Table 7 . The effect of varying nitrogen treatments on grass yields (dry matter) and percent nitrogen, Kelly farms 1980.

Trt			lbs, D.M./A				%N		
			cuttings				cuttings		
N	P_2O_5	K_2O	1	2	3	Total	1	2	3
0	0	0	1816	645	313	2774	1.32	1.99	2.52
0	40	40	2013	614	267	2894	1.44	1.75	2.37
30	40	40	2836	735	228	3798	1.40	1.88	2.35
60	40	40	4163	911	316	5390	1.61	1.92	2.47
120 (60+60)	40	40	4361	1182	308	5852	2.20	2.34	2.64
Significance			**	**	+	**	**	*	+
BLSD (.05)			565	300	61	660	.81	.31	.19
C.V.			13.1	23.3	15.0	11.2	8.0	9.7	5.3

Table 8. Pounds of nitrogen removed per acre and yield of protein. Kelly Farm 1980.

Trt							yield, protein/acre			
			cuttings				cuttings			
N	P_2O_5	K_2O	1	2	3	Total	1	2	3	Total
0	0	0	24.0	13.2	7.9	45	8	12	16	281
0	40	40	28.6	10.9	6.3	46	9	10	15	286
30	40	40	39.7	13.7	5.4	59	9	12	15	367
60	40	40	66.8	17.5	7.8	92	10	12	15	575
120	40	40	95.6	27.5	8.1	131	14	15	17	820
Significance			**	**	*	**	**	*	+	**
BLSD (.05)			9.0	5.7	1.7	12	1	2	1	74
C.V.			12.5	23.2	14.6	11.2	8.	9.7	5.3	11.2

Table 9. Brome grass yield and percent nitrogen (1980) comparing effects of urea vs. ammonium nitrate topdressing on high pH soils, Morris, MN 1979, & 1980.

	Total Yield of 2 Cuttings			
N, lbs/A	1979	1980	% N 1980 1st cut	% N 1980 2nd cut
none	10636	3947	2.03	1.51
50 urea	10465	4615	2.79	1.73
50 A.N.	9068	5107	2.67	1.62
100 urea	9966	5588	2.71	1.82
100 A.N.	9644	6039	2.64	1.88
Significance	ns	**	+	**
BLSD (.05)	-	761	.54	.28

Table 10. Comparison of two nitrogen farms urea vs. ammonium nitrate on high pH soils by cutting by year. Morris, MN 1979, & 1980.

	1st cut		2nd cut		% N 1980	
	1979	1980	1979	1980	1st cut	2nd cut
urea	6480	2742	3728	10349	2.75	1.86
A.N.	5806	3230	3627	9784	2.65	1.79
Significance	+	*	ns	+	ns	ns

Discussion and Summary

Kelly farms

1. Applications of dolomitic lime in the spring of 1978 did not increase magnesium content of grass that year, but in 1979 magnesium significantly increased from the topdressed application in 2 of the 4 cuttings. Epsom salts also increased magnesium. In 1980 magnesium was increased slightly by lime and epsom salts.

2. Potassium, at very high rates, decreased magnesium content but at recommmended rates no serious reduction occurred.

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

4. Soil pH, on the surface 3 inches, has increased from 5.2 to 6.4 in 1979 and to 6.8 in 1980 from 4 tons of lime.

Morris, MN

Comparisons of ammonium nitrate and urea topdressed on high pH soil (7.8) 1979 and 1980.

1. There was no significant nitrogen response in 1979 hence comparison differences are difficult to evaluate. Urea plots yielded significantly higher at the 10 percent level of significance at first cut and ammonium nitrate was significantly higher than urea in 1980 at this cutting time.

2. Yields from the second cutting from the two forms of nitrogen were different but urea was higher only at the 10 percent level of significance.

3. There was no difference in percent nitrogen in the plot from the two forms at the first or second cutting in 1980. No nitrogen content measurements were made in 1979.

4. The limited information from the two cuttings each of the two years would not indicate inferiority of urea to perform on high pH soils.

THE EFFECTS OF 3 NITROGEN LEVELS ON SUGARBEET VARIETY PERFORMANCE

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The objective of this trial is to investigate the responses of currently grown sugarbeet varieties to different soil nitrogen regimes. Specific items being investigated are, 1) nitrogen effects on yield and quality factors, b) nitrogen x variety interactions, and c) varietal responses to nitrogen from the northern end of the sugarbeet growing area of Minnesota to the southern end.

Excess nitrogen has been recognized as a major contributor to reduced sugar content and to increased levels of impurities in the sugarbeet crop. With payments to producers based on recoverable sugar per acre, rather than on tons produced, management of nitrogen becomes increasingly important. If excess nitrogen exists due to uncontrollable environmental conditions or past mismanagement, selection of a sugarbeet variety that would minimize these consequences would be of great value.

Procedure:
Trials were planted at Crookston, MN on June 10 and at Bird Island, MN on April 22. The June 10 planting at Crookston represents a replanting situation. At each location, 4 randomized blocks with nitrogen levels as whole plots and varieties as sub-plots were established. Nitrogen treatments (soil NO_3-nitrogen, 0-2', plus added ammonium nitrate) were 150, 250 and 350 total pounds of nitrogen per acre. At Crookston a check plot was included in 1980. These nitrogen levels represent the recommended level (150 lb/A) and two excess levels. Phosphorus and potassium levels were high. Seven varieties were planted at Crookston and 6 at Bird Is. These varieties were Beta 1443, Beta 1345, Hilleshog Mono-309, Mono-Hy R1, Bush Monofort, ACS-ACH-17 and ACH-30. ACH-17 was not planted at Bird Island. These varieties represent over 90 percent of the sugarbeet varieties grown in Minnesota.

Eptam was fall applied at a rate of 4.25 lb/a at Crookston and spring applied at 3.0 lb/A at the southern Minnesota locations. Insecticide was used at planting.

The beets were planted in 22-inch rows, thinned to a uniform population of 125/100 ft. of 22-inch row in late June, and harvested the first week in October. Quality factors were determined at the American Crystal Tare Lab in Grand Forks, North Dakota.

A split plot design with N levels as main plots and varieties as sub-plots was used at each location.

Results:
The results of the Crookston trial for yield, percent sugar, gross and recoverable sugar and sugarbeet impurities are summarized in Table 1 as variety means over nitrogen levels and nitrogen means over varieties. Varieties were significant for all variables measured except percent recoverable sugar, Na content and the impurity index. Nitrogen effects were significant for percent sugar, recoverable sugar, percent recoverable, recoverable per ton, amino nitrogen and impurity index. The effect of nitrogen on overall yield was nonsignificant. No nitrogen by variety interaction was present in 1980.

Table 1. Means for varieties and N fertilizer rates (Crookston, MN).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1345	10.8	14.0	3037	2494	81	229	518	3028	779	1204
Beta 1443	11.0	14.0	3088	2561	82	232	483	3136	670	1139
Hilleshog 309	11.8	13.4	3193	2597	81	219	575	3294	677	1246
ACS-ACH-17	9.8	13.3	2608	2114	81	215	578	2934	773	1265
Mono-Hy R1	10.7	13.6	2908	2386	82	223	437	3069	741	1198
ACS-ACH-30	10.5	13.9	2956	2446	82	231	559	2722	766	1156
Bush Monofort	10.6	14.2	3019	2514	83	238	518	2794	714	1116
Significance	**	**	**	**	NS	**	NS	*	**	NS
LSD (05)	.64	.61	226	216		15.4		431	68	
N-Rate lb/A										
Check	10.8	14.2	3104	2604	83	239	615	2839	640	1086
150	10.8	13.8	3013	2499	82	230	509	2870	715	1137
250	10.8	13.5	2941	2398	81	220	488	3012	772	1231
350	10.5	13.5	2833	2277	80	218	486	3266	800	1303
Significance	NS	*	NS	*	**	**	NS	NS	**	**
LSD (05)		.59		264	1.6	13.3			55	108

Mean varietal responses to the 3 nitrogen levels at Crookston are shown in Table 2. At the recommended nitrogen rate (150 lb/A) Hilleshog 309 had significantly higher yield than all varieties except Beta 1345. As the nitrogen level increased to 350 lb/A, Hilleshog-309 showed the greatest decrease in percent sugar. Hilleshog 309 and Beta 1345 showed the largest decline in recoverable sugar per acre between the 150 and 350 lb/A nitrogen rates. At the recommended nitrogen level, Beta 1345 had excellent yield and sugar percentage.

Because of the late planting and extremely droughty conditions of 1980, the varieties in this trial failed to reach their full potential. While the yields were relatively low, the percent sugar for all varieties was surprisingly good.

Results of the Bird Island trial are summarized as variety means over nitrogen levels and nitrogen means over varieties in Table 3. The main effects of varieties were significant for percent sugar, gross and recoverable sugar, recoverable per ton, percent recoverable and impurity index. Mono-Hy R1, Bush Monofort and ACH-30 had significnatly higher sugar percentages than Hilleshog 309 and Beta 1443. Bush Monofort, Mono-Hy R1 and ACH-30 produced significantly more recoverable sugar per acre than the other 3 varieties.

The main nitrogen effects were significant for all variables except yield, gross sugar, Na and K content (Table 3). The recommended rate of nitrogen produced significantly more recoverable sugar per acre than did the other nitrogen levels.

Table 2. Varietal response at varying N levels (Crookston, 1980).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities ppm Na	Impurities ppm K	Impurities ppm Amino N	Impurity Index
Beta 1345	Check	11.0	14.1	3143	2578	81	232	701	3060	730	1210
	150	11.4	14.6	3334	2801	84	245	414	2741	761	1064
	250	11.3	13.6	3098	2543	82	224	474	2674	830	1191
	350	9.4	13.6	2574	2053	79	217	485	3638	797	1353
Beta 1443	Check	10.9	14.8	3247	2755	84	251	605	3111	526	1006
	150	10.9	13.8	3027	2515	82	229	506	3031	669	1136
	250	10.8	13.9	2998	2453	81	227	440	3305	723	1205
	350	11.4	13.5	3081	2518	81	221	383	3100	764	1211
Hilleshog 309	Check	11.2	14.4	3242	2734	84	243	521	2969	611	1047
	150	12.2	13.8	3375	2767	81	226	518	3229	705	1202
	250	12.0	12.9	3120	2491	79	206	635	3484	676	1340
	350	11.9	12.7	3032	2397	79	201	629	3495	718	1395
ACS-ACH-17	Check	9.5	13.2	2537	2068	81	215	683	2717	748	1233
	150	10.2	13.4	2744	2262	82	221	552	2710	734	1170
	250	9.8	13.2	2624	2116	80	214	540	3061	797	1294
	350	9.6	13.2	2526	2008	79	212	539	3250	814	1364
Mono-Hy R1	Check	11.2	14.0	3167	2681	84	237	478	2325	718	1022
	150	10.0	13.5	2698	2235	82	223	431	2980	685	1144
	250	10.6	13.2	2833	2284	80	213	441	3611	693	1297
	350	10.8	13.6	2934	2346	80	218	400	3360	869	1329
ACS-ACH-30	Check	10.6	14.5	3092	2600	83	245	686	2888	604	1068
	150	10.4	14.1	2960	2466	83	234	528	2627	769	1116
	250	10.5	13.5	2854	2341	81	222	499	2619	826	1204
	350	10.6	13.7	2917	2378	81	223	523	2756	864	1235
Bush Monofort	Check	11.2	14.7	3298	2812	84	250	630	2802	542	1019
	150	10.6	13.9	2953	2449	83	231	611	2775	684	1125
	250	10.7	14.2	3058	2561	83	237	389	2333	858	1088
	350	10.0	14.1	2768	2236	81	231	441	3264	771	1232
Significance		*	*	**	**	**	*	NS	*	**	**
LSD (05)		1.2	1.6	554	450	1.4	38.2		1113	136	297

Table 3. Means for varieties and N fertilizer rates (Bird Island, 1980).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	18.7	13.5	5044	4211	83	225	420	2310	800	1101
Beta 1345	18.3	14.2	5206	4414	84	241	338	2185	810	1013
Hilleshog 309	19.3	12.5	5830	4014	83	208	466	2224	716	1127
Mono-Hy R1	19.7	14.6	5768	4882	84	248	338	2229	851	1015
Bush Monofort	19.2	14.5	5611	4783	85	248	422	2165	791	996
ACS-ACH-30	18.8	14.8	5608	4791	85	254	446	2176	771	973
Significance	NS	**	**	**	**	**	NS	NS	NS	**
LSD (05)		.47	366	299	1.5	10.6				103
N-Rate lb/A										
150	18.4	14.7	5444	4727	86	257	356	2146	670	886
250	19.2	13.8	5326	4474	84	231	382	2225	826	1072
350	19.3	13.6	5262	4347	82	224	478	2273	873	1154
Significance	NS	**	NS	*	**	**	NS	NS	**	**
LSD (05)		.39		250	1.4	7.2			80	94

Mean varietal response to the 3 nitrogen levels is shown in Table 4. Hilleshog 309 showed a significant increase in yield as the nitrogen level increased to 250 lb/A. At the 150 lb/A nitrogen rate this variety had the lowest yield and recoverable sugar in the trial. This was due mainly to Cercospora leaf spot which affected this nitrogen level to a greater extent than at the other levels. This variety had significantly lower percent sugar at all nitrogen levels than the other varieties. Bush Monofort produced the highest recoverable sugar at the 150 lb/A nitrogen rate, but showed the largest decrease as the nitrogen rate was increased to the 350 lb/A rate.

Tables 5 and 6 show trial results at Crookston for 1978-80. All variables measured showed significant differences except amino nitrogen and percent recoverable sugar for varieties (Table 5). Hilleshog 309 had the highest yield and recoverable sugar over the 3 years but the lowest sugar content, percent recoverable sugar and sugar per ton of beets. Bush Monofort, Mono-Hy R1 and ACH-30 had the highest percent recoverable sugar.

The effects of nitrogen were nonsignificant for yield and Na content (Table 5). All other variables were highly significant, indicating deleterious effects from fertilizing above the recommended rate of nitrogen.

Table 4. Varietal response at varying N levels (Bird Island, 1980).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities ppm Na	Impurities ppm K	Impurities ppm Amino N	Impurity Index
Beta 1443	150	18.9	14.1	5308	4490	84	238	476	2467	697	1025
	250	18.2	13.5	4930	4072	82	222	410	2220	915	1164
	350	19.0	13.0	4920	4050	83	214	391	2263	886	1186
Beta 1345	150	17.5	14.8	5180	4524	87	259	285	1978	687	846
	250	18.2	14.1	5124	4297	83	236	313	2195	902	1074
	350	19.3	13.7	5314	4420	83	228	417	2381	840	1120
Hilleshog 309	150	16.7	13.5	4516	3841	85	229	368	2101	737	1004
	250	21.5	12.2	5282	4370	82	202	462	2195	740	1161
	350	19.9	11.8	4691	3829	81	192	569	2376	671	1216
Mono-Hy R1	150	19.3	15.0	5782	5006	87	259	240	2103	766	892
	250	20.3	14.5	5894	5019	85	247	314	2325	779	987
	350	19.4	14.6	5671	4748	84	244	460	2258	1008	1074
Bush Monofort	150	20.0	15.4	6161	5446	88	271	402	2217	517	777
	250	18.4	14.4	5294	4458	84	242	374	2212	874	1054
	350	19.2	14.0	5378	4446	82	231	489	2067	982	1157
ACS-ACH-30	150	18.0	15.9	5722	5067	88	285	362	2010	621	773
	250	19.1	14.6	5601	4731	84	247	437	2241	842	1037
	350	19.4	14.2	5501	4586	83	236	540	2278	852	1109
Significance		*	**	**	**	**	**	*	NS	**	**
LSD (05)		2.47	.91	717	552	2.4	20.2	184		227	164

Table 5. Means for varieties and N fertilizer rates (Crookston, 1978-80).

Variety	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	16.9	14.4	4891	3967	81.0	233	747	2439	1012	1264
Beta 1345	16.2	14.8	4889	3960	81.0	239	680	2336	1110	1266
Hilleshog 309	18.1	14.2	5181	4164	80.4	228	826	2483	1001	1307
Bush Monofort	16.1	14.8	4780	3928	82.2	243	740	2291	981	1189
Mono-Hy R1	16.9	14.6	4955	4091	82.3	240	594	2442	961	1183
ACS-ACH-30	15.7	14.8	4667	3843	82.2	243	762	2228	981	1189
ACS-ACH-17	15.6	14.2	4455	3653	81.6	233	751	2226	967	1225
LSD (05)	.37	.23	122	142		7.1	68	184		152
N-Rate lb/A										
150	16.5	14.8	4918	4111	83.4	247	692	2247	881	1105
250	16.6	14.5	4853	3927	81.0	235	727	2350	1063	1270
350	16.5	14.3	4723	3793	81.2	228	768	2450	1062	1321
LSD (05)		.18	130	104	.6	3.9		134	79	42

Table 6. Varietal response at varying N levels (Crookston, 1978-80).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities ppm Na	Impurities ppm K	Impurities ppm Amino N	Impurity Index
Beta 1443	150	16.9	14.5	4920	4070	82.5	239	747	2316	905	1166
	250	17.3	14.6	5070	4105	80.8	235	696	2496	1056	1279
	350	16.5	14.2	4680	3726	79.8	225	795	2502	1074	1345
Beta 1345	150	16.4	15.3	5050	4255	84.1	257	611	2130	924	1056
	250	16.8	14.6	4949	3844	78.3	227	706	2283	1420	1448
	350	16.1	14.3	4667	3781	80.5	231	724	2592	1006	1293
Hilleshog 309	150	17.9	14.6	5237	4311	82.2	240	772	2423	907	1185
	250	18.4	14.0	5221	4172	80.0	224	900	2522	982	1332
	350	18.1	13.9	5085	4008	78.9	218	804	2501	1114	1403
Bush Monofort	150	16.1	15.0	4885	4079	83.4	251	742	2309	875	1105
	250	16.0	15.0	4819	3973	82.5	247	709	2121	1028	1164
	305	16.1	14.3	4635	3729	80.5	230	768	2441	1038	1297
Mono-Hy R1	150	16.4	14.7	4854	4080	83.8	246	578	2289	867	1082
	250	17.1	14.5	4992	4095	81.8	237	619	2523	976	1213
	350	17.1	14.5	5018	4098	81.2	235	584	2512	1040	1252
ACS-ACH-30	150	16.1	14.9	4825	4078	84.3	251	729	2107	817	1047
	250	15.3	14.8	4540	3742	82.3	243	690	2263	983	1179
	350	15.9	14.6	4636	3707	79.9	232	866	2314	1142	1338
LSD (05)		.88	.41	232	261	2.8	12.2	124	290	285	191

Within varieites Mono-Hy R1 showed the lowest decline in gross and recoverable sugar per acre as the nitrogen levels increased (Table 6, Figure 1). Beta 1345 showed the largest decrease in recoverable sugar as the nitrogen level was increased from the recommended level to the 350 lb/A level. Hilleshog 309 showed the largest drop in percent sugar between nitrogen levels, while Mono-Hy R1 and ACH-30 showed the least (Figure 3).

Tables 7 and 8 show results of the southern Minnesota trials for 1978-80. Varieties were significant for all variables measured (Table 7). As with the Crookston trial, Hilleshog 309 produced the highest tonnage, but had the lowest percent sugar. This variety along with Mono-Hy R1 and Beta 1443 produced the largest amounts of gross and recoverable sugar per acre. Hilleshog 309 and Beta 1443 had significantly lower percent recoverable sugar than the other varieties.

The effects of nitrogen were significant for all variables except yield and K content. As with the Crookston trial, this indicates that only deleterious effects were realized from the addition of nitrogen over the recommended rates.

Within varieties Beta 1443 had the largest drop in gross and recoverable sugar per acre as the nitrogen rates increased (Table 8, Figure 2). Mono-Hy R1 showed the least decline. ACH-30 had the largest drop in percent sugar over nitrogen levels (Figure 3).

Table 7. Means for varieties and N fertilizer rates (Southern Minnesota (1978-80).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	23.6	14.6	6912	5755	83.0	242	650	2177	929	1131
Beta 1345	22.2	15.1	6604	5639	84.1	253	572	2071	933	1063
Hilleshog 309	24.5	14.3	7061	5878	83.2	237	673	2159	863	1120
Bush Monofort	22.2	14.8	6568	5529	84.1	250	646	2027	884	1058
Mono-Hy R1	23.2	15.0	6934	5844	84.3	253	511	1971	950	1046
ACS-ACH-30	22.3	15.1	6734	5688	84.4	256	660	2066	867	1042
LSD (05)	.70	.19	225	224	.7	4.6	42	138	71	48
N-Rate lb/A										
150	22.9	15.3	7012	5995	85.5	262	574	2059	804	966
250	23.0	14.8	6799	5695	83.6	247	634	2052	926	1091
350	23.1	14.4	6645	5477	82.4	237	648	2124	982	1172
LSD (05)		.16	179	149	.7	4.1	66		49	49

Table 8. Varietal response at varying N levels (Southern Minnesota (1978-80).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	150	24.2	15.0	7322	6216	84.7	255	639	2210	799	1017
	250	23.2	14.5	6771	5557	81.8	237	700	2133	1041	1210
	350	23.3	14.2	6640	5490	82.5	234	609	2187	944	1164
Beta 1345	150	22.6	15.3	6938	5940	85.6	262	533	1965	829	954
	250	21.8	15.2	6688	5650	84.2	257	549	2072	938	1049
	350	22.1	14.6	6483	5327	82.2	241	635	2176	1030	1185
Hilleshog 309	150	24.0	14.8	7215	6113	84.7	251	622	2095	814	1019
	250	25.1	14.2	7217	5999	83.0	236	683	2151	878	1133
	350	24.4	13.7	6751	5521	81.8	223	712	2229	894	1208
Bush Monofort	150	21.9	15.4	6733	5787	86.0	264	625	2084	731	931
	250	22.0	14.7	6447	5400	83.6	246	625	2071	926	1091
	350	22.7	14.4	6523	5399	82.7	238	686	1923	994	1150
Mono-Hy R1	150	22.6	15.3	6891	5875	85.3	260	444	1980	896	980
	250	23.2	15.0	6926	5874	84.8	253	509	1814	929	1010
	350	23.8	14.8	6983	5781	82.8	244	578	2117	1023	1146
ACH-ACH-30	150	21.9	15.9	6972	6033	86.6	276	578	2015	754	892
	250	22.5	15.0	6740	5689	84.2	252	737	2071	838	1051
	350	22.4	14.5	6488	5341	82.3	239	663	2111	1006	1180
LSD (05)		1.3	.36	389	354	1.2	8.6	80	215	108	84

The analysis of variance table for N levels, varieties and N x variety interactions for the northern and southern Minnesota locations for 1978-80 is shown in Table 8A.

Table 8A. Analysis of variance.

	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurity Index
			Northern Minnesota 1978-80				
N-Level	NS	**	**	**	**	**	NS
Variety	**	**	**	**	NS	**	**
N x Var.	*	NS	**	+	NS	NS	NS
			Southern Minnesota 1978-80				
N-Level	NS	**	**	**	**	**	**
Variety	**	**	**	**	**	**	**
N x Var.	NS	**	**	*	*	**	*

*, ** Significant at 5 and 1% levels, respectively.

Results of the combined trials (3 years-2 locations) are shown in Tables 9, 10 and Figures 3, 4. The variety and nitrogen effects for this combined data is similar to that reported in the above text for individual locations.

Table 11 shows the loss (-) or gain (+) in recoverable sugar per acre for the varieties in this trial over years and locations. Mono-Hy R1 shows the smallest decline over nitrogen levels of the varieties tested. At the recommended nitrogen rate, this variety produces significantly less recoverable sugar than several of the other varieties. This is reversed at the higher nitrogen levels.

Table 11. Recoverable sugar loss or gain per acre between the 150, 250 and the 350 lb/A nitrogen rate (average 3 yr-2 location).

	Varieties					
Nitrogen Levels	Beta 1443	Beta 1345	Hilleshog 309	Bush Monofort	Mono-Hy R1	ACS-ACH-30
150 N → 250 N	-312	-350	-127	-246	+7	-341
150 N → 350 N	-535	-543	-447	-369	-39	-532

Summary:

In six trials conducted in both northern and southern Minnesota from 1978-80, no benefit has been realized from the addition of nitrogen fertilizer in excess of the recommended rate of 150 lb/A. These trials have represented large variations in weather patterns as well as times of planting.

Of the varieties tested all perform well at the recommended rates of nitrogen fertilization. Mono-Hy R1 has shown the least decline in recoverable sugar at the excess nitrogen rates, however. How varieties not included in these trials will react is not known.

Table 9. Means for varieties and N fertilizer rates (3 yr.-2 loc. average).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	20.2	14.5	5901	4861	82.0	238	698	2307	970	1197
Beta 1345	19.3	14.9	5796	4799	82.5	246	626	2203	1021	1164
Hilleshog 309	21.3	14.2	6121	5021	81.8	232	749	2320	932	1213
Bush Monofort	19.1	14.8	5674	4728	83.1	246	692	2158	932	1123
Mono-Hy R1	20.0	14.8	5944	4967	83.2	246	552	2206	955	1114
ACS-ACH-30	19.0	14.9	5700	4765	83.2	249	711	2147	923	1115
LSD (05)	.32	.12	106	112	1.0	3.8	43	102		68
N-Rate lb/A										
150	19.7	15.1	5987	5070	84.4	254	635	2160	843	1036
250	19.9	14.7	5865	4842	82.2	241	677	2210	998	1180
350	19.9	14.3	5716	4659	81.3	232	702	2300	1025	1247
LSD (05)		.11	106	90	.5	2.7	48	90	52	34

Table 10. Varietal response at varying N levels (3 yr.-2 loc. average).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	150	20.6	14.8	6121	5143	83.6	247	693	2263	852	1092
	250	20.3	14.5	5920	4831	81.3	236	698	2315	1049	1245
	350	19.9	14.2	5660	4608	81.1	230	702	2344	1009	1254
Beta 1345	150	19.5	15.3	5994	5097	84.9	259	572	2047	877	1005
	250	19.3	14.9	5818	4747	81.3	242	627	2178	1169	1248
	350	19.1	14.5	5575	4554	81.4	236	679	2384	1018	1239
Hilleshog 309	150	20.9	14.7	6226	5212	83.4	246	697	2259	860	1102
	250	21.7	14.1	6219	5085	81.5	230	791	2336	930	1232
	350	21.2	13.8	5918	4765	80.4	221	758	2365	1004	1305
Bush Monofort	150	19.0	15.2	5809	4933	84.7	257	683	2197	803	1018
	250	19.0	14.9	5633	4687	83.0	246	667	2096	977	1127
	350	19.4	14.3	5579	4564	81.6	234	727	2182	1016	1223
Mono-Hy R1	150	19.5	15.0	5873	4977	84.5	253	511	2134	881	1031
	250	20.1	14.8	5959	4984	83.3	245	564	2169	952	1112
	350	20.4	14.6	6000	4938	82.0	239	581	2314	1031	1199
ACS-ACH-30	150	19.0	15.4	5898	5056	85.4	264	654	2061	786	969
	250	18.9	14.9	5640	4715	83.2	247	714	2167	911	1115
	350	19.1	14.5	5562	4524	81.1	235	765	2212	1074	1259
LSD (05)		.81	.27	239	231	1.5	7.5	74	193	156	107

FIGURE 1: GROSS & RECOVERABLE SUGAR (NORTHERN MN 1978-80)

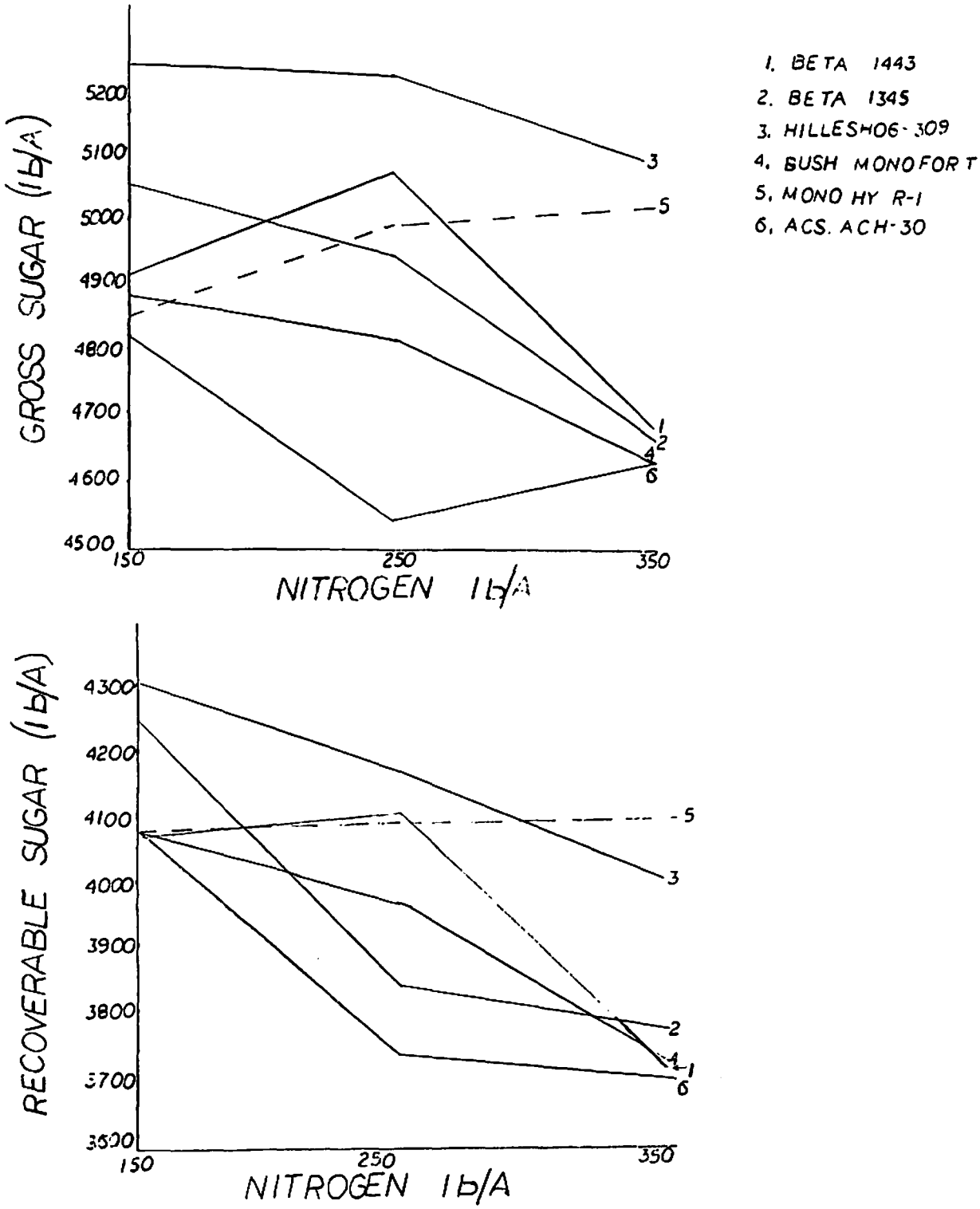


FIGURE 2: GROSS & RECOVERABLE SUGAR (SOUTHERN MN 1978-80)

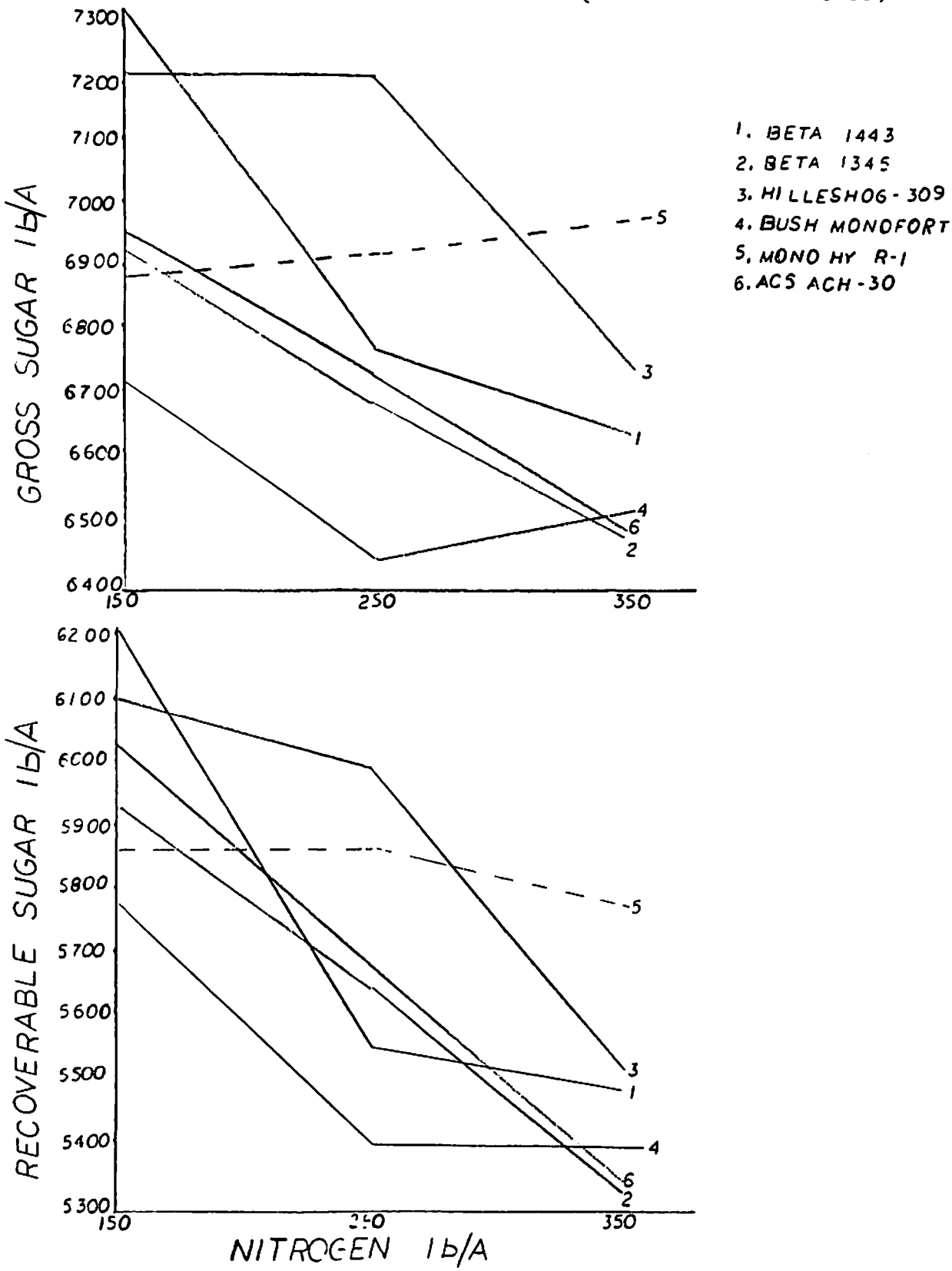


FIGURE 3: PERCENT SUGAR (SOUTHERN MN., NORTHERN MN (COMBINATION) 1978-80

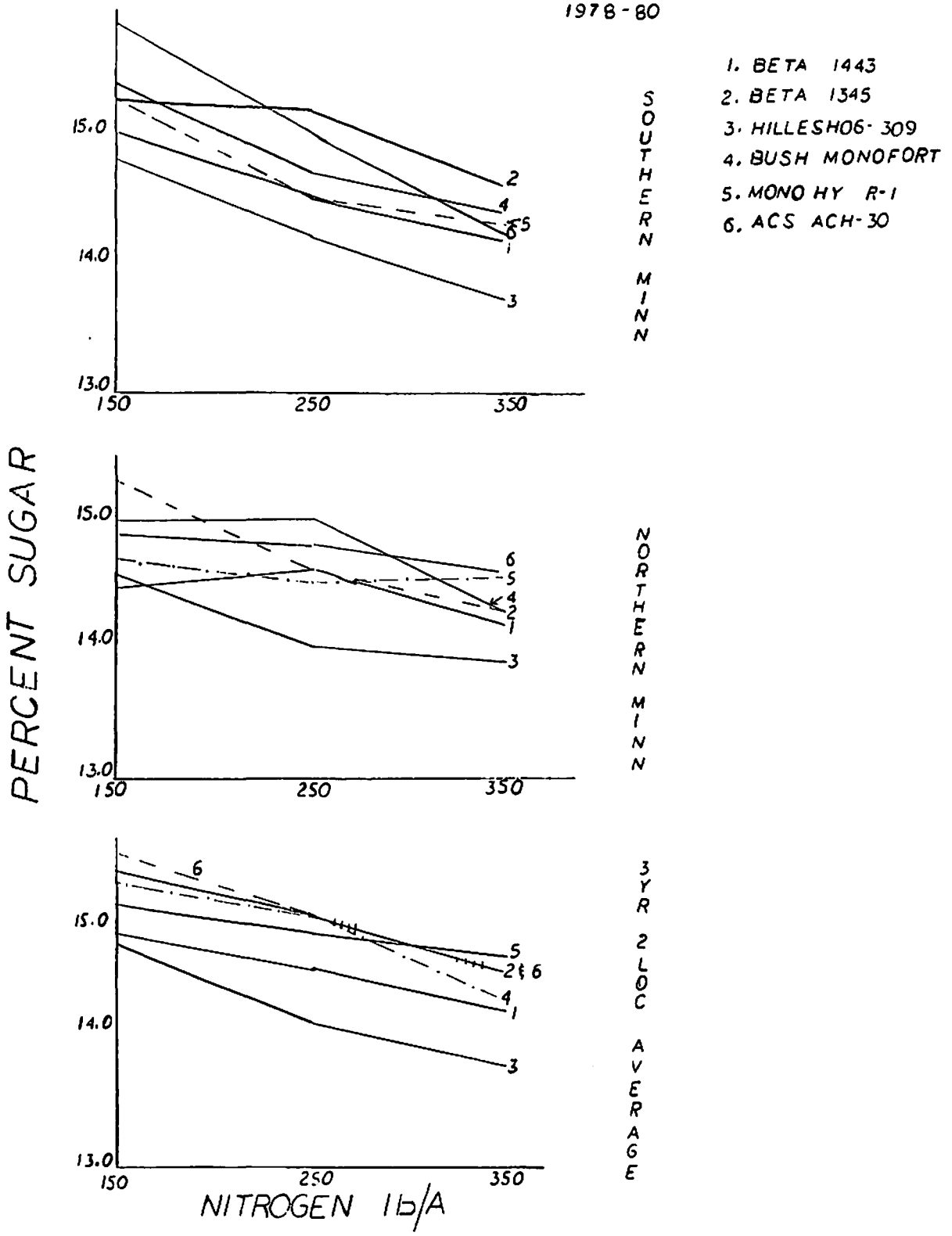
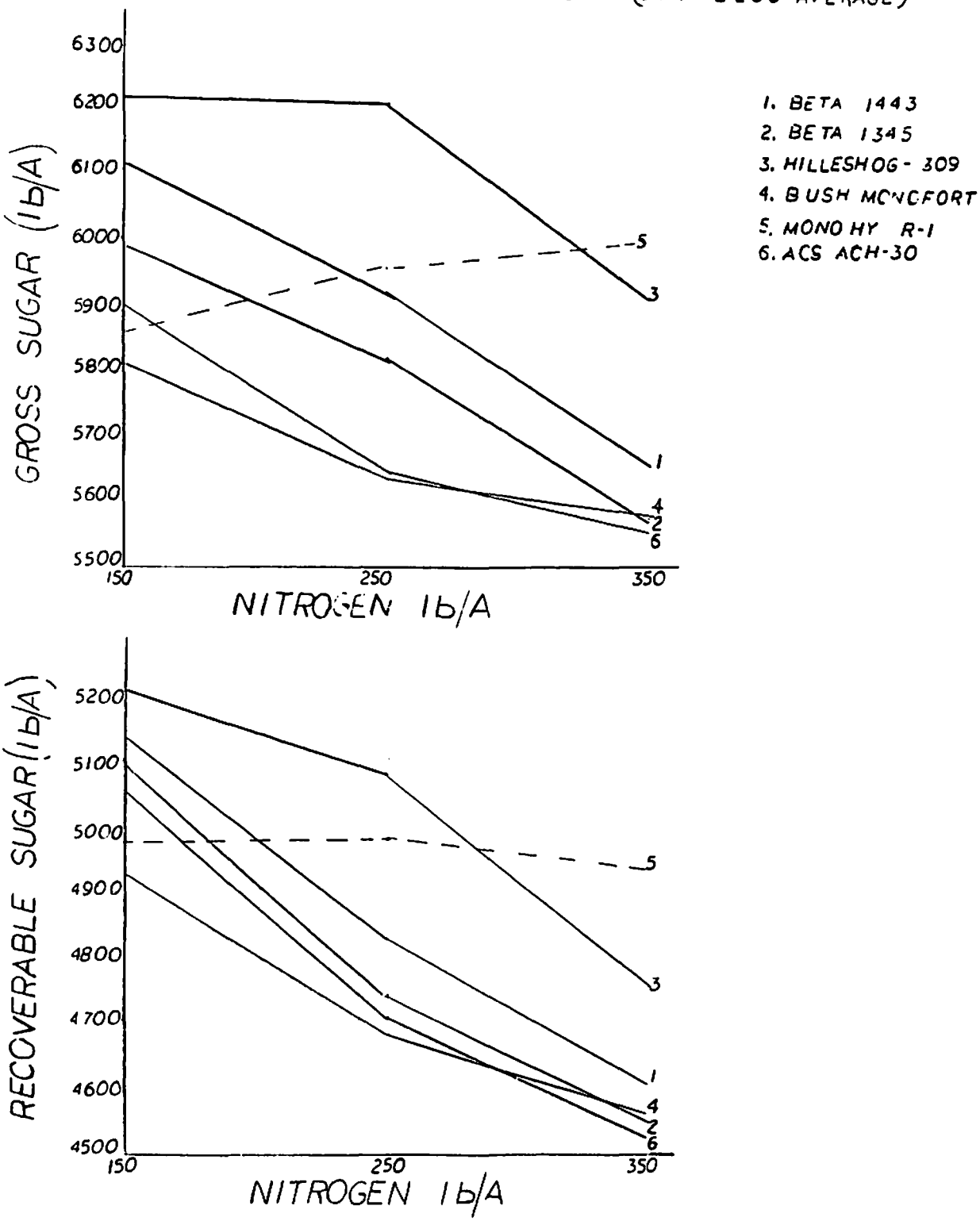


FIGURE 4: GROSS & RECOVERABLE SUGAR (3 YR - 2 LOC AVERAGE)



NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA - 1980

G.L. Malzer, J.N. Lensing, and O.M. Gunderson

Nitrogen management continues to be a prime consideration that sugarbeet growers not only in West-Central Minnesota, but also in other sugarbeet production areas should be concerned with if they are to attain maximum sugar production per acre. The need for nitrogen in sugarbeet production is well documented, but it has also been demonstrated that excess nitrogen fertilizer may decrease the sugar percentage and purity thereby lowering the recoverable sugar per acre. An accurate prediction of nitrogen needs is therefore essential in the overall nitrogen management system. The measurement of residual nitrates in the soil to a depth of two feet has aided a great deal in estimating the nitrogen needs for sugarbeets, but depending on the year (weather), soil type, soil organic matter, soil drainage and previous cropping history, the nitrogen fertilizer requirement may vary from one location to another. The sugarbeet variety planted and the plant population utilized could also influence the yield, quality and the nitrogen needs of the crop.

Research was initiated in 1976 to study the problem of predicting fertilizer nitrogen requirements for sugarbeets in West-Central Minnesota. One of the major concerns of the research in 1976 was to determine the adequacy of the two foot nitrate-nitrogen test in making fertilizer recommendations. Since many soils outside of the Red River Valley have better drainage characteristics, large accumulations of nitrate-nitrogen below a depth of two feet may be encountered. If sugarbeets are capable of utilizing large quantites of nitrate-nitrogen below a depth of two feet, then fertilizer recommendations and associated soil testing techniques should be modified to more accurately predict fertilizer nitrogen needs. The objectives of the studies in 1980 were to look at various aspects of nitrogen management and to evaluate the following: 1) the importance of deep subsoil nitrates, and to determine the optimum soil sampling depth; 2) the correlation and calibration of soil nitrate-nitrogen levels to fertilizer nitrogen rates; 3) the evaluation and importance of nitrogen rates and plant populations and 4) the varietal response of sugarbeets to increasing rates of nitrogen application.

Materials and Methods: Seven location were selected in West-Central Minnesota for nitrogen management studies in 1980. Of the seven locations, five of the locations were selected for fertilizer nitrogen correlation-calibration research, one location for plant population and nitrogen rate investigation and one location for studying the nitrogen response to different sugarbeet varieties.

The correlation-calibration experiments consisted of four locations with nitrogen rates of 0,40,80 and 120 pounds of nitrogen per acre applied in the fall as urea. These trials were established with four replications and arranged in a randomized

complete block design. One location consisted of four paired comparisons of nitrogen fertilizer versus a no nitrogen control. These 200-400 foot strips were established by the farmers utilizing the nitrogen fertilizer rate and form which was used on the remainder of the field. A trial was established at Wayne Schwitter's to evaluate the effect of nitrogen and plant populations on yield and sugarbeet quality. The trial was conducted with three plant populations, three nitrogen rates and four replications in a split plot arrangement. Nitrogen rates were 0, 60, 120 lbs N/A applied as urea in the fall of 1979. Beets were thinned to plant populations of 75, 125 and 175 plants/100 foot row. A trial to investigate the importance of nitrogen rates and sugarbeets varieties was established at the LeRoy Stamer farm in Renville County. This trial was conducted in cooperation with Dr. Larry Smith at the Crookston station. The trial was conducted with six varieties, three nitrogen levels and four replications in a split block arrangement. Nitrogen treatments included rates of 150, 250 and 350 lbs of N/A as total fertilizer N plus soil NO_3 -N within the surface two feet. The six varieties utilized were: Beta 1443, G.W. R-1, ACH-30, Beta 1345, Bush Monofort, and Hilleshog 309.

Soil cores were taken to a depth of five feet prior to fertilization in all experiments. The soil cores were separated into increments of 0-½', ½-1', 1-2', 2-3', 3-4' and 4-5' and analyzed for nitrate-nitrogen. In addition, a composite sample of the 0-½' depth was analyzed for pH, organic matter, available phosphorus, exchangeable potassium and zinc. Petiole samples were obtained for nitrate-nitrogen determination from the Stamer and Schwitter locations three times during the season. The first samples were taken on August 18th with subsequent samplings taken over a three week period.

Plots were harvested in late September and early October utilizing either a four row farmhand lifter or a modified one row plot harvester supplied by Dr. Smith at the Crookston Experiment Station. Subsamples were collected and processed through the tare lab at the American Crystal lab at East Grand Forks.

Results and Discussion: In 1980, three out of five nitrate calibration-correlation sites had low nitrate levels throughout the profile (less than 100#N/A in the top 4 feet). These sites showed a significant response to the addition of fertilizer nitrogen. One site with a nitrate test of 92 #N/A showed a trend toward a nitrogen response with the addition of 40 #N/A. The remaining trial showed no response to fertilizer nitrogen. The high soil nitrate test on this site (148 #N/A) would predict minimal response.

The nitrogen by population trial showed no significant response to nitrogen or plant population. There was, however, a high accumulation of nitrate-nitrogen in the subsoil (142 #N/A in the 2-4 foot depth). The high subsoil nitrate-nitrogen plus the limited moisture during portions of the growing season may have contributed to a lack of response.

The information from the trial conducted at the Stamer location is included in an overall summary compiled by Dr. Larry Smith in the 1980 Sugarbeet Research and Extension Report.

General Comments: The present two foot soil sample for nitrate-nitrogen is a very valuable tool in predicting the nitrogen needs for sugarbeets. When the nitrate test is high (greater than 150# N/A) response to fertilizer nitrogen is minimal. When the nitrate test (2') is less than 150 lbs. N/A responses and calibration are less clear cut. In several situations an estimate of the nitrate-nitrogen below a depth of two feet was useful in predicting the type of response which would be expected. The positioning of the nitrates in the soil profile may also be important and a 0-3' or 0-4' may not be as good as a 0-2' and 2-4' sample.

Minnesota soils have a tremendous ability to release nitrogen from organic matter when the moisture and growing season are adequate. The sugarbeet grower should, therefore, not be misled into believing he needs to apply large amounts of nitrogen to obtain high tonnage. These excessive rates of nitrogen fertilization can decrease sugar and purity and not necessarily increase tonnage.

Acknowledgements: Sincere appreciation is extended to the Sugarbeet Research and Education Board and to the University of Minnesota Experiment Station for financing and supporting this research project. Recognition should be given to our farmer-copperators for their interest and assistance and to Wayne Schwitter for his special assistance during harvest. Special appreciation is also extended to the Department of Soil Science field crew for their attention to the field phases of the project and to Dr. Larry Smith for his assistance with the experiments.

Table 1. Soil nitrate-nitrogen levels at the experimental locations in 1980

Soil Depth	Pete Frieborg Renville Co. Site 1	Site 2	Harold Peterson Chippewa Co. Site 1	Site 2	Wayne Schwitters Chippewa Co.	Leroy Stamer Renville Co.	Norman Bosch Chippewa Co.
inches	lbs NO_3-N/A						
0-12	71	14	18	19	13	32	98
12-24	21	16	32	33	21	10	50
24-36	14	6	5	11	48	6	17
36-48	14	6	2	33	144	6	9
48-60	12	4	4	14	164	8	10

Table 2. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Pete Frieborg, Site 1 Renville Co. 1980.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	19.1	14.2	5404	83.8	4531	237
40	22.5	15.4	6982	84.9	5925	263
80	23.0	14.1	6487	83.1	5390	234
120	20.3	14.8	6069	84.8	5150	254
Significance	NS	NS	NS	NS	NS	NS
BLSD (.05)	--	--	--	--	--	--

Table 3. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, recoverable sugar. Pete Frieborg, Site 2, Renville Co. 1980.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	14.0	16.7	4692	87.2	4093	292
40	16.1	16.5	5329	88.0	4691	291
80	17.6	17.0	6003	88.7	5323	302
120	19.5	17.0	6648	88.3	5868	301
Significance	*	NS	*	NS	*	NS
BLSD	4.0	--	1325	--	1160	--
C.V.	13.5	4.8	13.5	1.9	13.5	6.4

Table 4. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson, Site 1, Chippewa Co. - 1980

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	14.2b	17.0	4802	89.5	4296	303
40	15.9b	17.3	5494	88.4	4859	306
80	16.3ab	16.6	5420	86.5	4687	288
120	19.4a	16.2	6278	87.6	5501	283
Signifance	*	NS	NS	NS	NS	NS
BLSD	3.1	--	--	--	--	--
C.V.	11.0	7.4	12.7	3.0	13.0	9.5

Table 5. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson, Site 2, Chippewa Co. - 1980

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	19.2	16.4	6297	86.6	5454	284
40	21.5	17.0	7302	87.2	6365	296
80	23.3	16.0	7327	87.1	6380	274
120	20.2	16.4	6780	84.4	5720	283
Signifance	*	NS	NS	NS	NS	NS
BLSD (.05)	3.2	--	--	--	--	--
C.V.	8.5	7.3	10.5	3.4	12.3	10.6

Table 6. Effect of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Norman Bosch Chippewa Co. - 1980.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	21.1	16.3	6907	85.0	5871	277
100	21.5	15.9	6840	85.1	5837	271
Significance	NS	NS	NS	NS	NS	NS
C.V.	6.3	6.0	11.2	2.8	13.2	8.6

Table 7. Effect of various nitrogen rates and plant populations on sugarbeet yield, percentage sugar, gorss sugar, purity, and recoverable sugar. Wayne Schwitters, Chippewa Co. - 1980.

Nitrogen Rate		Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A		T/A	%	lbs/A	%	lbs/A	lbs/T
0		19.7	15.0	5898	84.2	4973	252
60		21.4	14.9	6346	83.0	5284	248
120		21.3	15.2	6476	84.0	5468	255
Significance		NS	NS	NS	NS	NS	NS
Population plants /100' row							
75		20.9	14.8	6173	83.3	5148	246
125		21.3	14.9	6350	83.8	5334	251
175		20.2	15.3	6198	84.2	5242	259
Significance		NS	NS	NS	NS	NS	NS
Interaction N Rate X Pop.							
0	75	20.1	14.7	5911	83.7	4949	247
0	125	19.1	15.1	5989	84.3	5062	254
0	175	19.2	15.1	5795	84.6	4908	255
60	75	21.0	14.6	6108	82.4	5032	240
60	125	22.3	14.5	6427	82.8	5318	240
60	175	20.8	15.6	6504	84.0	5503	264
120	75	21.7	15.0	6499	83.8	5465	251
120	125	21.7	15.2	6632	84.4	5623	257
120	175	20.5	15.3	6297	83.9	5315	258
Signif.		NS	NS	NS	NS	NS	NS
C.V.		6.3	7.8	11.6	3.5	14.4	11.1

STARTER AND BROADCAST FERTILIZER TRIAL ON SUNFLOWERS

Pennington County, 1980

W. E. Jokela and M. O'Leary

Experimental Procedure

This trial was established to examine the effect of starter and broadcast fertilizer, especially potassium, on sunflower yield and oil content on a soil testing medium in potassium. It was located on a Clearwater/Thief River fine sandy loam soil on the farm of Ken Mehrkens, Pennington County. Soil test levels in the plow layer are as follows (lbs/A): pH 7.6, P 24 (Bray 1, 1:50), K 133. Organic matter level is high.

Broadcast fertilizer was applied in the spring and incorporated with secondary tillage. A randomized complete block design was used with four replications. Starter fertilizer at the rate of 95 lbs/acre of 10-20-20 was applied to half of each broadcast treatment plot. Adequate nitrogen was applied to the whole plot area. Interstate 894 variety was planted on May 10. Plant population at harvest was 21,000 plants/acre. Leaf samples were taken at early bloom and heads were harvested at maturity.

Results and Discussion

Nutrient content of the 5th leaf at early bloom is shown in Table 1. Potassium content of leaves increased and magnesium content decreased significantly with increasing rates of potash. Magnesium content was also reduced by use of the starter. When phosphorus was applied the concentration of zinc in the leaves decreased significantly. Yields were quite high (over 2000 lbs/A), especially considering the drought conditions in 1980, but there was no significant yield response to either starter or broadcast fertilizer (Table 2). Oil percentage increased slightly with the use of the starter.

Table 1. Nutrient content of sunflower leaves (5th leaf) at early bloom as affected by fertilizer treatment. Pennington County (Mehrkens), 1980.

Fertilizer Rate lbs/A		%				ppm					
P_2O_5	K_2O	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
0	0	.31	3.86	1.51	1.16	70	7	51	40	13	72
0	60	.32	3.86	1.56	1.09	74	15	55	41	13	66
0	120	.32	4.12	1.45	.99	67	7	50	39	12	71
0	240	.29	4.30	1.53	.89	68	9	53	41	13	72
60	0	.35	3.63	1.62	1.32	70	8	55	35	11	61
60	120	.34	4.08	1.52	1.01	71	6	52	35	11	69
significance		ns	*	ns	**	ns	ns	ns	**	ns	ns
BLSD (.05)		-	.25	-	.18	-	-	-	3	-	-
No starter		.31	3.94	1.56	1.13	71	8	53	39	13	71
Starter		.33	4.01	1.50	1.02	69	9	52	38	12	66
Significance		ns	ns	ns	**	ns	ns	ns	ns	ns	ns
BLSD (.05)		-	-	-	.06	-	-	-	-	-	-
C.V.		13.5	5.8	12.3	9.6	9.9	38.1	14.6	15.7	17.0	18.1

Table 2. Yield, oil content, and test weight of sunflowers as affected by fertilizer treatment. Pennington County (Mehrkens), 1980.

Fertilizer Rate lbs/A		Yield (D.M.) lbs/A	Oil %	Oil lbs/A	Test weight lb/bu
P_2O_5	K_2O				
0	0	2057	49.0	1006	29.2
0	60	2051	49.5	1015	29.4
0	120	2110	50.4	1063	30.1
0	240	2094	49.6	1037	28.8
60	0	2064	49.2	1015	29.9
60	120	2165	49.1	1061	29.6
Significance		ns	ns	ns	+
BLSD (.05)		-	-	-	.8
Starter					
-		2119	49.1	1040	29.1
+		2062	49.8	1026	29.9
Significance		ns	**	ns	**
BLSD (.05)		-	.3	-	.5
C.V.		10.7	1.1	10.2	2.7

SUNFLOWER FERTILIZATION

G. E. Varvel and R. K. Severson

The objective of these studies was to determine the effect of N, P and K fertilizer on sunflower yield and oil content.

Experimental Procedure:

The experiment was conducted at 2 locations, Fosston and McIntosh. Three factors (N, P, K) each at 2 levels were combined in a factorial arrangement. A randomized complete block design with 4 replications was used. All treatments were broadcast on April 24 and 25 at Fosston and McIntosh respectively. Sunflower was planted April 28 at McIntosh and May 1 at Fosston and harvested at both locations on September 28. Leaf samples were taken at 40-50% pollination on July 29 at the Fosston location.

Soil test results from samples taken at the start of the study at Fosston were: NO_3-N (0-2') - 140 lb/A, $NaHCO_3$ P (0-6") - 23 lb/A, and exchangeable K (0-6") - 360 lb/A. Those from McIntosh were: NO_3-N (0-2') - 100 lb/A, $NaHCO_3$ P (0-6") - 14 lb/A and exchangeable K (0-6") - 295 lb/A.

Results:

Elemental analyses of the leaf samples taken at the Fosston location are shown for the main effects (N, P, K) only (Table 1). No significant interactions were obtained. Nitrogen had no significant effect on the leaf analyses, P significantly increased N, P and Mn content in the leaf and K significantly increased K content in the leaf. All nutrient levels in the leaf appeared to be above those required for optimum growth. Also, in support of this statement, no yield response was obtained at Fosston (Table 2).

Results shown for the McIntosh location are quite different (Table 2). Nitrogen, P and K each significantly increased seed and oil yield with the highest yields being obtained with the treatment which included all three. In addition, as N was added, oil content was significantly reduced. No significant interactions were obtained.

Table 1. The main effects of N, P and K on the elemental analyses of sunflower leaf samples taken at approximately 40-50% pollination at Fosston.

N Rate (lb/A)	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					ppm						
0	3.44	.31	3.48	2.61	1.36	27	78	8	55	42	22	91
100	3.57	.30	3.53	2.55	1.39	19	71	8	53	47	22	84
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	5.5	10.7	7.4	8.6	12.0	88.9	22.5	16.3	12.0	15.2	18.4	14.4
P_2O_5 Rate (lb/A)												
0	3.41	.29	3.56	2.52	1.33	24	74	8	50	46	23	86
80	3.60	.33	3.45	2.64	1.42	22	75	8	57	43	21	89
Significance	*	**	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
B.L.S.D. (.05)	.14	.02							5			
K_2O Rate (lb/A)												
0	3.54	.31	3.40	2.62	1.40	23	75	8	53	44	21	85
100	3.48	.31	3.61	2.54	1.34	23	74	8	54	45	23	89
Significance	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)			.18									

Table 2. The effect of N, P and K fertilizer on sunflower seed yield, oil content and oil yield.

Treatment			Location					
			McIntosh			Fosston		
			Seed			Seed		
N	P_2O_5	K_2O	Yield	Oil	Oil Yield	Yield	Oil	Oil Yield
- - - lbs/A - - -			lbs/A	%	lbs/A	lbs/A	%	lbs/A
0	0	0	1550	49.3	764	1913	46.6	890
100	0	0	1914	48.6	930	1905	45.3	862
0	80	0	1929	50.4	973	1961	45.2	884
100	80	0	2145	48.5	1040	1980	46.4	918
0	0	100	1801	50.2	903	1876	46.0	863
100	0	100	2178	48.4	1050	1976	45.6	900
0	80	100	2012	50.0	1007	1999	45.4	906
100	80	100	2305	48.5	1117	1813	45.0	815
Significance			**	**	**	NS	NS	NS
B.L.S.D. (.05)			252	1.4	111			
C.V. (%)			8.8	1.8	8.0	12.4	2.6	12.0
Main Effects								
N-Rate lb/A								
0			1823	50.0	912	1937	45.8	886
100			2135	48.5	1034	1918	45.6	874
Significance			**	**	**	NS	NS	NS
B.L.S.D. (.05)			129	.7	57			
P_2O_5 Rate lb/A								
0			1861	49.1	912	1918	45.9	879
80			2098	49.4	1034	1938	45.5	881
Significance			**	NS	**	NS	NS	NS
B.L.S.D. (.05)			129		57			
K_2O Rate lb/A								
0			1884	49.2	927	1940	45.8	889
100			2074	49.3	1019	1916	45.5	871
Significance			**	NS	**	NS	NS	NS
B.L.S.D. (.05)			129		57			

PHOSPHORUS AND POTASSIUM FERTILITY STUDIES ON SUNFLOWER*

G. E. Varvel and R. K. Severson

The objective of these studies were to measure total above ground plant growth, nutrient uptake, seed yield and oil content of sunflower as affected by P and K fertilizer.

Experimental Procedures:
Two locations were used with a P and K experiment at both. A randomized complete block design with 6 treatments was used for all experiments.

Location:	McIntosh	Fosston
Variety:	USDA 894	USDA 894
Population:	19,500 Plants/A	23,000 Plants/A
Herbicides:	Fargo-Treflan	Treflan
Planting Date:	April 28, 1980	May 1, 1980
Harvest Date:	Sept. 23, 1980	Sept. 23, 1980
Soil Test Levels:		
NO_3-N (0-2')	100 lb/A	140 lb/A
$NaHCO_3$ P (0-6")	14 lb/A	23 lb/A
K (0-6")	310 lb/A	365 lb/A
pH (0-6")	8.0	8.1

At Fosston and McIntosh, the P studies had 100 lb/A K_2O and 80 lb/A N broadcast over the entire experimental areas while the K studies had 120 lb/A P_2O_5 and 80 lb/A N broadcast over the entire experimental area.

Results:
Results for each location are shown in the following tables. A significant yield response to P was obtained at the McIntosh location (Table 1). No significant yield response was obtained for K at either location or for P at the Fosston location (Tables 1 and 2). Oil content was not affected by the treatments at any of the locations (Tables 1 and 2).

Fosston P Study: Above ground dry matter yields and elemental analyses are shown in Tables 3, 4 and 5 for the June 23, July 29 and September 4 sampling dates respectively. Differences in some of the nutrient contents at the various dates are not well explained by the treatments. No significant difference in dry matter yield, P content of the plant or P uptake was obtained.

Leaf samples were also taken on July 29 and the elemental analyses are shown in Table 6. Phosphorus, Mg and Zn content of the leaf were affected, but somewhat erratically. In general, P and Mg content increased and Zn levels decreased with additions of P fertilizer.

Fosston K Study: Above ground dry matter yields and elemental analyses are shown in Tables 7, 8 and 9 for the June 23, July 29 and September 4 sampling dates respectively. Potassium content of the plant was significantly increased by the addition of potassium at the August 4 sampling. No significant differences in elemental analyses, total dry matter or K_2O uptake were obtained.

Leaf samples were taken on July 29 and the elemental analyses are shown in Table 10. Potassium content increased and Mg content decreased with the addition of K fertilizer. Zinc differences seem to have no relationship to the fertilizer treatments.

* Project financed in part by Potash and Phosphate Institute of America.

McIntosh P Study: Above ground dry matter yields and elemental analyses are shown in Tables 11, 12 and 13 for the June 24, July 29 and September 4 sampling dates respectively. Phosphorus content of the plant and P_2O_5 uptake were significantly increased by the addition of phosphorus fertilizer at all three sampling dates. Total dry matter at the June 24 sampling and Zn and Cu analyses at the July 29 sampling dates were also significantly affected by the fertilizer treatments.

Leaf samples taken on July 29 and the elemental analyses are shown in Table 14. Phosphorus content increased and Zn and Cu content decreased signficantly with the addition of P fertilizer.

McIntosh K Study: Above ground dry matter yield and elemental analyses are shown in Tables 15, 16 and 17 for the June 24, July 29 and September 4 sampling dates respectively. Magnesium content of the plant was significantly reduced at the first and second sampling date. No other significant differences were obtained.

Leaf samples were taken on July 29 and the elemental analyses are shown in Table 18. Potassium content increased and Mg content decreased as the rate of applied K increased.

Conclusions:
Results from the four experiments reported here correlate very well with responses predicted by the soil test levels. A significant response to P was obtained at the McIntosh location which had a medium P soil test. Soil test results at the other three locations were all high and no responses were obtained.

Table 1. The effect of P on sunflower seed yield and oil content in 1980.

P_2O_5	Seed			
	Yield		Oil Content	
Rate	McIntosh	Fosston	McIntosh	Fosston
lb/A	-lb/A-		-%-	
0	1940	1990	48.8	46.0
40	2400	2100	48.1	45.1
80	2310	2100	48.2	45.8
120	2380	2300	47.5	44.8
160	2340	2170	47.4	45.6
200	2470	2310	47.4	44.8
Significance	*	NS	NS	NS
B.L.S.D. (.05)	320			
C.V. (%)	8.4	11.1	1.8	1.6

Table 2. The effect of K on sunflower seed yield and oil content in 1980.

K_2O	Seed			
	Yield		Oil Content	
Rate	McIntosh	Fosston	McIntosh	Fosston
lb/A	-lb/A-		-%-	
0	2500	1920	47.9	46.6
50	2400	1930	47.6	47.6
100	2260	1860	48.0	47.1
150	2180	2090	47.9	47.2
200	2360	2080	48.1	46.1
250	2270	2070	48.1	47.0
Significance	NS	NS	NS	NS
C.V. (%)	7.7	12.1	1.7	2.2

Table 3. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately the 18 leaf stage at Fosston.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	3.58	0.29	6.14	2.00	1.06	134	157	129	50	24	8	47	668	4.4
40	3.53	0.28	5.83	2.13	1.02	172	191	122	54	23	8	48	650	4.1
80	3.58	0.29	5.05	2.23	1.22	140	167	173	63	24	8	48	472	3.0
120	3.61	0.30	6.37	1.86	0.99	93	120	105	47	26	10	48	557	3.8
160	3.47	0.29	5.66	2.18	1.11	123	148	190	59	25	8	49	723	4.8
200	3.55	0.30	5.08	1.95	1.35	92	118	271	49	25	9	49	497	3.3
Significance	NS	NS	NS	NS	NS	*	*	NS	**	NS	NS	NS	NS	NS
B.L.S.D. (.05)						52	52		9					
C.V. (%)	6.4	9.5	12.2	11.6	18.7	25.0	20.3	51.5	10.7	6.7	16.6	7.6	27.8	24.3

Table 4. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at Fosston.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	2.11	0.24	3.47	1.43	1.00	69	79	58	36	27	10	50	6949	36.7
40	1.82	0.23	2.95	1.39	1.08	72	79	85	36	27	9	48	7031	37.3
80	1.83	0.22	3.56	1.45	1.02	72	88	40	33	25	9	51	7804	40.2
120	1.83	0.26	3.17	1.50	1.03	84	91	56	38	26	9	51	8652	51.9
160	1.97	0.24	3.34	1.50	1.10	118	125	59	34	24	10	53	6108	34.3
200	1.93	0.24	3.48	1.52	1.04	64	74	52	37	23	9	49	6238	34.0
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	12.5	15.3	11.7	5.9	9.1	41.8	35.4	46.5	10.4	9.7	13.0	7.4	21.0	27.7

Table 5. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at Fosston.

P_2O_5 Rate	Elemental Analyses											Total Dry Matter	Uptake P_2O_5
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%				ppm							lb/A	
0	0.22	2.88	1.11	0.75	63	73	78	23	29	11	36	9121	46.1
40	0.21	2.58	0.93	0.75	62	65	101	20	26	9	31	8232	39.3
80	0.23	2.91	1.11	0.73	104	109	63	22	27	10	38	8724	46.7
120	0.24	2.55	1.13	0.78	97	104	146	24	27	10	35	8221	45.2
160	0.24	2.69	1.09	0.74	73	83	80	21	24	10	35	8846	48.9
200	0.24	2.68	1.16	0.77	105	110	108	26	26	10	34	8238	45.8
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	13.5	12.5	11.6	11.1	30.5	24.8	48.3	20.5	12.3	9.3	8.9	18.6	25.5

Table 6. The effect of P on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at Fosston.

P_2O_5 Rate	Elemental Analyses										
	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
lb/A	%					ppm					
0	3.52	0.35	3.77	2.80	1.22	98	75	64	48	24	96
40	3.49	0.38	3.36	2.96	1.40	100	79	75	50	21	97
80	3.62	0.35	3.84	2.91	1.35	99	78	61	42	21	93
120	3.60	0.44	3.46	3.15	1.33	103	79	72	44	21	97
160	3.63	0.36	3.35	2.87	1.47	98	77	58	37	21	89
200	3.53	0.42	3.68	3.07	1.32	102	78	62	42	20	92
Significance	NS	*	NS	NS	*	NS	NS	NS	*	NS	NS
B.L.S.D. (.05)		0.06			0.16				7		
C.V. (%)	6.3	10.4	9.1	7.9	6.9	7.5	10.0	13.8	10.3	11.4	11.2

Table 7. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately the 18 leaf stage at Fosston.

K_2O Rate	Elemental Analyses												Total Dry Matter	Uptake K_2O
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	3.62	0.34	6.08	2.37	1.13	214	232	116	64	26	9	52	636	46.3
50	3.36	0.31	6.05	2.08	1.15	208	210	133	58	26	9	49	888	64.6
100	3.50	0.32	5.55	2.21	1.13	213	271	148	64	26	8	50	767	51.4
150	3.59	0.32	5.74	2.22	1.12	241	254	136	74	27	8	50	807	56.6
200	3.69	0.33	5.89	2.24	1.01	253	265	116	63	25	8	51	612	43.0
250	3.53	0.33	6.35	1.99	1.03	177	189	107	51	24	8	47	746	57.9
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	5.1	11.6	8.6	13.3	9.7	43.0	44.2	30.3	15.0	10.2	13.5	7.8	28.9	32.7

Table 8. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at Fosston.

K_2O Rate	Elemental Analyses												Total Dry Matter	Uptake K_2O
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	1.66	0.17	2.44	1.32	1.00	65	70	54	30	21	8	47	6578	193.5
50	1.75	0.19	2.31	1.34	1.14	69	80	49	37	22	8	48	6304	178.6
100	1.73	0.19	2.94	1.28	0.90	65	71	38	31	23	9	49	5494	192.4
150	1.89	0.19	3.17	1.35	0.75	84	96	38	32	24	9	50	6156	240.2
200	1.74	0.18	3.18	1.28	0.95	73	77	51	28	22	9	47	6672	256.6
250	1.82	0.19	3.50	1.39	0.84	69	74	34	38	26	8	49	5905	247.2
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	10.5	15.0	19.4	12.1	24.4	15.6	16.7	56.4	16.2	13.7	18.6	13.5	18.0	29.4

Table 9. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at Fosston.

K_2O Rate	Elemental Analyses											Total Dry Matter	Uptake K_2O
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%				ppm							lb/A	
0	0.20	2.09	1.19	0.80	108	115	79	25	26	9	38	7131	181.4
50	0.20	2.06	1.05	0.75	93	105	64	28	23	8	38	6498	160.9
100	0.19	2.47	1.17	0.69	125	132	80	25	24	10	40	7490	222.5
150	0.20	2.46	1.08	0.73	99	101	57	24	24	10	36	7156	213.8
200	0.21	2.55	1.14	0.74	92	100	95	24	26	10	39	6613	209.6
250	0.20	2.87	1.19	0.66	89	102	54	27	26	9	38	7495	268.3
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)		0.58											
C.V. (%)	8.6	14.0	7.0	14.8	25.2	20.7	49.2	13.6	8.1	15.4	5.9	18.1	26.3

Table 10. The effect of K on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at Fosston.

K_2O Rate	Elemental Analyses										
	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
lb/A	%					ppm					
0	3.31	0.30	3.26	2.73	1.38	90	70	52	37	18	85
50	3.31	0.29	3.16	2.66	1.48	91	70	62	35	17	85
100	3.36	0.31	3.55	2.55	1.23	86	71	52	31	16	85
150	3.29	0.33	3.85	2.62	1.18	91	76	53	38	21	96
200	3.31	0.31	3.85	2.67	1.26	90	71	53	39	20	90
250	3.47	0.32	3.90	2.67	1.09	92	74	60	37	19	84
Significance	NS	NS	**	NS	*	NS	NS	NS	**	NS	NS
B.L.S.D. (.05)			0.47		0.24				4		
C.V. (%)	6.9	10.7	8.2	10.8	11.3	7.3	6.0	15.6	6.8	19.7	11.3

Table 11. The effect of P on the elemental analyses, dry matter yield and uptake of the sunflower whole plants at approximately the 18 leaf stage at McIntosh.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	3.24	0.29	4.89	1.51	1.31	154	161	157	52	25	10	46	701	4.7
40	3.15	0.31	5.31	1.72	1.34	272	269	168	64	25	11	50	1017	7.2
80	3.05	0.28	5.15	1.61	1.41	151	157	180	50	25	11	48	1003	6.6
120	3.14	0.32	5.01	1.75	1.39	221	221	186	54	23	10	48	919	6.6
160	3.14	0.35	5.57	1.52	1.26	142	149	126	49	20	10	46	898	7.1
200	3.18	0.38	5.07	1.60	1.40	142	152	211	52	24	9	49	1146	9.5
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	**
B.L.S.D. (.05)		0.05											279	
C.V. (%)	6.1	10.5	9.8	12.1	9.8	68.7	60.8	21.8	19.6	14.9	7.8	7.6	17.3	20.6

Table 12. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at McIntosh.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	1.60	0.15	2.70	1.13	1.03	89	97	41	34	21	10	39	6265	21.6
40	1.66	0.20	3.24	1.17	1.03	71	78	41	33	19	10	38	8129	36.7
80	1.73	0.19	2.09	1.15	1.03	85	90	44	33	18	8	33	6031	25.6
120	1.55	0.20	2.66	1.27	1.08	79	86	47	33	20	10	39	7060	33.0
160	1.47	0.20	2.93	1.17	1.06	73	78	60	30	15	8	35	6100	28.2
200	1.77	0.25	2.70	1.19	1.13	71	81	47	34	17	8	38	7142	40.1
Significance	NS	**	NS	NS	NS	NS	NS	NS	NS	**	*	NS	NS	**
B.L.S.D. (.05)		0.05								2	1			10.7
C.V. (%)	11.1	15.2	18.3	8.1	9.8	18.4	15.5	26.9	11.6	8.3	8.7	9.0	14.9	21.6

Table 13. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at McIntosh.

P_2O_5 Rate	Elemental Analyses											Total Dry Matter	Uptake P_2O_5
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%				ppm							lb/A	
0	0.15	2.41	1.11	0.86	155	151	76	28	23	11	33	7469	26.3
40	0.21	2.70	1.05	0.78	133	133	65	25	21	11	32	8384	40.3
80	0.22	2.44	1.17	0.83	174	183	100	28	22	10	33	8349	41.8
120	0.22	2.52	1.19	0.89	158	161	62	27	20	10	33	8597	44.1
160	0.24	2.84	1.22	0.84	140	148	82	26	19	10	33	7847	43.6
200	0.25	2.55	1.23	0.92	177	176	86	30	19	10	33	9073	54.1
Significance	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
B.L.S.D. (.05)	0.04												16.4
C.V. (%)	11.7	14.7	8.2	6.8	14.6	13.8	60.0	7.5	11.0	10.8	6.6	13.8	23.3

Table 14. The effect of P on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at McIntosh.

P_2O_5 Rate	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	%					ppm						
0	3.20	0.25	3.69	2.09	1.29	60	86	11	54	30	22	57
40	3.20	0.27	3.61	2.30	1.33	46	77	8	56	26	19	45
80	3.39	0.28	3.47	2.09	1.39	43	75	6	51	26	18	47
120	3.27	0.32	3.58	2.26	1.41	47	80	7	55	25	20	51
160	3.07	0.36	3.61	2.25	1.36	45	76	6	52	23	18	49
200	3.27	0.38	3.42	2.33	1.54	46	78	8	62	23	17	53
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS	*	*	NS
B.L.S.D. (.05)		0.08								5	3	
C.V. (%)	6.0	16.5	7.6	11.8	8.2	24.6	12.7	31.2	14.5	12.3	9.5	19.3

Table 15. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately the 18 leaf stage at McIntosh.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Total Dry Matter	Uptake K_2O
lb/A	%					ppm							lb/A	
0	3.22	0.31	5.10	1.62	1.46	215	213	235	49	21	11	45	837	51.1
50	3.15	0.32	5.69	1.65	1.13	131	142	130	44	25	10	47	828	56.3
100	3.14	0.34	6.24	1.47	1.10	130	134	127	41	23	9	45	994	76.3
150	3.36	0.31	5.65	1.62	1.04	132	142	161	52	21	10	44	791	52.8
200	3.43	0.34	6.50	1.65	1.13	158	161	136	51	22	10	47	764	58.8
250	3.00	0.28	6.13	1.46	1.07	124	105	149	46	25	10	41	855	61.7
Significance	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)					0.25									
C.V. (%)	8.1	10.8	9.1	16.2	10.9	40.7	32.2	34.3	26.5	15.4	16.9	8.0	26.1	29.6

Table 16. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at McIntosh.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Total Dry Matter	Uptake K_2O
lb/A	%					ppm							lb/A	
0	1.60	0.19	2.63	1.26	1.18	83	89	77	32	17	10	28	6504	206.9
50	1.60	0.27	3.46	1.28	0.85	64	70	41	24	22	9	34	5823	241.5
100	1.46	0.25	3.26	1.21	0.82	106	109	36	23	19	9	34	5365	202.2
150	1.78	0.23	3.60	1.35	0.89	85	90	39	33	19	10	39	6332	273.8
200	1.73	0.22	3.38	1.23	0.90	87	98	41	30	21	9	34	6138	246.6
250	1.52	0.19	3.44	1.21	0.83	72	76	29	28	19	9	34	6844	287.3
Significance	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)					0.20									
C.V. (%)	12.0	22.7	18.9	9.2	11.6	34.3	29.1	43.6	16.4	23.4	18.7	6.7	27.1	36.0

Table 17. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at McIntosh.

K_2O Rate	Elemental Analyses P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Total Dry Matter	Uptake K_2O
lb/A	%				ppm							lb/A	
0	0.20	2.44	1.12	0.81	148	140	67	24	19	11	34	6407	188.3
50	0.25	2.86	1.11	0.63	127	120	46	17	22	10	30	7970	280.7
100	0.26	2.82	1.20	0.64	159	146	39	19	22	11	30	8855	318.6
150	0.21	2.35	1.25	0.72	219	200	60	25	18	10	29	8973	258.4
200	0.22	2.87	1.18	0.72	149	138	48	23	21	10	31	7819	267.2
250	0.19	3.02	1.15	0.69	174	155	48	22	19	10	30	7788	295.3
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	12.9	13.9	16.5	15.5	47.3	44.3	29.1	22.6	18.8	13.1	9.0	21.8	35.6

Table 18. The effect of K on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at McIntosh.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	%					ppm						
0	3.29	0.37	3.66	2.41	1.42	46	74	11	49	21	18	34
50	3.19	0.40	3.67	2.69	1.14	43	74	13	50	28	19	58
100	3.20	0.39	3.61	2.46	1.20	48	82	12	48	24	17	37
150	3.19	0.33	3.93	2.39	1.03	50	76	11	46	25	20	58
200	3.34	0.36	4.01	2.46	1.06	48	77	13	48	30	20	54
250	3.32	0.37	4.32	2.35	0.87	50	77	14	42	29	20	53
Significance	NS	NS	*	NS	*	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)			0.49		0.32							
C.V. (%)	5.9	12.9	7.5	9.3	17.3	18.5	11.8	50.5	22.3	29.2	16.2	32.3

FERTILIZER TRIALS ON SUNFLOWERS - 1980

C. J. Overdahl, S. D. Evans, G. W. Randall

Field trials on sunflowers were started in 1978 and continued in 1979 and 1980.

Plots were located at Waseca, Morris, and Becker, Minnesota. Additional trials were conducted by Dr. Varvel in the Crookston area his data and that by William Jokela are reported elsewhere in the annual report. Tables 1 through 7 show results from nitrogen and potash treatments.

Summary of results

Significant responses from nitrogen were observed at Becker and Waseca and a significant response to potash was measured at Becker.

Where nitrogen responses were measured the nitrate-nitrogen tests were quite low such as at Becker and Waseca but at Morris where the nitrate test was quite high, 119 lbs to 5 feet, no response was obtained.

Potassium tests at Becker were very low and were increased with K treatments but best yields were obtained where K tests were still low.

Table 1. Sunflower yields, percent oil, pounds of oil per acre and test weight of sunflowers according to potash treatments on sunflowers. Becker 1980.

lbs. K_2O/A	D.M. #seed/A	% oil (D.M.)	lbs. Oil/A	test wt.
0	1292	45.4	586	26.8
60	1588	47.5	754	27.7
120	1765	48.5	855	27.8
180	1866	48.6	906	27.8
240	1725	47.4	821	28.0
480	1906	48.6	927	28.0
significance	*	*	**	*
BLSD (.05)	345	1.9	173	1.3
C.V.	12.6	2.5	13.6	2.7

120 + 40 + 0 added to all plots in split applications.
160 lbs/acre 18-46-0
60 lbs N preplant
60 lbs N July 1

Table 2. Soil tests and percent K in sunflowers due to potash treatments. Becker 1980.

K_2O lbs/A	Soil test K	% K 5th leaf
0	42	2.76
60	54	2.94
120	60	3.19
180	72	3.43
240	67	3.74
480	104	4.28
significance		**
BLSD (.05)		.37
C.V.		7.7

Table 3. Emission spectrograph analysis of sunflowers from potash treatments, 5th leaf at pollination, Becker 1980.

	%				ppm						
lbs, K_2O/A	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.52	2.75	3.04	1.35	11	58	11	104	44	16	46
60	.50	2.94	3.23	1.11	14	62	10	113	37	17	47
120	.45	3.19	2.91	1.04	14	56	8	100	35	16	45
180	.49	3.43	2.74	.90	22	64	12	100	36	16	43
240	.47	3.74	2.75	.78	22	64	14	103	33	18	43
480	.42	4.28	2.54	.61	25	65	14	90	30	18	40
significant	ns	**	*	**	*	+	ns	ns	**	ns	ns
BLSD (.05)	-	.37	.37	.18	9	6	-	-	4	-	-
C.V.	13.0	7.7	8.0	12.8	29.6	7.3	22.7	16.9	7.9	16.4	13.6

Table 4. Sunflower yields, percent oil, pounds of oil per acre, percent N in leaf and test weight from N treatments, Becker, 1980.

lbs. N/A	D.M. #seed/A	% oil (D.M.)	lbs. oil/A	% N 5th leaf	test wt.
0	1736	48.8	848	3.49	30.2
60	2194	48.6	1065	3.69	29.5
90	2412	47.2	1141	4.09	29.0
120	2318	46.8	1085	4.10	29.4
150	2313	47.4	1099	3.98	29.8
180	2258	46.5	1052	4.04	29.4
significance	*	ns	+	ns	ns
BLSD (.05)	451	-	200	-	-
C.V.	12.0	3.1	12.9	12.9	3.9

Added across all plots:
300 lbs/acre of sul-po-mag plowed down
0 + 17 + 85 as starter

Table 5. Sunflower yields, percent oil, oil in pounds per acre, percent N and test weights, Morris, 1980.

lbs. N/A	D.M. #seed/A	% oil (D.M.)	lbs. oil/A	% N 5th leaf	test wt.
0	1696	42.9	726	3.51	35.4
30	1630	42.7	698	3.51	34.9
60	1881	43.6	819	3.72	35.3
90	1840	42.4	784	3.99	34.9
120	1926	42.2	814	4.15	36.1
150	1908	42.4	810	3.97	35.0
Significance	ns	ns	ns	ns	ns
BLSD (.05)	-	-	-	-	-
C.V.	9.3	2.2	9.7	13.3	2.9

Table 6. Sunflower yields, percent oil, oil pounds per acre, leaf N test weight, population and head diameter. Waseca, 1980.

lbs. N/A	D.M. #seed/A	% oil (D.M.)	lbs. oil/A	% N 5th leaf	test wt.	population x 1000	Head Diam. (CM)
0	2332	48.6	1131	2.80	34.0	21.8	15.1
30	2482	49.3	1223	2.86	33.7	21.6	15.1
60	2776	48.3	1341	2.90	33.7	20.6	16.2
90	2721	48.5	1319	3.00	34.1	21.9	15.6
120	2721	47.9	1305	3.27	34.0	22.4	15.8
150	2894	47.8	1385	3.25	33.8	20.4	17.1
Significance	**	ns	*	ns	ns	**	**
BLSD (.05)	303	-	148	-	-	1.1	1.0
C.V.	9.2	2.1	9.0	14.2	1.8	4.1	5.2

0 + 120 + 200 per acre added to all plots

Table 7. Profile nitrate-nitrogen soil test pounds per acre. Morris and Waseca, 1980.

depth feet	Morris	Waseca
0 - 1	11	29
1 - 2	9	14
2 - 3	17	9
3 - 4	36	12
4 - 5	46	24
Total		
0 - 5	119	88

FERTILIZER TRIALS ON WHEAT ON HIGH FERTILITY SOILS IN NORTHWESTERN MINNESOTA - 1980*

W. E. Jokela, M. O'Leary and T. Courneya

Several trials were established in 1980 to evaluate the effect of starter and/or broadcast fertilizer on the yield and protein content of wheat on high fertility soils in northwestern Minnesota. Due to a serious drought 8 of the 10 trials were abandoned. Yields were reduced substantially in the remaining 2 trails, which are reported here.

I. Starter and broadcast fertilization of wheat in Pennington County.

This experiment was located on a Clearwater loam soil on the farm of Ken Mehrkens near Thief River Falls. Soil pH was 6.7 and phosphorus and potassium tests were 46 and 451 lbs/acre, both very high. Solar variety of wheat was planted on April 23. Adequate nitrogen was applied to all plots.

Four broadcast treatments - 0, 40 P_2O_5 only, 60 K_2O only, and 40 P_2O_5 + 60 K_2O - were applied in four replications in the spring and incorporated with secondary tillage. Half of each broadcast treatment area received drill applied starter at the rate of 170 lbs/acre of 10-20-20. Experimental design was randomized complete block with starter as a split plot treatment.

Table 1. Yield, test weight, and protein content of wheat as affected by fertilizer treatment. Pennington County - (Mehrkens) 1980.

Fertilizer Treatment			Yield	Test wt.	Protein Content
P_2O_5/A	K_2O/A		bu/A	lbs/bu	%
0	0		26.3	61.6	11.5
40	0		28.5	61.8	12.5
0	60		28.4	61.8	11.7
40	60		28.3	61.7	12.5
Significance			ns	ns	ns
No starter			27.4	61.8	12.2
Starter			28.4	61.7	12.0
Significance			+	ns	ns
P	K	Start			
0	0	-	25.4	61.6	11.4
0	0	+	27.2	61.6	11.6
40	0	-	27.6	61.8	12.7
40	0	+	29.3	61.8	12.2
0	60	-	28.3	61.8	11.7
0	60	+	28.6	61.6	11.8
40	60	-	28.1	61.8	12.8
40	60	+	28.6	61.6	12.2
Significance			ns	ns	ns
C.V.			5.5	.5	6.5

*This project was supported in part by funds from the Minnesota Wheat Council.

The effect of fertilizer treatment is shown in Table 1. Broadcast phosphorus and/or potassium had no effect on yield, test weight, or protein content of grain. Starter had no effect except for a 1.0 bushel increase in yield, which was significant at the 10% level.

II. Starter fertilizer on wheat in Marshall County.

This trial was located on the farm of Medard Yutrzenka near Argyle, MN on a site that had been summer fallowed the previous season. When the wheat was seeded, strips the width of the grain drill were left without starter fertilizer and were compared to wheat seeded with drill applied starter. Starter rate was 15 gallons/acre of a 20-10-0 liquid, which supplies approximately 34 lbs of N and 17 lbs of P_2O_5 per acre. Four paired comparisons were made at one site. Soil test results on this high organic matter, loam soil were a pH of 7.6, P test of 49 lbs/acre, (Bray 1, 1:10), and a K test of 372 lbs/acre.

Grain, test weight and protein content are shown in Table 2. There was no significant response to drill applied fertilizer on this high fertility soil under the weather conditions of 1980.

Table 2. Yield, test weight, and protein content of wheat as affected by starter fertilizer. Marshall County (Yutrzenka). 1980.

	Yield bu/A	Test Wt. lbs/bu	Protein Content %
Starter	40.9	63.3	16.2
No starter	42.0	63.9	16.0
Significance	ns	ns	ns

POTASSIUM ON WHEAT - PENNINGTON COUNTY, 1980*

William Jokela and Micheal O'Leary

This trial was established to determine the effect of broadcast applications of potassium on wheat yield, potassium uptake, and soil test level on a soil testing medium in potassium.

Experimental Procedures

The experimental site is located on a Borup loam soil on the Evert Flesche farm in Pennington County. Six rates of potassium were broadcast and incorporated with secondary tillage. Plot design was randomized complete block with four replications. Solar variety of wheat was planted and 100 lbs/acre of 18-46-0 fertilizer was applied as a starter with the drill to all plots. Soil test results are shown in Table 1. Potassium level is medium (158 lbs/A) in the surface layer and low in the subsurface layers.

Results and Discussion

Yield, test weight, and protein percentage of grain and yield and potassium uptake of forage at soft dough stage are shown in Table 2. There were no significant differences in grain yield or percent protein or in forage yield or potassium uptake. Test weight was significant at the 10% level, increasing slightly with increase in potash applications. Both forage and grain yield were low and highly variable due to drought conditions.

Nutrient content of whole plants at soft dough stage are shown in Table 3. Potassium in the forage increased and magnesium decreased consistently with increasing potash application rate.

Some other elements showed a significant difference but the generally decreasing trend was variable, perhaps due to dilution effects with the variable forage yield.

Drought conditions in 1980 reduced yields substantially, probably contributing to the lack of yield response.

Table 1. Soil test results. Pennington County (E. Flesche). Spring 1980.

Depth (inches)	pH	P* (lbs/A)	K (lbs/A)
0 - 6	7.8	28	158
6 - 12	8.0	7	92
12 - 18	8.1	2	48

*Bray 1 (1:50)

*This project was supported in part by funds from the Minnesota Wheat Council.

Table 2. Effect of potassium rate on yield, test weight, and % protein of wheat grain and yield and potassium uptake of forage. Pennington County (E. Flesche). 1980.

K_2O Rate (lbs/A)	Grain			Forage (soft dough)	
	Yield (bu/A)	Test Wt. (lb/bu)	Protein %	Dry Matter (lbs/A)	K uptake (lbs/A)
0	21.1	58.0	17.7	3544	40
40	25.3	58.3	16.8	3886	50
80	28.4	59.2	17.0	4954	67
120	28.2	58.8	18.1	4505	66
160	30.2	59.4	16.5	4506	68
320	24.3	59.0	17.1	4228	58
Significance	ns	+	ns	ns	ns
BLSD (.05)	-	1.0	-	-	-
C.V. (%)	23.8	1.1	7.4	25.3	31.3

Table 3. Effect of potassium rate on nutrient content of whole wheat plants at soft dough stage. Pennington County (E. Flesche). 1980.

K_2O Rate (lbs/A)	%				ppm						
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.177	1.15	.403	.277	160	185	19	57	29	2	13
40	.183	1.28	.340	.262	93	120	25	54	29	2	11
80	.156	1.31	.346	.263	94	117	13	49	24	2	12
120	.167	1.45	.276	.250	58	81	18	44	28	2	13
160	.158	1.46	.326	.256	69	92	16	50	29	2	12
320	.146	1.37	.308	.241	76	101	10	50	25	2	10
Significance	+	*	*	ns	**	**	ns	*	ns	ns	ns
BLSD (.05)	.025	.211	.068	-	47	46	-	8	-	-	-
C.V.	10.6	9.3	12.5	9.3	33.0	25.8	46.3	9.7	11.2	11.4	22.5

COPPER AND MANGANESE FERTILIZATION OF WHEAT ON AN ORGANIC SOIL

Roseau County - 1980*

C. A. Simkins, W. E. Jokela, and M. O'Leary

Attempts to raise wheat on organic soils in the Roseau County area in recent years have been largely unsuccessful. In addition to limitations due to the short growing season there have been production problems that appear to be caused by nutrient deficiencies. Some fields were diagnosed as showing copper deficiency, but applications of copper on wheat in the following year did not correct the problem. This trial was conducted on the Roger Welin farm near Roseau, MN on a field where copper had been applied unsuccessfully three years earlier.

Experimental Procedures

The experiment was located on a high pH organic soil consisting of 1½ to 2 feet of peat over clay mineral soil. Soil test results are shown in Table 1. Plot design was a randomized complete block with four replications and five treatments. The fertilizer treatments consisted of a no fertilizer check and four NPK treatments with or without copper and/or manganese, applied as indicated in Table 2. Fertilizer was applied at the time of seeding on May 13.

Results and Discussion

Yield, test weight, and protein percentage of grain are shown in Table 2. Yields were low due to a late spring frost and an extremely dry growing season, but the manganese treatments resulted in large and significant yield increases over the other treatments. Yield from the NPK application was not significantly greater than the absolute check, and the application of copper did not increase yields significantly over the NPK treatment.

These limited results from one year indicate that the application of manganese may be beneficial in increasing wheat yields on high pH organic soils where nutrient related production problems have occurred. There is not adequate information available to know if a soil test can be used to determine the need for manganese on these soils.

Table 1. Soil test results on organic soil. Roseau County (Welin farm), 1980.

pH	P*	K	S	Zn*	Cu*	Mn*
	lbs/A		ppm			
7.7	26	64	40+	7.1	4.7	50.9

*Extractant is Bray 1 (1:10) for P and DTPA for Zn, Cu, and Mn.

*This project was supported in part by funds form the Minnesota Wheat Council.

Table 2. Yield, test weight, and protein percentage of wheat grain as affected by fertilizer treatment. Roseau County (Welin). 1980.

Fertilizer Treatment	Grain Yield (bu/A)	Test Weight (lb/bu)	% protein
Check	13.5	51.5	14.8
NPK[1]	16.0	50.7	15.6
NPK + Cu[2]	17.8	51.8	15.2
NPK + Mn[3]	25.6	53.2	15.8
NPK + Cu + Mn	24.5	52.7	16.0
Significance	**	+	*
BLSD (.05)	3.4	1.6	0.8
C.V. (%)	12.1	2.1	3.2

[1]40 N, 40 P_2O_5, and 120 K_2O (lbs/A) applied broadcast and disked in prior to seeding.
[2]24 lb/A copper sulfate (6 lbs/A Cu) applied broadcast and disked in prior to seeding.
[3]64 lb/A manganese sulfate (16 lbs/A Mn) drill applied with the seed.

N Rate, Source, and Incorporation Study - Wheat

W. Nelson, S. Evans, J. Lensing, M. O'Leary and H. Meredith

Objective of Study: Delineate effect of N fertilization on wheat yields when broadcast N forms are incorporated into the soil surface or left on the surface unincorporated.

Locations: Morris and Lamberton Experiment Stations.

N Sources: Urea, ammonium nitrate and 28% urea ammonium nitrate solution.

N Rate: 0, 40, and 80 pounds N per acre.

	Morris	Lamberton
Date of Planting:		
	April 18	April 22
Nitrogen application:		
Incorporation	April 18	April 22
Nonincorporation	April 18	April 23
Previous Crop:	Corn	Wheat
Grain harvested:	July 29	July 31
Seeding rate:	1-3/4 bu/A	
Starter Fertilizer:	115#/A of 0-26-26	
Herbicide:	¼#/A Bromoxynil + ¼#/A MCPA ester	
Soil Test Data:		
	pH - 7.5 P - 19 K - 270	

Depth In	NO_3-N Lb/A
0-1	10.5
1-2	10.5
2-3	8.0
3-4	8.5
4-5	6.9

Table 1. Maximum Temperatures °F at Lamberton and Morris Experiment Stations Ten Days Following Application of N Sources, 1980.

Date	Morris	Date	Lamberton
4/18	73	4/23	81
4/19	76	4/24	64
4/20	77	4/25	58
4/21	93	4/26	62
4/22	98	4/27	56
4/23	72	4/28	72
4/24	64	4/29	71
4/25	60	4/30	71
4/26	65	5/1	78
4/27	58	5/2	81

Note: There was no recorded moisture over the 10 day period following application of nitrogen.

Table 2. Available Water From Nonfertilized Plots From the N Source x Incorporation Study at Lamberton Experiment Station, 1980 (Sampled 5/2/80).

Depth, Ft.	Available Water, In.
0-1	1.24
1-2	.90
2-3	1.02
3-4	1.38
4-5	1.50
Total	6.04

Ave. of 4 reps.

Table 3. Summary of N Rate, Source, Incorporation Study, Lamberton and Morris Experiment Stations, 1978-80.

	Am. Nitrate						Urea						28% N Soln.					
	Incorporated			Nonincorporated			Incorporated			Incorporated			Nonincorporated			Incorporated		
Morris	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80
0	44	13	38	44	13	38	44	13	38	44	13	38	44	13	38	44	13	38
40	46	24	55	51	25	56	53	28	58	51	22	57	50	25	54	44	24	47
80	52	24	70	44	25	70	52	26	60	42	28	66	43	27	50	49	25	58
Sig.	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**
BLSD			8.0			8.0			8.0			8.0			8.0			8.0
CV	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4
Rate x Source x Inc.																		
Sig.			NS			NS			NS			NS			NS			NS
CV			10.4			10.4			10.4			10.4			10.4			10.4
Lamberton																		
0	28	15	36	28	15	36	28	15	36	28	15	36	28	15	36	28	15	36
40	33	20	43	29	19	43	31	19	42	32	20	44	28	20	47	29	18	46
80	33	22	50	28	22	49	30	20	46	30	21	48	30	22	52	31	22	48
Sig.	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**
BLSD (.05)			4.8			4.8			4.8			4.8			4.8			4.8
CV	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4
Rate x Source x Inc.																		
Sig.	NS		NS			NS			NS			NS			NS			NS
CV			6.3			6.3			6.3			6.3			6.3			6.3

Table 4. Summary of Era Wheat Grain Yields When Fertilized With Three Sources of Nitrogen, Lamberton and Morris Experiment Stations, 1980.

			Morris				Lamberton			
N-Rate	Source	Inc.	Bu/A	Grain %N	Grain % Prot.	Test Wt.	Bu/A	Test Wt.	Grain %N	Grain % Prot.
	Check		38.0	1.94	11.1	60.7	36.1	59.6	2.35	13.4
40	AN	+	55.3	1.98	11.3	60.4	43.3	58.9	2.44	13.9
80	AN	+	70.3	2.30	13.1	60.0	49.6	58.5	2.54	14.5
40	Urea	+	58.0	2.00	11.4	60.7	42.1	59.2	2.41	13.7
80	Urea	+	60.0	2.24	12.8	60.3	45.9	58.6	2.40	13.7
40	28%	+	53.6	1.88	10.7	60.5	47.0	59.8	2.39	13.6
80	28%	+	49.8	1.90	10.8	60.2	52.0	59.0	2.51	14.3
40	AN	-	55.6	1.98	11.3	60.8	43.4	59.5	2.44	13.9
80	AN	-	70.4	2.22	12.7	60.6	48.6	56.7	2.68	15.3
40	Urea	-	56.6	1.98	11.3	59.6	44.0	59.3	2.44	13.9
80	Urea	-	65.8	2.23	12.7	59.6	48.3	57.8	2.53	14.4
40	28%	-	47.0	1.99	11.3	60.2	46.4	59.8	2.47	14.1
80	-		58.0	1.97	11.2	60.5	48.0	57.5	2.61	14.9
Signif.			**	**	NS	**	*	**	**	**
BLSD (.05)			8.0	.12	.7	--	4.8	2.0	.18	1.1
C.V.			10.4	4.3	4.3	1.3	7.4	2.0	4.5	4.5
Rate x Source x Inc.										
Signif.			NS	NS	NS	NS	NS	NS	NS	NS
BLSD (.05)			--	--	--	--	--	--	--	--
C.V.			10.4	3.4	3.4	1.1	6.3	2.1	4.6	4.6

Table 5. Summary of Era Wheat Yields Comparing N Sources, Rates and Incorporation, Morris and Lamberton Experiment Stations, 1980.

	Morris				Lamberton			
							Grain	
Rate	Bu/A	Grain %N	Grain % Prot.	Test Wt.	Bu/A	Test Wt.	%N	% Prot.
40	54.4	1.97	11.2	60.4	44.4	59.4	2.43	13.9
80	62.3	2.14	12.2	60.2	48.7	58.0	2.55	14.5
Signif.	**	**	**	NS	**	**	**	**
BLSD (.05)	3.6	.04	.2	--	1.7	.7	.07	.4
Source								
AN	62.9	2.12	12.1	60.4	46.2	58.4	2.53	14.4
Urea	60.0	2.11	12.0	60.0	45.1	58.7	2.44	13.9
28%	52.1	1.93	11.0	60.4	48.3	59.0	2.50	14.2
Signif.	**	**	**	NS	*	NS	NS	NS
BLSD (.05)	4.1	.05	.3	--	2.1	--	--	--
Incorporation								
Yes	57.8	2.05	11.7	60.3	46.6	59.0	2.45	14.0
No	58.9	2.06	11.7	60.2	46.4	58.4	2.53	14.4
Signif.	NS	NS	NS	NS	NS	NS	*	*
BLSD (.05)	--	--	--	--	--	--	.07	.4
C.V.	10.4	3.4	3.4	1.1	6.3	2.1	4.6	4.6

Table 6. Statistical Analyses of N Sources x Incorporation Study, Morris and Lamberton Experiment Stations, 1980.

		Morris				Lamberton		Grain	
Rate x	Source	Bu/A	Grain %N	Grain % Prot.	Test Wt.	Bu/A	Test Wt.	%N	% Prot.
40	AN	55.5	1.98	11.3	60.6	43.3	59.2	2.44	13.9
40	Urea	57.3	1.99	11.4	60.2	43.1	59.2	2.42	13.8
40	28%	50.3	1.94	11.0	60.4	46.7	59.8	2.43	13.8
80	AN	70.3	2.26	12.9	60.3	49.1	57.6	2.61	14.9
80	Urea	62.8	2.24	12.7	59.9	47.1	58.2	2.46	14.0
80	28%	54.0	1.93	11.0	60.4	50.0	58.3	2.56	14.6
Signif.		*	**	**	NS	NS	NS	NS	NS
BLSD (.05)		6.4	.07	.4	--	--	--	--	--
Rate x	Inc.								
40	+	55.7	1.95	11.1	60.5	44.1	59.3	2.41	13.8
40	-	53.1	1.98	11.3	60.2	44.6	59.4	2.45	14.0
80	+	59.9	2.14	12.2	60.2	49.2	58.7	2.48	14.2
80	-	64.7	2.14	12.2	60.3	48.3	57.3	2.61	14.9
Signif.		*	NS	NS	NS	NS	**	NS	NS
BLSD (.05)		4.4	--	--	--	--	1.0	--	--
Source x	Inc.								
AN	+	62.8	2.14	12.2	60.2	46.4	58.7	2.49	14.2
AN	-	63.0	2.10	12.0	60.7	46.0	58.1	2.56	14.6
Urea	+	59.9	2.12	12.1	60.5	44.0	58.9	2.40	13.7
Urea	-	61.2	2.11	12.0	59.6	46.1	58.5	2.48	14.2
28%	+	51.7	1.89	10.8	60.4	49.4	59.4	2.45	14.0
28%	-	52.5	1.98	11.3	60.4	47.2	58.7	2.54	14.5
Signif.		NS	*	*	*	NS	NS	NS	NS
BLSD (.05)		--	.07	.4	.7	--	--	--	--
C.V.		10.4	3.4	3.4	1.1	6.3	2.1	4.6	4.6

Table 7. Statistical Analyses of Corn Grain From N Source x Incorporation Study, Waseca Experiment Station, 1980.

N-Lbs/A	Source	Inc.	% N
0	-	-	1.40
75	AN	+	1.56
150	AN	+	1.72
75	U	+	1.54
150	U	+	1.74
75	UAN	+	1.54
150	UAN	+	1.66
75	AN	-	1.62
150	AN	-	1.61
75	U	-	1.57
150	U	-	1.69
75	UAN	-	1.55
150	UAN	-	1.65
Significance			**
BLSD (.05)			.09
C.V.			5.3

N Rate

75	1.56	
150	1.68	
Significance	**	
BLSD (.05)	.03	Rate x Source
		NS

N Rate x Incorporation

				Form
75	+	1.55		NS
75	-	1.58		
150	+	1.71		
150	-	1.65		Incorporation
				NS
Significance		*		
BLSD (.05)		.06		

Rate x Form x Incorporation

NS

Form x Incorporation

NS

WILD RICE FERTILIZATION RESEARCH - 1980

A PROGRESS REPORT
December 18, 1980

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Research was continued during 1980 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. Two nitrogen experiments were conducted with the Netum variety on a mineral soil at Grand Rapids. A fertilization trial was conducted with K2 wild rice on peat in Aitkin County. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

The growing season of 1980 started exceptionally early and higher than normal temperature during April and May advanced plant development ahead of the usual pattern. At Grand Rapids, for example, the average air temperature (Table 1) was 6.2° and 7.2°F above normal during April and May, respectively.

Soil, water and air temperatures were measured at three locations by automatic sensing and recording thermographs (see Fig. 1, 2, 3). Water temperature was not recorded at Gully because of an instrument malfunction.

The air and water temperatures, as expected, fluctuated more than the soil temperature. The mineral soil at Grand Rapids also showed greater temperature fluctuations than the two organic soils. The temperature of both organic soils measured about 45°F during plant emergence on May 2, increased to about 55° by mid-May and remained somewhat constant within the range of 55-65° for the rest of the season.

Plants emerged on May 2 at Grand Rapids and in Aitkin County (Fig. 4, 5). The jointing stage was reached by Netum (2nd year stand) at Grand Rapids on June 12, 41 days after emergence, and by K2 in Aitkin County on June 25, 54 days after emergence. Netum was harvested on July 30, 89 days after emergence. The K2 in Aitkin County was harvested on August 18, 108 days after emergence. During 1979, for comparison, Netum at Grand Rapids emerged on May 11, reached the jointing stage on July 6 and was harvested on August 2, 108 days after emergence. The K2 variety in Aitkin County emerged on May 8, 1979, reached the jointing stage on July 9 and was harvested on August 28, 112 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
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M	68.5	71.0	64.6	62.9	3466
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
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
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
1979	37.7	50.6M	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394

1/ Source: Climatological Data, Minnesota, Vol. 80-86 (1974-80), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

Figure 1.

MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS-1980

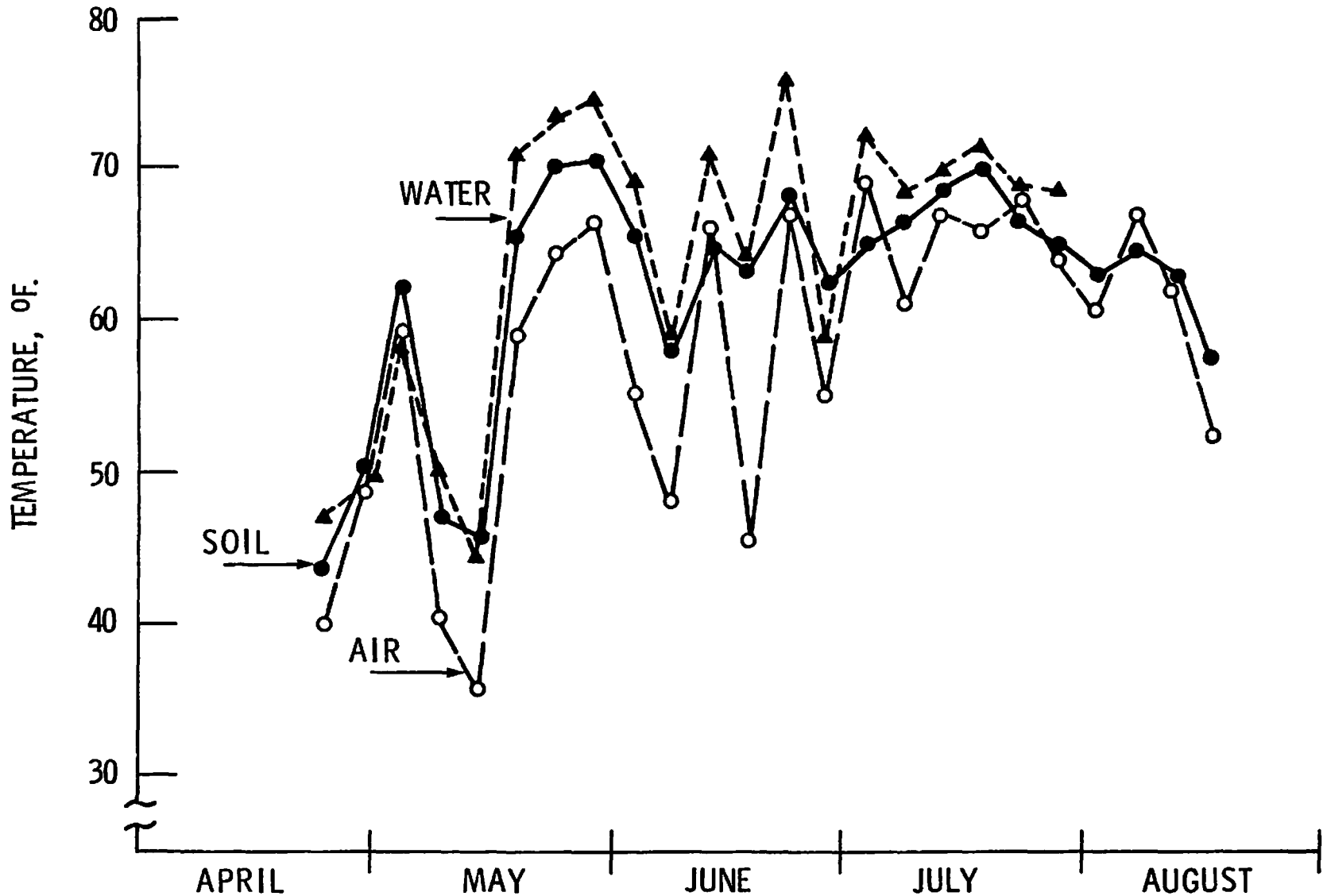


Figure 2.

MEAN AIR, WATER AND SOIL TEMPERATURES
KOSBAU BROS., AITKIN CO.-1980

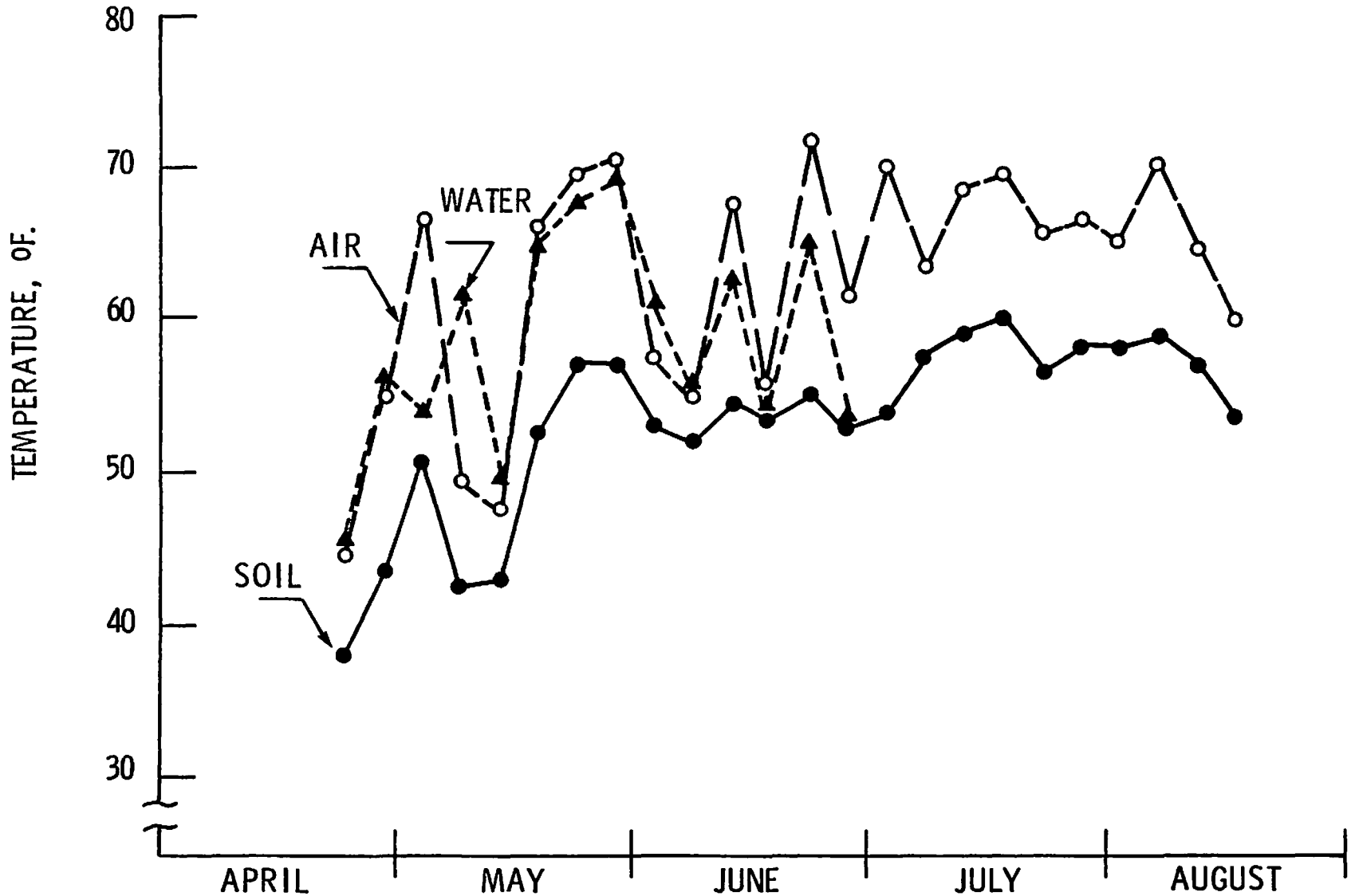


Figure 3.

MEAN AIR AND SOIL TEMPERATURES
GULLY-1980

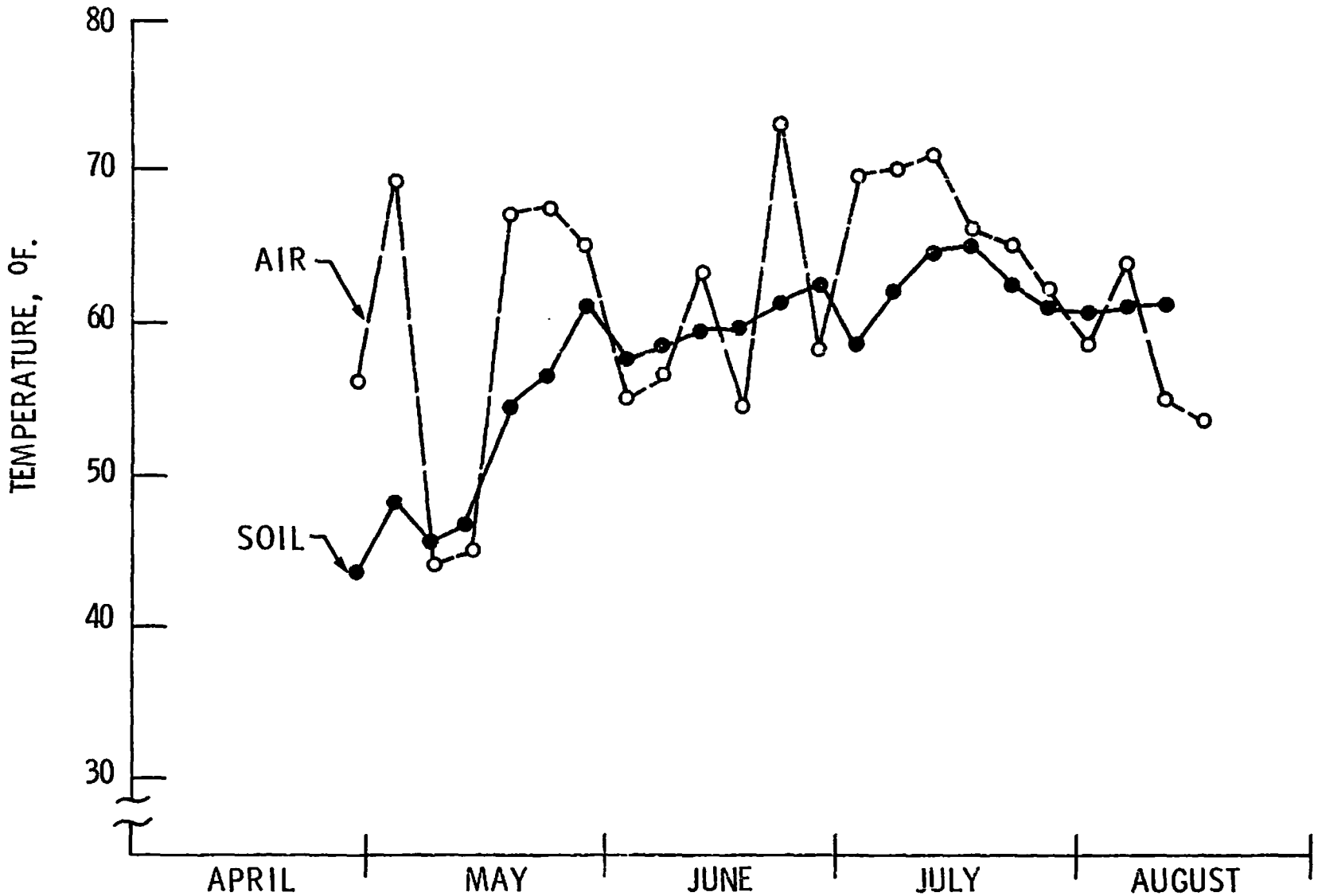
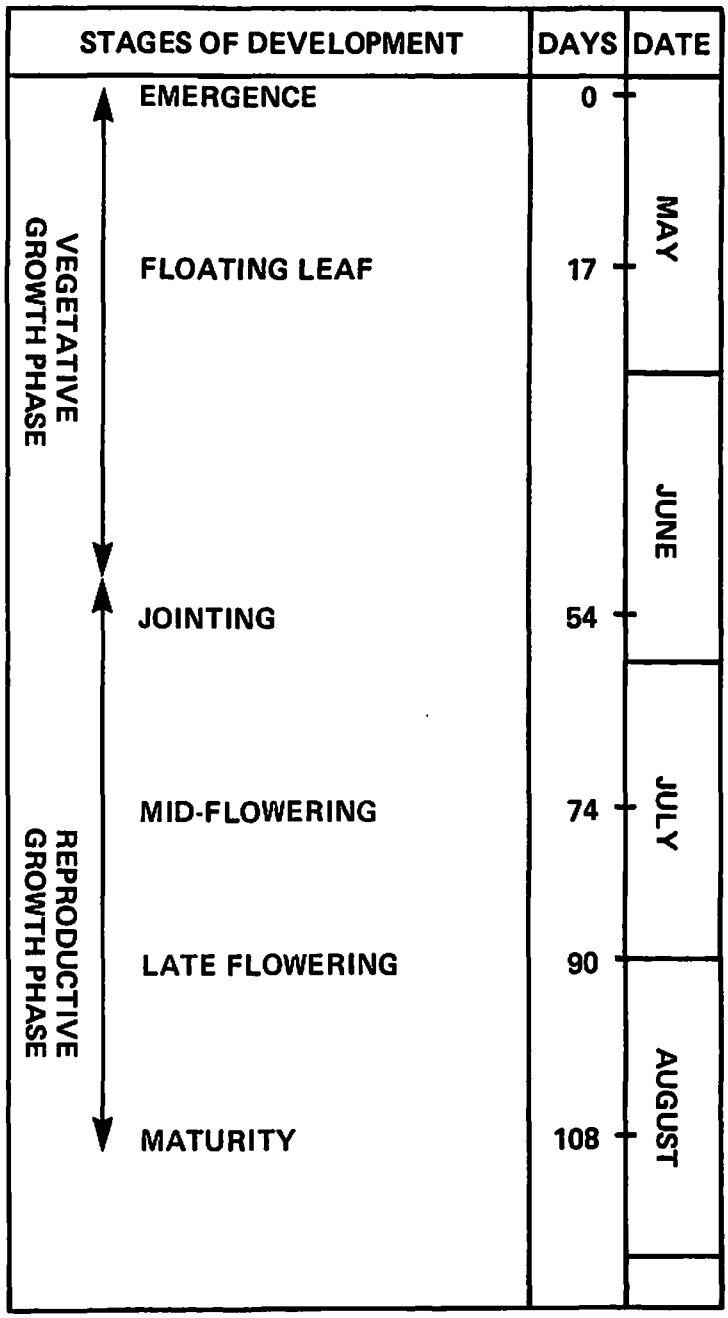


Figure 4. WILD RICE DEVELOPMENT
NETUM VARIETY, 2ND YEAR STAND
GRAND RAPIDS, 1980

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	11	
	AERIAL LEAF	21	
	TILLERING	34	JUNE
REPRODUCTIVE GROWTH PHASE	JOINTING	41	
	BOOT	46	
	HEADING	51	
	MID-FLOWERING	62	JULY
	LATE FLOWERING	74	
	MATURITY	89	

Figure 5. WILD RICE DEVELOPMENT
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1980



B. CHEMICAL CHARACTERISTICS OF PADDY WATER

Water samples were collected from several sites at three different paddy locations during the 1980 growing season. At Grand Rapids, samples were collected from two experimental paddies used for nitrogen studies on mineral soil, and from the Prairie River which was the source of water. Water was also sampled within an experimental paddy in Aitkin County. Paddies at this site derived water from the Little Willow River via a diversion ditch. The third sampling site was in the Imle and Gunvalson paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles, with a preservative added (2 ml 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 data of water is given in Table 2.

The electrical conductivity measurement gives an indication of total concentration of salts in the water. The conductivity of samples from Grand Rapids and Aitkin County locations was relatively low ranging from 0.14 to 0.30 mmhos/cm, while that of the water at Gully ranged from 0.58 to 0.78 mmhos/cm. The hardness of water is a measure of dissolved calcium and magnesium, and is expressed as mg $CaCO_3$/ liter. The water from the Clearwater River was very hard (251 mg/L) while water from the Prairie River and Little Willow River was moderately hard (76 and 63 mg/L).

At Grand Rapids, total N, P and K concentrations of paddy water were slightly higher than those of the river water, and increased as the growing season progressed. Total concentrations in the water ranged from 0.6 to 2.4 ppm N, 0.02 to 0.19 ppm P, and 1.5 to 6.3 ppm K.

At Gully, nutrient concentrations of the water ranged from 1.0 to 4.3 ppm N, 0.07 to 0.25 ppm P, and 3.2 to 9.6 ppm K.

Paddy water at the Aitkin County location had considerably higher concentration of total N, P and K than that found in the river water. Total N concentration of paddy water ranged from 3.2 to 10.0 ppm compared to 0.9 to 2.4 ppm found in samples collected from the diversion ditch. Total P concentration in paddy water ranged from 0.81 to 1.84 ppm compared to 0.05 to 0.23 ppm in the water from the diversion ditch. Potassium levels of paddy water ranged from 3 to 10 ppm while the water from the diversion ditch had a concentration of 1 to 4 ppm K.

The sulfate concentration of water is reported in terms of parts per million of sulfate-sulfur. To convert results to the sulfate form, they must be multiplied by 3. For example, 14 ppm sulfate-S x 3 = 42 ppm sulfate (SO_4) in the water.

The water at Grand Rapids and in Aitkin County, generally, contained about 15 ppm of sulfate. The sulfate concentration of the water at Gully, however, was relatively high (131-157 ppm SO_4).

Table 2. Chemical composition of water collected from wild rice paddies during 1980 growing season.

Sample No.	Sampling Date	Location	Conductivity 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	Na ppm
Location: Grand Rapids															
3.	4/23	EP-E	.19	59.0	62.9	1.5		<0.1	0.07	<0.01	5.0	16.4	4.7	1.7	2.1
4.	4/23	EP-W	.18	60.5	66.9	1.1		0.1	0.07	<0.01	5.1	17.3	5.0	1.5	2.2
5.	4/23	PR	.20	76.0	75.8	1.0		0.1	0.02	<0.01	5.0	20.4	5.5	1.5	2.2
12.	5/22	EP-E	.19			1.6			0.06			19.4	5.3	1.2	2.4
13.	5/22	EP-W	.19			1.0			0.06			19.7	5.2	1.2	2.4
14.	5/22	PR	.22			0.6			0.03			21.4	6.0	1.5	2.4
18.	6/17	EP-E	.17			2.2			0.11			25.1	7.7	3.6	3.6
19.	6/17	EP-W	.18			1.4			0.08			24.9	7.5	2.3	2.8
17.	6/17	PR	.20			0.6			0.04			27.7	7.7	3.3	3.0
26.	7/3	EP-E	.18			0.8			0.10			19.8	6.3	3.7	3.6
27.	7/3	EP-W	.15			0.3			0.05			19.6	6.6	1.6	2.5
28.	7/3	PR	.19			0.8			0.04			26.3	7.1	2.0	2.9
33.	7/23	EP-E	.22			2.4			0.19			25.1	8.2	6.3	4.6
32.	7/23	EP-W	.20			2.1			2.15			27.3	7.8	2.9	3.5
31.	7/23	PR	.20			0.9			0.13			28.2	7.7	4.4	3.3

Abbreviations and description of sampling sites at Grand Rapids: EP-E = Experimental Paddy #1 East; EP-W = Experimental Paddy #1 West; PR = Prairie River.

Table 2 continued.

Sample No.	Sampling Date	Location	Conductivity 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	Na ppm
Location: Kosbau Bros., Aitkin Co.															
1.	4/23	EP	.14	9.5	33.2	10.0		<0.1	0.94	0.08	14.0	7.7	2.5	9.0	3.4
2.	4/23	DD	.18	62.0	62.6	1.7		<0.1	0.06	0.01	5.1	15.8	5.1	1.3	2.6
8.	5/13	EP	.23			4.4			0.42			18.1	5.9	7.7	4.2
9.	5/13	DD	.22			0.9			0.05			20.9	6.6	1.8	3.2
10.	5/22	EP	.26			3.2			0.65			20.7	6.5	1.6	4.5
11.	5/22	DD	.24			2.4			0.09			24.3	7.7	1.9	3.4
16.	6/12	EP	.24			3.3			1.26			30.7	9.8	10.3	5.6
15.	6/12	DD	.24			1.3			0.07			34.0	10.5	3.7	4.3
22.	6/25	EP	.19			8.2			1.84			31.0	10.2	3.1	4.7
23.	6/25	DD	.26			2.1			0.23			41.6	11.9	0.9	4.3
30.	7/7	EP	.26			3.9			0.81			38.7	12.2	6.1	7.3
29.	7/7	DD	.27			2.1			0.13			39.0	12.2	1.9	5.5
34.	7/31	DD	.30			2.4			0.25			45.0	14.1	1.9	5.9

Abbreviations and description of sampling sites at Kosbau Bros.: EP = Experimental Paddy; DD = Diversion Ditch at bridge near the Little Willow River.

Location: Imle and Gunvalson, Gully															
6.	4/28	PP	.60	169.5	247.6	4.3		<0.1	0.21	0.02	52.2	63.1	21.3	9.6	5.2
7.	4/28	CR	.60	210.5	251.4	1.1		<0.1	0.07	0.01	43.6	64.6	21.3	4.0	4.7
20.	6/18	PP	.78			2.9			0.25			121.2	44.6	3.2	9.2
21.	6/18	CR	.61			1.1			0.19			88.5	32.9	5.7	8.0
25.	7/1	PP	.58			1.4			0.11			85.1	32.6	3.9	7.8
24.	7/1	CR	.65			1.0			0.13			94.9	34.5	5.2	8.3

Abbreviations and description of sampling sites at Gully: PP = Production Paddy; CR = Clearwater River.

C. NITROGEN STUDIES ON MINERAL SOIL

Two field experiments were conducted with Netum wild rice on a mineral soil at the North Central Experiment Station, Grand Rapids. Soil tests (Table 3) indicated a very high level of extractable phosphorus (60 and 80 pp2m) and medium to high level of exchangeable potassium (164 and 230 pp2m).

N Rate Trial

The nitrogen rate study, initiated in 1979, was continued on paddy No. 1 East with 2nd year stand of Netum. Four rates of nitrogen were used in this experiment: 0, 20, 40, 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. A randomized block design was used in this experiment. Each nitrogen treatment was replicated five times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. To ensure a sufficient stand, 27 pounds per acre of seed was broadcast - applied by hand on October 17 and rototilled into the soil. Plant density, at harvest, was about 8 plants per square foot. Water level was maintained at about 6 to 10 inches. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 12 (Fig. 4). A 32 sq. ft. area from each plot was hand-harvested on July 30 for yield determination.

Netum wild rice produced 543 to 684 pounds of grain per acre (Table 4). The yield, however, was not affected by the application of nitrogen.

The second leaf at jointing contained 2.63 to 3.37% N, considered to be low to medium concentration (Table 5). The total amount of nitrogen accumulated by the plant at jointing and late flowering stages was relatively low and was not affected by the N treatments (Table 6).

Generally, individual Netum plants in this experiment were somewhat shorter and had fewer tillers than observed in previous seasons. Individual plants had accumulated about 3 and 6.5 grams of dry matter at jointing and late flowering, respectively. This may have been partially due to the exceptionally early and warm growing season which hastened plant development, and to the relatively thick stand (8 plants/sq. ft.). Also the grain yield could have been higher if the harvest had been delayed by about one week.

Table 3. Soil test values of experimental paddies, Grand Rapids.[1)]

Location	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
Paddy No. 1 East	5.8	88	164	18
Paddy No. 1 West	5.7	60	230	18

1) Samples collected from 0-6 inch depth on 10/17/79.

Table 4. Effect of nitrogen application on the yield of Netum wild rice, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	Grain Yield lbs/acre
0	565[1)]
20	543
40	604
80	684
Significance	ns

1) 7% moisture, average of 5 replications

Table 5. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	N % in Dry Matter
0	2.89
20	2.69
40	2.63
80	3.37
Significance	ns

Table 6. Effect of nitrogen application on total uptake of N by the wild rice plant at jointing and late flowering, Netum variety, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	Stage of Development	
	Jointing	Late Flowering
	---N in milligrams per plant---	
0	55	77
20	57	80
40	47	80
80	59	78
Significance	ns	ns

N Rate and Time of Application Trial

This experiment was established in paddy No. 1 West in fall of 1979. The paddy had been in fallow during 1979 and had been fumigated with methyl bromide. Nitrogen treatments consisted of four rates (0, 20, 40, 80 lb N/acre) applied in single (fall) or split-applications (½ fall + ½ jointing, or ½ fall + ½ early flowering). Urea (46-0-0) was the source of nitrogen. Fall-application of urea was made on October 17 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing or early flowering. A randomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Seed of Netum variety was broadcast-applied by hand on October 17 and rototilled into the soil. Plant density, at harvest, ranged from 1 to 2 plants per square foot.

It was extremely difficult to maintain the water level in this paddy at the desired level, particularly during the early stages of plant development. Frequently the surface soil in some areas was not covered with water. This appeared to delay the emergence and development of plants. Generally, the plants of this 1st year stand (Paddy No. 1 West) was from 7 to 10 days behind in development to the 2nd year stand of Netum in Paddy No. 1 East. Jointing stage was reached on June 19. A 16 sq. ft. area from each plot was harvested on August 19 for yield measurement. Harvesting was delayed on purpose to allow the grain to ripen, shatter and thus ensure a sufficient stand of wild rice next season.

Grain yields (7% moisture) ranged from 833 to 1144 lb/acre (Table 7). The yield of wild rice was not affected by any of the nitrogen treatments.

The second leaf at jointing contained 4.33 to 5.05% N, considered to be a relatively high concentration (Table 8). Total nitrogen uptake by the plant at jointing or late flowering was not affected by the N treatments (Table 9).

Generally, the stand in areas that appeared to be most affected by the low water level was sparse, and the plants were shorter and behind in development to normal plants in other areas. The affected plants were light green in color with yellow lower leaves. While these symptoms are generally associated with nitrogen deficiency, they were observed also in plants that had received 40 or 80 lb/acre of nitrogen in the fall. Poor growth of wild rice appeared to be more related to the location within the paddy than to nitrogen treatments.

Table 7. Effect of nitrogen application on the yield of Netum wild rice, 1st year stand, Grand Rapids, 1980.

Treatment No.	N Rate lbs/acre	Time of Application			Grain Yield lbs/acre
		Fall	Jointing	Early Flowering	
		---------N lbs/acre----------			
1	0	-	-	-	1144
2	20	20	-	-	833
3	40	40	-	-	1063
4	40	20	20	-	909
5	40	20	-	20	937
6	80	80	-	-	1141
7	80	40	40	-	960
8	80	40	-	40	1105
Significance					ns

Table 8. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, 1st year stand, Grand Rapids, 1980.

N Rate lbs/acre	N % in Dry Matter
0	4.56
20[1)]	4.88
40[1)]	5.05
80[1)]	4.33

1) Fall applied treatments

Table 9. Effect of nitrogen application on total uptake of N by Netum wild rice, 1st year stand, Grand Rapids, 1980.

Treatment No.	N Rate[1)] lbs/acre	Stage of Development	
		Jointing	Late Flowering
		---N in milligrams per plant---	
1	0	37	165
2	20	29	106
3	40	47	118
4	40	-	127
5	40	-	131
6	80	48	125
7	80	-	124
8	80	-	143

1) See Table 7 for time of application

D. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on organic soil in a Kosbau Bros. paddy in Aitkin County. Relatively high extractable phosphorus (23 pp2m), and medium/low exchangeable potassium (103 pp2m) levels were indicated by soil tests. The soil pH was 5.6. This was an incomplete factorial experiment with six NPK treatments, replicated six times, arranged in randomized blocks. Individual plots occupied a 14 x 16 ft. area. Fertilizer materials (46-0-0, 0-46-0, 0-0-60) were applied by hand on October 18, 1979 and incorporated into the soil by disking. The stand was thinned once by airboat on May 20. Average plant density, at harvest, was 5 plants per square foot.

Plants reached the jointing stage on June 25. The paddy was drained on June 28. A 16 sq. ft. area from each plot was harvested on August 18 for yield determination. Some grain from the primary panicles had been lost through shattering and some grain in the panicles of tillers had not filled. This may explain why the wild rice in this experiment produced only moderate yield (Table 10). Fertilizer treatments had no effect on the yield.

The concentration of nutrient elements in the 2nd leaf at jointing (see Table 10) was relatively high: 3.85-4.29% N, 0.59-0.65% P, 3.67-4.02% K.

Table 10. Effect of fertilization on grain yield and N concentration in 2nd leaf of K2 wild rice at jointing, Kosbau Bros., 1980.

Treatment					Grain Yield	N%	P%	K%
N		P_2O_5		K_2O				
lbs/acre					lbs/acre	in Dry Matter		
None					528	4.10	0.59	3.74
0	+	40	+	60	584	3.86	0.59	3.78
30	+	40	+	0	535	4.04	0.60	3.67
30	+	0	+	60	505	3.85	0.61	3.82
30	+	40	+	60	452	4.29	0.65	4.02
60	+	40	+	60	467	3.95	0.64	3.86
Significance					ns	ns	ns	ns

ACKNOWLEDGMENTS

Grateful acknowledgments are made to the following cooperators and University personnel for their assistance during 1980 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; Messrs. Paul Imle and John Gunvalson, East Polk County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Alan Juhnke, and Henry Schumer, University of Minnesota.