Table 2a. Wheat yields at 13% moisture 1982 from 4 phosphate levels broadcast plus starter and no starter at 6 locations and corresponding check plot P soil test using 3 methods[1/].

Lbs. P_2O_5/A Broadcast	Crookston Sta. W	Crookston Sta. H	Morris Sta.	Mehrkens W.	Mehrkens S.	Dahl
	bu/acre					
0	53	51	61	46	52	58
30	55	46	65	50	51	62
60	57	48	68	48	49	61
90	55	46	69	52	51	59
significance	ns	ns	*	*	ns	ns
starter	-	-	68	50	49	-
no starter	-	-	64	48	53	-
significance	-	-	*	ns	ns	-
P test lbs/acre						
Bray 1:10	16	54	10	17	2	23
Bray 1:50	60	84	12	24	8	57
Olsen's	15	20	6	9	16	17
K test lbs/acre						
pH	8.2	8.0	7.8	7.9	8.0	8.3

Table 2b. Plant analysis of entire wheat plant at boot stage and relationship to P treatment and soil test[1/].

Lbs. P_2O_5/A Broadcast	Crookston Sta. W	Crookston Sta. H	Morris Sta.	Mehrkens W.	Mehrkens S.	Dahl
	% P 1982					
0	.28	.30	.22	.27	.35	.27
30	.26	.30	.26	.32	.36	.28
60	.28	.30	.29	.37	.35	.29
90	.28	.31	.31	.39	.38	.29
significance	+	ns	**	**	ns	ns
	Bray's 1:10 lbs/A P					
0	16	54	10	17	2	23
30	-	-	18	21	2	-
60	-	-	23	23	2	-
90	-	-	33	21	4	-
	Bray's 1:50 lbs/A P					
0	60	84	12	24	8	57
30	-	-	23	25	5	-
60	-	-	25	28	9	-
90	-	-	33	25	11	-
	Olsen's lbs/A P					
0	15	20	6	9	16	17
30	-	-	13	11	17	-
60	-	-	15	12	21	-
90	-	-	23	13	24	-

1/ Crookston & Dahl farms sampled spring of 1982 prior to treatment, others sampled fall 1981.

Table 3a. Corn or soybean yields 1982 from 4 phosphate levels broadcast at 3 locations and corresponding check plot P soil test (fall 1981) using 3 methods.

Lbs P_2O_5/A Broadcast	Heineke S.B.	Klassen Corn	Klenz Corn
	bu/acre		
0	42	164	162
30	43	160	172
60	45	165	172
90	44	173	167
significance	ns	ns	ns
P test lbs/acre			
Bray 1:10	5	6	13
Bray 1:50	15	15	33
Olsen's	9	6	10
pH	7.8	8.0	7.7

Table 3b. Plant analysis of ear leaf on corn and upper mature triofoliate leaves at initial flowering of soybeans and relationship to P treatment and 1981 fall soil test.

Lbs P_2O_5/A Broadcast			
	% P 1982		
0	.35	.27	.26
30	.38	.27	.29
60	.38	.29	.30
90	.39	.30	.30
significance	ns	-	**
	Bray's 1:10 lbs/A P		
0	5	6	13
30	7	4	18
60	9	7	21
90	7	5	27
	Bray's 1:50 lbs/A P		
0	15	15	33
30	20	14	36
60	33	15	39
90	35	15	46
	Olsen's lbs/A P		
0	9	16	10
30	8	17	12
60	17	17	14
90	22	18	19

Table 4. Plant analyses of wheat at boot stage Wheatville and Hegne soils at Crookston and Dahl farms, 1982.

Wheatville	Bu/A @ 13%									
Lbs P_2O_5/A	M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
Broadcast										
0	53	.28	2.69	.28	.24	81	47	31	3	5
30	55	.26	2.60	.27	.24	82	48	30	2	4
60	57	.28	2.47	.24	.24	75	50	24	2	6
90	55	.28	2.45	.27	.24	70	46	24	2	6
significance	ns	+	ns	ns	ns	ns	ns	*	ns	*
C.V.	7	4.0	10.6	22.7	19.7	40.9	14.1	14.6	47.9	14.8
Hegne										
Lbs P_2O_5/A										
Broadcast										
0	51	.30	2.92	.34	.30	64	44	20	2	5
30	46	.30	3.06	.36	.31	64	43	20	2	5
60	48	.30	2.94	.34	.29	63	41	18	2	4
90	46	.31	2.95	.36	.31	58	42	18	2	4
significance	+	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	6.0	3.1	6.3	8.9	10.0	8.5	6.3	8.9	26.7	24.4
Dahl										
Lbs P_2O_5/A										
Broadcast										
0	58	.27	2.89	.31	.29	60	49	29	4	3
30	62	.28	2.89	.27	.43	42	35	40	6	4
60	61	.29	2.76	.28	.30	51	45	27	5	3
90	59	.29	2.80	.33	.30	62	42	25	4	3
significance	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	18	5.1	3.1	31.0	49.6	32.1	30	36.4	25.2	16.0

Table 5. Plant analysis of wheat at boot stage at Morris and Mehrkens farms, 1982.

Morris Station

Broadcast P_2O_5/A	Starter	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			%				ppm				
0	-	60	.20	2.82	.32	.22	77	68	19	2	3
0	+	67	.24	2.80	.35	.26	101	84	16	2	3
30	-	64	.26	2.64	.34	.24	91	77	17	2	3
30	+	67	.27	2.66	.34	.24	80	84	16	2	3
60	-	68	.28	2.61	.34	.24	78	81	16	2	3
60	+	69	.30	2.82	.36	.26	76	88	15	2	3
90	-	69	.30	2.70	.35	.24	68	84	16	2	3
90	+	68	.32	2.68	.36	.26	78	94	16	2	4
significance		*	*	ns	ns	*	ns	ns	ns	ns	ns
C.V.		5.7	3.2	4.8	7.4	4.5	26.8	7.4	10.8	16.7	13.6

Mehrkens (S)

Broadcast P_2O_5/A	Starter										
0	-	53	.36	3.61	.38	.35	81	40	34	3	5
0	+	51	.35	3.78	.39	.33	82	42	34	3	5
30	-	53	.37	3.18	.37	.34	72	41	28	2	5
30	+	49	.36	3.57	.35	.31	68	43	25	2	5
60	-	51	.38	3.60	.40	.35	71	41	24	2	5
60	+	48	.33	3.26	.38	.31	70	38	22	2	5
90	-	54	.38	3.60	.40	.33	68	39	21	2	4
90	+	48	.37	3.49	.42	.30	70	46	21	1	5
significance		ns	ns	*	ns	ns	ns	ns	ns	ns	ns
C.V.		7.5	10.5	5.8	11.7	11.2	8.9	12.0	7.3	21.5	24.1

Mehrkens (W)

Broadcast P_2O_5/A	Starter										
0	-	41	.26	3.36	.29	.22	68	32	24	3	5
0	+	50	.29	3.47	.26	.23	65	33	21	2	6
30	-	51	.31	3.32	.27	.24	66	36	19	2	5
30	+	50	.32	3.61	.29	.26	64	38	21	2	5
60	-	49	.36	3.42	.35	.27	68	40	20	2	6
60	+	48	.38	3.68	.32	.24	64	36	18	2	5
90	-	50	.38	3.25	.30	.27	62	42	17	2	5
90	+	54	.41	3.66	.34	.31	75	42	19	2	6
significance		*	ns	ns	ns	ns	ns	ns	*	ns	ns
C.V.		7.0	5.6	6.2	14.0	11.3	14.0	13.3	8.1	27.7	17.4

Table 6. Plant analysis of soybeans and corn at Heinecke, Klassen and Klenz farms, 1982.

Heinecke	Lbs P_2O_5/A	Bu/A @ 13% M	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Soybeans initial flowering			%				ppm				
	0	42	.35	2.62	1.22	.61	142	115	46	11	50
	30	43	.38	2.67	1.24	.60	132	102	50	12	48
	60	45	.38	2.63	1.26	.56	171	85	45	11	50
	90	43	.39	2.62	1.21	.59	132	100	46	11	50
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		4.9	9.6	4.9	5.0	9.4	33.6	30.6	20.0	9.3	3.8
Klassen											
Corn, 8 leaf stage											
	0	164	.17	2.41	2.52	.78	4300	184	52	9	6
	30	160	.19	2.76	2.32	.74	4000	174	46	8	6
	60	165	.19	2.46	2.65	.80	4125	180	48	9	6
	90	173	.22	2.80	2.30	.72	3625	168	48	9	6
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		4.4	11.6	11.6	19.6	13.0	10.5	7.2	5.8	10.0	11.6
Klassen											
Corn ear leaf											
	0		.28	2.41	.34	.43	95	86	24	7	8
	30		.28	2.32	.32	.41	91	85	23	7	8
	60		.29	2.11	.34	.46	95	89	24	6	8
	90		.30	2.18	.33	.43	94	83	22	7	8
significance			ns	+	ns	ns	ns	ns	ns	ns	ns
C.V.			4.5	7.0	9.3	11.8	3.0	6.6	5.9	13.8	7.4
Klenz											
Corn, 8 leaf stage											
	0	161	.34	2.15	.90	.47	1800	123	30	10	4
	30	172	.36	2.27	.95	.45	2125	141	29	10	4
	60	172	.36	2.14	.94	.43	2275	142	26	9	3
	90	167	.35	2.30	.96	.45	1975	142	26	10	4
significance		ns	ns	ns	ns	ns	ns	ns	*	ns	ns
C.V.		4.2	7.2	25.6	8.3	15.6	24.6	8.9	4.5	13.0	22.0
Klenz											
Corn ear leaf											
	0		.26	1.18	.56	.63	88	92	21	6	5
	30		.29	1.21	.61	.63	90	104	20	6	5
	60		.30	1.12	.64	.68	91	109	17	5	5
	90		.30	1.28	.60	.63	90	106	18	6	5
significance			**	ns	ns	ns	ns	ns	*	ns	ns
C.V.			2.9	17.2	9.1	11.7	6.6	12.5	8.0	8.2	4.9

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS

W. E. Fenster and C. J. Overdahl

The micronutrient study was initiated in 1981 at 6 locations, all plots were with corn. Three locations were discontinued for various reasons in 1982 and the three that were continued were planted to soybeans.

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. Sulfur and magnesium, even though not micronutrients, were included as a variable.

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

Tables 1 through 5 show the 1982 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 Testing

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. The trials will continue for 3 more years.

Acknowledgments

The efforts of Mike O'Leary and Greg Buzicky in arranging details of securing, weighing and packaging materials is gratefully acknowledged. Also Todd King, Gene Peters, and Negussie Berihun helped make the results shown here possible. Also thanks go to Brian Schreiber, Bob Olson, and Floyd Bellin for their efforts with farm cooperators.

Funding of the micronutrient research project was made possible by the Cenex Foundation and the boron special study was funded in part by U.S. Borax and Chemical Corporation, to these companies the authors are indeed grateful. To the three laboratories making the many tests goes a special thanks.

Table 1. Corn and soybean yields, plant boron, and soil test boron from four levels of boron applications. 1981 & 1982.

lbs B/A	yield bu/A[1]		ppm B[1] leaf		soil test - ppm[1] hot H_2O	
	1981	1982	1981	1982	1981	1982
	Corn	Soybeans	Corn	Soybeans		
Jokela Farm - Goodhue Co. non-irrigated Mt. Carroll silt loam						
0	170	49	4.3	38	0.60	0.79
1	178	42	4.6	44		1.10
2	175	47	4.6	51		1.53
4	174	42	6.8	61		2.54
significance	ns	+	ns			
BLSD (.10)		5				
C.V.	3.7	7.2	9.8			
Kingston Farm - Dakota Co. - irrigated loamy sand						
0	155	36	7.0	43	0.25	0.19
1	159	34	8.1	52		0.25
2	147	32	11.8	67		0.47
4	160	27	18.2	112		0.86
significance	ns	**	**			
BLSD (.05)		4	3.5			
C.V.	5.0	82	21.9			
Geiger Farm - Morrison Co. - irrigated loamy sand						
0	92		4.1		0.09	
1	87		6.7			
2	90		10.9			
4	90		13.7			
significance	ns		**			
BLSD (.05)			3.4			
C.V.	11.7		24.8			

[1] average of 4 replications, soil test U. of MN.

Table 2. Soybean yields[1/] in three counties comparing complete treatments of micronutrients plus Magnesium to plots using missing element techniques. 1982.

Treatment[2/] omitted (-) added (+)	Martin Yield	Goodhue Yield	Dakota[3/] Yield
none	56	47	33
-Mg	51	43	35
-Zn	52	45	33
-Fe	53	44	34
-Mn	54	43	34
-B	52	44	34
-Cu	52	45	33
+ complete includes S	54	47	33
significance	ns	ns	ns

[1/] average of 4 repplications

[2/] pounds per acre of nutrient added Mg=50, Zn=10, Fe=10, Mn=10, B=1, Cu=5.

[3/] irrigated sandy loam, other two counties fine textured non-irrigated soils.

Table 3. Plant analysis[1/] from micronutrient and magnesium treatments in trials at three counties. 1982.

Treatment omitted (-) added (+)	Martin		Goodhue		Dakota	
	(ppm except Mg which is %)					
	-	+	-	+	-	+
Mg	.48	.52	.46	.43	.43	.49
Zn	42	48	42	46	45	47
Fe	113	131	104	99	84	92
Mn	61	97	44	44	63	58
B	50	50	41	44	39	54
Cu	10	11	10	10	10	10

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

Table 4. Soybean yields,[1/] plant sulfur and soil test sulfur with and without sulfur treatments in three counties. 1982.

Sulfur Treatment	Yield bu/A	Ear Leaf % S	U of M Soil Test PPM S
	Martin		
None	54	.31	1
50#/A	53	.31	-
Significance	ns		
	Goodhue		
None	44	.32	10
50#/A	43	.35	19
Significance	ns		
	Dakota[2/]		
None	33	.28	1
50#/A	34	.30	2
Significance	ns		

1/ average of 4 replications

2/ irrigated sandy loam soil, other two counties are fine textured non-irrigated soils

Table 5. Soil test means for micronutrients. U. of M. Lab. 1981 & 1982.

County	#/A Mg	ppm Zn	Mn	Cu	B	Fe
			1981 Tests*			
Goodhue	579	2.0	31	0.75	.60	55
Dakota	312	1.0	21	0.48	.25	41
Martin	881	1.0	41	1.28	1.20	21

1982 Tests**

Treatment omitted (-) added (+) 1981	Martin -	Martin +	Goodhue -	Goodhue +	Dakota -	Dakota +
	(ppm except Mg which is lbs/A)					
Mg	990	970	495	595	295	364
Zn	1.2	2.3	4.8	8.0	1.4	4.2
Fe	42	26	76	90	78	80
Mn	40	40	30	30	19	18
B	2.1	1.8	1.0	3.2	2.2	2.4
Cu	1.8	2.5	1.5	4.0	0.6	3.1

* before 1981 treatments

** from treated plots in 1981

TILLAGE-SOIL FERTILITY STUDIES ON A TYPIC EUTROCHREPT IN GOODHUE CO.

J. B. Swan, J. F. Moncrief, and B. P. Schreiber

This research includes two separate studies:

1) Determining the effect of tillage on the response of corn to potassium at two levels of nitrogen (N-K Study).

2) Evaluation of tillage system performance and nitrogen release from injected manure (Manure study).

NEED FOR STUDY

Since soil erosion by water is of major concern in much of southeastern Minnesota, conservation tillage systems which retain crop residue on the soil surface are of great importance in the region. Water conservation due to conservation tillage can increase corn yield even though the region has the states greatest average growing season rainfall. Increased yields from surface residue are most likely to occur in years when moldboard plowed fields experience water stress due to extended periods between rainfall events, due to high runoff from the bare soil surface which seals readily under raindrop impact, or due to the low water holding capacity of shallow soils. Time saving during periods of peak labor demand is another potential benefit of conservation tillage.

Tillage can affect fertilizer considerations and may require change in fertilizer use and application methods. Reduction in the availability of soil potassium and modification of the nitrogen response were reported for tillage systems which leave large amounts of crop residue on the soil surface and cause little soil disturbance compared to moldboard or chisel plowing (Moncrief 1981).

Because of the large number of livestock enterprises in southeastern Minnesota, animal manure is an important source of plant nutrients as well as a potential source of pollution if improperly handled. Ideally the manure is applied in the cropping sequence so as to maximize crop use of the nutrients in the manure without significantly delaying or otherwise adversely modifying production practices. Method of application, weather and time pressures can prevent the achievement of this goal.

The extent to which different tillage systems and methods of manure application benefit or interfere with each other is not well documented. Manure injection accomplishes some tillage but restricts the spacial distribution of nutrients unless redistributed by additional tillage. The rate of release of nitrogen from manure may also be affected by the soil conditions created by the tillage operation. The type of tillage may also affect the time of manure application, while the date of manure injection may delay subsequent tillage or planting operations.

OBJECTIVES

1) To assess the effect of tillage on the availability of nitrogen and potassium to corn.

2) To evaluate nitrogen release from manure under two tillage systems.

3) To compare changes in potassium soil test level with the amount applied in manure and as Kcl.

4) To evaluate tillage systems for corn where manure is injected.

METHODS AND MATERIALS

Site: The experimental plots are located on four acres of land on the farm of Dale Flueger in Sec. 15 of Hay Creek Twp. of Goodhue Co. The soil is a Timula silt loam (Typic Eutrochrept) with an organic matter level of about 2.5 percent, pH of 6.5$\pm$ 0.5, initial range in K (ammonium acetate extraction) of 90 to 280, P (Bray 1) of 32 to 85. The site has been in corn for at least two years. 3-Ton/A of limestone were applied in 1980 and approximately 9000 gal/A of dairy manure was injected in the fall of 1979. Corn silage was removed from the site in 1981 leaving the surface essentially bare.

Experimental Procedure: Tillage comprises the main plots of a RCB design (3 replicates) with fertility and manure subplots. The treatments and associated practices for the studies are:

Tillage/Planting	N - K Study	Manure Study
Chisel plow, field cultivate, plant	5/20	5/20
No-till plant		
Fertility		
Nitrogen 0, 200 lbs N/A Bdcst. as ammonium nitrate	5/20	-
Potassium 0, 200, 400 lbs/A K_2O B Bdcst. as potassium chloride	5/4	-
Manure:12,700 gallons/A dairy manure Injected: (375 lbs/A total N of which 190 lbs/A was in ammonium form, 234 lbs/A K_2O; 141 lbs/A P_2O_5	-	5/4
Starter:111 lbs/A of 0-46-0 at planting on all plots area	At planting	
Insecticide:7 lbs/A counter	At planting	
Herbicide:2 lbs (active ingredient) each of Atrazine and Lasso as post at 4-5 leaf stage		6/8
2 qts/A Round up on No-till only for quack Weed control was excellent over entire area	5/28	5/28
Hybrid:Pioneer 3732 (105 day) Planting rate of 29,000 plants/A		

Equipment

Chisel (Soil saver)
Field cultivator (Bushog soil finisher)
Planter (John Deere 7000 Max emerge with light duty coulters for trash - 38 inch row width

RESULTS AND DISCUSSION

1) Soil Tests

N-K study-soil test K was sampled for the 0 to 6 inch depth on each plot on 7/15. A great range in soil test K occurred for each K application level (table 1). The averagesoil test K value of the 0 and 224 kg/ha applications of K_2O were within one standard deviation of the 224 and 448 kg/ha applications, respectively.

SOIL TEST K

K_2O Applied	Plot range	Plot Average	Std. Dev.
Kg/ha		Kg/ha	
0	92 to 213	149	36
224	112 to 264	195	48
448	152 to 394	271	76

Soil nitrates were measured on 6/25, one measurement per replicate. In the upper 60 cm 112, 103 and 76 kg/ha nitrate were measured for replications 1, 2 and 3 respectively. For the 150 cm depth the respective values were 211, 134 and 161 kg/ha soil nitrates. Soil nitrate levels also showed considerable variation. Plots with levels similar to those measured in replications 1 and 3 would be expected to have reduced yield response to nitrogen application.

EARLY GROWTH

(Was measured on 7/13/82; table 3)

A. Dry matter

Significant differences were measured between the individual nitrogen and potassium (N-K) treatment levels on no-till plots but differences were not significant between individual N-K levels on chisel plots. For no-till, greatest early growth occurred on the 448 kg/ha K_2O, 224 kg/ha N treatment which was significantly greater than the 0 K_2O treatment with N and all levels of K_2O without N. The no-till 0 N,0 K_2O treatment had the least early growth which was significantly less than all the N treatments and the 224 kg/ha K_2O treatment without N. The early growth on the other four no-till treatments was not significantly different. The effect of applied K was largely masked by the wide range in soil test K at each treatment level of K_2O.
When the data were analyzed as a 2x3 factorial, effect of nitrogen on early growth was highly significant for no-till and significant for chisel tillage.

Soil test K: The effect of soil test K on early growth was described by the following sets of equations:

No-till	EG gms/plant	R^2
N = 0	$= 19.74 - 3.48 \times 10^{30} K^{-15}$	0.47
N = 224 kg/ha	$= e^{0.125935} K^{0.59428}$	0.46
Chisel		
N = 0	$*= e^{-28.986} K^{11.711-1.0660 \ln K}$	0.61
N = 224 kg/ha	= 28.5 (avg. value)	-

*gms/10 plants

Regression lines of early growth on soil test K converged at soil test K of 120 kg/ha for no-till treatments with and without N. For soil test K >120 kg/ha, early growth increased as soil test K increased with N but remained nearly constant without N. Regression relationships explained slightly less than one half the variation in early growth.

For the chisel treatment without N, early growth increased as soil test K increased reaching an apparent maximum at soil test K values greater than 200 kg/ha. Within the range measured, soil test K had no detectable effect on early growth when 224 kg/ha N was added. In general soil test K level was more closely related to early growth than was applied K.

B. Total K uptake

For the no-till plots, total K uptake for the different N and K treatments was significantly different. The 224 kg/ha N, 448 kg/ha K_2O plots had significantly greater K uptake than any other treatment. All other treatments were not significantly different. K uptake was significantly greater with N compared to without N. The effect of K applications on K uptake was highly significant but the NxK interaction term was not significant.

With the chisel treatment there were no significant differences detected in K uptake due to treatments or due to N, K level or NxK interaction. The effect of applied K on K uptake was significant at the 10% level. Again the wide range in soil test K at each K treatment level tended to mask the effect of applied K.

The following relationships between soil test K and total K uptake were determined by regression:

No-till	gms K uptake/plant	R^2
N = 0	$= 61.67 - 530.74\ K^{-1/2}$	0.66
N = 224 kg/ha	$= -23.6 + 0.2683\ K$	0.51
Chisel		
N = 0	$= e^{-5.772675}K^{1.7183799}$	0.57
N = 224 kg/ha	$= 36.38 - 6.13 \times 10^{32}K^{-15}$	0.41
Both N rates	$= e^{-2.70}K^{1.14}$	0.41

For no-till treatments without N, K uptake increased rapidly up to K soil test values of about 150 kg/ha, but increased more slowly at greater values of soil test K. The equation explained about 2/3 of the variation in K uptake. When N was applied, K uptake increased approximately linearly with K soil test ($R^2 = 0.51$) and no indication of a maximum value of K uptake was detected.

For the chisel treatments the results appeared similar to those of the no-till with N in that K uptake increased nearly linearly with K soil test and that the effect of N was not discernable.

C. Ear moisture

Ear moisture was significantly different between N-K treatments for no-till but not for chisel; the effect of N was highly significant for the no-till.

No-till treatments receiving both N and K had significantly lower ear moisture than the 0 and 224 kg/ha K treatments without N. Again the variation in soil test K within each level of applied K tended to mask the differences due to level of applied K.

For no-till, ear moisture was highly correlated with soil test K ($R^2 = 0.80$) when no N was applied. The correlation between ear moisture and soil test K was $R^2 = 0.64$ when 224 kg/ha of N was applied. At soil test K levels below 200 kg/ha, ear moisture increased markedly. N application reduced ear moisture about 2 percent over most of the soil test range.

The effect of N on ear moisture was not detectable with the chisel treatment; nor was the effect of soil test K when all chisel data were considered together. However, for each level of applied K, ear moisture decreased as soil test K increased.

D. Corn yields

When analyzed as a 3x2x2 factorial the effect of blocks was significant and the effect of N and of N-K tillage treatments were significant at the 1 percent level. All other main effects, factors and interaction terms were not significant.

When chisel and no-till were analyzed separately the effect of blocks and N-K treatments were significant for the no-till but not the chisel; however, the effect of N on yield was highly significant for both no-till and chisel. The variation of soil test K again masked the effect of applied K.

Soil test K was closely correlated with corn yield ($R^2 = 0.83$) (Figure 1) for the no-till; yield decreased markedly with decreasing soil test K levels below about 200 kg/ha soil test K when N was applied. Within both 0 and 224 kg/ha levels of applied K_2O, corn yield increased as soil test K increased; however, for 448 kg/ha of K_2O, increased soil test K had no effect on yield. Without N the effect of soil test K on yield was not discernable except possibly at the 448 kg/ha level where yield appeared to increase as K level increased.

For the chisel treatment without N, at each level of applied K, the corn yield generally tended to increase with increased soil test K as indicated by a positive slope (Δ yield/Δ soil test K). When 224 kg/ha N was applied, there was no discernable yield response to soil test K except possibly at soil test K values below 150 kg/ha; thus, yield was poorly correlated with soil test K (R^2 = 0.31). The regressions between yield and soil test K indicate that at soil test K values below about 170 kg/ha chisel treatments generally outyielded no-till and over 200 kg/ha the reverse was true. For K soil tests greater than 225 kg/ha, no-till outyielded chisel sufficiently for the yield differences to be significant at the 10 percent level.

Comparing the yield responses of no-till and chisel, without N the no-till yields for 0 and 224 kg/ha K_2O were depressed to a greater extent than the chisel treatments as was the 0 K treatment with 224 kg/ha N. Apparently both K and N uptake were depressed more with no-till at these N and K levels than with chisel. These conclusions agree with the previous research results of Moncrief 1981.

E. Yield and early growth

Since both corn yield and early growth for no-till were affected by N and soil test K levels, it would be expected that yield and early growth would be related and they are (R^2 = 0.45). The data points cluster into two groups, with and without N. For early growth values over 24 gms/plant, yield appears unrelated to early growth. The relationship appears even more well defined for chisel. Without N, yield increases as early growth increases (R^2 = 0.64) until yields essentially equal those with N. With N, yield appears unaffected by early growth. Thus for both no-till and chisel when 224 kg/ha N was applied, early growth and yield were not well correlated; however, when both levels of N were considered the relationship of yield to early growth improved considerably.

MANURE STUDY

The results of the manure study are briefly summarized in table 5. The chisel and no-till treatments with manure both significantly outyielded their counterparts without manure. The chisel without manure outyielded the no-till without manure by 31 bu/acre. No-till with manure averaged 7 bu/acre less than chisel with manure. The difference is largely due to positional unavailability of manure for the no-till treatment caused by unequal spacing of injectors and lack of distribution from the point of injection on the no-till treatment.

REFERENCE

Moncrief, J. F. 1981. The effect of tillage on soil physical properties and the availability of nitrogen, phosphorus, and potassium to corn. Ph.D. Thesis, University of Wisconsin - Madison, WI.

Table 1. Soil test K (N-K Study)

Tillage	Fertilizer application N	Fertilizer application K_2O	Kg/Ha Replicate 1	2	3	Avg
	kg/ha					
No-till	0	0	163	139	92	131.3
		224	235	137	112	161.3
		448	246	374	204	274.7
	224	0	148	190	132	156.7
		224	246	211	208	221.7
		448	197	347	242	262.0
Rep. Avg. No-till			206	233	165	201.3
Chisel	0	0	213	155	101	156.3
		224	246	150	166	187.3
		448	336	152	233	240.3
	224	0	190	125	141	152
		224	264	172	195	177
		448	394	246	276	305.3
Rep. Avg. Chisel			274	167	185	203.0
Rep. Avg. No-till & Chisel			240	200	175	202

Table 2. Corn yield - grain (N-K Study)

Tillage	Fertilizer Application N	Fertilizer Application K_2O	Bu/A Replicate 1	Bu/A Replicate 2	Bu/A Replicate 3	Bu/A Avg	Mg/ha Replicate 1	Mg/ha Replicate 2	Mg/ha Replicate 3	Mg/ha Avg
	kg/ha									
No-till	0	0	98.3	136.1	91.1	108.5	6.17	8.54	5.71	6.81
		224	70.4	128.6	88.0	95.7	4.42	8.07	5.52	6.00
		448	123.1	158.1	95.8	125.7	7.72	9.92	6.01	7.88
	224	0	126.7	170.9	117.7	138.4	7.95	10.72	7.38	8.68
		224	178.8	154.3	146.6	159.9	11.21	9.68	9.19	10.03
		448	163.2	165.0	161.9	163.4	10.23	10.34	10.15	10.25
	0	Avg				109.9				6.90
	224	Avg				153.9				9.65
Chisel	0	0	145.8	140.9	113.2	133.3	9.14	8.84	7.10	8.36
		224	161.0	118.4	118.3	132.6	10.10	7.43	7.42	8.32
		448	127.4	108.8	131.9	122.7	7.99	6.82	8.27	7.70
	224	0	167.3	151.8	132.5	150.5	10.49	9.52	8.31	9.44
		224	153.7	155.3	152.9	154.0	9.64	9.74	9.59	9.66
		448	149.5	155.6	159.6	154.9	9.37	9.76	10.01	9.72
	0	Avg				129.5				8.12
	224	Avg				153.1				9.60

Table 3. Early growth (N-K Study), sampled 7/13/82

Tillage	Fertilizer Application		Replicate gms/10 plants				
	N	K_2O	1	2	3	Avg	
No-till	0	0	159	182	76	139.0	a
		224	205	250	188	214.3	b
		448	248	224	116	196.0	ab
		Avg	204	218.7	126.7	183.1	
	224	0	232	292	187	237.0	b
		224	233	312	260	268.3	bc
		448	217	341	415	324.3	c
		Avg	227.3	315	287.3	276.5	
Chisel	0	0	313	198	114	208.3	ns
		224	276	226	144	215.3	
		448	192	153	235	193.3	
		Avg	260	192.3	164.3	205.6	
	224	0	381	219	330	310.0	ns
		224	272	279	256	269.0	
		448	296	262	267	275.0	
		Avg	316.3	253.3	284.3	284.7	
Rep Avg No-till & Chisel			251.9	244.8	215.7	237.5	

Table 4. Percent ear moisture (N-K Study), cob and grain

Tillage	Fertilizer Application N	Fertilizer Application K_2O	Percent H_2O Replicate I	2	3	Avg	
	kg/ha						
No-till	0	0	43.0	41.3	46.1	43.5	a
		224	41.4	43.3	45.3	43.2	a
		448	41.0	41.8	40.9	41.2	ab
		Avg	41.8	42.1	44.1	42.7	
	224	0	41.4	38.9	41.4	40.6	ab
		224	38.3	40.0	40.1	39.5	b
		448	40.5	39.1	38.1	39.2	b
		Avg	40.1	39.3	39.9	39.8	sig. at 5% level
Chisel	0	0	38.4	41.3	39.8	39.8	
		224	38.8	44.3	41.3	41.4	
		448	41.2	44.9	41.4	42.5	
		Avg	39.4	43.5	40.8	41.2	
	224	0	38.3	40.9	40.2	39.8	
		224	38.3	41.4	44.0	41.2	
		448	39.7	42.3	39.8	40.6	
		Avg	38.8	41.5	41.3	40.5	
Rep Avg No-till & Chisel			40.0	41.6	41.5	41.1	

Table 5. Tillage-manure study with continuous corn

	Corn yield bu/A			
	Rep 1	Rep 2	Rep 3	Avg
Chisel manure	163	165	163	164
No-till manure	150	163	158	157
Chisel none	147	130	118	132
No-till none	80	132	90	101

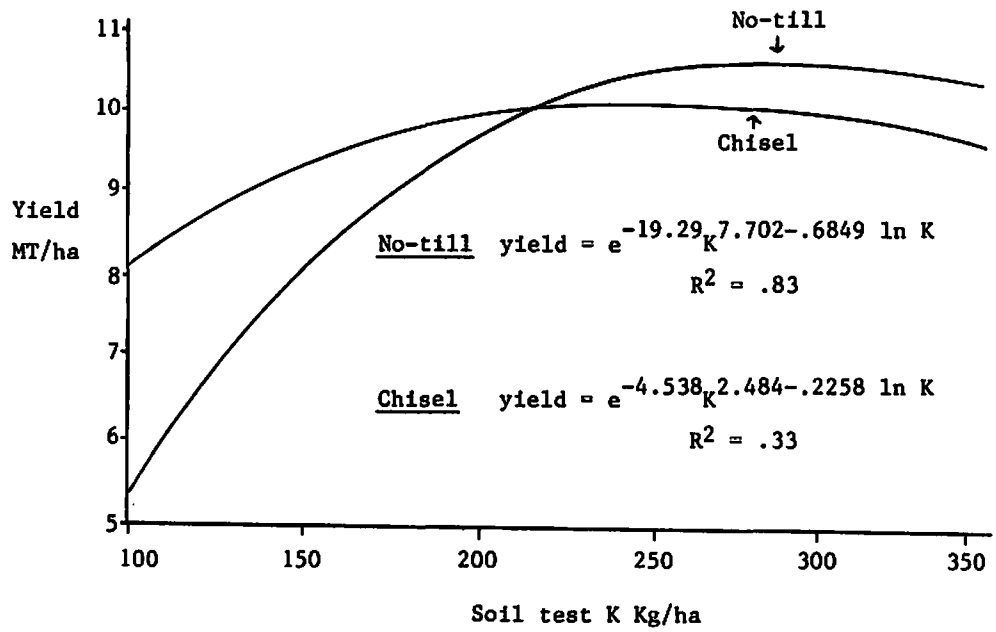
Manure application

375 lbs/A N (total)

234 lbs/A K_2O

141 lbs/A P_2O_5

Figure 1. The effect of tillage on potassium response , Goodhue Co., MN, 1982



THE EFFECT OF TILLAGE, N RATE, AND NITRAPYRIN ON CORN GROWTH, GOODHUE COUNTY, MN., 1982

J. F. Moncrief, G. L. Malzer, J. B. Swan, M. J. O'Leary, and T. J. Graff

INTRODUCTION

Conservation tillage systems for corn production are imperative in parts of Minnesota where water erosion is of paramount importance. Growers as well as researchers have found reductions in N availability to be associated with systems which leave large amounts of crop residue on the soil surface and result in very little soil disturbance. The purpose of this study is to explore several management scenarios which may improve the availability of N.

OBJECTIVES

1. To assess the effect of tillage on the availability of nitrogen to corn.
2. To evaluate the potential for increased N availability with nitrification inhibitors.

METHODS AND MATERIALS

The experimental plots are located in Goodhue County, Minnesota on a Typic Hapludalf, fine-silty, mixed, mesic and Mollic Hapludalf, fine-silty,mixed, mesic (Seaton, silt loam and Mt. Carroll silt loam respectively). Tillage was done April 30 (chisel plow followed by a light disc). Both the no-till and till plant systems were planted with a Hiniker planter in the till plant configuration. Consequently during the establishment year these two systems are similar (until cultivation of the till plant system). Planting in the chiseled area was done with the fluted coulter and trash sweeps lifted. Residue cover was measured by the line transect method.

This site has been in continuous corn for the past ten years. The two years prior to this study were cropped with till plant tillage. Corn was planted (Pioneer 3732 single cross 105 day) on May 20, 1982 in 97 cm rows at a population of 70,000 plants/ha. Anhydrous ammonia was applied on May 11 at 0, 85, 170 and 340 Kg/ha. Plots were split with a .56 Kg/ha application of nitrapyrin. Weeds were controlled with a pre-emergence application of Atrazine (1.3 Kg/ha) and Alachlor (4.2 l/ha). A post-emergence application of 2,4-D amine (.56 Kg/ha) was needed to control Atrazine resistant Lambs Quarter. Grain and stover yields were measured at physiological maturity and tissue samples analyzed for N.

RESULTS AND DISCUSSION

A final stand of 68,000 plants/ha was obtained and not influenced by tillage. The effect of tillage on residue distribution is shown in table 1. There is no difference in cover in the row due to tillage. There is more cover between the rows with the no-till and till plant systems. These two systems had significant differences in and between the row. Chisel tillage resulted in similar cover regardless of position relative to the row.

Table 1. The effect of tillage on residue distribution (June 17, 1982)[+].

	Position Retalive to Row[++]	
Tillage	In	Between
No-till	24 a	46 a
Till plant	18 a	49 a
Chisel	25 a	35 b

[+] Means within the same column followed by different letters are significantly different at $\alpha = .10$, N = 48.

[++] "In" is defined as the 20 cm area centered over the row and "Between" is the remainder. The no-till and till plant treatments are similar at this point in time.

The effect of tillage on nitrapyrin response is shown in table 1. There was no grain response beyond the first rate of applied N at this site. This makes it very dubious that there is a grain response to inhibitor at the higher rates. Corn grown under the chisel system had lower stover yields and N uptake at the 85 Kg/ha N rate. This may have caused the positive change in N index. Although May was very wet and conducive to N losses the anhydrous ammonia probably did not have a change to nitrify and therefore was less likely to be denitrified. June and July were very dry at this site. The inhibitor responses are spotty and show no obvious trend.

Least squares estimates for yields and N uptake are shown in table 2. Curves described by these equations are shown in figure 1. There are differences due to tillage of grain yield and N uptake with no N applied. The chisel system resulted in higher grain and stover yields as well as N uptake. Total N uptake appears to be higher over all levels of applied N for this system. There was little difference due to tillage in yields and grain N uptake beyond the first rate of applied N. The stover N uptake response over all rates of applied N are due to luxury consumption of N. Since there was very little N response at this location it is not possible to draw many conclusions. The differences in yield and N uptake (with no N applied) due to tillage suggest future differences with higher yield levels.

Table 1. The effect of tillage, N rate, and nitrapyrin on yield and N uptake at Goodhue County, MN, 1982+.

		Grain		Stover		Total Dry Matter		Index**	
	N rate Kg/ha	Yld Mg/ha	N upt Kg/ha	Yld Mg/ha	N upt Kg/ha	Yld Mg/ha	N upt Kg/ha	Harvest	N
No Till	85								
	170						*(11.6)		
	340		*(9.5)						
Till Plant	85								
	170								*(.016)
	340	*(.76)				*(1.0)		*(.017)	
Chisel	85			*(-.81)	*(-11.0)	*(-.58)			*(.046)
	170	*(.64)	*(12.7)				*(12.9)		
	340								

+ Values in parenthesis are mean differences.

* Means are significantly different at $\alpha = .10$ with $N = 4$ as the result of a paired t test.

** Index is defined as: harvest = grain yield/total dry matter, and N = grain N uptake/total N uptake. Cob mass is included in stover estimates. It is assumed that cobs have the same N concentration as stover.

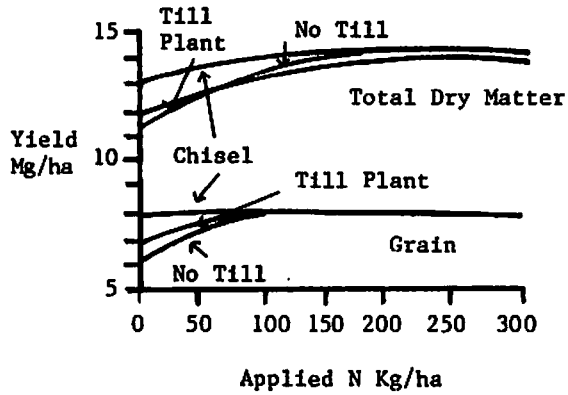
Appreciation is expressed for partial funding of this project to the Minnesota Plant Food and Chemical Association.

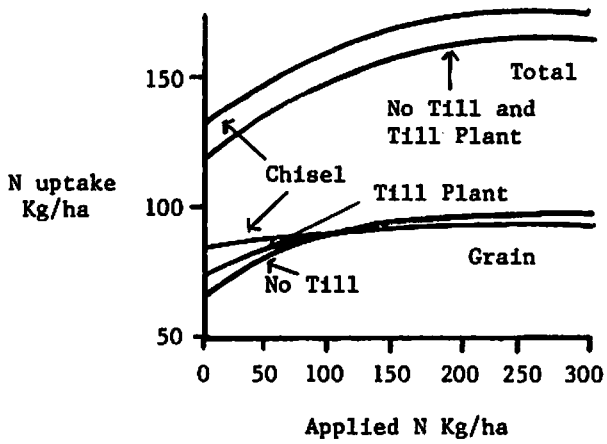
Table 2. Least squares estimates of corn yields and N uptake at Goodhue County, MN., 1982.[+]

No Till		
Grain	$= e^{-7.6285}\ N^{3.4053-.29664 \ln N}$	$R^2 = .57$
Total Dry Matter	$= e^{-4.2761}\ N^{2.3747-.20303 \ln N}$	$R^2 = .58$
Grain N uptake	$= e^{-10.758}\ N^{5.3245-.46177 \ln N}$	$R^2 = .59$
Total N uptake	$= e^{-4.9228}\ N^{3.3755-.28315 \ln N}$	$R^2 = .64$
Till Plant		
Grain	$= e^{-3.6938}\ N^{1.9778-.16823 \ln N}$	$R^2 = .62$
Total Dry Matter	$= e^{-3.0370}\ N^{1.9410-.16572 \ln N}$	$R^2 = .65$
Grain N uptake	$= e^{-6.9337}\ N^{4.0524-.35789 \ln N}$	$R^2 = .28$
Total N uptake	$= e^{-6.5178}\ N^{4.0162-.34665 \ln N}$	$R^2 = .61$
Chisel		
Grain	$= e^{1.8592}\ N^{.041747}$	$R^2 = .05$ (ns)
Total Dry Matter	$= e^{-1.2472}\ N^{1.3629-.11870 \ln N}$	$R^2 = .21$
Grain uptake	$= e^{3.7918}\ N^{.13106}$	$R^2 = .29$
Total N uptake	$= e^{-2.3024}\ N^{2.4785-.20534 \ln N}$	$R^2 = .64$

[+]Grain yields are at 15.5 percent moisture, N = 32 for each regression.

Figure 1. The effect of tillage and nitrogen rate on yield and N uptake, Goodhue, MN., 1982.





THE EFFECT OF TILLAGE, N RATE, SOIL P AND K AND NITRAPYRIN ON CORN GROWTH LANCASTER, WI - 1981 and 1982

J. F. Moncrief, E. E. Schulte and K. C. Killian

INTRODUCTION

There are many examples in the research literature which show reductions in nutrient availability to be associated with conservation tillage extremes (systems which involve very little soil manipulation and a high percentage of the soil surface covered with crop residues). In southeastern Minnesota (as well as NE, NW, and SW Iowa, Illinois and Wisconsin respectively) the soils are generally steeply sloping alfasols which have been shown to result in reduced N availability when very little tillage is employed (in a continuous corn monoculture). The study reported here is designed to characterize the response of corn to N, P, and K under different tillage as well as an attempt to enhance the N recovery with the use of nitrapyrin.

OBJECTIVES

1. To assess the effect of tillage on the availability of N, P, and K to corn.
2. To evaluate the potential for increased N availability with nitrapyrin.

METHODS AND MATERIALS

Experimental plots are located at the Lancaster, Wisconsin Experiment Station. The soil is a Typic Hapludalf, fine-silty, mixed, mesic (Fayette, silt loam). The plots are on a contour strip that had been in alfalfa in 1976. A heavy application of manure was applied and plowed down by the farmer owner in 1977 prior to a corn crop in this year. In 1978, fertilizer applications were made to adjust N, P, and K levels to those desired. In 1978, corn yields and tissue concentrations of ear leaves exhibited no N response and only a modest response to P and K. Tillage variables were introduced in 1979. Tillage treatments comprise main plots with fertility subplots. Tillage treatments are: spring moldboard plow, disc, plant; spring chisel plow, disc, plant; and no tillage. The 1981 and 1982 results will be discussed. A 108 day single cross hybrid (Blaney 606) was planted May 7, 1981 and May 5, 1982 and thinned to a population of 72,000 plant/ha (91 cm row width). Whole plant samples were taken on September 5, 1981 and September 9, 1981 (dough stage). There has been only modest response to P and K at this site so only N will be discussed. Nitrogen was applied on April 17, 1981 as broadcast ammonium nitrate (0, 110, 120, 340 Kg/ha) and April 29, 1982 as anhydrous ammonia (0, ∿100, ∿200, ∿250). In 1982 the time spent in each plot in combination with the mass of N applied was used to calculate the rate. This was necessary because of wheel slippage caused by varying soil conditions due to tillage. Differing levels of N was obtained by keeping the nitrolator setting constant and changing the tractor speed. So in this year there are three groups of applied N levels with variation in each group due to wheel slippage. Plots were split in 1982 with and application of .56 Kg/ha nitrapyrin. Weeds were controlled with a pre-emergence application of Atrazine (2.2 Kg/ha) and Alachlor (5 l/ha). Glyphosate was applied on local problem areas to control perennials. Soil covered by crop residue was estimated in mid June by the meterstick method in 1981 and line transect method in 1982.

RESULTS AND DISCUSSION

The percent of the soil surface covered with crop residue is shown in table 1. There are differences due to tillage. Values are higher between the row with the no-till (both years) and chisel (1982) probably because of the incorporation by the fluted coulter at planting in addition to planting off the old row with no-till. Higher values in 1982 are due to trash accumulation and the method of measurement.

The effect of nitrapyrin on corn growth is shown in table 2. In four instances the N rate of the minus inhibitor treatment was significantly higher than the plus inhibitor treatment. A reverse trend was apparent with the first rate of N under the no-till system. If the rates had been equal these differences may have been significant. There was a significant grain response with chisel tillage even though the rate was lower. There were no significant responses under moldboard tillage. It is interesting to note that in the only instance with a significant grain response there was also an increase in harvest index.

Table 1. Percent of the soil surface covered with crop residue. Lancaster, WI+.

Tillage	1981 In	1981 Between	1982 In	1982 Between
No-till	56(25)	89 (12)	72(15)	92(7)
Chisel	18(14)	18 (10)	32(14)	44(13)
Moldboard	3(5)	6 (7)	10(7)	13(8)

+ "In" is defined as the 20 cm area centered over the row and "Between" is the remaining area between rows. Numbers in parenthesis are standard deviations, N = 32.

Least squares estimates of grain yields and N uptake are shown in table 3. The lines that these equations describe are shown in figure 1. In both years the response with chisel and moldboard plowing were similar. This is also consistent with 1979 and 1980 (not shown). Corn grown with no tillage consistently required more applied N (also consistent for four years of the study). In the four years of study the no-till system resulted in significantly higher grain yields than under moldboard tillage in two, lower in one and equal in one. This was found to be related to rainfall (not shown here). In a dry year residue proved to be an advantage and in a wet year a detriment. It took much higher rates of applied N however.

The total N uptake with no N applied for the four years of study is shown in table 4. This is a bioassay of available N. It reflects mineralization of soil organic matter as well as crop residues, immobilization by crop removal, denitrification and leaching. With the exception of the first year the chisel and moldboard systems resulted in similar uptake values. Introduction of the no tillage treatment hastened the disappearance of residual N from the alfalfa and manure plow down in 1976 and 1977 respectively. This treatment has also stabilized at a lower value. If losses of applied N under this system were due to denitrification and/or leaching these should be reduced with a nitrification inhibitor, ammonium sources of N and injection. Although there are some encouraging trends in this direction with the 1982 data, any conclusions at this point would be premature.

Table 2. The effect of tillage, nitrogen rate, and nitrapyrin on corn grain and stover yields, nitrogen uptake and harvest index at Lancaster, WI., 1982.

N rate Kg/ha		Grain Yields Mg/ha (dry wgt)		Total Dry Matter Mg/ha (dry wgt)		Total Uptake Kg/ha		Harvest Index+	
-	+	-	+	-	+	-	+	-	+
				No Till					
0	-	2.78	-	6.19	-	46.1	-	.446	-
115	100*	5.10	5.73	11.3	11.6	113	127	.466	.504
195	202	6.45	6.73	12.1	12.3	169	173	.545	.557
252	256	6.17	6.25	10.7	12.1*	149	171*	.583	.523
				Chisel					
0	-	3.65	-	7.95	-	73.9	-	.459	-
114	97*	6.27	7.03*	12.8	12.2	164	167	.492	.582*
191	196	6.59	6.69	12.3	13.3	166	169	.535	.510
248	248	6.74	6.69	13.8	13.5	202	189	.496	.503
				Moldboard					
0	-	3.80	-	8.31	-	72.5	-	.458	-
103	98*	6.73	6.44	12.7	12.5	170	164	.538	.526
197	195	6.67	6.46	12.9	13.1	183	174	.520	.490
249	259*	7.05	6.67	12.6	12.9	169	173	.573	.522

* Treatment means (- = without and + = with nitrapyrin) are significantly different at $\alpha = .10$ as the result of a paired t test, N = 12.

+ Harvest index is defined as the ratio of grain/total dry matter.

Table 3. Least squares estimates of response of grain yields and N uptake at Lancaster, WI[+].

No Till		
1981 Grain	$= e^{5.14223}\ N^{1.0181-.33123 \ln N+.24627 \ln K}\ K^{-2.4627+.24627 \ln N}$	$R^2 = .83$
N uptake	$= e^{-7.5700}\ N^{4.4427-.39146 \ln N}$	$R^2 = .80$
1982 Grain	$= e^{-19.165}\ N^{.48311}\ K^{7.0417-.66691 \ln K}$	$R^2 = .62$
N uptake	$= e^{-3.3002}\ N^{2.6326-.20414 \ln N}$	$R^2 = .76$
Chisel		
1981 Grain	$= e^{6.4435}\ N^{3.1197-.28174 \ln N}$	$R^2 = .58$
N uptake	$= e^{-4.6899}\ N^{3.2085-.25860 \ln N}$	$R^2 = .67$
1982 Grain	$= e^{11.975}\ N^{5.1050-.46345 \ln N}$	$R^2 = .63$
N uptake	$= e^{-8.6483}\ N^{4.7516-.40733 \ln N}$	$R^2 = .70$
Moldboard		
1981 Grain	$= e^{-.41726}\ N^{1.9291-.28511 \ln N+.11873 \ln K}\ K^{1.1873+.11873 \ln N}$	$R^2 = .69$
N uptake	$= e^{-11.816}\ N^{5.9015-.51156 \ln N}$	$R^2 = .79$
1982 Grain	$= e^{-9.1595}\ N^{4.0422-.36377 \ln N}$	$R^2 = .58$
N uptake	$= e^{-13.689}\ N^{6.4337-.58136 \ln N}\ K^{.19057}$	$R^2 = .71$

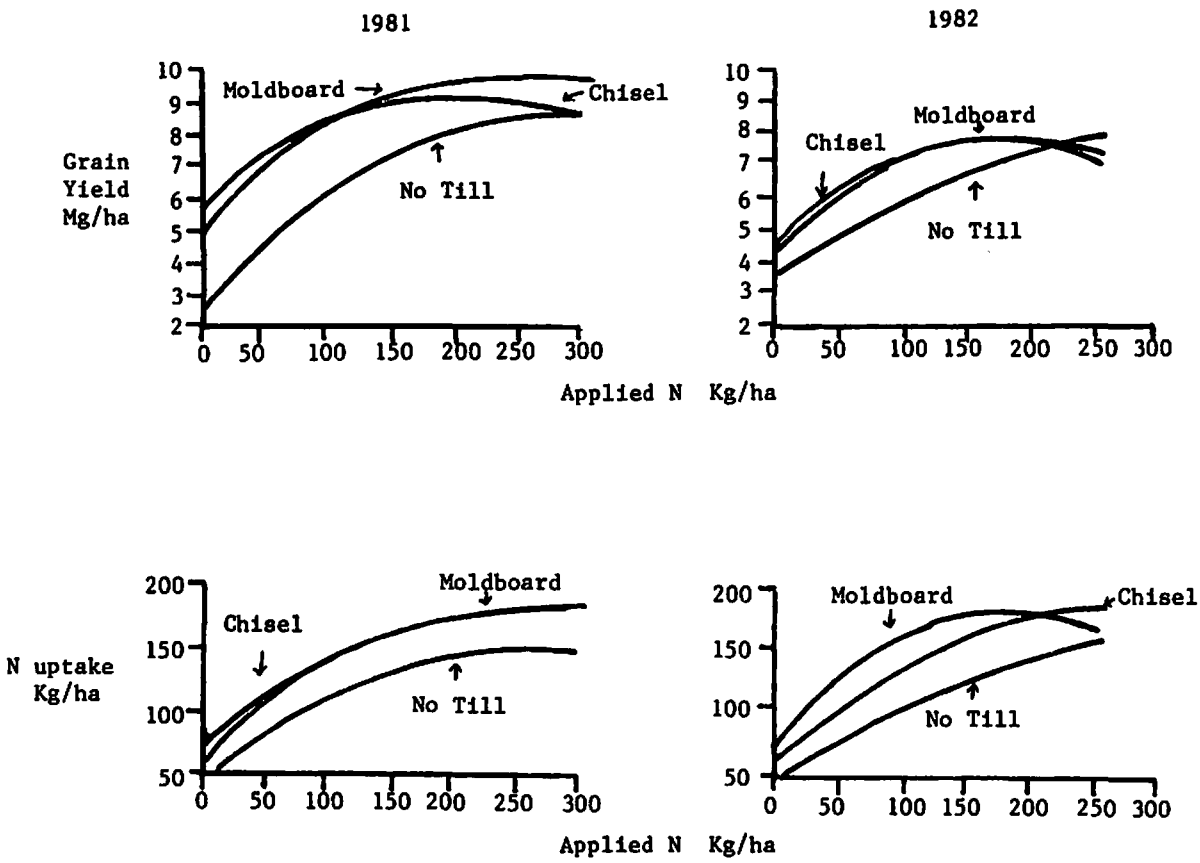
[+] Grain yield estimates are at 15.5% moisture, N = 96 for each regression (averaged over inhibitor treatment).

Table 4. The effect of tillage on total N uptake of corn with none applied. Lancaster, WI[+].

	1979	1980	1981	1982
No Till	108 a	61.1 a	44.0 a	46.1 a
Chisel	138 b	110 b	77.9 b	73.9 b
Moldboard	163 c	118 b	60.4 b	72.5 b

[+]Means within the same column followed by different letters are significant at $\alpha = .10$, N = 12.

Fig. 1 Response of grain yields (at 15.5 percent moisture) and N uptake to applied N at Lancaster, WI+.



+ In 1981 N was applied before spring tillage as ammonium nitrate and in 1982 after tillage as anhydrous ammonia.

CORN TILLAGE RESIDUE MANAGEMENT, LANCASTER, 1982

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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 on the Lancaster Experimental Farm. Five tillage treatments are replicated four times (table 1) the first replication is located on Palsgrove silt loam; the other three replications are located on Rozetta silt loam. Each treatment is split into normal and mulched subtreatments. On the slot plant and till-plant plots on additional subtreatment (bare) is established by removing all residue prior to planting; the residue is then placed on the adjacent mulched plots of the same tillage treatment. On mulched subtreatments, corn residue additions are made after tillage but before planting to obtain approximately 60 percent surface cover. Plots are approximately 90 to 100 feet in width and 80 feet in length. Row width is 36 inches in 1982, slightly less than the 38 inch row width which predominate in the region. In 1982 corn (Pioneer 3734) was planted (at 30,500 plants/A) on May 17 following spring primary tillage on May 13 and secondary tillage with a disc on plow and chisel treatments on May 14. A Hiniker planter was used for the till-plant, slot plant, fall chisel and spring plow treatments. An AC model 77 planter was used on the wheeltrack treatment.

Nitrogen (250 lbs/A as ammonium nitrate) was broadcast on April 26, 1982. On Nov. 18, 1981, 0-0-60 was applied to 2.5 acres at a rate of 600 lbs/A to equalize fertility levels between replications. Liquid starter was applied at planting. Insecticide used was Counter at 8 lbs/A. Chemical weed control used was: 2lbs/A Aatrex 1.5 qts/A. Prowl and 1 pt/A Banvel. The till plant treatment was cultivated on July 7-8 to create ridges using furrow opener (lister type) shovels without covering discs. Stand reduction from herbicide injury was observed on much of the plot area; sufficient unaffected plot area remained to permit yields to be taken on most plots.

Mulch rates, crust strength, planting depth, plant height, silking date and early growth measurements were made on designated portions of each plot. Random roughness measurements were made on all treatments in replication No. 2 on May 17 and again on June 7-8.

Ten plot frames (40x40 inch) were emplaced on May 18 and covered to protect the surface. Infiltration measurements were made on the wheeltrack plant bare, conventional mulch, conventional bare, till plant normal, slot plant normal treatments on June 7-11.

Neutron probe measurements were made on June 28; equipment failure precluded additional measurements. Soil nitrate-N content within the rooting depth was measured July 8, 1983. Bulk density measurements were made on the 1-3 inch depth.

Yields were determined by hand harvesting duplicate 60 foot samples from each subplot on November 4, 1982.

RESULTS

Differences in early growth due to the tillage-mulch treatments were significant at the 0.01 level. The greatest early growth occurred on the bare slot plant treatment and the least on the mulched wheeltrack plant treatment. The second highest early growth occurred on the mulched till plant treatment. All the other treatments did not differ significantly from each other. Early growth was consistently depressed (REG < 1) as mulch cover increased for all treatments except till plant

(REG > 1) where the trend was reversed (table 2). Thus mulch in the row consistently decreased early growth (REG < 1), while mulch between row did not affect or possibly increased early growth (REG < 1) if the row area was bare.

The strong effect of mulch on early growth was apparently related to the 4.5°F below normal average temperature in June (table 3). The response of relative yield (yield with mulch/yield without mulch) was similar to relative early growth and the two were closely correlated in 1982 as percent cover increased. Relative yield decreased for all treatments except till plant. The presence of cover significantly decreased yield when (O) and (IX) levels were analyzed as a 2 x 5 factorial; however, the effects of tillage system was not significant nor was the tillage cover interaction.

Plant height measurements were not significantly different when measured on July 8. All treatments reached 50% silking within 1-day of each other. Very little difference was observed in rate of emergence between treatments in 1982. Significant differences occurred in depth of planting within the wheeltrack plant treatment where the presence of residue reduced depth of planting by a factor of 2. The other treatments were planted with the Hiniker planter and no significant differences due to residue were detected within any tillage treatment.

Soil nitrate nitrogen amounts were measured on each replication for the conventional and slot plant treatment on July 8, 1982. Average values for the two treatments were nearly identical and were in excess of 260 lbs/A (table 4).

Large differences in final (60 minute) infiltration rates were measured between treatments (table 5). When mulch was present on the conventional tillage tillage, final infiltration rate was 50 percent greater than the bare conventional tillage treatment. Slot plant had the lowest final infiltration rate and the lowest amount of infiltration before runoff began of all the treatments, even though between 3 and 4-tons per acre of surface residue cover was present on the slot plant treatment. The infiltration rate for the till plant and wheeltrack plant treatments were intermediate between the conventional bare and conventional mulch treatment. These results illustrate the dual requirement of 1) a porous surface with high saturated hydraulic conductivity and 2) a protective mulch cover in order to have rapid sustained infiltration. Residue cover by itself is not sufficient to produce a high infiltration rate.

SUMMARY

Four year results of Lancaster with continuous corn show nearly equal average yield from conventional, chisel, slot plant, and till plant treatments (table 5).

Thus famers in the driftless soil area 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 also offer savings in time, labor, and fuel compared to conventional moldboard plow tillage methods.

Table 1. Effect of tillage and mulch treatments on planting depth, corn early growth, plant height, silking date and yield, Lancaster, 1982.

Treatment Tillage	Residue	Dry[1] matter T/A	Percent cover	Avg planting depth inches	Avg Early growth gms DM/ plants	Avg inches height July 8 inches	Date 50% plants silked day after July 1	Avg Population at harvest[4]	Avg yield bu/A *	Avg yield incl. plots with reduced population
Till plant	Bare (0)	-	3	1.5 bc	24.0 abc	29.3	30.5	18,000	151*	131
	Normal (IX)	2.1	20	1.8 bc	25.7 abc	31.5	30.3	19,000	147*	137
	Mulch (2X)	4.5	32	1.7 bc	28.6 ab	32.3	30.8	19,000	145	
Slot Plant	Bare (0)	-	5	1.7 bc	34.8 a	33.0	30.5	21,800	153	
	Normal (IX)	2.1	50	1.6 bc	16.2	29.2	31.0	20,000	141*	132
	Mulch (2X)	5.5	76	1.3 c	21.8 bcd	30.8	31.3	23,900	142	
Conventional[2]	Normal (0)	-	3	1.7 bc	23.9 abcd	35.5	30.5	20,100	151*	138
	Mulch	5.5	55	2.0 ab	16.1 abcd	32.3	30.8	22,200	151	138
Fall Chisel[3]	Normal (N)	1.3	12	1.7 bc	26.6 abc	33.3	30.8	21,400	154*	124
	Mulch (IX+N)	3.3	58	1.9 ab	15.6 cd	33.8	31.0	20,500	134	
Wheeltrack plant	Normal (0)	-	1	2.5 a	15.5 cd	32.3	31.0	26,900	147	
	Mulch (IX)	3.5	65	1.2 c	11.1 d	30.0	31.3	26,100	135	
Significance level				0.05	0.01	ns			ns	

* Plots with population 18,000 plants per acre due to herbicide injury were treated as missing plots

[1] Reps 1 and 2

[2] Spring moldboard plow, spring disk

[3] Fall chisel, spring disk

[4] Includes plots with severe stand reduction due to herbicide injury

Table 2. Effect of mulch on relative early growth (REG) and relative yield (RY)*

$$\text{Where REG} = \frac{\text{Early growth with mulch}}{\text{Early growth without mulch}} \qquad \text{RY} = \frac{\text{Yield with mulch}}{\text{Yield without mulch}}$$

Tillage	Mulch level	Percent Cover	REG	RY
BTP	(IX)	20	1.07	1.021
	(2X)	32	1.19	1.069
Slot	(IX)	50	0.47	0.906
	(2X)	76	0.63	0.882
Conventional	(IX)	55	0.67	0.946
Chisel	(IX+N)	58	0.59	0.915
WTP	(IX)	65	0.71	0.936

*Yield adjusted to equal populations for each RY comparison

Table 3. 1982 Weather Summary, Lancaster Experimental Farm

Month	Precipitation inches		Growing* Degree Days		Air Temperature			
	Total	Departure	1982	Departure	Avg max	Avg min	Average	Departure
April	1.96	-1.25	(54)	-	54.5	31.0	42.8	-3.9
May	5.46	2.10	414	108	72.4	52.7	62.6	4.6
June	3.45	-1.16	405	-107	73.8	50.9	62.4	-4.5
July	5.27	0.93	688	33	81.5	62.1	72.3	1.1
August	4.06	-0.64	585	- 3	78.9	59.1	69.0	0.4
September	1.29	-2.14	368	19	71.5	51.1	61.3	0.5
October	3.28	1.14	(145)	-	63.5	41.5	52.5	2.0
April-Oct.	24.77	-1.02	2460	50				

Last day in spring with minimum temperature: 32° on <April 27 (31°)
28° on <April 21 (27°)

First day in fall with minimum temperature: 32° on <Oct. 16 (32°)
28° on <Oct. 21 (25°)

Table 4. Soil nitrate nitrogen for conventional and slot plant treatments measured July 8, 1982, Lancaster - Wisconsin.

Sample depth	Rep I ppm		Rep II ppm		Rep III ppm		Rep IV ppm	
	Conv	Slot	Conv	Slot	Conv	Slot	Conv	Slot
0-1	27	47	30	37	44	35	53	32
1-2	18	20	27	16	14	23	14	14
2-3	*	*	10	12	5	13	7	8
3-4			*	*	5	*	6	6
4-5					*		6	6
Total ppm	45	67	67	65	68	71	86	66

Tillage	Total Profile Soil Nitrate-N in lbs/A				Avg lbs/A N
Conv	180	268	272	344	266
Slot	268	260	284	264	269

Table 6. Continuous corn tillage yield results at Lancaster, Wisconsin, 1979-1982.

Tillage	1979	1980 Bu/A	1981	1982	Average Bu/A
Till Plant*	162*	157	157*	147	156
Soil Plant	163	146	151	141	150
Chisel	160	150	167	154	158
Conventional	169	159	168	151	162

*Planted flat in 1979 and 1981.

Table 5. Infiltration rate

Tillage System	Residue T/A	Random Roughness	Inches inf. to start of runoff	Appl. rate in/hr	Infiltration rate* at time indicated after runoff commences (Inches/hour) 5 min	10	15	20	25	35	45	55	60	75	90 min	ic
Slot Plant					1.77	1.46	1.32	1.24	1.18	1.11	1.06	1.02	1.01		0	0.70
E	4.0	0.83	0.50	4.64												
W	8.3	0.53	0.23	4.64												
Conv-Plow Disk-Bare					2.59	2.14	1.94	1.82	1.74	1.63	1.56	1.51	1.49			1.05
E	T	1.30	0.89	3.92												
W	T	1.40	0.55	5.12												
Mulch					2.65	2.50	2.44	2.40	2.37	2.34	2.32	2.30	2.29	2.28	2.27	2.15
E	1.2	1.46	1.06	4.72												
W	0.9	1.64	1.02	5.12												
Wheeltrack Plant					2.81	2.51	2.38	2.30	2.25	2.18	2.13	2.10	2.09			1.80
E	T	1.72	0.61	5.04												
W	T	1.48	0.73	4.64												
Till Plant					3.72	2.89	2.52	2.31	2.16	1.96	1.84	1.75	1.71			0.90
E	1.4	1.07	0.81	5.28												
W	2.1	1.22	1.17	5.22												

*Calc. from regression EQ developed from paired infiltration runs ($i = ic + S/2\ t^{-y2}$)

	ic	S/2
Slot Plant	0.70	2.40
Conv. Bare	1.05	3.45
Mulch	1.12	2.15
WTP	1.80	2.27
Till Plant	0.90	6.30

SULFUR, BORON AND MAGNESIUM TRIALS ON A PROBLEM ALFALFA FIELD

W. E. Fenster, M. O'Leary and G. Buzicky

Yields of irrigated alfalfa on sandy loam soils have been unsatisfactory at some locations in Stearns County. This led to the establishment of a trial with sulfur, boron and magnesium where phosphorus and potassium were maintained at very high levels. These trials were on the Eugene Heinen farm.

Tables 1 and 2 show alfalfa yields, related soil tests and plant analysis resulting from sulfur, boron and magnesium treatments.

Plant analysis shows only copper and magnesium for all cuttings to be below adequate levels. The sulfur soil test of 5 is considered below the adequate level.

There was no significant effect of treatments on yield. Except for sulfur at the first cutting the concentration of nutrients in the upper third of alfalfa plants was not affected by treatment.

The alfalfa stands were good but growth appeared to be less than expected. First cutting yields were below the other two cutting yields because irrigation was not possible for the first cutting. It would appear that there is some limiting factor affecting yields but the one year's data fails to reveal the problem.

It would appear on the basis of plant analysis that rates of copper should be included in the trial.

Table 1. Alfalfa yields by cutting and relationship to sulfur, boron and magnesium treatments. Stearns Co. 1982.

trt	lbs/A	Tons/A @ 15% M 1	2	3	Total
check		1.00	1.27	1.35	3.62
S	100	0.91	1.48	1.46	3.85
B	3	0.85	1.46	1.40	3.71
Mg	300	0.93	1.58	1.43	3.94
significance		ns	+	ns	ns
C.V.		12.7	7.2	11.7	4.4

Soil Test	
Text	SL
O.M.	M
pH	7.3
P	200+
K	443
Mg	204
S	5 ppm

Table 2. Plant analysis of alfalfa for 3 individual cuttings according to sulfur, boron and magnesium treatments.

		Tissue Analysis									
		%					ppm				
1st cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
trt	lbs/A										
check		.41	.44	3.28	1.67	.25	119	55	30	3	43
S	100	.44	.44	3.40	1.63	.25	110	52	31	3	40
B	3		.43	3.17	1.75	.25	116	55	30	3	43
Mg	300		.43	3.19	1.81	.26	116	57	29	3	36
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		-	2.0	5.5	1.7	9.5	5.3	9.4	3.7	9.7	18.6
2nd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.32	.44	2.81	1.96	.29	115	69	32	5	47
S	100	.35	.47	2.75	2.05	.28	118	72	33	5	45
B	3		.45	2.80	2.04	.27	110	65	31	6	42
Mg	300		.47	2.72	2.04	.27	111	65	33	5	38
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		*	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		-	3.6	2.2	2.5	7.7	6.4	14.4	4.2	4.1	17.7
3rd cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
check		.33	.37	2.65	2.12	.26	104	75	26	4	55
S	100	.34	.37	2.49	2.25	.26	104	76	26	4	51
B	3		.35	2.58	2.14	.24	99	70	26	5	50
Mg	300		.36	2.61	2.26	.26	104	78	27	5	45
adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.		-	3.1	3.0	3.6	9.3	4.3	11.6	5.8	9.7	20.6

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1982

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, '81
	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 and 1981.

[6] 100 + 0 was applied at all locations in 1980 and 1981.

The P and K materials were broadcast on cornstalks and plowed down at all locations in the fall of 1981. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Starter fertilizer was not used.

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

At Lamberton each of the plots were split with the east half planted to corn and the west half to soybeans. Corn (Pioneer 3732) was planted in 30-inch rows on April 28 at 24500 ppA. Nitrogen was applied at 150 lb N/A. Weeds were controlled with Lasso (2½#) and Bladex (1½#). The leaf opposite and below the ear was sampled at silking. Yields were taken on October 11.

Table 2. Experimental procedures for soybeans on the high P and K rate study at the three branch stations in 1982.

Variable	Lamberton	Morris	Waseca
Planting date	5/4	5/20	5/20
Row spacing	30"	6"	15"
Planting rate	9 seeds/foot	3 beans/foot	5 beans/foot
Variety	Corsoy-79	Evans	Corsoy-79
Herbicide	3/4# Treflan + 2# Amiben/A (Bdct)	3#Lasso + 2½# Amiben + 3/4# Basagran/A (Bdct)	3½# Lasso + 2½# Amiben/A (Bdct)
Harvest date	10/25	10/18	10/25

RESULTS AND DISCUSSION

Soil samples taken at the end of the 1982 growing season indicate significant differences in Bray P_1 extractable P and exchangeable K 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 indicated about twice as much extractable P in this soil as with the 1:10 ratio at the higher levels and about 4 times as much at the low soil P levels. Soil P values obtained with Olsen's $NaHCO_3$ test on the calcareous soil at Morris were slightly lower than with the Bray P_1 test (1:10 ratio), but compared very similarly on a relative basis. The response to the annual K applications was not as pronounced as with P. A linear increase in soil test K with increasing K application rates was not always found. Soil pH was not related to the P and K treatments.

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

Treatment		pH			P					K		
No.	Description[2]	La	Mo	Wa	La	M_{10}	M_{01}	M_{50}	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A				lb/A							
1	0 + 0	6.0	7.7	6.6	51	6	4	26	25	275	286	311
2	0 + 100	6.1	7.8	6.5	44	6	4	25	17	390	448	369
3	50 + 100	6.4	7.7	6.3	71	32	24	71	58	375	385	380
4	100 + 100	5.9	7.7	6.5	94	64	45	126	92	366	376	355
5	0 + 100	6.3	7.7	6.5	72	22	14	52	53	374	369	406
6	100 + 0	5.8	7.7	6.5	95	69	48	134	96	280	305	331
7	100 + 50	6.0	7.7	6.5	94	60	53	134	91	342	327	327
8	100 + 0	6.0	7.6	6.4	100	72	56	140	83	316	313	320
9	0 + 100	6.2	7.8	6.5	48	22	14	51	31	321	285	349
10	100 + 0	6.2	7.8	6.5	88	13	8	38	68	303	297	318
	Signif.Level (%):[3]	56	NS	14	99	99	99	99	99	99	99	99
	BLSD (.05) :				22	11	10	16	13	46	51	40
	CV (%) :	5.6	21.	2.9	20.	23.	27.	15.	13.	10.	11.	6.5

[1] Samples were taken in October before the 1982 treatments were applied.

[2] Rates applied in fall of 1981 for 1982 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.

Table 4. Effect of high P and K rates on the nutrient concentrations in the soybean leaves at the three experimental sites in 1982.

Treatment No.	Treatment Description	Nutrient Concentration[1] P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
					Lamberton					
1	0 + 0	.43	2.10	1.08	.49	132	49	49	10.9	67
2	0 + 100	.41	2.44	1.05	.38	129	47	50	11.6	69
3	50 + 100	.42	2.38	1.10	.41	137	52	44	9.5	64
4	100 + 100	.44	2.50	1.14	.42	131	49	46	8.5	67
5	0 + 100	.42	2.32	1.07	.41	135	52	46	10.3	66
6	100 + 0	.43	2.10	1.19	.51	134	53	45	7.6	67
7	100 + 50	.44	2.41	1.11	.44	128	54	48	8.5	68
8	100 + 0	.44	2.27	1.14	.46	138	53	45	7.4	70
9	0 + 100	.42	2.37	1.05	.41	140	54	49	11.4	66
10	100 + 0	.43	2.17	1.16	.49	134	49	44	9.0	69
	Signif. Level (%):	96	99	99	99	53	52	44	99	69
	BLSD (.05) :	.02	.21	.08	.02				0.8	
	CV(%) :	3.0	5.9	4.4	3.9	5.6	9.3	10.	6.0	5.0
					Morris					
1	0 + 0	.44	2.28	.85	.41	166	77	50	13.7	43
2	0 + 100	.40	2.33	.85	.40	162	82	53	14.0	42
3	50 + 100	.47	2.25	.86	.40	155	71	44	12.1	43
4	100 + 100	.47	2.40	.91	.38	157	79	41	11.1	45
5	0 + 100	.46	2.32	.85	.39	161	76	44	12.9	44
6	100 + 0	.49	2.22	.95	.45	156	75	41	10.3	47
7	100 + 50	.49	2.29	.93	.40	152	90	41	10.9	46
8	100 + 0	.49	2.31	.92	.40	153	72	40	9.9	45
9	0 + 100	.48	2.19	.90	.44	155	78	43	11.2	45
10	100 + 0	.46	2.29	.89	.42	151	77	45	12.9	44
	Signif. Level (%):	NS	NS	NS	*	NS	NS	99	99	*
	BLSD(.05) :				.04			7	1.4	3
	CV(%) :	10.	5.8	6.9	6.4	7.0	12.	10.	8.6	4.0
					Waseca					
1	0 + 0	.43	2.00	1.10	.49	110	42	44	9.9	45
2	0 + 100	.40	2.28	1.04	.41	111	44	44	10.7	45
3	50 + 100	.46	2.32	1.11	.43	112	46	43	9.2	48
4	100 + 100	.48	2.34	1.08	.42	107	45	41	7.6	46
5	0 + 100	.47	2.30	1.06	.42	109	44	42	9.1	44
6	100 + 0	.48	1.96	1.13	.50	110	46	41	7.6	47
7	100 + 50	.49	2.15	1.04	.45	109	45	42	7.5	44
8	100 + 0	.49	2.10	1.06	.47	106	44	44	7.5	46
9	0 + 100	.45	2.26	1.06	.42	109	45	42	9.7	45
10	100 + 0	.48	2.06	1.07	.48	108	46	42	8.2	46
	Signif. Level(%):	87	99	39	99	3	48	54	99	72
	BLSD(.05) :		.21		.04				0.7	
	CV(%) :	9.1	6.3	5.9	6.6	6.2	6.2	5.3	6.0	4.3

[1] Uppermost, mature trifoliate at the R2 stage.

Soybean leaf nutrient concentrations were affected significantly by the P and K treatments at Lamberton but to a lesser degree at Waseca and Morris (Table 4). At all locations leaf P was slightly less with the 0 + 100 treatment (no. 2) than with the 0 + 0 treatment (no. 1). Leaf Cu was reduced with increasing P rate at all three sites. At Lamberton, the increasing P rates increased leaf P, Ca and Mg. The K treatments had a lesser effect than P, but leaf K was increased slightly and leaf Mg decreased with increasing K rate. Although the trend toward higher leaf P was seen at Morris, the P treatments did not affect leaf P significantly due to the high variability (CV=10%). Leaf Zn was

decreased significantly by the P treatments. The K rates had no effect on leaf K at Morris. Similar to Morris, leaf P showed an upward trend with increasing P rates at Waseca, but this was only significant at the 87% probability level. Leaf K was significantly improved with increasing K rates while Mg was reduced.

Soybean yields were influenced significantly (95% level) at all three locations by the treatments (Table 5). At Lamberton, no consistent relationship existed between the P or K treatments and yield. Oddly enough, the highest soybean yields at Lamberton occurred where K has not been applied during the 9-year course of study. Distinct yield responses to the annual 50-lb P_2O_5 rate were observed at Morris and Waseca. The annual 100-lb rate of P_2O_5 did not improve yields significantly over the 50-lb rate. When comparing the yield data in Table 5 with the leaf P data in Table 4, it appears that a leaf P concentration of at least 0.46% was needed to optimize soybean yields at Morris and Waseca. No yield response to K was seen at any of the sites.

All nutrient concentrations in the corn except B were increased by the P and K treatments at Lamberton (Table 6). The increasing P rates resulted in a slight but significant increase in leaf P (due to extremely low variability, CV=4.6%) and a signficiant reduction in leaf Cu. Leaf K was very low with those treatments that never contain K (trt. nos. 1 and 6) and was increased linearly with increasing rates of fertilizer K. Concomitant decreases in leaf Ca, Mg and Mn were found with increasing K rates.

Table 5. Soybean yields at the three sites as influenced by high P and K rates in 1982.

Treatment No.	Description	Lamberton	Morris	Waseca
	lb P_2O_5+K_2O/A	bu/A		
1	0 + 0	51.2	47.1	53.3
2	0 + 100	47.8	45.6	51.5
3	50 + 100	50.0	53.0	58.4
4	100 + 100	49.9	56.3	57.9
5	0 + 100	48.9	54.6	55.9
6	100 + 0	51.4	56.7	57.7
7	100 + 50	49.8	54.7	58.0
8	100 + 0	48.3	57.8	55.9
9	0 + 100	49.0	57.6	55.1
10	100 + 0	49.3	53.1	56.0
Significance Level(%):		95	99	99
BLSD(.05)	:	2.8	4.8	3.2
CV(%)	:	3.1	6.3	3.8

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn earleaf at silking at Lamberton in 1982.

Treatment No.	Description	Nutrient Concentration P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
1	0 + 0	.31	1.41	.46	.47	136	80	37	4.9	6.2
2	0 + 100	.29	2.02	.40	.31	126	60	27	4.9	5.2
3	50 + 100	.29	1.83	.39	.32	117	52	28	4.4	5.7
4	100 + 100	.33	1.83	.42	.34	130	64	31	3.8	5.8
5	0 + 100	.30	1.82	.41	.33	121	53	28	4.1	5.6
6	100 + 0	.31	1.32	.48	.50	130	75	36	3.7	6.3
7	100 + 50	.31	1.58	.45	.42	126	62	29	3.4	5.8
8	100 + 0	.31	1.49	.46	.43	123	64	27	4.0	5.7
9	0 + 100	.29	1.70	.42	.37	119	50	27	3.7	5.5
10	100 + 0	.31	1.48	.48	.46	126	69	31	4.2	5.6
Significance:		99	99	99	99	99	99	98	99	65
BLSD (.05)	:	.02	.10	.03	.03	8	13	8	0.9	
CV (%)	:	4.6	4.7	4.6	6.1	4.1	14.	15.	14.	11.

Due to the high variability (CV=25%), early plant weight was not significantly different at the 90% level (Table 7). However, early weight was increased by 36 and 57% with the annual 50 and 100-lb P_2O_5/A treatments over the 0 P_2O_5 rate (trt. no. 2). Weight increases with the same K_2O rates were only 5 and 16% over the 0 K_2O rate (no. 6).

Plant height was increased significantly (99% level) by both the P and K treatments. Small plant height was increased over the 0 lb P_2O_5 treatment (no. 2) by 42 and 47% with the annual 50 and 100-lb P_2O_5 treatments, respectively. Response to K was less but still showed 12 and 17% increases to the 50 and 100-lb K_2O rates, respectively.

Neither grain yield nor final population were related to or affected significantly by the P and K treatments at Lamberton in this year with good growing conditions (Table 7). Variability within the experiment was very low as shown by a CV of 4.1% for yield.

Table 7. Early plant growth, plant population, and grain yield as influenced by high P and K rates at the Lamberton site in 1982.

Treatment		Early plant		Final	Grain
No.	Description	Weight	Height	popl'n.	Yield
	lb P_2O_5+K_2O/A	g/dry plant	cm	x 10^{-3}	bu/A
1	0 + 0	1.2	19	21.6	146.9
2	0 + 100	1.4	19	21.4	147.5
3	50 + 100	1.9	27	21.5	151.5
4	100 + 100	2.2	28	21.6	149.0
5	0 + 100	1.6	25	21.6	151.4
6	100 + 0	1.9	24	21.4	146.4
7	100 + 50	2.0	27	21.9	155.3
8	100 + 0	2.1	27	21.6	150.7
9	0 + 100	1.6	21	21.8	150.4
10	100 + 0	1.9	24	21.2	148.9
Signif. Level (%):		87	99	28	34
BLSD (.05) :			3		
CV (%) :		25.	10.	2.3	4.1

ACKNOWLEDGEMENT

Sincere appreciation is extended to the Tennessee Valley Authority-National Fertilizer Development Center for their financial assistance in this project.

NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZATION OF POTATOES ON NONIRRIGATED MINERAL SOILS IN NORTHWESTERN MINNESOTA

W. E. Fenster, J. Grava, M. O'Leary, T. King, G. Buzicky, D. Preston

Five field experiments were conducted with potatoes at two locations in Polk County during 1982 to generate experimental data which would provide a basis for examination of current fertilizer recommendations based on soil tests. At the present time there are large discrepancies in the N, P, K recommendations between North Dakota and Minnesota, with Minnesota recommending considerably higher rates. Since the University of Minnesota has not conducted any recent research on potatoes in NW Minnesota it was felt that research needed to be done to ascertain if our recommendations could be lowered without sacrificing yield or quality.

EXPERIMENTAL PROCEDURE

Paul Hoff Farm, East Polk County

Effects of broadcast N, P, K, applied with and without row fertilizer were determined in three separate experiments on a calcareous loam soil. Wheat had been grown the previous year. Soil was plowed and field cultivated in fall 1981. Ammonium nitrate, triple superphosphate and muriate of potash were broadcast and incorporated into the soil on May 26, 1982. Row fertilizer, consisting of 300 lb/a of 10-10-10 was applied with a row-marker which places the fertilizer in a band directly below the seed. Burbank Russet potatoes were planted on May 29. Weeds and insects were controlled by farmer's regular practices. Potatoes had sprouted on June 15 and emerged on June 20.

Don Mack Farm, West Polk County

Effects of N and P, applied with and without row fertilizer were determined in two experiments on a calcareous silty clay soil. The field had been in wheat in 1981 and it was fall plowed. Broadcast and row fertilizers were applied on May 25 and incorporated into the soil with a row-marker. Norchip potatoes were planted on May 25. Farmer's regular practices were effective in controlling weeds and insects.

Treatments in these fertilizer experiments with potatoes consisted of broadcast N, P, and K rates with and without the row fertilizer (30+30+30) arranged in a split block design replicated four times. Individual plots were 38 ft wide and 40 ft long (Mack Farm), and 26 ft wide and 40 ft long (Hoff Farm); a half of each plot received row fertilizer and another half received none.

Soil samples were collected in spring of 1982 prior to fertilizer application and were analyzed by the University of Minnesota Soil Testing Laboratory. Soil test results (Table 1) indicated very high levels of Olsen extractable phosphorus in the plow layer at both locations; exchangeable K was very high on the Mack Farm (499 lb/a) and medium on the Hoff Farm. Medium levels of NO_3-N in the top two feet of soil were found on these two fields (55 and 34 lb/a).

The petiole and leaflets of the 4th leaf from the growing tip of 15 plants were collected at random from each half-plot at two different times during the growing season. At the early season sampling on July 20, about 30 days after plant emergence, the plants were in the early flowering stage with some flowers open. At the midseason sampling which occurred on August 9, or about 50 days after emergence, after full bloom and late flowering, Kjeldahl N, and elemental analyses were made by the Research Analytical Laboratory, University of Minnesota.

Potatoes were harvested with a potatoe digger. Total weight of nongraded tubers was determined and expressed as cwt/acre.

RESULTS

The experimental results should be viewed in light of a rather atypical growing season in 1982. Planting was delayed 2 weeks due to three inches of rain that fell between May 4 and May 19. In addition, June was abnormally cool, having the lowest mean monthly temperature in the past 93 years.

Hoff Farm

Broadcast nitrogen applied at rates ranging from 0 to 150 lb/a markedly increased the N concentration in the leaf at both samplings but depressed the total weight and specific gravity of tubers (Table 2). While row fertilizer (30+30+30) had no effect on tuber weight or quality, it resulted in slightly higher leaf-N in early season.

In the phosphorus experiment, neither broadcast P nor row fertilizer had any effect on the yield or quality of tubers, and the concentration of P and other chemical elements in the leaf (Table 3). It should be noted that Olsen P at this location was 57 lb/a indicating a very high level of this plant nutrient.

Broadcast potassium applied at five rates ranging from 0 to 500 lb K_2O/a to a soil having a medium level of exchangeable K (126 lb/a) increased the yield of tubers from 182 to 217 cwt/a, decreased the specific gravity from 1.084 to 1.074, and significantly increased the concentration of leaf K at both samplings (Table 4). While row fertilizer had no effect on tuber yield or specific gravity, leaf K was slightly increased by it at early and midseason.

Mack Farm

Generally, neither broadcast N nor row fertilizer had any effect on the yield or specific gravity of tubers, and the leaf-N (Table 5). The only exception to this was an increase in leaf-N at midseason associated with the application of 150 lb N/a. At this location, 55 lb/a of NO_3-N were measured in the top 2 ft of the soil. The tuber yield ranged from 134 to 174 cwt/a.

The potato yield in the phosphorus experiment ranged from 152 to 195 cwt/a (Table 6). Generally, neither broadcast P nor row fertilizer had any effect on the yield and specific gravity of tubers or the concentration of plant nutrients in the leaf tissue of potatoes. Extractable P by the Olsen method in the plow layer was 31 lb/a, considered to be a very high level.

Table 1. Soil Test Results[1/] of samples collected from experimental sites.

Location Experiment	Sampling depth (inches)	pH	O. M. %	Bray 1 1:10 P lb/A	Bray 1 1:50 P lb/A	Olsen P lb/A	Exch. K lb/A	Zn ppm	NO_3-N lb/A	Exch. Mg lb/A
Hoff Farm	0-6	8.0	4.2	88	158	57	134	0.8		
Phosphorus trial	6-12	8.1		34	61	16				
Nitrogen trial	0-24								34	
Potassium trial	0-6	8.0		75	133	44	126			633
Mack Farm	0-6	8.2	5.2	13	145	31	499	0.8		
Phosphorus trial	6-12	8.4		2	9	8				
Nitrogen trial	0-24								55	

[1/] Soil test results are averages of 4 samples

Table 2. The effect of broadcast Nitrogen and row fertilizer on yield, specific gravity, and N content of leaf tissue of potatoes. Hoff Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling	
				Early Season Leaf-N %	Midseason Leaf-N %
Main Effects					
Broadcast N, lb/A					
0		229	1.083	5.08	4.47
50		202	1.076	5.23	4.98
100		192	1.072	5.41	5.30
150		180	1.070	5.38	5.35
Significance		**	**	*	**
BLSD (.05)		19	.009	.38	.19
Row Fertilizer					
-		201	1.075	5.19	4.92
+		200	1.076	5.36	5.13
Significance		ns	ns	*	ns
Broadcast N, lb/A	Row Fertilizer				
0	-	227	1.083	4.91	4.31
0	+	231	1.083	5.25	4.63
50	-	201	1.078	5.24	4.79
50	+	203	1.075	5.22	5.18
100	-	194	1.069	5.29	5.28
100	+	189	1.075	5.54	5.32
150	-	182	1.069	5.33	5.29
150	+	177	1.070	5.44	5.40
Significance		ns	ns	ns	ns
C.V. (%)		9	.4	5	3

All plots received broadcast 0+100+300+10 Zn lb/A of P_2O_5, K_2O and Zinc; row treatment consisted of 300 lb/A of 10-10-10.

Table 3. The effect of broadcast phosphorus and row fertilizer on yield, specific gravity, and elemental analyses of leaf tissue of potatoes. Hoff Farm, W. Polk Co., 1982.

Treatment	Yield Cwt/A	Specific Gravity	Sampling: Early Season									Sampling: Midseason								
			Elemental Analyses																	
			P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			---------%---------				---------ppm---------					---------%---------				---------ppm---------				
Main Effects																				
Broadcast P_2O_5, lb/A																				
0	216	1.075	.37	4.04	1.82	1.01	392	61	22	3	22	.41	2.95	1.49	.98	120	48	23	3	19
25	186	1.077	.40	4.21	1.85	1.00	415	55	22	2	22	.41	2.96	1.50	.96	118	43	22	3	19
50	199	1.074	.39	4.04	1.79	.96	365	54	22	2	22	.40	3.14	1.46	.98	114	44	24	3	19
100	197	1.076	.42	3.87	1.89	1.04	375	63	22	2	22	.43	2.84	1.66	1.08	118	50	22	3	18
150	210	1.078	.42	4.02	1.85	.94	414	61	21	2	22	.42	2.98	1.68	.99	124	48	21	3	19
Significance	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	ns
BLSD (.05)	-	-	-	-	-	-	-	-	-	-	-	-	-	.14	-	-	-	-	-	-
Row Fert.																				
-	214	1.077	.40	3.92	1.87	1.02	402	56	22	2	22	.42	2.89	1.49	.94	116	46	22	3	19
+	189	1.075	.41	4.15	1.81	.96	382	61	22	2	22	.42	3.06	1.63	1.06	121	48	23	3	19
Significance	ns	*	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Broadcast P_2O_5, lb/A / **Row**																				
0 -	234	1.076	.38	4.03	1.80	1.02	418	58	21	3	23	.41	2.88	1.46	.92	115	47	22	3	19
0 +	198	1.074	.40	4.05	1.83	.99	367	64	22	2	22	.42	3.02	1.52	1.04	124	50	24	3	19
25 -	205	1.080	.39	4.10	1.84	1.04	406	54	22	2	22	.41	2.90	1.40	.89	110	44	22	3	21
25 +	197	1.075	.40	4.31	1.85	.96	424	56	22	2	22	.41	3.01	1.60	1.02	126	42	22	3	18
50 -	203	1.074	.39	3.87	1.82	.98	374	54	22	2	22	.41	3.10	1.37	.90	115	43	24	3	19
50 +	194	1.073	.40	4.21	1.76	.95	356	55	22	2	22	.40	3.18	1.56	1.05	112	45	24	3	19
100 -	202	1.077	.42	3.71	1.93	1.10	402	58	22	2	22	.42	2.72	1.64	1.07	119	48	22	3	17
100 +	192	1.075	.44	4.03	1.85	.98	349	68	22	2	21	.43	2.96	1.68	1.10	117	52	22	3	18
150 -	228	1.080	.42	3.90	1.94	.96	411	60	21	2	22	.43	2.85	1.58	.91	122	48	21	3	19
150 +	192	1.076	.43	4.14	1.77	.92	416	62	22	2	22	.42	3.11	1.79	1.08	126	48	21	2	20
Significance	+	ns	ns	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	5.9	.3	3.7	5.2	5.5	8.2	20.3	12.1	7.3	13.6	3.8	3.3	8.0	7.1	7.0	12.1	5.2	5.9	12.2	11.9

All plots received broadcast 150+0+300+10 Zn lb/acre of N, K_2O and zinc; row treatment consisted of 300 lb/A of 10-10-10.

Table 4. The effect of broadcast potassium and row fertilizer on yield, specific gravity, and elemental analyses of leaf tissue of potatoes. Hoff Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling: Early Season									Sampling: Midseason								
				Elemental Analyses																	
				P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
				---------- % -------				-------- ppm ------					-------- % --------				------- ppm ---------				
Main Effects																					
Broadcast K_2O, lb/A																					
0		182	1.084	.40	2.76	2.07	1.34	374	59	19	3	23	.41	1.79	1.64	1.31	139	43	21	4	20
100		205	1.085	.41	3.24	2.01	1.17	350	56	19	2	23	.41	2.28	1.67	1.15	123	42	20	3	20
200		206	1.082	.41	3.61	1.90	1.03	376	58	20	2	23	.41	2.71	1.66	1.05	120	45	21	3	19
300		217	1.075	.38	3.80	1.81	1.02	353	60	21	3	23	.39	3.10	1.51	1.06	106	48	22	3	20
500		215	1.074	.40	4.21	1.75	.94	379	58	22	2	22	.41	3.44	1.50	.96	114	48	22	3	20
Significance		*	*	ns	**	**	**	ns	ns	**	ns	ns	ns	**	ns	**	*	ns	ns	ns	ns
BLSD (.05)		33	.010	-	.54	.12	.19	-	-	2	-	-	-	.40	-	.24	33	-	-	-	-
Row Fertilizer																					
-		204	1.080	.39	3.38	1.94	1.16	369	56	20	3	23	.41	2.54	1.53	1.05	114	43	21	3	19
+		206	1.080	.41	3.66	1.87	1.04	364	60	20	3	23	.40	2.79	1.66	1.16	126	47	21	3	20
Significance		ns	ns	**	+	+	+	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns
Broadcast K_2O, lb/A	**Row**																				
0	-	181	1.085	.38	2.69	2.10	1.39	330	54	19	3	22	.42	1.76	1.61	1.28	126	40	21	4	20
0	+	183	1.083	.41	2.83	2.04	1.30	418	63	19	3	23	.41	1.83	1.67	1.34	153	46	21	4	20
100	-	204	1.085	.39	2.96	2.10	1.26	390	55	20	2	22	.41	2.22	1.58	1.07	118	40	20	3	19
100	+	206	1.086	.42	3.52	1.93	1.08	310	56	19	2	23	.41	2.34	1.77	1.22	128	45	20	3	20
200	-	210	1.079	.40	3.41	1.94	1.12	398	54	20	2	23	.42	2.58	1.57	.98	114	42	21	3	18
200	+	201	1.081	.41	3.81	1.85	.95	354	62	20	2	22	.41	2.83	1.76	1.12	126	48	20	2	20
300	-	220	1.075	.38	3.66	1.82	1.08	340	59	22	3	23	.40	3.00	1.45	1.00	104	48	22	3	20
300	+	215	1.076	.39	3.94	1.81	.96	367	60	21	3	23	.38	3.20	1.58	1.12	107	48	21	3	21
500	-	205	1.076	.39	4.20	1.76	.97	389	56	22	2	22	.42	3.12	1.46	.92	111	46	22	3	18
500	+	224	1.073	.40	4.22	1.74	.90	370	59	21	2	22	.40	3.76	1.54	.99	118	49	21	3	21
Significance		ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)		9.2	.3	3.8	6.8	5.7	7.6	12.6	10.8	20.4	2.6	4.5	3.4	7.9	8.5	9.7	14.1	7.0	5.4	14.3	5.2

All plots received broadcast 150+100+0+10 Zn of N, P_2O_5 and Zinc; row fertilizer consisted of 300 lb/A of 10-10-10.

Table 5. The effect of broadcast Nitrogen and row fertilizer on yield, specific gravity, and N content of leaf tissue of potatoes. Mack Farm, W. Polk Co., 1982.

Treatment		Yield Cwt/A	Specific Gravity	Sampling	
				Early Season Leaf-N %	Midseason Leaf-N %
Main Effects					
Broadcast N, lb/A					
0		136	1.085	5.04	3.86
50		150	1.084	5.02	3.97
100		152	1.082	5.26	4.22
150		158	1.083	5.19	4.36
Significance		ns	ns	ns	*
BLSD (.05)		-	-	-	.44
Row Fertilizer					
-		145	1.083	5.12	4.16
+		152	1.084	5.14	4.04
Significance		ns	ns	ns	ns
Broadcast N, lb/A	Row Fertilizer				
0	-	138	1.085	4.99	3.94
0	+	134	1.085	5.09	3.78
50	-	152	1.082	5.10	4.06
50	+	148	1.085	4.93	3.88
100	-	150	1.082	5.28	4.25
100	+	154	1.083	5.24	4.20
150	-	142	1.083	5.09	4.41
150	+	174	1.083	5.29	4.31
Significance		ns	ns	ns	ns
C.V. (%)		12	.2	7	4

All plots received broadcast 0+100+0 lb/A of P_2O_5; row fertilizer consisted of 300 lb/A of 10-10-10.

Table 6. The effect of broadcast phosphorus and row fertilizer on yield, specific gravity, and elemental analyses of leaf tissue of potatoes. Mack Farm, W. Polk Co., 1982.

Treatment	Yield Cwt/A	Specific Gravity	Sampling: Early Season									Sampling: Midseason								
			Elemental Analyses																	
			P	K	Ca	Mg	Fe	Mn	Zn	Cu	B	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
			---------%---------				---------ppm---------					---------%---------				---------ppm---------				
Main Effects																				
Broadcast P_2O_5, lb/A																				
0	184	1.082	.43	4.53	1.51	1.09	583	66	23	9	32	.31	2.85	1.12	1.00	268	47	17	9	21
25	168	1.082	.42	4.16	1.66	1.11	768	72	22	10	28	.31	3.10	1.15	.99	361	48	17	9	21
50	182	1.082	.43	4.52	1.59	1.09	558	64	21	9	30	.31	2.89	1.15	1.01	272	45	16	9	22
100	159	1.082	.43	3.98	1.63	1.12	595	69	22	10	31	.31	3.06	1.21	1.06	344	50	16	9	22
150	184	1.083	.45	4.48	1.62	1.15	625	66	22	9	31	.31	3.06	1.18	1.07	277	46	16	9	22
Significance	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns
Row Fertilizer																				
-	170	1.081	.43	4.47	1.58	1.12	587	66	22	9	31	.31	2.92	1.20	1.05	318	48	16	9	22
+	181	1.083	.43	4.19	1.62	1.10	664	68	22	10	30	.31	3.06	1.13	1.00	291	46	17	9	21
Significance	ns	ns	ns	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Broadcast P_2O_5, lb/A / **Row**																				
0 -	173	1.081	.42	4.60	1.50	1.10	588	65	22	9	32	.31	2.80	1.20	1.06	297	50	16	9	22
0 +	195	1.083	.44	4.47	1.52	1.09	577	67	24	10	32	.32	2.92	1.04	.94	239	43	17	9	20
25 -	164	1.080	.44	4.18	1.60	1.08	688	68	22	10	29	.31	3.08	1.15	1.00	390	48	18	9	22
25 +	171	1.084	.40	4.14	1.72	1.14	848	76	22	10	27	.31	3.13	1.15	.99	333	48	16	9	21
50 -	180	1.082	.42	4.60	1.60	1.09	518	65	20	9	30	.31	2.96	1.19	1.02	274	46	15	8	22
50 +	184	1.082	.45	4.44	1.58	1.08	597	63	22	10	30	.32	2.83	1.12	1.00	269	44	16	9	21
100 -	152	1.081	.44	4.13	1.59	1.14	527	69	22	9	33	.31	2.82	1.21	1.06	316	50	16	8	22
100 +	165	1.082	.43	3.82	1.66	1.11	662	69	22	10	28	.31	3.30	1.21	1.08	372	50	17	9	22
150 -	180	1.082	.45	4.86	1.62	1.20	614	65	22	9	31	.31	2.96	1.24	1.13	312	48	16	9	22
150 +	188	1.084	.45	4.10	1.63	1.10	636	67	21	9	32	.31	3.15	1.12	1.01	242	43	16	8	22
Significance	ns	ns	**	ns	ns	ns	ns	+	+	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V. (%)	11	.3	3	10	4	4	21	5	5	7	31	6	13	7	9	28	8	7	9	8

All plots received broadcast 100+0+0 lb/A of N; row fertilizer consisted of 300 lb/A of 10-10-10.

THE RELATIONSHIP OF SOIL SOLUTION CHEMISTRY TO IRON CHLOROSIS AND YIELD OF SOYBEANS ON HIGH LIME SOILS

P.R. Bloom and W.P. Inskeep

Iron chlorosis is a common problem on soybeans on the high lime soils of in the western part of the state. The problem occurs in the high lime soils surrounding depressions and is generally most severe in isolated areas in fields. The objective of this study was to determine the relationship of the chemical composition of soil solutions to the expression of chlorosis and to the reducton in yields that results from chlorosis.

METHODS

Three varieties of soybeans, Anoka, Hodgson and Swift each with different susceptibilities to chlorosis were planted in 4 row strips across spots in field where soybean chlorosis was observed in 1981. The plots were located on the Hustoff farm 2 miles south of Willmar and on the Southwest Experiment Station. Throughout the growing season soil and plant samples were taken at sampling stations 25 ft apart along the 4 row strips. Soil samples were taken between the center rows and plant samples and yields were taken from the two inner rows. Soil samples were taken from the 0-6" depth, sealed in Whirl-Pak bags and brought to the laboratory in an ice chest. The most recently mature trifoliate leaves were sampled for chlorophyll content (DMF extraction) and for total elemental content.

After transport to the laboratory the soils were brought to 50% moisture with distilled water. The soil slurry was centrifuged at 13,200 g for 40 minutes and the supernatant was decanted and filtered through a 0.45 µm membrane filter under pressure. Bicarbonate was determined immediately by titration with HCl. A portion of the sample was submitted for elemental analysis by ICP. Anions were determined by ion chromatography. The soil and plant composition data presented here are for samples taken on July 12 and 13. The grain yields were determined by sampling 10 ft. sections of the inner two rows of mature field-dry plants. The sampling of the Southwest Experiment Station was of a preliminary nature and not as intense as at the Willmar site. Only data from the Hodgson variety is presented here.

RESULTS

The yields reported in Table 1 show that at Willmar chlorosis was severe enough in part of the plot to result in plant death. With increasing distance from sampling station no. 1 both yield and relative chlorophyll control. The chlorophyll contents for Swift and Hodgson attained a maximum value and then did not change. For the Anoka variety the chlorophyll content did not reach a maximum value. For Swift and Hodgson the yields appeared to reach a maximum value and then decrease. The statistical significance of this phenomenon could not be tested with the data available.

Table 1. Relative chlorophyll contents of third trifoliate leaves sampled July 12 and 13, and grain yields in bushels per acre.

Location	Willmar						Southwest Exp. Station	
Variety	Swift		Hodgson		Anoka		Hodgson	
Sampling Station	Chlorophyll	Yield	Chlorophyll	Yield	Chlorophyll	Yield	Chlorophyll	Yield
1	.26	2	.29	0	.19	0	.61	37
2	.24	0	.41	6	.26	0	.56	37
3	.19	4	.38	30	.23	0	.76	37
4	.19	3	.63	49	.33	0	1.0	39
5	.29	43	.68	61	.24	0	1.0	46
6	.38	53	.89	54	.44	14	.73	43
7	.66	48	.85	57	.42	31		
8	.68	41	.93	47	.54	47		
9	.68	39	.90	43	.69	42		
10	.83	39						

At the Southwest Experiment Station the chlorosis was not as severe at Willmar and the yields did not vary greatly although there was a very significant variation in chlorophyll contents. At both sites the increases in chlorophyll contents corresponded to increase in elevation with respect to the depression. Chlososis as measured by chlorophyll contents was well correlated with the Mg/Ca ratio in the soil solution extracts (Table 2). Chlorosis was also correlated with soil bicarbonate but at a lower level of significance. The correlation with soil bicarbonate is confirmation of the conclusions of Chaney, USDA Beltsville, who found that in solution culture bicarbonate is the causative factor in iron chlorosis when adequate iron is supplied to the nutrient solution. The low level of significance for the correlation of chlorophyll with bicarbonate in some of the varieties may reflect the difficulty of getting good bicarbonate values especially in a system in which the partial pressure of CO_2 is greater than that in the ambient air. Our data from soil gas wells in the calcareous soils (not reported) suggest that the partial pressure of CO_2 in soil air can be as high as 100 times that in ambient air.

Table 2. Regression r^2 values for the linear regression of soil solution HCO_3^-, soil Mg/Ca and chlorophyll against plant Mg/Ca, chlorophyll content and yield.

Location	Willmar			Southwest Exp. Station
Regression \ Variety	Swift	Hodgson	Anoka	Hodgson
Chlorophyll vs. HCO_3^-	0.36d	0.93a	0.54d	0.56e
Chlorophyll vs. Soil Mg/Ca	0.89a	0.96a	0.84a	0.67d
Yield vs. Soil Mg/Ca	0.68b	0.62c	0.87a	0.64d
Yield vs. HCO_3^-	NS	0.70c	0.55d	0.77c
Yield vs. Chlorophyll	0.47c	0.62c	0.81b	NS
Plant Mg/Ca vs. Soil Mg/Ca	0.88a	0.98a	0.99a	0.81b

Significance: a) $\alpha = 0.001$
b) $\alpha = 0.005$
c) $\alpha = 0.010$
d) $\alpha = 0.025$
e) $\alpha = 0.05$
NS not significant

The correlation of chlorosis with soil Mg/Ca was not expected. The Mg/Ca ratio may indicate that the carbonates in the high chlorosis areas have a higher Mg content. Magnesium substituted $CaCO_3$ is more soluble than pure $CaCO_3$ and at a given pH, bicarbonate concentrations would be higher at higher Mg/Ca. An alternative explanation is that with high Mg the rate of precipitation of $CaCO_3$ is decreased and higher bicarbonate concentrations may result.

Plant response was not correlated with soil pH nor with other components in the soil solution. The soil solution pH was invariant at both sites (pH aproximately 8). At the Southwest Experiment station the calcareous soil contained gypsum and the soil solutions were high in sulfate. The sulfate, however, did not affect the plant response variables reported here.

The Mg/Ca ratio in the plants was very well correlated with Mg/Ca in soil (Table 2). The ratio of Mg/Ca in the plants, however, is not high enough to produce severe plant nutrition problems.

Yield was most consistently correlated with Mg/Ca in the soil (Table 2). Yield was also correlated with plant chlorophyll at Willmar and with soil bicarbonate at the Southwest Experiment Station and at Willmar with Hodgson and Anoka. The lack of highly signficant correlation of yield with chlorosis as measure by plant chlorophyll is not unexpected given the 1981 data of Bill Kennedy of the Department of Plant Pathology that show that yields are not well correlated with subjective ratings of chlorosis early in the season. However, it is evident that relative chlorophyll contents less than 0.30 resulted in extreme yield losses on all varieties.

CONCLUSIONS

Chlorosis as measured by leaf chlorophyll ocntent was correlated with both Mg/Ca and bicarbonate in soil solution extracts. The correlation was especially strong ($\alpha = 0.001$) for soil Mg/Ca at Willmar where the soil did not contain gypsum. Grain yield was inconsistently correlated with plant chlorophyll and soil bicarbonate but the best predictor of yield wa the soil solution Mg/Ca ratio.

WILD RICE FERTILIZATION RESEARCH - 1982

John Grava
Department of Soil Science

Research was continued during 1982 on fertilization and nutrient requirement of wild rice. Soil, water and air temperatures were monitored during the growing season at Grand Rapids and St. Paul. A nitrogen experiment was conducted with the Netum variety on a mineral soil at Grand Rapids. An NPK fertilization trial with the K2 variety was conducted on peat in Aitkin County.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

Average temperatures recorded at three U.S. weather stations were above normal in May and, generally, below normal during April, June, July and August (Table 1).

Soil, water and air temperatures were measured at Grand Rapids within the experimental paddy No. 1 West, and on the St. Paul Campus within an area where experiments in 4 x 4 ft. boxes were conducted (see Fig. 1 and 2).

At Grand Rapids, plants emerged on May 3 (Fig. 3). The jointing stage by Netum wild rice was reached on June 17th, 45 days after emergence. Wild rice was harvested on August 12th, 102 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 1982 season were 793 at jointing and 2275 at harvest, respectively.

B. NITROGEN STUDIES ON MINERAL SOILS

The nitrogen rate and time of application trial, initiated in the fall of 1979, was continued with 3rd year stand of Netum wild rice in paddy No. 1 West at the North Central Experiment Station, Grand Rapids. The soil is classified as an Indus clay loam (very fine, montmorillonitic, frigid Typic Ochraqualf). Soil tests (Table 2) indicated very high levels of extractable phosphorus (63 pp2m) and exchangeable potassium (300 pp2m). It should be noted that these two plant nutrients have remained at such very high levels since 1974 although no phosphate or potash fertilizers have been applied to this soil. It has been a common practice, however, to incorporate wild rice stubble and straw into the soil. Since nearly 75% of total P and 97% of total K taken up by the wild rice plant remain in stems and leaves, a certain recycling of these nutrients occurs.

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 5, 1981 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing (on June 23) or early flowering (on July 9). 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. Water level was maintained at about 6 to 10 inches. Plant density, at harvest, ranged from 7 to 11 plants per square foot. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 17th (Fig. 3). A 16 sq. ft. area from each plot was hand-harvested on August 12th.

The plants in this experimental paddy were very short, spindly and had a "grassy" appearance. One may speculate that poor plant growth on this mineral soil resulted from relatively high density and the age of stand.

Individual plants at jointing had accumulated less than one gram of dry matter and 15 to 20 milligrams of nitrogen (Table 3). The second leaf at jointing contained 2.53 to 2.68% N, considered to be a relatively low concentration. It should be noted that the concentration of leaf nitrogen at jointing ranged from 4.33 to 5.55% during the first year (1980).

Netum grain yield (7% moisture) ranged from 332 to 445 pounds per acre (Table 4). The yield of wild rice was not affected by any of the nitrogen treatments. At late flowering, the plant had accumulated from 1.72 to 3.74 grams of dry matter and 22 to 57 milligrams of nitrogen.

C. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on an organic soil in a Kosbau Bros. paddy in Aitkin County. A medium level of extractable phosphorus (15 pp2m) and a low level of exchangeable potassium (90 pp2m) were indicated by soil tests (Table 5). The soil pH was 5.8. 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, 0-0-60) were applied by hand on October 7, 1981 and incorporated into the soil by disking. Wild rice reached the jointing stage on June 29. A 32 sq. ft. area from each plot was harvested on August 17.

The concentration of nutrient elements in the 2nd leaf at jointing (see Table 6) was relatively high: 2.85 to 3.06% N, 0.44 to 0.48% P, 3.37 to 3.56% K. The grain yield (7% moisture) ranged from 671 to 720 pounds per acre (Table 7). Neither the yield nor the total uptake of N, P and K at late flowering were affected by fertilization.

ACKNOWLEDGEMENTS

Grateful acknowledgements are made to the following cooperators and University personnel for their assistance during 1982 in obtaining the information reported here: Messrs. Franklin and Harold Kosbau, Aitkin County; the Staff of the North Central Experiment Station; Dr. E. A. Oelke, Messrs. Jeffrey Schmidt and Henry Schumer, University of Minnesota.

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
1982	37.0	55.1	55.5	66.8	63.0	55.5	2477
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
1982	38.6	57.7	58.5	68.0	64.4	57.6	2753
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
1982	38.3	57.4	57.6	68.6	64.8	57.3	2723
St. Paul, U of M							
1982	43.4	61.3	62.4	73.9	67.3	61.6	3332

1/ Source: Climatological Data, Minnesota, Vol. 80-88 (1974-82), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.

Fig. 1

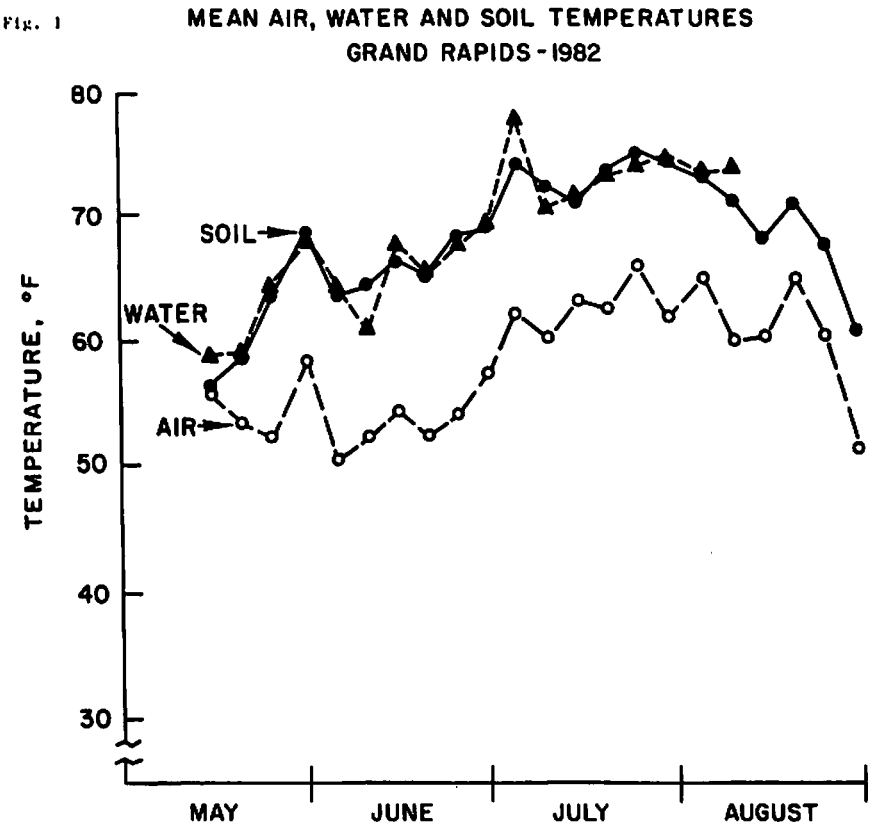
MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS - 1982
TEMPERATURE, °F
80
70
60
50
40
30
SOIL
WATER
AIR
MAY
JUNE
JULY
AUGUST

Fig. 2

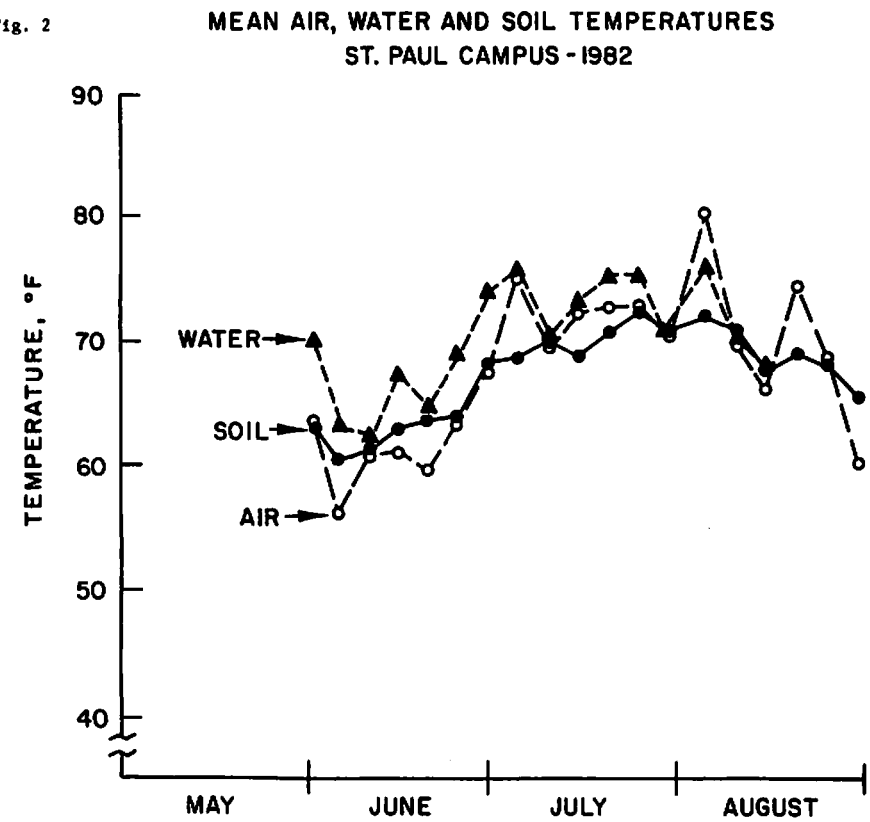
MEAN AIR, WATER AND SOIL TEMPERATURES
ST. PAUL CAMPUS - 1982
TEMPERATURE, °F
90
80
70
60
50
40
WATER
SOIL
AIR
MAY
JUNE
JULY
AUGUST

Fig. 3 WILD RICE DEVELOPMENT
NETUM VARIETY, 3RD YEAR STAND
GRAND RAPIDS, 1982

	STAGES OF DEVELOPMENT	DAYS	DATE	1/ GDD
VEGETATIVE GROWTH PHASE	EMERGENCE	0		0
	FLOATING LEAF	11	MAY	156
	AERIAL LEAF	24		400
	TILLERING	38	JUNE	662
REPRODUCTIVE GROWTH PHASE	JOINTING	45		793
	BOOT	53		943
	HEADING	64	JULY	1220
	EARLY-FLOWERING	67		1312
	LATE-FLOWERING	89		1797
	MATURITY	102	AUGUST	2275

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

Table 2. Soil test values of experimental paddy No. 1 West, Grand Rapids.[1)]

pH	Extractable P pp2m	Exchangeable K pp2m	Nitrate-N lb/A
6.1[2)]	63	300	7

1) Samples collected from 0-6 inch depth on 11/5/81.
2) Average of two composite samples.

Table 3. Effect of nitrogen application on weight of dry matter, N-concentration in 2nd leaf, and total uptake of N by wild rice plant at jointing, Netum variety, 2nd year stand, Grand Rapids, 1982.

N Rate lb/acre	Dry Matter grams per plant	N% in dry matter	N in milligrams per plant
0	0.66[2)]	2.68[2)]	18[2)]
20[1)]	0.64	2.68	15
40	0.69	2.67	18
80	0.91	2.53	20
Significance	ns	ns	ns

1) Applied in fall 1981.
2) Average of four replications.

Table 4. Effect of nitrogen application on the weight of dry matter, total uptake of N, and the yield of Netum wild rice, 3rd year stand, Grand Rapids, 1982.

Treatment No.	N Rate lb/acre	Time of Application			Dry Matter at late Flowering g/plant	N Uptake mg/plant	Grain Yield[1)] lb/acre
		Fall 11/5/81	Jointing 6/23/82	Early Flowering 7/9/82			
1	0	-	-	-	3.69	57	343
2	20	20	-	-	2.29	28	332
3	40	40	-	-	2.14	27	414
4	40	20	20	-	3.74	47	390
5	40	20	-	20	3.21	36	423
6	80	80	-	-	2.68	29	439
7	80	40	40	-	2.48	26	404
8	80	40	-	40	1.72	22	445
Significance					ns	ns	ns
C.V. %					50	58	30

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

Table 5. Soil test values of experimental area, Kosbau Bros., Aitkin Co.

pH	Extractable P pp2m	Exchangeable K pp2m	Magnesium pp2m	Copper ppm	Sulfur ppm
5.8	15	90	604	0.9	11

Samples collected from 0-6 inch depth on 10/7/81.

Table 6. Effect of fertilization on N, P, and K concentration in 2nd leaf of K2 wild rice at jointing, Kosbau Bros., 1982.

Treatment N	P_2O_5	K_2O	N%	P%	K%
lb/acre			in Dry Matter		
none			2.85[1)]	0.44	3.38
0 +	40 +	60	2.98	0.44	3.56
30 +	40 +	0	2.98	0.47	3.42
30 +	0 +	60	3.06	0.47	3.44
30 +	40 +	60	2.85	0.46	3.37
60 +	40 +	60	2.96	0.48	3.47
Significance			ns	ns	ns

1) Average of six replications.

Table 7. Effect of fertilization on total uptake of N, P, and K and the yield of K2 wild rice, Kosbau Bros., Aitkin Co., 1982.

Treatment N	P_2O_5	K_2O	Total Uptake at Late Flowering N	P	K	Grain Yield[1)]
lb/acre			mg/plant			lb/acre
none			26	7	56	720
0 +	40 +	60	34	8	64	690
30 +	40 +	0	30	7	59	708
30 +	0 +	60	28	7	54	700
30 +	40 +	60	27	7	52	671
60 +	40 +	60	35	8	66	691
Significance			ns	ns	ns	ns
C.V. %						12

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