The effect of tillage on leaf water potential readings taken on selected days as effected by tillage. The values in parenthesis are standard deviations,N=18.

Date	No-till	Chisel
	----------(-bars)---------	
7/26/83	8.0(2.0)	7.1(1.7)
7/28/83	6.2(1.2)	6.8(1.1)
8/1/83	10.0(2.0)	9.9(1.1)
8/8/83	7.8(2.2)	8.2(2.3)
8/12/83	6.7(1.5)	7.5(1.8)

There is no measured difference in moisture stress due to tillage. This is likely due to near sufficient rain during the monitoring period. Extremely hot weather late season may have had a detrimental affect on yields.

The effect of tillage and traffic on the bulk density, and moisture in the surface 20 cm on 7/22/83. The value in parenthesis is the standard deviation, N=6.

Sample Position	No-till		Chisel	
and Depth(cm)	B.D(g/cm^3)	% Water(by vol)	B.D.(g/cm^3)	% Water(by vol.)
With traffic				
2-10 cm	1.48(0.09)	31.7(2.22)	1.39(0.04)	28.7(1.98)
12-20 cm	1.43(0.86)	30.9(0.98)	1.38(0.05)	29.3(2.07)
No traffic				
2-10 cm	1.44(0.10)	30.5(1.37)	1.36(0.09)	28.0(3.85)
12-20 cm	1.39(0.10)	28.0(4.96)	1.40(0.04)	28.4(1.20)
In row				
2-10 cm	1.25(0.12)	24.1(3.14)	1.19(0.09)	22.8(4.13)
12-20 cm	1.37(0.06)	28.5(2.08)	1.31(0.04)	25.1(3.89)

Significant differences in soil density due to tillage are present in the 2-10 cm soil depth regardless of traffic or position relative to the row. A similar trend is apparent with soil moistrue. There does not seem to be appreciable increase in soil density due to traffic. This is probably the result of dry conditions at planting. Soil density in the row is lower as a result of tillage by disc openers and a fluted coulter on the planter.

Grain yields and K uptake

The effects of row K, tillage, and soil K on yields are shown in figures 1 and 2. The advantage to row K at lower soil K levels on grain yields is apparent. The advantage is greater without tillage. The starter NPK and NP lines also cross at a higher soil test with this treatment. It is difficult to tell why there was an apparent advantage to the absence of row K at higher soil K levels for both tillage treatments. This effect did not occur with stover yields suggesting an interaction of row K with crop phenology, physiology, and climate. Increases in K concentration in the grain more than compensated for yield differences resulting in convergence of starter treatments at a higher soil test(figure 2). The slope of yield and uptake curves may in part be due to the changes in soil buffering due to tillage discussed earlier.

Regression equations to characterize treatment differences of yields and K-uptake(yields on dry matter basis). n=9, see figure 1. and 2.

The equation used: $y=e^{a} K^{b}$

Variable	Tillage	Values in equation a	b	R^2	α-level
Stover(Mg/ha) Row N-P-K	No-till	1.3863	.10961	.168	.19
	Chisel	.87718	.21615	.332	.03
Stover(Mg/ha) Row N-P	No-till	1.1024	.15732	.341	.04
	Chisel	.59299	.27132	.738	.00
Grain(Mg/ha) Row N-P-K	No-till	-.74139	(1.1633-.130191nK)	.254	.27
	Chisel	-1.5412	(1.4671-.156621nK)	.122	.49
Grain(Mg/ha) Row N-P	No-till	1.1133	.14930	.572	.00
	Chisel	.87265	.21957	.824	.00
Total(Mg/ha) Row N-P-K	No-till	2.3628	.04157	.071	.40
	Chisel	2.0403	.11441	.223	.09
Total(Mg/ha) Row N-P	No-till	1.7999	.15366	.459	.02
	Chisel	1.4246	.24512	.932	.00
K-uptake(kg/ha) Row N-P-K	No-till	-.24033	(1.4570-.155271nK)	.098	.63
	Chisel	-2.3452	(2.3569-.245421nK)	.432	.05
K-uptake(kg/ha) Row N-P	No-till	2.3758	.15031	.350	.04
	Chisel	1.6023	.34363	.589	.00
K-uptake Stover(kg/ha) Row N-P-K	No-till	1.2811	.62470	.791	.00
	Chisel	-.37897	1.0004	.675	.00
K-uptake Stover(kg/ha) Row N-P	No-till	.57302	.75485	.636	.00
	Chisel	-1.4893	1.2294	.772	.00
K-uptake Total(kg/ha) Row N-P-K	No-till	2.2853	.47577	.786	.00
	Chisel	1.2250	.72669	.671	.00
K-uptake Total(kg/ha) Row N-P	No-till	1.6742	.58795	.658	.00
	Chisel	.00367	.97519	.813	.00

Summary

1. The advantage of row K on early growth occurred at lower soil K levels and was greater with no tillage.

2. The chisel plow treatment resulted in higher early growth and total corn yields.

3. The vertical gradient in soil K was steeper without tillage.

4. Changes in soil K with a given application were higher with no tillage.

5. The corn grown with no tillage required higher levels of soil K(this is mitigated by the soil buffering aspects of tillage).

6. At high soil K levels row K had a detrimental effect on grain yields.

THE EFFECT OF TILLAGE AND N MANAGEMENT ON CORN YIELDS - 1983

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As farmers adopt conservation tillage systems to control erosion and reduce production inputs, N management becomes more important. Research has shown reductions in N availability to be associated with extreme reductions in tillage. If N losses are the result of denitrification or increased leaching, there may be an advantage with nitrification inhibitors or delayed N application when conservation tillage extremes are used. The purpose of this study is to: assess the effect of tillage, time of N application, and use of nitrification inhibitors on N availability.

The experimental sites are located at the Sand Plains Experiment Station, Becker, Minnesota and on a cooperator's farm in Goodhue County, Minnesota. The soils are loamy sand under irrigation (Udorthentic Haploborolls) and a silt loam soil (Typic Hapludalf) at the east central (Becker) and southeast (Goodhue County) sites, respectively. Nitrogen was applied as anhydrous ammonia on May 6 at the east central site and May 12 and July 6 at the southeast site. Two nitrification inhibitors were evaluated at both sites (N-Serve and Dwell). For a detailed description of tillage treatments and characterization, cultural practices, and methods see "Placement of nitrogen solutions under differing tillage systems" in this publication. The experimental design is a split-split plot.

Results and Discussion - Southeast Minnesota Location

The probability values of treatment effects are shown in Table 1. The smaller this number is the higher the probability that the treatment effects are real and not due to chance. Grain and stover yields are shown in Tables 2 and 3, respectively. Grain yields with spring applied N generally are higher with a till plant (ridge till) system, but stover yields appear higher with corn grown under chisel plow tillage. With sidedressed N, corn yields appear to be slightly higher with chisel tillage over the till plant system. The no-till system resulted in slightly lower corn yields and appeared to be at a disadvantage with sidedressed N. The soil moisture advantage provided by this approach to residue management is maximum after a rain when soil moisture levels are relatively high. During a prolonged drought, advantages of residue due to moisture conservation would be much less or absent. Lower yields may also be due to less infiltration with this system if spotty rain is intense, resulting in more runoff. In 1983, the early season was cool and wet and the remainder extremely dry. This favored the ridge till and chisel treatments. This is supported by the data in Table 4. These measurements were made after a prolonged drought, Figure 1. Although the ridge system had lower moisture in the row, the trend shows larger moisture levels for this system and the chisel treatment over that with no tillage.

There is no consistent trend in yield response of nitrification inhibitor treatments. This would be expected in a dry year and when there is no effect of applied N past the first rate. This trend is also true of N uptake and ear leaf N concentrations (Tables 5, 6, 7, and 8).

It is interesting to note that the till plant system with spring N had more N uptake in the grain than the other two systems, but less in the stover. This is consistent with the grain and stover trends. Sidedressed N resulted in less N uptake by grain than spring applied N with this system. Less stover N uptake with spring applied N also occurred with this tillage treatment over the other two. Tillage effects on total N uptake were not significant as a result of reverse grain and stover uptake trends. In summary it appears that spring applied N resulted in more efficient partitioning of carbon and nitrogen assimilates into grain with the till plant system.

Results and Discussion - Becker (east central) Minnesota Location

Results on a loamy sand under irrigation were much different. Probability values, yields and N uptake data are shown in Tables 9, 10 and 11, respectively for this site. Significant inhibitor responses occurred at the first rate of applied N independent of tillage. This was the result of a major leaching event in June (Figure 2). In several cases, Dwell appeared to have an advantage over N-Serve.

Please refer to title page of this publication for information regarding application and use of this article.

Across inhibitor treatments and N rates, the till plant and chisel treatments had slightly higher grain yields. The stover yields were lower with the till plant treatment over those of the chisel treatment, similar to the trend at the other location. This resulted in total dry matter yields to be greatest with chisel plow.

Responses to the nitrification inhibitor treatments were similar with N uptake. Grain N uptake appeared to be higher with chisel plow tillage.

Table 1. Probability of treatment effects for selected variables at the Southeast Minnesota site, 1983.

Source	Variable						
	Grain Yield	Stoves Yield	Total Dry Matter	Grain N Uptake	Stoves N Uptake	Total N Uptake	Ear Leaf N
Rep	.1926	.0010	.0157	.0013	.0187	.0009	.0867
Tillage	.0488	.0330	.1294	.0168	.3915	.3581	.4149
N	.9408	.6173	.4444	.4642	.0028	.0431	.0012
Till x N	.0951	.5458	.1530	.0420	.0349	.0670	.9672
Time	.0001	.0001	.0001	.0068	.0001	.0001	.0001
Inhibitor	.1284	.2471	.0560	.7637	.5326	.5334	.3524
Till x Time	.0166	.6734	.3795	.0478	.0293	.0639	.4366
Till x Inhib.	.7936	.8880	.8506	.6812	.5997	.6275	.0209
N x Time	.0252	.0590	.0071	.0090	.1983	.0050	.7362
N x Inhib.	.1240	.1292	.3103	.0457	.8828	.1210	.1222
Time x Inhib.	.7405	.3994	.6842	.8112	.3495	.6124	.6544
Till x N x Time x Inhib.	.1813	.1798	.7745	.1432	.6992	.1258	.0073

Table 2. The effect of tillage, N rate, and nitrification inhibitor on grain yields in Southeast Minnesota, 1983*

N Rate	No-Till			Till Plant			Chisel		
	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Mg/ha 0% moisture								
Spring									
0	4.1			3.7			3.8		
95	6.9a	6.5a	6.5a	7.4a	7.5a	7.9b	7.4a	7.0a	7.2a
195	7.0a	7.2a	6.8a	7.5a	7.7a	6.8a	7.4a	7.6a	7.3a
390	7.3a	7.0a	6.7a	7.8a	7.9a	7.6a	7.1a	7.2a	7.6b
Sidedress									
0	3.8			4.2			4.1		
95	5.8a	6.6a	6.7a	7.3a	7.5a	7.4a	7.9a	7.1b	7.0b
195	6.7a	6.6a	6.6a	7.0a	6.7a	6.8a	7.3a	5.6a	6.9b
390	6.1a	7.0b	6.7b	6.7a	7.0a	6.8a	7.1a	7.2a	6.8a

*Means for a tillage treatment in the same row followed by different letters are significant at x=.10, N=4.

Table 3. The effect of tillage, N rate, and nitrification inhibitor on stover yields in Southeast Minnesota, 1983.*

N Rate	No Till			Till Plant			Chisel		
	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Mg/ha								
Spring									
0	5.1			4.3			4.5		
95	6.7a	6.6a	6.1a	6.1a	6.3a	6.6b	7.0a	6.6a	6.7a
195	6.7a	6.5a	6.3a	6.2a	6.2a	5.6b	7.1a	7.1a	6.7a
390	6.5a	6.3a	6.4a	6.6ab	6.7a	6.4b	6.8a	6.8a	6.9a
Sidedress									
0	4.2			4.4			4.1		
95	5.8a	6.3b	6.0a	5.1a	5.7a	6.1a	6.3a	6.1a	6.3a
195	6.5a	5.9a	5.5a	6.0a	5.5b	6.0a	6.3a	6.3a	6.5a
390	5.4a	6.0a	6.1a	5.4a	6.1b	5.3a	5.9ab	6.6b	5.5a

*Means for a tillage treatment in the same row followed by different letters are significant at x = .10, N = 4.

Table 4. The effect of tillage on soil density and moisture in Southeast Minnesota, Aug 23, 1983.*

Depth (cm)	Position Relative to row	No Till	Till Plant	Chisel
		Soil Density gm/cm^3		
2-10	In row	1.19 (.0841)	1.05 (.144)	1.10 (.061)
	Between no traffic	1.30 (.141)	1.33 (.121)	1.30 (.138)
	Between traffic	1.43 (.082)	1.43 (.136)	1.36 (.113)
12-20	In row	1.33 (.150)	1.28 (.093)	1.32 (.079)
	Between no traffic	1.32 (.142)	1.37 (.061)	1.35 (.010)
	Between traffic	1.44 (.111)	1.40 (.046)	1.44 (.101)
		Soil moisture cm^3/cm^3		
2-10	In row	24.1 (3.5)	22.0 (3.4)	25.3 (3.3)
	Between no traffic	24.6 (2.0)	27.1 (1.3)	28.4 (2.9)
	Between traffic	28.0 (1.2)	29.5 (1.5)	29.8 (2.2)
12-20	In row	22.2 (3.2)	23.8 (1.7)	26.3 (4.1)
	Between no traffic	23.0 (3.2)	24.6 (3.1)	25.6 (1.1)
	Between traffic	25.5 (3.0)	24.3 (2.1)	27.1 (2.7)

*The number on parenthesis is the standard deviation, N = 4.

Table 5. Effect of tillage, N rate, and nitrification inhibitor on grain N uptake in Southeast Minnesota, 1983.*

	No Till			Till Plant			Chisel		
N Rate	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Kg/ha								
Spring									
0	61.2			52.0			51.0		
95	96.9a	91.8a	100.4a	117 a	117a	121a	114 a	111a	104a
195	118 a	106 b	107 b	112 a	120a	105a	116 a	117a	109a
390	111 a	116 a	106 a	123 a	120a	122a	107 a	120a	123a
Sidedress									
0	49.8			51.8			53.0		
95	94.1a	91.3a	103.0b	119 a	115a	116a	126 a	111a	113a
195	102 a	104 a	101 a	110 a	105a	109a	113 a	118a	112a
390	92.2a	116 b	111 b	101 a	110b	102a	118 a	108a	108a

*Means for a tillage treatment in the same row followed by different letters are significant at x = .10, N = 4.

Table 6. The effect of tillage, N rate, and nitrification inhibitor on stover N uptake in Southeast Minnesota, 1983.*

	No Till			Till Plant			Chisel		
N Rate	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Kg/ha								
Spring									
0	30.7			23.4			25.7		
95	53.1a	47.5a	46.9a	44.0a	45.7a	48.3a	51.1a	43.8a	47.5a
195	51.6a	52.1a	49.0a	48.5a	46.6b	44.8b	57.6a	54.4a	54.1a
390	53.9a	55.3a	51.1a	49.5a	51.6a	49.6a	60.0a	58.3a	58.3a
Sidedress									
0	22.8			21.4			20.4		
95	47.6a	51.9a	48.3a	40.9a	42.4a	41.4a	44.1a	43.5a	43.9a
195	50.6a	54.6a	48.3a	44.6a	40.2a	45.6a	41.6a	48.7a	49.7b
390	45.9a	52.5a	53.2a	38.6a	40.4a	37.8a	59.6a	53.7a	46.5b

*Means for a tillage treatment in the same row followed by different letters are significant at x = .10, N = 4.

Table 7. The effect of tillage, N rate, and nitrification inhibitor on total N uptake in Southeast Minnesota, 1983.*

N Rate	No Till			Till Plant			Chisel		
	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Kg/ha								
Spring									
0	91.9			75.4			76.7		
95	150 a	139b	147a	161 a	163a	170a	165 a	155a	152a
195	170 a	158a	156a	161 a	167a	150a	174 a	172a	162a
390	164 a	171a	157a	173 a	171a	172a	167 a	178a	182a
Sidedress									
0	72.6			73.2			73.4		
95	142 a	143a	151a	160 a	157a	157a	170 a	154a	157a
195	152 a	159a	149a	154 a	146a	154a	155 a	166b	162ab
390	138 a	168b	164b	140 a	150a	140a	178 a	162a	155a

*Means for a tillage treatment in the same row followed by different letters are significant at x = .10, N = 4.

Table 8. The effect of tillage, N rate, and nitrification inhibitor on leaf N concentration in Southeast Minnesota, 1983.*

N Rate	No Till			Till Plant			Chisel		
	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	%								
Spring									
0	2.03			1.88			1.77		
95	2.75a	2.70a	2.69a	2.92a	2.92a	2.82a	2.75a	2.90a	3.03a
195	2.80a	2.96b	2.81a	3.09ab	3.14a	2.54b	3.18a	2.27b	3.01a
390	2.72a	2.92a	3.11a	3.08a	2.94a	3.01a	2.96a	2.98a	3.23a
Sidedress									
0	1.97			2.04			1.84		
95	2.74a	2.73a	2.58b	2.76a	2.62a	2.70a	2.64a	2.59a	2.72a
195	2.60a	2.55a	2.74b	2.58a	2.74a	2.77a	2.73a	2.64b	2.67ab
390	2.73a	2.84a	2.92b	2.93a	2.92a	3.00a	2.69a	2.81a	2.86a

*Means for a tillage treatment in the same row followed by different letters are significant at x = .10, N = 4.

Table 9. Probability of treatment effects for selected variables at Becker, Minnesota, 1983.

Source	Variable						
	Grain Yield	Stoves Yield	Total Dry Matter	Grain N Uptake	Stoves N Uptake	Total N Uptake	Ear Leaf N
Rep	.0221	.0916	.0043	.1949	.0070	.0390	.6919
Tillage	.0238	.0974	.0299	.0297	.4245	.1280	.0387
N	.0001	.0001	.0001	.0001	.0001	.0001	.0001
Till x N	.2514	.3431	.1288	.3693	.6172	.4807	.1763
Inhibitor	.0001	.0949	.0001	.0001	.0017	.0001	.0001
Till x Inhibitor	.3499	.2129	.0733	.3422	.0561	.2038	.3501
N x Inhibitor	.0001	.0067	.0001	.0001	.0738	.0001	.0001
Till x N x Inhibitor	.0657	.8389	.1591	.1685	.9733	.5801	.0850

Table 10. The effect of tillage, N rate, and nitrification inhibitor on yields at Becker, Minnesota, 1983.*

	No Till			Till Plant			Chisel			Moldboard		
N Rate	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Grain Mg/ha											
0	2.0			2.3			2.5			2.4		
85	3.3a	5.5b	5.4b	3.0a	4.7b	4.8b	3.6a	5.0b	6.7c	2.9a	4.6b	4.8b
170	5.5a	5.6a	6.7b	6.0a	6.5a	7.0a	7.4ab	6.9a	7.5b	6.3a	6.5a	6.5a
340	7.5a	7.0a	7.4a	8.4a	6.6b	7.5ab	8.0ab	7.9a	8.3b	7.7a	7.9a	8.2a
	Stover Mg/ha											
0	2.1			2.0			2.4			2.3		
85	4.2a	5.2ab	5.0b	3.3a	3.6a	3.4a	3.6a	4.2a	4.7a	3.5a	3.9a	3.6a
170	5.0a	4.6a	5.1a	4.1a	4.3ab	5.0b	5.2a	5.1a	6.3b	4.7a	4.7a	5.0a
340	6.0a	6.2a	5.9a	6.2a	5.1b	5.5ab	5.7a	5.9a	5.9a	6.2a	6.0a	5.7a
	Total Mg/ha											
0	4.1			4.3			4.9			4.7		
85	7.5a	10.6b	10.4b	6.3a	8.0ab	8.3b	7.2a	9.1b	11.9c	6.1a	8.6b	8.1b
170	10.5a	10.9ab	11.7b	10.2a	10.8ab	12.5b	13.0ab	12.5a	14.0b	11.0a	11.1a	11.6a
340	.2a .5a	13.0b	13.2ab	14.6a	11.4b	13.0ab	13.7a	13.7a	14.3a	13.9a	13.7a	13.9a

*Means for a tillage treatment in the same row followed by different letters are significant at X = .10, N = 4.

Table 11. The effect of tillage, N rate, and nitrification inhibitor on N uptake at Becker, Minnesota, 1983.*

	No Till			Till Plant			Chisel			Moldboard		
N Rate	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell	None	N-Serve	Dwell
Kg/ha	Grain N Uptake (Kg/ha)											
0	24.9			30.1			29.4			31.9		
85	40.9a	70.8b	74.7b	36.1a	61.0b	68.3b	48.5a	64.5b	87.1c	36.6a	60.5b	62.8b
170	70.5a	77.0a	96.7b	83.0a	91.6a	109 b	103 a	102 a	109 a	81.9a	87.1a	87.9a
340	116 a	116 a	118 a	128 a	104 b	111 ab	123 a	121 a	140 b	116 a	124 a	124 a
	Stover N uptake (Kg/ha)											
0	11.4			10.4			11.6			10.3		
85	17.9a	26.4b	25.4b	14.1a	17.4a	19.0a	16.1a	21.2a	25.5a	13.7a	19.2b	15.4a
170	27.9a	31.6a	31.5a	21.8a	27.1b	30.8a	25.7a	30.0a	40.0b	25.7a	26.7a	27.2a
340	38.5a	43.0a	39.6a	41.8a	36.7a	41.1a	36.4a	38.2a	42.3a	44.3a	37.4a	39.4a
	Total N uptake (Kg/ha)											
0	36.2			40.6			41.0			42.2		
85	58.8a	97.2b	100 b	50.2a	78.4b	87.3b	64.5a	85.7b	113 b	50.3a	79.8b	78.2b
170	98.3a	109 b	128 b	105 a	119 a	140 b	129 ab	132 a	149 b	108 a	114 a	115 a
340	156 a	159 a	158 a	170 a	141 b	152 ab	159 ab	159 a	182 b	160 a	161 a	164 a
	Ear leaf (% N)											
0	1.29			1.36			1.21			1.13		
85	1.60a	2.85b	3.01b	1.56a	2.28b	2.81b	1.80a	2.65b	2.81b	1.53a	2.29b	2.53b
170	2.51a	3.06b	3.07b	2.80a	2.95b	3.05b	2.90a	3.10a	3.05a	2.45a	2.71a	2.81b
340	3.17a	2.98a	2.98a	2.95a	3.11a	3.15b	2.89a	3.16a	3.04a	2.93a	3.02a	3.01a

*Means for a tillage treatment in the same row followed by different letters are significant at x - = .10, N = 4.

Figure 1. 1983 Precipitation at the Southeastern Minnesota site.

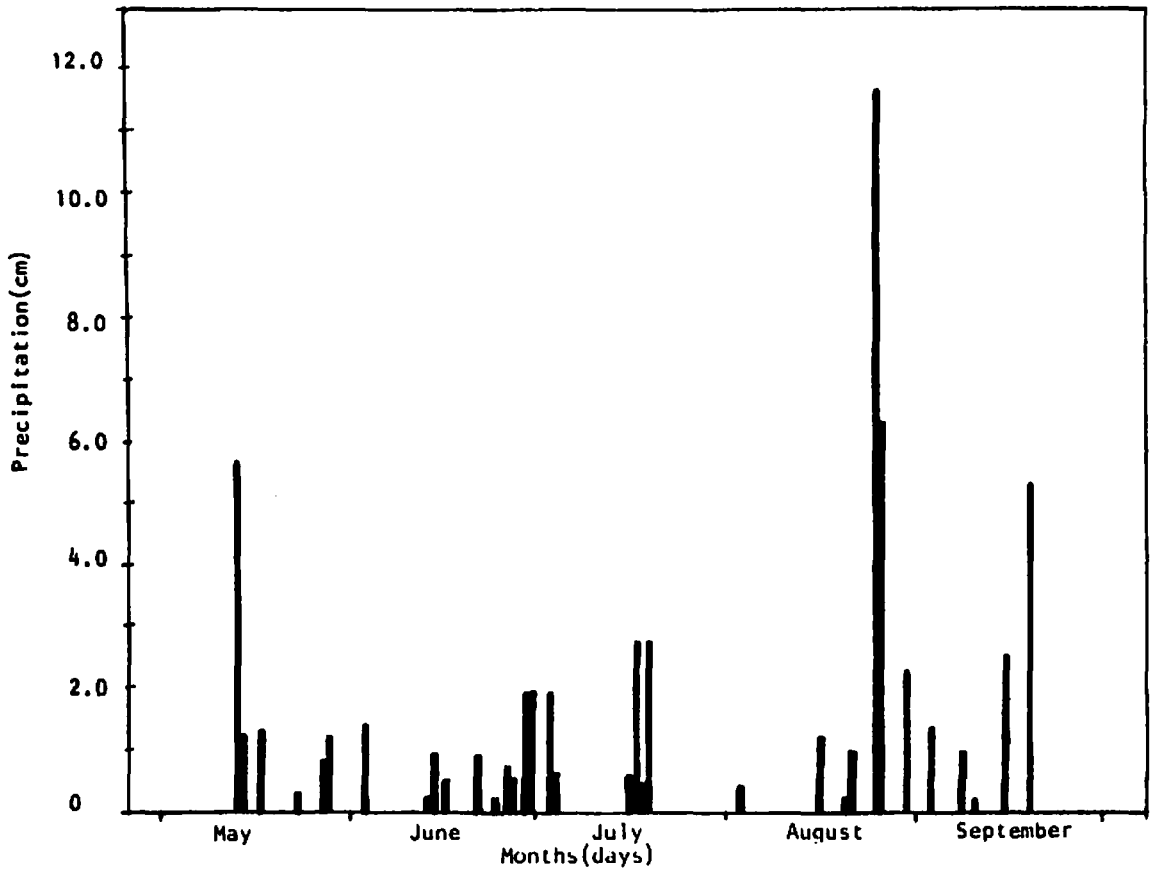
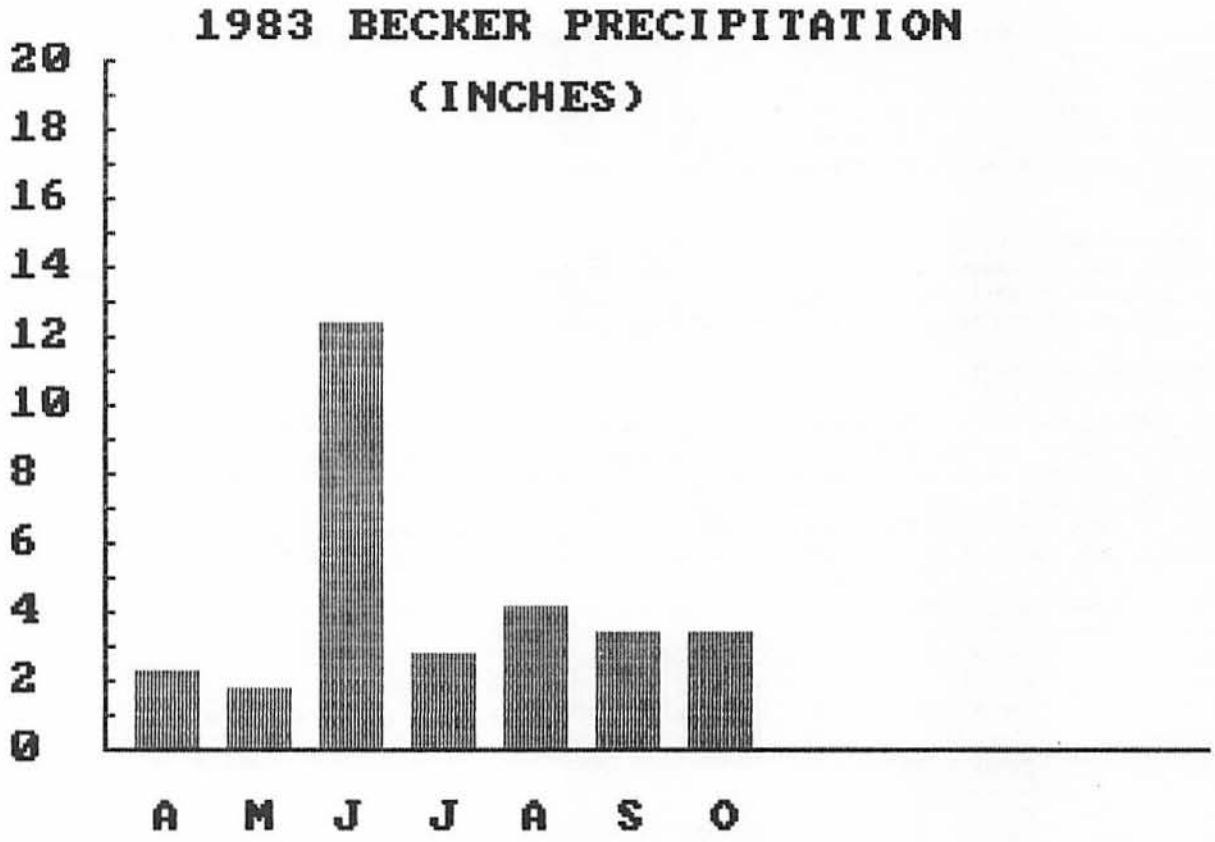


Figure 2.


1983 BECKER PRECIPITATION
(INCHES)
20
18
16
14
12
10
8
6
4
2
0
A
M
J
J
A
S
O

COMPARISON OF THREE PHOSPHORUS SOIL TEST PROCEDURES TO CROP YIELDS AND PLANT ANALYSIS DATA

W. E. Fenster, J. Grava, S. D. Evans, G. E. Varvel, M. O'Leary, G. Buzicky and R. K. Severson

Several soil test methods for extractable phosphorus have evolved over the years. The Bray P-1 method, used at a 1:10 soil-solution ratio, was adopted by the University of Minnesota Soil Testing Laboratory for routine analysis in 1954. This method is especially well suited for assessing phosphorus availability in acid to neutral soils. The reliability of the P soil test on calcareous soils was greatly improved in 1975 by changing the soil-solution ratio from 1:10 to 1:50. In 1982 the Olsen sodium bicarbonate method of extracting soil phosphorus was introduced for soils having pH over 7.4.

The primary objective of this study was to determine the relationship between crop yield and plant tissue P, and the amounts of phosphorus extracted by the various soil testing methods. These experiments to establish guidelines for making fertilizer recommendations from soil tests have been conducted on private farms and at the Branch Experiment Stations since 1981.

EXPERIMENTAL PROCEDURE

Seven field experiments were established on calcareous soils in western Minnesota in 1981 to evaluate three P soil tests and their relationship to crop response from P additions. Wheat was grown on six sites and soybeans on the other. There were three additional sites in 1982, six in wheat, two in corn and one in soybeans. One additional trial from 1981 was lost due to flooding in 1982. In 1983 there were three wheat trials, one each of barley, corn and soybeans. Information on location, soil type, crop, and soil test levels of 1983 trials is given in Table 1.

Table 1. Cooperator, county, soil type, crop, and initial soil test results for 1983 trials.

Cooperator:	Crookston Stn.		Dahl Farm	Klassen Farm	Klenz Farm	Morris Stn.
County:	W. Polk		Norman	Swift	Martin	Stevens
Soil Series:	Hegne	Wheatville	Vallers	Colvin	Webster	Doland
Texture:	Sicl	Sil	Sil	Sicl	Cl	Sil
Crop:	Wheat	Wheat	Barley	Corn	Soybeans	Wheat
Soil pH:	8.0	8.2	8.3	8.0	7.7	7.8
Olsen P, lb/A:	20	15	17	6	10	6
Exch. K, lb/A:	314	322	302	387	295	263

The three soil tests compared were the Bray P-1 method using either 1:10 or 1:50 ratio of soil to extracting solution, and the Olsen bicarbonate method. The Bray P-1 tests are affected by high soil pH while the Olsen test is largely independent of pH. During 1981 and 1982 at several locations starter and no starter comparisons were made in addition to the four broadcast P treatments. In the 1983 trials, phosphorus fertilizer was broadcast except at the Morris Station where the broadcast P effects were compared with and without the starter fertilizer.

RESULTS AND DISCUSSION

Table 2a gives wheat and barley yields for 1982 and 1983, Table 2b gives plant tissue and soil test results for 1981, 1982 and 1983. Similar results for corn and soybeans are reported in Tables 3a and 3b. Plant analysis data for small grain, and for corn and soybeans are given in Tables 4 and 5, respectively.

Wheat

Hegne sicl, Crookston Stn., Olsen P 16 lb/A (fall 1982). The yield was increased by 5 bu/A with 30 lb. P_2O_5/A over the check. Very high P relative levels were indicated by the Bray P-1 method (1:10 and 1:50) on this soil. Extractable P levels by all three methods and plant tissue P were increased by broadcast fertilizer. Some infection from scab was observed.

Please refer to title page of this publication for information regarding application and use of this article.

Wheatville sil, Crookston Stn., Olsen P 10 lb/A (fall 1982). Phosphorus fertilization resulted in increased P soil test levels by the three methods but neither the yield nor tissue P of wheat were affected. Early dying of the head caused by the fungal disease scab was a problem on this field.

Doland sil, Morris Stn., Olsen P 5 lb/A (fall 1982). The yield was increased by 4 bu/A with starter fertilizer. Broadcast rates of phosphorus applied in 1982 were reflected in increased P% of plant tissue and higher soil test levels by all three methods. Although only main effects of phosphorus are reported in Table 2a, broadcast P increased the yield of wheat considerably. The yield of the true check (0 P, no starter, Olsen P 5 lb/A), for example, was 44 bu/A. On plots where the Olsen P level had been built up to 12 or 15 lb/A, the corresponding wheat yield was 58 bu/A.

Barley

Vallers sil, Dahl Farm, Olsen P 14 lb/A (spring 1983). Barley response to P fertilization was noted at heading. Increased phosphorus rates appeared to hasten plant development and resulted in increased growth and lodging. The yields of different treatments were not significantly different because of variability due to severe lodging. The percentage of plump kernels was increased by 13 with 30 lb. P_2O_5/A over the check. Plant tissue P and soil test P levels of the three methods were increased by P fertilization.

Corn

Colvin sicl, Klassen Farm, Olsen P 11 lb/A (fall 1982). Corn yield was increased in 1983 by 11 bu/A with 30 lb. P_2O_5/A applied in 1982 and 1983 and by 14 to 20 bu/A from carryover of 60 or 90 lb. P_2O_5/A applied in 1982. Olsen P test levels of samples collected in fall of 1982 were increased from 11 to 20 lb/A by the application of 60 or 90 lb. P_2O_5/A applied in the spring.

Bray P-1, 1:10 test levels were extremely low and were not changed by fertilization. It is suspected that this Colvin sicl has a relatively high total carbonate content, predominantly as calcite ($CaCO_3$); carbonates of the other soil in this study probably are mainly dolomitic ($CaCO_3$ and $MgCO_3$). These assumptions are based mainly on the trends observed in Bray P-1, 1:10 and 1:50 test levels as affected by P fertilization. The Bray P-1, 1:50 test results were considerably higher than those obtained by using 1:10 ratio, and at higher rates reflected the carryover of P fertilizer.

Soybeans

Webster cl, Klenz Farm, Olsen P 13 lb/A (spring 1983). Phosphorus fertilization increased soybean yield by 5 bu/A and increased P levels of all three soil tests but did not significantly affect the P% of leaf tissue. No yield increase beyond the 30 lb. P_2O_5/A rate occurred.

In some instances the concentrations of Cu, Fe, Mn and Zn were significantly lowered by fertilization with phosphorus (Tables 4 and 5). But for Zn, Mn and Fe they were above the critical level even at the lowest concentration. Copper concentration of plant tissue from several locations was below 5 ppm, considered to be the critical level for small grain and corn. This may not be of practical significance, however, because copper deficiencies have not been observed on mineral soils of Minnesota.

Table 2a. Wheat and barley yields at 13% moisture and plumpness of barley kernels as affected by phosphorus fertilization in 1982 and 1983.

Treatment	Location									
Broadcast	Crookston Stn.				Morris Stn.			Dahl Farm		
P_2O_5	Hegne Wheat		Wheatville Wheat		Wheat			Wheat	Barley	
	1982	1983	1982	1983	1981	1982	1983	1982	1983	
Lb/acre	Bu/acre									plump kernels %
0	51	54	53	43	63	61	51	58	57	45.2
30[1/]	46	58	55	49	64	65	57	62	65	58.2
60	48	51	57	42	64	68	59	61	69	57.5
90	46	54	55	46	64	69	59	59	64	60.5
Significance	ns	+	ns	ns	ns	*	**	ns	ns	+
BLSD (0.05)		5								13.1
Starter	-	-	-	-	64	68	58			
No Starter	-	-	-	-	64	64	54			
Significance					ns	*	*			

[1/] P rates as indicated were broadcast in 1982; at Morris Station only 30 lb. rate was spread in 1983, yields from P carryover on 60 and 90 treatment plots.

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

Treatment	Location								
Broadcast	Crookston Stn.				Morris Stn.[2/]			Dahl Farm	
P_2O_5	Hegne Wheat		Wheatville Wheat		Wheat			Wheat	Barley
	1982	1983	1982	1983	1981	1982	1983	1982	1983
Lb/acre	Plant Tissue P %								
0	.30	.32	.28	.30	.16	.22	.27	.27	.27
30	.30	.33	.26	.30	.18	.26	.32	.28	.31
60	.30	.33	.28	.32	.18	.29	.32	.29	.33
90	.31	.34	.28	.33	.20	.31	.34	.29	.36
Significance	ns	*	+	ns	ns	**	*	ns	*
BLSD (0.05)		.01					.04		.06
	Bray 1 1:10 P lb/A								
0	54	34	16	10	15	10	7	23	12
30	-	45	-	13		18	12	-	16
60	-	46	-	22		23	17	-	22
90	-	52	-	28		33	19	-	22
	Bray 1 1:50 P lb/A								
0	84	81	60	54	21	12	38	57	45
30	-	96	-	54		23	34	-	46
60	-	101	-	72		25	42	-	64
90	-	111	-	70		33	48	-	66
	Olsen P lb/A								
0	20	16	15	10	11	6	5	17	14
30	-	22	-	10		13	9	-	15
60	-	24	-	16		15	12	-	19
90	-	30	-	18		23	15	-	21

1/ 1982 Crookston and Dahl trials were sampled in spring of 1982 prior to treatment, Morris sampled fall 1981.

1983 Crookston and Morris trials were sampled in fall of 1982, Dahl sampled in spring of 1983 prior to fertilization.

All soil test results are means of four replications.

2/ Plant and soil samples of Morris trial were collected from no starter plots.

Table 3a. Corn and soybean yields as affected by broadcast phosphorus fertilization in 1982 and 1983.

Treatment	Location				
Broadcast	Klassen		Klenz		
P_2O_5	Corn 1982	Corn 1983	Soybeans 1981	Corn 1982	Soybeans 1983
Lb/acre	Bu/acre				
0	164	98	49	162	43
30[1/]	160	109	51	172	48
60	165	112	51	172	48
90	173	118	52	167	48
Significance	ns	*	ns	ns	+
BLSD (0.05)		12			5

[1/] P rates as indicated were broadcast in 1982; in 1983, only the 30 lb. rate was spread, yields from P carryover on others.

Table 3b. Phosphorus concentration of ear leaf of corn at silking and upper mature trifoliate leaves of soybeans at initial flowering and relationship to P treatment and soil test.[1/]

Treatment	Location				
Broadcast	Klassen		Klenz		
P_2O_5	Corn 1982	Corn 1983	Soybeans 1981	Corn 1982	Soybeans 1983
Lb/acre	Plant Tissue P %				
0	.27	.20	.35	.26	.37
30[2/]	.27	.21	.41	.29	.42
60	.29	.22	.40	.30	.45
90	.30	.22	.40	.30	.43
Significance	ns	*	+	**	ns
BLSD (0.05)		.01		.01	
	Bray 1 1:10 P lb/A				
0	6	2	18	13	13
30[2/]	4	2		18	19
60	7	4		21	24
90	5	2		27	24
	Bray 1 1:50 P lb/A				
0	15	31	36	33	49
30[2/]	14	22		36	61
60	15	38		39	78
90	15	44		46	84
	Olsen P lb/A				
0	16	11	15	10	13
30[2/]	17	12		12	17
60	17	20		14	22
90	18	20		19	24

[1/] 1982 trials were sampled in fall of 1981.

1983 Klassen trial was sampled in fall of 1982, Klenz trial was sampled in spring of 1983 prior to fertilizer application.

All soil test results are means of four replications.

[2/] P rates as indicated were broadcast in 1982; in 1983, only the 30 lb. rate was spread, results from P carryover on others.

Table 4. Plant analysis data for wheat at Crookston Stn. and Morris Stn., and barley at Dahl Farm, 1983.

Treatment		Plant Nutrient								
P_2O_5	Yield	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Lb/A	Bu/A	----------%----------				----------ppm----------				
		Crookston Stn., Hegne, Wheat - whole plant at boot stage								
0	54	.32	3.08	.28	.24	68	44	24	7	4
30	58	.33	3.01	.30	.26	67	49	21	7	4
60	51	.33	3.05	.31	.24	72	44	19	7	4
90	54	.34	2.87	.29	.24	64	45	18	6	4
Significance	+	*	ns	ns	ns	ns	ns	*	ns	ns
BLSD (0.05)	5	.01						3		
		Crookston Stn., Wheatville, Wheat - whole plant at boot stage								
0	43	.30	3.15	.27	.23	67	52	33	3	6
30	49	.30	3.03	.24	.21	60	48	29	3	5
60	42	.32	2.83	.21	.20	53	46	23	2	5
90	46	.33	2.86	.23	.18	52	42	21	2	4
Significance	ns	ns	ns	ns	ns	**	+	**	*	*
BLSD (0.05)						8	8	3	.8	.1
		Morris Stn., Wheat - whole plant at boot stage								
0	51	.27	2.78	.32	.21	102	59	28	3	4
30	57	.32	2.59	.32	.22	75	64	21	2	4
60	59	.32	2.63	.34	.23	92	63	21	2	4
90	59	.34	2.66	.38	.24	94	70	20	2	4
Significance		*	ns	ns	ns	ns	ns	*	ns	ns
BLSD (0.05)		.04						5		
		Dahl Farm, Barley - whole plant at boot stage								
0	57	.27	3.32	.44	.29	48	48	29	6	6
30	65	.31	3.13	.51	.27	104	46	28	5	6
60	69	.33	2.85	.48	.33	55	44	22	4	6
90	64	.36	2.83	.49	.31	60	39	25	4	6
Significance	ns	*	ns	ns	ns	+	ns	*	*	ns
BLSD (0.05)		.06						4	2	

Table 5. Plant analysis data for corn at Klassen Farm, and soybeans at Klenz Farm, 1983.

Treatment		Plant Nutrient								
P_2O_5	Yield	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Lb/A	Bu/A	----------%----------				----------ppm----------				
		Klassen Farm, Corn, whole plant - 8th leaf stage								
0		.28	3.52	1.20	.70	1705	136	42	10	12
30[1/]		.26	3.37	1.36	.75	1783	137	38	9	13
60		.28	3.46	1.28	.73	1688	136	40	10	13
90		.26	3.38	1.46	.74	1861	140	40	9	12
Significance		ns	ns	ns	ns	ns	ns	ns	**	ns
BLSD (0.05)									0.7	
		Klassen Farm, Corn, ear leaf at tasseling								
0	98	.20	1.70	.35	.33	78	68	16	3	9
30[1/]	109	.21	1.81	.38	.36	74	70	16	3	8
60	112	.22	1.75	.36	.36	78	71	17	3	8
90	118	.22	1.66	.40	.34	79	68	15	3	8
Significance	*	*	ns	ns	ns	ns	ns	ns	ns	ns
BLSD (0.05)	12	.01								
		Klenz Farm, Soybeans, leaves at initial flowering								
0	43	.37	2.53	1.26	.50	208	80	34	11	49
30[1/]	48	.42	2.49	1.24	.51	180	84	31	10	50
60	48	.45	2.46	1.19	.50	174	82	34	10	49
90	48	.43	2.51	1.22	.50	193	92	31	10	50
Significance	+	ns	ns	ns	ns	ns	ns	ns	ns	ns
BLSD (0.05)	5									

[1/] Indicated P rates were broadcast in 1982; in 1983 only the 30 lb. rate was spread, results from P carryover on others.

MICRONUTRIENTS AND RELATIONSHIP TO MICRONUTRIENT SOIL TESTS

W. E. Fenster and G. W. Rehm

The micronutrient study was initiated in 1981. Three of the original 6 locations were discontinued for various reasons in 1982 and the three that were continued were planted to soybeans, in 1983 one of these was planted to snap beans the other two were in corn.

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 also included as a variable.

The "missing element" technique was used whereby a series of plots each having one of the nutrients omitted were 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 1981, 1982 and 1983 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 in final summary contribute a large volume of useful data.

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, 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.

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Please refer to title page of this publication for information regarding application and use of this article.

Table 1. Corn, soybean and snap bean yields, plant boron, and soil test boron from four levels of boron applications. 1981, 1982, & 1983.

Jokela Farm - Goodhue Co. non-irrigated
Mt. Carroll silt loam

lbs B/A	yield bu/A 1/			ppm B 1/ leaf			soil test - ppm hot H_2O		
	1981 Corn	1982 Soybeans	1983 Corn	1981 Corn	1982 Soybeans	1983 Corn	1981	1982	1983
0	170	49	127	4	38	8	0.6	0.8	0.7
1	178	42	124	5	44	9		1.1	1.2
2	175	47	128	5	51	10		1.5	1.7
4 2/	174	42	131	7	61	12		2.5	2.2
significance	ns	+	ns	ns					
BLSD (.10)		5							
C.V.	3.7	7.2	7.7	9.8					

Kingston Farm - Dakota Co. - irrigated
loamy sand

lbs B/A	Yield 1/ Bu/A		lb/A	ppm B 1/ leaf			soil test - ppm hot H_2O		
	1981 Corn	1982 Soybeans	1983 Snap beans	1981 Corn	1982 Soybeans	1983 Snap beans	1981	1982	1983
0	155	36	12,440	7	43	21	0.25	0.2	0.2
1	159	34	13,855	8	52	48		0.3	0.3
2	147	32	12,472	12	67	72		0.5	0.8
4 2/	160	27	13,728	18	112	60		0.9	1.4
significance	ns	**	ns	**					
BLSD (.05)		4		3.5					
C.V.	5.0	82	33	21.9					

Geiger Farm - Morrison Co. - irrigated, discontinued after 1981.
loamy sand

lbs B/A	yield bu/A 1/	ppm B 1/ leaf	soil test - ppm hot H_2O
	1981 Corn	1981 Corn	1981
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	28.8	

1/ Average of 4 replications, where statistics are shown.

2/ Four lb. rate not applied 1983

Table 2. Yields[1/] in three counties comparing complete treatments of micronutrients plus Magnesium to plots using missing element techniques. 1981, 1982, 1983.

Treatment [2/] omitted (-) added (+)	Martin Yield [4/] 1981	1982	1983	Goodhue Yield [4/] 1981	1982	1983	Dakota [3/] Yield [4/] 1981	1982	1983
None	179	56	143	173	47	130	156	33	12,185
-Mg	181	51	144	169	43	124	160	35	14,814
-Zn	181	52	145	175	45	129	159	33	16,044
-Fe	182	53	148	174	44	130	151	34	15,036
-Mn	180	54	148	174	43	124	159	34	12,814
-B	178	52	148	177	44	128	152	34	14,596
-Cu	178	52	146	170	45	131	157	33	16,676
+ complete includes S	184	54	141	169	47	129	156	33	16,246
Significance	ns	ns	ns	ns	ns	ns	ns	ns	ns
C.V.	4.9	5.0	6.7	5.5	6.3	4.5	5.6	7.8	27.2

[1/] average of 4 repplications

[2/] pounds per acre of nutrient added Mg=50, Zn=10, Fe=10, Mn=10, B=1, Cu=5 in 1981 and 1982, residual only in 1983.

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

[4/] corn in 1981 and 1983 except snap beans at Dakota Co. site. Soybeans grown in 1982 at all sites.

Table 3. Plant analysis [1/] from micronutrient and magnesium treatments in trials at three counties. 1981, 1982, 1983.

Treatment [2/] omitted (-) added (+)	Martin (ppm except Mg which is %) (-) 81	82	83	(+) 81	82	83	Goodhue [4/] (-) 81	82	83	(+) 81	82	83	Dakota [3/] (-) 81	82	83	(+) 81	82	83
Mg	.58	.48	.45	.58	.42	.53	.36	.46	.38	.38	.43	.36	.27	.43	.52	.27	.49	.50
Zn	21	42	14	24	48	20	35	42	30	40	46	37	29	45	25	34	47	27
Fe	93	113	100	97	131	99	113	104	128	109	99	126	120	84	94	117	92	94
Mn	56	61	46	61	97	57	59	44	66	60	44	62	76	63	54	77	58	60
B	5	50	8	5	50	7	6	41	6	7	44	6	5	39	24	9	54	40
Cu	3	10	3	3	11	3	11	5	5	6	0	6	10	10	8	10	10	8

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

[2/] symbol + is from treatment of all nutrients. Pounds of nutrients added Mg=50, Zn=10, Mn=10, B=1, Cu=5, in 1981 and 1982. Residual in 1983.

[3/] irrigated sandy loam, others textured non-irrigated soils.

[4/] corn in 1981 and 1983 except sonapbeans at Dakota Co. site. Soybeans in 1982 at all sites.

Table 4. Yields, [1/] plant sulfur and soil test sulfur with and without sulfur treatments in three counties. 1981, 1982, and 1983.

Sulfur Treatment	Yield (bu/A)			Ear Leaf (% S)			U of M Soil Test (PPM S)		
	1981	1982	1983	1981	1982	1983	1981	1982	1983
				Martin Co.					
None	183	54	144	.23	.31	.20	16	1	6
50#/A	180	53	152	.29	.31	.22	--	--	5
Significance	ns	ns	ns						
				Goodhue Co.					
None	181	44	129	.24	.32	.23	16	10	3
50#/A	179	43	130	.27	.35	.27	--	19	5
Significance	ns	ns	ns						
				Dakota [2/]					
None	151	33	15966	.24	.28	.21	6	1	6
50#/A	154	34	14493	.25	.30	.21	--	2	6
Significance	ns	ns	ns						

[1/] average of 4 replications, corn at 3 sites 1981, soybeans in 1982, corn in 1983 except snap beans in Dakota Co.

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

Table 5. Soil test means for micronutrients. University of Minnesota Lab. 1981, 1982, and 1983.

Treatment 1/ omitted (-) added (+)	Martin					Goodhue					Dakota				
	(ppm except Mg which is lbs/A)														
		(-)		(+)			(-)		(+)			(-)		(+)	
	1981	1982	1983	1982	1983	1981	1982	1983	1982	1983	1981	1982	1983	1982	1983
Mg	881	990	1124	970	1096	579	495	641	595	722	312	295	317	364	435
Zn	1.0	1.2	2.2	2.3	5.4	2.0	4.8	3.4	8.0	8.9	1.0	1.4	1.4	4.2	6.2
Fe	21	42	25	26	24	55	76	70	90	66	41	78	56	80	48
Mn	41	40	22	40	17	31	30	18	30	17	21	19	10	18	8
B	1.20	2.1	2.2	1.8	2.4	.60	1.0	0.8	3.2	1.7	.25	2.2	0.4	2.4	0.9
Cu	1.28	1.8	1.7	2.5	3.0	0.75	1.5	1.5	4.0	3.8	0.48	0.6	0.9	3.1	3.4

1/ 1981 soil test results before treatment applied, 1982 from treatment plots in 1981 and 1983 from treatment plots in 1981 and 1982.

FIELD TRIALS WITH "BASIC-H" 1983

W. E. Fenster and G. W. Rehm

The effects of the wetting agent "Basic-H" were studied at several experimental farms and by growing various crops. This product is not marketed as a plant food but meant to improve water penetration and thus better water use efficiency.

Plots were established on fine textured, clay loam soils of high organic matter at Waseca, and Lamberton. The trials at the Morris station were on silt loam soils. The experiments conducted at Crookston were on high organic matter soils, the sugarbeet trial on a loam soil, the sunflower trial on a fine sandy loam soil. The trials at Becker were on very well drained loamy sands with low organic matter and were conducted under irrigation.

Under the weather conditions of 1983 which were below normal in rainfall in most areas no benefits were obtained by the use of the wetting agent except from one treatment on wheat at the Morris station.

Trials at the Waseca and Lamberton stations were conducted by G. W. Randall, W. W. Nelson, and W. E. Fenster. Table 1 gives results of Basic-H on corn.

Table 1. Effects of Basic-H on corn yields, moisture at harvest and plant population at Waseca and Lamberton experiment stations 1983.

	Yield (Bu/A)		Moist (%)		Pop. (x 1000)
	Waseca	Lamberton	Waseca	Lamberton	Waseca
Control	56	62	21.6	23.2	27.1
Fertilizer (U of M recommendation)*	121	85	20.5	21.7	27.0
Fertilizer + Basic-H (1 gal./A)	111	87	20.4	22.1	27.6
Fertilizer + Basic-H (2 gal./A)	117	87	20.6	21.4	26.3
Basic-H only (1 gal./A)	53	54	21.8	23.1	26.8
Significance	**	**	**	ns	ns
BLSD (.05)	9.8	13.9	.6	--	--
C.V.	7.6	9.0	.8	4.2	4.9

*Fertilizer recommended	N	P_2O_5	K_2O
Waseca lbs/A	175	50	150
Lamberton lbs/A	150	60	60

*This research partially funded by the Shaklee Corporation.

Please refer to title page of this publication for information regarding application and use of this article.

In table 1b results at Waseca of another wetting agent "Amway Spray Adjuvant" are shown.

Table 1b. Effects of Amway Spray Adjuvant on corn yield, moisture at harvest and plant population, Waseca, MN 1983.

	Yield (Bu/A)	Moist %	Population (1000)
Control	56	21.6	27.1
Fertilizer (U of M recommendation)*	121	20.5	27.0
Fertilizer + Amway (1 gal./A)	115	20.4	27.2
Fertilizer + Amway (2 gal./A)	114	20.4	27.6
Amway only (1 gal./A)	50	21.8	26.6
Significance	**	**	ns
BLSD (.05)	8.4	.8	--
C.V.	6.6	1.1	4.3
*Fertilizer recommended	N	P_2O_5	K_2O
lbs./A	175	50	150

Results from trials with "Basic-H" at the Morris station on wheat conducted by S. D. Evans and W. E. Fenster are shown in Table 2.

Table 2. Effects of Basic-H on wheat yields and moisture at harvest time. Morris, MN 1983.

	Yield (Bu/A)	Moist (%)
Control	41	13.2
Fertilizer (U of M recommendation)*	55	12.2
Fertilizer + Basic-H (1 gal./A)	59	13.8
Fertilizer + Basic-H (2 gal./A)	56	13.9
Basic-H only (1 gal./A)	46	13.0
Significance	**	ns
BLSD (0.5)	4.5	--
C.V.	6.1	2.8

*Fertilizer recommended	N	P_2O_5	K_2O
lbs/A	50	0	0

"Basic-H" effects on sunflower production were conducted at the Crookston station by G. E. Varvel and W. E. Fenster. Table 3 shows the sunflower yields, oil content and corresponding population to treatment.

Table 3. Effects of Basic-H on sunflower yield, oil content and plant population. Crookston, MN 1983.

	Seed Yield (lbs/A)	Oil %	Pop. (x 1000)
Control	964	37.5	20.9
Fertilizer (U of M recommendation)*	1180	38.0	21.3
Fertilizer + Basic-H (1 gal./A)	1192	37.4	22.5
Fertilizer + Basic-H (2 gal./A)	1169	37.1	22.4
Basic-H only (1 gal./A)	996	37.8	20.9
Significance	ns	ns	ns
C.V.	11.4	3.4	7.8
*Fertilizer recommendation	N	P_2O_5	K_2O
lbs/A	90	50	100

"Basic-H" effects on sugar beet production were conducted at the Northwest Experiment Station in Crookston by L. J. Smith and W. E. Fenster. "Basic-H" is sold or labeled as a concentrated soil conditioner and makes no claim to being a plant food product. Major claims made by the manufacturer are that the product, when properly applied, increases the rate at which water penetrates the soil, makes water wetter thereby overcoming water repellancy, and promotes maximum water utilization by reducing runoff and loss by evaporation.

Procedure

Great Western R-2 sugarbeet seed was planted in a Wheatville loam soil on April 29, 1983. The soil before treatment tested NO_3-N - 32 lb/A, $NaHCO_3$P - 9 lb/A, and exchangeable K - 150 lb/A. The fertilizer and "Basic-H" treatments listed in Table 1 were applied on April 29. The "Basic-H" treatments were applied with a bicycle sprayer at a volume of 44 gpa of solution and a pressure of 40 psi. All treatments were thinned to a uniform population of 32,000 plants/A on June 6. The trial was harvested September 19 and the quality factors determined at the American Crystal Sugar Co-op Quality Laboratory.

RoNeet (4.0 lb/A) and Avadex (1.5 lb/A) were used for weed control, Counter insecticide (1.0 lb. ai/A) was furrow applied for sugarbeet maggot control and Mertect plus Duter (12 oz/A + 20 oz/A) was applied for cercospora leaf spot control.

The experiment design was randomized complete block with four replications.

Results and Discussion

The treatments in this trial had nonsignificant effects on all variables measured except % sugar recovery, the impurity index, and the impurity amino nitrogen (Table 4). The % sugar recovery with the control plus "Basic-H' treatment was significantly higher than the normal fertilizer and normal fertilizer plus "Basic-H" treatments, but was not significantly different from the control. The amino nitrogen

impurities were significantly higher for all treatments involving normal fertilization and explains the differences noted in % sugar recovery and the imputiry index.

No differences in the degree of plant wilting was noted for any of the treatments during August when moisture was limited.

Table 4. Effects of "Basic-H" on sugarbeet yield

Treatment	Fertilizer lb/A	Basic-H Gal/A	Yield T/A	Sugar %	Recoverable Sugar lb/A	%	lb/T	Impurities, ppm Na	K	Amino Nitrogen	Impurity Index
Control	--	--	21.5	13.80	5228	88.1	243.1	425	2217	415	795
Normal Fert.	90 N, 80 P_2O_5 80 K_2O	--	23.1	13.67	5456	86.4	236.3	495	1962	607	907
Control + Basic-H	--	1	21.2	13.95	5255	89.0	248.2	395	2065	390	734
Normal Fert. + Basic-H	90 N, 80 P_2O_5 80 K_2O	1	23.2	13.92	5572	86.1	239.9	457	2070	642	926
Normal Fert. + 2x Basic-H	90 N, 80 P_2O_5 80 K_2O	2	23.2	13.98	5636	86.7	242.4	355	2012	642	887
Statistical Significance			ns	ns	ns	**	ns	ns	ns	**	**
B.L.S.D. (.05)			--	--	--	1.7	--	--	--	110	111

The effect of "Basic-H" was studied on potatoes at an experimental field under irrigation at Becker. Data by W. E. Fenster and Michael O'Leary are shown in table 5.

Table 5. The effect of "Basic-H" on potato yield. Becker, MN 1983.

	Yield (Wt/A)	Grading % Composition by Weight (oz.) 0-3	3-6	6-9	9-12	12-16
Control	334	18.5	39.8	33.8	8.0	--
Fertilizer (U of M recommendation)*	460	9.0	37.0	34.0	9.8	10.1
Fertilizer + Basic-H (1 gal./A)	446	12.0	32.6	37.9	11.2	6.1
Fertilizer + Basic-H (2 gal./A)	424	13.8	27.6	31.2	16.9	10.4
Basic-H only (1 gal./A)	318	10.3	45.8	35.2	8.7	--
Significance	**					
BLSD (.05)	98					
C.V.	11.0					

*Fertilizer recommendation	N	P_2O_5	K_2O	S
lbs/A	150 (split) 3 times	150	400	15

SULFUR, BORON AND MAGNESIUM TRIALS ON A PROBLEM ALFALFA FIELD 1983

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. The plot location was changed in 1983 but still on the same field.

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

In 1982 plant analysis shows below adequate levels of copper and magnesium. Copper was therefore added for 1983.

There was no significant effect of sulfur, magnesium or boron treatments on yield in 1982. In plant analysis, except for sulfur at the second cutting, the concentration of nutrients in the upper third of alfalfa plants was not affected by treatments.

In 1982 the alfalfa stands were good but growth appeared to be less than expected. First cutting yields in 1982 were below the other two cutting yields because irrigation was not possible for the first cutting. In 1983 alfalfa yields were reasonably good on the new location but there appeared to be no yield benefit from treatments. Additions of copper and magnesium failed to increase nutrient content in plants to adequate levels for none of the three cuttings, see table 2.

Table 1. Alfalfa yields relationship to sulfur, boron, copper and magnesium treatments. Stearns County 1982, 1983.

	lbs/A		Tons/acre Total		Soil Test		
Treatment	1982	1983	1982	1983		1982	1983
Check			3.62	5.35	Text	SL	SL
S	100	50	3.85	5.27	O.M.	M	M
B	3	3	3.71	5.11	pH	7.3	7.2
Mg	300	300	3.94	5.04	p lb/A	200+	200+
Cu	--	6	--	5.47	K lb/A	443	410
Significance			ns	ns	Mg lb/A	204	201
C.V.			4.4	4.4	S ppm	5	2
					Cu ppm	--	0.6
					B ppm	--	0.5
					Zn ppm	--	4.5

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Table 2. Plant analysis of alfalfa for three individual cuttings related to S, B, Mg and Cu treatments 1983.

First Cut		S	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Trt.	lbs/A	%					ppm				
Check		.34	.46	2.58	2.15	.24	144	72	35	4	36
S	50	.41	.46	2.62	2.22	.25	144	76	38	4	38
B	3		.47	2.59	2.13	.25	143	72	36	4	70
Mg	100		.46	2.62	2.24	.26	150	84	36	4	38
Cu	6		.47	2.62	2.12	.24	148	73	37	4	40
Adequage levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		*	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)			--	--	--	--	--	--	--	--	6
C.V.			3.1	6.5	3.6	3.9	9.0	10.9	5.4	9.8	8.8
Second Cut											
Check		.35	.41	3.00	1.60	.25	111	46	26	4	43
S	50	.41	.42	3.15	1.65	.26	103	45	28	4	42
B	3		.42	3.03	1.68	.25	110	51	27	4	62
Mg	300		.41	2.88	1.68	.27	111	50	28	4	44
Cu	6		.42	3.00	1.62	.26	110	46	28	4	46
Adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		ns	ns	ns	ns	ns	ns	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	--	--	--	--	3
C.V.			2.8	4.5	3.8	3.6	4.8	7.2	3.3	9.3	5.2
Third Cut											
Check		.30	.36	2.74	1.65	.20	64	35	22	4	40
S	50	.29	.38	2.72	1.70	.20	67	37	22	4	40
B	3		.38	2.76	1.68	.19	64	35	22	4	53
Mg	300		.38	2.81	1.68	.20	64	35	22	4	41
Cu	6		.38	2.79	1.67	.19	68	36	23	4	44
Adequate levels		.30	.25	2.40	1.70	.30	30	30	20	10	30
Significance		ns	ns	ns	ns	ns	**	ns	ns	ns	**
BLSD (.05)		--	--	--	--	--	3	--	--	--	2
C.V.			5.1	4.6	2.9	5.2	2.5	5.2	7.2	15.2	3.9

HIGH PHOSPHORUS AND POTASSIUM RATES IN A CORN-SOYBEAN ROTATION

Waseca, 1983

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

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. Treatments 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. In 1982, soybeans were planted at Morris and Waseca after 8 years of continuous corn to begin a long-term corn-soybean rotation phase of this experiment.

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,'82	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, 1981 and 1982.

6/ 100 + 0 was applied at all locations in 1980, 1981 and 1982.

The P and K materials were broadcast on soybean residue and plowed down at all locations in the fall of 1982. 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 at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location. Nitrogen rates were slightly higher than optimum.

At Lamberton each of the plots were split with the west half planted to corn and the east half to soybeans. Corsoy 79 soybeans were planted in 30-inch rows on May 10 at a rate of 9 seeds/foot. Weeds were controlled with a ppi application of Lasso (3 lb) and Amiben (2½ lb). Plant tissue samples were not taken. Soybeans were combine harvested on September 27.

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Planting in 1983 was delayed by late snow in April and yields were reduced by a hot and dry July and August. Grain yields at Lamberton were severely reduced by herbicide carryover (Trifluralin) from the previous year's soybeans, dry weather and severe lodging at the ear later in the season.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1983.

Variable	Lamberton	Morris	Waseca
Planting date	5/10	5/10	5/9
Row spacing	30"	30"	30"
Planting rate	26,000	27,800	32,000
Hybrid	Pioneer 3732	Pioneer 3901	Pioneer 3732
Nitrogen rate	150#	120#	160#
Herbicide	3# Lasso + 2# Bladex/A ppi	2½# Lasso + 2½# Bladex/A preemerge	3½# Lasso + 3½# Bladex/A preemerge
Insecticide	None	None	None
Harvest date	9/16	9/22	10/7

RESULTS AND DISCUSSION

Soil samples taken at the end of the 1983 growing season indicate significant differences in Bray P1 extractable P and exchangeable K at all locations (Tables 3 and 4).

There appeared to be a good linear response between extractable Bray P1 and P application rate. 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. Soil test P values at Lamberton and Waseca were quite similar to those obtained in 1982. Soil test P values at Morris, however, averaged approximately 40 percent higher than 1982. The application of 150-lb P_2O_5 (treatment 5) and 100-lb P_2O_5 + K_2O (treatment 10) at Morris resulted in P values more than twice as high as in 1982.

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

Treatment No.	Treatment Description	pH Mo	pH Wa	P M_{10}	P M_{50}	P M_{01}	P W_{10}	K Mo	K Wa
	lb P_2O_5+K_2O/A[2/]			lb/A					
1	0 + 0	7.7	6.5	9	27	8	20	336	251
2	0 + 100	7.8	6.4	11	31	9	18	476	327
3	50 + 100	7.7	6.1	44	99	38	49	430	291
4	100 + 100	7.7	6.3	88	168	67	84	429	299
5	150 + 100	7.7	6.4	61	120	54	67	444	337
6	100 + 0	7.7	6.6	105	194	86	93	341	291
7	100 + 50	7.8	6.3	73	150	61	87	356	280
8	100 + 150	7.6	6.2	87	168	74	83	393	303
9	0 + 100	7.8	6.4	24	59	20	32	363	314
10	100 + 0	7.8	6.4	33	71	28	68	359	287
	Signif. Level(%) :	84	84	99	99	99	99	99	94
	BLSD(.05),(.10)* :			18	27	14	15	64	48*
	CV(%) :	27.	2.9	24.	19.	23.	15.7	11.	9.3

1/ Samples were taken in September before the 1983 treatments were applied.

2/ Rates applied in fall of 1982 for 1983 crop.

Use of the 1:50 soil to Bray P1 solution ratio on the calcareous Aastad soil at Morris indicated slightly more than twice as much extractable P in the soil as with the 1:10 ratio at higher levels

and about 3 times as much when no P was applied. Soil P values obtained with Olson's $NaHCO_3$ test on the calcareous soil at Morris were slightly but consistently lower than values from the Bray P1 test (1:10 ratio).

Soil test K was influenced by K applications at all locations in 1983 (Tables 3 and 4). The response to annual K applications was not as pronounced as with P. Highest soil test K levels were associated with the annual application of 100-lb K_2O/A; however, these values were not always greater than the annual application of 50-lb K_2O/A (treatment 7). Soil pH was not related to P and K treatments.

Soil samples were taken from both the corn and soybean areas at Lamberton in 1983 (Table 4). P values averaged lower and K values higher following soybeans. Differences in P and K values were not great between sites and values compared very similarly on a relative basis. Soil pH was significantly lower on the 1983 corn site. Differences in soil pH between the corn and soybean sites had no effect on the relative extraction of P by the 1:50 soil to Bray P1 solution ratio or the Olson's $NaHCO_3$ test when compared to the 1:10 ratio (Table 4). The 1:50 ratio averaged 70% higher and the Olson's $NaHCO_3$ test averaged 30% lower than the 1:10 ratio across all treatments.

Table 4. Soil test values as influenced by ten year's application of P and K treatments for the corn and soybeans at Lamberton.[1/]

Treatment		Corn					Soybean				
No.	Description[2/]	pH	P_{10}	P_{50}	P_{01}	K	pH	P_{10}	P_{50}	P_{01}	K
	lb P_2O_5+K_2O/A		----------lb/A----------					----------lb/A----------			
1	0 + 0	5.4	45	107	31	269	6.1	45	81	29	250
2	0 + 100	5.6	32	60	22	338	6.0	42	74	27	323
3	50 + 100	5.9	62	114	47	340	6.4	64	124	45	363
4	100 + 100	5.4	95	166	67	318	6.1	115	174	74	379
5	150 + 100	5.7	79	125	52	311	6.3	56	104	38	320
6	100 + 0	5.4	107	150	69	263	6.0	87	154	59	279
7	100 + 50	5.5	102	164	74	298	6.1	78	134	53	324
8	100 + 150	5.6	111	177	85	291	6.1	85	159	62	303
9	0 + 100	5.8	38	69	27	312	6.3	44	76	30	342
10	100 + 0	5.5	80	121	58	289	6.0	71	122	47	311
	Signif. Level(%):	57	99	99	99	99	43	99	99	99	99
	BLSD(.05) :		23	48	16	38		17	31	11	44
	CV(%) :	6.2	22.4	26.3	21.7	8.3	5.3	18.1	18.8	18.0	9.6

1/ Samples were taken in September before the 1983 treatments were applied.

2/ Rates applied in fall of 1982 for 1983 crop.

Approximately 9½, 6½ and 6 weeks after planting at Lamberton, Morris and Waseca, respectively, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant weight and height were increased significantly (p=99) by treatments at Morris and Waseca (Table 5). Although plant weight was increased by treatments at Lamberton, there was no corresponding increase in plant height. Both early plant weight and height were lowest with the check treatment (no. 1) at all locations; however, plant height was not statistically different at Lamberton. At Morris and Waseca, both early plant height and weight were increased by the 50 and 100-lb P_2O_5 rates over the 0-P_2O_5 rate (no. 2). At the Waseca site, there was a significant increase in plant height from the 50 and 100-lb K_2O treatments over the 0-K_2O treatment (no. 6) by 7.7 and 9.7%, respectively. Early plant weight was also significantly higher at the 100-lb K_2O rate when compared to the 0-K_2O rate at Waseca.

Analysis of the leaf opposite and below the ear at silking was made at the Waseca site only in 1983 (Table 6). Concentrations of P, K, Ca, Mg, Mn, Zn and Cu were significantly affected (p=99) by the treatments at Waseca. Leaf P was significantly increased by the application of P although no difference was detected between the 50 or 100-lb P_2O_5 treatments. Leaf K concentration was increased by K application at all rates. Annual applications of 100-lb K_2O with P resulted in significantly higher leaf K than lower or less frequent K_2O applications (nos. 7 and 8) or K applications without P (nos. 2 and 9) (Table 6). Leaf Ca and Mg were reduced by K treatments. Leaf Mn was reduced by K application and leaf Zn was reduced below the control (no. 1) by all P and K additions. Leaf Cu was

significantly increased by the application of K but reduced by the application of P. Lowest leaf Cu was observed with the application of 100-lb P_2O_5/A without K (treatments 6 and 10).

Table 5. Early plant growth as influenced by high P and K rates at the three experimental sites in 1983.

Treatment No.	Treatment Description	Weight La	Weight Mo	Weight Wa	Height La	Height Mo	Height Wa
	lb P_2O_5+K_2O/A	g/dry plant			-------inches-------		
1	0 + 0	35.0	4.0	2.5	36.8	24.4	14.5
2	0 + 100	43.8	5.1	2.5	40.3	26.6	19.7
3	50 + 100	40.5	6.1	3.2	38.6	29.2	20.8
4	100 + 100	45.0	7.0	3.4	40.9	30.3	21.3
5	150 + 100	39.8	6.4	3.5	39.2	30.4	20.6
6	100 + 0	40.0	6.0	2.6	38.7	28.7	19.4
7	100 + 50	48.2	6.5	3.1	41.4	29.9	20.9
8	100 + 150	43.5	6.4	3.3	40.4	30.0	21.1
9	0 + 100	50.5	5.4	2.8	40.9	28.2	19.5
10	100 + 0	43.0	6.1	2.9	38.5	29.0	19.9
Signif. Level(%):		96	99	99	43	99	99
BLSD(.05) :		10.4	1.2	0.58		1.9	0.9
CV(%) :		13.6	12.4	10.6	7.9	4.6	2.7

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf plants at Waseca in 1983.

Treatment No.	Treatment Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	----------%----------				----------ppm----------				
1	0 + 0	.25	.94	.47	.49	161	50	28	3.8	8.3
2	0 + 100	.23	1.38	.42	.34	143	40	25	4.8	8.8
3	50 + 100	.25	1.66	.38	.32	156	38	23	4.9	7.9
4	100 + 100	.29	1.57	.41	.32	158	39	21	4.1	8.3
5	150 + 100	.30	1.54	.44	.33	167	42	23	4.4	8.4
6	100 + 0	.31	.92	.54	.50	176	52	22	3.2	8.7
7	100 + 50	.30	1.24	.46	.38	162	46	22	3.5	8.3
8	100 + 150	.30	1.25	.46	.39	163	50	25	3.5	8.4
9	0 + 100	.26	1.35	.44	.37	141	42	23	4.3	8.5
10	100 + 0	.30	.99	.50	.45	169	48	22	3.0	8.3
Significance:		99	99	99	99	82	99	99	99	18
BLSD(.05) :		.02	.14	.04	.04		6	3	.6	
CV(%) :		4.6	6.7	6.0	6.3	9.3	8.0	6.4	9.8	6.8

Plant populations were significantly affected by treatments at the Morris site. Final population was lowest on the check plots but populations on P and K fertilized plots were affected inconsistently and differences were probably not due to treatments alone.

Ear and grain moisture at Lamberton and Morris (respectively) was significantly higher for treatments 1 and 2 which received no P (Table 7). No difference in grain moisture was observed among treatments at Waseca.

The influence of 10 years of P and K applications on silage and grain yield is given in Table 8. Silage yields were significantly increased (p=92) over the control by P treatments at Morris and Waseca. No advantage was observed for the application of P at rates over 50-lb P_2O_5/A. Response to the triannual application of 150-lb P_2O_5/A was favorable. No response to K on silage yields was noted at either site. Grain yields at Morris were depressed on those plots with soil P tests in the low range (treatments 1 and 2). No differences in grain yield due to P and K applications were detected at either the Lamberton or Waseca sites.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1983.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Ear Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb P_2O_5+K_2O/A	plants/A x 10^{-3}			----------%----------		
1	0 + 0	24.5	24.7	25.7	34.0	35.7	20.1
2	0 + 100	24.9	25.8	26.1	35.6	37.3	21.1
3	50 + 100	24.2	26.6	26.4	31.2	31.4	20.4
4	100 + 100	25.9	25.9	26.4	32.8	32.0	20.5
5	150 + 100	24.8	25.3	25.5	31.4	31.4	20.9
6	100 + 0	24.8	26.4	25.3	32.2	30.7	20.6
7	100 + 50	26.0	25.8	26.2	31.5	31.0	20.4
8	100 + 150	26.3	26.1	26.6	30.9	31.6	20.9
9	0 + 100	25.0	24.9	26.6	32.2	31.4	20.4
10	100 + 0	25.6	26.1	26.4	29.6	31.5	20.1
	Signif. Level (%):	82	94	32	96	99	52
	BLSD (.05),(.10)*:		1.2*		3.9	2.5	
	CV (%) :	4.5	3.	3.5	6.9	5.3	2.9

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1983.

Treatment No.	Treatment Description	Silage Yield La	Silage Yield Mo	Silage Yield Wa	Grain Yield La	Grain Yield Mo	Grain Yield Wa
	lb P_2O_5+K_2O/A	--------T DM/A--------			----------bu/A----------		
1	0 + 0	ND[1/]	5.94	5.53	51.2	106.5	128.1
2	0 + 100		6.13	5.23	48.9	105.1	126.9
3	50 + 100		7.18	6.68	50.0	129.0	130.1
4	100 + 100		7.19	6.11	48.5	128.2	129.8
5	150 + 100		7.31	6.67	47.9	128.3	130.5
6	100 + 0		7.13	6.35	54.2	126.6	134.7
7	100 + 50		6.90	5.91	55.7	133.6	125.8
8	100 + 150		6.90	6.73	57.3	125.7	137.0
9	0 + 100		7.18	5.30	57.3	124.7	127.6
10	100 + 0		7.18	5.64	63.2	127.6	128.3
	Signif. Level (%):		92	92	59	94	06
	BLSD (.10) :		0.96	1.23		19.0	
	CV (%) :		8.8	11.5	18.	9.9	7.7

1/ ND = Not Determined. Silage yields not taken because of severe lodging.

Soybean yields were not influenced by the P and K treatments at Lamberton (Table 9).

Table 9. Soybean yields at Lamberton as influenced by high P and K rates in 1983.

Treatment No.	Treatment Description	Yield
	lb P_2O_5+K_2O/A	bu/A
1	0 + 0	34.4
2	0 + 100	34.9
3	50 + 100	34.4
4	100 + 100	38.2
5	150 + 100	35.0
6	100 + 0	32.4
7	100 + 50	37.8
8	100 + 150	35.4
9	0 + 100	35.8
10	100 + 0	33.8
	Significance Level(%):	32
	CV(%) :	11.7

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NITROGEN AND PHOSPHORUS FERTILIZATION OF POTATOES ON NONIRRIGATED SOILS OF NORTHWESTERN MINNESOTA

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

The main objective of this study was to generate experimental data for an examination of macronutrient recommendations for potatoes on nonirrigated mineral soils. Currently Minnesota recommendations are considerably higher than those made by the North Dakota State University, particularly for phosphorus. A second objective of these investigations was to generate plant analysis data for potatoes. Results of five field trials conducted in 1982 were summarized in Misc. Publ. 2, 1983.

EXPERIMENTAL PROCEDURE

Three separate experiments were established in the spring of 1983 on the Paul Hoff Farm, East Polk County, to determine effects of N, P and K on the yield and quality of potatoes. The trials were discontinued because of delayed growth and extreme stand variability caused by heavy rainfall during June.

Don Mack Farm, West Polk County

Effects of N and P were determined in two separate experiments on a calcareous silty clay soil. The field had been in wheat in 1982 and it was fall plowed. Broadcast and band fertilizers were applied on May 19 and incorporated into the soil with a row-marker. Norchip potatoes were planted on May 19, and emerged on June 3. The farmer's regular practices were effective in controlling weeds and insects.

Broadcast N treatments consisted of four rates (0, 50, 100, 150 lb. N/A). Urea (46-0-0) was the source of nitrogen. All plots received broadcast 50 lb. P_2O_5/A. In the phosphorus trial, three rates of phosphorus (0, 25, 50 lb. P_2O_5/A) were used with the fertilizer either broadcast or band (just below seed-piece placement) applied. All plots received broadcast urea at 80 lb. N/A. Fertilizer treatments in these trials were arranged in a randomized complete block design replicated four times. Individual plots were 19 ft. wide and 40 ft. long.

Soil samples were collected in the spring of 1983 prior to fertilizer application and were analyzed by the University of Minnesota Soil Testing Laboratory. Soil test results (Table 1) indicated high levels of Olsen extractable P (27, 26 lb/A); exchangeable K was very high (477, 490 lb/A). Medium levels of NO_3-N in the top two feet of soil were found on this field (47, 35 lb/A).

The petiole and leaflets of the 4th leaf from the growing tip of 15 plants were collected at random from each plot at two different times during the growing season. At the early season sampling on July 19, 61 days after planting (45 days after emergence), the plants were in the initial flowering stage with some flowers just appearing. At the second sampling on August 8, or 81 days after planting (65 days after emergence), the potatoes had reached the late flowering stage with most plants past the peak of flowering. Kjeldahl N, nitrate-N (both the NO_3 and NO_2 forms are measured), and elemental analyses were made by the Research Analytical Laboratory.

Potatoes were harvested with a potato plot harvester. Total weight of nongraded tubers was determined and expressed as cwt/A.

RESULTS

Broadcast nitrogen treatments increased the total N and NO_3-N concentration of leaf tissue at initial and late flowering stages (Table 2). Although only 35 lb/A of NO_3-N were measured in the top two feet of the soil, nitrogen fertilization did not significantly affect either the yield or specific gravity of tubers. In the phosphorus experiment, the yield was increased by 20 cwt/A with 25 lb. P_2O_5/A applied either broadcast or in band (Table 3). Neither the specific gravity of tubers nor the concentration of P in leaf were affected by phosphorus fertilization. Leaf-P was 0.45 and 0.35% at initial flowering and late flowering, respectively. Extractable P by the Olsen method was 27 lb/A, considered to be a high level. Currently, 75 lb. P_2O_5/A would be recommended for potatoes on nonirrigated mineral soils at such a soil test level.

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The concentration of other macro- and micronutrients in leaf tissue from the phosphorus trial is reported in Table 4. Although there was significantly higher Ca and Mg in leaf tissue at initial flowering associated with some phosphorus treatments, adequate levels of these two plant nutrients existed in all treatments. There is no pattern or logical explanation for this significance. The exceptionally high Mn and Zn levels in leaf tissue at late flowering, however, were due to the application of a fungicide containing these chemical elements.

SUMMARY

Data from this two-year study indicate that potato yields ranging from 125 to 231 cwt/A can be produced on nonirrigated mineral soils of northwestern Minnesota with lower N and P rates than are currently recommended by the University of Minnesota. At high Olsen P levels (21-30 lb/A), for a 200-250 cwt/A yield, the phosphate rate could be decreased from 75 to 25 lb. P_2O_5/A without adversely affecting the yield or quality of potatoes.

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Table 1. Soil test results, Mack Farm.[1/]

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
Phosphorus trial	0-6	8.2	4.6	6	56	27	477	0.6	
	0-24								47
Nitrogen trial	0-6	8.0	4.6	3	ND	26	490	ND	ND
	0-24								35

[1/] Soil test results are averages of four samples collected from check plots in May 1983 prior to planting.

ND = not determined

Table 2. The effect of broadcast nitrogen on yield, specific gravity and N content of leaf tissue of potatoes, Mack Farm, W. Polk Co., 1983.

Treatment N lb/A	Yield cwt/A	Specific Gravity	Sampling: Initial Flowering Total Kjeldahl N %	Initial Flowering NO_3-N ppm	Late Flowering Total Kjeldahl N %	Late Flowering NO_3-N ppm
0	130	1.074	4.06	916	3.44	430
50	151	1.075	4.72	2735	3.63	994
100	148	1.072	5.09	3863	3.85	1576
150	146	1.072	5.42	5276	4.24	2462
Significance	ns	ns	**	**	**	**
BLSD (0.05)	--	--	0.31	879	0.37	834
C.V., %	10.5	0.2	4.1	17.9	5.9	37.7

All plots received broadcast 50 lb/A of P_2O_5.

Table 3. The effect of broadcast and row phosphorus on yield, specific gravity and P content of leaf tissue of potatoes, Mack Farm, W. Polk Co., 1983.

Treatment: P_2O_5 lb/A	Treatment: Method of Application	Yield cwt/A	Specific Gravity	Sampling: Initial Flowering P %	Sampling: Late Flowering P %
0		125	1.072	0.45	0.33
25	broadcast	145	1.072	0.44	0.32
25	band	148	1.074	0.45	0.33
50	broadcast	143	1.071	0.46	0.35
50	band	148	1.074	0.44	0.33
Significance		+	ns	ns	ns
BLSD (0.05)		19			
C.V., %		7.8	0.2	3.8	5.7

All plots received broadcast 80 lb. N/A.

+ = significant at 10% level of probability

Table 4. The concentration of macro- and micronutrients of potato leaf tissue collected from phosphorus trial at two different stages of growth, Mack Farm, W. Polk Co., 1983.

Treatment		Sampling															
		Initial Flowering								Late Flowering							
P_2O_5 lb/A	Method of Application	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm	Cu ppm	B ppm	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm	Cu ppm	B ppm
0		3.58	1.05	0.91	222	41	25	15	34	3.23	1.05	0.95	140	194	132	13	30
25	broadcast	3.64	1.22	1.04	258	45	24	15	39	3.17	1.10	1.00	143	159	107	12	30
25	band	3.64	1.16	0.98	238	43	24	14	39	3.23	1.03	0.94	130	156	104	12	30
50	broadcast	3.53	1.04	0.93	221	40	25	14	37	3.32	1.06	0.98	143	170	120	13	30
50	band	3.61	1.16	1.05	231	43	23	14	39	3.38	1.07	0.99	142	171	113	12	30
Significance		ns	**	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
BLSD (0.05)			0.09	0.09													
C.V., %		4.6	5.3	5.5	10.2	6.6	4.8	5.3	9.1	7.8	5.5	5.9	20.8	14.5	13.8	7.3	5.0

RESEARCH IN SOIL FERTILITY AND CHEMISTRY OF SOIL AND WATER - 1983

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Research during 1983 focused on nitrogen loss mechanisms in paddy soil and water, factors associated with crop failure, and possible causes for growth differences observed along the ditches. The research was conducted on University land in Grand Rapids and in growers' fields near Aitkin and Gully. A growth chamber and 4 x 4 ft. boxes at St. Paul were also utilized for some of the work.

A. WEATHER CONDITIONS

Average air temperatures recorded at four U. S. weather stations were below normal during April and May, followed by nearly normal June, and above normal during July and August (Table 1).

Several growers in the Aitkin area had commented that the wild rice yield in some paddies fell below expectations. General browning and early dying of plants was observed, apparently not caused by disease. The possible cause was the high air temperature between flowering and maturity which resulted in moisture stress. Weather data recorded at the Pine River Dam U. S. Weather Station (northwest of Aitkin) showed 12 days during July and 8 days during August with the maximum air temperature of 90° F or above. In contrast, during 1982, such high temperatures were recorded only on 4 days in July and on 2 days in August.

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

B. YIELD VARIABILITY ON A MINERAL SOIL

A stand of Netum wild rice was established in paddy No. 1 East 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 a very high level of Bray-1 extractable phosphorus (85 lb/A) and a medium level of exchangeable potassium (202 lb/A).

Wild rice seed was broadcast by hand on May 5 at a rate of 45 lb/A. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Since the objective was to establish a stand for future studies, no fertilizer treatments were made. Water level was maintained at 8 to 12 inches. A 16 sq. ft. area from each plot was hand-harvested on August 22nd.

Netum grain yield (7% moisture) of individual plots ranged from 512 to 1027 pounds per acre. The overall mean yield was 778 lb/A with a standard deviation of 158, and a coefficient of variability of 20%. These data illustrate the variability of grain yield frequently observed in first year wild rice stands.

C. DIURNAL CHANGES IN THE pH OF PADDY FLOODWATER

Nitrification-denitrification was traditionally thought to be the major mechanism of nitrogen loss from flooded soils. Recently researchers with white rice have suggested that ammonia volatilization may be more important, especially in soils such as peat in which ammonium ions are not held strongly by the soil cation-exchange complex. High floodwater pH and high NH_4-N concentration in the floodwater result in high nitrogen losses. Urea hydrolysis and algal CO_2 consumption are known to raise the pH of paddy water above 9 under the afternoon sun.

Floodwater samples were collected from six wild rice paddies during June and July. The water samples were collected in 250 ml polyethylene bottles by submerging the bottle 2.5 cm below the surface. The pH was determined immediately after sample collection using a combination electrode and portable pH meter. Duplicate water samples were collected and stored in 250 polyethylene bottles, with a preservative added. Chemical analyses were made by the Research Analytical Laboratory. Chemical composition of the water is given in Table 3.

Floodwater pH showed considerable variation during a 24-hour period. The strongest alkalinity (high pH) and greatest variation of the floodwater pH were observed in paddies having shallow water depth

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(15 cm) (see Fig. 3 and 4). The floodwater pH at Gully, Polk County, during afternoon hours on a sunny day was above 9.0, reached a maximum of 9.5 (water temperature 29°C) and then steadily declined to a minimum of 7.9, measured at 7:00 a.m. (water temp. 17°C). This paddy had considerable growth of waterplantain, other weeds and some algae. In the paddies with relatively deep water (35 cm), the floodwater pH showed similar but less pronounced variation than that observed in shallow water, and the maximum pH values did not exceed 8.5. The wild rice was in the tillering stage.

At Grand Rapids on a mineral soil, at 15 cm water depth, the maximum floodwater pH of 9.6 was recorded at 2:30 p.m. (water temp. 28°C), declined to 7.0 at 7:00 a.m. (water temp. 23°C) and by noon reached 9.0 (water temp. 29°C). Various rooted water plants and some algae were observed at this sampling site. In 35 cm deep water, the floodwater pH showed less pronounced diurnal change.

In a Kosbau Bros. paddy, Aitkin County, floodwater samples were collected from an area with relatively deep water level (45 cm). No weeds or algae were present. The floodwater pH on this acidic peat remained constant near 6.5 during a 24-hour period. The water temperature fluctuated from a maximum of 27° to 23° C.

Theoretically, 12.5% of ammonium (NH_4) present in the water at pH 8.4 is in the ammonia (NH_3) form, which can volatilize. At higher pH values a larger fraction of the ammonium nitrogen is in the NH_3 form while at low pH less is in the volatile form. Ammonia volatilization should not occur in paddies similar to that investigated in Aitkin County where the floodwater was slightly acid. Nitrogen losses through NH_3 volatilization may be significant, however, at shallow water depth particularly in paddies of the Clearwater River area because of extremely high floodwater pH. Maintenance of proper depth of water in the paddy until the plant canopy closes appears to be important to minimize possible nitrogen losses through NH_3 volatilization.

D. STUDIES IN 4 x 4 FT. BOXES

A nitrogen source and placement experiment was conducted in 4 x 4 ft. wooden boxes on the St. Paul Campus. A 30 cm thick layer of hemic peat was placed into the boxes. Dolomitic aglime was added to the peat to increase its pH from 4.1 to 6.0 and the corresponding base saturation from 15 to 50 percent. Seven fertilizer treatments were replicated four times. Nitrogen fertilizers were applied at a 90 kg/ha (80 lb/A) rate; all boxes received 67 kg/ha of P_2O_5 and 135 kg/ha of K_2O. Nitrogen fertilizer was either deep placed at a 10 cm depth or applied on the soil surface. Phosphorus, potassium and deep placed nitrogen were applied pre-plant; surface nitrogen was applied after seeding. Seed of K2 wild rice variety was placed in rows on May 27. Two extra boxes (51 and 52) without plants were set up, No. 51 with deep placed urea and No. 52 as Control. Boxes were filled with 15 cm of water. On June 1 gas development in several boxes caused foaming and scum accumulation on the surface of water. By June 6 all boxes had gone through the first cycle of foaming and had developed a floating peat condition. The gas was mainly CO_2 with traces of CH_4. A small amount of "Triton" wetting agent was sprayed on the surface to break up the scum (and later the algae) so that it could be skimmed off. Wild rice developed slowly and very few plants survived. So, the experiment was used mainly for monitoring inorganic nitrogen, pH and temperature of the water and soil.

Samples of the floodwater were collected in 250 ml polyethylene bottles 2.5 cm below the surface. Diurnal sampling was conducted to measure the changes in pH and inorganic nitrogen from day to night so as to determine the potential for ammonia volatilization.

Soilwater was collected in ceramic cups placed in selected boxes at depths of 5 cm and 30 cm below the soil surface, i.e., shallow and deep, respectively. The cups and the connecting 91 cm long (6.25 cm diameter) plastic tubes were purged of air with three volumes of argon and sealed to prevent oxygen from entering the anaerobic peat. Samples were extracted by means of a small hand-held vacuum pump. The pH was determined immediately and samples for N analyses were treated with 1 ml of 20% H_2SO_4/100 ml and refrigerated at 4° C. Nitrogen was analyzed by distillation. On August 4 ceramic cups were removed from boxes No. 24 and 44 because of extremely poor rice stand and placed in boxes No. 33, 42 and 43.

The temperature and dissolved oxygen (DO) profiles of floodwater were established in two boxes (No. 24 GU, surface; 44 GU, 10 cm) to determine if stratification in 23-30 cm of water was possible. Both DO and temperature were measured with a YSI DO meter.

The pH values of the diurnal study of floodwater in selected boxes on 6/23 are reported in Table 4. Most of the boxes, except No. 35, showed significant changes in pH from daytime highs of 9-10 and nighttime lows of 5.5-6.5. There was a potential for NH_3 volatilization at these high pH values.

The pH may not have changed much in box No. 35 (GU, surface) because of a lack of a high algal (phytoplankton) population. The dominant algae in the boxes appeared to be Cyanophyta (blue-greens).

The concentrations of ammonium and nitrate in the floodwater on 6/23 from the diurnal study are given in Table 5. Lowest amounts of NH_4-N and NO_3-N were found in boxes receiving no nitrogen fertilizer (Control). It is difficult to determine which placement of urea contributed the greatest amount of N to the floodwater. Gas production within the peat caused a very significant disruption of the soil stability and convectively carried N into the floodwater. There appeared to be very little change in inorganic N from day to night. It is expected, however, that as the pH decreased from 9-10 to 5-7 most of the ammonia was changed to ammonium.

Only trace amounts of inorganic N in floodwater was found on 7/19. The algal growth was very heavy, suggesting that any ammonium or nitrate N would be quickly taken up by algae.

Before the collection of soilwater samples, the water in the ceramic cups was discarded and fresh soilwater was allowed to enter the cups. Liming had achieved the desired pH levels as indicated by soilwater pH (Table 6). The inorganic N levels of soilwater on 7/1/83 are shown in Table 7.

An attempt was made to determine if NH_4-N would be higher in box No. 52 (Control, no plants) compared to box No. 34 (Control, with plants). But the plant growth in all boxes was so poor that there appeared to be no reduction in the NH_4-N level due to an uptake by plants. The soilwater in Control boxes had about one-half of the NH_4-N as the fertilized boxes. The nitrate values of boxes No. 24 and 44, with cups placed 30 cm deep, indicate that argon may have escaped and oxygen was causing nitrification in the cups. It is unlikely that the nitrate came from the floodwater because it contained less than 2 ppm of NO_3-N on 6/23. Later on improvements were made to seal the argon in the cups and very little NO_3-N was detected in the soilwater on subsequent samplings. Ceramic cups were removed from boxes No. 24 and 35 and placed in boxes No. 33, 42 and 43.

The concentrations of NH_4-N in soilwater samples collected on 8/15 and 9/16 are reported in Tables 8 and 9. No NO_3-N was detected in the soilwater on these two dates. Soilwater pH ranged from 5.7 to 6.2 on 8/15.

Dissolved oxygen and temperature profiles were determined in boxes No. 24 and 44 on 6/30 at 9:00 a.m. (Fig. 5). There was a substantial profile development of DO indicating that the floodwater was not mixing from top to bottom. The graphs show that the water near the surface was highly enriched with oxygen and the DO level decreased with depth and approached zero near the surface of peat.

There was very little wind on 6/30. Open areas of paddies with very little plant growth would probably have thoroughly mixed floodwater. As plants develop and buffer the effects of wind energy, stratification could occur. The reason for the stratification is the temperature gradient from the top to the bottom of the floodwater. At 9:00 a.m. a 2°C temperature difference existed in the profile. As the day progressed the topmost layers of water probably became warmer, imparting an even stronger density stratification to inhibit mixing.

Discussion- Wild rice developed slowly and grew poorly in the boxes because of heavy algal growth which caused low light penetration into the floodwater. This could have inhibited vigorous growth by starving the plants of an energy source. Early planting that would permit the plants to develop before the algae would help this situation. The algae may also have given off toxins detrimental to wild rice. The blue-green algae (Mycrocystis) is notorious for toxin production that can badly blister the udders of cattle wading into farm ponds.

Mechanical disruption of the seedbed by CO_2 evolution prevented many plants from establishing a solid footing in the peat.

Generally, inorganic N concentration was higher in flood- and soilwater in boxes receiving nitrogen fertilizer compared to the Control. Nitrogen concentration in floodwater decreased with increased algal growth while nitrogen in the soilwater tended to increase due to mineralization. The analytical results may be somewhat suspect because of the disruption in the boxes by CO_2 evolution. But NH_4-N levels in Control boxes increased from about 5-10 ppm to 10-15 ppm with the fertilized boxes having 20-30 ppm. The attempt to observe a decrease in NH_4-N through plant uptake did not materialize because of poor plant growth.

E. EFFECTS OF THE ADDITIONS OF HIGH LEVELS OF STRAW AND SULFATE

The effect of straw, nitrogen and gypsum (calcium sulfate) on wild rice growth was investigated in one-gallon plastic containers in an environmental growth chamber. Each container was filled to a depth of 15 cm with either an acidic peat from the Kosbau Bros. paddies, Aitkin County, or a neutral peat from the Clearwater Rice, Inc., Clearwater County. The soil was amended with the above mentioned materials, flooded with 5-7.5 cm of demineralized water and planted with K2 variety of wild rice. The young plants ranged from 5 to 10 cm in length. Growth conditions were: 16 hrs. of light at 18-19°C, 8 hrs. of dark at 15-16°C, and a humidity of approximately 90-95%. Wild rice tops were harvested after 50 days, dry weight and chemical composition of plant tissue were determined.

Results of the growth chamber experiment are reported in Table 10. The plants in containers No. 2, 6 and 8 did not grow well and developed no panicles. The plants in containers No. 1, 4, 7 and 9 grew relatively well and developed panicles. Percentage of N in the plant ranged from 1.19 to 1.52% and varied very little while the dry weight of tops varied from zero to 3.73 g per container.

Measurements of the redox potential, Eh, of the soil were in the negative range indicating strongly reduced conditions.

The two containers with Kosbau peat (No. 1 and 2) had drastically different plant growth after 50 days. Containers No. 3 and 9 with the Clearwater peat and various amendments had quite different levels of plant production. The combination of gypsum and 3X rate (24,900 kg/ha) of wheat straw killed all wild rice seedlings even with repeated replanting. The addition of ammonium to 3X rate of straw (container No. 4) increased plant weight nearly five times over 3X straw only (container No. 6), but it did not help the survival of plants in container No. 5 (3X straw + gypsum + N).

The application of a low rate of straw (8,300 kg/ha) produced about 5.5 times more dry matter than the 3X rate of straw. Gypsum alone had a detrimental effect on wild rice and reduced the yield even more than 1X rate of straw. The highest dry weight of wild rice was produced with the application of nitrogen (container No. 9), but the vegetative growth was stimulated by N to such extent that the plants had difficulty remaining upright.

The environmental growth chamber study with various treatments of straw, ammonium and gypsum was designed to establish extreme conditions in an organic soil and to observe wild rice growth under such conditions. Nutrient elements such as N, P, K, Ca, Zn did not seem to be the factors in the growth problems observed. This experiment may provide a clue to the problems observed in the nitrogen source and placement study, i.e., various interrelationships of phytotoxins originating either in the soil or in the root or both. This is an area that needs further investigation.

F. INVESTIGATIONS RELATING TO THE "DITCH EFFECT"

Growers and others have observed strips along ditches where the wild rice appears to be greener and taller (and presumably yield more grain) than the plants in the rest of the field. Thus, the term "ditch effect".

Manomin

On July 26, color differences were observed from a distance in several paddies of the Manomin Wild Rice Company, Aitkin County. On August 22, soil samples were collected and wild rice was hand-harvested from several 4 x 4 ft. areas. The yield and stand density of wild rice, percent of ash, pH and chemical composition of peat determined either by soil tests or ICP analysis of acid digest are given in Table 11.

Wild rice near ditches produced from 50 to 238 pounds of grain per acre more than harvested in the field. In two paddies the number of stems per 16 square feet was greater near the ditch compared to the field. The ash content of the organic soils (0-6 inch depth) near the ditch was 2 to 4 percent higher than the peat further in the paddy. Such a slightly higher ash content of the peat may reflect higher proportion of mineral matter apparently deposited near the ditches during the digging and dredging operations. The content of aluminum (Al) and iron (Fe) found in the soil from the two different areas show trends similar to those observed in ash content, and again, may indicate a peat with more mineral matter along the ditch than the organic soil in the main part of a paddy. The soil of both areas in the field had similar content of other macro- and micronutrients.

Diebold Farm

Similar striking differences in height of wild rice had been observed prior to harvest in several paddies of Diebold Farms, Aitkin County. Soil samples were collected from two paddies near the ditch and in the field. The main difference in soil characteristics (Table 12) is the higher ash content in samples collected along the ditches compared to the soil in the field. In paddy No. 11, the soil along the ditch actually is a mineral soil, containing 89% ash and a high content of exchangeable potassium, deposited there during the ditch cleaning operation the previous year. No yield data were obtained on the Diebold Farm.

No definite conclusions as to the cause of the so-called "ditch effect" can be drawn because of preliminary nature of these investigations. The growth differences in wild rice observed along the ditches and in the main field may be due to three factors: 1) More mineral matter in the peat along the ditches. Differences in the ash content observed in Aitkin County would support this. 2) Plant density differences. There was some evidence of greater number of stems along the ditches. 3) There may be some differences in water depth (not measured in this study) that may affect the growth and nutrition of the plant.

ACKNOWLEDGEMENTS

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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
1983	37.7	50.5[4/]	63.7[4/]	69.0	68.5	57.9	2819
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
1983	39.0	49.7	62.5	71.1	70.1	58.5	2873
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
1983	39.6M	49.3M	60.3M	72.1M	71.9M	58.6	2881
St. Paul, U of M							
1982	43.4	61.3	62.4	73.9	67.3	61.6	3332
1983	42.1	55.2	68.7	76.4	76.0	63.7	3640

1/ Source: Climatological Data, Minnesota, Vol. 80-89 (1974-83), U.S. Dept. of Commerce.
2/ Normals for the period 1931-1960.
3/ M = less than 10 days record missing.
4/ Northwest Divisional Data.

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

pH	Organic Matter %	Bray-1 P lb/A	Exchangeable K lb/A	Exchangeable Mg lb/A	S ppm	DTPA Extractable Zn ppm	DTPA Extractable Cu ppm	NO_3-N lb/A
5.6	3.4	85	202	446	8	5.6	0.8	30

1/ Samples collected from 0-6 inch depth on 5/5/83.

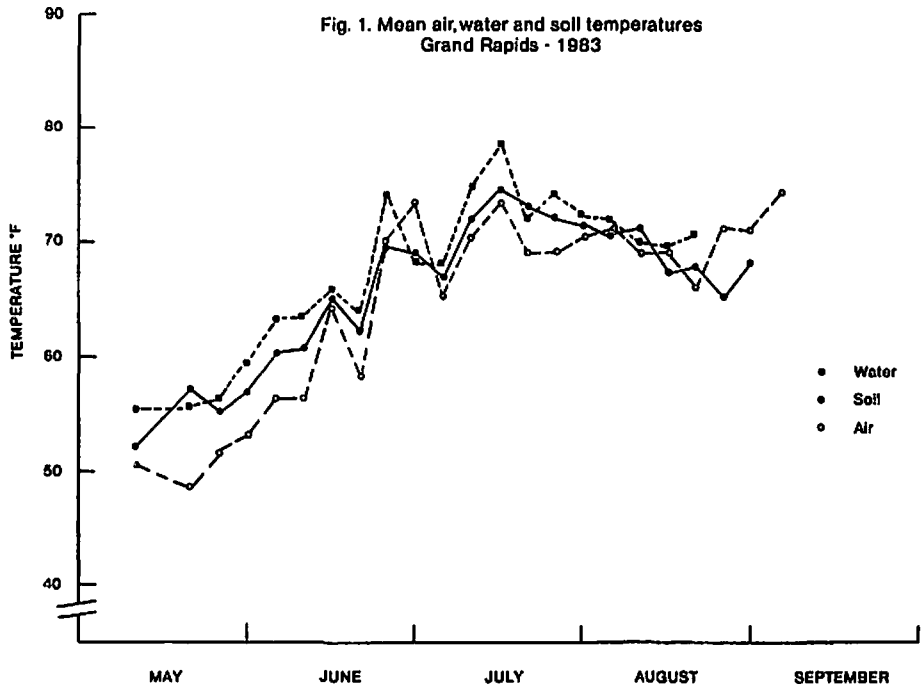
Fig. 1. Mean air, water and soil temperatures
Grand Rapids - 1983
TEMPERATURE °F
90
80
70
60
50
40
MAY
JUNE
JULY
AUGUST
SEPTEMBER
Water
Soil
Air

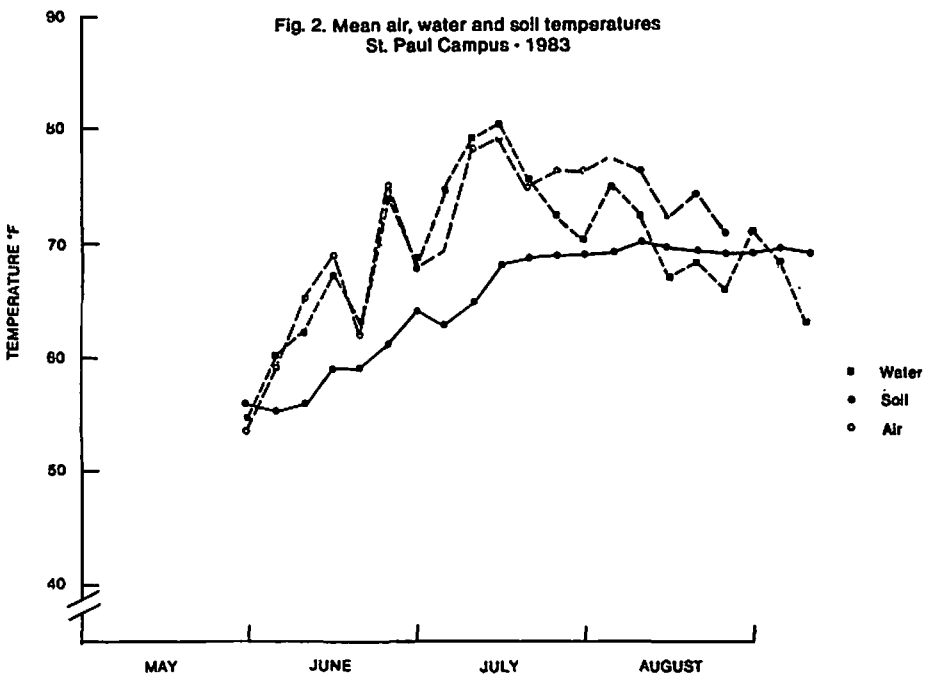
Fig. 2. Mean air, water and soil temperatures
St. Paul Campus - 1983
TEMPERATURE °F
90
80
70
60
50
40
MAY
JUNE
JULY
AUGUST
Water
Soil
Air

Table 3. Chemical composition of water collected from wild rice paddies - 1983.

Sample No.	Sampling Date	Location	pH	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Nitrate & Nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm	Na ppm
1	6/28	Gully-E, deep water	7.7	152	279	3.6	<0.05	0.30	0.20	28.5	71.8	23.9	9.3	7.7
6	6/28	Gully-W, shallow water	9.2	167	335	1.2	<0.05	0.40	0.34	45.6	84.5	29.7	2.1	8.8
12	6/28	Gully-W, deep water	8.5	ND[1/]	473	2.2	<0.05	0.52	0.49	ND	122.2	40.2	8.7	9.2
18	7/7	Aitkin, diversion ditch	ND	63	85	1.2	<0.05	0.09	0.02	1.6	22.1	6.7	0.6	2.7
19	7/7	Aitkin, pump	ND	61	85	1.2	<0.05	0.08	0.03	1.4	22.1	6.7	0.6	2.7
20	7/7	Aitkin, paddy	6.6	58	78	1.9	<0.05	1.20	1.09	1.4	18.7	7.2	1.8	4.0
24	7/20	Grand Rapids, paddy 1E, 30-35 cm depth	7.9	68	79	0.9	<0.05	0.08	0.04	1.0	21.2	5.8	1.3	2.8
25	7/20	Grand Rapids, paddy 9A, 15 cm	9.6	67	75	1.5	<0.05	0.11	0.05	0.7	18.7	6.1	2.5	3.4
26	7/20	Grand Rapids, Prairie River	ND	68	79	1.0	<0.05	0.08	0.02	0.9	21.4	5.7	0.9	2.5

1/ ND = not determined.

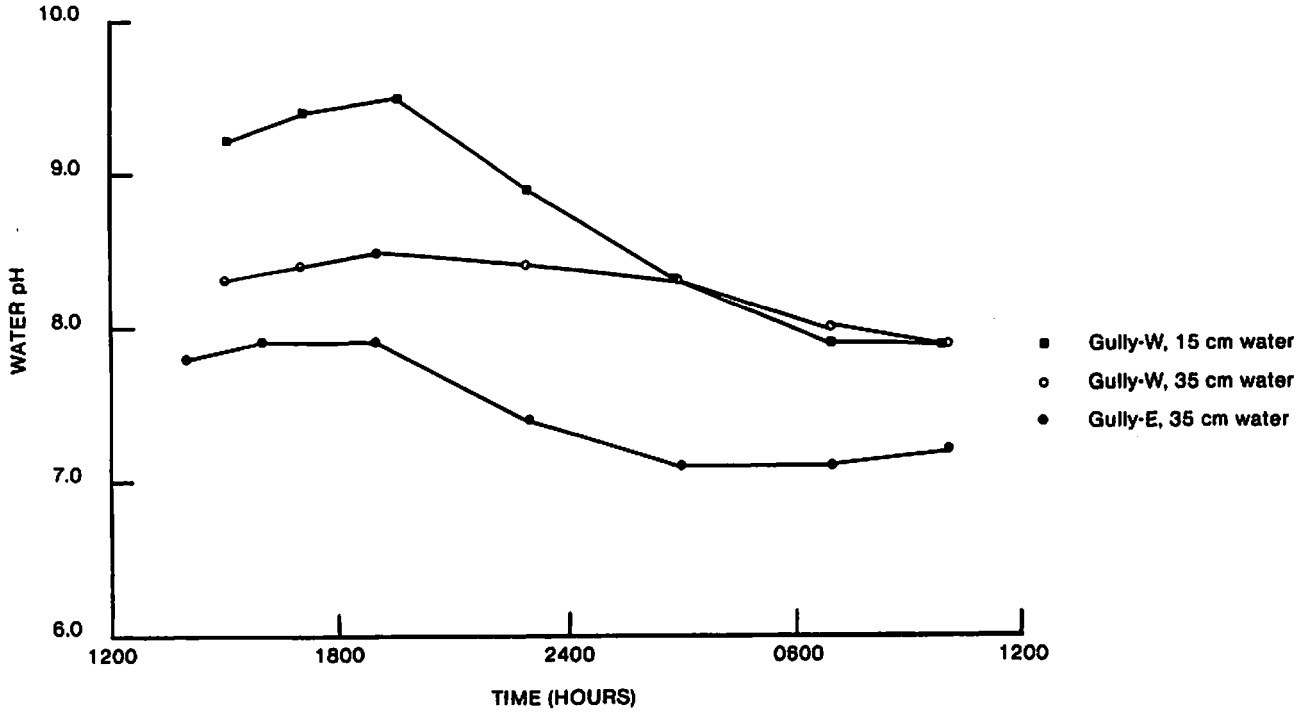

Fig. 3. Changes in the pH of paddy floodwater on peat.

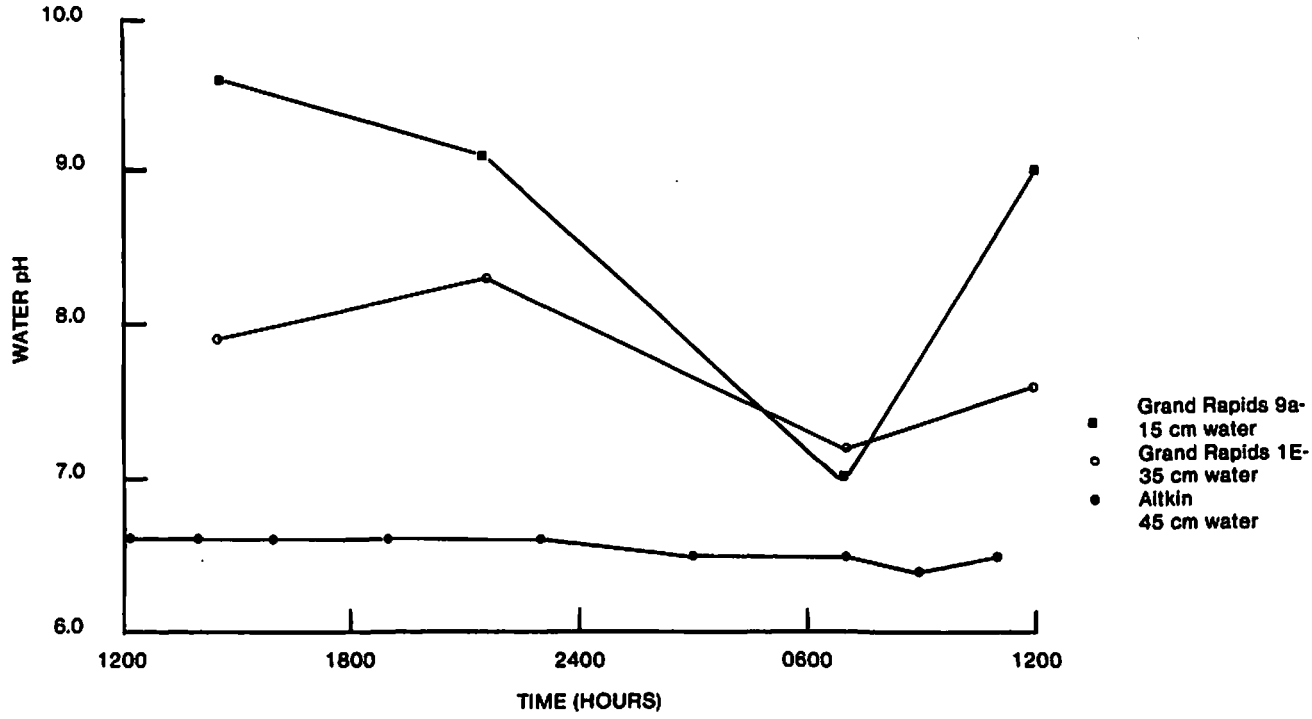

Fig. 4. Changes in the pH of paddy floodwater on mineral and organic soils.

Table 4. Diurnal changes in the pH and temperature of floodwater in 4 x 4 ft. boxes on 6/23-24/83.

Box No.	Fertilizer Treatment	Time (hours) 1200	1400	1600	1900	2300	0300	0700	1200
		Floodwater Temperature, °C							
		29.4	32.3	31.8	28.5	24.5	22.4	20.9	20.2
		Floodwater pH							
34	Control	9.6	9.8	10.1	9.7	6.4	5.4	5.6	5.8
42	Control	9.1	9.6	9.8	9.5	7.5	6.6	6.6	6.5
52	Control	10.0	9.8	9.9	9.3	6.4	6.9	6.4	6.3
24	GU, surf. applied	9.0	8.9	9.3	8.6	6.5	6.4	6.2	6.3
35	GU, surf. applied	6.4	6.5	6.6	6.8	6.4	6.1	6.2	6.1
36	GU, 10 cm depth	9.0	9.0	9.0	8.6	6.5	6.3	6.3	6.3
44	GU, 10 cm depth	8.0	8.1	8.1	7.3	6.2	6.0	6.1	5.8
51	GU, 10 cm depth	9.2	7.9	8.8	6.9	6.2	7.6	6.5	6.1

GU = Granular urea, commercial grade.

Table 5. Inorganic N of floodwater in 4 x 4 ft. boxes from diurnal study on 6/23-24/83.

Box No.	Fertilizer Treatment	Time (hours) 1400	2300	0300	Time (hours) 1400	2300	0300
		NH_4-N, ppm			NO_3-N, ppm		
34	Control	0.07	**	**	0.0	0.0	0.07
42	Control	0.0	0.28	0.21	0.0	0.0	0.0
52	Control	0.07	0.35	0.0	0.0	0.71	0.0
24	GU, surf. applied	3.12	2.69	2.62	1.28	0.92	0.99
35	GU, surf. applied	2.13	2.20	1.91	2.48	2.48	2.55
36	GU, 10 cm depth	1.13	1.20	1.13	1.42	1.13	1.13
44	GU, 10 cm depth	2.13	2.27	2.41	1.20	0.92	0.92
51	GU, 10 cm depth	1.13	1.84	1.84	0.43	0.35	0.07

** Values were about 3 ppm NH_4-N, but are omitted because the water became turbid from suspended matter.

Table 6. Soilwater pH at different depths in 4 x 4 ft. boxes on 7/1/83.

Box No.	Fertilizer Treatment	5 cm Deep, Ceramic Cup No. 1	2	3	30 cm Deep, Ceramic Cup No. 1	2	3
		Soilwater pH					
34	Control	5.8	6.0	5.9	ND	ND	ND
52	Control	5.9	6.3	6.2	6.0	5.8	ND
24	GU, surf. applied	7.2	6.3	6.1	6.4	5.9	ND
44	GU, 10 cm depth	5.6	5.9	5.9	5.9	5.4	ND
51	GU, 10 cm depth	6.2	6.6	5.7	6.2	5.8	ND

ND = not determined.

Table 7. Soilwater inorganic N at different depths in 4 x 4 ft. boxes on 7/1/83.

Box No.	Fertilizer Treatment	5 cm Deep Ceramic Cup No. 1	2	3	30 cm Deep Ceramic Cup No. 1	2	3
		Soilwater NH_4-N, ppm					
34	Control	8.71	8.3	7.6	-	-	-
52	Control	10.0	7.8	6.1	9.1	7.9	-
24	GU, surf. applied	21.1	16.9	24.3	16.1	14.5	-
44	GU, 10 cm depth	17.0	16.0	21.6	11.3	7.9	-
51	GU, 10 cm depth	22.4	15.2	16.2	12.6	13.4	-
		Soilwater NO_3-N, ppm					
34	Control	0.0	0.0	0.0	-	-	-
52	Control	0.0	0.0	0.0	0.0	0.0	-
24	GU, surf. applied	0.0	0.0	0.3	16.5	21.7	-
44	GU, 10 cm depth	0.0	0.0	-	7.3	0.0	-
51	GU, 10 cm depth	0.2	0.0	-	0.9	0.0	-

- = no ceramic cup available

Table 8. Soilwater inorganic N at different depths in 4 x 4 ft. boxes on 8/15/83.

Box No.	Fertilizer Treatment	5 cm Deep Ceramic Cup No. 1	2	3	30 cm Deep Ceramic Cup No. 1	2	3
		Soilwater NH_4-N, ppm					
34	Control	15.2	12.9	15.9	-	-	-
42	Control	16.2	15.7	-	17.2	-	-
52	Control	7.5	11.4	-	15.9	13.6	-
43	GU, surf. applied	25.6	25.7	-	27.3	-	-
51	GU, 10 cm depth	21.3	17.3	23.5	24.7	-	-
33	SCU, 10 cm depth	38.5	32.2	-	30.7	29.3	-

GU = Granular urea, commercial grade; SCU = Sulfur coated urea; - = no ceramic cup available.

Table 9. Soilwater NH_4-N at different depths in 4 x 4 ft. boxes on 9/16/83.

Box No.	Fertilizer Treatment	5 cm Deep Ceramic Cup No. 1	2	3	30 cm Deep Ceramic Cup No. 1	2	3
34	Control	13.1	5.6	15.4	-	-	-
42	Control	16.4	13.8	-	16.8	-	-
52	Control	10.9	22.8	16.0	6.0	-	-
43	GU, surf. applied	21.0	13.8	-	23.7	-	-
51	GU, 10 cm depth	17.0	15.4	23.4	17.0	15.4	23.4
33	SCU, 10 cm depth	36.8	29.4	-	29.2	30.5	-

GU = Granular urea, commercial grade; SCU = Sulfur coated urea; - = no ceramic cup available.

Table 10. Effect of straw, ammonium and gypsum application on growth of wild rice.

Container No.	Peat	Amendment	pH 6 cm in peat	Eh mv	Dry Wt. of Plant g	Concentration in Plant Tops N %	P %	K %	Ca %	Mg %	Fe ppm	Mn ppm	Zn ppm	Cu ppm	B ppm	Al ppm	Na ppm
1	Kosbau	None	5.2	-105	2.5*	1.26	0.53	2.6	0.39	0.15	81	194	41	16	7	25	764
2	"	3S	5.9	-126	0.1	1.37	-	-	-	-	-	-	-	-	-	-	-
3	Clearwater	3S, G	6.9	-172	-	-	-	-	-	-	-	-	-	-	-	-	-
4	"	3S, N	6.7	-176	1.8*	1.19	0.35	3.1	0.37	0.10	29	238	25	8	3	4	452
5	"	3S, G,N	6.9	-137	-	-	-	-	-	-	-	-	-	-	-	-	-
6	"	3S	7.0	-192	0.4	1.43	0.42	3.2	0.53	0.10	39	245	26	7	4	12	739
7	"	1S	6.8	-214	2.1*	1.25	0.38	3.3	0.43	0.09	42	405	32	8	4	12	629
8	"	G	6.9	-178	0.9	1.52	0.42	2.0	0.11	0.23	65	374	47	16	15	5	972
9	"	N	7.0	-204	3.7*	1.44	0.31	1.1	0.35	0.17	26	118	22	10	6	6	3068

3S = 24,900 kg/ha wheat straw; 1S = 8,300 kg/ha; G = 10,000 kg/ha gypsum; N = ammonium chloride, 150 kg N/ha;
* = plants developed panicles

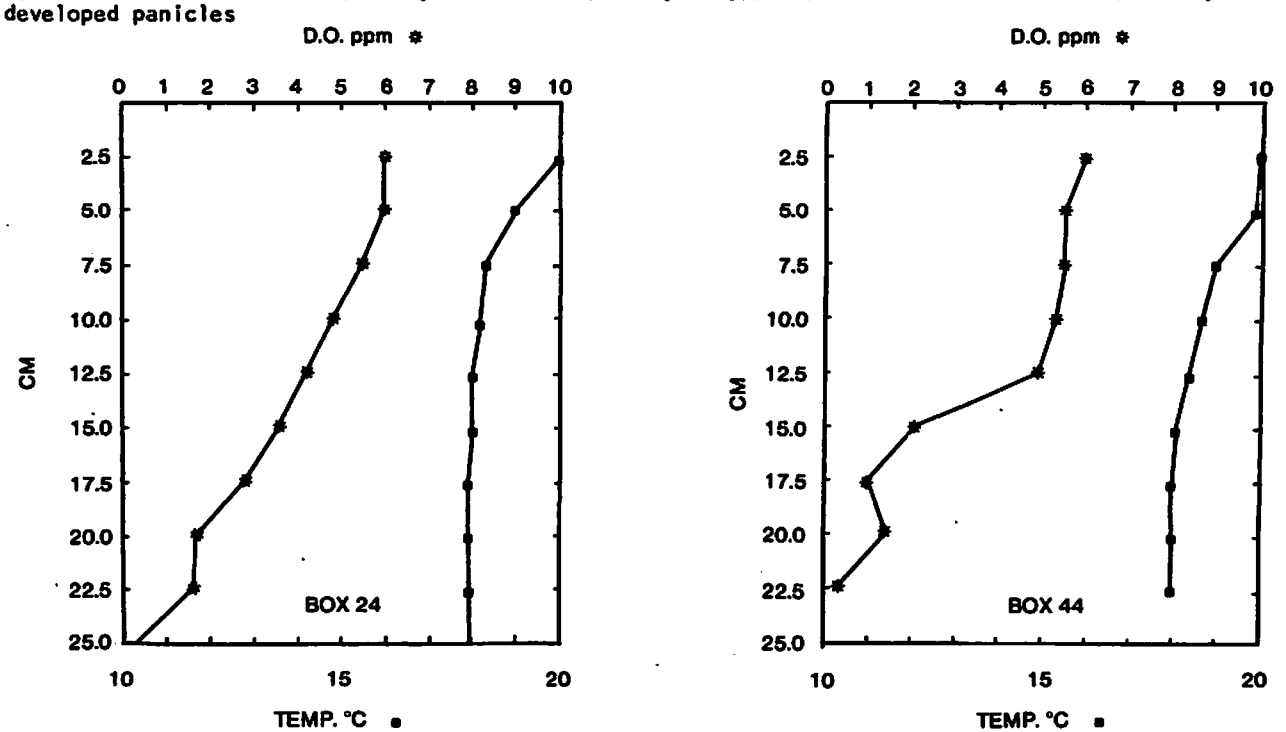

Fig. 5. Dissolved oxygen (DO) and temperature profiles of the floodwater in boxes No. 24 (GU, Surf) and 44 (GU, 10 cm.) on 6/30/83, 9:00 a.m.

Table 11. Yield and density of wild rice, and soil characteristics in different areas of paddies, Manomin Wild Rice Company, Aitkin County - 1983.

Paddy No.	Location	Sampling Depth inches	Grain Yield lb/A	Stems per 16 sq.ft.	Ash %	pH	Extract-able P lb/A	Exchange-able K lb/A	Zn ppm	S ppm	Cu ppm	N %	Ca %	Mg %	Al %	Fe %	Mn ppm	B ppm
116	near	0-6	301	57	34	6.2	56	49	13	53	5	2.1	2.7	0.3	0.80	0.92	239	15
	ditch	6-12			27	6.1	37	35	8		3	2.3	2.7	0.2	0.76	0.89	198	12
		12-18			26	6.1	14	44	3		2	ND	→					
116	distant	0-6	230	63	31	5.9	51	53	14	49	5	ND	→					
	from	6-12			26	5.6	18	68	11		4	ND	→					
	ditch	12-18			21	5.4	9	68	3		1	ND	→					
117	near	0-6	458	85	35	6.1	57	55	14	92	5	2.4	2.6	0.3	0.89	1.01	233	15
	ditch	6-12			26	5.8	12	48	4		3	3.0	2.5	0.3	0.70	1.18	175	14
		12-18			54	6.0	10	86	2		3	2.0	1.9	0.4	1.60	1.75	161	14
117	distant	0-6	408	56	31	6.0	35	56	16	48	5	2.2	2.5	0.3	0.84	0.86	181	11
	from	6-12			23	5.6	8	35	6		3	2.6	2.7	0.3	0.60	1.03	144	9
	ditch	12-18			24	5.6	9	47	ND		ND	3.1	2.4	0.3	0.62	1.01	144	10
118	near	0-6	498	76	35	6.0	52	51	14	61	4	2.2	2.4	0.3	0.78	1.01	227	10
	ditch	6-12			24	5.8	27	22	8		3	2.7	2.2	0.3	0.53	0.96	166	11
		12-18			22	5.6	9	50	5		3	3.0	1.9	0.3	0.57	1.08	115	9
118	distant	0-6	260	61	33	6.0	39	84	13	40	4	2.4	2.5	0.3	0.73	0.95	198	11
	from	6-12			20	5.7	8	35	5		2	2.9	2.1	0.3	0.51	0.93	137	9
	ditch	12-18			24	5.7	9	58	4		2	2.9	2.0	0.3	0.70	0.97	127	10

ND = not determined

Table 12. Soil characteristics in different areas of paddies, Diebold Farm, Aitkin County - 1983.

Paddy No.	Location	Sampling Depth inches	Ash %	pH	Extract-able P lb/A	Exchange-able K lb/A	Zn ppm	S ppm	Cu ppm	B ppm
10	near ditch	0-6	25	5.2	34	95	18	21	1.4	0.3
		6-12	22	5.1	17	73	15	31	1.4	0.3
10	distant	0-6	21	5.3	31	117	19	47	1.1	0.3
	from ditch	6-12	21	5.3	34	135	18	23	1.3	0.3
11	near ditch	0-6	89	5.4	36	303	1	12	1.0	0.1
		6-12	87	5.5	60	260	2	10	1.6	0.2
11	distant	0-6	23	5.5	50	191	23	22	2.2	0.4
	from ditch	6-12	20	5.3	26	137	22	24	2.1	0.2