SOYBEAN CANOPY AND RESIDUE DATA COLLECTION

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Soil scientists and conservationists use the Universal Soil Loss Equation (USLE) to estimate the amount of soil removed from fields by sheet and rill erosion. The estimates are expressed as long-term annual average losses in tons per acre. The cover and management factor (C factor) is one of six major factors in the equation.

C factors may be derived from tables in Predicting Rainfall Erosion Losses, U.S.D.A. Agriculture Handbook 537, by W.H. Wischmeier and D.D. Smith (1978). But dates when crop canopies protect 10, 50, and 75 percent of the soil surface must be known for such derivations. The percent of ground protected at maximum canopy, the date when maximum canopy is achieved and the percent of ground covered by residues after harvest must also be known.

Two of the variables, presumably affecting time to achieve various canopy levels, are row spacing and time of planting. Additionally, soybeans do not maintain maximum canopy through harvest. The Wischmeier tables assume they do. Soybean leaf residues are also known to disintegrate rapidly after leaf fall.

More knowledge of dates when various canopy levels are achieved, amount of canopy decline in the latter part of the growing season, and the amount of residue protection afforded the soil from leaf fall to tillage would be useful and reduce the amount of "guesstimation" that becomes a part of estimating soil losses. Increased confidence in the USLE would also occur.

Procedures

A five-year project was started in 1981 to gather the type of information discussed above (Table 1). County extension agents in nine counties collected data from 20 fields (Table 2). The agents were asked to use the line-transect method in MN Extension Folder 477, Estimating the Effects of Crop Residue Mulches on Soil Erosion by Water, to estimate the percent of soil surface covered by canopy or residues. Plant populations were estimated at the 10 percent canopy level by counts in a representative portion of the field. Yield information was provided by the farmers.

General Results

The following data are very preliminary. No statistical analyses were performed on the 1981 data. The average planting date was May 22 with plantings ranging from May 11th to June 5th. Row widths were tabulated in 3 groupings; 8 fields had rows between 6 and 14 inches apart. Nine fields had 30-inch spacings and 3 fields had 36- to 38-inch spacings. Plant populations ranged from 82,000 to 286,000 plants per acre when estimated at 10 percent canopy.

Generally, fields with wide row spacing required more days to achieve various canopy percentages than fields with narrower spacings (Table 3). This trend was most noticeable in fields planted between May 19 and May 25 (data not shown).

Fields planted between May 10 and May 18, in general, required more days to achieve the various canopy levels than fields planted later (Tables 4a and 4b). This trend was most noticeable with narrow row spacings. Average dates when various canopy levels were reached are shown in Tables 5a and 5b.

Maximum percent of ground protected by canopy ranged from 85 to 100 percent. By harvest time, canopy levels generally had decreased to an average of 30 percent canopy and ranged from 0 to 95 percent canopy. The percent of ground covered by surface residue at harvest averaged 55 percent and ranged from 20 to 100 percent.

The average soybean yield was 41 bushels per acre.

Fall tillage, where done, decreased the percentage of ground covered by residue by 70 to 90 percent. Percent of ground covered after tillage averaged 10 percent and ranged from 2 to 35 percent.

Table 1. Information gathered.

Row spacing
Plant population
Planting date
Canopy and residue cover (measured as percent soil surface protected from raindrops)
Canopy heights
Yield
Type and date of fall tillage

Table 2. Participating counties.

Varietal maturity zone	County	Number of Fields
Southern	Steele	2
	Waseca	3
South Central	Goodhue	3
	Lincoln	1
	Lyon	1
	Pipestone	4
	Renville	3
	Swift	1
Central	Grant	1

Table 3. Average number of days to different canopy levels

Row width (in)	Percent of soil surface protected by canopy 10	50	75	Maximum	Number of Fields sampled
	- - -days after planting- - - -				
6-7	17.6	37.4	45	53	5
12-14	25	43.7	52	60	3
30	24	51	67	80	9
36-38	31	52	55	72	3

Table 4a. Average number of days to different canopy levels on fields with 6-14 inch rows.

Planting date (1981)	Percent of soil surface protected by canopy 10	50	75	Maximum	Number of Fields sampled
	- - - -days after planting- - - -				
5/10-5/18	29	48	55	62	2
5/19-5/25	17.5	36	44	53	5
5/26-6/5	-	-	-	-	-

Table 4b. Average number of days to different canopy levels on fields with 30-36 inch rows.

Planting date (1981)	Percent of soil surface protected by canopy 10	50	75	Maximum	Number of Fields sampled
	- - - -days after planting- - - -				
5/10-5/18	35	53	67	73	3
5/19-5/25	27	52	68	82	5
5/26-6/5	19	42	55	72	4

Table 5a. Average dates on which fields with 6-14 inch rows achieved various canopy levels.

Planting date	Percent of soil surface protected by canopy 10	50	75	Maximum
	- - - - -Date (1981)- - - -			
5/10-1/18	6/9	6/28	7/6	7/12
5/19-5/25	6/7	6/28	7/4	7/18
5/26-6/5	--	--	--	--

Table 5b. Average dates on which fields with 30-36 inch rows achieved various canopy levels.

Planting date	Percent of soil surface protected by canopy 10	50	75	Maximum
- - - - - - - - - Date (1981)- - - - - - - -				
5/11-5/18	6/18	7/7	7/21	8/3
5/19-5/25	6/17	7/12	7/26	8/11
5/26-6/5	6/20	7/14	7/29	8/10

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO WHEAT AND SOYBEAN YIELDS

W.E. Jokela, W.E. Fenster, M. O'Leary, G. Buzicky and C.J. Overdahl

Seven experiments were established in Western Minnesota in 1981 to evaluate three P soil tests and their relationship to response from P additions. Wheat was grown on six sites and soybeans on the other.

The three soil tests were Bray No. 1 1:10 ratio of soil to reagent, Bray No. 1 1:50 ratio and Olsen's bicarbonate test. The Bray No. 1 tests are affected by high soil pH while Olsen's test is largely indepent of pH. The Olsen tests were run by the North Dakota State University Laboratory. At four of the locations starter and no starter comparisons were made in addition to the four broadcast P treatments.

Table 2 gives yields of wheat and soybeans plus initial soil tests. There were no significant yield increases due to P treatment. There was no significant increase in percent P in whole plants for wheat but a significant increase in leaf P on soybeans only at the 10 percent level of confidence.

Table 3 shows plant analysis P and soil test P differences from P additions. The latter according to the three soil test procedures.

The Bray 1:10 ratios tests on these soils with pH above 7.6 appear much too low with the high crops yields, especially when it is apparent that no yield increase was obtained from P treatments.

No correlation with yield was run since no yield increase was obtained. This study will be continued for an additional two years.

Table 1. Soil type, county, and rates of starter fertilizer where used.

	Heineke	Klassen	Morris Sta.	Mehrkens W	Mehrkens S	Eckman	Klenz
County	Swift	Swift	Stevens	Pennington	Pennington	Marshall	Martin
Soil Type	Colvin	Colvin	Doland	Clearwater	Glyndon	Fargo	Webster
Texture	SiCL	SiCL	SiL	Loam	Loam	SiC	CL
Starter Fertilizer[1]							
N	-	-	0	15	15	18	-
P_2O_5	-	-	30	30	30	46	-
K_2O	-	-	0	30	30	0	-

[1]Adequate N and K applied across all plots.

Table 2. Wheat and soybean yields from four phosphate levels broadcast plus starter and no starter at seven locations and corresponding initial P soil test using three methods. 1981.

lbs. P_2O_5/A Broadcast	Heineke	Klassen	Morris Sta.	Mehrkens W.	Mehrkens S.	Eckman	Klenz[1]
	bu/acre						
0	58	47	63	68	47	57	49
30	56	51	64	63	48	61	51
60	58	46	64	62	49	63	51
90	59	49	64	69	50	60	52
significance	ns	ns	ns	*	ns	ns	ns
starter	-	-	64	65	48	62	-
no starter	-	-	64	66	49	59	-
P test lbs/acre (spring)							
Bray 1:10	6	4	15	22	2	9	18
Bray 1:50	19	14	21	33	7	30	36
Olsen's	26	17	11	16	19	16	15
K test lbs/acre	280	421	219	223	170	556	293
pH	7.8	8.0	7.8	7.9	8.0	7.8	7.7
Zn ppm	.4	.3	.3	.4	.6	-	.6

[1]soybeans

Table 3. Plant analysis of entire wheat plant at soft dough stage and uppermost leaves of soybeans and relationship to P treatment and fall soil test. 1981.

lbs. P_2O_5/A Broadcast	Heineke	Klassen	Morris Sta.	Mehrkens W.	Mehrkens S.	Eckman	Klenz
	% P						
0	.17	.15	.16	.16	.19	.16	.35
30	.18	.17	.18	.18	.19	.19	.41
60	.20	.15	.18	.19	.19	.19	.40
90	.18	.17	.20	.18	.20	.17	.40
significance	ns	ns	ns	ns	ns	ns	+
			Bray's 1:10 lbs/A P				
0	5	6	10	2	17	15	13
30	7	4	18	2	21	8	18
60	9	7	23	2	23	5	21
90	7	5	33	4	21	10	27
			Bray's 1:50 lbs/A P				
0	15	15	12	8	24	30	33
30	20	14	23	5	25	22	36
60	33	15	25	9	28	26	39
90	35	15	33	11	25	27	46
			Olsen's lbs/A P				
0	9	16	5	16	9	11	10
30	8	17	22	17	11	13	12
60	17	17	25	21	12	20	14
90	22	18	22	24	13	18	19

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS

W. E. Fenster and C. J. Overdahl

Even though micronutrients for agriculture have been in use for a long time, little or no research has been done to relate soil tests of these elements to their response in the field. Experimental work was initiated with corn at five locations in the spring of 1981. Sulfur and magnesium was also included as a variable at these sites.

The "missing element" technique was used whereby a series of plots each having one of the nutrients omitted and compared to a treatment with all elements included. This design prevented other nutrients from being limiting factors if there was possible interaction. Only one rate of each element was used. Since most of the added nutrients were in the sulfate form the sulfur comparisons were established by themselves on an adjacent area. A boron trial, in addition to being included in the main experiment, was established on an adjacent area in order to have four levels of boron compared. Nitrogen, phosphorus and potassium were applied at or above adequate amounts. All plots were replicated four times.

Yields and plant analysis

Since the results are only for one year no conclusions are drawn. Tables 1 through 5 show the 1981 results. No significant yield increases were obtained but it is apparent that nutrient content in the leaves are increased by treatments (Tables 1 and 3).

Soil test comparisons

There has been fine cooperation of private laboratories in testing soils from these plots. The Harris Laboratory at Lincoln, Nebraska, the A & L Laboratories at Omaha, Nebraska and Minnesota Valley Testing at New Ulm, Minnesota, have run soil analysis from all plots which will contribute a large volume of useful data.

Although many comparisons of treatments vs. yield, plant analysis and soil tests were made in 1981 it is desirable to delay recommendations until a three year study has been completed.

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To the three laboratories making the many tests goes a grateful thanks.

Table 1. Corn yields, plant boron, and soil test boron from four levels of boron applications. 1981.

lbs B/A	yield bu/A[1]	ppm B[1] ear leaf	soil test - ppm[1] hot H_2O
	Jokela Farm - Goodhue Co. non-irrigated Mt. Carroll silt loam		
0	170	4.3	.60
1	178	4.6	
2	175	4.6	
4	174	6.8	
significance	ns	ns	
	Kingston Farm - Dakota Co. - irrigated loamy sand		
0	155	7.0	.25
1	159	8.1	
2	147	11.8	
4	160	18.2	
significance	ns	**	
BLSD (.05)		3.5	
C.V.		21.9	
	Geiger Farm - Morrison Co. irrigated loamy sand		
0	92	4.1	.09
1	87	6.7	
2	90	10.9	
4	90	13.7	
significance	ns	**	
BLSD (.05)		3.4	
C.V.		24.8	

[1]average of 4 replications

Table 2. Corn yields[1] and soil tests at five locations comparing complete treatments of micronutrients plus magnesium to plots using missing element techniques. 1981.

Treatment[2] omitted (-) or added (+)	Martin Yield	Martin Soil Test	Goodhue Yield	Goodhue Soil Test	Dakota[3] Yield	Dakota[3] Soil Test	Morrison[3] Yield	Morrison[3] Soil Test	Pope[3] Yield	Pope[3] Soil Test
none	179	-	173	-	156	-	84	-	129	-
- Mg	181	881	169	580	160	312	85	195	125	567
- Zn	181	0.8	175	2.1	159	1.0	93	1.0	124	1.8
- Fe	182	20	174	55	151	41	89	23	127	54
- Mn	180	41	174	31	159	21	85	6	126	36
- B	178	1.04	177	.60	152	.25	91	.09	126	.51
- Cu	178	1.31	170	.75	157	.46	90	.23	132	1.01
+ complete includes S	184	-	169	-	156	-	89	-	129	-
Significance	ns		ns		ns		ns		ns	

[1]average of 4 replications
[2]pounds per acre of nutrient added Mg = 50, Zn = 10, Fe = 10, Mn = 10, B = 1, Cu = 5.
[3]irrigated sandy loams, Martin and Goodhue Co. plots on non-irrigated fine textured soils.

Table 3. Plant analysis[1] from micronutrient and magnesium treatments. 1981.

Treatment omitted (-) added (+)	Martin -	Martin +	Goodhue -	Goodhue +	Dakota -	Dakota +	Morrison -	Morrison +	Pope -	Pope +
	(ppm except Mg which is %)									
- Mg	.58	.58	.36	.38	.27	.27	.20	.21	.32	.33
- Zn	21	24	35	40	29	34	23	26	25	24
- Fe	93	97	113	109	120	117	221	218	335	330
- Mn	56	61	59	60	76	71	45	38	48	49
- B	4.9	4.6	6.1	6.7	4.9	9.2	4.9	8.0	4.2	4.2
- Cu	3.0	3.4	10.7	6.4	10.3	10.2	8.4	9.3	3.8	3.9

[1]average of 4 replications from leaf opposite and below ear at silking time.

Table 4. Corn yields[1], plant sulfur, and soil test sulfur with and without sulfur treatments. 1981.

Sulfur Treatment	Martin Yield	Martin Soil Test[2] ppm	Martin Plant Test ppm	Goodhue Yield	Goodhue Soil Test ppm	Goodhue Plant Test ppm	Dakota[3] Yield	Dakota[3] Soil Test ppm	Dakota[3] Plant Test ppm	Pope[3] Yield	Pope[3] Soil Test ppm	Pope[3] Plant Test ppm
none	183	16	.23	181	16	.24	151	6	.24	121	14	.24
50#/A	180	-	.29	179	-	.27	154	-	.25	118	-	.23
Significance	ns			ns			ns			ns		

[1]average of 4 replications
[2]sulfur soil test U of M lab, spring 1981
[3]irrigated sandy loams, Martin and Goodhue County are non-irrigated fine textured soils.

Table 5. Initial soil tests[1] 0 to 6" samples.

	pH	P	K	S	Mg	Texture	OM
Martin	7.2	34	220	16	881	clay loam	H
Goodhue	6.3	63	417	16	580	silt loam	M
Dakota	5.8	70	192	6	312	loamy sand	M
Morrison	6.3	35	190	-	195	loamy sand	L
Pope	5.6	23	152	14	567	sandy loam	M

[1]average of 4 replications.

COPPER FERTILIZATION OF BARLEY ON AN ORGANIC SOIL

Roseau County - 1981

W. E. Jokela and M. O'Leary

Barley has responded to copper fertilization on organic soils in northern Minnesota. But questions remain as to the most effective form and method of application. This study was initiated in response to these questions.

Experimental Procedures

This experiment was conducted on the Habstritt farm in Roseau County, on a site consisting of 1½ to 2 feet of peat over clay mineral soil. Soil analysis of the 0 to 6 inch depth was:

pH	P	K	Cu	Mn
	---lb/A---		--ppm (DTPA)--	
7.0	83	248	1.3	75.6

The five treatments listed in Table 1, were arranged in a randomized complete block design with four replications. Broadcast treatments were applied and incorporated with two passes of a double disk drill on May 13. The row treatment was applied with a drill and Manker barley seeded on May 26. All plots received 40-40-120 (N-P_2O_5-K_2O) broadcast. Forage harvest was taken on July 21 at heading and grain harvest on August 19.

Results and Discussion

Grain yields and forage yields, uptake, and analyses are shown in Table 1 and 2. Highly significant responses of grain and forage yield, as well as content and uptake of several elements, was observed. All copper treatments increased yield, with broadcast solution greater than broadcast dry or row application. Difference in elemental content of forage appear to be primarily due to dilution with the higher yields on the fertilized treatments. Copper concentration in the forage was not significantly increased by application of copper. Variability was very high.

Table 1. Effect of copper treatment on barley grain yield and forage yield and uptake. Roseau Co. (Habstritt). 1981.

Treatment[1] lb Cu/A as $CuSO_4$	Grain Yield Bu/A	Forage (at heading) Dry Matter lb/A	Uptake lbs/A Zn	Mn	Cu
0	9.4	1826	.061	.094	.002
6 row	28.0	2635	.087	.128	.003
6 bdcst sol	40.0	3351	.094	.147	.014
12 bdcst sol	44.9	3597	.109	.148	.006
12 bdcst dry	35.7	2827	.096	.121	.012
Significance	**	**	**	**	ns
BLSD (.05)	7.2	558	.022	.034	-
C.V.	16.0	13.3	15.9	16.4	108.6

[1]Row treatment was applied with the drill. Broadcast treatments were applied either in solution (sol) or as $CuSO_4$ crystals (dry).

Table 2. Effect of copper treatment on elemental analysis of forage. Roseau County (Habstritt). 1981.

Elemental Analysis of Forage (at heading)

Treatment[1] lb Cu/A as $CuSO_4$	%				ppm						
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.46	4.02	.80	.38	24	92	1551	51	34	1.2	8.4
6 row	.39	3.24	.81	.38	22	88	1135	48	34	1.3	6.5
6 bdcst sol	.36	2.73	.83	.40	26	76	1151	44	29	3.8	5.5
12 bdcst sol	.34	2.98	.76	.38	20	71	1532	41	30	1.8	5.0
12 bdcst dry	.39	3.36	.67	.35	20	83	1386	43	34	4.4	4.1
Significance	**	**	ns	ns	ns	**	ns	*	ns	ns	*
BLSD (.05)	.05	.39	-	-	-	10	-	7	-	-	3.0
C.V.	8.6	8.1	11.7	8.5	20.7	8.1	28.0	8.9	11.6	102.0	29.7

[1]Row treatment was applied with the drill. Broadcast treatments were applied either in solution (sol) or as $CuSO_4$ crystals (dry).

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1981

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

EXPERIMENTAL PROCEDURES

Ten P and K treatments (Table 1) were applied at three branch experiment stations (Southern Experiment Station, Waseca; Southwest Experiment Station, Lamberton; and West Central Experiment Station, Morris) in Minnesota. A randomized, complete-block design with four replications was used. The 50-pound rates were estimated to be "maintenance" rates, and the 0, 100 and 150-pound rates provide the response curves for each element. Treatment 5 and 8 receive P and K, respectively, every third year for the duration of the experiment. Treatments 9 and 10, applied in the fall of 1973, did not receive P and K again until the fall of 1978 when the treatments were resumed at Waseca because P appeared to be limiting. These two treatments were resumed at Morris in 1979 for the same reason. All other treatments have been applied annually.

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

Trt. No.	Application Year (Fall) 1973,'76,'79	1974,'75,'77,'78,'80
	----------lb P_2O_5 + K_2O/A----------	
1	0 + 0	0 + 0
2	0 + 100	0 + 100
3	50 + 100	50 + 100
4	100 + 100	100 + 100
5	150 + 100	0 + 100
6	100 + 0	100 + 0
7	100 + 50	100 + 50
8	100 + 150	100 + 0
9[1]	150[2] + 100	0 + 100[3][5]
10[1]	100 + 150[2]	100 + 0[4][6]

[1] Neither P nor K was applied in 1976.

[2] The 150-lb rate was not applied at Lamberton or Waseca in 1979 but was applied at Morris.

[3] 150 + 100 applied at Waseca in 1978.

[4] 100 + 150 applied at Waseca in 1978.

[5] 0 + 100 was applied at all locations in 1980.

[6] 100 + 0 was applied at all locations in 1980.

The P and K materials were broadcast on cornstalks and plowed down at all locations in the fall of 1980. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Zinc was applied at a rate of 10 lb Zn/A as $ZnSO_4$ prior to plowing at Lamberton. Starter fertilizer was not used.

Specific experimental procedures used at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location. Nitrogen rates were slightly higher than optimum.

At Lamberton each of the plots were split with the west half planted to corn and the east half to soybeans. Vickery soybeans were planted in 30-inch rows on April 27 at a rate of 9 seeds/foot. Weeds were controlled with Treflan (3/4#) and Amiben (2#). Plant tissue samples were not taken. Soybeans were combine harvested on September 28.

Weather conditions during 1981 were quite favorable for early planting. However, at Lamberton the soils were so dry that germination was poor, emergence was erratic and weed control was not adequate. Areas in each plot were marked for harvest at about the 8-leaf stage and were hand weeded to optimize corn yields.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1981.

Variable	Lamberton	Morris	Waseca
Planting date	4/24	4/28	5/8
Row spacing	30"	30"	30"
Planting rate	26,000	22,000	30,800
Hybrid	Pioneer 3732	Pioneer 3901	Pioneer 3732
Nitrogen rate	150#	125#	200#
Herbicide	2½# Lasso + 1½# Bladex/A (Bdct)	2½# Lasso + 2 1/5# Bladex/A (Bdct)	3½# Lasso + 3# Bladex/A (Bdct)
Insecticide	1# Counter/A	1.3# Counter/A	1# Counter/A
Harvest date	10/20	10/19	10/31

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1981 growing season. Responses to the treatments were quite similar to those obtained in 1980 except at Lamberton where P values were more than twice as high as in 1980. Soil test P was affected significantly at all three locations (Table 3). There appeared to be an almost linear response to P application rates. Soil test P was always lowest with treatments 1 and 2, which received no P. Intermediate P levels were found with treatment 3 (50 lb P_2O_5 annually) and treatment 5 (150 lb P_2O_5 every third year). Highest soil test P values were associated with the annual 100 lb P_2O_5 treatments at all locations. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio.

Soil test K was influenced (P=.05) by the K treatments at all locations (Table 3). The response to the annual K applications was not as pronounced as with P. But, a linear increase in soil test K was generally shown with the increased K application rates. Soil pH was not related to the P and K treatments.

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

Treatment No.	Treatment Description[2/]	pH La	pH Mo	pH Wa	P La	P M_{10}	P M_{50}	P Wa	K La	K Mo	K Wa
	lb P_2O_5+K_2O/A				lb/A						
1	0 + 0	5.5	7.6	6.1	62	12	28	23	269	330	211
2	0 + 100	5.6	7.7	6.0	54	11	26	18	341	427	254
3	50 + 100	6.0	7.6	5.9	65	32	66	45	301	386	254
4	100 + 100	5.6	7.6	6.0	98	62	112	71	327	421	260
5	0 + 100	5.8	7.6	6.1	76	29	61	46	330	383	268
6	100 + 0	5.6	7.6	6.1	112	65	128	64	257	335	214
7	100 + 50	5.7	7.6	6.1	88	51	108	68	290	339	237
8	100 + 0	5.6	7.5	5.9	101	62	123	62	301	343	240
9	0 + 100	6.0	7.6	6.2	51	30	61	27	292	339	230
10	100 + 0	5.6	7.6	6.1	68	16	40	43	282	332	237
Signif. Level (%):	[3/]	54	NS	46	99	**	**	99	96	**	99
BLSD (.05)	:				22	7	17	10	63	36	32
CV (%)	:	5.9	20.	3.1	20.	16.	17.	16.	12.	7.1	8.3

1/ Samples were taken in October before the 1981 treatments were applied.

2/ Rates applied in fall of 1980 for 1981 crop.

3/ **, *, and + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level. Numeric values for Lamberton and Waseca indicate probability level of statistical significance.

Approximately 8, 7 and 5 weeks after planting at Lamberton, Morris and Waseca, respectively, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine

early plant growth. Early plant weight and height were increased significantly (P=.01) by the treatments at Morris and Waseca (Table 4). Although a definite trend toward increased plant weight appeared with P additions at Lamberton, significant (P=.05) effects were not noted due to the variability. Both plant weight and height were generally lowest with the check treatment (no. 1) and the 0 P_2O_5 treatment (no. 2) indicating that the growth response was due primarily to P. Early weight was increased by the 50 and 100 lb P_2O_5 rates over the 0 P_2O_5 rate (no. 2) by 20 and 29% at Lamberton, 38 and 56% at Morris, and 22 and 40% at Waseca, respectively. Potassium generally did not affect either early plant weight or height.

Table 4. Early plant growth as influenced by high P and K rates at the three experimental sites in 1981.

Treatment		Weight			Height		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	g/dry plant			-------inches-------		
1	0 + 0	12.1	6.1	3.2	40.8	23.0	24.4
2	0 + 100	11.4	6.9	3.7	40.0	24.1	24.0
3	50 + 100	13.7	9.5	4.5	39.0	28.1	26.0
4	100 + 100	14.7	10.8	5.2	43.7	29.8	27.0
5	0 + 100	13.2	9.9	4.0	42.1	28.0	26.2
6	100 + 0	13.9	10.4	4.9	42.9	28.0	26.5
7	100 + 50	14.0	10.0	4.7	39.2	28.1	26.9
8	100 + 0	13.7	11.4	5.0	42.6	31.0	27.0
9	0 + 100	12.2	10.2	3.6	38.8	27.2	24.5
10	100 + 0	13.5	9.0	4.5	43.3	27.0	26.2
Signif. Level(%):		83	**	99	96	**	99
BLSD (.05)	:		1.8	0.5	4.4	1.8	0.9
CV (%)	:	12.	13.	8.7	6.0	4.9	2.6

The small plants from Morris and Waseca were chemically analyzed with the results shown in Table 5. Because of the poor stand and erratic emergence, the plants from Lamberton were not analyzed. Concentrations of P, K, Ca, Mg, Mn and Cu were affected significantly (P=.10) by the treatments at both locations. Whole plant P and K were consistently increased by the P and K treatments while Ca and Mg were generally decreased by the K additions. The response to K rate was more linear than was the P response. Zinc, Mn and Cu concentrations were depressed and B increased with increasing P rates at Morris while Cu was depressed at Waseca. The high Fe and Mn concentrations at Morris are probably due to soil splash into the whorls.

Analysis of the leaf opposite and below the ear at silking indicated significant effects of the P and K treatments at both locations (Table 6). Leaf P was increased by the higher P treatments while K was increased linearly (P=.01) with increasing rates of K. Leaf Ca and Mg were reduced by the K treatments. Leaf Zn concentrations were reduced by the P treatments at both Morris and Waseca.

Planting populations were thinned to uniform stands at Lamberton and Waseca in 1981. A slight difference in final plant population was found at Morris (Table 7). Grain moisture an indication of maturity at harvest was affected inconsistently by the treatments at Lamberton and Waseca (Table 8) but was reduced by the P treatments at Morris.

The influence of the eight years of P and K application on silage and grain yields is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at Morris or Waseca. However, a definite trend toward higher silage yields did appear with the 50 and 100-lb P treatments. Grain yields were affected significantly (P=.01 level) at the Morris and Waseca locations. The response at Morris was associated with a P_2O_5 rate of 50 lb with no additional response to the 100-lb rate. A response to K was not seen at Morris. At Waseca, a definite response was obtained with the 50-lb P_2O_5 rate with slightly higher but not significant (P=.10 level) increases when 100 lb of P_2O_5 was applied. Also, a trend toward slightly higher yields with the K additions was observed at Waseca but was not statistically significant.

Soybean yields were not influenced by the P and K treatments at Lamberton (Table 9). The significance value of 15 indicates that in only 15 times out of 100 could these differences be duplicated under these experimental conditions.

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the two experimental sites in 1981.

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
						Morris				
1	0 + 0	.32	3.47	.62	.60	2173	140	53	9.4	1.4
2	0 + 100	.31	4.45	.53	.49	2064	129	60	9.1	1.7
3	50 + 100	.38	4.41	.54	.49	1410	111	48	8.4	2.3
4	100 + 100	.42	4.46	.56	.48	1192	112	42	8.1	2.6
5	0 + 100	.38	4.23	.54	.51	1250	121	44	9.1	2.6
6	100 + 0	.41	3.04	.70	.69	1143	119	43	8.5	2.6
7	100 + 50	.41	3.86	.64	.54	1627	126	41	8.6	2.2
8	100 + 0	.42	4.01	.58	.58	930	99	42	7.5	2.8
9	0 + 100	.38	3.53	.60	.62	1294	121	45	9.0	2.3
10	100 + 0	.36	3.82	.59	.56	1375	120	45	9.4	2.4
	Significance:	**	**	**	**	**	**	**	**	**
	BLSD (.05) :	.04	.27	.06	.05	511	13	9	1.0	0.6
	CV (%) :	7.1	5.2	7.5	6.7	24.	7.4	12.	7.3	18.
						Waseca				
1	0 + 0	.38	3.48	.54	.52	283	66	53	15.1	7.4
2	0 + 100	.37	4.52	.44	.35	354	56	52	16.0	7.8
3	50 + 100	.40	4.62	.46	.36	306	62	49	14.3	7.4
4	100 + 100	.46	4.58	.49	.36	326	61	48	14.3	7.3
5	0 + 100	.40	4.56	.48	.38	343	62	48	13.4	6.4
6	100 + 0	.45	3.34	.59	.52	336	69	46	13.0	6.8
7	100 + 50	.45	4.04	.53	.42	386	65	50	12.4	7.8
8	100 + 0	.44	4.06	.52	.44	314	66	52	12.3	6.9
9	0 + 100	.39	4.28	.48	.41	330	60	50	16.0	7.3
10	100 + 0	.43	3.85	.53	.44	374	68	49	12.9	7.2
	Signif.Level(%):	99	99	99	99	72	98	76	98	22
	BLSD (.05) :	.02	.30	.04	.05		9	8	2.7	
	CV (%) :	4.0	5.4	5.4	8.7	16	7.9	7.3	12.	15.

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the two experimental sites in 1981.

Treatment No.	Treatment Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	----------%----------				----------ppm----------				
						Morris				
1	0 + 0	.24	1.46	.48	.54	102	83	28	4.5	6.6
2	0 + 100	.24	1.78	.42	.41	102	76	31	4.5	5.6
3	50 + 100	.28	1.70	.50	.46	98	79	22	3.9	4.9
4	100 + 100	.29	1.74	.51	.47	98	78	20	3.9	5.8
5	0 + 100	.28	1.73	.46	.46	96	76	23	3.9	5.9
6	100 + 0	.29	1.38	.56	.61	100	87	20	4.2	6.9
7	100 + 50	.28	1.59	.53	.53	99	83	20	4.2	7.3
8	100 + 0	.29	1.56	.53	.54	96	74	20	3.9	6.4
9	0 + 100	.27	1.41	.53	.61	98	85	23	4.0	6.1
10	100 + 0	.26	1.57	.50	.52	98	83	23	4.3	5.5
	Significance:	**	**	**	**	NS	**	**	*	NS
	BLSD (.05) :	.02	.11	.05	.05		8	3	0.5	
	CV (%) :	5.2	5.1	6.5	6.6	24.	6.	9.5	7.4	18.
						Waseca				
1	0 + 0	.29	1.49	.49	.50	106	76	30	5.1	4.0
2	0 + 100	.28	1.90	.46	.39	104	66	29	5.2	4.2
3	50 + 100	.31	1.97	.47	.39	109	67	26	4.8	4.1
4	100 + 100	.33	1.94	.50	.38	111	66	22	4.2	4.0
5	0 + 100	.31	1.79	.50	.41	109	66	24	4.3	4.0
6	100 + 0	.32	1.38	.54	.51	106	75	22	3.5	3.9
7	100 + 50	.33	1.76	.49	.44	110	68	23	4.5	4.1
8	100 + 0	.31	1.63	.54	.47	110	75	24	4.1	4.0
9	0 + 100	.28	1.82	.49	.43	101	61	25	4.3	5.0
10	100 + 0	.31	1.67	.51	.47	107	64	25	4.8	4.2
	Signif.Level(%):	99	99	99	99	75	37	99	99	22
	BLSD (.05) :	.02	.19	.04	.04			4	.9	
	CV(%) :	4.2	7.9	4.6	6.8	5.0	17.	12.	13.	19.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1981.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Grain Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb P_2O_5+K_2O/A	plants/A x 10^{-3}			---------%---------		
1	0 + 0	20.6	19.2	27.6	22.5	22.0	22.4
2	0 + 100	21.4	18.7	28.7	23.5	22.1	23.0
3	50 + 100	20.6	20.3	27.6	22.5	20.4	22.2
4	100 + 100	21.1	21.4	28.0	22.4	20.2	22.0
5	0 + 100	21.0	20.1	28.1	23.5	20.5	22.2
6	100 + 0	20.6	19.9	27.2	22.2	19.2	22.0
7	100 + 50	20.0	20.3	27.9	23.2	19.7	22.5
8	100 + 0	20.8	20.6	28.2	21.8	19.6	22.3
9	0 + 100	20.4	20.4	28.4	23.8	20.0	22.5
10	100 + 0	20.3	19.7	28.5	21.4	20.7	22.2
	Signif. Level(%):	10	**	63	94	**	99
	BLSD (.05) :		1.0			1.1	0.4
	CV (%) :	5.8	3.4	3.0	4.7	3.8	1.3

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1981.

Treatment		Silage Yield			Grain Yield		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	------T DM/A-------			---------bu/A---------		
1	0 + 0	ND[1/]	6.91	8.63	110.8	120.5	182.9
2	0 + 100		7.06	8.93	111.6	115.2	181.2
3	50 + 100		7.03	9.54	113.9	130.5	190.4
4	100 + 100		7.56	9.05	117.1	136.1	195.7
5	0 + 100		7.74	9.32	111.2	132.0	185.7
6	100 + 0		7.33	9.09	114.6	130.1	188.2
7	100 + 50		7.18	9.31	104.7	132.1	199.3
8	100 + 0		7.68	9.24	113.4	129.4	194.6
9	0 + 100		7.58	9.31	108.8	128.3	193.5
10	100 + 0		7.90	9.46	111.5	129.8	194.1
Signif. Level(%):			NS	52	80	**	99
BLSD (.05)	:					11.1	7.8
CV (%)	:		6.8	5.9	5.0	5.3	2.8

[1/] ND = Not Determined. Silage yields not taken because of erratic stands and growth due to poor emergence.

Table 9. Soybean yields at Lamberton as influenced by high P and K rates in 1981.

Treatment		
No.	Description	Yield
	lb P_2O_5+K_2O/A	bu/A
1	0 + 0	47.7
2	0 + 100	46.0
3	50 + 100	49.5
4	100 + 100	48.6
5	0 + 100	45.9
6	100 + 0	44.5
7	100 + 50	46.5
8	100 + 0	45.5
9	0 + 100	44.6
10	100 + 0	46.3
Significance Level (%):		15
CV (%)	:	9.8

ACKNOWLEDGMENT

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Nitrogen Fertilization and Use of a Nitrification Inhibitor for Corn Production in Southeastern Minnesota - 1981[1]

W.E. Jokela, G.L. Malzer, and M. O'Leary

This study was established to evaluate nitrogen management practices on the well-drained silt loam soils of southeastern Minnesota. Specifically, the objectives were: 1) to determine optimum nitrogen rates for corn production on these soils, 2) to determine if a nitrification inhibitor results in improved N use efficiency or increased yields, 3) to investigate the influence of nitrate-N in the soil profile on N fertilizer response.

Experimental Procedures

Two sites were selected, one on a Seaton silt loam (2.1% O.M.) on the Edwin Graner farm in Wabasha County and the other on a Mount Carroll silt loam (4.2% O.M.) on the Paul Voxland farm in Goodhue County. Treatments at each site consisted of three N rates - 60, 120 (140 in Goodhue Co.), and 180 lbs/A, each applied as anhydrous ammonia with and without a nitrification inhibitor (N-Serve at ½ lb a.i./A), plus a no nitrogen check. Earleaf samples were taken at silking and grain was harvested at physiological maturity. Selected treatments were sampled to five feet in one-foot increments for nitrate analysis prior to planting and after harvest.

At the Wabasha County location corn (Pioneer 3732 variety) was planted on May 8 in 38 inch rows at a population of 24,000 plants/A. 18 lbs N/A was applied to all treatments in the starter. The field had been in corn the previous year and in alfalfa the year before that. No manure had been spread for several years. Tillage was moldboard plowing with two diskings. At the Goodhue County site corn (Pioneer 3906 variety) was planted on May 9 in 30 inch rows at 24,000 plants/A. All treatments received 12 lbs N/A in the starter. The field had been cropped to corn for the five previous years, and no manure had been spread for at least three years. Corn was grown under a till plant system.

Results and Discussion

Results are shown in Table 1.

No significant yield response to N fertilizer or nitrification inhibitor occurred at either location, although there was a trend toward higher yields with applied N. Percent N in the earleaf at silking and, at the Wabasha Co. site, %N in the grain were increased by both N rate and nitrification inhibitor.

The lack of response may be a result of the relatively high nitrate-N levels in the soil profile (Table 2 and 3). The amount of nitrate-N in the 5-foot profile in the spring ranged from about 90 to 140 lbs/A. These levels were depleted by the end of the season at the Wabasha location, suggesting utilization of profile nitrates by the growing crop. Since there was no yield response to N fertilizer, a response to a nitrification inhibitor would not be expected.

[1]This project was supported in part by funds from the Minnesota Plant Food and Chemical Association.

Table 1. Response of corn to N rate and nitrification inhibitor. Wabasha and Goodhue County. 1981.

		Wabasha Co.				Goodhue Co.			
N Rate lbs./A	Inhib[1]	Grain Yield bu/A	Grain %N	Grain N Uptake lb/A	Leaf %N	Grain Yield bu/A	Grain %N	Grain Yield bu/A	Leaf %N
0	-	164.0	1.19	92.7	2.69	156.6	1.38	102.4	2.59
60	-	171.1	1.23	99.8	2.86	169.2	1.48	118.1	2.97
60	+	170.6	1.26	101.6	2.95	168.4	1.48	117.5	3.17
120 (140)	-	179.0	1.24	105.0	2.80	161.1	1.46	111.5	2.95
120 (140)	+	172.9	1.34	109.5	2.91	162.6	1.47	112.8	2.99
180	-	176.2	1.26	105.1	2.83	163.6	1.52	117.3	2.88
180	+	180.0	1.25	106.2	3.00	167.2	1.40	110.8	2.87
signif.		ns	ns	*	+	ns	ns	ns	**
BLSD (.05)		-	.07	11.0	.21	-	-	-	.22
C.V.		5.0	3.6	7.1	4.9	6.4	5.6	8.0	4.8
N Rate									
60		170.8	1.24	100.7	2.90	168.8	1.48	117.8	3.07
120 (140)		176.0	1.29	107.3	2.85	161.9	1.46	112.1	2.87
180		178.1	1.25	105.6	2.92	165.4	1.46	114.1	2.87
signif.		ns	+	ns	ns	ns	ns	ns	*
BLSD (.05)		-	.04	-	-	-	-	-	.16
Inhibitor									
-		175.4	1.24	103.3	2.83	164.6	1.48	115.6	2.93
+		174.5	1.28	105.8	2.95	166.1	1.45	113.7	3.01
signif.		ns	*	ns	*	ns	ns	ns	ns
BLSD (.05)		-	.03	-	.11	-	-	-	-
Factorial N* I									
signif.		ns	*	ns	ns	ns	ns	ns	ns
BLSD (.05)		-	.06	-	-	-	-	-	-
C.V.		5.0	3.1	8.6	4.7	6.8	5.6	8.5	4.7

[1]Inhibitor is "N-Serve" at ½ lb a.i./A.

Table 2. Nitrate-N in the soil profile. Wabasha Co. 1981

Depth (ft)	N Rate (lb/A), +/- Nit. Inhib.							
	0-		60-		60+		120-	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
	NO_3-N (lb/A)							
0 - 1	70	8	52	12	45	18	-	15
1 - 2	30	5	43	9	32	22	-	14
2 - 3	25	3	37	4	22	12	-	11
3 - 4	10	4	11	8	12	13	-	10
4 - 5	5	5	4	10	5	9	-	10
0 - 5	140	25	147	43	116	74	-	60

Table 3. Nitrate-N in the soil profile. Goodhue Co. 1981

Depth (ft.)	N Rate (lb/A), +/- Nit. Inhib.							
	0-		60-		60+		140-	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
	NO_3-N (lb/A)							
0 - 1	25	18	-	14	22	19	20	41
1 - 2	38	6	-	10	24	8	35	62
2 - 3	32	7	-	12	16	10	33	46
3 - 4	24	15	-	17	14	15	27	26
4 - 5	18	24	-	16	16	19	27	24
0 - 5	137	70	-	69	92	71	142	199

CORN TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1981

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The driftless soils area has the greatest county average estimated soil losses from cropland in Minnesota, ranging from 4.0 to 6.6 t/ac/yr in the six counties involved. Typical soils of the region, such as Fayette-Dubuque, Seaton, and associated soils, are highly erodible, form dense crusts if unprotected from raindrop impact, and consequently, have low final infiltration rates and high runoff from the intense storm events common to the region. New and improved tillage practices are increasingly being relied upon to meet environmental goals under more intense cropping systems. These systems modify the soil and water losses as well as the kind and concentration of materials in the runoff. A more complete understanding of these tillage systems will allow a more accurate prediction of their effect on the environment; will permit the maximization of the benefits of the tillage systems for production; and will permit them to be more effectively incorporated into the overall farming systems of the region.

Experimental Procedures

The experimental site is located at the Lancaster Experimental Farm on a Rozetta silt loam. Five tillage treatments are replicated four times (Table 1). Each treatment plot is split into normal and mulched subtreatments. On the slot plant and till-plant plots an additional subtreatment (bare) is established by removing all residue prior to planting. On mulched subtreatments, corn residue additions are made following planting to obtain approximately 100 percent cover. Plots are approximately 90 to 100 feet in width and 80 foot in length. Row width is 38 inches, which is typical of the region. In 1981, corn (Pioneer 3747) was planted May 6 following tillage on May 5 and 6. A slot-planter was used to plant the conventional and chisel treatments as well as the slot-plant treatment. Attachable wings were bolted on the slot-planter to convert it to a till-planter which was then used on the till-plant plots and guard area. An AC Model 77 tool bar planter attached to a Ford tractor was used to plant the wheel track treatment.

Nitrogen (200 lbs/Ac as urea) was applied prior to tillage. Chemical weed control was used as follows: 2 lbs/Ac Aatrex, 2 qts/Ac Lasso, and 1 qt/Ac Banvel +24-D were applied May 7. On June 6, 1.5 lbs/Ac Aatrex and oil was applied post-emergence due to the very low rainfall in May (0.85 inches) and subsequent lack of effect of the preemergence herbicide. Two hundred lbs/Ac of 6-24-24 was applied as starter. Corn earleaf tissue samples were collected at silking. The plow, chisel, and Buffalo till treatments were cultivated on June 28 when corn was approximately 24 inches tall.

Mulch rates, corn emergence rate, plant height, planting depth, and growth measurements were made on designated portions of each plot. Random roughness measurements were made in Rep 2 on May 8 in wheel track plant, till plant, chisel, and conventional plots. Additional measurements were made on May 14 and June 16 to evaluate changes over time.

Ten plot frames (40-inch x 40-inch) were emplaced on May 8 and covered to protect the surface. Infiltration measurements were made on the wheel track (mulch and normal), conventional (mulch and normal) and slot plant (mulch) on June 1-4.

Neutron probe measurements were made June 22 and 29, July 6, 17, and 27, and August 4, 11, and 17. Surface soil moisture measurements were made on the same dates. Periodic bulk density measurements were made on the 1-3 inch depth.

Yields were determined by hand harvesting duplicate 60-foot samples from each subplot.

Results

Significant differences (Table 1 and 2) in grain yield, population and early growth occurred between tillage treatments. Yields from conventional and chisel plow tillage treatments were significantly greater than till-plant bare and slot plant normal treatments. Associated reductions in final population of about 3000 plants/acre on the latter treatments would largely explain the observed yield reductions.

The treatments with the lowest early growth also had lowest populations indicating less favorable conditions for germination and growth on these treatments (till plant bare and slot plant normal).

Table 1. Effect of tillage and mulch treatments on corn early growth, plant height, population at harvest, and yield.

Treatment		Dry Matter	Percent	Early Growth	Inches Plant Height at		Population at	Yield	Date 50% Plants Silked
Tillage	Residue	T/Ac[2]	Cover	gms/10 Plants	57 days	62 days	Harvest	Bu/Ac[1]	July
Till plant	Normal	3.5	46	9.0a	38	50	21,100 ab	156.6 ab	20.5
	Bare		7	5.8b	36	48	19,170 b	151.1 b	20
Slot plant	Normal	3.9	55	5.5b	37	51	19,240 b	151.3 b	21
	Bare		7	7.3ab	41	53	21,270 a	154.9 ab	20.7
Fall Chisel[3]		1.2	11	7.8ab	42	59	22,850 a	166.5 a	19.5
Conventional[4]			Trace	9.8a	42	60	22,650 a	167.6 a	19.5
Wheeltrack plant			Trace	9.5a	43	61	22,240 a	157.0 ab	19.7
Significance Level				*			*	*	

[1] Values not followed by same letter are significantly different at 5 percent level by Duncan's New Multiple Range Test.

[2] Rep 3 only.

[3] Fall chisel, spring disk.

[4] Spring plow-disk 2x.

*5 percent level of significance

Table 2. ANOVA for corn yields.

Source	df	ss	ms	f
Blocks	3	222.0500	74.0167	1.22
TMT	6	1072.8521	178.8087	2.94*
Error	18	1093.265	60.7369	

*5 percent level of significance

Normal till-plant, conventional, and wheel track planting treatments had significantly greater early growth than till-plant bare and slot plant normal treatments measured at the 5-leaf stage. Plant height measured July 2 and 7 at 57 and 62 days after planting was greatest on the wheeltrack, conventional and chisel treatments and somewhat less (5 to 10 inches less) on the till-plant and slot plant treatment. The till-plant treatment was planted flat as ridges were not prepared in 1980; this resulted in the till-plant treatment being planted essentially level or in a slight depression and not in a ridge as normally practiced. Fifty percent silking was delayed about 1 day on the non-plow treatments which is a much smaller difference than that measured in emergence.

Significant differences in planting depth were measured (Table 3). Planting depth was significantly greater on wheeltrack and conventional treatments, and was significantly less on the till-plant treatment.

Table 3. Planting Depth Measurements

Treatment	Planting Depth --------mm------- Avg	Sx	Range	2/3 Seeds between depths of
Till plant	30.25c[1]	10.39	14-55	19.8-40.6mm
Slot plant	37.50bc	11.30	20-60	26.2-48.8mm
Chisel	61.0a	9.10	50-80	51.8-70.0mm
Conventional	64.75a	12.21	45-85	52.5-77.0mm
Wheeltrack plant	44.50b	17.48	17-85	27.2-62.1mm

Significance level *

[1] See Table 1.

The percent of emergence is given as a function of time in Table 4 for the 5 tillage systems. The rate of emergence of wheeltrack, conventional, and chisel treatments was essentially the same from 17 days after planting to complete emergence; slot-plant was delayed about 3 days; and till-plant was delayed about 2 days. For the heavily (100% cover) mulched treatments, emergence was delayed approximately 6 days. The average temperature for May (Table 5) was 1.2°F below the station normal which tended to further delay the emergence of the 100 percent cover mulch treatment. This rate of mulch is clearly excessive for the climatic conditions encountered and the treatment will be modified to keep residues out of the row and decreased levels of residue will be applied.

Table 4. Influence of tillage method and mulch rate on percent emergence.

Treatment		Days after planting date of May 6 - - - - percent emerged- - - -									
Tillage	Cover	15 (May 21)	17	20	21	23	26	27	29	30	33 (June 8)
Till plant	Normal	3	28	66	75	83	94	99	100	100	100
	Bare	4	42	69	75	86	91	99	100	100	100
	100% Mulch	0	0	1	4	37	58	81	89	97	100
Slot plant	Normal	0	16	49	62	85	93	99	100	100	100
	Bare	0	22	69	80	89	95	100	100	100	100
	100% Mulch	0	0	1	4	22	64	83	91	94	100
Chisel	Normal	3	52	83	89	95	98	100	100	100	100
	100% Mulch	0	0	2	6	32	61	84	89	95	100
Conventional	Normal	4	55	86	93	97	100	100	100	100	100
	100% Mulch	0	0	2	8	48	83	92	95	99	100
Wheeltrack plant	Normal	14	55	84	90	96	100	100	100	100	100
	100% Mulch	0	0	2	4	19	48	67	79	91	100

Table 5. 1981 Weather Summary, Lancaster Experimental Farm.

Month	Precipitation inches		Growing* degree days		Temperature			
	Total	Departure	1981	Departure	Avg Max	Avg Min	Avg	Departure
April	4.22	0.95	-	-	63.2	39.7	51.4	4.5
May	0.85	-2.40	310	10	68.3	45.0	56.6	-1.2
June	4.28	-0.39	534	16	78.6	56.8	67.7	0.6
July	2.91	-1.38	646	- 7	81.6	60.8	71.2	0
August	11.35	6.62	600	12	79.6	58.9	69.2	0.7
September	3.54	0	360	12	71.3	49.9	60.6	-0.2
October	2.98	0.90	-	-	59.1	38.2	48.6	-1.8
Apr-Oct	30.13	+4.30	2450	43				

*50°F base temperature
Last day in spring with minimum temperature of 32°F = May 12 at 32°F.
First day in fall with minimum temperature of 32° or less = October 2 at 29°F

Significant differences were found between tillage treatments with respect to %K in earleaf samples. The moldboard plowed treatments (conventional and wheeltrack plant) had significantly greater %K in the earleaf sample than did till-plant (Table 6). This occurred even though all of the plots tested high (250 to 300) to very high (300+ lbs/K/Ac) in K except for 1 wheeltrack plant plot which tested 247 lbs/Ac K. These results are in accord with other Wisconsin research showing reduced uptake of potassium with non-plow systems. All plant concentrations measured appear to be sufficient for optimum yields.

Table 6. Influence of tillage method on nutrient concentration in earleaf at Lancaster, 1981.

Treatment	Nutrient						
	%				ppm		
	N	P	K	Ca	Mg	Mn	Zn
Till plant	3.34	0.33	2.26b[1]	0.67	0.37	59	26
Slot plant	3.21	0.32	2.36ab	0.60	0.34	53	25
Chisel	3.28	0.33	2.41ab	0.62	0.35	54	24
Conventional	3.31	0.34	2.45a	0.58	0.32	55	26
Wheeltrack plant	3.12	0.32	2.53a	0.58	0.33	54	25
Significance level	NS	NS	*	NS	NS	NS	NS

*5% level of significance.
[1]See Table 1

Large differences in final infiltration rates were measured on the conventional tillage treatment (Table 7); when mulch was present, the final infiltration rate was more than doubled compared to the bare treatment. The results with the wheeltrack treatment were less spectacular. Runoff began in the shortest time after water application started on the slot plant treatment, even though the treatment was heavily mulched. The relatively flat shape of the runoff curve for the bare WTP treatment occurred because there was runoff from only the downslope half of the bare wheeltrack treatment for much of the run since the ridge acted as a dam retaining water behind it. Once the ponded area filled with water, runoff occurred from the entire area. These results illustrate the dual requirement of both 1) a porous surface with high saturated hydraulic conductivity, and 2) a protective mulch cover in order to have rapid infiltration. Residue cover by itself does not guarantee a high final infiltration rate.

Table 7. 1981 Lancaster infiltration rate measurements.

Treatment Tillage	Mulch	Application Rate in/hr	H_2O Applied Before Runoff inches	Infiltration Rate X minutes after runoff commences 2.5min	7.5min	15min	25min	35min	45min	55min
				- - - - - - - - -inches/hour- - - - - - - - -						
Wheeltrack (E)	Bare	4.48	0.67	3.76	3.04	2.98	2.38	1.72	1.12	1.00
(W)	Bare	4.48	0.82	3.16	2.44	2.32	1.60	0.94	1.06	0.94
(E)	Mulch	4.56	0.61	3.12	2.40	2.28	2.04	1.56	1.68	1.68
(W)	Mulch	4.32	0.86	3.48	3.48	2.52	1.62	1.62	1.20	1.20
Conventional (107)	Bare	4.32	0.79	3.12	2.16	1.56	1.20	0.96	0.72	0.84
(108)	Bare	4.40	0.88	3.20	2.48	1.76	1.28	1.28	0.98	1.10
(105)	Mulch	5.28	1.23	4.32	3.60	3.12	2.88	2.52	2.52	2.52
(106)	Mulch	4.72	2.20	4.22	3.77	3.46	3.46	3.28	3.29	2.92
Slot Plant (109)	Mulch	4.48	0.37	3.64	2.92	2.08	1.96	1.84	1.84	1.84
(110)	Mulch	4.80	0.48	3.60	2.88	2.28	1.68	1.50	1.02	1.08

Summary

Three-year results at Lancaster with continuous corn show nearly equal average yields from conventional, chisel, slot plant, and till plant treatments (Table 8).

Thus, farmers in the region can choose between a variety of tillage options which have yields comparable with conventional tillage, but which are superior in soil and water conservation and offer some savings in time, labor, and fuel compared to conventional tillage methods.

Table 8. Continuous corn tillage results at Lancaster, Wisconsin, 1979-1981.

Tillage Treatment	Yield Bu/Ac 1979	1980	1981	Average
Till plant*	162	157	157	159
Slot plant	163	146	151	153
Chisel	160	150	167	159
Conventional	169	159	168	165

*planted flat in 1979 and 1981.

FERTILIZATION OF GRASSES GROWN FOR SEED PRODUCTION

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Research with cool season grasses during 1981 included: 1) a nitrogen source comparison study on mineral soils, 2) a nitrogen rate study on peat, and 3) a copper study on peat. Five trials with Kentucky bluegrass and timothy were conducted on growers' fields in Roseau and Lake of the Woods counties. Effects of fertilization were determined by measuring the yield and by chemical analysis of grass tissue and the soil.

A. WEATHER CONDITIONS DURING THE 1980/81 GROWING SEASON

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

Generally, during the period from August 1980 to July 1981, 26.09 inches of precipitation (5.1 inches above normal) was received at Roseau, while the average air temperature was slightly below normal. During August, September and October, nearly 11 inches of rainfall was received which replenished the soil moisture that had been exhausted during the extreme drought of 1979/80. From November to April, the temperature was nearly 3° above normal and the precipitation was about 2 inches below normal. May was cooler than usual with about normal rainfall. June was very wet and very cool. Over 2.5 inches of rainfall was received during July with the average air temperature being 4.4°F below normal.

Table 1. Precipitation and temperature data for the 1980/81 growing season as measured at Roseau Weather Station (KRWB Radio)*.

	Precipitation (inches)		Air Temperature (°F)		
Period	Total	Departure from Normal	Average	Departure from Normal	GDD T_b=40°F
1980 Aug.	5.19	+1.97	61.7	-3.2	673
Sept.	4.12	+1.51	51.9	-2.7	357
Oct.	1.66	+0.44	38.2	-6.3	100
1980 Nov. to 1981 Apr.	2.85	-2.14	19.6	+2.8	109
1981 May	2.79	+0.34	50.0	-1.9	310
June	6.85	+3.43	56.8	-5.0	504
July	2.63	-0.82	62.8	-4.4	707
Total	26.09	+5.10			2760
Average			36.6	-0.6	
Normal (1941-1970)	20.99		37.2		

* Calculated from Climatological Data, Minnesota, Vol. 86 and 87, 1980 and 1981, U.S. Dept. of Commerce.

B. NITROGEN SOURCE COMPARISON

Two field experiments were conducted with Park Kentucky bluegrass and Climax timothy to evaluate the effectiveness of anhydrous ammonia, urea and ammonium nitrate as sources of nitrogen. The soils contained about 9 lb/acre of nitrate-N in the top six inches of soil which is the main rooting zone of the two grass species. The soils were calcareous with pH values above 7.5 (Table 2).

Prepared for presentation at the Grass Seed Institute, Baudette, MN, March 17, 1982.

The objectives of this investigation were: 1) to determine effectiveness of different nitrogen sources, and 2) to determine sod injury from the knives of ammonia applicator.

All dry fertilizer materials were applied on October 21, 1980. Urea (46-0-0) and ammonium nitrate (34-0-0) were applied to 10 x 40 foot plot areas with a 5-foot Gandy spreader. A 0+40+40 fertilizer treatment was made across all plots. Anhydrous ammonia (82-0-0) was applied with commercial applicators with the knives set 15 inches apart to 24 x 40 foot plot areas. Anhydrous ammonia was applied during the later part of October 1980. All nitrogen treatments were replicated six times.

Park Kentucky bluegrass produced high seed yield and showed significant response to the application of 120 lb of nitrogen per acre (Table 3). Moderate lodging occurred in the plots receiving nitrogen treatments. The highest seed yield was produced with the solid nitrogen fertilizers, ammonium nitrate and urea. While anhydrous ammonia resulted in highest N concentration of tissue, it produced nearly 200 lb/acre less seed than the solid N sources. Knifing did not significantly affect the yield, as shown by the urea vs. urea + knife treatments (606 vs. 505 lb/acre). These data are consistent with results obtained with Park K. bluegrass at this location in 1979.

Climax timothy showed significant response to the application of 90 lb of nitrogen per acre (Table 4). The highest yield was produced with anhydrous ammonia. Although the knives of AA applicator caused some ripping of timothy sod, the damage was not sufficient to affect seed yield.

Table 2. Soil test results of samples collected from 0-3 and 3-6 inch depths.+

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu ppm
Helmstetter Bros.	0-3	SIL	7.6	46	83	
Park K. bluegrass	3-6	SIL	7.7	33	70	
Erickson	0-3	SIL	7.8	28#	240	
Climax timothy	3-6	SIL	7.9	17	132	
Kveen	0-3	P	6.7	29	282	
Park K. bluegrass (N-Rate trial)	3-6	P	6.5	27	83	
Kveen	0-3	P	6.7	45	221	0.5
Park K. bluegrass (Copper trial)	3-6	P	6.5	24	93	0.5

+ samples collected on October 21-22, 1980.

1:50 soil/solution ratio.

Table 3. Effect of nitrogen treatments on seed yield and N concentration in tissue of Park Kentucky bluegrass, Helmstetter Bros. farm, Lake of the Woods County, 1981.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	301 a	2.03 a
Urea + Knife	505 bc	2.98 b
Urea	606 d	2.78 b
Ammonium Nitrate	627 d	2.93 b
Anhydrous Ammonia	427 b	3.37 c
Significance	**	**
BLSD (0.05)	73	0.25
C.V., %	14	8

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

Table 4. Effect of nitrogen treatments on seed yield and N concentration in tissue of Climax timothy, Douglas Erickson farm, Roseau County, 1981.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	280 a	2.76 a
Ammonium Nitrate + Knife	445 bc	3.77 b
Ammonium Nitrate	421 b	4.05 c
Urea	390 b	3.64 b
Anhydrous Ammonia	494 c	4.09 c
Significance	**	**
BLSD (0.05)	56	0.23
C.V., %	12	6

Nitrogen materials were applied at a rate of 90 lb N/acre; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

C. NITROGEN RATE STUDY ON PEAT

A field experiment with Park Kentucky bluegrass on peat was established in the fall of 1980 to investigate the effectiveness of different rates of nitrogen. Five N rates were used: 0, 20, 40, 60, 80 lb/acre,and the treatments were replicated four times. All plots received uniform 0+40+40 lb/acre phosphate and potash treatment. Fertilizer materials were applied with a Gandy spreader on October 22,1980. The soil contained 14 lb/acre of nitrate-N in the top six inches.

Very high seed yield was produced at this location even without nitrogen (Table 5). Moderate to severe lodging of the grass was noted prior to harvest. Some lodging had occurred even in the check plots.

Table 5. Effect of fertilization on seed yield and N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen farm, Roseau County, 1981.

Nitrogen Rate lb/acre	Seed Yield lb/acre	N Percent in Dry Matter
0	549 a	3.23
20	612 abcd	3.77
40	594 abc	3.75
60	566 ab	3.88
80	690 d	4.09
Significance	+	ns
BLSD (0.10)	92	
C.V., %	11	11

Ammonium nitrate (34-0-0) was applied on October 22, 1980; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

D. COPPER STUDY ON PEAT

A field experiment with Newport Kentucky bluegrass on peat was established in the fall of 1978. The soil contained 1.6 ppm DTPA extractable copper in the top 3 inches, indicating a relative low availability of this micronutrient (Table 6, Treatment: None). Originally, the copper treatments included two sources (copper sulfate and copper chelate), single application made either in fall of 1978 or spring of 1979 (residual treatment), and an annual application (made either in fall or spring). The treatments were arranged in a split-plot design with the time of application as main

plots, and the subplots consisting of residual and annual treatments. All treatments were replicated four times. Copper sulfate and copper chelate were dissolved in water and sprayed on 10 x 20 ft. plot areas. The entire field received 30+40+40 lb/acre of plant nutrients (N, P_2O_5 and K_2O) in fall. The application of all annual treatments (either fall or spring) was made at one time on May 12.

No lodging occurred in the experimental area. Relatively low seed yield (138 to 174 lb/acre) of Newport K. bluegrass was produced at this location and copper had no beneficial effect (Table 7). Copper concentration in bluegrass tissue from check plots was 2.14 ppm, considered a low level; annual application of copper sulfate (44 lb/acre of actual Cu applied during 3 years) increased it to 210 ppm. The application of copper sulfate increased DTPA extractable copper content in the soil to 36-47 ppm compared with 1.6 ppm found in the samples from check plots (Table 6).

A copper trial with Park Kentucky bluegrass was established in the spring of 1981. An extremely low extractable Cu level (0.5 ppm) was indicated by soil test (Table 2). Fertilization with copper had no beneficial effect on the yield (Table 8). Copper concentration in the tissue was increased from 3.4 ppm in control to 11.4 ppm by the application of 50 lb/acre of copper sulfate.

Table 6. DTPA extractable copper content in the soil collected from 0-3 and 3-6 inch depths+, Newport Kentucky bluegrass, Gus Kveen farm, Roseau County, 1981.

Copper Treatment	Sampling Depth (inches)	DTPA Extractable Cu ppm
None	0-3	1.6
	3-6	1.1
50 lb/A Copper Sulfate - Residual[1)]	0-3	46.9
	3-6	2.1
50 lb/A Copper Sulfate - Annual	0-3	36.4
	3-6	1.9
6 lb/A Copper Chelate - Residual[1)]	0-3	2.2
	3-6	1.3
6 lb/A Copper Chelate - Annual	0-3	3.3
	3-6	0.6

+ samples collected on May 12, 1981.

1) residual treatments were made once in spring 1979.

Table 7. Seed yield and copper concentration in tissue of Newport Kentucky bluegrass as affected by copper application, Gus Kveen farm, Roseau County, 1981.

Copper Treatment	Seed Yield lb/acre	Copper, ppm in Dry Matter
None	138	2.14 a
50 lb/acre Copper Sulfate - Residual[1)]	156	8.60 a
50 lb/acre Copper Sulfate - Annual[2)]	174	210.21 b
6 lb/acre Copper Chelate - Residual[1)]	142	3.85 a
6 lb/acre Copper Chelate - Annual[2)]	172	14.54 a
Significance	ns	**
BLSD (0.05)		36.06
C.V., %		53

1) Residual treatments were made once in spring 1979.

2) Annual treatments were made on May 12, 1981.

Table 8. Seed yield and copper concentration in tissue of Park Kentucky bluegrass as affected by copper application, Gus Kveen farm, Roseau County, 1981.

Copper Treatment	Seed Yield lb/acre	Copper, ppm in Dry Matter
None	581	3.41 a
50 lb/A Copper Sulfate	579	11.43 b
6 lb/A Copper Chelate	501	5.89 a
Significance	ns	*
BLSD (0.05)		4.70
C.V., %	10	39

All plots received 20+40+40 lb/acre of N, P_2O_5, K_2O.

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NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA , 1981

G. L. Malzer, Gregory C. Buzicky and Larry Smith

The goal of the sugarbeet grower is to manage the crop in such a way as to produce maximum recoverable sugar. One of the most influential and potentially manageable factors involved in recoverable sugar production is the nitrogen status of the soil.

Research was continued in 1981 as part of a study that was initiated in 1976 in West-Central Minnesota to investigate nitrogen management of sugarbeets. The primary objectives were a) to correlate residual soil nitrate levels to optimum nitrogen fertilization; b) to determine the optimum sampling depth for correlation of soil nitrate-nitrogen levels to sugar yields; c) to demonstrate and calibrate the relationship of soil nitrate-nitrogen levels and fertilizer nitrogen rates to recoverable sugar content.

Method: Two sites were selected in West-Central Minnesota in 1981. These were located on the Harold Peterson farm in Chippewa county and the Paul Brutlag farm in Grant county. Soil test results (0-6") for the two sites are given in Table 1. The soil was also sampled to a depth of two feet in the spring and subsoil samples were collected in the previous fall for nitrate-nitrogen (NO_3-N) analysis (Table 2).

Each site received nitrogen treatments of 0,40,80,120, and 160 lbs/A applied as anhydrous ammonia before planting. Treatments were replicated four times, however one replication was abandoned at the Brutlag site due to vandalism. Experimental design was a randomized complete block.

The plots were planted on April 9 with Maribo Monova. Emergence was good at both sites but temperatures of 22°F on May 10 caused considerable stand reduction and consequently the stands were hand-thinned to a relatively low, uniform population of 115 plants/100' row at the Peterson site and 100 plant/100' row at the Brutlag site. Weed control was accomplished by hand weeding while control of Cercospora leaf spot was attempted by spraying, however the disease was so severe that spraying was ineffective. This was especially evident at the Peterson site. Beets were harvested with a modified one row lifter on October 1 and 2 and tare samples were process by the American Crystal tare laboratory at East Grand Forks.

Results and Discussion: Beet yields at both sites were good despite severe Cercospora damage. There was no yield response to nitrogen fertilizer at either site (Tables 3 and 4). This can be explained by the high NO_3-N concentrations in the upper two feet at the Peterson site and high NO_3-N levels in the upper five feet at the Brutlag site.

All sugar parameters were adversely effected by N fertilizer at the Brutlag site although only gross sugar and recoverable sugar proved significant (Table 3). Impurity parameter were not influenced by N application. A minimal response to nitrogen fertilizers at this site was anticipated due to the excessive buildup (329 lbs/A) of NO_3-N.

At the Peterson site, sugar yields and concentrations were significantly adversely effected by N fertilizer (Table 4). The large amount of NO_3-N in the top 2 feet of soil, plus the mineralized N, provided enough nitrogen so that there was no response to fertilizer N with respect to yield. However, sugar yields and concentrations were effected by N fertilizer. Increased fertilizer applications decreased all sugar parameters and also increased the Na concentrations and impurity index significantly.

Table 1. Some of the chemical properties of the soil (0-9") at the two sites.

Site	Texture	O.M.	pH	P	K	Zn
				--lbs/A---		ppm
Peterson	Clay	6.0	7.9	17	397	3.1
Brutlag	Clay	4.0	7.0	68	232	0.9

Table 2. Soil NO_3-N concentrations at the two sites by depth.

	Increment						
Site	0-1'	1-2'	2-3'	3-4'	4-5'	0-2'	3-5'
Peterson	------197-----		9	5	5	197	19
Brutlag	82	58	73	82	82	140	329

Table 3. Yield parameters of sugarbeets as effected by N fertilization Paul Brutlag farm (Grant Co.), 1981.

Treatment	Yield	Gross Sugar	Rec. Sugar	Percent Sugar	Percent Rec.Sugar	Yield Sugar	Impurities Na	K	Amino N	Impurity Index
	T/A	---lbs/A-----		-------%---------		lbs/T	--------ppm-------			
Check	22.5	6046	4553	13.4	75.0	201	1220	1990	1370	1664
40 lbs/A	20.4	5175	3890	12.7	74.8	190	1170	1913	1283	1678
80 lbs/A	21.9	5224	3785	12.3	71.7	179	1373	2127	1320	1884
120 lbs/A	20.7	4973	3640	12.0	73.0	176	1077	2053	1310	1803
160 lbs/A	20.5	4721	3311	11.5	70.2	162	1270	1903	1437	1986
Sig.	NS	*	+	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)	-	788	699	-	-	-	-	-	-	-
C.V.	5.2	7.5	12.1	6.4	5.1	10.2	16.6	11.0	10.0	13.8

Table 4. Yield parameters of sugarbeets as effected by N fertilization, Harold Peterson Farm (Chippewa Co.,) 1981.

Treatment	Yield	Gross Sugar	Rec. Sugar	Percent Sugar	Percent Rec.Sugar	Yield Sugar	Impurities Na	K	Amino N	Impurity Index
	T/A	-------lbs/A----		----------%----------		----------ppm--------				
Check	21.5	5575	4256	13.0	76.3	198	1188	2605	1028	1579
40 lbs.N/A	23.0	5359	3895	11.6	72.6	169	1498	2438	1042	1827
80 " "	22.1	5157	3790	11.7	73.3	172	1180	2430	1102	1782
120 " "	22.4	4816	3316	10.7	68.5	147	1415	2555	1168	2099
160	22.5	4738	3290	10.5	69.1	146	1408	2570	1065	2060
Sig.	NS	+	*	**	**	**	**	NS	NS	**
BLSD(.05)	-	576	615	.98	3.4	21.1	200	-	-	238
C.V.	5.1	7.8	10.2	5.6	3.2	8.4	9.3	9.3	7.4	8.3

NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA 1976-1981

G. L. Malzer, Gregory C. Buzicky, Larry Smith, Jerome Lensing, Bob Schoper, Orville Gunderson, William Fenster

The ultimate goal of the sugarbeet growers is to manage sugarbeets in such a way as to produce the highest yield with the highest percent surgar and lowest impurity level. To do this, the grower utilizes a vast array of management options such as tillage, varieties, plant population, herbicides, fungicides, and fertilizer. Other factors such as mositure and temperature are not manageable, but very important in determining sugar yield. Since sugarbeet roots increase sugar storage only afer a deficiency of one of several primary growth factors, it is obvious that control of one of these factors is important in determining maximum recoverable sugar yields. The most influential and manageable factor is the nitrogen status of the soil.

Research was initiated in West-Central Minnesota in 1976 to investigate nitrogen management of sugarbeets. The primary objectives were a) to correlate residual soil nitrate levels to optimum nitrogen fertilization; b) to determine the optimum sampling depth for correlation of soil nitrate-nitrogen levels to sugar yield; c) to demonstrate and calibrate the relationship of soil nitrate-nitrogen levels and fertilizer nitrogen rates to recoverable sugar content.

Methods:

Nitrogen correlation studies were begun in 1976 and continued through 1981. Thirty-eight plot sites, with a total of 131 replicated treatments, were harvested during this study with several other sites chosen but subsequently abandonded due to various complications. These sites were located in seven west-central Minnesota counties: Renville (11), Chippewa (12), Kandiyohi (1), Swift (4), Stevens (1), Grant (8), and Traverse (1). The plots were located on representative soils of the area and located on growers' fields with a single exception. Besides the nitrogen correlation study, a number of other studies were instituted or incorporated into the correlation study (these results have been previously reported).

Experimental designs consisted of the Latin Square, randomzied complete block, and paired comparison. Nitrogen fertilization rates ranged from 0 to 200 lbs/A with nitrogen applied in late fall or early spring. Sites were fertilized to optimum levels for other nutrients. Varieties, population, weed and disease control varied depending upon the grower or year. However, plots were thinned by hand to optimum uniform populations and hand-weeded if necessary.

Soil samples were taken to a depth of five feet in one foot increments (before fertilization) from all but seven sites. These samples were analyzed for nitrate-nitrogen at the University of Minnesota. Time of harvest varied with each year, usually occurring in late September or early October. Beets were lifted with a four-row lifter, a modified one-row lifter, or by hand. Subsamples were collected from the harvest area and processed at the Min-Dak Farmers Cooperative and American Crystal lab at Moorhead, the American Crystal lab at East Grand Forks, or the tare lab at NDSU.

Data were compiled and analyzed with the facilities of the St. Paul Computer Center at the University of Minnesota using the Statistical Analysis System (SAS) developed by North Carolina University.

Results and Discussions

A variety of growing and management conditions occurred during the course of this six-year study. The independent variables chosen, for modeling purposes only, were nitrate-nitrogen levels. Recoverable sugar was chosen as the dependent variable since it is a result of yield, gross sugar and purity.

Table 1 contains the mean nitrate values, at various depths, encountered during the course of the study. Graphs 1 and 2 show the distribution of nitrates in the 0-2' and 2-5' increments, respectively. As seen in the graphs, the majority of sites had less than 100 lbs NO_3-N/A in the top 2' and little build-up in the 3-5' increment. The distribution of nitrate-nitrogen plus fertilizer nitrogen of the 131 treatments is shown in Graph 3. A good distribution between 40 and 300 lbsN/A+ NO_3-N/A was achieved during this study.

Analysis of scatter diagrams of nitrogen levels versus recoverable sugar demonstrated a quadratic curve. Therefore, regression analysis was conducted utilizing forty nitrate- derived variables. Table 2 lists the best one, two, and three variable models resulting from the regression analysis. Corresponding equations are listed in Table 3. Additionally, a model equation using a soil nitrate and fertilizer nitrogen variable is listed. Equations 2 and 4 are represented in Graph 4 and Equation 3 is represented in Graph 5 and 6.

It is interesting to note that Equation 2 predicts an optimum soil nitrate level of 85.7 lbs/A in the top 2' with a 112 lb/A credit to mineralization (4155/ 37.2 = 111.7). Equation 3 predicts an optimum of 96 lbs NO_3-N/A and credits 99 lbs/A to mineralization (3722/37.7 = 98.7). Inspection of Equation 4 (Graph 4), which incorporates both soil nitrate plus fertilizer nitrogen, shows an optimum level of 155 lbs/A. Equation 3, represented in Graph 5 and 6, incorporates soil nitrates to a depth of three feet. As shown in Graph 6, nitrates at the 2-3' increment contribute positively to recoverable sugar yield at levels up to 34.3 lbs/A regardless of the 0-2' nitrate-nitrogen levels. Amounts greater than 34 lbs/A result in a decrease in recoverable sugar yield. This decrease is substantial past approximately 65 lb/A.

A number of conclusions can be drawn from the analysis of data compiled in this study:

1) Soil sampling to a depth of 2' is a good tool for monitoring the residual NO_3-N in the profile and predicting the effect of the residual nitrates on recoverable sugar yield.

2) Applying fertilizer nitrogen such that the 0-2' NO_3-N + fertilizer equals 155 lbs/A, provides the optimum chances for top recoverable sugar yields.

3) The optimum nitrogen status indicated by the data is 90 lbs/A NO_3-N/A distributed in the top two feet with an additional 65 lbs/A applied as fertilizer nitrogen.

4) If the 0-2 ' NO_3N test plus fertilizer nitrogen is greater than 155, chances are greater that a decrease in recoverable sugar yield will result.

5) Sampling to a depth of greater than 3' did not provide a good correlation with recoverable sugar yield.

6) Sampling to a depth of 3' does a better job of predicting optimum recoverable sugar yields if the samples is divided into 0-2' and 2-3' increments.

7) If nitrate-nitrogen at the 2-3' increment is greater than 35 lbs/A, recoverable sugar yields will probably decrease. Substantial build-ups greater than 65 lbs/A can result in substantial decreases in recoverable sugar yields.

8) Nitrates at depths greater than 2' are not as available as nitrates in the 0-2' increment.

Table 1. Mean values of soil NO_3-N at various increments during six-year period.

	0-1*	1-2*	2-3**	3-4**	4-5**	0-2***	3-5**	0-5
	lbs NO_3-N/A							
$\bar{x}$	50.5	36.2	30.5	31.4	22.0	95.0	85.1	178.9

* N = 25 sites
** N = 30 sites
*** N = 38 sites

Table 2. The variables involved in the best one, two, and three variable models for predicting recoverable sugar.

	Variable	R^2	C.V.	Sig
1.	$(0\text{-}2'\ NO_3\text{-}N)^2$	.26	14.6	**
2.	$(0\text{-}2'\ NO_3\text{-}N)$, $(0\text{-}2'\ NO_3\text{-}N)^2$	.40	13.3	**
3.	$(0\text{-}3'\ NO_3\text{-}N)$, $(0\text{-}2'\ NO_3\text{-}N)^2$, $(.3(2'\text{-}3'\ NO_3\text{-}N))^2$	.65	10.1	**
4.	$(0\text{-}2'\ NO_3\text{-}N + \text{Fert. N})$, $(0\text{-}2'\ NO_3\text{-}N + \text{Fert. N})^2$	.25	14.8	**

Table 3. Model equations for predicting recoverable sugar yields (RS) using nitrate-nitrogen values.

1) $RS = 5845.5 - 0.04643\ (0\text{-}2')^2$

2) $RS = 4155 + 37.2\ (0\text{-}2') - .2069\ (0\text{-}2')^2$

3) $RS = 3733 + 37.7\ (0\text{-}3') - .19546\ (0\text{-}2')^2 - 6.1\ (.3\ (2' - 3'))^2$

4) $RS = 4225 + 20.3\ (0\text{-}2' + \text{Fert. N}) - .0655\ (0\text{-}2' + \text{Fert. N})^2$

9) Optimum soil nitrate and fertilizer applications only maximize the probability of top recoverable sugar yield. Actual recoverable sugar yield is influenced by a wide variety of environmental conditons and management options.

10) Excessive fertilizer application increases the possibility for lower recoverable sugar yields by creating a greater chance of surpassing the optimum N fertility status.

11) Do not base fertilizer nitrogen application rates only on yield goal. Optimum growing conditions invariably provide optimum mineralization of organic matter to usable inorganic nitrogen.

Based on the data from this six-year study, the following fertilizer nitrogen recommendations can be made for sugarbeets in West Central Minnesota:

1) If the 0-2' nitrate test is greater than 80 lbs/A, then subtract from 155 to obtain the fertilizer rate;

Example: test = 100 lbs NO_3-N/A, (0-2')
155 - 100 = 55 lbs N/A

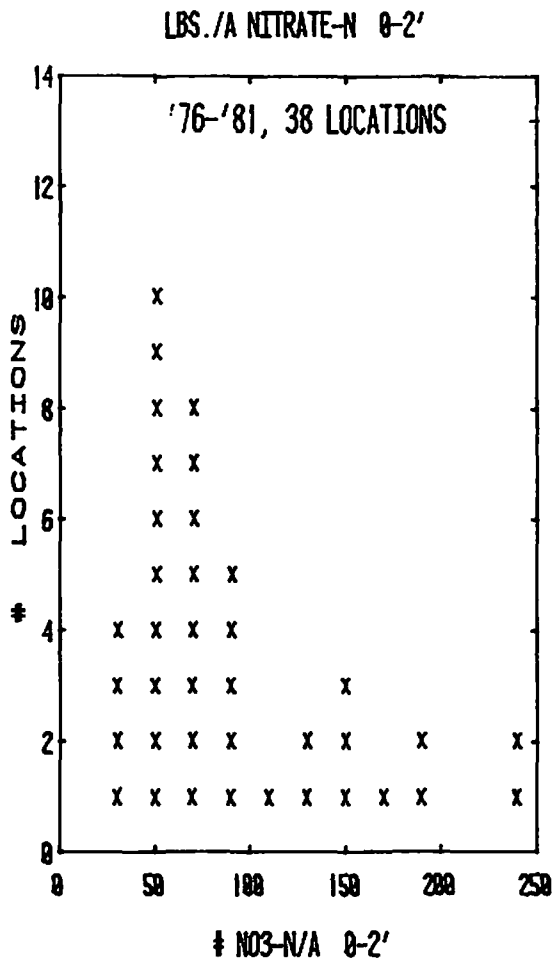
2) To avoid excessive fertilizer application, if the 0-2' nitrate test is less than 80 NO_3-N/A, subtract from 135 to obtain the fertilizer rate;

Example: test 50 = lbs NO_3-N/A, (0-2')
135 - 50 = 85 lbs N/A

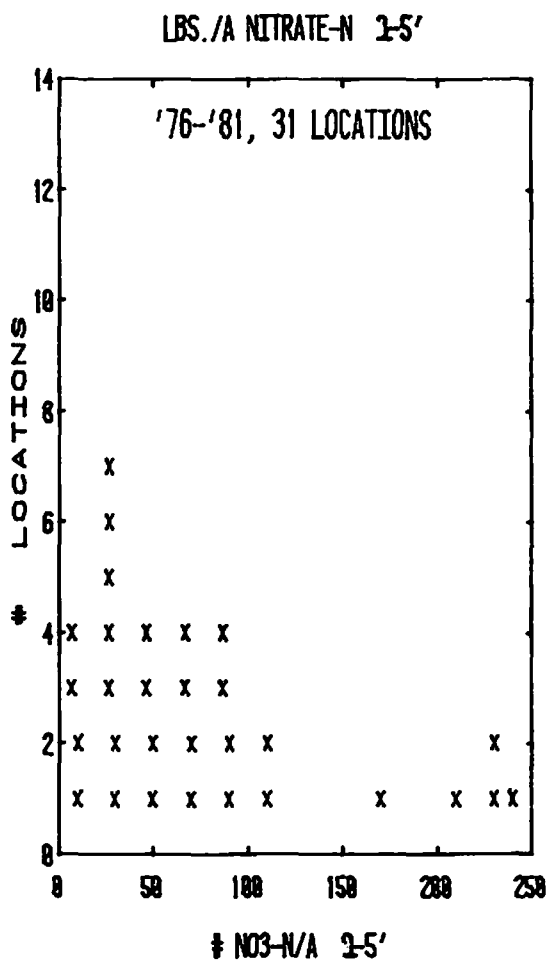
3) If a build-up of nitrates is suspected, a nitrate test should be made on the 2-3' increment. If the 2-3' nitrate test is greater than 35 lbs/A, reduce N application by 10 lb/A; if the 2-3' nitrate test is greater than 65 lbs-A, reduce N application by 20 lbs/A.

Of 33 trials conducted during the last six years, these fertilizer nitrogen recommendation would have predicted the top recoverable yields at 22 sites. Seven times the recommendations would have been less than necessary for top recoverable sugar yield and only four times would the recommendations been excessive. These recommendations, therefore, create the optimum nitrogen status and tend to prevent excessive fertilization.

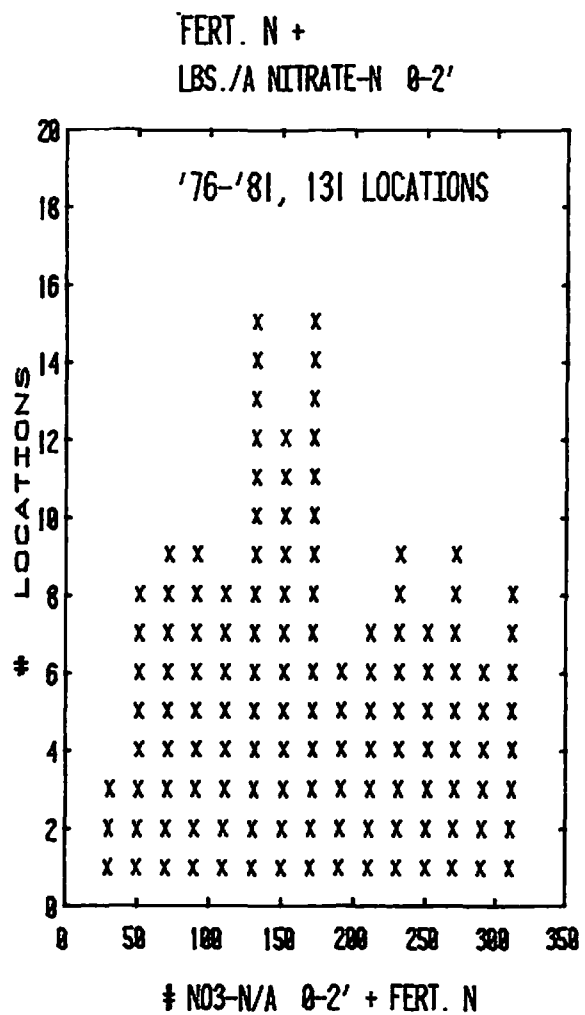
Acknowledgement is made to Dr. Bill Fenster, Orville Gunderson, Bob Schoper, Jerome Lensing, and Dr. Larry Smith for invaluable contributions to this study. Also, special thanks is extended to the sugarbeet growers of West Central Minnesota who contributed land, equipment, and time to this project. Finally, appreciation is made known to the Sugarbeet Research and Education Board for their funding of this project.



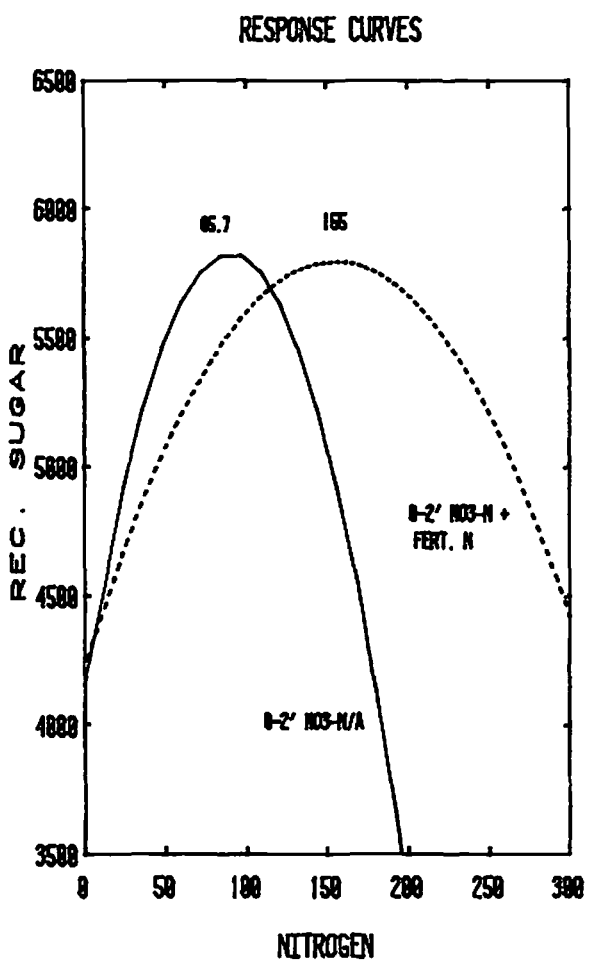
Graph 1. Distribution of nitrates, 0-2', encountered for 38 locations, 1976-1981.



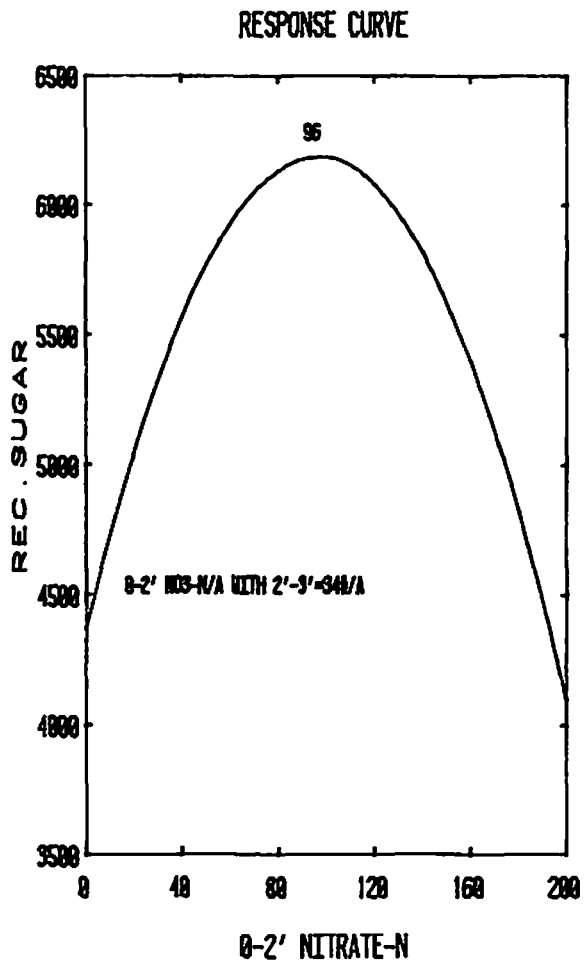
Graph 2. Distribution of nitrates, 2-5', encountered for 31 locations, 1976-1981.



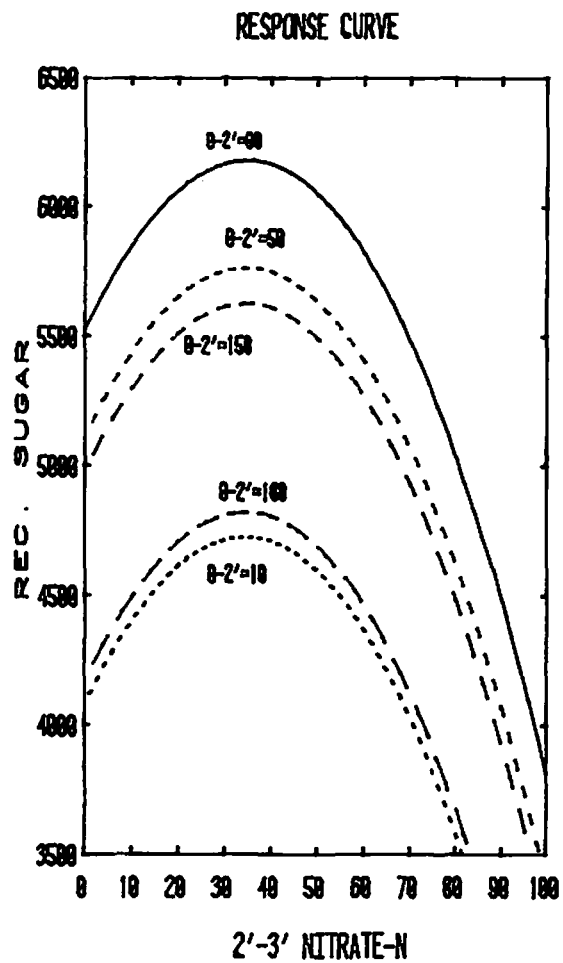
Graph 3. Distribution of nitrate-nitrogen (0-2') + fertilizer nitrogen for 131 replicated plots, 1976-1981.



Graph 4. Response curves for Equation 2: RS = 4155 + 37.2 (0-2')- .2069 $(0\text{-}2')^2$ and Equation 4:RS = 4255 + 20.3 (0-2' + Fert. N)- .0655 $(0\text{-}2' + \text{Fert. N})^2$



Graph 5. Response curve for Equation 3: RS = 3722 + 37.7 (0-3')-.19546 $(0\text{-}2')^2$ - 6.1 (.3 $(2'\text{-}3')^2$ when 2'-3' nitrate-N equals 34 lbs/A.



Graph 6. Response curve for Equation 3: RS = 3722 + 37.7 (0-3') -.19546 $(0\text{-}2')^2$- 6.1 (.3(2'-3') $)^2$ when 0-2' nitrate -N is 10,50,90, 150, and 180 lbs/A.

YIELD RESPONSE OF WHEAT TO STARTER FERTILIZER IN NORTHWESTERN MINNESOTA - 1981

W. E. Jokela and M. O'Leary

Application of low rates of fertilizer with the drill at planting time is a common practice for wheat production in northwest Minnesota. In an effort to evaluate the benefit of this practice on medium to high fertility soils several wheat growers in the area cooperated in this study. In Marshall County the cooperators were Art and Les Howard, Warren, and Medard and Don Yutrzenka, Argyle, and in Pennington County they were Clyde Christianson, Ken Mehrkens, and Mark and Charles Naplin, all in the Thief River Falls area.

Each grower left check strips without drill-applied fertilizer, alternated with strips with their normal rate of fertilizer. Nitrogen was applied to both treatments but no other broadcast fertilizer was used. Soil analysis from the check strips and the amount of starter fertilizer used are given in Table 1. Fertilizer was applied in a granular form on all sites except Yutrzenka (sites 3-5), where liquid (10-34-0) was used. Yield samples, consisting of four to eight samples per treatment depending on the site, were taken at maturity. Results are tabulated in Table 2.

Two of the nine comparisons showed a significant yield increase of approximately 10 bu/acre due to drill applied fertilizer. Both of these, as well as site 7 which showed a non-significant 7 bu/acre increase, were on soils testing medium-high in P and medium in K. Most of the non responding sites had high or very high levels of both P and K. No protein differences were observed and an average value is given.

Table 1. Soil analysis and starter fertilizer rates for 9 sites in northwestern Minnesota. 1981.

	Site Number	Soil Analysis, 0-6 in.				Starter Fertilizer Rate		
		Texture	pH	P(Bray 1) lb/A	K lb/A	N	P_2O_5	K_2O
						-------lb/A----------		
Marshall Co.								
Howard	1	C	8.1	29	600+	18	46	0
	2	C	8.1	16	580	18	46	0
Yutrzenka	3	CL	8.0	44	237	12	39	0
	4	CL	7.8	36	481	12	39	0
	5	CL	7.5	40	279	12	39	0
Pennington Co.								
Christianson	6	CL	7.6	23*	144	10	26	26
	7	SL	7.1	20*	98	10	26	26
Mehrkens	8	CL	6.6	36	201	15	30	30
Naplin	9	L	8.2	28*	122	11	22	22

*1:10 soil to solution ratio

Table 2. Wheat grain yields and protein percentage for 9 sites in northwestern Minnesota. 1981.

Marshall County	Site Number	Grain Yield bu/A Starter	No Starter	Signif.	Protein % Average
Howard	1	68.8	64.8	ns	11.3
	2	56.5	56.5	ns	12.5
Yutzrenka	3	61.6	60.5	ns	12.1
	4	45.5	44.3	ns	15.5
	5	52.6	55.8	ns	12.6
Pennington County					
Christianson	6	55.1	44.5	**	12.0
	7	52.8	45.6	ns	12.0
Mehrkens	8	60.1	63.2	ns	13.2
Naplin	9	62.2	51.3	**	11.9

COPPER AND MANGANESE FERTILIZATION OF WHEAT ON AN ORGANIC SOIL

Roseau County - 1981*

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.

Method of application was suspected as a factor in effectiveness of copper fertilization. Also, in 1980 a response to manganese was observed in a Roseau County study. This trial was conducted to further examine these possible factors.

Experimental Procedures

This experiment was conducted on two sites on organic soils in Roseau County, consisting of 1½ to 2 feet of peat over clay mineral soil. At the Welin location copper had been applied to the field about five years earlier, whereas at the Habstritt site none had been applied. This difference is reflected in the copper soil analysis in Table 1.

Treatments consisted of rates of copper sulfate applied broadcast as dry crystals or in solution, incorportated with two passes of a double disk drill, with or without drill applied granular manganese. All treatments except the absolute check received 40-40-120 (N-P_2O_5-K_2O) broadcast. Fertilizer was applied and Era wheat planted on May 13. Forage samples were taken at heading on July 21. Experimental design was randomized complete block with four replications.

Results and Discussion

Grain yields and forage yields, uptake, and analyses for the two sites are shown in Table 2 through 5. At the Welin site yields were low and there were no differences in grain yield or forage yield or nutrient uptake. The only significant effect on forage elemental analysis was a depression of %Mg with NPK application. The poor production appears to be due to non-fertility factors.

At the Habstritt site dramatic copper deficiencies were observed. On July 21 when forage samples were collected most plants in the treatments without copper were dead. The treatment with dry copper showed large variation in growth between plants and many dead plants. These treatments with copper in solution looked somewhat better, but still quite poor. No dry matter yield could be obtained from the no copper treatments. Yields from other selected treatment (3 replications only) were highly variable, but do show a statistical difference at the 10% level. Little or no grain was produced by any treatments.

Table 1. Soil analysis, 0 to 6 inches. Organic soil. Roseau County. 1981. (U of M Soil Testing Lab).

Site	pH	P	K	S	Zn[1]	Cu[1]	Mn[1]
	---------lb/A---------			----------ppm----------			
Welin	7.4	41	226	40+	5.6	4.5	56.1
Habstritt	7.2	94	250	40+	12.0	1.6	73.0

[1]Zn, Cu, and Mn by DTPA extraction.

Table 2. Effect of copper and manganese treatments on grain yield and forage dry matter and nutrient uptake of wheat. Roseau County (Welin). 1981.

Treatment lb/A		Grain Yield	Forage (at heading) Dry Matter	Uptake lb/A				
Cu[1]	Mn[2]	Bu/A	lb/A	P	K	Zn	Cu	Mn
0 (no NPK)	0	24.2	1616	6.51	67.6	.04	.005	.15
0	0	23.8	1824	7.88	83.3	.05	.006	.18
12 sol	0	22.5	1953	7.67	86.0	.05	.007	.17
0	13	21.1	1799	7.32	82.5	.04	.006	.15
6 sol	13	23.0	1706	7.03	77.0	.05	.006	.17
12 sol	13	24.9	1961	7.98	89.6	.05	.007	.18
12 dry	13	25.4	2182	8.96	95.4	.05	.007	.22
Significance		ns	ns	ns	ns	ns	ns	ns
BLSD		-	-	-	-	-	-	-
C.V.		14.2	18.8	18.1	19.2	16.2	25.5	23.2

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with drill.

Table 3. Effect of copper and manganese treatments on elemental analysis of wheat forage at heading. Roseau Co. (Welin). 1981.

Treatment lb/A		Elemental Analysis of Forage (at heading)										
		%				ppm						
Cu[1]	Mn[2]	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0 (no NPK)	0	.41	4.22	.54	.43	27	75	113	90	28	3.3	5.4
0	0	.43	4.54	.48	.37	28	78	81	96	26	3.2	5.2
12 sol	0	.40	4.46	.46	.36	24	70	74	86	24	3.5	5.0
0	13	.41	4.61	.48	.38	26	74	116	84	24	3.2	5.5
6 sol	13	.41	4.53	.47	.37	22	71	98	95	27	3.5	4.7
12 sol	13	.41	4.63	.49	.38	28	76	76	93	25	3.5	6.4
12 dry	13	.41	4.40	.49	.36	28	72	78	96	24	3.2	7.0
Significance		ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns
BLSD		-	-	-	.03	-	-	-	-	-	-	-
C.V.		6.1	7.3	7.7	5.6	22.6	9.5	29.5	10.1	10.7	17.8	29.2

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with the drill.

Table 4. Effect of copper and manganese treatments on forage dry matter and nutrient uptake of of wheat. Roseau Co. (Habstritt). 1981.

Treatment lb/A		Forage (at heading)					
			Uptake lb/A				
Cu[1]	Mn[2]	Dry Matter lb/A	P	K	Mn	Zn	Cu
12 sol	0	2416	10.35	92.0	1.54	.06	.004
6 sol	13	1682	7.82	65.4	.96	.05	.002
12 sol	13	1737	7.90	69.2	1.07	.05	.003
12 dry	13	1066	6.47	44.6	.53	.04	.002
Significance		+	ns	+	ns	ns	+
BLSD		861	-	31.0	-	-	.001
C.V.		27.6	31.0	25.3	50.5	26.8	26.8

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with the drill.

Table 5. Effect of copper and manganese treatments on elemental analysis of wheat forage at heading. Roseau Co. (Habstritt). 1981.

Treatment lb/A		Elemental Analysis of Forage (at heading)										
		%				ppm						
Cu[1]	Mn[2]	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	0	.81	2.69	.87	.48	153	204	60	576	41	1.2	14.0
12 sol	0	.43	3.89	.49	.40	35	89	49	606	27	1.8	9.8
6 sol	13	.47	3.90	.50	.43	40	88	62	574	28	1.5	8.0
12 sol	13	.46	3.98	.51	.40	47	92	58	605	27	1.8	10.1
12 dry	13	.61	4.15	.57	.44	59	110	51	495	36	2.0	9.2
Statistics, excluding check (no Cu)[3]												
Significance		+	ns	ns	ns	*	+	ns	ns	*	ns	ns
BLSD (.05)		.14	-	-	-	14	18	-	-	8	-	-
C.V.		13.8	8.7	7.5	6.6	14.6	9.0	28.3	22.2	12.3	24.9	33.5

[1]Cu applied broadcast as $CuSO_4$ in solution (sol) or as $CuSO_4$ crystals (dry).
[2]Mn applied in granular form with the drill.
[3]No Cu treatment excluded from statistical analysis because plants were dead at time of sampling.

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

POTASSIUM ON WHEAT - PENNINGTON COUNTY, 1981*

William Jokela and Micheal O'Leary

This trial was established in 1980 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 in 1980 and again in the spring of 1981. Plot design was randomized complete block with four applications. In 1981 Solar variety of wheat was planted on April 25. No starter was used. Initial soil tests (Spring, 1980) for the 0 to 6 inch depth were pH - 7.8, P (Bray 1, 1:50) - 28 lb/A, and K - 158 lb/A.

Results and Discussion

The effect of potash rate on grain yield, on forage yield, % K, and K uptake, and on soil test K are shown in Table 1. Grain yield averaged about 6 bu/acre more on plots receiving K, but the difference was not statistically significant. Forage yield did not change, but % K, and consequently K uptake, increased with increasing K rate. Exchangeable K in the surface layer of soil after two years of fertilization increased with K rate, but the difference was significant only at the highest rate.

Table 1. Effect of potassium rate on grain yield, on forage yield, % K, and K uptake, and on exchangeable soil K. Pennington County (E. Flesche) 1981.

		Forage (soft dough)			Exchangeable Soil K
K_2O Rate (lb/A)	Grain Yield bu/A	Dry Matter lb/A	K %	K Uptake lb/A	Fall, 1981 lb/A, 0-6 in.
0	48.0	6501	1.10	72.0	186
40	54.6	6710	1.36	91.0	189
80	53.4	6917	1.46	101.5	189
120	54.0	7188	1.63	118.7	204
160	53.7	6833	1.54	105.2	203
320	54.8	6665	1.67	111.1	252
Significance	ns	ns	**	**	**
BLSD (.05)	-	-	0.16	24.5	29
C.V. (%)	8.3	10.2	7.8	15.5	9.4

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

Nitrogen Fertilization of Wheat and Barley

Under Irrigated and Dryland Conditions.

J. Wright, T. King, W. Jokela

Small grain plots were set out in Spring 1981 at the Westport research farm in Pope County. Four varieties of wheat were grown at four nitrogen rates under sprinkler irrigation. Era wheat and Morex barley were grown at four nitrogen rates without irrigation. Ammonium nitrate was applied at rates of 40, 80 and 120 pounds of nitrogen per acre on Estherville sandy loam. Yields were reduced by quackgrass competition. Rainfall for the growing season was 9.5 inches with 5.7 inches added through irrigation. The previous crop was soybeans.

The irrigated wheat experiment was designed to evaluate variety performance at four nitrogen fertility levels. A split plot design replicated four times with varieties as main plots and nitrogen rate as sub-plots was used. Nitrogen rates up to 120 lbs/A increased yields significantly for irrigated wheat. Test weight decreased with increased nitrogen rates. There was no significant yield difference between varieties under irrigation although test weight did show a difference.

On the dryland plots Era wheat responded to nitrogen at 40 lbs/A with no significant increase at higher rates. Test weight decreased with increased nitrogen rates. Yield for Morex barley was highest at 120 lbs N/A. Test weight and percent plump Kernels decreased with increased nitrogen rates. Percent protein increased with higher nitrogen applications.

Table 1. Comparison of four nitrogen rates and wheat variety performance under irrigation.

N-Rate	Yield bu/A	Test wt lbs/bu	Variety	Yield bu/A	Test wt lbs/bu
0#N/A	9.4	54.8	Era	25.7	54.4
40"	24.1	55.4	Len	23.5	53.6
80"	27.1	53.4	Olaf	21.8	52.0
120"	36.3	52.7	Mn70170	25.9	56.4
Significance	**	**		NS	**
BLSD (.05)	4.4	1.4		—	1.4
C.V.	28.2	3.6		28.2	3.6

Table 2. Era wheat and Morex barley at four nitrogen rates without irrigation.

	Era Wheat		Morex Barley			
Treatment	Yield	Test wt	Yield	Test wt	Protein	Plumpness
N-Rate	bu/A	lbs/bu	bu/A	lbs/bu	%	%
0#N/A	15.0	57.0	23.1	45.7	8.8	68
40"	28.2	57.3	37.1	46.1	9.1	68
80"	31.0	55.3	49.5	45.7	12.0	59
120"	30.9	55.0	53.2	44.4	13.5	48
Significance	**	*	**	+	**	**
BLSD (.05)	7.7	1.6	3.2	1.2	1.7	10
C.V.	14.5	1.4	4.1	1.5	7.9	8.1

WILD RICE FERTILIZATION RESEARCH - 1981

A PROGRESS REPORT
December 29, 1981

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Research was continued during 1981 on fertilization and nutrient requirement of wild rice. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season at several locations to obtain information on the environment in which wild rice grows. A nitrogen experiment was conducted with the Netum variety on a mineral soil at Grand Rapids. A fertilization trial with the K2 variety was conducted 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

Average temperatures recorded at four U.S. weather stations were slightly above normal in April and remained near normal during the main part of the growing season (Table 1).

Soil, water and air temperatures were measured at four locations by automatic sensing and recording thermographs (see Fig. 1, 2, 3, 4). Soil and water temperatures were not recorded at Gully because of an instrument malfunction.

Plants emerged on May 4 at Grand Rapids (Fig. 5). The jointing stage was reached by Netum on June 21, 48 days after plant emergence. Wild rice was harvested on August 12, 100 days after emergence. Accumulated Growing Degree Days (GDD) at each stage of plant development was calculated with a base temperature of 40°F. Accumulated GDD's for the 1981 season were 2,247, while total solar radiation for the season at Grand Rapids reached 36,745 langleys or calories per square centimeter.

B. CHEMICAL CHARACTERISTICS OF PADDY WATER

Water samples were collected at three different paddy locations during the 1981 growing season. At Grand Rapids, samples were collected from an experimental paddy used for nitrogen studies on mineral soil, and from the Prairie River which was the source of water. Water was also sampled within a production 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. This paddy 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, prepared 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 <u>hardness</u> of water is a measurement of calcium and magnesium, expressed as $CaCO_3$, mg/liter. The water from the Clearwater River was very hard (348-389 mg/L). The water from the Prairie River and the Little Willow River was moderately hard, with values near 80 mg/L. At Gully and Grand Rapids, the levels of hardness, calcium and magnesium of paddy water were nearly the same as those found in the river water. In Aitkin County on peat, however, the paddy water showed 25 to 37% lower calcium and 28 to 58% lower magnesium content than the river water, and a 3-fold decrease in the hardness. Consequently, the water within the Kosbau paddy in Aitkin County was relatively soft, having values of 26 to 36 mg/liter.

At Grand Rapids, concentrations of total P, and K in paddy and river water were nearly the same. The paddy water, however, had slightly higher total N concentration than found in the river water.

At Gully, no difference was detected in the total P concentration of river and paddy water. The paddy water, however, had slightly higher concentration of total N, and K than river water. Nitrogen and potassium concentrations in samples of July 2 sampling appeared to be inconsistent.

Table 1. Average air temperature as measured at four 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[3/]	68.5	71.0	64.6	62.9	3466
1981	44.4	55.3	60.8	68.1	65.7	58.8	2898
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
1981	43.9	54.8	62.0	68.0	67.0	59.1	2941
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M	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	50.6	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394
1981	45.1M	53.8	62.1M	67.5	66.0	58.9	2902
Chaska, Carver Co.							
Normal[4/]	45.9	58.1	67.8	72.4	70.7	62.9	3528
1981	51.3	57.9	67.8	73.5	70.6	64.2	3715

1/ Source: Climatological Data, Minnesota, Vol. 80-87 (1974-81), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.
4/ Normals for the period 1941-1970.

Table 2. Chemical composition of water collected from wild rice paddies during the 1981 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	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm	Na ppm
Location: Grand Rapids														
14-2	4/22	EP-W	0.19	60.0	83.0	0.7	0.08	0.01	0.01	1.2	22.2	6.4	2.5	3.1
14-1	4/22	PR	0.20	65.0	86.0	0.3	0.16	0.02	0.02	1.3	23.6	6.5	3.0	3.2
23-2	5/26	EP-W	-	52.0	64.3	0.6	<0.05	0.07	0.01	1.7	18.1	4.2	0.9	1.8
23-1	5/26	PR	-	55.5	74.7	0.5	<0.05	0.07	0.01	2.4	20.1	5.8	1.7	2.8
25-3	6/9	EP-W	0.16	64.0	75.2	1.3	<0.05	0.10	0.02	2.2	19.9	5.6	1.1	2.6
25-4	6/9	PR	0.13	70.5	79.2	0.4	<0.05	0.07	0.01	2.6	21.7	5.9	1.4	2.7
28-3	6/23	EP-W	0.16	69.5	80.7	0.4	<0.05	0.15	0.01	2.1	21.3	6.1	1.1	2.9
28-4	6/23	PR	0.20	68.5	82.0	1.3	<0.05	0.14	0.02	2.4	22.4	6.2	1.5	3.0
43-6	7/7	EP-W	0.18	-	-	2.9	-	0.09	-	-	21.6	5.9	2.0	4.1
43-5	7/7	PR	0.16	-	-	3.3	-	0.08	-	-	22.1	6.0	1.2	3.0
43-7	7/23	EP-W	0.22	-	-	2.0	-	0.13	-	-	23.3	6.6	1.9	3.2
43-8	7/23	PR	0.18	-	-	0.7	-	0.08	-	-	23.4	6.6	1.5	3.4
43-10	7/31	EP-W	0.16	-	-	2.0	-	0.07	-	-	21.6	5.9	1.0	2.7
43-9	7/31	PR	0.16	-	-	0.6	-	0.07	-	-	22.2	6.2	1.0	3.1
Abbreviations and descriptions of sampling sites at Grand Rapids: EP-W = Experimental Paddy #1 West; PR = Prairie River														
Location: Kosbau Bros., Aitkin Co.														
14-6	4/23	PP	0.11	25.0	26.0	2.1	<0.05	0.74	0.54	2.2	5.7	2.2	8.9	4.5
14-5	4/23	DD	0.22	80.0	91.0	0.7	0.05	0.02	0.02	1.6	22.9	7.8	1.4	4.3
23-4	5/26	PP	-	20.5	36.5	2.3	<0.05	1.08	0.71	3.1	8.4	3.5	7.4	4.9
23-3	5/26	DD	-	67.0	83.3	1.3	<0.05	0.07	0.01	1.7	22.8	6.0	0.7	2.9
25-1	6/9	PP	0.12	15.5	36.4	2.5	<0.05	1.47	1.24	3.4	8.2	3.5	6.2	4.8
25-2	6/9	DD	0.18	79.5	89.4	1.1	<0.05	0.16	0.04	2.7	22.7	7.5	0.7	4.2
28-2	6/23	PP	<0.10	9.0	28.8	1.9	<0.05	1.59	1.19	3.4	6.4	2.8	4.5	3.5
28-1	6/23	DD	0.16	63.0	84.1	1.0	<0.05	0.09	0.02	3.1	21.4	6.8	0.5	3.1
43-3	7/7	PP	0.10	-	-	9.2	-	1.86	-	-	8.9	4.3	4.5	4.2
43-4	7/7	DD	0.20	-	-	1.2	-	0.15	-	-	26.8	8.2	<0.5	3.9
Abbreviations and descriptions of sampling sites at Kosbau Bros.: PP = Production Paddy; DD = Diversion Ditch at bridge near the Little Willow River														
Location: Imle and Gunvalson, Gully														
14-4	4/22	PP	0.72	170.0	352.0	1.6	<0.05	0.07	0.04	48.8	88.1	31.9	9.2	8.4
14-3	4/22	CR	0.75	300.0	389.0	1.0	<0.05	0.06	0.04	36.3	96.7	35.7	6.7	9.3
28-8	5/14	PP	0.90	269.0	474.0	1.8	<0.05	0.14	0.05	64.0	121.0	41.5	11.5	11.9
28-7	5/14	CR	0.75	262.0	348.0	1.2	<0.05	0.15	0.05	26.6	86.0	32.0	4.6	9.0
43-1	7/2	PP	0.55	-	-	16.7	-	0.11	-	-	71.1	30.0	0.8	7.5
43-2	7/2	CR	0.50	-	-	3.4	-	0.13	-	-	66.3	25.8	2.4	6.2
Abbreviations and descriptions of sampling sites at Gully: PP = Production Paddy; CR = Clearwater River														

Fig. 1

MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS - 1981

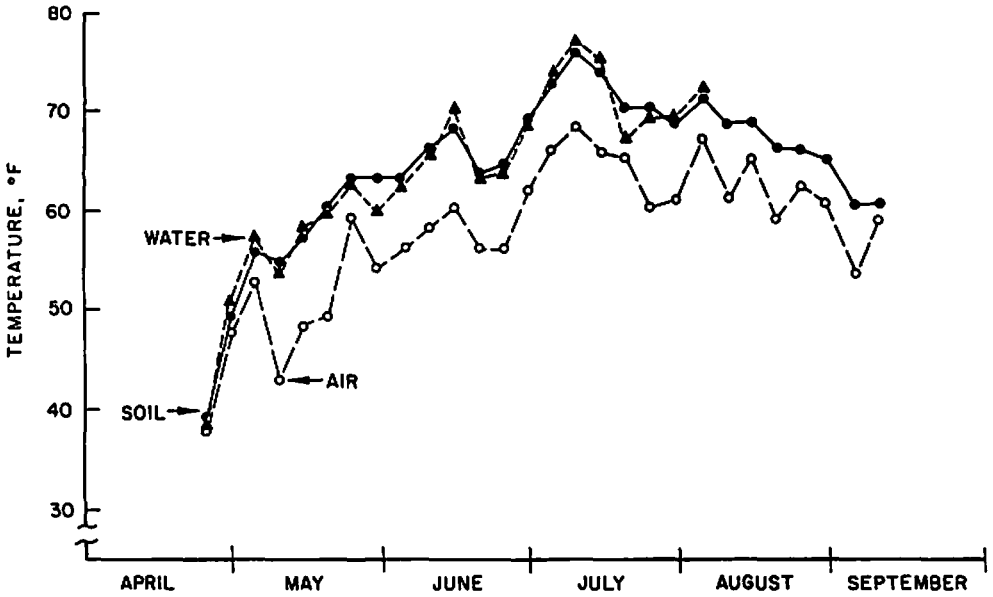

Fig. 2

MEAN AIR, WATER AND SOIL TEMPERATURES
KOSBAU BROS., AITKIN COUNTY - 1981

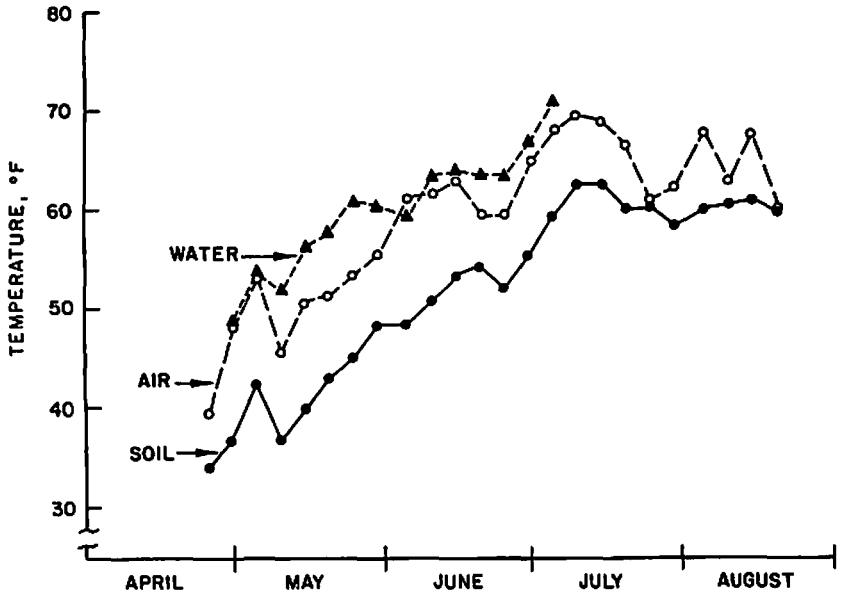

Fig. 3

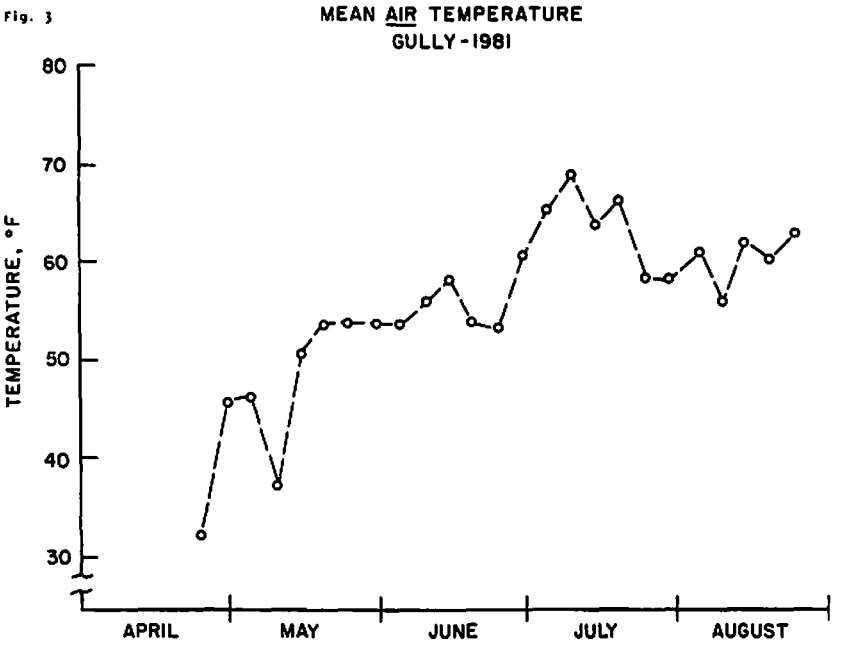
MEAN AIR TEMPERATURE
GULLY-1981
TEMPERATURE, °F
80
70
60
50
40
30
APRIL
MAY
JUNE
JULY
AUGUST

Fig. 4

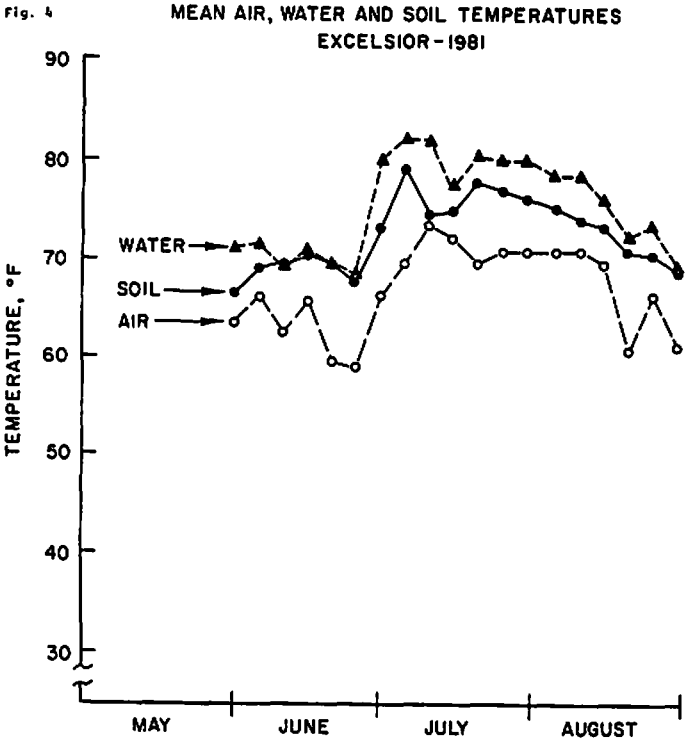
MEAN AIR, WATER AND SOIL TEMPERATURES
EXCELSIOR-1981
TEMPERATURE, °F
90
80
70
60
50
40
30
WATER
SOIL
AIR
MAY
JUNE
JULY
AUGUST

Fig. 5 WILD RICE DEVELOPMENT
NETUM VARIETY, 2ND YEAR STAND
GRAND RAPIDS, 1981

	STAGES OF DEVELOPMENT	DAYS	DATE	1/ GDD	2/ SOLAR
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY	0	0
	FLOATING LEAF	14		151	6273
	AERIAL LEAF	32	JUNE	495	12442
	TILLERING	44		774	17021
	JOINTING	48		855	18306
	BOOT	52		932	19288
REPRODUCTIVE GROWTH PHASE	HEADING	61	JULY	1152	23097
	MID-FLOWERING	67		1349	26329
	LATE-FLOWERING	73		1533	27903
	MATURITY	100	AUGUST	2247	36745

1/ - ACCUMULATED GROWING DEGREE DAYS, $T_b = 40°F$

2/ - SOLAR RADIATION ACCUMULATED, LANGLEYS PER DAY (CAL.CM^{-2})

The paddy water of the Aitkin County location had considerably higher concentrations of total N, P, and K than found in the river water. This was consistent with the results of nutrient concentrations obtained at this location during previous growing seasons.

The sulfate concentration of water is reported in terms of parts per million of sulfate- sulfur, expressed as S. To convert results to the sulfate (SO_4) form, they must be multiplied by 3. For example, 1.2 ppm sulfate-S x 3 = 3.6 ppm sulfate (SO_4) in the water.

The water at Grand Rapids and in Aitkin County, generally, contained less than 10 ppm of sulfate. The sulfate concentration of the water at Gully, however, was relatively high (80 to 192 ppm SO_4).

C. NITROGEN STUDIES ON MINERAL SOIL

The nitrogen rate and time of application trial, initiated in fall of 1979, was continued with 2nd year stand of Netum in paddy No. 1 West at the North Central Experiment Station, Grand Rapids. Soil tests (Table 3) indicated very high levels of extractable phosphorus (59 pp2m) and exchangeable potassium (303 pp2m). It should be noted that the experimental area had not received any phosphate or potash fertilizer since the establishment of the paddy in 1974. It has been a common practice, however, to incorporate wild rice stubble into the soil.

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 November 6, 1980 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. Plant density, at harvest, ranged from 1 to 3 plants per square foot. Water level was maintained at about 6 to 10 inches. Five plants were collected at random from each plot at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 21 (Fig. 5). A 32 sq. ft. area from each plot was hand-harvested on August 12 for yield determination.

Individual plants at late flowering had accumulated 4 to 6 grams of dry matter and 63 to 86 milligrams of nitrogen (Table 4).

Netum grain yields (7% moisture) ranged from 280 to 538 pounds per acre (Table 5). The yield, however, was increased above the check only by two N treatments, namely, 40 lb/A (fall) and 80 lb/A (½ fall + ½ early flowering).

Table 3. Soil test values of experimental paddy No. 1 West, Grand Rapids.[1)]

pH	Extractable P pp2m	Exchangeable K pp2m	Nitrate-N lb/A
6.2[2)]	59	303	12

1) Samples collected from 0-6 inch depth on 11/6/80.

2) Average of four composite samples.

Table 4. Effect of nitrogen application on total uptake of N by Netum wild rice, 2nd year stand, Grand Rapids, 1981.

Treatment No.	N Rate lb/acre	Time of Application			N Uptake[1] mg/plant
		Fall	Jointing	Early Flowering	
		---------N lb/acre---------			
1	0	-	-	-	71
2	20	20	-	-	63
3	40	40	-	-	86
4	40	20	20	-	85
5	40	20	-	20	65
6	80	80	-	-	85
7	80	40	40	-	77
8	80	40	-	40	73
Significance					ns
C.V. (%)					39

1) Average of four replications.

Table 5. Effect of nitrogen application on the yield of Netum wild rice, 2nd year stand, Grand Rapids, 1981.

Treatment No.	N Rate lb/acre	Time of Application			Grain Yield[1] lb/acre
		Fall	Jointing	Early Flowering	
		---------N lb/acre---------			
1	0	-	-	-	311
2	20	20	-	-	280
3	40	40	-	-	538
4	40	20	20	-	335
5	40	20	-	20	401
6	80	80	-	-	476
7	80	40	40	-	380
8	80	40	-	40	502
Significance					+
BLSD (0.1)					171
C.V. (%)					29

1) At 7% moisture, average of four replications.

\+ Denotes significance at the 10% level.

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 (25 pp2m), and medium exchangeable potassium (145 pp2m) levels were indicated by soil tests. The soil pH was 5.3. This was an incomplete factorial experiment with six NPK treatments, replicated six times, and arranged in randomized blocks. Individual plots occupied a 14 x 16 ft. area. Fertilizer materials (46-0-0, 0-46-0, 60-0-0) were applied by hand on October 8, 1980 and incorporated into the soil by disking.

Plants emerged on May 1 and reached the jointing stage on June 30. The paddy was drained on July 1.

The wild rice stand was extremely thin and spotty and the plants were short with only one or two tillers. The experimental area suffered from a heavy infestation by waterplantain which appeared to be related to a relatively shallow water level. On June 11, MCPA (¼ lb/acre a.i.) was applied with a 10-foot boom. A 0.1 inch localized thundershower, several hours after application, may have removed much of the applied herbicide. Herbicide application did not effectively control waterplantain in the experimental area.

Because of extremely poor stand and growth of wild rice, only one row of plots on the east side of the experiment (where the growth was best) was harvested on August 17 for yield determination. The grain yield (7% moisture) ranged from 96 to 164 pounds per acre. Average plant density, at harvest, was 2.5 plants per square foot. It should be noted that wild rice produced 392 to 555 lb/acre of grain in other areas within the same paddy with deeper water and little or no waterplantain.

ACKNOWLEDGMENTS

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