replicated four times. Spray applications were made at a pressure of 80 lbs. per sq. in.

Wheat and oats were seeded with a grain drill at conventional seeding rates of 90 and 60 lbs. of seed per acre respectively.

The wheat variety Era was seeded at all locations. The oat variety seeded at the Morris location was Dahl.

Results and Discussion

The grain yields at the various locations as influenced by fertilizer nutrient applications are shown in Table 1.

Table 1. Grain Yields as Influenced by Fertilizer Nutrient Applications - 1978

Lbs/Acre				Grain Yield Bu/A			
N	P	K	S	Oats Morris	Wheat Morris	Wheat Waseca	Wheat Crookston
0	0	0	0	90.4	27.0	31.7	58.1
15	6	9	1.3	84.4	25.2	32.3	55.3
30	12	18	2.6	84.1	26.0	31.1	57.9
15	18	27	3.9	85.8	24.6	29.5	55.3
		Sig.		NS	NS	NS	NS
		BLSD		--	--	--	--

No significant increases in grain yields were obtained as a result of the foliar application of plant nutrients. The yields of wheat at the Morris and Waseca locations were relatively low due in part to the severe attack of leaf diseases. The grain yields of wheat at the Morris and Waseca locations were significantly increased by the application of 2 lbs. per acre of Manzate Fungicide. The grain yields with and without fingicide application are shown in Table 2.

Table 2. Grain Yields as Influenced by Fungicide Spray Applications - 1978

	Grain Yields/Bu/A			
Fungicide	Oats Morris	Wheat Morris	Wheat Waseca	Wheat Crookston
Without	86.7	24.0	29.8	56.0
With	85.7	27.4	32.6	57.3
Sig.	NS	+	+	NS
BLSD (.05)	--	2.6	2.3	--

Yield increases from the application of fungicide at the Morris and Waseca locations was generally from 3 to 4 bushels per acre. Wheat yields at the Crookston location were not increased significantly by fungicide applications.

The foliar application of fertilizer nutrients resulted in significant increases in the protein content of the wheat grain at 2 of the 3 locations. It also resulted in a significant increase in the chaff and straw at the Crookston location. The percent protein in the wheat grain chaff and straw are shown in Table 3.

Table 3. Protein Content of Wheat Grain, Straw and Chaff - Foliar Applications - 1978

Lbs/N/Acre				Wheat Protein %				
N	P	K	S	Grain Morris	Grain Waseca	Grain Crookston	Chaff Crookston	Straw Crookston
0	0	0	0	18.2	17.0	15.1	4.6	3.6
15	6	9	1.3	18.2	16.9	15.2	4.7	3.7
30	12	18	2.6	18.5	17.2	15.4	5.0	4.0
45	18	27	3.9	19.6	17.7	15.6	5.1	4.1
Sig., BLSD, 5%				.4	.4	NS	.35	.36

The quantity of phosphorus and potassium contained in the chaff of the harvested wheat was measured at the Crookston location. The percent P and K are shown in Table 4.

Table 4. Percent Phosphorus and Potassium in Wheat Chaff - Crookston Location - 1978

Lbs/Acre			%P	%K
N	P	K		
0	0	0	.078	.854
15	6	9	.083	.885
30	12	18	.077	.969
45	18	27	.092	1.005
Sig., BLSD (.05)			--	.063

The foliar application of potassium sulfate resulted in significant increases in the K content of the wheat chaff. The phosphorus content of the wheat chaff was not consistently increased by foliar application of the fertilizer nutrients.

The application of fungicides did not result in significant increases in the protein content of the wheat or oat grain or the straw or chaff of the wheat at Crookston.

Summary

Foliar application of N-P-K and S, fertilizer nutrients, on wheat and oat plants did not result in significant increases in yield at 3 locations in Minnesota in 1978.

The foliar application of fertilizer materials containing nitrogen resulted in significant increases in the protein content of wheat grain at 2 of the 3 locations. The protein content of the straw and chaff of the wheat plant was also significant increased by foliar applications of fertilizer nitrogen.

The application of 2 lbs. of Manzate Fungicide increased wheat yields at the Morris and Waseca locations. This increase was consistently at a level of 3 to 4 bushels per acre.

N Rate, Source, and Incorporation Study

W. Nelson, S. Evans, G. Varvel, J. Lensing, and H. Meredith

Background: N losses from surface applied fertilizers containing urea have received much attention in the literature. These studies have been conducted in the laboratory under conditions favoring large losses of N. Field studies from urea containing fertilizers have shown N losses to be quite variable. Factors as soil pH, temperature, moisture, etc. are some of the more important variables.

The three leading broadcast N sources - urea, ammonium nitrate, and urea-ammonium nitrate solution - are surface applied and one-half of the treatments is incorporated with a tillage instrument prior to planting. Era wheat is used to deliniate N response.

Objective of Study: The primary objective of this study is to determine if crop response to applied nitrogen is altered when spring applied nitrogen is incorporated or nonincorporated prior to planting. Secondary objectives involve correlating N response to soil test nitrate and differing rates of applied N.

Duration of Study: The study was initiated in 1978. Intentions are to evaluate this study for at least three years at Crookston, Morris, and Lamberton. A fourth location will hopefully be added at Waseca in 1979 using corn as the indicator crop.

Nitrate Soil Test: The primary ingredient in the N source evaluation is the N response to applied N. Accumulated nitrate in the soil profile must be sufficiently low to require a need for supplemental nitrogen to attain high yields under favorable environmental conditions.

The guide to supplemental N use on wheat appears in University of Minnesota Extension Bulletin No. 416, page 8. Data in Table 1 is a summation of this guide.

Table 1. A Guide to N Use Based on Nitrate Soil Tests.

Nitrate Soil Test	Pounds N-NO3 in Soil Profile	Lbs. N to Apply
Low	<50	90
Medium	50-100	70
High	>100	15

Nitrate tests at the three locations are summarized in Table 2.

Table 2. Nitrate Soil Tests at Lamberton, Morris, and Crookston, 1978.

Depth (ft.)	Lamberton	Morris	Crookston
	- - - - - - - - - -	Lbs NO_3-N	- - - - - - - - - -
0-1	16	72	--
1-2	12	60	72 1/
2-3	26	129	--
3-4	57	120	--
4-5	48	50	--
	159	431	72

1/ 0-2'

Based on the nitrate soil test in the top 24 inches a nitrogen response would have been expected at Lamberton and Crookston. However, the lower profile, 2 to 5 feet, contained sufficient nitrate to negate a response to applied nitrogen at the yield level attained in 1979 at Lamberton, Table 3.

Table 3. Era Wheat Grain Yields, Test Weight and Percent N in Grain at Lamberton, Morris, and Crookston, 1978.

Trt			Lamberton			Morris			Crookston	
N Rate	N Source	Inc.	Bu/A	Test Wt.	% N Grain	Bu/A	Test Wt.	% N Grain	Bu/A	% N Grain
0	--	--	28.2	59.1	2.80	44.0	49.0	3.30	27.9	2.02
40	AN	+	33.2	60.5	2.74	46.1	49.2	3.25	45.5	2.12
80	AN	+	33.0	56.4	2.90	52.2	50.0	3.34	58.5	2.34
40	U	+	31.0	59.1	2.84	52.7	48.9	3.33	48.2	2.10
80	U	+	29.6	59.4	2.88	52.2	49.8	3.27	59.3	2.18
40	28%	+	28.4	60.0	2.78	50.3	50.0	3.23	45.4	1.98
80	28%	+	29.6	58.6	2.91	42.6	49.6	3.41	59.1	2.26
40	AN	--	29.4	59.8	2.82	50.8	49.4	3.32	44.0	1.99
80	AN	--	28.4	58.4	2.86	44.5	47.8	3.37	60.9	2.24
40	U	--	32.5	59.8	2.78	51.2	49.6	3.30	51.0	2.10
80	U	--	30.5	59.5	2.85	42.5	47.7	3.38	60.6	2.33
40	28%	--	28.6	59.3	2.84	44.4	48.2	3.25	43.5	1.98
80	28%	--	30.9	59.3	2.71	49.1	47.6	3.35	60.3	2.14
Signif.			NS	NS	NS	NS	NS	NS	**	**
BLSD (.05)			--	--	--	--	--	--	6.1	.15
C.V.			9.8	2.9	3.1	18.3	3.4	3.7	8.4	5.1

+ = incorporated
- = unincorporated

A yield response to applied nitrogen was observed at Crookston. Data in Table 4 indicate there was no difference in incorporation versus nonincorporation of applied N.

Table 4. Yield of Era Wheat and Percent N in Grain at Crookston, 1978.

Treatment	N Source	Yield Bu/A	% N in Grain
Check	--	27.9	2.02
AN	40_1 1/	45.5	2.12
AN	40_2 2/	44.0	1.99
Urea	40_1	48.2	2.10
Urea	40_2	51.0	2.10
28% N Soln	40_1	45.4	1.98
	40_2	43.5	1.98
AN	80_1	58.5	2.34
	80_2	60.9	2.24
Urea	80_1	59.3	2.18
	80_2	60.6	2.33
28% N Soln	80_1	59.1	2.26
	80_2	60.3	2.14
Signif.		**	**
BLSD (.05)		6.1	.15
C.V.		8.4	5.1

1/ = incorporated

2/ = unincorporated

Nitrogen fertilizer was applied on May 3 and seeded on the same day. Precipitation sufficient to place the N in contact with the soil occured within a few days.

As little as 0.1 inch of moisture is sufficient to negate losses of N to the atmosphere. The probability of precipitation in late fall or early spring is generally high.

INFLUENCE OF NITRATE-NITROGEN LEVEL OF VARIOUS SOILS OF THE RED RIVER BASIN AND THEIR RESPONSE TO ADDED NITROGEN FERTILIZER - WHEAT FERTILITY RESEARCH 1978

Charles Simkins, Michael O'Leary, and Terrance Courneya

The ability to estimate the available nitrogen level in the soil and adjust this level to the production potential of a given soil under existing climatic conditions is largely the key to economic use of fertilizer on non-legume crops. On most soils in Minnesota, nitrogen is the most limiting plant nutrient for wheat. An inadequate supply can greatly reduce yield and profit. The response of wheat to nitrogen fertilizer is similar to that of other small grain crops except, that normally more nitrogen is required to reach the yield potential of the wheat crops.

The recent introduction and adoption of the nitrate-nitrogen test has been a valuable tool in assisting farmers in adjusting their nitrogen fertilizer use for wheat. There is still considerable need for refinement of the test in Minnesota. The diverse soil types on which wheat is grown vary in their inherent ability to grow crops. Each soil has its won unique yield potential and reaction to applied plant nutrients. It is important that we look at different soils as different individuals and determine more closely their ability to produce. (i.e. their production potential).

Methods and Materials

Trials were established at six locations in the Red River Basin of Minnesota near Thief River Falls, Crookston and Warren, Minnesota. The general profile description of the series are as follows:

POPPLETON-FINE SAND

Very dark grayish brown fine sand overlying grayish brown fine sand, brown mottling in B horizon, fine sandy texture to depth of 50 inches, free carbonates at 45 inches.

FOXHOMME SANDY LOAM

Black sandy loam over very dark brown sandy loam, some pebbles at 11 inches, coarse sand 20 to 24 inches, grayish brown loam at 30 inches, free carbonates at 30 inches.

WHEATVILLE SANDY CLAY LOAM

Black sandy clay loam over very dark gray sandy clay loam, grayish brown clay at 30 inches, free carbonates throughout the profile.

ROLISS LOAM

Surface black loam over olive gray loam, grayish brown clay loam at 18 inches, free carbonates throughout profile.

MAVIE LOAM

Black loam over light brownish gray sandy loam, gravelly sandy loam at 18 inches, light olive gray loam at 30 inches, some rocks and gravel on surface.

FARGO SILTY CLAY

Black silty clay over very dark gray silty clay, olive gray silty clay at 20 inches, lime at 48 inches.

Wheat was seeded at all locations using a grain drill with single disk furrows. The rates of seeding varied from 75 to 90 lbs. of seed per acre. The wheat variety ERA was used in all trials. The general soil fertility properties at the six locations are shown in Table 1.

Table 1. Analysis of Soils Used in Nitrate-Nitrogen Studies - Red River Basin - 1978.

Location and Series		NO_3N-2'	P	K
Crookston - Wheatville		180	22	231
Skaar	Mavie	139	10	133
Howard	Fargo	246	67	600+
Christiansen	Roliss	98	33	164
Sanders	Foxhomme	134	29	312
Fleshe	Poppleton	113	27	106

Fertilizer materials were applied at seeding time with grain drill attachment. The quantity of fertilizer varied from 100 to 200 lbs. of complete fertilizer (6-24-24, 10-26-26, and 12-30-20). After seeding an application of nitrogen fertilizer equivalent to 60 pounds of N per acre was applied as a top dressing as a randomized block design with 4 replications.

At harvest time yields were determined by harvesting representative samples from each plot. (Four grain drill rows ten feet in distance). The samples were dried, threshed, and yield and protein determinations were made on the grain samples.

Results and Discussions

The yield results are presented in Table 2. Yields given are the average of 4 replications of each location.

Table 2. Yields of ERA Wheat on Nitrogen and No Nitrogen Treated Areas - Red River Basin of Minnesota - 1978.

Location	No Nitrogen	Yield Bu/A 60 lbs. Nitrogen Acre	Increase
Fleshe	35.7	37.5	1.8
Sanders	61.4	66.5	4.9
Skaar	38.8	38.2	-0.6
Christiansen	55.6	53.4	-2.2
Howard	55.7	54.4	-1.3
Crookston	54.5	52.4	-2.1

Non-significant at 5% level

The nitrate-nitrogen level of the soil at all locations was relatively high (range 98 to 246 lbs. NO_3N in top 2 feet). This was the result of previous nitrogen applications and legume summer fallow.

The yield increases due to additional nitrogen applications (60 lbs. N per acre) were not significant at any of the 6 locations. Moisture stress was observed at the Fleshe, Howard, and Crookston locations 10-14 days prior to maturity yields at the Fleshe location were probably adversely affected by an abundant growth of yellow and green foxtail. These yields indicate, however, the ability of the soils of the so called "beach area" of the Red River Basin to produce when properly fertilized and managed. The results of these trials confirms early findings in respect to response of grain yields to nitrogen fertilizer applications and nitrate-nitrogen levels in the top two feet of soil.

The protein content of the harvested wheat is shown in Table 3. The protein percentage at each location is an average of 4 applications with and without added nitrogen fertilizer.

Table 3. Protein Content of ERA Wheat as Influenced by Nitrate-Nitrogen Content of Soil and Applied Nitrogen Fertilizer - Red River Basin, Minnesota - 1978.

Location	Protein % No Nitrogen	60 lbs. Nitrogen Acre	Increase
Fleshe	14.9	15.2	0.3
Sanders	13.5	14.6	1.1
Skaar	14.0	15.0	1.0
Christiansen	15.2	15.0	- .2
Howard	14.9	15.3	0.4
Crookston	14.9	15.0	0.1

Non-significant at 5% level

The protein content of the harvested grain was relatively high for the wheat variety ERA. The lack of soil moisture near the maturity stage of the wheat was possibly partially responsible for the high protein in the grain.

The average protein content of the grain was increased at all except the Christiansen location. These increases in protein percentage, however, were not statiscally significant at the 5 percent level.

THE YIELD AND PROTEIN CONTENT OF ERA WHEAT AS INFLUENCED BY STARTER FERTILIZER AT SEVERAL FARM LOCATIONS IN PENNINGTON COUNTY, MINNESOTA - 1978

Charles Simkins, Michael O'Leary, and Terrance Courneya

The application of fertilizer at seeding time with an attachment on the grain drill is a common practice in the Red River Basin of Minnesota and North Dakota. Early investigators have shown that the application of phosphorus fertilizer in this manner, particularly on soils low in available phosphorus, was an efficient means of meeting the phosphorus needs of the crop. As a general guide for low testing soils it was recommended that 40 lbs. of P_2O_5 per acre be applied with the seed at planting time. Doubling these rates was required for the same response when the fertilizer was broadcast and worked into the soil.

With time, the phosphorus reserves of most soils producing wheat have reached rather high levels in the Red River Basin. Agriculturists question the need for applying phosphorus fertilizer with the grain drill at planting time. It is generally agreed that if fertilizer could be omitted at planting time without loss of yield or quality, there would be several opportunities for economic savings.

Methods and Materials

Trials were established at 4 locations in Pennington County, Minnesota. Wheat producers prepared seed beds, applied nitrogen fertilizer and seeded wheat with grain drills in their customary manner. The starter fertilizer applied at seeding time with the grain drill varied from location to location but contained more than 20 lbs. of P_2O_5 and 20 lbs. of K_2O at all locations. The quantity used by each producer is shown in Table 2.

During seeding the fertilizer attachment on the grain drill was shut down, so that strips the width of the grain drill were seeded without starter fertilizer.

Previous to seeding soil samples were taken for chemical analysis. These chemical properties are shown in Table 1.

Table 1. Some Chemical Properties of Soils in Trials of Starter Versus No Starter Fertilizer - Pennington County - 1978.

	Pounds/Acre		
Location	NO_3N-2'	P	K
Sanders	134	29	312
Skaar	139	10	133
Fleshe	113	27	106
Christianson	98	33	164

At harvest time plant samples were harvested from those strips which received starter fertilizer and those strips which received no starter fertilizer. Four samples were collected from each treatment at each location. The samples consisted of 4 drill rows 12 feet in length. Yield and protein determination were made on threshed samples.

Results and Discussion

The nitrate-nitrogen content of the soil on which the trials were conducted was relatively high. Nitrogen fertilizer had either been applied the previous fall or a legume-summer fallow program had been practiced. This lessened the possibility that nitrogen fertilizer would be a big factor in increasing yields. The influence which starter fertilizer exerted on wheat yields are shown in Table 2.

Table 2. The Effect of Starter Fertilizer on Yield of ERA Wheat, Pennington County, Red River Basin, Minnesota - 1978.

Location	Starter Used Lbs./A	N	P_2O_5	K_2O	Yield Bu/A No Starter	Yield Bu/A Starter	Bu/A Increase
Sanders	150	6	24	24	61.4	64.6	3.2
Skaar	150	12	30	20	38.8	44.4	5.6
Fleshe	200	6	24	24	36.5	44.8	8.3*
Christiansen	100	10	26	26	51.9	53.4	1.5

*Significant at 5% level

Yields of wheat were increased by starter fertilizer at the 4 locations. The increases in yield ranged from 1.5 to 8.3 bushels per acre. The only location where a statiscally significant increase was obtained was at the Fleshe location.

The influence of the starter fertilizer was quite visible at both the Fleshe and Skaar locations. The heighth and vigor of the plants on the starter treated areas were inferior to those on the non-starter treated areas shortly after emergence of the plants. There was evidence of delay in germination and emergence of the wheat seedlings. Later the starter treated areas recovered and after several weeks the growth and vigor of the wheat plants were superior to those on the non-starter treated areas. At harvest time there was evidence of earlier maturing and greater stooling of wheat plants at the Skaar and Fleshe locations.

There was little visual evidence of increased plant growth at the Christiansen and Sanders location.

The effect of starter fertilizer on the percent protein content of the grain is shown in Table 3.

Table 3. The Effect of Starter Fertilizer on the Protein Content of ERA Wheat - Pennington County, Minnesota - 1978.

Location	Starter Used Lbs./A	N	P_2O_5	K_2O	Protein % No Starter	Starter	% Increase
Sanders	150	6	- 24	- 24	13.5	13.9	0.4
Skaar	150	12	- 30	- 20	14.0	15.1	1.1*
Fleshe	200	6	- 24	- 24	14.6	15.1	0.5*
Christiansen	100	10	- 26	- 26	13.8	13.7	---

*Significant at 5% level

The percent protein content of the wheat grain was increased at 3 of the 4 locations. The increases were statistically significant at the Skaar and Fleshe locations. The protein content of the grain at all locations was relatively high for the variety of wheat ERA.

Summary

Wheat yields and protein content of ERA wheat were increased by starter fertilizer at 3 of 4 locations in the Red River Basin of Minnesota. Those fields in which the greatest increase in yields were realized were either relatively low in available phosphorus or potassium.

DTPA SOIL EXTRACT ANALYSIS FOR METALS

Comparative Studies between Inductively Coupled Plasma Emission and Atomic Absorption Spectroscopy

Robert Munter and John Grava

Research Analytical Laboratory and the Soil Testing Laboratory
Department of Soil Science

The DTPA soil extraction method developed by Lindsay and Norvell[1] has been widely used for the determination of plant "available" Cu, Zn, Fe and Mn in soils. This method is currently used for the "zinc test" by the Soil Testing Laboratory. Although the DTPA method was originally developed for Cu, Zn, Fe and Mn, it has also been used for the determination of heavy metals in soils receiving industrial waste and for environmental monitoring of soils for plant "available" metals.

The most common method for measurement of metals in the DTPA extract has been atomic absorption spectrophotometry (AA). Soils and DTPA extracts submitted after January 1977 to the Research Analytical Laboratory for extractable metals (Cu, Zn, Fe, Mn, Cd, Ni, Pb, Cr, Hg) have been determined by the new method of inductively coupled plasma atomic emission spectroscopy (ICP-AES). Preliminary work showed the two spectroscopy methods to be comparable but since such large numbers of research samples are submitted to this laboratory for this determination it was important to further compare the two methods on DTPA extracts from a wide variety of soils and soil like materials.

Table I shows a comparison between analysis by flame atomic absorption in the Soil Testing Laboratory using a Perkin-Elmer model 406, and ICP emission spectroscopy in the Research Analytical Laboratory using an Applied Research Laboratories' plasma spectrometer model 137. Determinations were made on twenty-eight soil samples that were used in a micronutrient sample exchange study by the North Central Regional (NCR-13) Soil Testing Committee 1978, with the Soil Testing Laboratory participating. The agreement between the two departmental laboratories with each using different spectroscopy methods is excellent excepting Fe at high concentrations. Which method is more correct at these levels is not known. In regard to fertility testing this problem is not important since agreement is very good at low iron concentrations. The upper limit for plant response to iron as reported by Lindsay and Norvell is 4.5 ppm Fe in the soil as extracted by DTPA.

Table II shows a comparison between AA and ICP analysis performed in the Research Analytical Laboratory on the same DTPA extracting solution. The AA used was a Perkin Elmer model 303. Background correction was used for Ni, Pb and Cd. The thirty-two Minnesota soil samples used in this study were subsamples of a collection of representative soil series collected by the Soil Survey staff of the USDA Soil Conservation Service. These samples were collected for a sulfur project as part of a thesis study[2] by George Rehm under Dr. A. Caldwell.

The commercial soil group are laboratory "check samples" obtained from Urbana Laboratories, Urbana Illinois. The river sediment samples are dredge material that were used in an SEA-AR USDA study in this department. The scrubber sludge sample was obtained from the Northern States Power plant at Becker Minnesota. The fly ash sample is the National Bureau of Standards' SRM 1633 standard reference material.

Table III is a summary of statistics from tables I and II.

[1]Lindsay, W.L. and Norvell, W.A. 1969. Development of a DTPA micronutrient test. Agron. Abstr. p84. Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. Soil Science Soc. Am. J. 42:421-428.

[2]Sulfur oxidation and supplying power of some Minnesota soils. MS. thesis 1965.

TABLE I

COMPARATIVE ANALYSIS OF DTPA SOIL EXTRACTS[1]
BY ATOMIC ABSORPTION (AA) IN THE SOIL TESTING LABORATORY
AND ICP ATOMIC EMISSION SPECTROSCOPY IN THE RESEARCH ANALYTICAL LABORATORY

(concentrations as ppm in air dry soil)

	Cu		Zn		Fe		Mn	
	ICP RAL	AA STL	ICP RAL	AA STL	ICP RAL	AA STL	ICP RAL	AA STL
31	0.30	0.30	0.20	0.20	1.2	1.0	8.1	6.9
7	0.24	0.23	0.34	0.30	1.4	1.8	8.1	6.9
32	0.49	0.50	0.34	0.35	5.0	4.8	16.7	16.2
11	0.90	0.90	1.95	2.15	6.3	6.0	9.1	8.4
30	0.56	0.59	0.30	0.30	6.7	7.0	1.3	<2.0
33	0.68	0.68	0.49	0.40	6.9	6.8	27.5	26.8
22	0.83	0.91	2.10	2.10	7.4	7.2	13.0	12.2
27	0.76	0.78	0.99	0.95	8.7	8.8	10.3	10.3
21	0.99	1.03	1.82	1.85	9.1	9.0	20.7	20.3
10	0.35	0.29	0.74	0.70	10.3	9.0	12.2	11.2
12	0.86	0.92	0.98	1.05	11.9	11.4	16.0	16.4
29	0.30	0.27	1.93	1.75	11.8	11.6	3.4	3.0
16	0.16	0.16	0.30	0.30	13.7	13.2	2.4	2.3
20	0.99	0.99	1.95	1.95	14.7	14.6	9.2	7.9
8	1.37	1.34	0.28	0.35	18.7	16.8	7.7	7.1
9	0.57	0.49	0.40	0.40	18.6	16.8	10.0	8.6
15	1.63	1.65	1.53	1.40	19.4	18.8	10.6	9.8
5	0.22	0.16	0.42	0.40	22.0	19.8	3.4	3.3
28	0.53	0.60	15.3	14.7	31.2	31.2	38.0	36.0
4	0.21	0.13	0.48	0.40	36.6	33.4	0.5	<2.0
1	1.81	1.81	0.99	0.90	48.9	44.0	19.4	19.1
14	1.76	1.85	0.81	0.80	59.0	62.0	4.6	4.6
2	0.57	0.52	3.24	3.70	60.4	54.0	36.4	36.2
13	1.84	1.88	2.00	1.95	83.2	86.0	8.7	8.3
3	2.95	2.91	6.08	6.25	120	98.0	1.5	<2.0
6	0.70	0.72	12.3	12.0	213	185	66.0	58.0
25	0.97	1.16	8.10	8.40	673	596	23.7	24.7
26	3.09	3.01	6.87	6.95	707	621	18.5	19.4
Mean	0.95	0.96	2.62	2.60	80	71	16.1	15.4
s	0.77	0.77	3.78	3.71	178	157	14.0	13.2
r	0.997		0.999		1.000		0.996	

NOTE: Samples are categorized according to increasing iron concentrations.

[1]ICP and AA determinations were made on solutions from different extractions except for Fe where the same solution was used for both methods.

TABLE II

COMPARATIVE ANALYSIS OF DTPA EXTRACTS OF SOILS, SEDIMENTS, SCRUBBER SLUDGE AND FLY ASH
BY ICP ATOMIC EMISSION AND ATOMIC ABSORPTION (AA) SPECTROSCOPY
IN THE RESEARCH ANALYTICAL LABORATORY

(concentrations as ppm in air dry material)

	Cu		Zn		Fe		Mn		Cd		Pb		Ni		Cr	
	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA
MINNESOTA SOILS																
Bearden	1.24	1.50	0.98	1.04	6.6	6.0	50	54	0.10	0.12	0.74	0.80	1.24	1.32	<.02	<.04
Ulen	0.54	0.52	0.64	0.56	7.2	6.0	20	20	0.06	<.04	0.58	0.60	0.70	0.72	0.04	<.04
Hegne	1.76	1.98	1.76	1.98	9.6	9.0	29	34	0.10	<.06	1.30	1.40	1.16	1.20	0.06	<.04
Flom	2.28	2.24	1.80	1.88	16	16	44	49	0.26	0.22	2.18	2.60	2.96	3.24	0.04	<.04
Downs	0.96	1.02	0.88	0.94	22	20	34	34	0.08	<.04	0.76	0.60	0.84	0.80	0.02	<.04
Webster S*	0.97	1.14	2.18	2.34	28	28	42	44	0.08	0.10	1.06	1.00	1.48	1.60	<.02	<.04
Kasson	1.02	1.08	1.00	0.98	32	32	45	49	0.08	0.10	0.88	0.80	1.14	1.28	0.04	<.04
Hayden	0.96	0.98	1.78	1.80	34	30	85	88	0.10	0.06	0.80	0.40	1.70	1.60	0.04	<.04
Fargo	3.28	3.58	2.62	2.74	34	34	136	140	0.36	0.38	1.26	1.20	4.78	4.68	<.02	<.04
Tama	0.92	1.08	1.28	1.52	40	38	60	65	0.08	0.08	0.64	0.80	1.58	1.60	<.02	<.04
Waukegan	0.62	0.78	0.84	1.08	44	36	39	42	0.06	0.08	0.48	0.60	0.68	0.48	<.02	<.04
Aastad	1.40	1.54	1.58	1.76	48	46	95	99	0.14	0.14	0.62	1.00	3.06	3.12	<.02	<.04
MEAN	1.32	1.45	1.45	1.55	26.8	25.1	57	60	0.14	0.14	1.02	1.02	1.88	1.92	-	-
Hiwood	0.05	0.07	0.78	0.90	47	46	16	16	<.02	<.04	0.06	<.20	0.08	0.08	0.02	<.04
Lester	0.76	0.81	3.16	3.20	50	42	125	133	0.14	0.08	0.92	0.40	1.60	1.60	0.04	<.04
Chetek	0.63	0.70	0.58	0.60	51	43	14	15	0.06	<.06	0.56	0.40	0.16	0.16	0.04	<.04
Zimmerman	0.17	0.10	0.94	0.92	57	54	19	20	0.06	<.04	0.80	0.40	0.16	-	0.08	<.04
Blue Earth	1.71	1.92	6.08	6.70	58	56	82	80	0.18	0.22	1.22	1.20	2.24	2.00	<.02	<.04
Parnell	0.11	0.03	2.12	1.60	63	67	10	12	<.02	0.04	<.02	<.20	<.02	0.36	<.02	<.04
Webster R*	2.06	2.14	1.38	1.38	67	56	64	65	0.14	0.14	1.76	1.60	2.80	2.74	0.06	<.04
Hubbard	0.44	0.40	1.26	1.16	71	60	63	66	0.12	0.06	0.96	0.20	0.72	0.72	0.08	<.04
Kilkeny	2.10	2.30	1.30	1.44	74	74	88	94	0.12	0.08	1.44	1.60	1.56	-	0.04	<.04
Esterville	0.58	0.60	1.88	1.90	75	63	94	98	0.08	0.10	0.66	0.40	1.10	1.00	0.02	<.04
Nicollet	1.07	1.22	2.30	2.44	80	80	142	143	0.22	0.18	0.86	0.80	3.28	3.58	<.02	<.04
Dorset	1.56	1.84	3.62	3.94	91	72	67	73	0.12	0.08	0.40	0.40	0.68	0.68	<.02	<.04
Rocksbury	1.28	1.48	2.08	2.28	94	93	32	36	0.08	0.06	1.48	1.80	1.68	1.92	0.08	0.06
MEAN	0.96	1.05	2.11	2.19	68	62	63	66	0.13	0.11	1.01	0.84	1.43	1.45	-	-

NOTE: Samples are categorized according to increasing iron concentrations.

*Steele and Redwood counties

Table Continued

TABLE II CONTINUED

	Cu		Zn		Fe		Mn		Cd		Pb		Ni		Cr	
	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA
Kenyon	1.39	1.52	3.04	3.20	110	106	134	138	0.14	0.16	1.40	1.20	3.16	3.14	0.02	<.04
Fayette	1.07	1.22	3.14	2.96	120	114	189	195	0.14	0.10	1.58	1.20	2.08	1.84	0.04	<.04
Milaca	0.39	0.32	5.66	5.26	164	149	79	85	0.12	0.06	1.04	0.60	0.50	0.48	0.12	0.06
Brainard	0.62	0.54	1.87	1.78	192	163	146	156	0.06	<.04	1.24	0.80	1.02	0.96	0.18	0.10
MEAN	0.87	0.90	3.43	3.30	148	133	137	144	-	-	1.32	0.95	1.69	1.61	-	-
Ontanogan	2.12	2.24	5.12	4.76	212	206	64	75	0.10	0.16	1.68	1.60	0.80	0.80	0.06	<.04
Zim	0.76	0.78	1.23	1.26	266	252	10	12	0.08	0.08	2.04	1.80	0.74	0.80	0.10	<.04
Isanti	0.01	0.06	0.08	0.08	544	458	4	5	<.02	0.04	0.12	<.20	0.48	0.32	0.08	<.04
MEAN	0.96	1.03	2.14	2.03	341	305	26	31	-	-	-	-	0.67	0.64	-	-
COMMERCIAL SOIL CHECKS (ILLINOIS)																
Ca	2.82	2.82	2.44	3.06	252	228	45	47	0.14	0.06	6.54	6.20	1.58	1.32	0.08	<.04
106	0.65	0.68	0.43	0.57	47	39	46	48	0.06	0.06	1.14	1.00	0.20	0.20	0.04	<.04
107	2.34	2.42	2.22	2.23	102	88	62	69	0.16	0.10	2.98	3.00	1.50	1.44	0.04	<.04
114	0.78	0.78	0.89	0.82	151	110	59	63	0.06	0.06	2.38	2.00	0.32	0.28	0.10	<.04
201	1.52	1.58	2.02	2.22	70	53	47	51	0.14	0.14	1.64	1.40	0.90	0.88	0.06	<.04
205	3.28	3.34	3.10	3.36	298	296	117	123	2.58	2.61	3.04	3.00	2.76	2.96	0.02	<.02
MEAN	1.90	1.94	1.85	2.06	153	136	63	67	0.52	0.51	2.95	2.77	1.21	1.19	-	-
RIVER SEDIMENT (DREDGE MATERIAL)																
New York	60.2	60.8	88.2	93.4	151	143	60	65	2.64	2.86	61.8	59.6	1.02	1.00	0.04	<.04
Ohio	11.7	11.3	12.2	14.3	171	173	36	40	1.62	1.82	11.8	12.4	1.68	1.66	0.02	<.04
Michigan	62.0	61.0	61.2	61.2	189	182	52	55	2.02	2.18	18.5	17.8	6.78	6.82	0.08	<.04
MEAN	44.6	44.4	53.9	56.3	170	166	50	.54	2.09	2.29	30.7	29.9	3.16	3.16	-	-
POWER PLANT SCRUBBER SLUDGE AND FLY ASH																
Sludge	1.63	1.44	3.00	2.98	41.2	37.6	7.2	7.6	0.16	0.14	0.62	0.20	0.26	0.14	0.08	<.04
Ash (NBS)	7.34	7.40	0.21	0.22	133	131	0.0	0.0	0.16	0.16	1.62	1.20	0.30	0.48	0.90	0.86

TABLE III

SUMMARY OF STATISTICS OF ICP AND AA DATA FROM TABLES I AND II

(concentrations as ppm in air dry soil)

	Cu		Zn		Fe		Mn		Cd		Pb		Ni	
	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA	ICP	AA
MEANS														
Minnesota Soil n=33	1.09	1.18	2.03	2.07	73.0	67.6	66.3	69.9	0.13	0.12	1.05	0.97	1.53	1.53
Illinois Soil n= 6	1.90	1.94	1.85	2.06	153.0	136.0	62.5	66.9	0.52	0.51	2.95	2.77	1.21	1.19
River Sediment n= 3	44.6	44.4	53.9	56.3	170.0	166.0	49.5	53.5	2.09	2.29	30.7	29.9	3.16	3.16
NCR-13 Soil n=28	0.95	0.96	2.62	2.61	79.5	71.3	16.1	15.4	ND		ND		ND	
STANDARD DEVIATIONS														
Minnesota Soil n=33	0.74	0.81	1.44	1.45	61.5	57.5	47.1	48.5	0.07	0.07	0.49	0.56	1.11	1.14
Illinois Soil n= 6	1.09	1.10	1.00	1.14	102.0	103.0	27.6	28.9	1.01	1.03	1.91	1.87	0.95	1.00
River Sediment n= 3	28.5	28.6	38.5	39.8	19.0	20.4	12.2	12.5	0.51	0.53	27.1	25.8	3.15	3.18
NCR-13 Soil n=28	0.77	0.77	3.78	3.71	178	157.0	14.0	13.0	ND		ND		ND	
CORRELATION COEFFICIENTS														
Minnesota Soil n=33	0.994		0.989		0.995		0.999		0.882		0.873		0.993	
Illinois Soil n= 6	1.000		0.983		0.991		0.999		0.999		0.997		0.990	
River Sediment n= 3	1.000		0.998		0.963		0.998		0.999		1.000		1.000	
NCR-13 Soil n=28	0.997		0.999		1.000		0.996		ND		ND		ND	
LINEAR REGRESSION COEFFICIENTS (y=a+bx) y=ICP x=AA														
Minnesota Soil n=33	y=-.02+0.905x		y=-.008+0.982x		y=1.00+1.07 x		y=1.49+0.970x		y=0.03+0.818x		y=0.37+0.727x		y=0.05+0.970x	
Illinois Soil n= 6	y=-.02+0.989x		y= .09 +0.863x		*y= 21+0.975x		y= .97+0.952x		y=0.03+0.977x		y=0.14+1.08 x		y=0.11+0.932x	
River Sediment n= 3	y= .44+0.996x		y=-.57 +0.967x		y= 22+0.897x		y= 2.6+0.976x		y=-.13+0.972x		y=-.74+1.05 x		y=0.03+0.989x	
NCR-13 Soil n=28	y=0.00+0.99 x		y= .03 +1.02 x		y=-1.5+1.14 x		y= .40+1.08 x		ND		ND		ND	

*Curve for iron is best defined by a three degree polynonomial giving an intercept of 1.22

Progress Report on Foliar Fertilizers on Soybeans

W.D. Poole[1], G.E. Ham[2], G.W. Randall[3], W.W. Nelson[4] and S.D. Evans[5]

During the 1978 growing season the foliar fertilizer treatments shown in Table 1 were applied to two high yielding soybean varieties at Lamberton, Morris, Rosemount and Waseca. Vickerey variety is the phytophthora resistant sister line of Corsoy variety that was released in 1978. The soybeans were planted in 14-inch rows on May 8-12. Soil tests indicated that no soil fertilizer was needed.

The standard foliar fertilizer of comparison was the Iowa State University-TVA (Tennessee Valley Authority) formulation that produced the 22 and 23 bushel yield increases reported by Iowa State University in 1975. The time and rate of applications are given in Table 1. The commercial products were applied according to the label except for treatment 11 in which Eco-Gro was applied at the same time and rate of nitrogen as treatments 2 and 5 rather than at the recommended rate of one (1) quart per acre. All treatments were applied with 0.1% Tween 80 as a wetting agent.

Samples for seed yield were obtained by harvesting a measured area from each plot with a plot combine. Seed from the plots were dried, cleaned and weighed to determine seed yields. No significant yield increase was obtained from any foliar fertilizer treatment at any location. These results indicate that further research is necessary before the process of foliar fertilization can be understood in order to produce consistent and economical yield increases. At the present time we consider the concept of foliar fertilization of soybeans to be experimental and the practice is not recommended for routine use in commercial soybean production.

Table 1. Influence of various commercial foliar fertilizers on 1978 soybean seed yields.

Treatment	Number Applications Flowering	Number Applications Pod-fill	Fertilizer[e] Applied N+P+K+S lbs/acre	Lamberton Hodgson '78	Lamberton Vickerey	Morris Evans	Morris Hodgson '78	Rosemount Evans	Rosemount Hodgson '78	Waseca Hodgson'78	Waseca Vickerey	4-Location Average Hodgson '78
				bu/acre								
1 Control	-	-	-	51	57	43	44	54	60	56	56	53
2 Folian	1		12+4+4+0.5	51	53	46	44	54	59	53	55	52
4 Folian	-	1	12+4+4+0.5	50	53	38	44	53	59	55	55	52
3 Folian	1	1	24+8+8+1	50	54	47	45	55	60	54	56	52
5 NPKS[a]	1	-	12+4+4+0.5	51	54	41	45	56	61	55	57	53
6 NPKS[a]	-	1	12+4+4+0.5	51	57	45	46	57	59	55	55	53
7 NPKS[a]	-	2	24+8+8+1	53	55	40	46	54	61	55	57	54
8 NPKS[a]	-	4	48+16+16+2	50	52	44	43	57	62	55	56	53
9 Seaborne + F[b]	1	-	0.14+0.02+ 0.03+0	53	55	45	41	52	59	54	56	52
10 Eco-gro[c]	1	-	0.19+0.1+0.1+0	52	54	42	44	55	60	55	56	53
11 Eco-gro[d]	1	-	12+6+6+0	50	52	40	43	56	59	54	55	52
12 10-34-0+urea+ KS	-	3	36+12+12+1.5	53	54	44	46	54	62	54	56	54
SE				2.6		3.1		2.0		1.4		
CV(%)				8.4		12.3		6.2		4.2		
F-Test				1.4NS		1.6NS		<1.0NS		<1.0NS		

[a]Iowa State materials; [b]N-P_2O_5-K_2O, 6-3-3-0 @ 1 quart/acre; [c]N-P_2O_5-K_2O-S, 8-4-4-0 @ 1 quart/acre; [d]15.5 gallons/acre; [e]N+P_2O_5+K_2O+S

Response of Soybean Genotypes to Foliar Fertilization

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

In order to evaluate the influence of soybean genotype on the response to foliar fertilization, 9 commercial soybean varieties, 11 experimental soybean lines (that have the potential of becoming named varieties) and 6 semideterminate-indeterminate isoline pairs received Folian commercial foliar fertilizer. The rate of application was 12+4+4+0.5 pounds per acre of $N+P_2O_5+K_2O+S$ during the early podfilling stage of growth at three field locations (not all soybeans were grown at every location because of maturity differences). All treatments were applied with 0.1% Tween 80 as a wetting agent. The soybeans were planted in 14-inch rows on May 8-12. Soil tests indicated that no soil fertilizer was needed. The seed yield of one experimental line was increased 7 bushels per acre at Becker; otherwise, no significant yield increases were obtained (Table 1). The failure to produce consistent and economical yield increases indicates the need for further research before the process of foliar fertilization is used routinely in commercial soybean production.

Table 1. Influence of foliar fertilization on the seed yield of soybean genotypes in 1978

Soybean Line	Becker		Rosemount		Waseca	
	No Folian	Folian[a]	No Folian	Folian[a]	No Folian	Folian[a]
	bu/acre					
Clay[b]			50	52		
Coles					54	55
Evans	58	59	54	52		
Grande			52	55		
Harcor					55	55
Harlon			57	56		
Hodgson '78	64	67	58	58	59	59
Swift	59	55	55	58		
Vickerey					60	59
M-68-176	65	69				
M-68-333					54	57
M-69-36			59	61		
M-69-122					50	52
M-69-239					51	53
M-70-9					50	49
M-70-74	56	55	54	54		
M-70-77	58	65	58	57		
M-70-127	60	57	57	53		
M-70-153	60	62	58	57		
M-70-330	60	63	58	57		
12-12-1					50	53
12-12-2					52	50
12-22-1			58	59		
12-22-2			60	59		
12-25-1			52	52		
12-25-2			53	53		
13-47-1					57	56
13-47-2					54	54
13-82-1			56	56		
13-82-12			53	55		
13-84-1			56	55		
13-84-2			55	54		
SE	2.3		2.4		3.7	
CV (%)	6.6		7.5		11.6	
F-test	1.5NS		<1.0NS		< 1.0NS	

[a]Applied at the rate of 100 lbs/acre during pod filling; total nutrient elements applied 12-4-4-0.5 ($N+P_2O_5+K_2O+S$); [b]M-genotypes obtained from J.W. Lambert. 12- and 13- genotypes obtained from D.E. Green, Iowa State University.

NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA - 1978

R. P. Schoper and O. M. Gunderson

Accurate prediction of nitrogen needs for sugarbeets is of prime economic importance to the beet growers of west-central Minnesota. 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.

Research was initiated in 1976 to study the problem of predicting fertilizer nitrogen requirements for sugarbeets in west-central Minnesota. The objectives of this study are: a) to determine the optimum sampling depth for use of the nitrate-nitrogen soil test in predicting fertilizer nitrogen needs, b) to correlate and calibrate soil nitrate-nitrogen levels to fertilizer nitrogen response by sugarbeets and c) to observe the influence of soil nitrate-nitrogen levels and fertilizer nitrogen rates on the nitrate-nitrogen content of sugarbeet petioles at various points in the growing season.

Materials and Methods: Twelve locations were selected in west-central Minnesota for nitrogen correlation-calibration studies in 1978. Five experiments consisting of nitrogen fertilizer rates of 0, 50, 100, 150, and 200 pounds per acre, arranged in a 5 x 5 Latin Square design, were applied as ammonium nitrate in October of 1977. The representative soils were Marna silty clay and Colvin silty clay loam in Renville County, Hamerly loam in Chippewa County, and Svea loam in Swift County. Seven additional experiments consisted of four paired comparisons of nitrogen fertilizer versus a no-nitrogen control. These 400 foot strips were established by farmers utilizing the nitrogen fertilizer rate and form which was used on the remainder of the field.

Soil cores were taken to a 5 foot depth for the nitrogen rate experiments and to a 3 foot depth for the strip trials. Increments of 0-6", 6-12", 12-24", 24-36", 36-48" and 48-60" were analyzed for nitrate-nitrogen. In addition, soil analyses were made on a composite sample of the 0-6" depth for organic matter, available phosphorus, exchangeable potassium, and zinc.

Young-mature petioles were sampled 5 times in 2-week intervals beginning on July 17 to monitor nitrate-nitrogen levels in the sugarbeet tissue. Emission spectographic analyses were also run to ascertain the level of other essential nutrients in the plant tissue.

Plots were harvested with a 4-row Farmhand lifter during the last week of September. Sub-samples were collected and transported to the Minn-Dak Farmers Cooperative where the sugarbeets were processed through the tare laboratory and analyzed for percentage sugar, nitrate, conductivity, and purity.

Results and Discussion: Above average early season moisture followed by dry conditions in late summer resulted in beet yields near the record-breaking year of 1977.[1/] In the 1978 nitrogen rate studies (Tables 1-6), on soils with soil nitrate levels (0-2') ranging from 66 to 91 pounds per acre, the trend was for increased sugar yields with the use of 50 pounds nitrogen per acre and in one case 100 pounds nitrogen per acre. It is noteworthy, that excess use of nitrogen fertilizer reduced the percentage sugar, decreased purity and reduced sugar yield when compared to moderate nitrogen application rates. Similar results were obtained from the strip trials (Table 7) with one exception. At the Olson farm sugar yield was reduced with the addition of nitrogen fertilizer even though the soil nitrate level was low.

Results from the analysis of young mature petioles for nitrate-nitrogen content is presently unavailable and will be reported at a later date.

3-Year Summary: Several observations can be drawn from the 19 nitrogen experiments conducted since 1976.

1) The nitrate-nitrogen soil test is a useful tool in protecting the beet grower against excessive use of nitrogen fertilizer on soils testing high in soil nitrates, greater than 150 pounds per acre 2 feet. The calibration of proper nitrogen fertilizer rate at soil nitrate levels less than 150 pounds is less clear. Variable results are likely due to a combination of factors including soil type, soil organic matter level, soil drainage, plant population, sugarbeet variety, time and depth of sampling for soil nitrates, past cropping history, and the greatest variable of all, the weather.

2) Sampling soils to a 2 foot depth for soil nitrates appears to be reasonably accurate, however, ample evidence exists indicating that sampling to a 3 foot depth would improve the accuracy of the test.

3) Basing nitrogen fertilizer recommendations on yield goal can lead to a large error if improperly used. For example, in 1977 and 1978 it is well documented that average beet yields in excess of 22 tons are possible. However, the grower should not be misled into believing he needs to apply large amounts of nitrogen fertilizer to take advantage of a high tonnage year. If adequate moisture is available to produce high tonnages, an increased rate of nitrogen release from soil organic matter will also be realized. Excessive use of nitrogen fertilizer can lead to a lower sugar percentage and purity in both average and above average tonnage situations.

Recommendations: Based on the nitrogen fertilization studies conducted in west-central Minnesota since 1976, a general guide has been formulated for nitrogen fertilizer use and is presented in Table 8.

Acknowledgements: Sincere appreciation is extended to the Sugarbeet Research and Education Board and to the University Agricultural Extension Service for financing and supporting this research project.

1/ See "1977 Sugarbeet Research and Extension Reports," pp. 106-111.

Recognition should be given to our farmer-cooperators, whose interest and aid made these experiments a success. Wayne Schwitter should receive special recognition for his donation of a 4-row Farmhand lifter to the University of Minnesota.

Special recognition should also be given to Jerome Lensing, Mike O'Leary, George Nelson, Peter Groves, and James Coffman in the Soil Science Department, University of Minnesota, for their untiring efforts and attention to the field phase of this project.

Table 1. Soil nitrate-nitrogen levels at the experimental locations in the fall of 1977.

Soil Depth	L. Stamer Renville Co	P. Frieborg Renville Co	E. Schwitter Chippewa Co	H. Peterson Chippewa Co	V. Arnold Swift Co
inches	lbs NO_3-N/A				
0-6	15	24	26	9	14
6-12	23	41	25	13	14
12-24	37	26	12	44	50
24-36	38	11	24	54	21
36-48	29	6	8	20	9
48-60	15	7	6	8	8

Table 2. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. LeRoy Stamer farm, Renville County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	21.7	14.8	6274	87.4	5483
50	23.5	14.4	6782	86.6	5877
100	23.0	14.3	6567	87.0	5716
150	24.7	13.4	6647	85.8	5703
200	24.8	13.4	6653	85.8	5711
Significance	*	**	NS	**	NS
BLSD (.05)	2.0	0.7	--	0.9	--

Table 3. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Pete Frieborg farm, Renville County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	22.5	15.0	6750	87.0	5878
50	21.2	15.2	6443	86.9	5595
100	24.6	15.0	7290	86.7	6321
150	25.5	14.4	7355	86.0	6327
200	23.5	14.4	6757	86.4	5834
Significance	*	NS	+	NS	+
BLSD (.05)	2.9	--	--	--	--

Table 4. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Eugene Schwitter farm, Chippewa County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	23.6	13.8	6504	85.8	5579
50	25.5	14.0	7163	86.2	6172
100	24.0	14.0	6727	86.2	5799
150	26.3	14.1	7418	86.2	6394
200	25.6	13.9	7140	86.9	6205
Significance	NS	NS	NS	NS	NS
BLSD (.05)	--	--	--	--	--

Table 5. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson farm, Chippewa County - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	20.1	15.2	6069	86.3	5238
50	24.4	15.0	7319	86.2	6309
100	22.0	14.5	6381	86.0	5496
150	22.2	14.3	6358	85.9	5468
200	22.0	13.6	6965	85.0	5063
Significance	NS	**	NS	NS	NS
BLSD (.05)	--	0.8	--	--	--

Table 6. Effect of various rates of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. Vernon Arnold, Swift Co. - 1978.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
lbs/A	T/A	%	lbs/A	%	lbs/A
0	25.5	15.0	7628	87.3	6655
50	27.9	14.9	8263	86.9	7177
100	27.3	14.4	7889	87.1	6870
150	26.5	13.9	7325	86.4	6330
200	25.7	13.7	7039	86.2	6060
Significance	NS	**	*	*	**
BLSD (.05)	--	0.4	709	0.7	596

Table 7. Effect of nitrogen on sugarbeet root yield, percentage sugar, gross sugar, purity, and recoverable sugar. 1978.

Cooperator	Nitrate Test (0-2')	Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar
	lbs/A	lbs/A	T/A	%	lbs/A	%	lbs/A
C. Morrow	270	0	17.2	14.7	5047	84.3	4257
		100	16.6	14.3	4716	82.7	3902
J. Berger	60	0	17.5	14.7	5141	84.2	4336
		80	18.0	14.6	5202	83.2	4329
W. Olson	33	0	20.3	14.6	5910	87.4	5170
		75	19.0	14.3	5411	85.9	4646
D. Gibson	58	0	19.5	14.6	5656	87.1	4926
		80	21.4	13.7	5888	87.2	5133
L. Kramer	45	0	16.7	13.3	4444	86.1	3831
		70	16.5	14.2	4667	87.6	4089
B. Skalbeck	48	0	15.1	13.8	4171	86.6	3619
		80	18.5	14.0	5191	86.6	4503
H. Zimmer	70	0	23.9	13.3	6399	87.9	5619
		100	25.3	13.0	6585	86.8	5715

Table 8. Nitrogen recommendations for sugarbeets in west-central Minnesota based on previous cropping history.

Previous Crop	Amount of Nitrogen (N) To Apply When the Organic Matter Level Is Low to Medium	High
	lbs/A	
Corn	100	80
Small grain, Soybeans	80	60
Black fallow, Alfalfa, Clover	20	0

**Nitrogen recommendations for sugarbeets in west-central Minnesota based on soil nitrate-nitrogen level.

- 0-2' - Subtract the soil test nitrate-nitrogen value from 150 pounds per acre.
- 0-3' - Subtract the soil test nitrate-nitrogen value from 180 pounds per acre.

Nitrogen X Variety Interaction Trial on Sugarbeets

In Chippewa County - 1978

Larry Smith, Robert Schoper and Jerome Lensing

In order to produce the highest possible yield of gross sugar per acre, nitrogen fertilizer is generally needed on sugarbeets. However, if excess nitrogen is found in the profile or applied, it increases the level of impurities, which decreases the processors extraction rate and lowers the percent sucrose in the root. A trial designed to study the effects of high nitrogen rates on sugarbeet varieties was initiated at Clara City in 1978.

EXPERIMENTAL PROCEDURES

Sugarbeets were planted on May 5, in a split-plot design replicated 6 times with nitrogen rates as main plots and sugarbeet varieties as the split plots. The nitrogen rate was determined by the sum of the soil NO_3-nitrogen test (0-2') and applied ammonium nitrate to a total of 150, 250, and 350 pounds nitrogen per acre. The sugarbeet varieties used were Beta Seed 1443, 1345, and 1934; American Crystal ACH-17 and 30; and Great Western R-1. The soil contained 114 lb/A NO_3-nitrogen (0-2'), 35 lbs/A phosphorus and 309 lb/A potassium. Eptam was spring applied at 2.5 lb/A. The beets were harvested October 5 with a Farmhand 4-row lifter. Quality factors were determined at the American Crystal research facility at Moorhead, Minnesota.

RESULTS

Increasing nitrogen rates significantly reduced percent sugar, lbs gross and recoverable sugar per acre and percent recoverable sugar. (Table 1) ACH-17 had a significantly lower sugar percentage than the other sugarbeet varieties.

Increasing nitrogen rates significantly reduced the ppm of K and significantly increase the ppm of Na and amino-N in the sugarbeet brei. (Table 2) The impurity index was significantly increased with additional nitrogen. There was a significant difference in the ppm of Na in the sugarbeet varieties.

The data in this trial represents 1 year of study. Results may vary from year to year and conclusions drawn from 1 year of work may not hold true in another year. This trial will be repeated in 1979.

Table 1. Effect of variety and nitrogen rates on sugarbeet yield, percentage sugar, gross sugar, and recoverable sugar. Wayne Schwitter, Chippewa Co. - 1978.

Treatment	Yield	Sugar	Gross Sugar	Recoverable Sugar	
Variety	Tons/A	%	lb/A	lb/A	%
Beta 1443	28.8	14.6	8421	7266	86.1
Beta 1345	26.2	14.9	7788	6714	86.2
Beta 1934	27.7	14.6	8062	6896	85.4
GW R-1	27.2	14.4	7823	6733	86.0
ACH - 17	26.0	13.9	7235	6195	85.6
ACH - 30	26.4	14.8	7803	6734	86.3
Signif.	NS	**	+	+	NS
BLSD(.05)	-	.4	-	-	-
N Rate					
150#N/A	26.8	15.0	8060	7025	87.2
250#N/A	27.3	14.7	8018	6920	86.4
350#N/A	27.0	13.9	7490	6317	84.2
Signif.	NS	**	*	**	**
BLSD(.05)	-	.26	555	482	.8
Interaction					
1443 x 150 N/A	29.3	15.3	8925	7815	87.7
1345 x "	27.4	14.7	8079	7014	86.7
1934 x "	28.0	15.2	8496	7387	87.0
R-1 x "	25.9	15.0	7787	6785	87.3
ACH-17 x "	24.0	14.6	7008	6072	86.7
ACH-30 x "	26.0	15.5	8065	7077	87.7
1443 x 250 N/A	28.7	14.6	8397	7225	86.0
1345 x "	26.3	15.5	8068	7044	87.7
1934 x "	28.3	14.7	8323	7148	86.0
R-1 x "	27.0	14.4	7803	6705	86.0
ACH-17 x "	27.3	13.9	7585	6500	85.7
ACH-30 x "	26.5	15.0	7919	6900	87.3
1443 x 350 N/A	28.3	14.0	7941	6758	84.7
1345 x "	24.8	14.6	7216	6048	84.3
1934 x "	26.7	13.8	7366	6153	83.3
R-1 x "	28.7	13.7	7879	6708	84.7
ACH-17 x "	26.7	13.3	7113	6014	84.3
ACH-30 x "	26.6	14.0	7425	6224	84.0
Signif.	NS	+	NS	NS	NS
C.V.	8.9	3.0	9.7	10.5	1.5

Table 2. Effect of variety and nitrogen rates on impurity index and ppm content of Na, K, and Amino-nitrogen in sugarbeet brei. Wayne Schwitter, Chippewa Co. - 1978.

Treatment	ppm on beets			Impurity Index
Variety	Na	K	Amino N	
Beta 1443	672	1168	861	923
Beta 1345	640	1109	925	928
Beta 1934	710	1165	898	938
GW R-1	574	1054	920	900
ACH - 17	689	771	856	958
ACH - 30	740	1095	861	917
Signif	**	+	NS	NS
BLSD(.05)	100	-	-	-
N Rate				
150#N/A	578	1168	838	859
250#N/A	705	1148	848	913
350#N/A	731	1061	973	1043
Signif.	**	*	**	*
BLSD(.05)	61	87	68	51
Interaction				
1443 x 150 #N/A	620	1190	795	832
1345 x "	551	1151	867	890
1934 x "	616	1156	864	874
GWR-1 x "	491	1125	883	859
ACH-17 x "	612	1207	819	887
ACH-30 x "	577	1177	803	813
1443 x 250 #N/A	724	1182	867	934
1345 x "	612	1151	851	846
1934 x "	723	1315	843	942
GWR-1 x "	638	1018	924	939
ACH-17 x "	715	1117	842	958
ACH-30 x "	818	1104	763	861
1443 x 350 #N/A	672	1138	922	1002
1345 x "	758	1024	1057	1048
1934 x "	792	1194	986	1099
GW R-1 x "	594	1018	954	1001
ACH-17 x "	741	988	906	1028
ACH-30 x "	826	1005	1017	1078
Signif.	NS	NS	NS	NS
C.V.	14.4	11.0	12.0	8.9

Fertilizer trials on Sunflowers - 1978

C. J. Overdahl, R. P. Schoper, G. E. Varvel, S. D. Evans, W. W. Nelson
G. W. Randall

Experimental work on sunflower fertility has been quite limited. In 1961 R. G. Robinson, U of Mn Agronomy Department, and colleagues reported that sunflowers yielded more on fertile soils and had earlier flowering and maturity. In 1973 Robinson suggested, on the basis of his trials in Northwest Minnesota, 40 pounds per acre of phosphate for low testing soils and 20 pounds for medium tests. Nitrogen rates suggested varied from 0 to 90 pounds per acre, depending on previous crop, soil organic matter, nitrate test and moisture expectations. Dr. Robinson's field trials have been the chief basis for fertilizer recommendations by Extension Specialists.

In 1978 nitrogen trials were established by branch stations personnel on farmers' fields or at the station. These farms were near Lamberton, Norman Co. (also P variable) and 2 farms near Waseca, as well as on the Morris station. land. Nitrogen treatments per acre applied prior to planting were 0, 30, 60, 90, 120 and 150 pounds of nitrogen per acre replicated 6 times. Blanket phosphorus and potassium treatments were made across all nitrogen plots as needed. Soil nitrate tests to 5 feet were taken, emission spectrometer readings and Kjeldahl-N determinations were made on leaves.

Yields and nitrogen in leaves are shown in the following tables:

Table 1. Yields of sunflowers from nitrogen at 5 locations - 1978.

Treatment N lbs/A	Norman Co. Uelard	Lamberton	Morris Sta.	Waseca Frodl	Waseca Marzahn
	lbs/acre				
0	1939	2032	2088	1980	2553
30	2234	1952	2114	2098	2505
60	2211	2002	2098	2095	2459
90	2263	1916	2106	2074	2510
120	1958	2262	2175	2438	2610
150	2264	2042	2140	2084	2520
Significance	ns	ns	ns	*	ns
BLSD (5%)	-	-	-	270	-
C.V.	13.4	9.7	4.8	9.8	12.5
Nitrate (0-2) lbs/A	74	73	71	57	59

Table 2. Percent nitrogen in sunflower leaves at Morris and Waseca and percent oil content from Norman County trials, 1978.

Treatment N lbs/A	Norman Co. % oil	Norman Co.	Morris %N			Waseca	
		leaf tops	leaf tops	5th leaf	9th leaf	5th leaf	5th leaf
	Ueland	Ueland	Sta.	Sta.	Sta.	Frodl	Marzahn
0	45,07	3.27	3.75	4.23	4.28	3.23	3.98
30	45.10	3.31	3.75	4.14	4.27	3.22	3.97
60	43.56	3.50	3.97	4.50	4.52	3.32	4.06
90	43.32	3.58	3.94	4.52	4.56	3.70	4.16
120	44.30	3.55	4.09	4.57	4.57	3.56	4.06
150	44.40	3.64	4.07	4.63	4.71	3.76	4.29
Significance	ns	ns	*	**	**	*	*
BLSD (5%)	-	-	.28	.19	.16	.47	.24
C.V.	3.7	2.6	4.2	2.8	2.4	.0	4.4

Table 3. Sunflower yields from phosphorus and oil content, Norman Co. 1978.

P_2O_5 lbs/A Broadcast	Yield lbs/A	Oil Content %
0	1815	46.32
30	2265	44.71
60	2151	44.32
90	1886	44.17
120	1975	44.55
150	2300	44.52
Significance	**	ns
BLSD (5%)	301	-
C.V.	9.3	3.3

Soil test lbs/A, P=5 lbs, K=275 lbs, pH. 8.4, 40 lbs N over all plots.

Summary

No conclusions will be drawn on the basis of this one year trial. The field trials will be continued in 1979.

On the very low phosphorus test in Norman County there was a highly significant response to phosphorus, and evidence of a nitrogen respons on one plot in Waseca County.

WILD RICE FERTILIZATION RESEARCH - 1978

A PROGRESS REPORT
January 4, 1979

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

Research was continued during 1978 on fertilization, nutrient requirement and water quality. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season to obtain information on the environment in which wild rice grows. Nitrogen rate studies were conducted on a mineral soil at Grand Rapids with two varieties in first production year, and with three varieties in third production year. Three fertilization experiments were established on peat with a first year stand in Aitkin County to study N, P, K rates, and the effectiveness of foliar fertilization. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER AND PLANT DEVELOPMENT

The average air temperature (table 1) was nearly 5°F above normal in May. During the main part of the growing season, air temperature was nearly normal. Heavy rainfall on August 22-23 made harvesting in the Aitkin area difficult.

Soil, water and air temperatures were measured at two locations by 3-point automatic sensing and recording thermographs (Fig. 1,2). The measurement of soil temperature at the Aitkin County location was discontinued after mid-May because of instrument malfunction. The air and water temperatures fluctuated much more than the soil temperature.

Plants emerged on May 8 in Aitkin County and on May 15 at Grand Rapids (Fig. 3,4,5). The jointing stage was reached by Netum on June 29, 45 days after emergence, and by K2 about a week later, on July 6. Netum was harvested at Grand Rapids on August 23, 100 days after emergence, and the K2 variety was harvested a week later. In Aitkin County, K2 wild rice was ready for harvest 108 days after emergence.

Table 1. Average air temperature as measured at three U.S. weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	----------average air temperature, °F----------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M[3/]	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5M	64.1M	67.0M	66.9	59.2	2938

1/ Source: Climatological Data, Minnesota, Vol. 80, 81, 82, 83, 84 (1974-78), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

FIG. 1 MEAN AIR, WATER, AND SOIL TEMPERATURES GRAND RAPIDS - 1978

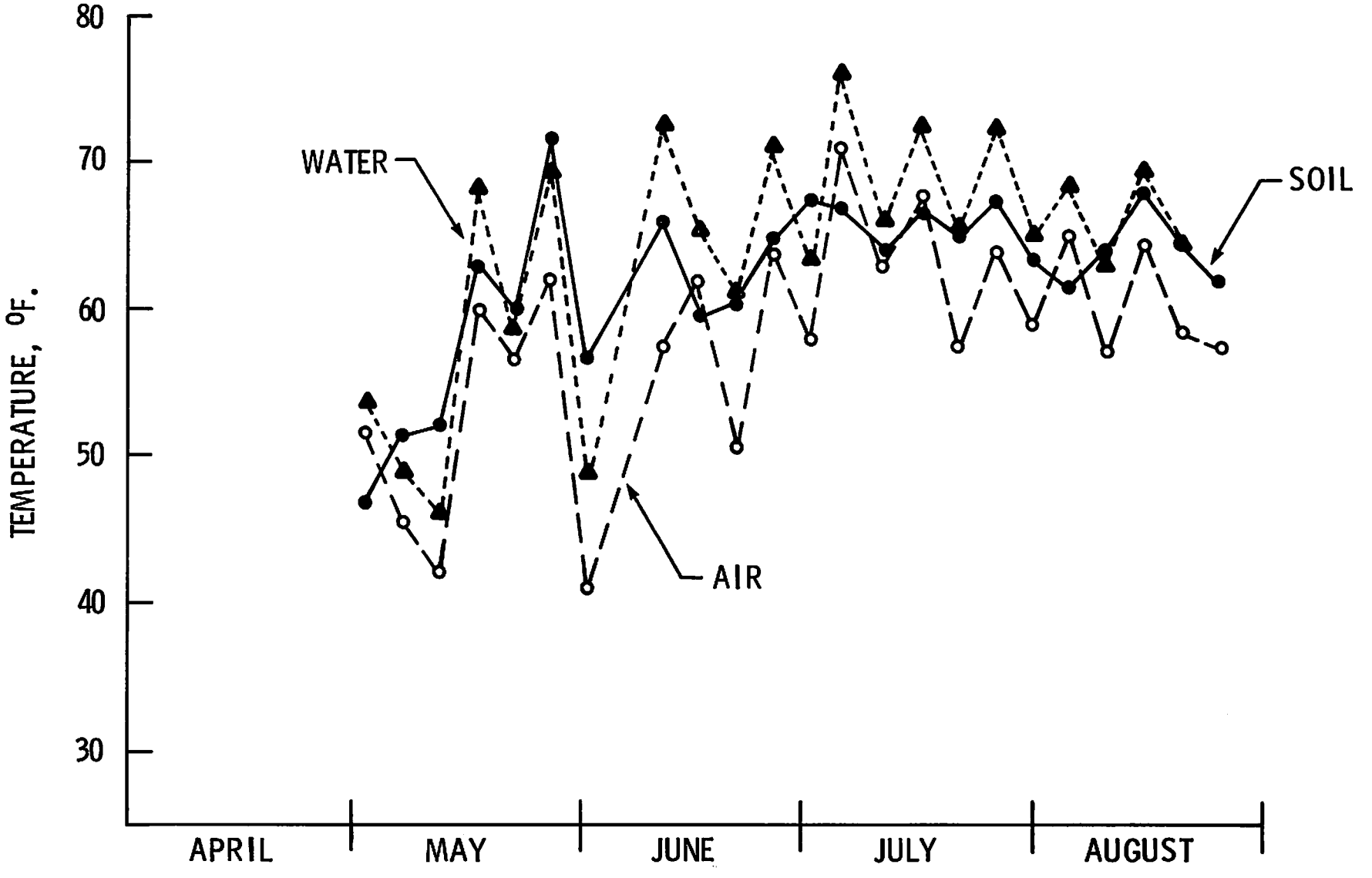

FIG. 2 MEAN AIR, WATER, AND SOIL TEMPERATURES KOSBAU BROS., AITKIN COUNTY - 1978

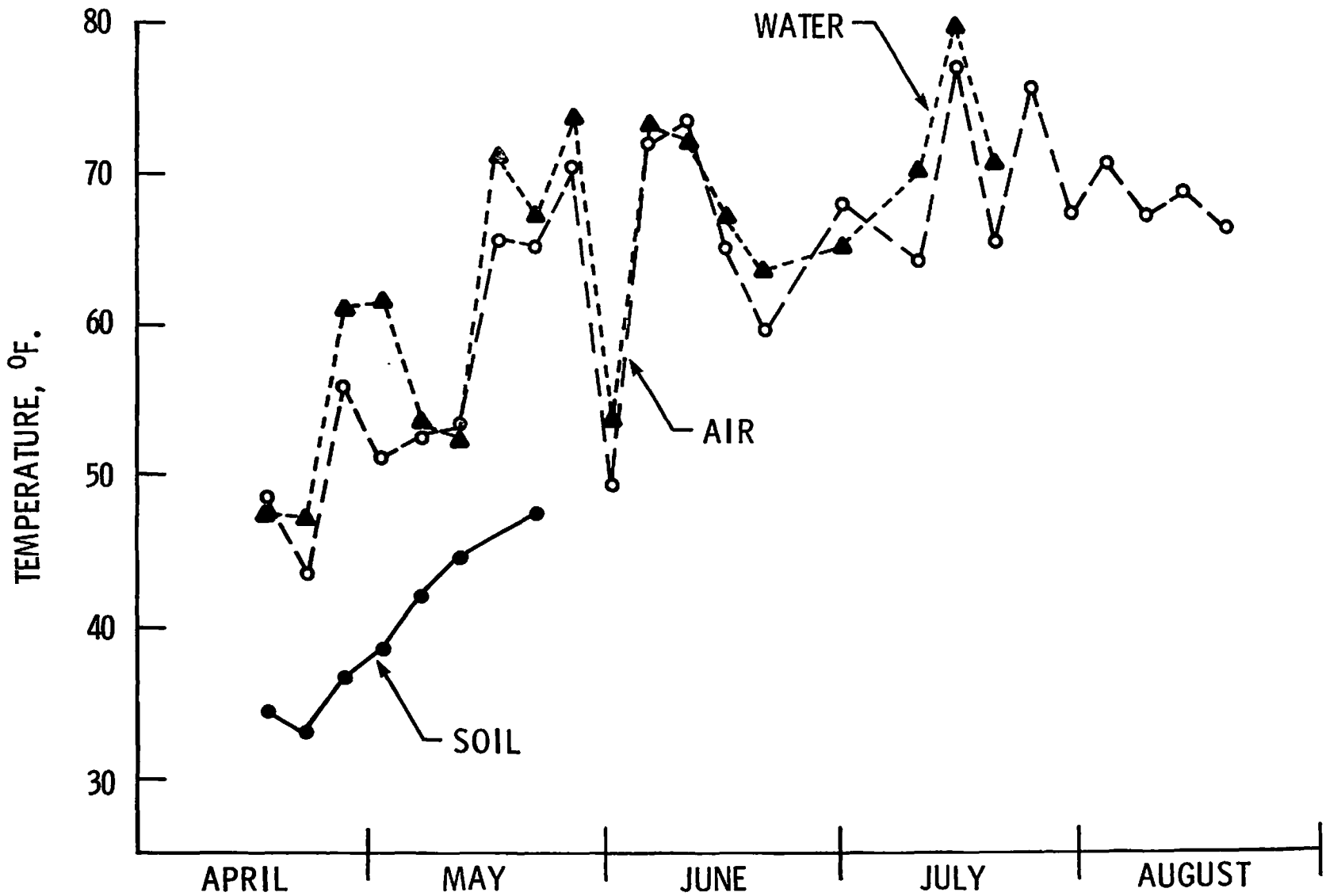

FIG. 3

WILD RICE DEVELOPMENT
NETUM VARIETY, GRAND RAPIDS, 1978

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	9	
	2ND AERIAL LEAF	19	JUNE
	EARLY TILLERING	29	
REPRODUCTIVE GROWTH PHASE	JOINTING	45	
	EARLY FLOWERING	64	JULY
	LATE FLOWERING	80	AUGUST
	MATURITY	100	

FIG. 4

WILD RICE DEVELOPMENT
K2 VARIETY, GRAND RAPIDS, 1978

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	9	
	2ND AERIAL LEAF	19	JUNE
	EARLY TILLERING	29	
	TILLERING	45	
REPRODUCTIVE GROWTH PHASE	JOINTING	53	JULY
	EARLY FLOWERING	64	
	MID FLOWERING	80	AUGUST
	LATE FLOWERING	86	
	MATURITY	106	

FIG. 5

WILD RICE DEVELOPMENT
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1978

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	17	
	2ND AERIAL LEAF	31	JUNE
	EARLY TILLERING	37	
REPRODUCTIVE GROWTH PHASE	JOINTING	55	JULY
	BOOT	63	
	EARLY FLOWERING	71	
	MID FLOWERING	79	
	EARLY GRAIN FORMATION	93	AUGUST
	MATURITY	108	

B. CHEMICAL CHARACTERISTICS OF PADDY WATER

The quality of paddy water is of interest to the grower as well as to state and federal agencies. The grower may be concerned, for example, with the concentration of sulfate in the water. Plant response to fertilization may be related to nutrient levels found in the water. Public control agencies may want to know levels of nitrogen and phosphorus present in the water when it is released during draining of paddies.

Water samples were collected from several sites at three different paddy locations during the 1978 growing season. At Grand Rapids, samples were collected from two experimental paddies used for N rate studies on a mineral soil. Source of water is the Prairie River. Water was also sampled at two sites within Kosbau Bros. paddies in Aitkin County. Paddies at this location derived water from the Little Willow River via a diversion ditch. One sampling site was located at the beginning of the diversion ditch, near the river; the other site was within a paddy in which three fertilization trials were conducted. The third sampling location was in the Gunvalson and Imle paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles. After the determination of pH and conductivity, a preservative was added (2 ml of mercuric chloride solution, made by dissolving 40 mg $HgCl_2$/L, to 250 ml of sample). Chemical analyses were made by the Research Analytical Laboratory, University of Minnesota. Information on location, sampling dates and chemical composition of water are given in tables 2, 3, and 4.

Table 2. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Grand Rapids

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
6	5/10	PR	6.6	.12	52	52.8	0.7	0.04	<.1	0.11	0.02	<2.0	14.4	4.1	1.9
7	"	EP #1	6.8	.10	42	42.6	0.7	0.08	<.1	0.12	0.02	2.0+	11.3	3.5	1.4
8	"	EP #6	6.7	.11	42	44.9	1.0	0.08	<.1	0.01	0.01	<2.0	11.9	3.7	1.5
13	5/18	EP #1	6.4	.14			1.1			0.12					1.7
14	"	EP #6	6.5	.13			1.1			0.07					1.4
15	"	PR	6.6	.15			0.8			0.05					1.2
20	5/30	PR	6.2	.14			0.2			<0.01					1.3
21	"	EP #1	6.5	.11			0.2			<0.01					1.0
22	"	EP #6	6.6	.13			0.2			<0.01					1.2
26	6/8	EP #1	6.0	.10			0.8			0.16					1.5
27	"	EP #6	6.3	.13			0.7			0.06					1.3
28	"	PR	6.5	.13			0.6			0.04					1.1
31	6/14	EP #1	7.1*	.10			1.7			0.21					1.2
32	"	EP #6	7.3*	.09			0.8			0.06					1.0
33	"	PR	7.1*	.12			0.7			0.04					1.1
38	6/28	EP #1	7.0				2.1			0.05					1.0
39	"	EP #6	7.3				1.9			0.02					1.7
40	"	PR	7.3				1.9			0.07					1.8
45	7/11	EP #1	7.3	.06			0.9			0.11					0.4
46	"	EP #6	7.0	.13			0.9			0.03					1.2
47	"	PR	6.9	.14			1.8			0.03					1.3
52	8/23	EP #1		.12	30	48.3	0.9	<0.1	<0.1	0.08	0.07	1.3	11.50	4.93	2.96
53	"	EP #6		.11	46	47.9	0.7	0.2	<0.1	0.10	0.05	1.8	12.46	3.97	2.96
54	"	PR		.16	70	75.7	0.8	<0.1	<0.1	0.23	0.06	2.8	20.51	5.70	.72

* pH tested in lab - late afternoon 6/14
\+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites at Grand Rapids

PR	Prairie River
EP #1	Experimental Paddy #1, 3rd year stand
EP #6	Experimental Paddy #6, 1st year stand

Table 3. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Kosbau Bros., Aitkin Co.

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
1	4/17	DD	7.3	.12	49	52.9	0.8	0.03	<0.1	<0.01	<0.01	2.2+	13.1	4.9	1.2
2	"	EP	5.4	.08		10.8	3.6	1.92	0.7	2.19	2.19	2.2	2.5	1.1	8.6
4	5/3	DD	7.1	.18	70	79.0	0.9	0.04	<0.1	0.09	0.03	<2.	19.6	7.3	1.1
5	"	EP	4.6	.11		18.7	3.9	0.76	0.2	2.64	2.38	<2.	4.2	2.0	13.8
9	5/10	DD	6.6	.17			1.2			<0.01					0.9
10	"	EP	4.5	.11			3.8			3.08					13.5
16	5/18	DD	6.5	.18			1.3			0.04					0.8
17	"	EP	4.6	.11			3.9			2.68					13.7
23	5/31	DD	6.6	.14			1.4			0.02					1.0
24	"	EP	4.7	.10			4.7			2.68					9.9
25	"	EP	4.9	.10			4.8			2.87					9.9
29	6/8	DD	6.4	.16			1.0			0.06					0.8
30	"	EP	4.4	.10			4.6			3.09					12.6
34	6/14	DD*	6.9	.15			1.0			0.08					0.6
35	"	EP*	4.7	.10			4.4			3.42					11.4
41	6/28	DD	6.5				1.3			0.08					0.7
42	"	EP	4.2				7.7			3.67					19.0
43	7/10	DD	6.1	.15	54	79.0	2.7	<0.1	<0.1	0.09	<0.01	<1.	20.3	6.4	1.1
44	"	EP	4.5	.06		17.4	5.1	0.1	<0.1	2.08	1.84	3.2	2.2	2.1	6.6
48	7/18	EP	5.1	.05		22.0	8.1	0.1	<0.1	2.20	1.66	3.9	3.6	2.1	5.4
49	"	DD	6.4	.20		98.4	3.4	0.1	<0.1	0.37	0.04	1.9	25.3	7.5	1.2

* pH tested in lab - late afternoon 6/14
\+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites
DD = Diversion ditch at bridge near Little Willow River
EP = Experimental paddy

Table 4. Chemical composition of water collected from wild rice paddies during 1978 growing season. Location: Gunvalson and Imle, Gully

Sample Number	Sampling Date	Location	pH	Cond. milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm
3	5/3	PP	7.0	.42	124	172.0	2.3	0.04	<.1	0.36	0.12	20.8+	45.5	14.0	9.8
11	5/17	CR	7.2	.50	228	249.0	0.8	0.06	<.1	0.12	0.01	15.8	64.0	21.6	2.6
12	"	PP	6.9	.52	166	225.0	1.6	0.09	<.1	0.36	0.36	25.0	59.3	18.8	14.3
18	5/24	CR	7.2	.46			0.3			<0.01					2.1
19	"	PP		.57			1.5			0.69					13.1
36	6/26	PP	6.8				2.2			1.51					6.8
37	"	CR	7.1				1.2			0.06					2.7
50*	7/19	PP	6.5	.13	39	45.2	2.0	0.5	0.2	1.18	0.97	4.0	11.1	3.9	10.0
51	"	CR	6.4	.44	204	242.0	1.8	<0.1	<0.1	0.28	0.09	8.7	58.9	22.6	2.4

* Paddy recently drained, almost dry
\+ ppm sulfate-S x 3 = ppm sulfate (SO_4)

Abbreviations and description of sampling sites
PP = Production paddy
CR = Clearwater River

C. NITROGEN RATE AND VARIETY STUDIES ON MINERAL SOIL

Two experiments were conducted on a mineral soil at the North Central Experiment Station, Grand Rapids. Experiment 1 (first year stand) was established in the fall of 1977 with two early maturing varieties: Netum and K2. Experiment 2 (third year stand) had been established in the spring of 1976 with K2, M3 and Johnson varieties.

First Year Stand[1/]

The experimental paddy No. 6 was in fallow during 1977 and was fumigated with methyl bromide in the fall. Four rates of nitrogen were used in this experiment: 0, 20, 40 and 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. Phosphorus and potassium were not applied because of relatively high soil tests. Two early maturing varieties, Netum and K2, were grown. A split-plot design was used in this experiment, with the N rates as main plots and varieties as subplots. Each plot, containing one N rate and both varieties, occupied a 12 x 15 ft. area. Each N treatment was replicated five times. The wild rice was planted in rows that were one foot apart on November 8. Plant population, at harvest, was one plant per square foot. Water level was maintained at about 8-12 inches. Ten plants were selected at random from each plot at jointing stage, and five plants at late flowering for weight measurements and plant analysis. The jointing stage was reached by Netum (Fig. 3) on June 29 and by K2 (Fig. 4) by July 6. An 80 sq. ft. area from each plot was hand-harvested for yield determination. Netum was harvested on August 23 and K2 six days later.

The K2 variety outyielded Netum by 143 pounds per acre (table 5). The grain yield of both varieties was increased by nitrogen fertilization. Maximum yields were produced with 40 pounds of N per acre.

Dry matter production was not affected by N fertilization, but K2 plants were slightly heavier than Netum at jointing and late flowering (table 6).

Nitrogen concentration of 2nd leaf at jointing was not affected by N treatments and no varietal differences were detected (table 7). Total uptake of N by the plant was related to the amount of nitrogen applied (table 8).

1/ This experiment was conducted in cooperation with Mr. Gary Linkert, Department of Agronomy and Plant Genetics.

Table 5. Effect of nitrogen application on the yield of two wild rice varieties, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	Grain Yield, lb/Acre				
K2	895[1)]	947	1038	1045	981
Netum	778	767	935	872	838
Average (Rate)	836	857	986	959	

1) 7% moisture

(a)

Variety	Grain yield, lb/Acre
K2	981 b
Netum	838 a
Significance	**
BLSD (0.05)	85

(b)

N Rate, lb/Acre	
0	836 a
20	857 ab
40	986 c
80	959 bc
Significance	*
BLSD (0.05)	118
C.V.	14

Table 6. Effect of nitrogen application on plant weight of two varieties at jointing and late flowering, Grand Rapids, 1st year stand, 1978.

Development stage and variety	N Rate, lb/Acre 0	20	40	80	Average (variety)
	----------Dry matter, grams per plant----------				
(a) Jointing					
Netum	3.70	3.72	4.43	3.91	3.94
K2	5.09	4.47	4.79	5.20	4.89
Average (rate)	4.40	4.10	4.61	4.56	
(b) Late Flowering					
Netum	15.57	19.13	18.64	20.16	18.38
K2	20.85	18.63	20.97	21.79	20.56
Average (rate)	18.21	18.88	19.81	20.98	

Table 7. Effect of nitrogen application on N concentration in 2nd leaf at jointing, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre				Average (variety)
	0	20	40	80	
	N % in dry matter				
K2	4.44	4.10	4.40	4.32	4.32
Netum	4.23	4.36	4.50	4.32	4.35
Average (rate)	4.34	4.23	4.45	4.32	

Table 8. Effect of nitrogen application on total uptake of N by the wild rice plant at late flowering, Grand Rapids, 1st year stand, 1978.

Variety	N Rate, lb/Acre				Average (variety)
	0	20	40	80	
	N in milligrams per plant				
K2	237	258	293	321	277
Netum	231	294	300	304	282
Average (rate)	234	276	297	313	

Third Year Stand

The nitrogen-variety experiment, established in the spring of 1976, was continued in 1978. Three wild rice varieties were grown: the relatively early maturing K2 and M3, and the later maturing Johnson. Three N rates were used: 0, 40, 80 pounds per acre. To minimize cross-pollination, the Johnson wild rice was placed between the two earlier maturing varieties and each variety was grown in a 48 x 72 foot area separated from adjoining variety by a 10 ft. wide alley. Individual plots were 12 x 14 ft. in size. Nitrogen treatments were replicated five times. Straw was disked and rototilled into the soil. Urea was applied on May 2 and rototilled into the soil. Phosphorus and potassium were not applied because of relatively high soil test levels (P 72, K 308, pH 6.0; nitrate-N 16 lb/A 0-6 inch depth). The plant density of M3 was excessive and required manual thinning. At early tillering, average plant density of K2 was 4, while M3 and Johnson had six plants per square foot. There was heavy infestation of broadleaf weeds, especially in the K2 area. On July 5, 2,4-D (¼ lb/acre) was sprayed to control weeds.

Fertilization with nitrogen resulted in striking height and color differences. Plants in N0 plots were shorter and lighter in color than those receiving either N40 or N80 treatments. There was moderate lodging in the N80 treatment plots.

Blackbird control was ineffective and heavy yield losses occurred. Nearly 80% of grain was lost, particularly in M3 plots. The yield ranged from 211 - 233 lb/acre for K2, 120 - 190 lb/acre for Johnson, and 152 - 189 lb/acre for M3.

Visual differences in plant height and color, observed during the growing season, also were reflected by weight and plant analysis data (tables 9, 10 and 11). The application of 40 or 80 lb/acre of nitrogen resulted in the production of more dry matter and increased the total N uptake by the plant compared to the control.

Table 9. Effect of nitrogen application on plant weight of three varieties at jointing and late flowering, Grand Rapids, 3rd year stand, 1978.

Development stage and variety	N Rate, lb/Acre 0	40	80	Average (variety)
	----------Dry matter, grams per plant----------			
(a) Jointing				
K2	1.69	2.64	3.12	2.48
Johnson	2.58	3.36	4.38	3.44
M3	2.80	2.93	3.36	3.03
Average (rate)	2.36	2.98	3.62	
(b) Late Flowering				
K2	6.68	9.53	11.75	9.32
Johnson	6.53	6.55	10.66	7.91
M3	9.23	9.29	15.78	11.43
Average (rate)	7.48	8.46	12.73	

Table 10. Effect of nitrogen application on N concentration in 2nd leaf at jointing, Grand Rapids, 3rd year stand, 1978.

N Rate lb/Acre	Variety K2	M3	Johnson	Average (rate)
	----------N % in dry matter----------			
0	2.46	2.62	2.29	2.46
40	2.74	2.77	1.94	2.48
80	2.84	2.95	2.39	2.73
Average (variety)	2.68	2.78	2.21	

Table 11. Effect of nitrogen application on total uptake of N by the wild rice plant at late flowering, Grand Rapids, 3rd year stand, 1978.

N Rate lb/Acre	Variety K2	M3	Johnson	Average (rate)
	----------N in milligrams per plant----------			
0	68	98	58	75
40	105	123	87	105
80	142	208	112	154
Average (variety)	105	143	86	

D. FERTILIZATION STUDIES ON PEAT

Three fertilizer experiments were conducted in a Kosbau Bros. paddy in Aitkin County. During 1977, rye was grown, receiving 12 + 72 + 72 lb/acre of N, P_2O_5 and K_2O. Fertilizer was applied by hand to 12 x 12 foot plot areas on October 19, 1977. K2 wild rice was seeded, and the seed and fertilizer were incorporated into the soil by rototilling. Wild rice started to emerge on May 8 and by July 2 had reached the jointing stage (Fig. 5). Some lodging occurred throughout the experimental area, and in some areas, the stand was spotty and thin with heavy infestation of cattails. Average plant density was two plants per square foot. The paddy was drained on July 22. A 4 x 4 foot area was hand-harvested from each plot for yield measurement on August 24. No color or height differences were observed during growing season and there was a general lack of response to fertilizer treatments. The grain yield ranged from 300 to 500 lb/acre.

Table 12. Soil test values of experimental areas, Kosbau Bros., Aitkin Co.

Area	Soil Test Results for 0-6 inch Depth			
	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
NK trial	3.9	18	145	3
NP trial	4.0	19	240	3
Foliar-Fertilization	4.2	21	116	2

Samples collected on 10/19/77.

NK RATE TRIAL

Exchangeable potassium in the experimental area was 145 pp2m, considered to be a medium level (table 12). Nitrogen treatments consisted of the following rates: 0, 20, 60 pounds per acre. Potassium was applied at rates of 0, 60 and 200 pounds of K_2O per acre. All plots received 40 pounds of P_2O_5 per acre. Fertilizer treatments were replicated six times. Urea, muriate of potash and concentrated superphosphate were applied by hand during the fall of 1977 and incorporated into the soil by rototilling.

The yield of wild rice ranged from 349 to 431 pounds per acre (table 13). Neither nitrogen nor potassium treatments had any effect on the yield.

Table 13. Effect of nitrogen and potassium application on grain yield of wild rice, Kosbau Bros., 1978.

K Rate K_2O lb/acre	N rate, lb/acre 0	20	60	Average (K rate)
	----------Grain yield, lb/acre----------			
0	342[1)]	358	431	377
60	425	392	365	394
200	369	379	342	363
Average (N rate)	379	376	379	

1) 7% moisture

Significance ns

NP RATE TRIAL

Extractable phosphorus in the experimental area was 19 pp2m, indicating medium relative level (table 12). Nitrogen was applied at rates of 0, 20, 40 lb/acre, and phosphorus treatments included 0, 40 and 80 pounds of P_2O_5 per acre. All plots received 60 lb/acre of K_2O. Fertilizer treatments were replicated six times. Urea, concentrated superphosphate and muriate of potash were applied by hand in the fall and incorporated into the soil by rototilling.

Grain yields ranged from 298 to 494 pounds per acre (table 14). Although the application of phosphorus, combined with either the N0 or the N20 treatments, tended to increase the yield by nearly 100 lb/acre, the differences were not statistically significant.

Table 14. Effect of nitrogen and phosphorus application on grain yield of wild rice, Kosbau Bros., 1978.

P Rate P_2O_5 lb/acre	N rate, lb/acre 0	20	40	Average (P rate)
	----------Grain yield, lb/acre----------			
0	374[1)]	298	491	388
40	485	467	468	473
80	469	461	494	475
Average (N rate)	443	409	484	

1) 7% moisture

Significance ns

FOLIAR FERTILIZATION TRIAL

Foliar fertilization studies initiated in 1976 were continued. In the fall of 1977, a new experiment was established in an area adjoining NK and NP trials. Soil application of fertilizer (20 + 40 + 60) was made during the fall and incorporated into the soil. Fertilizer solution was sprayed on 12 x 12 foot plot areas with a backpack sprayer at a rate of 26.4 gallons per acre or 250 pounds per acre. Spraying pressure was maintained at 30 psi by using a carbon dioxide cylinder. The formulation, fertilizer materials used and costs were reported, in detail, in the 1976 Wild Rice Research Progress Report. In 1978, foliar fertilizer applications were made on the following dates:

1st spraying, 7/10 - at boot stage,
2nd spraying, 7/26 - mid-flowering,
3rd spraying, 8/9 - early grain formation.

No "leaf burn" damage was observed in this trial.

The grain yield in this experiment ranged from 380 to 492 pounds per acre. Fertilizer, either by soil or foliar application, had no effect on the grain yield (table 15).

Table 15. Effect of foliar and soil application of fertilizer on grain yield of wild rice, Kosbau Bros., 1978.

Foliar Application					Soil Application		
	Total Plant Nutrients Applied, lb/Acre						
Number	N	P_2O_5	K_2O	S	None	20+40+60	Average (Foliar)
					-----Grain yield, lb/Acre-----		
None		none			492[1)]	419	456
1 x	15 +	6 +	9 +	1.3	-	389	389
2 x	30 +	12 +	18 +	2.6	-	389	389
3 x	45 +	18 +	27 +	3.9	380	388	384
Average (soil)					436	396	

1) 7% moisture, average of 6 replications; Significance ns

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the following cooperators and University personnel for their valuable assistance during 1978 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; Messrs. John Gunvalson and Paul Imle, East Polk County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Robert Stassen, Gary Linkert, Loren Nickelson, and Henry Schumer, University of Minnesota.