EFFECTS OF NITROGEN ON SUNFLOWER

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The objective of this study was to evaluate the effect of anhydrous ammonia applied at planting time on the germination of sunflower and subsequently plant N status, seed yield, and oil content.

Experimental Procedure:
The treatments consisted of 4 rates of N (0, 50, 100 and 150 lb/A) as anhydrous ammonia which were applied just prior to planting. The anhydrous application was made at a depth of 5-6 inches with a knife spacing of 12 inches on May 18, 1983. Sunflower, Dahlgren 704, was planted in 30 inch rows perpendicular to the direction in which the anhydrous was applied immediately after the anhydrous application. Stand counts were taken on June 8, 1983 to determine the effects of the treatments on germination. Leaf samples were taken August 5, 1983 to determine plant N status at pollination.

Results:
Insect problems again destroyed the experiment in 1983 so only stand counts and leaf N analyses were obtained. The effect of the N as anhydrous ammonia on germination and leaf N analyses is shown in Table 1. A significant reduction in germination was obtained with the 150 lb/A N rate and N in the leaf increased significantly as the applied N increased.

Discussion:
The reduction (approximate 10%) in stand with anhydrous ammonia at planting time was obtained at the 150 lb/A N rate which indicates that N rates commonly applied to sunflower could be made safely at planting time. These results also agree with results from the 1982 study.

Table 1. The effects of anhydrous ammonia at planting time on sunflower germination and leaf N analyses.

N Rate	Stand Count	Leaf N
lb/A	Plants/Plot	%
0	569	3.02
50	572	3.26
100	594	3.35
150	533	3.44
Significance	*	+
B.L.S.D. (.05)	36	0.37
C.V. (%)	3.7	5.2

TITLE: Phosphorus, Potassium and Nitrogen Fertility Studies on Sunflower

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LOCATIONS: Three experiments were conducted at each of two locations. Location 1 - Ron Peterson farm, Crookston, MN. Location 2 - Gerald Green farm, Ada, MN. Additional information on each location is shown below.

Location	Variety	Herbicide	Date (1983) Fertilizer Application & Planting	Harvest
1	Dahlgren 704	Treflan & Amiben	5-25	9-20
2	Dahlgren 704	Treflan & Amiben	5-18	10-12

Location	Soil Tests pH	Organic Matter	NO_3-N	$NaHCO_3$ P	Exchangeable K
		%	lb/A-2'	lb/A	lb/A
1	8.2	4.7	148	12	125
2	8.2	2.8	100	11	168

EXPERIMENTAL METHODS: All experiments were fertilized, planted, and cultivated with equipment of the experiment station. The recent purchase of a planter with starter fertilizer attachments (dry materials only) made the comparisons of P methods possible. A description of each of the experiments is given below:

1) The N experiment at both locations had five treatments (0, 30, 60, 90 and 120 lb N/A) in a randomized complete block design with four replications. Blanket applications of 100 lb K_2O/A and 100 lb P_2O_5/A were applied at both locations over the experimental area.

2) The K experiment at both locations had five treatments (0, 50, 100, 150, and 200 lb K_2O/A) in a randomized complete block design with four replications. Blanket applications of 90 lb N/A and 100 lb P_2O_5/A were applied at both locations over the experimental area.

3) The P experiment at both locations had six treatments, a check plot, two rates of P_2O_5 from TSP (50 and 100 lb/A) broadcasted and banded, and a 50 lb P_2O_5/A DAP banded treatment in a randomized complete block design with four replications. Blanket applications of 90 lb N/A and 100 lb K_2O/A were applied at both locations over the experimental area. The banded treatments were applied in the conventional 2x2 method at planting.

All experiments had leaf samples taken at 50-80% bloom. Whole plant samples were also taken at maturity from each experiment. The samples taken at maturity were separated into heads and stems with leaves for analyses. Results will be presented in the tables which follow for the plant parts separately and also the total analyses.

RESULTS: The effects of the N, P, and K treatments on sunflower at location 1 are shown in Tables 1-15. Nitrogen did not cause any significant differences. Phosphorus significantly increased P content in the head (Table 5) and whole plant (Table 7) and P uptake by the head (Table 5) and whole plant (Table 7). Other differences were obtained and they are shown in Table 5-8. Potassium significantly increased K content (Tables 9-12) and K uptake (Tables 9 and 10) in all cases. Seed yield was also significantly increased (Table 14).

The effects of the N, P and K treatments on sunflower at location 2 are shown in Tables 16-30. Nitrogen significantly increased N content in the head (Table 16). Phosphorus significantly increased P content in the leaves (Table 23). Potassium had no effect on any of the measured variables.

DISCUSSION: The lack of response and general variability of the results were not unexpected. The growing season of 1983 was one which had constant insect pressure at both locations. The constant pressure of sunflower beetle, midge, and banded sunflower moth damaged the experiments even though an extensive spray program was conducted at both locations. The damage inflicted was severe enough to mask any differences that could or should have been obtained.

Table 1. The effect of N on sunflower head dry matter yield, elemental analyses, and N uptake at maturity (Location 1).

N Rate	Elemental Analyses									Dry Matter	N
	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
lb/A	%					ppm				lb/A	lb/A
0	2.12	0.49	2.01	0.88	0.78	27	45	38	52	2330	49.1
30	2.21	0.50	1.96	0.98	0.75	29	46	34	54	2263	49.8
60	2.05	0.47	2.08	0.97	0.74	28	44	36	54	2522	51.6
90	2.12	0.47	2.02	0.99	0.79	29	44	36	55	2364	49.8
120	2.13	0.49	2.01	0.90	0.74	27	45	36	52	2458	52.2
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	3.1	6.5	4.1	5.4	5.0	5.9	6.1	16.6	4.0	9.8	8.1

Table 2. The effect of N on sunflower stems and leaves dry matter yield, elemental analyses, and N uptake at maturity (Location 1).

N Rate	Elemental Analyses									Dry Matter	N
	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
lb/A	%					ppm				lb/A	lb/A
0	1.67	0.19	1.47	1.53	2.14	46	12	7	49	3229	53.6
30	1.73	0.20	1.43	1.67	2.23	52	16	6	54	3096	52.9
60	1.73	0.19	1.72	1.56	1.96	44	10	6	55	3321	57.7
90	1.73	0.19	1.61	1.56	2.07	45	11	6	53	3069	52.6
120	1.77	0.18	1.63	1.60	2.15	46	15	5	49	3329	59.1
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	8.0	14.2	12.4	9.1	5.7	9.6	37.5	17.7	9.3	10.1	9.4

Table 3. The effect of N on elemental analyses of sunflower whole plants at maturity (Location 1).

N Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	1.85	0.32	1.70	1.26	1.57	38	26	20	50
30	1.93	0.32	1.65	1.38	1.60	42	29	18	54
60	1.87	0.31	1.78	1.30	1.43	37	25	19	54
90	1.90	0.31	1.78	1.31	1.52	38	25	19	53
120	1.92	0.31	1.79	1.30	1.55	38	28	18	51
S.L.S.D. (.05)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	4.6	8.1	7.8	6.5	4.2	6.5	15.3	14.2	5.5

Table 4. The effect of N on elemental analyses of sunflower leaf samples taken at 50-80% bloom (location 1).

N Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.69	0.46	2.65	2.77	2.59	73	24	9	104
30	3.76	0.43	2.60	3.09	2.52	83	23	8	121
60	3.68	0.41	2.62	2.94	2.47	75	24	10	114
90	3.80	0.42	2.66	2.81	2.46	76	23	8	114
120	3.75	0.39	2.57	2.87	2.45	75	24	7	107
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	3.1	6.6	9.7	6.2	4.9	5.3	7.5	19.7	11.2

Table 5. The effect of P on sunflower head dry matter yield, elemental analyses, and P uptake at maturity (location 1).

Treatment			Elemental Analyses									Dry Matter	P
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
	lb/A		%					ppm				lb/A	
--	0	--	2.02	0.30	1.97	1.04	0.65	28	51	35	53	2317	7.0
TSP	50	B	2.24	0.41	2.00	1.09	0.69	28	51	33	56	2403	9.9
TSP	50	S	2.10	0.38	1.93	0.99	0.65	26	48	40	50	2466	9.4
TSP	100	B	2.13	0.43	1.97	1.17	0.84	33	45	33	56	2472	10.5
TSP	100	S	2.19	0.40	1.98	1.04	0.68	27	46	33	54	2453	9.8
DAP	50	S	2.06	0.35	1.94	1.07	0.69	29	48	35	52	2357	8.2
Significance			N.S.	**	N.S.	N.S.	*	*	N.S.	N.S.	N.S.	N.S.	*
B.L.S.D. (.05)				0.06			0.11	4					2.4
C.V. (%)			4.9	10.2	5.0	7.9	9.9	9.2	8.7	21.9	5.6	11.4	15.5

Table 6. The effect of P on sunflower stem and leaves dry matter yield, elemental analyses, and P uptake at maturity (location 1).

Treatment			Elemental Analyses									Dry Matter	P
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
	lb/A		%					ppm				lb/A	
--	0	--	1.67	0.13	2.00	1.80	1.38	51	23	8	57	3043	4.1
TSP	50	B	1.70	0.16	1.82	2.04	2.01	55	18	7	62	3365	5.3
TSP	50	S	1.69	0.15	1.94	2.04	2.04	54	17	7	65	3399	5.3
TSP	100	B	1.64	0.17	1.90	1.79	1.99	47	14	6	58	3416	5.7
TSP	100	S	1.68	0.15	1.88	1.90	1.92	47	15	6	59	3911	5.9
DAP	50	S	1.61	0.15	1.77	2.04	1.93	54	18	8	61	3524	5.1
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	**	*	*	N.S.	N.S.	N.S.
B.L.S.D. (.05)								5	5	2			
C.V. (%)			7.2	14.5	10.9	9.8	19.2	6.6	18.1	15.1	11.5	14.5	20.0

Table 7. The effect of P on the elemental analyses of sunflower whole plants at maturity (location 1).

Treatment			Elemental Analyses								
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
- - - -	lb/A	- - - -	- - - - - - - - - -		%	- - - - - - - - - -		- - - - - -		ppm	- - - - - -
--	0	--	1.82	0.21	1.98	1.47	1.04	41	35	20	55
TSP	50	B	1.92	0.26	1.88	1.64	1.45	44	32	18	60
TSP	50	S	1.86	0.25	1.93	1.59	1.45	42	30	21	59
TSP	100	B	1.84	0.28	1.92	1.53	1.50	41	27	17	57
TSP	100	S	1.88	0.25	1.91	1.56	1.43	39	28	17	57
DAP	50	S	1.79	0.23	1.82	1.65	1.43	44	30	19	57
Significance			N.S.	*	N.S.	N.S.	N.S.	*	*	N.S.	N.S.
B.L.S.D. (.05)				0.05				3	5		
C.V. (%)			4.9	11.4	6.1	8.2	15.5	4.8	9.7	18.6	7.4

Table 8. The effect of P on the elemental analyses of sunflower leaf samples taken at 50-80% bloom (location 1).

Treatment			Elemental Analyses								
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
- - - -	lb/A	- - - -	- - - - - - - - - -		%	- - - - - - - - - -		- - - - - -		ppm	- - - - - -
--	0	--	3.58	0.32	3.13	3.32	1.88	82	39	15	130
TSP	50	B	3.68	0.37	2.93	3.42	2.05	85	32	12	130
TSP	50	S	3.64	0.34	2.81	3.37	2.25	83	33	11	139
TSP	100	B	3.85	0.40	2.77	3.36	2.13	83	30	10	116
TSP	100	S	3.58	0.35	2.65	3.53	2.24	84	30	10	135
DAP	50	S	3.53	0.34	2.70	3.62	2.20	90	34	11	140
Significance			*	*	**	N.S.	N.S.	N.S.	N.S.	**	N.S.
B.L.S.D. (.05)			0.17	0.05	0.17					2	
C.V. (%)			2.9	8.4	4.1	9.1	9.2	6.6	13.4	12.8	8.8

Table 9. The effect of K on sunflower head dry matter yields, elemental analyses, and K uptake at maturity (location 1).

	Elemental Analyses									Dry Matter	K
K_2O Rate	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
lb/A	- - - - - - - -		%	- - - - - - - -		- - - -		ppm	- - - -	- - - lb/A	- - -
0	2.12	0.53	1.99	1.19	0.89	32	56	26	62	2278	44.9
50	2.17	0.55	2.22	1.17	0.79	32	55	32	62	2589	57.6
100	2.26	0.56	2.32	1.13	0.79	32	56	27	63	2529	58.5
150	2.31	0.58	2.33	1.17	0.79	32	59	37	61	2316	54.0
200	2.17	0.60	2.41	1.13	0.74	34	59	37	61	2317	56.0
Significance	N.S.	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*
B.L.S.D. (.05)			0.32								8.4
C.V. (%)	6.1	11.0	8.2	13.9	10.3	11.3	14.8	21.0	8.4	8.5	9.5

Table 10. The effect of K on sunflower stems and leaves dry matter yields, elemental analyses, and K uptake at maturity (location 1).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B	Dry Matter Yield	K Uptake
lb/A	%					ppm				lb/A	
0	1.70	0.26	0.70	2.25	2.61	62	17	6	66	3917	28.4
50	1.69	0.27	1.46	2.17	2.33	60	18	6	71	4125	60.4
100	1.72	0.28	1.70	1.94	2.33	59	16	6	63	4049	68.3
150	1.83	0.24	2.02	1.96	2.23	57	17	6	62	3695	75.6
200	1.63	0.25	2.56	1.88	2.16	55	13	6	62	3477	88.0
Significance	N.S.	N.S.	**	N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	**
B.L.S.D. (.05)			0.44		0.29						27.9
C.V. (%)	9.0	10.4	18.1	13.4	7.3	12.7	28.0	12.6	14.5	16.3	27.8

Table 11. The effects of K on the elemental analyses of sunflower whole plants at maturity (location 1).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	1.86	0.36	1.18	1.85	1.96	50	31	14	65
50	1.87	0.37	1.75	1.78	1.72	49	32	16	68
100	1.93	0.38	1.93	1.63	1.74	48	31	14	63
150	2.02	0.37	2.15	1.66	1.68	47	33	18	61
200	1.85	0.39	2.50	1.58	1.59	46	31	18	61
Significance	N.S.	N.S.	**	N.S.	**	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			0.27		0.14				
C.V. (%)	6.7	9.2	10.1	13.8	5.2	12.9	12.6	18.3	11.2

Table 12. The effects of K on the elemental analyses of sunflower leaf samples taken at 50-80% bloom (location 1).

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.63	0.46	1.56	3.69	2.92	96	36	7	125
50	3.67	0.46	2.17	3.71	2.44	91	36	6	146
100	3.55	0.48	2.29	3.44	2.44	91	34	7	142
150	3.66	0.47	2.60	3.19	2.22	80	33	7	119
200	3.61	0.48	2.73	3.23	2.20	84	30	7	127
Significance	N.S.	N.S.	**	N.S.	**	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)			0.47		0.32				
C.V. (%)	5.7	5.6	13.6	11.7	8.5	11.0	18.2	21.0	14.0

Table 13. The effect of N on plant population, seed yield, oil content, and dry matter yields and nutrient content of sunflower at maturity (location 1).

N Rate	Plant Population	Seed Yield	Seed Oil Content	Dry Matter (Maturity) Yield	Uptake N	Uptake P	Uptake K
lb/A	Plants/A	lb/A	%	lb/A			
0	22,070	675	38.4	5559	102.8	17.6	94.5
30	20,618	690	38.0	5359	102.7	17.2	87.8
60	22,506	713	38.4	5843	109.3	18.2	103.7
90	23,232	729	38.6	5433	102.4	16.8	97.5
120	22,506	867	39.2	5788	111.3	17.9	103.6
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	**
B.L.S.D. (.05)							13.1
C.V. (%)	6.9	16.4	3.6	8.9	8.1	11.1	8.3

Table 14. The effect of K on plant population, seed yield, oil content, and dry matter yields and nutrient content of sunflower at maturity (location 1).

K_2O Rate	Plant Population	Seed Yield	Seed Oil Content	Dry Matter (Maturity) Yield	Uptake N	Uptake P	Uptake K
lb/A	Plants/A	lb/A	%	lb/A			
0	21,054	391	36.7	6196	114.9	21.9	73.3
50	20,473	396	37.9	6714	124.9	24.9	118.1
100	19,602	390	36.0	6578	126.6	25.2	126.8
150	17,860	680	37.8	6011	120.9	22.2	129.5
200	21,344	605	37.6	5794	107.0	22.3	144.0
Significance	N.S.	*	N.S.	N.S.	N.S.	N.S.	**
B.L.S.D. (.05)		259					32.5
C.V. (%)	8.3	30.9	4.2	12.4	12.8	14.0	17.6

Table 15. The effect of P on plant population, seed yield, oil content, and dry matter yields and nutrient content of sunflower at maturity (location 1).

Treatment Source	Treatment P_2O_5 Rate	Treatment Method	Plant Population	Seed Yield	Seed Oil Content	Dry Matter (Maturity) Yield	Uptake N	Uptake P	Uptake K
	lb/A		Plants/A	lb/A	%	lb/A			
--	0	--	21,199	735	38.9	5360	97.4	11.2	103.4
TSP	50	B	21,199	686	37.8	5768	110.2	15.2	108.7
TSP	50	S	22,651	710	37.9	5865	108.9	14.7	112.1
TSP	100	B	21,780	626	36.5	5888	108.4	16.2	112.9
TSP	100	S	21,780	619	37.4	6364	119.8	15.7	119.4
DAP	50	S	20,038	616	37.0	5881	105.0	13.3	106.9
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.
B.L.S.D. (.05)								4.1	
C.V. (%)			7.7	19.7	3.2	11.5	11.8	16.0	11.8

Table 16. The effect of N on sunflower head dry matter yield, elemental analyses, and N uptake at maturity (location 2).

N Rate	Elemental Analyses									Dry Matter Yield	N Uptake
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		
lb/A	%					ppm				lb/A	
0	1.96	0.44	2.21	0.79	0.54	24	41	35	46	3014	59.0
30	1.85	0.44	2.26	0.81	0.56	21	37	33	45	2507	46.4
60	1.97	0.41	2.20	0.81	0.52	20	43	34	47	2626	51.8
90	2.07	0.42	2.20	0.83	0.52	22	43	33	46	2958	61.0
120	2.03	0.42	2.16	0.83	0.54	21	48	34	46	2942	59.6
Significance	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)	0.14										
C.V. (%)	3.5	6.5	5.0	8.2	6.9	7.9	3.4	5.4	4.2	11.1	11.2

Table 17. The effect of N on sunflower stem and leaves dry matter yield, elemental analyses, and N uptake at maturity (location 2).

N Rate	Elemental Analyses									Dry Matter Yield	N Uptake
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		
lb/A	%					ppm				lb/A	
0	1.38	0.13	4.67	1.87	1.36	50	15	9	62	3038	41.7
30	1.23	0.14	4.99	1.84	1.15	48	14	10	58	2960	36.5
60	1.38	0.14	4.34	1.83	1.32	48	16	9	60	3630	50.7
90	1.38	0.11	4.55	1.90	1.33	52	16	8	59	3381	46.4
120	1.39	0.11	4.44	1.80	1.29	49	16	7	61	3252	45.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	9.6	15.8	12.3	12.9	10.6	9.7	24.8	22.8	11.4	13.1	20.5

Table 18. The effect of N on the elemental analyses of sunflower whole plants at maturity (location 2).

N Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	1.67	0.29	3.44	1.33	0.95	37	28	22	54
30	1.52	0.28	3.74	1.37	0.88	35	25	21	52
60	1.64	0.26	3.36	1.40	0.99	36	28	20	55
90	1.70	0.25	3.46	1.40	0.95	38	29	20	53
120	1.69	0.26	3.36	1.34	0.93	35	31	20	54
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	4.2	7.7	8.6	10.4	11.1	9.3	7.0	7.9	6.8

Table 19. The effect of N on the elemental analyses of sunflower leaf samples taken at 50-80% bloom (location 2).

N Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.86	0.40	4.69	2.25	1.27	55	31	21	90
30	3.79	0.41	4.64	2.15	1.28	51	31	19	96
60	3.73	0.39	4.46	2.39	1.28	54	33	20	112
90	3.99	0.37	4.81	2.19	1.23	51	36	18	99
120	3.95	0.37	4.83	2.19	1.37	52	40	16	101
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	4.0	6.9	3.9	5.8	7.5	7.7	10.6	11.3	10.7

Table 20. The effect of P on sunflower head dry matter yield, elemental analyses, and P uptake at maturity (location 2).

Treatment			Elemental Analyses									Dry Matter	P
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
	lb/A		%					ppm				lb/A	
--	0	--	2.05	0.38	2.12	0.91	0.46	21	45	36	45	3215	12.1
TSP	50	B	2.03	0.44	2.12	0.94	0.47	19	46	40	46	3041	13.3
TSP	50	S	2.13	0.39	2.21	0.92	0.49	20	46	37	46	3013	11.5
TSP	100	B	2.00	0.42	2.11	0.82	0.47	19	41	37	45	3032	12.6
TSP	100	S	2.11	0.42	2.17	0.90	0.46	19	44	36	47	3032	12.7
DAP	50	S	2.06	0.39	2.19	0.88	0.48	20	44	33	45	3015	11.8
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			6.2	10.5	4.8	9.3	6.3	6.9	8.9	10.9	5.7	13.1	10.7

Table 21. The effect of P on sunflower stem and leaves dry matter yield, elemental analyses, and P uptake at maturity (location 2).

Treatment			Elemental Analyses									Dry Matter	P
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B	Yield	Uptake
	lb/A		%					ppm				lb/A	
--	0	--	1.50	0.12	4.47	2.00	1.12	45	16	9	67	3329	3.9
TSP	50	B	1.46	0.11	4.15	1.96	1.15	40	14	10	64	3168	3.6
TSP	50	S	1.38	0.11	4.15	2.03	1.27	50	15	10	62	3362	3.7
TSP	100	B	1.48	0.13	4.39	1.91	1.24	44	13	9	63	3363	4.5
TSP	100	S	1.35	0.10	4.42	1.90	1.13	43	13	9	60	3298	3.4
DAP	50	S	1.57	0.11	4.68	1.86	1.13	40	13	7	61	3338	3.5
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			5.7	13.1	7.7	8.3	6.8	10.0	16.9	20.0	8.9	9.9	13.0

Table 22. The effect of P on the elemental analyses of sunflower whole plants at maturity (location 2).

Treatment			Elemental Analyses								
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
- - - -	lb/A	- - - -	- - - - - - - - - -		%	- - - - - - - - - -		- - - - - -		ppm	- - - - - -
--	0	--	1.77	0.25	3.31	1.46	0.80	33	30	23	56
TSP	50	B	1.74	0.27	3.16	1.46	0.81	29	30	25	55
TSP	50	S	1.73	0.24	3.23	1.51	0.90	36	29	22	55
TSP	100	B	1.72	0.27	3.32	1.40	0.88	32	27	22	54
TSP	100	S	1.71	0.25	3.34	1.42	0.81	31	28	22	54
DAP	50	S	1.80	0.24	3.50	1.39	0.82	31	28	19	54
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			4.1	6.9	7.2	8.8	4.6	9.1	9.1	11.3	5.6

Table 23. The effect of P on the elemental analyses of leaf samples taken at 50-80% bloom (location 2).

Treatment			Elemental Analyses								
Source	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Mn	Zn	Cu	B
- - - -	lb/A	- - - -	- - - - - - - - - -		%	- - - - - - - - - -		- - - - - -		ppm	- - - - - -
--	0	--	3.89	0.37	4.49	2.59	1.15	52	38	20	120
TSP	50	B	4.04	0.40	4.37	2.42	1.13	48	37	20	111
TSP	50	S	3.91	0.36	4.59	2.35	1.26	50	37	19	109
TSP	100	B	3.82	0.39	4.46	2.59	1.21	51	34	20	115
TSP	100	S	3.80	0.37	4.48	2.41	1.23	49	33	21	105
DAP	50	S	3.93	0.39	4.38	2.49	1.24	52	36	19	128
Significance			N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)				0.04							
C.V. (%)			2.7	5.5	4.7	7.8	7.5	7.9	9.0	12.0	8.9

Table 24. The effect of K on sunflower head dry matter yield, elemental analyses, and K uptake at maturity (location 2).

K_2O Rate	Elemental Analyses									Dry Matter Yield	K Uptake
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		
lb/A	- - - - - - - -		%	- - - - - - - -		- - - -		ppm	- - - -	- - - lb/A	- - -
0	1.99	0.47	2.16	0.92	0.61	20	43	36	49	2704	58.2
50	2.03	0.49	2.34	0.91	0.55	21	45	37	49	2963	69.6
100	2.01	0.49	2.28	0.91	0.54	19	43	39	47	2695	61.7
150	2.16	0.49	2.25	0.92	0.60	22	43	35	48	2885	65.0
200	1.94	0.44	2.29	0.87	0.56	21	41	36	47	2813	64.3
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	2.8	7.5	4.4	10.8	6.5	6.8	7.9	7.7	3.0	11.5	14.3

Table 25. The effect of K on sunflower stem and leaves dry matter yield, elemental analyses, and K uptake at maturity (location 2).

K_2O Rate	Elemental Analyses									Dry Matter Yield	K Uptake
	N	P	K	Ca	Mg	Mn	Zn	Cu	B		
lb/A	%					ppm				lb/A	
0	1.56	0.16	3.01	1.81	1.55	43	16	10	59	3230	98.8
50	1.38	0.12	4.24	1.69	1.17	37	13	8	55	3301	139.1
100	1.33	0.12	4.54	1.85	1.28	45	15	9	53	3529	160.5
150	1.37	0.12	4.55	1.67	1.31	37	13	8	52	3212	146.4
200	1.38	0.11	4.65	1.80	1.29	45	15	9	60	3158	147.3
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	11.6	14.5	20.6	13.4	12.4	17.0	20.1	15.2	10.0	8.9	25.7

Table 26. The effect of K on the elemental analyses of sunflower whole plants at maturity (location 2).

K_2O Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	1.76	0.30	2.62	1.41	1.13	33	28	22	54
50	1.69	0.29	3.32	1.32	0.88	30	28	22	52
100	1.63	0.28	3.56	1.44	0.96	34	27	22	51
150	1.74	0.30	3.46	1.32	0.97	30	28	21	50
200	1.64	0.27	3.54	1.36	0.95	34	28	22	54
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	4.7	7.9	14.7	12.3	11.0	12.3	10.9	10.1	6.1

Table 27. The effect of K on the elemental analyses of sunflower leaf samples taken at 50-80% bloom (location 2).

K_2O Rate	Elemental Analyses								
	N	P	K	Ca	Mg	Mn	Zn	Cu	B
lb/A	%					ppm			
0	3.93	0.39	3.89	2.56	1.49	50	30	20	82
50	3.75	0.40	4.52	2.42	1.28	46	33	18	89
100	3.90	0.40	4.34	2.53	1.18	50	33	21	90
150	3.88	0.40	4.66	2.32	1.22	47	31	20	86
200	3.95	0.37	4.44	2.29	1.22	49	31	21	83
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	7.5	5.9	10.7	12.4	13.7	10.6	7.8	16.4	14.0

Table 28. The effect of N on plant population, seed yield, oil content, and dry matter yield and nutrient content of sunflower at maturity (location 2).

N Rate	Plant Population	Seed Yield	Seed Oil Content	Dry Matter (Maturity) Yield	Uptake N	Uptake P	Uptake K
lb/A	Plants/A	lb/A	%	lb/A			
0	21,344	1332	40.6	6052	100.7	17.4	209.1
30	22,070	1364	42.6	5467	83.0	15.1	204.8
60	21,054	1188	42.5	6256	102.4	16.0	208.6
90	22,942	1390	43.0	6339	107.3	16.1	217.9
120	21,780	1308	42.5	6195	104.6	16.0	207.9
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	4.6	9.0	3.4	6.6	7.9	4.4	7.7

Table 29. The effect of K on plant population, seed yield, oil content, and dry matter yield and nutrient content of sunflower at maturity (location 2).

K_2O Rate	Plant Population	Seed Yield	Seed Oil Content	Dry Matter (Maturity) Yield	Uptake N	Uptake P	Uptake K
lb/A	Plants/A	lb/A	%	lb/A			
0	22,216	1178	41.6	5934	104.6	18.2	157.0
50	22,216	1272	41.0	6264	105.5	18.3	208.7
100	22,506	1457	41.9	6224	101.0	17.5	222.1
150	22,216	1238	41.1	6098	106.1	17.9	211.4
200	22,216	1321	42.0	5971	98.1	16.0	211.6
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	5.1	11.7	2.4	9.0	7.3	9.2	21.1

Table 30. The effect of P on plant population, seed yield, oil content, and dry matter yield and nutrient content of sunflower at maturity (location 2).

Treatment Source	Treatment P_2O_5 Rate	Treatment Method	Plant Population	Seed Yield	Seed Oil Content	Dry Matter (Maturity) Yield	Uptake N	Uptake P	Uptake K
	lb/A		Plants/A	lb/A	%	lb/A			
--	0	--	22,651	1564	42.6	6544	115.6	16.0	216.3
TSP	50	B	22,651	1539	42.7	6209	107.9	16.9	196.1
TSP	50	S	21,344	1449	43.3	6374	109.9	15.2	204.4
TSP	100	B	22,361	1547	42.5	6395	110.4	17.1	211.6
TSP	100	S	22,216	1436	42.2	6330	108.6	16.1	211.3
DAP	50	S	21,054	1650	42.4	6353	114.1	15.3	220.4
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			4.5	7.5	2.1	10.1	10.0	9.4	10.2

FERTILIZATION OF SOYBEAN IN NORTHWESTERN MINNESOTA

G. E. Varvel and R. K. Severson

The expansion of the soybean industry into northwestern Minnesota has generated the need for information on how to effectively fertilize them for maximum yield and oil content. These experiments were initiated to determine what levels of response could be attained with various methods of fertilization.

Experimental Procedure:
Two varieties, McCall and Maple Amber were used in these studies. The first study compared TSP (0-44-0) versus DAP (18-46-0) as starter fertilizers and the second study was designed to measure the effects of applied N on soybean. Both studies were conducted on each variety in separate experiments.

The starter fertilizer studies consisted of three rates of applied P_2O_5 (0, 50, and 100 lb/A) from both sources in a randomized complete block design with four replications. The standard 2 x 2 application method was used for the treatments. Blanket applications of N (90 lb/A) and K_2O (150 lb/A) were applied to the plot area before planting. Both varieties were planted on May 25, 1983 with the various fertilizer treatments. The plots were harvested on October 27, 1983. Soil test levels for the study were: pH - 8.2, $NaHCO_3$ P - 12 lb/A, exchangeable K - 125 lb/A, and NO_3-N (0-2') - 148 lb/A.

The nitrogen studies consisted of five rates of N (0, 30, 60, 90, and 120 lb/A) broadcast and incorporated just prior to planting. A randomized complete block design with four replications was used. Both varieties were planted on May 26, 1983 and harvested on October 27, 1983. Soil test levels for the study were: pH - 8.2, $NaHCO_3$ P - 14 lb/A, exchangeable K - 175 lb/A, and NO_3-N (0-2') - 62 lb/A.

Results:
The effects of the starter treatments are shown in Table 1. No significant differences were obtained between either source or P rates with McCall or Maple Amber.

The effects of the N treatments are shown in Table 2. Nitrogen significantly increased yields on both varieties.

Table 1. The effect of starter fertilizer phosphorus on yield of two soybean varieties.

Treatment		Variety	
		McCall	Maple Amber
Source	P_2O_5 Rate	Yield	Yield
	lb/A	Bu/A	Bu/A
TSP	0	30.7	22.3
	50	30.2	19.1
	100	31.4	14.3
DAP	0	30.5	21.2
	50	27.1	15.6
	100	31.1	18.1
Significance		N.S.	N.S.
B.L.S.D. (.05)			
C.V. (%)		13.5	28.5

Table 2. The effect of nitrogen on yield of two soybean varieties.

	Variety	
	McCall	Maple Amber
N Rate	Yield	Yield
lb/A	Bu/A	Bu/A
0	20.2	19.7
30	24.4	22.1
60	27.5	25.2
90	29.0	23.6
120	27.4	27.5
Significance	*	*
B.L.S.D. (.05)	5.5	4.9
C.V. (%)	13.0	12.4

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1983

Month	Period	Precipitation 1983	Precipitation 94-yr. av.	Precipitation Dev. from av.	Temperature 1983	Temperature 94-yr. av.	Temperature Dev. from av.	Soil Temperature (10 cm depth) 1983	Soil Temperature (10 cm depth) 10 yr. av.
January	1-31	.75	.68	+ .07	16.4	8.0	+8.4	22.0	20.7
February	1-28	.15	.67	- .52	22.2	12.6	+9.6	25.9	23.9
March	1-31	2.34	1.09	+1.25	30.8	26.7	+4.1	32.7	29.2
April	1-10	.23	.58	- .35	37.9	37.9	0	35.2	
	11-20	.39	.65	- .26	35.8	44.4	-8.6	35.9	
	21-30	.22	1.08	- .86	48.7	48.2	+0.5	43.5	
Total or av.		.84	2.31	-1.47	40.8	43.5	-2.7	38.2	41.4
May	1-10	.76	.78	- .02	51.4	51.9	-0.5	48.6	
	11-20	1.03	.95	+ .08	51.3	55.8	-4.5	52.2	
	21-31	.34	1.25	- .91	56.0	60.1	-4.1	58.8	
Total or av.		2.13	2.98	- .85	53.0	56.1	-3.1	53.4	57.1
June	1-10	.13	1.26	-1.13	59.5	63.1	-3.6	63.7	
	11-20	1.64	1.27	+ .37	65.5	66.5	-1.0	59.5	
	21-30	1.92	1.38	+ .54	70.4	68.2	+2.2	73.7	
Total or av.		3.69	3.91	- .22	65.1	66.0	-0.9	67.9	69.3
July	1-10	.97	1.48	- .51	71.5	70.0	+1.5	73.2	
	11-20	2.19	1.03	+1.16	75.6	71.3	+4.3	80.0	
	21-31	1.16	1.03	+ .13	74.1	71.5	+2.6	79.9	
Total or av.		4.32	3.54	+ .78	73.7	71.0	+2.7	73.0	76.7
August	1-10	0	1.05	-1.05	75.4	70.3	+5.1	82.6	
	11-20	2.83	.90	+1.93	71.1	69.2	+1.9	78.5	
	21-31	2.40	.98	+1.42	72.7	66.9	+5.8	74.6	
Total or av.		5.23	2.93	+2.30	73.1	68.7	+4.4	78.5	73.9
September	1-30	1.83	2.19	- .36	59.1	59.1	0	61.6	61.5
October	1-31	2.18	1.62	+ .56	45.0	47.3	-2.3	46.9	47.8
November	1-30	2.74	.96	+1.78	31.9	29.7	+2.2	36.2	33.6
December	1-31	.75	.68	+ .07	-1.2	15.5	-16.7	26.4	23.4
April-August Growing Season		16.21	15.67	+ .54	61.2	61.1	+0.1	62.3	63.8
January-December Annual		26.95	23.56	+3.39	42.6	42.0	+0.6	47.0	46.7

MANURE RATE STUDY

West Central Experiment Station - Morris

S. D. Evans, P. R. Goodrich and R. C. Munter

Solid and liquid beef manures were applied at three rates and the effects were compared against check plots. Treatments and results from previous years are given in Soil Series 91, 95, 97, 99, 103, 105, 107, 109, and Misc. Publ. 2-1982 and 1983. The last manure applications were made in the fall of 1978, but fertilizer has been applied to the fertilized check each year.

I. Planting Information

The plots were planted with Pioneer 3901 on May 10, 1983. Counter @ 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row to the entire area at planting. The plots were fertilized on October 27, 1982, with 10-26-26 urea to provide 63 + 40 + 40 ($N + P_2O_5 + K_2O$) per acre. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were broadcast on May 11, 1983. The plots were cultivated on June 21, 1983.

II. Soil Sampling and Analysis

A. 1982 Measurements

NO_3-N was the only variable measured in the fall of 1981. The values shown in Table 1 indicate some changes from those values one year earlier. In general the NO_3-N in the 0-2' zone decreased slightly in the manure treated plots and increased slightly in the 2-4' zone.

B. 1983 Measurements

The soils were sampled again to a depth of 4 feet for NO_3-N analysis but the results are not yet available.

III. Plant Tissue Analysis (Table 2)

There were significant effects on all elements except copper and manganese. There were some significant effects of solid beef manure on increasing leaf levels of P, K, and Fe and decreasing leaf levels of Mg and Zn as compared to the fertilized check. The effects of liquid beef manure were similar to those of solid beef manure but the effects were reduced.

IV. Growth and Yield Measurements (Table 3)

A. Early plant height and dry matter - Plants on the manure treated plots were taller (except for LB1) and weighed more (except for LB1) than on the fertilized check.

B. Grain - Yields of the solid beef manure treatments were not significantly different from the fertilized check, but the liquid beef manure treatments yielded significantly more than the fertilized check.

C. Silage - The LB1 and LB3 treatments yielded significantly less than the fertilized check.

V. Summary

The 1983 season was the fifth since manure had been applied. It appears that even the lowest rates of each manure were sufficient for grain yields equal to or higher than the fertilized check.

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

Table 1. Effect of two types of beef cattle manure and commercial fertilizer on the NO_3-N level of a Tara soil profile - Fall 1982.

Depth - ft -	Treatment CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				- NO_3-N, ppm -				
0-1	7.3	8.9	10.0	22.0	19.7	9.6	9.7	13.3
1-2	3.7	51.9	13.9	55.1	54.2	9.4	21.6	63.6
2-3	1.5	109.3	81.0	266.7	211.6	34.7	40.8	156.7
3-4	1.1	65.8	95.6	158.7	176.9	32.5	67.3	162.3

Table 2. Summary of analysis of corn leaves at silking - 1983.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.92	.18	1.52	.44	.43	78	13.6	5.7	69	5.3
FE	2.83	.23	1.70	.45	.40	86	19.0	5.7	87	6.1
SB1	2.73	.30	2.44	.42	.26	95	13.6	6.4	85	6.2
SB2	2.85	.42	2.83	.42	.22	105	14.5	5.4	83	6.3
SB3	2.79	.44	2.78	.36	.19	100	14.0	4.9	65	6.1
LB1	2.45	.25	1.86	.47	.37	88	14.5	6.4	88	6.2
LB2	2.66	.27	2.10	.45	.33	95	13.3	6.4	96	6.6
LB3	2.71	.34	2.35	.42	.27	101	12.1	5.2	80	6.4
Signif. level (%)	99	96	99	96	99	99	99	86	44	91
BLSD(.05)	.16	.06	.18	.07	.05	13	2.6	-	-	.9
CV(%)	3.8	11.8	5.1	8.0	9.8	7.4	10.2	12.6	18.2	7.1

Table 3. Summary of plant measurements - 1983.

Treatment	Early plant height inches	Early plants (10) dry weight grams	Grain: Moisture at harvest %	Grain: Yield @ 15.5% M Bu/A	Grain: Nitrogen %	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lbs/A	Silage: Ear wt. ÷ Silage wt. %
CK	21.0	28.7	36.6	74.8	1.15	43.0	8995	53.3
FE	23.7	38.7	34.9	116.6	1.51	39.7	14901	57.6
SB1	28.7	78.0	31.6	128.0	1.51	41.5	14354	58.2
SB2	31.6	96.7	29.5	117.1	1.59	36.8	14093	53.3
SB3	31.6	105.7	30.2	122.9	1.59	37.5	14985	54.3
LB1	24.0	39.3	35.2	131.5	1.41	40.8	13111	60.3
LB2	27.5	59.3	32.3	130.2	1.45	42.6	14600	60.6
LB3	29.3	80.0	31.9	129.4	1.54	38.5	13312	57.5
Signif. level (%)	99	99	99	99	99	99	99	99
BLSD(.05)	1.5	9.8	2.0	12.3	.07	2.6	1301	4.1
CV(%)	3.4	9.3	3.7	6.3	3.0	3.7	5.9	3.9

RESIDUAL EFFECT OF HEAVY APPLICATIONS OF ANIMAL MANURES ON CORN GROWTH AND YIELD AND ON SOIL PROPERTIES

West Central Experiment Station - Morris
S. D. Evans, P. R. Goodrich and R. C. Munter

The experiment initiated in 1970 was continued. Treatments and results from previous years are given in Soil Series 88, 89, 91, 95, 97, 99, 103, 105, 107, 109, and Misc. Publ. 2-1982 and 1983. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year.

I. Planting Information

Twenty-four rows of corn (var. Pioneer 3901) were planted in each plot on May 10, 1983. Counter at 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row at planting to all plots. The plots were fertilized on October 27, 1982, with 10-26-26 and urea to provide 63 + 40 + 40 ($N + P_2O_5 + K_2O$) per acre. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were broadcast on May 11, 1983. All plots were cultivated on June 21, 1983.

II. Soil Sampling and Analysis

A. 1982 Measurements

NO_3-N was the only variable measured in the fall of 1982. The values shown in Table 1 indicate that levels in most soil zones changed little in the past year. The total NO_3-N in the 0-4' profile was greater on all manure treatments than on the fertilized check.

B. 1983 Measurements

The soils were sampled again to a depth of 4 feet for NO_3-N analysis but the results are not yet available.

III. Plant Tissue Analysis

The nutrient concentrations in the ear leaves at silking in 1983 are given in Table 2. There were significant effects on most elements. The concentration of K was higher and Mg lower in all manure treatments than in the fertilized treatment. There were significant differences between at least one manure treatment and the fertilized treatment for N, P, Mg, Zn, Cu and B.

IV. Growth and Yield Measurements (Table 3)

A. Early plant height and dry matter - Plants on the manure treated plots were taller than those on the fertilized treatment. Dry matter differences were significantly higher on the manure treated plots.

B. Grain - There were no significant differences in grain yield. The grain N content of the LH treatment was significantly lower than that of the fertilized check.

C. Silage - There were no significant differences between the manure treatments and the fertilized treatment in silage yield.

V. Summary

The effects of the manure treatments applied in 1970 and 1971 still show up in most plant and soil measurements. Plant and soil analysis show that the liquid hog manure treatment is starting to lose some of its effect as compared to the other two manure treatments, but grain yield is still not significantly lower than the fertilized check.

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

Table 1. Effect of high rates of manure and commercial fertilizer twelve years (fall 1982) after application on the NO_3-N level of a Tara soil profile.

Depth - ft -	Treatment CK	FE	SB	LB	LB
			- NO_3-N, ppm -		
0-1	5.9	4.8	5.5	8.3	5.8
1-2	3.3	11.4	4.5	10.7	4.0
2-3	1.3	83.1	14.4	48.5	27.5
3-4	2.3	50.0	52.3	83.4	47.2

Table 2. Summary of analysis of corn leaves at silking - 1983.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.87	.17	1.49	.48	.44	78	14.2	5.9	80	4.9
FE	2.64	.24	1.73	.47	.41	90	19.2	4.7	74	5.9
SB	2.55	.30	2.57	.44	.24	109	17.9	6.4	88	6.0
LB	2.55	.37	2.64	.43	.23	102	12.5	5.9	70	5.7
LH	2.26	.28	2.29	.47	.32	117	21.0	7.0	75	6.5
Signif. level (%)	99	99	99	53	99	68	90	98	31	99
BLSD(.05)	.19	.06	.20	-	.10	-	7.7	1.3	-	.6
CV(%)	4.5	11.2	5.4	8.0	15.7	22.9	21.4	10.8	19.9	5.2

Table 3. Summary of plant measurements - 1982.

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M. Bu/A	Grain: Nitrogen %	Silage: Dry matter at harvest %	Silage: Silage yield (D.M.) lb/A	Silage: Ear wt. + silage wt. %
CK	18.7	25.3	37.2	64.3	1.07	43.0	9500	52.0
FE	22.3	37.0	35.1	126.3	1.46	40.2	14503	58.7
SB	28.2	75.0	31.6	129.4	1.39	42.0	14606	57.7
LB	28.2	77.7	32.6	129.9	1.39	39.2	15174	60.0
LH	25.0	55.7	33.7	108.8	1.37	40.9	13468	60.7
Signif. level (%)	99	99	99	99	99	76	99	99
BLSD(.05)	2.1	14.5	2.7	17.5	0.13	-	2011	4.1
CV(%)	4.8	14.9	4.1	8.7	5.3	4.7	8.1	3.7

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris
S. D. Evans

I. Experimental Description

In 1965 an experiment was initiated on McIntosh silt loam to determine the effect of removal of continuous corn silage and fertilizer on corn grain and corn silage yields and on soil properties. Rates of fertilizer used were 74 + 48 + 48 ($N + P_2O_5 + K_2O$) and 148 + 96 + 96. All plots received a broadcast application of 10 lbs/acre of zinc as zinc sulfate in the fall of 1965.

II. 1983 Operations

In 1983 the variety was Trojan TXS99. Counter was applied at 1 lb/acre (active ingredient) at planting on May 10. Lasso @ 2.5 lbs/acre plus Bladex @ 2.2 lbs/acre were applied broadcast on May 11. Silage yields were taken on September 19 and grain yields on September 27.

III. Silage Yields - Dry matter; tons/acre

Treatment	1983 yield	1966-83 yield
Silage, low fertility	6.49	5.68
Silage, high fertility	7.09	6.13
Grain, low fertility	6.58	5.70
Grain, high fertility	6.80	5.95

IV. Grain Yields - Bushels/acre @ 15.5% M.

	1983 yield	1966-83 yield
Grain, low fertility	104.76	90.48
Grain, high fertility	103.72	93.48

V. Check Yields

Yields on an additional unfertilized, unreplicated check adjacent to the experimental area:

	1983 yield	1966-83 yield
Grain (0 + 0 + 0)	31.49	47.98
Silage (0 + 0 + 0)	3.42	3.71

VI. Discussion

A. In 1983 there were no significant differences in silage yields but the silage high fertility plots yielded slightly more than the low fertility plots, especially where the silage was removed.

B. The 18-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

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COMPARISON OF TWELVE HARD RED SPRING WHEAT VARIETIES TO NITROGEN FERTILIZATION - MORRIS 1983

S. Comfort, G. Malzer, R. Busch, and S. Evans

Introduction

Maximizing the benefits of nitrogen fertilization depends largely on the responsiveness of the individual plant. Spring wheat genotypes, as with many other crops, differ considerably in growth response to increases in nitrogen fertilizer. The reason why some wheat varieties respond more to nitrogen fertilization than others in not well understood, but it has been suggested that it may be related to favorable plant characteristics both above and below the ground. The general objective of this study was to evaluate twelve spring wheat varieties under three different nitrogen rates. More specifically, the study intended to determine which varieties continued to show an increase in growth to added nitrogen and also which varieties performed better within an individual nitrogen rate. It was hoped that knowledge of varietal performances over a range of growing seasons would 1) aid in a more efficient use of nitrogen fertilizer for a specific variety and 2) aid in determining which varieties' morphological and physiological characteristics should be more critically examined.

Experimental Procedures

Twelve varieties of hard red spring wheat were compared at 0, 67, and 137 kg/ha at the West Central Experimental Station at Morris, Minn. Nitrogen was applied as a spring application of ammonium nitrate broadcast and incorporated. The field experiment was arranged as split plot design with nitrogen rates as the whole plot treatments and varieties as the subplot treatments. Varieties were planted in an area 5' x 20' utilizing a cone seeder. Each treatment was replicated four times.

Total plant dry matter production was determined at approximately the "soft dough" stage of growth and samples were collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested with a 3 row grain binder from a 14 ft.^{2} area. The above ground gorwth (grain and straw) was removed from the experimental plot and placed in a forced air dryer. After drying, the samples were thrashed and the grain reweighed for yield determination. Straw weight was determined by difference. Samples of both straw and grain were collected and analyzed for nitrogen content and determination of nitrogen removal.

General Results

As was to be expected, all varieties did not respond in a similar manner to increasing rate of nitrogen fertilization. Consequently a significant nitrogen rate x variety interaction was observed for all response parameters. Significant interaction of main effects necessitates the need to analyze 1) varietal differences within each nitrogen rate and 2) responsiveness of each variety to nitrogen fertilization. With this criteria, varietal comparisons can be made from Table 1.

With respect to yield, Mn73167, Mn 73168, and Butte had the highest yield at the zero N rate, while Mn 73167 and Mn7357 were among the highest yielding at the 67 kg N/ha rate of application, with Butte, Mn7125, Mn7357 and Olaf leading the group when 134 kg N/ha was applied.

Table 2 allows for the analysis of the ability of each variety to continue to respond to nitrogen fertilizer application. Of the varieties tested only Era and Olaf provided significant yield increases with the first increment of nitrogen fertilization. The yields of Coteau and Mn7125 were also significantly increased (comparing the control vs. the highest nitrogen rate) with fertilization. The other eight varieties tested did not respond to N fertilization.

Table 1. Comparison of yield, N content, and N removal for forage, straw and grain at 3 nitrogen rates on 12 varieties of hard red spring wheat. Location: Morris, MN 1983.

		FORAGE			STRAW			GRAIN		
	N RATE	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV
	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}	Mg ha^{-1}	g kg^{-1}	kg ha^{-1}
Butte	0	6.28	13.7	86.1	3.45	3.38	11.5	2.99	23.7	70.9
Coteau	0	5.78	16.0	93.2	3.11	4.65	14.2	2.30	28.6	66.5
Era	0	4.50	15.1	68.1	2.27	3.95	8.9	1.85	23.1	42.9
Marshall	0	5.91	14.2	84.1	2.81	4.33	12.2	2.79	24.1	67.3
Mn 7125	0	6.04	14.0	84.9	2.71	4.28	11.6	2.55	23.8	60.4
Mn 7222	0	5.46	14.8	80.5	2.74	4.15	11.2	2.69	23.5	62.8
Olaf	0	5.05	16.2	81.9	2.59	4.40	11.5	2.16	29.3	63.2
Thatcher	0	5.42	13.0	70.9	3.30	4.43	14.5	2.77	24.8	68.8
Mn 7357	0	6.69	13.7	91.4	2.92	3.80	10.9	2.94	23.1	67.7
Mn 73167	0	4.92	15.0	73.9	2.62	4.28	11.4	3.24	22.7	73.9
Mn 73168	0	6.96	14.6	101.2	2.80	3.83	10.7	3.09	23.4	72.1
James	0	5.93	15.4	91.7	3.69	4.05	15.0	2.61	26.9	70.4
HSD (.05)*		1.77	1.9	30.7	1.07	1.34	7.0	0.75	3.2	21.6
(.10)		1.63	1.7	28.3	0.98	1.23	6.5	0.69	2.9	19.9
Butte	67	7.19	16.5	118.9	4.20	5.28	22.4	3.35	27.5	92.0
Coteau	67	6.92	16.2	111.1	4.05	5.20	21.1	2.86	29.3	83.6
Era	67	6.52	16.6	109.0	3.42	5.15	17.7	3.14	24.1	75.3
Marshall	67	7.00	17.0	119.3	3.64	5.73	21.0	3.33	25.6	85.2
Mn 7125	67	6.94	18.4	100.2	3.23	4.93	16.2	3.08	23.4	72.2
Mn 7222	67	7.81	16.8	130.7	3.79.	4.78	18.1	3.16	25.5	80.7
Olaf	67	7.08	16.7	118.5	3.54	5.25	19.0	2.97	28.3	83.9
Thatcher	67	7.25	16.1	116.7	3.67	5.80	21.4	2.54	26.3	66.8
Mn 7357	67	7.66	16.2	123.9	3.90	6.13	23.7	3.45	23.5	81.1
Mn 73167	67	7.12	15.9	113.5	3.31	5.08	17.0	3.65	23.7	86.5
Mn 73168	67	6.11	16.2	100.3	2.28	5.68	12.9	2.27	24.9	56.5
James	67	7.32	16.4	119.5	3.85	5.13	19.7	2.81	29.3	81.9
HSD (.05)*		1.77	1.9	30.7	1.07	1.34	7.0	0.75	3.2	21.6
(.10)		1.63	1.7	28.3	0.98	1.23	6.5	0.69	2.9	19.9
Butte	134	7.63	18.1	137.8	4.50	6.15	27.7	3.53	28.1	98.9
Coteau	134	7.77	17.8	138.0	4.35	6.23	27.0	3.09	30.2	93.2
Era	134	7.50	17.1	127.8	3.99	7.48	29.8	3.31	25.6	84.5
Marshall	134	7.74	18.3	140.8	3.91	6.88	26.9	3.24	28.0	90.7
Mn 7125	134	7.15	16.1	115.6	4.05	6.40	26.0	3.48	23.6	82.1
Mn 7222	134	6.73	17.4	117.3	3.72	5.48	20.5	3.23	26.5	86.1
Olaf	134	7.43	18.2	135.0	4.27	6.90	29.4	3.41	28.6	97.5
Thatcher	134	7.28	16.4	119.0	3.80	6.73	25.5	2.60	27 7	71.5
Mn 7357	134	7.23	17.7	127.4	3.91	8.30	32.5	3.42	26.9	92.1
Mn 73167	134	6.62	18.0	119.7	4.09	6.60	26.8	3.21	27.7	89.0
Mn 73168	134	7.14	18.3	130.3	4.06	7.90	32.1	3.42	26.7	91.2
James	134	8.01	16.8	134.3	4.40	5.73	25.2	3.11	29.1	90.5
HSD (.05)*		1.77	1.9	30.7	1.07	1.34	7.0	0.75	3.2	21.6
(.10)		1.63	1.7	28.3	0.98	1.23	6.5	0.69	2.9	19.9

*HSD values for comparison of variety means within one nitrogen rate.

Table 2. Comparison of means for nitrogen rates within one variety for forage, straw and grain. Morris, Mn. 1983.

		------Forage------			------Straw------			------Grain------		
VARIETY	N RATE	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV	YIELD	N CONT	N REMOV
	kg/ha	Mg/ha	g/kg	kg/ha	Mg/ha	g/ha	kg/ha	Mg/ha	g/ha	kg/ha
Butte	0	6.28	13.7	86.1	3.45	3.38	11.5	2.99	23.7	70.9
	67	7.19	16.5	118.9	4.20	5.28	22.4	3.35	27.5	92.0
	134	7.63	18.1	137.8	4.50	6.15	27.7	3.53	28.1	98.9
Coteau	0	5.78	16.0	93.2	3.11	4.65	14.2	2.30	28.6	66.5
	67	6.92	16.2	111.1	4.05	5.20	21.1	2.86	29.3	83.6
	134	7.77	17.8	138.0	4.35	6.23	27.0	3.09	30.2	93.2
Era	0	4.50	15.1	68.1	2.27	3.95	8.9	1.85	23.1	42.9
	67	6.52	16.6	109.0	3.42	5.15	17.7	3.14	24.1	75.3
	134	7.50	17.1	127.8	3.99	7.48	29.8	3.31	25.6	84.5
Marshall	0	5.91	14.2	84.1	2.81	4.33	12.2	2.79	24.1	67.3
	67	7.00	17.0	119.3	3.64	5.73	21.0	3.33	25.6	85.2
	134	7.74	18.3	140.9	3.91	6.88	26.9	3.24	28.0	90.7
Mn 7125	0	6.04	14.0	84.9	2.71	4.28	11.6	2.55	23.8	60.4
	67	6.94	14.4	100.2	3.23	4.93	16.2	3.08	23.4	72.2
	134	7.15	16.1	115.6	4.05	6.40	26.0	3.48	23.6	82.1
Mn 7222	0	5.46	14.8	80.5	2.74	4.15	11.2	2.69	23.5	62.8
	67	7.81	16.8	130.7	3.79	4.78	18.1	3.16	25.5	80.7
	134	6.73	17.4	117.3	3.72	5.48	20.5	3.23	26.5	86.1
Olaf	0	5.05	16.2	81.9	2.59	4.40	11.5	2.16	29.3	63.2
	67	7.08	16.7	118.5	3.54	5.25	19.0	2.97	28.3	83.9
	134	7.43	18.2	135.0	4.27	6.90	29.4	3.41	28.6	97.5
Thatcher	0	5.42	13.0	70.9	3.30	4.43	14.5	2.77	24.8	68.8
	67	7.25	16.1	116.7	3.67	5.80	21.4	2.54	26.3	66.8
	134	7.28	16.4	119.1	3.80	6.73	25.5	2.60	27.7	71.5
Mn 7357	0	6.69	13.7	91.4	2.92	3.80	10.9	2.94	23.1	67.7
	67	7.66	16.2	123.9	3.90	6.13	23.7	3.45	23.5	81.1
	134	7.23	17.7	127.4	3.91	8.30	32.5	3.42	26.9	92.1
Mn 73167	0	4.92	15.0	73.9	2.62	4.28	11.4	3.24	22.7	73.9
	67	7.12	15.9	113.5	3.31	5.08	17.0	3.65	23.7	86.5
	134	6.62	18.1	119.7	4.09	6.60	26.8	3.21	27.7	89.0
Mn 73168	0	6.96	14.6	101.2	2.80	3.83	10.7	3.09	23.4	72.1
	67	6.19	16.2	100.3	2.28	5.68	12.9	2.27	24.9	56.5
	134	7.14	18.3	130.3	4.06	7.90	32.1	3.42	26.7	91.2
James	0	5.93	15.4	91.7	3.69	4.05	15.0	2.61	26.9	70.4
	67	7.32	16.4	119.5	3.85	5.13	19.7	2.81	29.3	81.9
	134	8.00	16.8	134.3	4.40	5.73	25.2	3.11	29.1	90.5
BSD(.05)*		1.28	1.8	24.6	0.90	1.14	6.7	0.61	2.24	17.2

*BSD values for comparison of nitrogen means for one variety

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT - 1983

West Central Experiment Station - Morris

S. D. Evans. W. E. Fenster, J. Grava and G. L. Malzer

The objective of this study was to compare nitrogen and phosphorus application methods on spring wheat. This is the third year of this study initiated to determine if dual banding of nitrogen and phosphorus is more effective than broadcast or drill applications on spring wheat growth and yield.

Experimental Procedures

Soil sample results prior to plowing in September are given in Table 1. In the late fall the plots were sampled by rep prior to fertilizer application and the results are given in Table 2. The broadcast 0-46-0 was applied by hand on November 6, 1982. The anhydrous ammonia and 10-34-0 were applied with a dual applicator on the same day. The material was placed at about an 8-inch depth with a knife spacing of 12 inches. The fertilizer bands in reps 1, 3 and 5 of treatments 3 and 11 were marked with red flags so that the bands could be located after harvest. In the spring on April 28 the area was field cultivated and drug. The study was then seeded to Era wheat @ 1 3/4 bu/A.

Whole plant samples were collected on July 20 and were used to calculate forage yield and N and P uptake. The plots were harvested on August 2 with a plot combine. On selected treatments soil samples after harvest were taken on September 2 and the results are given in Table 3.

Yield and Nutrient Uptake

The nutrient uptake and yield results are given in Table 4. Dry matter yield was significantly affected by N application but there were no significant differences in application methods. The highest yield was where 10 N and 10 P_2O_5 were drill applied and 90 N and 30 P_2O_5 were deep, dual banded (trt. 9).

The phosphorus concentration in the tissue at the soft dough stage decreased as N was increased with the dual NP placement method, but was not significantly affected by N with the other placement methods. There were some differences between placement methods at a given N rate, but there were no definite trends.

Phosphorus uptake did not increase with increased N except when the P was broadcast. At the 50 N rate the P uptake of the treatments where some N and P were drill-applied was lower than where the N and P were deep, dual banded. At the 100 N rate the deep, dual banded treatment had higher P uptake than the broadcast treatment and the treatment with no P applied.

The N concentration was significantly affected by N application rate with all placement methods. The only significant effect of application method was at 50 N where 10 N + 40 P_2O_5 drill applied had a significantly greater N percentage than three other treatments.

Nitrogen uptake in the tissue at the soft dough stage was closely related to N rate and was not significantly affected by application method.

Grain yield was significantly increased by N rate with deep, dual placement, NP2 drill and N only treatments. At the 50 N rate the N only treatment was significantly lower yielding than deep, dual placement and NP2 drill placement. At the 100 N rate the NP2 drill placement was significantly higher yielding than NP1 drill and N only placement methods.

Grain protein levels were closely related to N rate with values at the 100 N rate significantly higher than at the 50 N rate with all placement methods. The only difference between methods of placement was at the 100 N rate where NP2 drill > NP1 drill and N only > NP1 drill.

The 1983 study on placement methods shows very few effects of placement on any of the variables measured. In no case was there a significant difference between deep, dual banding (2 and 3) and broadcast (4 and 5). At the P soil test levels in this study there were no significant differences between deep, dual banding (2 and 3) and N only (10 and 11).

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

Soil Sampling of the Deep Bands

One problem associated with deep banding P is the method of obtaining accurate soil samples of the area banded. An attempt was made again in 1983 to see if the P level in the bands was different than the P level between the bands after harvest. Results in Table 3 compare the band and between band levels with the check treatment (no P) and the broadcast P treatment. The P soil test was determined by three methods.

There was a significant difference between the P soil test in the band compared to between the bands. Only with the Bray 1:50 was there a significant difference between the broadcast P treatment and the check. The between band P levels were not significantly different from the check P levels.

Table 1. Soil test results on September 9, 1982.

Soil Texture	pH	Bray P 1:10	Exch. K	NO_3-N (lb/A) 0-1'	1-2'	2-3'	3-4'	4-5'
SiCl	8.1	17 lb/A	275 lb/A	7	6	6	6	6

Table 2. Soil test results in November 1982.

Rep	P Soil Test Olson	Bray 1:10	Bray 1:50	Exch. K	Soil pH
	lb/A			- lb/A -	
1	13	23	55	283	7.9
2	15	21	50	294	7.8
3	12	20	50	242	7.8
4	12	20	45	270	8.0
5	14	21	50	235	7.9
6	13	24	50	257	7.8

Table 3. The effect of P application methods on P soil test (September 1983).

Trt. No.	P Placement Method	Sample Location	P_2O_5	P Soil Test Method[1] Olson	Bray 1:10	Bray 1:50
			- lb/A -	lb/A		
1	Check	-	0	7	10	27
3	Deep Band	In Band	40	18	17	48
		Between Bands	40	6	9	28
11	Deep Band	In Band	30	19	22	48
		Between Bands	30	9	13	32
5	Broadcast	-	40	11	12	38
Significance level (%):				99	98	99
BLSD(.05):				7	6	8
CV(%):				29	21	11

[1]Average of three replications, 4 subsamples per plot 0-10" deep, except for trt. No. 11 In Band and Between Bands where there were only two replications.

Table 4. The effect of N and P application methods on spring wheat.

Trt. No.	Treatment Description: Placement	Fertilizer Treatment: Source[1]	N	P_2O_5	Whole Plants @ Soft Dough Stage: D.M. Yield	Phosphorus	Phosphorus Uptake	Nitrogen	Nitrogen Uptake	Grain Yield	Grain Protein
			- lb/A -		lb/A	%	lb/A	%	lb/A	Bu/A	%
1	Check	-	0	0	1990	.247	4.95	1.26	25.1	20.2	12.6
2	Dual NP, Knife	AA,APP	50	40	6196	.212	13.12	1.34	82.7	52.9	12.8
3	Dual NP, Knife	AA,APP	100	40	6792	.173	11.78	1.58	107.5	57.3	14.4
4	N Knife, P BCST	AA,TSP	50	40	5992	.198	11.88	1.30	77.9	56.2	12.8
5	N Knife, P BCST	AA,TSP	100	40	6821	.205	13.97	1.52	103.9	57.1	14.3
6	N Knife, NP1 DRILL[2]	AA,UR,TSP	50	40	5717	.200	11.39	1.45	83.7	52.9	12.8
7	N Knife, NP1 DRILL[2]	AA,UR,TSP	100	40	6466	.187	12.17	1.59	103.3	53.7	14.0
8	N Knife	AA	50	0	6050	.196	12.00	1.31	79.5	49.9	13.2
9	N Knife	AA	100	0	6719	.178	11.94	1.65	109.9	56.1	14.8
10	NP Knife, NP2 DRILL[3]	AA,APP,UR,TSP	50	40	6093	.185	11.26	1.28	78.2	53.9	12.8
11	NP Knife, NP2 DRILL[3]	AA,APP,UR,TSP	100	40	6929	.185	12.72	1.61	111.5	60.4	14.6
Significance level (%):					99	99	99	99	99	99	99
BLSD(.05):					555	.025	1.6	0.13	12.4	3.9	0.4
CV(%):					8.9	11.1	13.0	8.3	13.6	7.3	3.0

[1]AA = Anhydrous Ammonia (82-0-0), APP = Ammonium Polyphosphate (10-34-0), TSP = Triple Super-Phosphate (0-46-0), UR = Urea (46-0-0).

[2]NP1 DRILL = 10 N + 40 P_2O_5 at seeding with drill.

[3]NP2 DRILL = 10 N + 10 P_2O_5 at seeding with drill.

SOIL TEST LAB COMPARISON

West Central Experiment Station - Morris
S. D. Evans and C. A. Schrader

In the past few years the number of commercial laboratories testing soils in west central Minnesota has increased. In many cases the commercial laboratory recommendations differ greatly from those of the University of Minnesota Soil Testing Laboratory. In order to develop educational material for use by the extension soils specialists, trials were started at the West Central Experiment Station in 1980 on a corn-wheat rotation. Results from the 1980, 1981 and 1982 trials were summarized previously (Soil Series 109 and Misc. Publ. 2 - 1982 and 1983).

In the fall of 1982 soil samples of the plow layer and the 0-2' zone (corn only) were taken from each plot except the check. The soil from the four replications was combined to make two samples (plow layer and 0-2') from each treatment. The samples were dried thoroughly, mixed and subdivided and sent to the same laboratory as that treatment in 1981. Recommendations were requested for corn at a yield goal of 130 Bu/A and spring wheat at a yield goal of 65 Bu/A. Analyses requested were (1) a complete analysis on the plow layer samples and (2) a nitrate-N analysis and recommendation on the 0-2' samples on the treatments to be planted to wheat. After receiving the soil tests and recommendations (Tables 1 and 2), the fertilizer treatments were calculated with an adjustment for soil buildup with Lab C. With Lab C there was no indication that the 0-2' sample was used for the nitrogen recommendation on wheat.

General

The experiment was set up as a randomized complete block with four replications on each crop. Two blocks, each with 24 plots, are adjacent to one another and alternate between wheat and corn. The plot size is 15 feet by 40 feet. Row spacing on the corn is 30 inches.

Wheat

Zinc, manganese and copper were dissolved in water and sprayed on the plots on November 11, 1982. The N, P, K and S were applied by hand on November 11 and all plots were then plowed. In the spring the plots were field cultivated and dragged. On April 25, 1983, the plots were seeded to Era wheat @ 1 3/4 Bu/A. Bromate was applied @ 1 pt/A on June 2 and on June 9 Hoelon was applied @ 3 1/3 pts/A. The plots were harvested with a plot combine on August 2.

Corn

Zinc, manganese and copper were sprayed on the plots on November 11, 1982. N, P, K and S were hand spread on November 11 and the area was plowed. On May 10, 1983, the area was field cultivated and dragged. The plots were planted with Trojan TXS 99A on May 11, with Counter @ 8.8 lbs/A. On May 11 the plots were sprayed with Lasso (2.5 lbs/A) and Bladex (2.2 lbs/A). The plots were harvested on September 27 with a plot combine.

Results and Discussion of the Wheat Trial

As shown in Table 1, the soil tests and fertilizer recommendations varied greatly with laboratory. Two labs recommended sulfur and one copper, zinc and manganese. The N, P and K recommendations had wide variations.

There were no significant differences between labs in plant height, grain yield or grain moisture.

The fertilizer cost and economic returns are given in Table 4. The fertilizer cost differed by $26 between Lab C and Lab E. The return over fertilizer ranged from $223.40 (Lab D) to $180.17 (Lab C). The check had the lowest returns.

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Results and Discussion of the Corn Trial

Soil tests varied widely, as shown in Table 2. Recommendations for N, P, and K were different, but the range was not as great as for the wheat. One laboratory recommended sulfur, zinc, copper and manganese.

Corn grain yields from Lab B were significantly lower than from all other labs. Lab E had a significantly lower grain moisture level than Labs A, B and C.

Fertilizer costs are given in Table 4. The costs ranged from $69.94 (Lab C) to $39.07 (Lab E). The economic return over fertilizer varied about $69/acre between labs.

Four-Year Summary

The combined data for 1980-1983 (Table 5) shows quite a range in the return over check. For wheat, Lab C shows the smallest return, while Labs A and E show the greatest return. For corn, three labs are still showing negative results, while Labs A and E are now showing a positive return. The combined results show a change in ranking of the labs, with Lab D switching from a negative to a positive return. After four years of testing, it appears that the recommendations by some labs of sulfur, micronutrients and high rates of P and K are not resulting in significantly higher yields than the University of Minnesota recommendations. On the other hand, some labs give recommendations that are similar to the University of Minnesota.

Table 1. Soil test results and the suggested fertilizer program for wheat in 1983.

	Soil Test Results				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	7.8	7.8	7.7	7.9	7.8
P (Bray 1), ppm	-	16(M)	-	-	-
($NaHCO_3$), ppm	14(H)	43(H)	16	17(H)	12
K, ppm	136(H)	191(H)	158	146(H)	153
O.M., %	4.0	3.3(H)	5.3	M	H
Ca, ppm	3800	3050(H)	4363	4200(H)	-
Mg, ppm	565	473(VH)	605	620(H)	-
Na, ppm	9	3050(H)	19	-	-
S, ppm	8(M)	5(L)	-	11(MH)	1
Fe, ppm	16.5(VH)	20(H)	-	14(H)	-
Mn, ppm	3.8(H)	6(L)	-	5.1(ADQ)	-
Zn, ppm	1.45(H)	2.0(M)	-	1.6(H)	1.9
Cu, ppm	.55(H)	0.8(L)	-	.6(H)	-
B, ppm	-	1.4(H)	-	1.7(M)	-
ENR (lb/A)	-	96	-	-	-
Nitrate-N (lb/A)	32	22(M)	-	58	31
C.E.C. (meq/100 g)	24	19.7	30.1	-	-
Soluble salts (mmhos/cm)	.40	-	.15	-	-

	Suggested Fertilizer Program[1]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
	(lb/A)				
Nitrogen	88	57	110	62	90
Phosphorus (P_2O_5)	41	55	50	15	30
Potassium (K_2O)	42	55	160[2]	30	0
Sulfur	0	12	-	20	-
Zinc	0	1.5	-	0	-
Manganese	0	3	-	-	-
Copper	0	0.5	-	-	-
Boron	-	-	-	-	-

[1]All values indicate pounds of nutrient suggested per acre for a yield goal of 65 bushels per acre for wheat.

[2]Values include maintenance plus 1/2 of suggested buildup.

Table 2. Soil test results and the suggested fertilizer program for corn in 1983.

Test	Soil Test Results				
	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	8.0	8.0	7.9	8.0	8.0
P (Bray 1), ppm	-	8(L)	-	-	-
($NaHCO_3$), ppm	7(L)	36(M)	15	11(M)	5.5
K, ppm	98(M)	145(M)	130	121(H)	119
O.M., %	3.4	2.8(M)	2.9	(ML)	-
Ca, ppm	4700	3270(H)	5095	4400(H)	-
Mg, ppm	2009	386(VH)	516	700(H)	-
Na, ppm	6	-	14	-	-
S, ppm	4(L)	6(L)	-	12(MH)	2
Fe, ppm	9.2(H)	14(M)	-	13(H)	-
Mn, ppm	5.8(VH)	7(L)	-	8.3(ADQ)	-
Zn, ppm	1.02(H)	1.6(M)	-	1.4(H)	1.2
Cu, ppm	.56(H)	0.8(L)	-	.58(H)	-
B, ppm	-	1.2(M)	-	1.9(M)	-
ENR (lb/A)	-	86	-	-	-
Nitrate N (lb/A)	-	-	-	4	-
C.E.C. (meq/100 g)	-	19.9	30.1	-	-
Soluble salts (mmhos/cm)	.30	-	.15	-	-

Nutrient	Suggested Fertilizer Program[1]				
	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
	(lb/A)				
Nitrogen	132	160	145	150	90
Phosphorus (P_2O_5)	103	90	90	85	90
Potassium (K_2O)	73	100	240[2]	100	40
Sulfur	0	14	0	0	0
Zinc	0	2.5	0	0	0
Manganese	0	3	0	0	0
Copper	0	1	0	0	0
Boron	0	0	0	0	0

[1]All values indicate pounds of nutrient suggested per acre for a yield goal of 130 bushels of corn per acre.

[2]Values include maintenance plus 1/2 of suggested buildup.

Table 3. Effect of fertilizer recommendations on various plant measurements - 1983.

Lab	Corn				Wheat		
	Early Plant Height	Early Plants (10) Dry Weight	Grain Yield	Grain Moisture	Plant Height at Harvest	Grain Yield	Grain Moisture
	- in -	- grams -	-Bu/A-	%	- in -	-Bu/A-	%
A	29.8	78	116.4	28.2	24.2	60.4	13.1
B	29.9	82	103.5	28.2	25.0	60.2	13.4
C	29.4	77	116.6	28.1	23.8	56.6	13.3
D	31.0	89	114.1	26.6	24.2	61.0	13.4
E (UM)	31.4	92	117.6	25.4	25.5	57.7	13.5
Check	28.2	67	77.4	30.4	24.0	42.5	14.0
Signif. level (%)	97	94	99	99	77	99	84
BLSD (.05)	2.0	19	11.2	2.3	-	10.6	-
CV (%)	4.1	13.3	2.0	2.2	4.3	2.3	2.7

Table 4. Economic return over fertilizer costs - 1983.

	Wheat				Corn			
Lab	Value of crop @ $4/Bu	Fertilizer cost*	Return over fertilizer	Return over check	Value of crop @ $3/Bu	Fertilizer cost	Return over fertilizer	Return over check
	$/A							
A	241.60	27.25	214.35	44.25	349.28	51.99	297.29	65.18
B	240.80	40.10	200.70	30.60	310.43	65.20	245.20	78.32
C	226.30	46.13	180.17	10.07	349.95	69.94	280.01	117.84
D	243.80	20.32	223.40	53.38	342.30	53.35	288.95	110.19
E (UM)	230.90	20.07	210.83	40.73	352.80	39.07	313.73	120.69
Check	170.10	0	170.10	-	232.11	0	232.11	-

*Values used ($/lb) were as follows: N = $0.14, P_2O_5 = $0.24, K_2O = $0.12, S = $0.22, Zn = $0.38, Cu = $2.80.

Table 5. Four-year summary of yields and economic returns - 1980-83.

	Wheat*				Corn**				Combined
Lab	Total 4-year Yield	Total 4-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Total 4-year Yield	Total 4-year Fertilizer Cost	Economic Return over Fertilizer	Return over Check	Average Return per Year
	- Bu/A -	$/A			- Bu/A -	$/A			- $/A -
A	226.9	98.98	808.62	101.82	456.7	197.63	996.79	33.54	33.84
B	236.2	155.07	789.73	82.93	451.6	231.42	941.21	-22.04	15.22
C	232.40	198.78	730.82	24.02	465.5	267.90	949.53	-13.72	2.58
D	219.40	103.85	773.75	66.95	456.6	232.85	960.27	-2.98	15.99
E (UM)	228.6	82.18	810.55	103.75	458.2	161.32	1035.70	72.45	44.05
Check	176.7	0	706.80	-	370.3	0	963.25	-	-

*Wheat valued at $4/Bu, 1980-83.

**Corn valued at $3.00, $2.40, $2.00, and $2.50/Bu in 1980, 1981, 1982, and 1983, respectively.

PROBLEMS WITH IRRIGATED CORN 1983

W. E. Fenster, Mike O'Leary and Greg Buzicky

In 1982 field experiments were initiated at two irrigated sites, the CMIDRF at Staples and Roth farm northeast of Staples. Both areas had sandy textured soils. The objective was to probe possible causes for apparent corn yield restrictions.

County Agricultural Agents and irrigator farmers in recent years have reported corn production problems where corn yields appear to be on the decline. In 1979 two farmers in Morrison County complained that yields dropped by two-thirds from the year before. In 1980 and 1981 the Wadena County Agricultural Agent reported similar problems.

Treatments of the experiment are shown in table 1 along with 1983 corn yields at Staples. The Roth farm site was not in Corn in 1983 but the study will be resumed there in 1984.

Yield data in 1982 from the Roth farm indicated a significant response to nitrogen, and a significant benefit from the use of the inhibitor "N-Serve" but no benefit from boron even though plant analysis of the corn leaf at silking time showed below sufficient levels of boron. The Staples site showed no benefit from the inhibitor, the sulfur, the boron, or from split application of N in 1982.

Data from the Staples farm in 1983 show a significant response to nitrogen. The 80 pounds per acre N treatment at the eight leaf stage plus inhibitor provided significantly higher yield than 160 pounds of N per acre added preplant, also highest yield was attained with 160 pounds per acre of N plus inhibitor added at the eight leaf stage. With no inhibitor the treatment of 160 pounds in split applications added at eight leaf, 12 leaf and tasselling stages gave similar yields. The 200 pound N with inhibitor treatment gave no further yield increase over the 160 pound treatment with inhibitor There is no significant increase in yield from magnesium or sulfur when used as starter also with NPK fertilizer.

The efforts on this project of Todd King, Negussie Berihun and Mel Wiens are acknowledged.

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

Table 1. Nutrient treatments on corn at various growth stages at the Staples irrigation farm. 1983.

Trt	Total[2/] #N/A	Broadcast Nitrogen -----Amount and time of application------ ppl[1/]	8 leaf[1/]	12 leaf	Tassel	Starter[2/] N	P	K	S	Mg	Yield Bu/A @ 15.5% moist
1	20	--	--	--	--	+	+	+	+	+	66
2	100		80+			+	+	+	+	+	124
3	180	160				+	+	+	+	+	91
4	180	160+				+	+	+	+	+	136
5	180		160+			+	+	+	+	+	149
6	180	80+	80			+	+	+	+	+	146
7	180		80	40	40	+	+	+	+	+	145
8	180		80+	40	40	+	+	+	+	+	137
9	220	200				+	+	+	+	+	139
10	220	200+				+	+	+	+	+	138
11	220		80	80	40	+	+	+	+	+	141
12	220		80+	80	40	+	+	+	+	+	141
13	220		80+	80	40	+	+	+	-	+	143
14	220		80+	80	40	+	+	+	+	-	147
15	220		80+	80	40	+	+	+	-	-	134
16	220		80+	80	40	-	-	-	-	-	132

Trts	1-12	12-16
Significant	**	ns
BLSD (.05)	12.0	--
C.V.	7.6	7.8

Soil test averages: pH - 6.4, P - 54 lb/A, K - 319 lb/A, Mg - 242 lb/A, S - 5 ppm, Zn - 4 ppm.

[1/] + associated with N rate indicates use of N-Serve (1/2 lb/A a.i.)

[2/] 20 #N, 20 #P_2O_5, 40 #K_2O
10 #S and 10 #Mg applied per acre as starter

Table 2. Plant analysis of corn of the 6th leaf. Staples farm 1983.

Treatment	P (%)	K (%)	S (%)	M (%)	B (ppm)
12	.30	2.78	.22	.16	6
13	.30	2.82	.21	.16	7
14	.29	2.28	.20	.26	6
15	.30	2.68	.20	.16	7
16	.28	2.81	.20	.16	5
Adequate levels	.25	1.75	.20	.16	6

Table 3. Nitrogen content in 6th leaf at tasselling time from various nitrogen treatment rates and methods. Staples farm 1982 and 1983.

Treatment	N rate lb./A	1982	1983
1	0	2.08	1.67
2	80	2.48	2.68
3	160	2.93	1.99
4	160+	--	2.74
5	160+	2.97	2.81
6	80+ + 80	3.29	2.70
7	80 + 40 + 40	3.03	3.04
10	200+	3.39	3.18
Adequate		2.70	

+means inhibitor added

CORN - BEAN ROTATION

H. Meredith, Melvin Wiens and Greg Buzicky

A corn-bean experiment initiated in 1981 at the Staples Station to evaluate corn yields under a regime of continuous corn and corn following soybeans or edible beans continues.

Pioneer 3978 (85-day) and 3906 (95-day) relative maturity hybrids and Seafarer Navy beans and clay soybeans are utilized as the test crops in the experiment.

Purpose of Study: This study was initiated following complaints from farmers and extension personnel of the inability to meet corn yield expectations under irrigation on the sand plain. It is recognized that consistently high yields result from the best combination of management and climate. Temperatures ranging from excessively low spring and early fall to high summer offer adequate opportunities for havoc. Rainfall, both too little and too much on these coarse textured soils creates severe management problems. Typically farmers are ill prepared to supply sufficient irrigation water during periods of severe heat stress. Excess precipitation, especially following irrigation, may result in removal of nitrate nitrogen and possibly other vital soluble nutrients as sulfur from the rooting zone.

This study attempts to apply the best cultural management practices coupled with emphasis on timely irrigation and nutrition adequacy.

Table 1. Yield and Corresponding Information

Treatment	Bu/A	Shelling %	% Moisture	Grain Yield T/A	Stover Yield T/A	Grain/Stover	Total Tons
(1) C-C 3978	135.2	90.0	23.5	3.20	1.96	1.63	5.16
(2) C-C 3906	150.4	89.4	29.2	3.56	2.50	1.42	6.06
(3) C-SB 3978	148.2	89.7	22.5	3.51	2.28	1.54	5.79
(4) C-EB 3978	147.3	90.4	23.4	3.48	1.99	1.75	5.48
(7) C-C 3906 + Zn*	155.0	89.0	28.7	3.67	2.52	1.46	6.19
Sig	NS	NS	**	NS	**		*
P-value	85	88	99	85	99		97
BLSD	--	--	1.5	--	.36		.66
C.V.	6.9	.8	4.1	6.9	10.0		7.0

*Received Zinc in 81, 82, and 83, all other plots received zinc only in 1983.

C-C Continuous corn
C-SB Corn following soybeans
C-EB Corn following edible beans

Table 2. Fertilizer Applied to Corn Plots

	Broadcast	Starter	Total
N	180	18	198
P_2O_5		46	46
K_2O	240	60	300
Zinc		12.6	12.6

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Table 3. Supplemental Information

Date of planting:	4/28	Harvest:	10/10
Seed dropped/A:	32,000	Herbicide:	Lasso 2 qts/A (4/4)
Emergence date:	May 11		2,4-D, Banvel (8/1)
Tassel began:	7/10	Irrigation:	12.2 in.
		Rainfall (May-Aug)	16.46 in.

On May 16 a minimum temperature of 24°F was recorded at the Staples Station (approximately 5½ feet above grass under a shaded canapy). Obviously the ground temperature in the field was much lower, possibly as low as 18°F or lower. The corn was approximately 1 to 2 inches tall on this date. The growing point was well below the frost area although the ground was frozen, at least on the surface. The corn leaves suffered severe burn. The damage would have been lessened had near ideal temperatures prevailed after the freeze. Contrarily, overcast cold weather followed.

On May 16 or 10 days following the freeze "buggy whipping" was observed on many plants. Stand counts on May 31, 25 days following the freeze, indicated variations due to the freeze. Although stands were not reduced considerably, skips did occur in the plots contributing to some variability. Stand counts ranged from 28.8 to 31 thousand/A.

Table 4. Additional Information on Total Nutrient Removal

Treatment	Total N Removed Pounds/A	Total P Removed	Total K Removed	Total Ca Removed	Total Mg Removed	Total Zn Removed
	Pounds/A					
1	113.1	19.3	94.7	16.8	13.9	.19
2	148.0	25.3	118.4	22.0	16.3	.22
3	127.1	21.4	107.9	19.4	14.7	.20
4	123.8	22.0	100.3	16.8	13.8	.20
7	158.4	26.4	116.6	21.9	17.3	.25
Sig	**	*	*	NS	**	**
P-value	99	98	95	93	99	99
BLSD	13.2	4.2	18.8	--	2.1	.02
C.V.	6.8	11.4	10.3	15.5	8.6	6.0

Table 5. Nutrient Content of Corn Grain

Treatment	N	P	K	Ca	Mg	Zn	Cu	B	MN	Na	Fe	Al
	Percent					PPM						
1	1.33	.25	.39	.004	.107	22.0	2.16	24	4.3	.94	16.6	.40
2	1.62	.31	.40	.005	.139	23.6	.78	3.6	6.8	.94	24.6	.40
3	1.37	.26	.38	.004	.110	21.5	1.63	2.5	4.7	.94	17.6	.40
4	1.36	.27	.40	.004	.109	22.5	1.87	2.4	4.3	1.08	17.8	.40
7	1.65	.31	.39	.005	.138	25.6	1.31	3.7	6.8	.94	25.2	.40
Sig	**	**	NS	*	**	*	*	**	**	NS	**	
P-value	99	99	20	98	99	97	98	99	99	65	99	
BLSD	.06	.04	-	.007	.015	2.6	8	.2	.77	-	2.6	
C.V.	3.1	8.7	7.3	8.8	8.4	23	30.5	5	9.9	12.4	8.8	

Table 6. Nutrient Content of Corn Stover

Treatment	N	P	K	Ca	Mg	MN	Zn	Cu	B
	- - - - - - -		%	- - - - - - - -		- - - - - - -		PPM	- - - - - -
1	.72	.08	1.8	.42	.18	60.8	13.0	2.6	7.0
2	.65	.06	1.8	.43	.13	60.2	10.0	2.5	7.1
3	.69	.07	1.8	.42	.15	55.1	11.4	2.2	6.6
4	.72	.09	1.8	.42	.16	56.4	11.5	2.4	6.3
7	.75	.08	1.7	.43	.14	58.9	13.6	2.7	7.2
Sig	NS	NS	NS	NS	**	NS	NS	NS	*
P-value	84	79	2	2	99	45	87	56	95
BLSD	-	-	-	-	.02	-	-	-	.7
C.V.	7.4	20.1	10.7	8.9	7.4	10.7	15.9	16.5	6.0

Table 7. Leaf Tissue Analyses, Sampled at Silking and at Later Intervals

Date	N	P	K	Ca	Mg	MN	Zn	Cu	B
	- - - - - - -		%	- - - - - - - -		- - - - - - -		PPM	- - - - - -
7/22 L	2.66	.31	3.0	.59	.18	60	19	4.0	5.7
8/4 L	2.90	.31	2.6	.80	.23	70	19	4.8	8.8
8/4 H	3.11	.34	2.0	.71	.22	67	33	4.4	12.6
8/15 L	2.67	.27	2.4	.87	.26	81	20	5.1	11.5
8/15 H	2.79	.27	1.8	.86	.27	76	30	5.4	14.4

7/22 L Leaf opposite and below ear
8/4 L " " " " "
8/4 H " " " above "
8/15 L " " " below "
8/15 H " " " above "

Hybrid 3978. 7/22 sampling at 90% silk stage.

Uptake of Residual Fertilizer Nitrogen by Irrigated Barley

by Gregory C. Buzicky

When nitrogen (N) fertilizer is applied to the soil a portion is immobilzed by soil microbes and comes incorporated in the soil organic matter. This nitrogen, referred to as residual fertilizer nitrogen, is slowly mineralized over a period of years. The objective of this study was to determine the amount of residual fertilizer N taken up by subsequent crops one and two years after fertilizer application and to determine if subsequent N applications would affect the uptake of the residual fertilizer nitrogen.

Experimental Procedure. The experimental site was located at the Staples Irrigation Center and Demonstration Farm on a Sverdrup sandy loam. This site recieved 300 lbs N/A in 1980. Eight microplots (10' by 3') recieved N as approximately 5 % atom enriched 15-N. Four of the eight microplots recieved 15-N as ammonium chloride (NH_4Cl) while the other four recieved 15-N as calcium nitrate ($Ca(NO_3)_2$.

The treatments applied in 1981 and 1982 were 40 or 80 lbs N/A as ammonium nitrate in split applications (2/3 planting,1/3 boot). Soil test results from the site were: O.M.-2.7, pH-7.1, P-71, K -221, S-3. The plot area recieved approximately 6 acre-inches of supplemental irrigation each year.

In 1981, following broadcast application of 40 lbs K_2O/A and 20 lbs S/A and disking, Morex barley was planted on 4/16 at a rate of 96 lbs/A with 10 lbs P_2O_5/A as starter. Bromoxynil was sprayed on 6/3 for weed control and the boot application of N was applied. Forage yields were taken at the hard dough stage on 7/2 from the 15-N microplot areas. Soil samples for 15-N analysis were taken at this time also. Plots were harvested for yield on 7/27.

In 1982, following application of 50 lbs/A Sul-Po-Mag and seedbed preparation, Morex barley was planted on 4/27 at a rate of 96 lbs/a with 10 lbs P_2O_5/A as starter. Weed control was achieved with applications of dicloflop (Hoelon) on 6/4 and Bronimal+ on 6/15. Diathane M-45 was sprayed on 6/19. Forage yields were taken from microplots on 7/20 with yield determinations made on 8/6.

The forage samples were used for maximum plant growth and 15-N determinations. The soil samples were taken at this time were analysized for 15-N atom enrichment in the 0-9" and 9-18" increments. Standard precationary procedures for 15-N determinations were observed in sampling, handling and processing of the soil and plant 15-N samples.

Results. As would be expected on a coarse textured, irrigated soil, there was a yield and N uptake response to increased N application in both years (Tables 1 and 2). Grain yields were not as high as would be desired due to severe outbreak of Helminthosporium net blotch and Alteneria. Although the plots were sprayed with fungicide in 1982, control was minimal. However, forage yields were not thought to be affected to the same extent as the grain.

The influence of rate of N application on the amount of residual fertilizer N taken up in 1981 and 1982 by barley at the hard dough stage is presented in Table 3. Residual fertilizer N contributed only a small amount of nitrogen to the plant with only 2 to 3 lbs/A of residual fertilizer N utilized by the first subsequent crop and about 1 lb/A was taken up by the barley in the second residual year. While nitrogen applications affect yield and total N uptake, the uptake of residual fertilizer N was not influenced.

Some large differences were noted in the uptake of residual fertilizer nitrogen with respect to the original source of fertilizer N. The influence of the original source of N fertilization was investigated and this data is presented in Table 4. Significant differences were noted in the total amount of residual fertilizer N taken up by the barley in both years. Also, the percent of nitrogen derived from the 1980 fertilizer is significantly different depending on the origin of the N source. If the source was ammonium, then 6% of the N in the barley was residual fertilizer N in 1981 and 2% in 1982. With the nitrate source, 3.3% of the N in the plants was due to residual fertilizer N in 1981 and 1.3% in 1982. The percent N recovered, based on the original 300 lbs N/A application, differs significantly for both years. However, in 1981 and 1982, the percent recovered based on how much was in the soil at the start of each year is not significantly different. This would indicate that the mineralization and/or availability of the residual

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fertilizer N is similiar regardless of the original source and that the amount of residual fertilizer N taken up by plants is largely dependent on the amount of fertilizer N immobilized and how recent that the immobilization occurred.

The amount of residual fertilizer N found in the upper 18" of soil at the start of the study and after each cropping year is presented in Table 5. The nitrogen from the ammonium source was immobilized to a greater degree than the nitrogen from the nitrate source. These differences remained throughout the duration of the study and resulted in the differential uptake of residual fertilizer N. Significant differences existed in the 0-9" increment but this was not the case in the 9-18" increment. With the exception of the nitrate source in 1981 to 1982, a small loss of residual fertilizer nitrogen was detected each year. This agrees with the plant uptake of residual fertilizer N discussed earlier.

Summary. A portion of applied fertilizer N is immobilized in the soil and is slowly mineralized over a period of time and can be referred to as residual fertilizer N. The uptake of residual fertilizer N, under conditions of this study, was only 1-3 lbs/A per year depending on the number of years since application. The amount of residual fertilizer N used by subsequent crops was dependent on the amount of N that was initially immobilized in the soil and was not affected by crop yield or subsequent N fertilization. Nitrogen applied in the ammonium form was immobilized to a much greater extent than the nitrogen applied in the nitrate form.

Table 1. Yield and quality parameters of barley grown under irrigation as influenced by N rates, 1981.

Rate	Grain				Forage		
	Yield	Test wt.	N	Plump	Yield	N	N Removed
lbs/A	bu/A	lbs/bu	------%	-------	lbs/A	%	--lbs/A--
0	22.8	44.4	2.03	73	2460	.98	24.1
40	41.0	43.6	1.80	76	4580	1.01	46.2
80	51.2	43.8	2.01	74	5334	1.26	67.3
Sig. Level	99	57	27	66	99	99	99
BLSD (.05)	10.1	--	--	--	618	.16	13.0
C.V.(%)	38.1	2.2	10.7	6.6	10.0	9.1	18.2

Table 2. Yield and quality parameters of barley grown under irrigation as influenced by N rates, 1982.

Rate	Grain				Forage		
	Yield	Test wt.	N	Plump	Yield	N	N Removed
lbs/A	bu/A	lbs/bu	------%	-------	lbs/A	%	--lbs/A--
0	30.7	40.4	2.00	57	2050	1.40	28.6
40	44.1	40.0	1.94	58	4248	1.09	46.2
80	58.2	40.4	2.09	56	5128	1.26	64.9
Sig. Level	99	61	34	79	99	99	99
BLSD (.05)	13.8	--	--	--	916	.12	12.3
C.V.(%)	19.2	1.6	6.5	9.1	15.5	6.3	16.8

Table 3. N uptake, residual fertilizer N uptake and % N derived from 1980 applied N fertilizer as influenced by rate.

Year	Rate	Total N Removed	1980 Fert. Removed in 1981 Crop	% N Derived from 1980 Fertilizer	% Recovered from 1980 Fertilizer	% Recovered from Amount in Soil F,1980	% Recovered from Amount in Soil F,1981
	lbs/A	lbs/A	lbs/A	%	%	%	%
1981	40	45.0	2.3	4.95	.76	7.89	--
	80	67.3	3.0	4.38	.99	7.73	--
Sig.		*	ns	ns	ns	ns	--
1982	40	46.2	0.8	1.69	.26	2.67	3.05
	80	65.7	1.0	1.56	.33	2.60	3.02
Sig.		*	ns	ns	ns	ns	ns

Table 4. N uptake, residual fertilizer N uptake and % N derived from 1980 applied N fertilizer as influenced by original N source.

Year	Fert. Source	Total N Removed	1980 Fert. Removed in 1981 Crop	% N Derived from 1980 Fertilizer	% Recovered from 1980 Fertilizer	% Recovered from Amount in Soil F,1980	% Recovered from Amount in Soil F,1981
		lbs/A	lbs/A	%	%	%	%
1981	Nitrate	50.1	1.6	3.31	.54	6.62	--
	Ammonium	62.2	3.6	6.01	1.21	8.50	--
Sig.		ns	*	+	*	ns	--
1982	Nitrate	50.4	0.6	1.28	.21	2.55	3.24
	Ammonium	60.7	1.2	1.96	.38	2.69	2.93
Sig.		ns	**	+	**	ns	ns

Table 5. Fertilizer N remaining in 0-9", 9-18" and 0-18" soil increments as influenced by the original N source.

Fertilizer Source	Fertilizer N Remaining in Soil								
	Fall, 1980			Fall, 1981			Fall,1982		
	0-9"	9-18"	0-18"	0-9"	9-18"	0-18"	0-9"	9-18"	0-18"
	lbs Residual Fertilizer N/A								
Nitrate	19.2	5.1	24.3	15.5	3.6	19.1	15.1	4.0	19.1
Ammonium	37.0	5.7	42.7	35.3	4.0	39.3	32.5	4.7	37.2
Sig.	*	ns	*	**	ns	**	*	ns	*

SOUTHERN EXPERIMENT STATION - WASECA

WEATHER DATA - 1983

Month	Period	Precipitation 1983	Precipitation Normal 1/	Avg. Air Temp. 1983	Avg. Air Temp. Normal 1/	Growing Degree Days 1983	Growing Degree Days Normal 1/
		-----inches------		-------°F--------			
January	1-31	0.87	0.84	17.0	10.0		
February	1-28	1.17	0.99	23.0	16.4		
March	1-31	4.92	1.99	30.6	27.6		
April	1-30	4.28	2.64	39.0	44.7		
May	1-10	2.39		50.6		53.5	
	11-20	1.63		53.4		69.5	
	21-31	0.92		55.3		89.0	
	Total	4.94	3.76	53.2	57.7	212.0	334
June	1-10	0.07		59.7		111.5	
	11-20	1.27		66.9		171.5	
	21-30	3.12		72.6		215.5	
	Total	4.46	4.48	66.4	67.1	498.5	518
July	1-10	4.26		71.7		211.0	
	11-20	1.03		78.2		266.0	
	21-31	0.01		76.3		273.0	
	Total	5.30	4.02	75.4	71.2	750.0	641
August	1-10	0.00		75.6		236.0	
	11-20	0.05		75.0		241.0	
	21-31	4.56		74.2		261.0	
	Total	4.61	3.99	75.0	68.8	738.0	579
September	1-30	4.23	3.36	61.4	59.8	292.5	311
October	1-31	3.15	2.08	48.2	48.9	0.0	38
November	1-30	4.73	1.43	33.8	32.5		
December	1-31	1.96	1.02	-0.1	18.0		
Year	Jan-Dec	44.62	30.60	43.6	43.6	2491.0	2421
Growing Season	May-Sep	23.54	19.61	66.3	64.9	2491.0	2383

Notes:

1) 30-year normal from 1951-1980.
2) Highest temp. on July 22 -- 96°.
3) Highest 24-hour precipitation on July 1 -- 3.45".
4) Growing degree days were 3% above normal.
5) Available soil moisture in 0-5' profile was below 60% of field capacity in mid-August.
6) Last spring frost -- April 20.
7) Frost on September 23.

ROTATION NITROGEN STUDY

Waseca, 1983

G. W. Randall and D. T. Walters

Increasing the efficiency of fertilizer N along with reducing fertilizer N recommendations by improved diagnostic techniques, symbiotic N fixation, crop rotation, etc. are goals which are gaining widespread research support throughout the United States. The adoption of crop rotations or sequences may play a vital role in the conservation of N. The purpose of this study is to determine the N needs of continuous corn (removed for grain), corn removed for silage, second year corn following soybeans, corn following soybeans and corn following wheat.

EXPERIMENTAL PROCEDURES

Four crop sequences (continuous corn, corn-soybean, corn-wheat and corn-wheat + alfalfa) were begun in 1974 on a Webster clay loam. Each N plot within each crop sequence is 15' wide (6 rows) by 50' long. Rates of N (0, 40, 80, 120, 160 and 200 lb N/A) have been applied annually to corn.

The corn-wheat + alfalfa sequence was dropped in 1981 in favor of a continuous corn system where all of the corn was removed as silage the preceding year. This gives us a comparison of the N needs between grain removal only compared to total above-ground biomass removal. In 1982, a C-C-Sb rotation was introduced to examine the N needs of second-year corn following soybeans.

In 1983, anhydrous ammonia was applied on April 29 to all corn plots. Wheat received 50 lb N/A as urea before planting. Broadcast P and K of 50 + 150 lb P_2O_5 and K_2O/A were applied in the fall of 1982 before moldboard plowing all plots. Starter fertilizer was not applied.

Each corn plot was split lengthwise and two corn hybrids (Pioneer 3732 and Pioneer 3906) were planted in 30" rows at 29900 ppA on May 4. Amaze was applied to all corn plots at 1 lb/A to control rootworms. Butte wheat was planted on May 5. Hardin soybeans were planted on May 24.

Weeds were chemically controlled along with one cultivation of the corn. A combination of 4 qt Lasso plus 3 lb Bladex/A was applied preemergence to corn. Soybeans received 4 qt Lasso plus 6 qt Amiben/A applied preemergence.

Corn leaf samples were taken at silking from rows 2 and 3 (Hybrid A) and from rows 4 and 5 (Hybrid B) of each 6-row plot. Corn yields were taken by mechanically harvesting the same rows. Grain moisture and grain N data were obtained on the harvested samples.

After the 1982 harvest, soil samples were taken in the fall to a depth of 5' from the 0 and 160-lb N treatments which were applied to the continuous corn and continuous corn (silage) rotations in 1981. The same depth soil samples were also taken from the 0-lb N treatments in the plots where soybeans and wheat were the 1982 crop. Two cores were taken/plot, divided into 1-foot increments, composited/rep, dried, crushed and analyzed for NO_3-N by the Soil Testing Laboratory.

RESULTS

Nitrate-N remaining in the soil profile after the 1982 crop which was available to the 1983 corn, is presented in Table 1. When no fertilizer N was applied in 1982 (except the blanket 50-lb rate to wheat) very little difference in residual NO_3-N appeared among the four crop sequences. Essentially no differences in residual NO_3-N existed following continuous corn (grain or silage) or soybeans. Lowest residual NO_3-N followed wheat. When 160-lb of N was applied some carryover of that N was found with continuous corn (grain and silage) with greater residual NO_3-N levels following continuous corn (silage).

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Table 1. Effect of previous crop and N rate applied to corn in the crop sequence on residual NO_3-N remaining in the 0-5' profile at the end of the 1982 growing season.

Profile depth	Corn (grain)	Corn (silage)	Soybeans	Wheat
	Previous Crop			
feet	lb NO_3-N/foot			
		0 lb N/A		
0-1	29	30	32	30
1-2	23	25	27	24
2-3	22	24	24	20
3-4	23	25	23	17
4-5	24	19	22	16
Total (lb NO_3-N/5')	121	123	128	107
		160 lb N/A		
0-1	40	58		
1-2	39	48		
2-3	33	41		
3-4	31	35		
4-5	31	31		
Total (lb NO_3-N/5')	174	213		

Grain yield, leaf N and grain N responded to fertilizer N with both hybrids regardless of the previous crop (Tables 2A-B). When averaged over all N rates, there was no difference in the grain yield between P3906 and P3732. Grain N, however, was significantly higher for P3906. As a result, more N was removed in the grain by P3906 regardless of previous crop. Grain moisture was consistently higher for P3732 across all N rates and was significantly reduced upon addition of N.

Grain yields were suboptimal for 1982 due to moisture stress conditions brought about by extremely dry weather in late July and August. When averaging the two hybrids together, corn grain yield response to 200-lb N rate over the 0-lb N rate averaged 61.1, 52.4, 56, 60.7 and 68.5 bu/A for the continuous corn (grain), continuous corn (silage), corn after soybeans, corn after wheat, and second year corn after soybeans, respectively, (Table 2).

When no N was added, yields of second year corn following soybeans were lowest and were approximately 20 bu/A lower than for continuous corn. This was probably due to higher corn yields and greater stover production in the year following soybeans which resulted in a larger amount of corn residue being plowed under. This residue then could have immobilized more of the mineralized soil N than with the smaller amount of residue with the continuous corn system. Grain yields following corn (silage) were comparable to grain yields from continuous corn.

Highest grain yields were obtained when corn followed soybeans or wheat (Table 2). In general, yields were maximized at a lower N rate with P3906 than with P3732. For hybrid P3906, yields were maximized at 120-lb N/A when the preceding crop was continuous corn (grain) or soybeans and at 160-lb N/A following continuous corn (silage), wheat, and corn following soybeans. With hybrid P3732, yields were maximized at 160-lb N/A when the previous crop was continuous corn (silage), soybeans or corn following soybeans and at 200-lb N/A following continuous corn (grain) or wheat. At the 200-lb N rate corn yields (averaged over hybrids) exhibited differences of 10, 24, 26 and -13 bu/A for corn (silage), soybeans, wheat or corn following soybeans when compared to continuous corn. These differences were much greater than previous years and attests to the advantage of rotation in a stress year.

When no N was added, leaf N was highest following wheat and slightly lower following soybeans. Leaf N for second year corn following soybeans was lower than corn (silage) which was lower than continuous corn (grain). This is closely related to the yield differences mentioned previously. No significant difference occurred in leaf N between hybrids. Leaf N associated with the optimum yield level averaged 2.62 $\pm$ .1% (Table 2).

Table 2A. Corn grain yield, leaf N, grain N, grain N removed and grain moisture as influenced by previous crop, N-rate and hybrid at Waseca, 1983.

Previous Crop	Hybrid	N-rate (lb/A) 0	40	80	120	160	200
		Yield (bu/A)					
Cont. Corn (grain)	3906	51.3	68.4	93.1	110.5	111.1	108.3
	3732	56.8	77.3	91.4	102.5	108.1	122.1
Cont. Corn (silage)	3906	52.8	69.9	99.8	107.8	113.7	107.3
	3732	52.7	77.3	90.6	103.6	106.7	102.8
Soybeans	3906	80.6	107.4	115.0	138.0	137.3	140.1
	3732	86.0	115.2	127.2	134.8	139.0	138.6
Wheat	3906	76.1	103.3	120.7	134.3	140.7	138.1
	3732	84.8	110.6	130.1	131.7	139.7	144.3
Corn after soybeans	3906	33.8	61.0	89.0	99.9	110.8	99.5
	3732	33.4	56.4	84.8	96.7	102.9	104.7
		Leaf N (%)					
Cont. Corn (grain)	3906	1.48	1.58	2.00	2.52	2.56	2.64
	3732	1.52	1.59	1.84	2.40	2.64	2.53
Cont. Corn (silage)	3906	1.50	1.70	2.12	2.51	2.69	2.57
	3732	1.45	1.67	2.14	2.53	2.66	2.63
Soybeans	3906	1.52	2.00	2.42	2.71	2.71	2.78
	3732	1.56	1.97	2.34	2.55	2.70	2.77
Wheat	3906	1.64	2.01	2.27	2.61	2.68	2.75
	3732	1.59	1.91	2.06	2.71	2.76	2.61
Corn after soybeans	3906	1.44	1.51	1.86	2.34	2.63	2.63
	3732	1.35	1.43	2.02	2.51	2.51	2.62
		Grain N (%)					
Cont. Corn (grain)	3906	1.49	1.39	1.48	1.59	1.70	1.72
	3732	1.29	1.25	1.28	1.42	1.47	1.50
Cont. Corn (silage)	3906	1.52	1.48	1.43	1.63	1.68	1.71
	3732	1.37	1.26	1.30	1.48	1.49	1.53
Soybeans	3906	1.41	1.48	1.50	1.68	1.66	1.75
	3732	1.18	1.21	1.32	1.38	1.45	1.41
Wheat	3906	1.47	1.48	1.48	1.63	1.71	1.69
	3732	1.17	1.22	1.25	1.37	1.41	1.40
Corn after soybeans	3906	1.52	1.40	1.43	1.66	1.62	1.73
	3732	1.33	1.27	1.30	1.43	1.48	1.50
		Grain N Removed (lb/A)					
Cont. Corn (grain)	3906	36.1	45.1	65.0	83.1	89.3	87.4
	3732	33.7	45.4	55.2	67.7	74.7	85.4
Cont. Corn (silage)	3906	38.0	49.1	67.6	82.7	90.5	86.7
	3732	33.3	46.7	55.9	71.3	74.8	73.0
Soybeans	3906	54.1	75.5	81.3	109.5	106.9	116.0
	3732	48.1	66.1	79.3	87.9	95.0	91.7
Wheat	3906	53.5	72.9	84.7	103.3	112.9	110.4
	3732	46.9	63.8	77.0	85.5	92.6	95.3
Corn after soybeans	3906	23.9	40.6	60.5	77.6	84.8	80.7
	3732	20.7	33.4	52.0	63.9	72.1	72.6
		Grain Moisture (%)					
Cont. Corn (grain)	3906	18.8	17.2	17.7	17.0	17.2	17.2
	3732	23.0	21.3	20.8	20.6	20.9	19.7
Cont. Corn (silage)	3906	17.8	18.0	17.7	17.7	17.0	16.9
	3732	23.2	21.4	20.9	21.2	20.4	21.2
Soybeans	3906	19.2	18.6	17.8	14.4	17.5	17.9
	3732	22.2	21.2	20.0	20.2	20.0	20.4
Wheat	3906	19.2	18.5	18.2	18.0	18.2	18.3
	3732	21.8	22.0	20.7	20.6	20.9	20.8
Corn after soybeans	3906	18.6	17.0	17.1	16.7	16.8	16.1
	3732	23.1	21.8	20.6	20.8	20.1	20.4

Table 2B. Statistical interpretation of Rotation x N data at Waseca in 1983.

Source	Yield	Grain Moisture	Grain N	Grain N removed	Leaf N
	Probability level of significance				
Main effects					
Sequence	99	34	42	99	99
N rate	99	99	99	99	99
Hybrid	72	99	99	99	86
Interactions					
Sequence x N rate	15	73	43	06	97
Sequence x Hybrid	96	96	99	86	18
N rate x Hybrid	98	77	79	99	09
Seq x NR x Hybrid	34	34	09	59	71
BLSD: Sequence (.10)	8.7			6.0	.11
(.05)	10.3			7.0	.13
N rate (.10)	4.5	.39	.03	3.0	.06
(.05)	5.2	.45	.03	3.5	.07
CV (%)	8.6	6.9	5.2	9.7	7.1

Grain N data do not follow the yield and N data closely (Table 2). Grain N ranked according to previous crop as continuous corn (silage) > corn after soybeans > continuous corn > soybeans > wheat when no N was applied. This most likely resulted from dilution and to differences in grain yield. Grain N was significantly higher for hybrid P3906 when compared to P3732. When 200-lb N/A was applied, differences in grain N did not exist among the crop sequences. Protein levels at the optimum N rates averaged about 10.4 and 9.1% with the P3906 and P3732 hybrids, respectively.

The relationship between N rates needed for the optimum yields shown in Table 2 did not show any apparent relationship to the residual NO_3-N values shown in Table 1. This effect was complicated by the differential response of hybrid to previous crop and N rate. Although the lowest residual NO_3-N was found in following wheat, yields were optimized at 160 and 200-lb N/A for P3906 and P3732, respectively.

Fodder and silage yields from the continuous corn (silage) treatment responded to fertilizer N with both hybrids (Table 3). Fodder and silage yields for both P3906 and P3732 were maximized at the 120-lb N/A rate. Pioneer 3732 yielded significantly more fodder and silage than P3906 when averaged over N rates.

To determine if N from the 1982 application to corn influenced 1983 soybean yields, soybeans from the 0 and 200-lb N/A treatments were harvested from all 5 replications. The data in Table 4 indicate no effect from the previous year's N treatment on soybean yield or seed moisture in 1983.

Table 3. Fodder and silage yield as influenced by N rate and hybrid in a silage corn rotation at Waseca, 1983.

N rate	Hybrid	Fodder Yield	Silage Yield
lb/A		T DM/A	T DM/A
0	3906	1.36	2.67
	3732	1.63	2.92
40	3906	1.75	3.64
	3732	2.32	4.31
80	3906	2.08	4.60
	3732	2.54	5.07
120	3906	2.21	5.33
	3732	2.68	5.57
160	3906	2.03	4.79
	3732	2.44	5.22
200	3906	2.17	5.12
	3732	2.42	5.33
Individual Factors			
N rate (lb/A)			
0		1.50	2.80
40		2.04	2.97
80		2.31	4.84
120		2.45	5.45
160		2.24	5.00
200		2.30	5.22
Signif. Level (%):[1/]		99	99
BLSD (.05) :		.14	.32
Hybrid			
3906		1.93	4.36
3732		2.34	4.75
Signif. Level (%):[1/]		99	99
Hybrid x N rate IA		60	63

[1/] Probability level of significance

Table 4. Influence of N applied to corn in 1982 on the yield and moisture of soybeans in 1983.

N rate (lb/A)	Yield bu/A	Moisture %
0	59.3	11.9
200	57.3	12.0

NITROGEN LOSS TO TILE LINES AS AFFECTED BY TILLAGE

Waseca, 1983

G. W. Randall and D. T. Walters

Nitrogen losses to tile lines have been documented in a number of research studies including some conducted at Lamberton and Waseca, Minnesota. These studies primarily showed that N losses were a function of the N application rate and amount of precipitation. To some degree the time of application and crop grown have been shown to influence NO_3-N loss to tile lines. The purpose of this proposed long-term study is to determine if tillage has an effect on N utilization, accumulation of NO_3-N in the soil profile, and the subsequent loss of NO_3-N to tile lines.

EXPERIMENTAL PROCEDURES

A study was initiated in 1975 on a Webster clay loam at Waseca to monitor the movement of N from 12 plots measuring 45' x 50' each enclosed with plastic sheeting to a 6' depth into a tile line installed in each plot. Annual N rates of 0, 100, 200, and 300 lb N/A were applied from 1975-1979. No N was applied for the 1980 and 1981 crops. Residual N from N applied over the 7-year period (75-79) was utilized by the 1980 and 1981 corn crops. Soil samples to 10' and tile water samples taken in late 1981 showed little remaining evidence of the previous treatments.

In the fall of 1981, the eight plots with the most uniform tile flow rates over the 1975-81 period were selected. Two tillage treatments (fall moldboard plow and no tillage) were replicated four times and randomized over the previous plot histories. A fertilizer application rate of 0 + 50 + 150 ($N+P_2O_5+K_2O$)/A was broadcast applied in October, 1982 before the moldboard plowing. Percent surface residue was measured on April 26, 1983 and averaged 10.5 and 96% for the moldboard plow and no tillage systems, respectively.

On April 30, 180 lb N/A as ammonium nitrate was broadcast applied to the surface of all plots. The moldboard treatment was then field cultivated. Corn (Pioneer 3732) was planted on May 9 at a population of 27700 plants/A with a John Deere Max-Emerge planter equipped with 2" fluted coulters. Starter fertilizer was not used because of the high soil tests. Furadan was applied at 1 lb (ai)/A to control rootworms. Weeds were controlled with a preemergence application of Lasso (3½#) and atrazine (3#/A). Control was excellent.

Early plant growth was determined by harvesting the above ground portion of 10 plants/plot 43 days after planting. The leaf opposite and below the ear was taken from 10 randomly selected plants per plot at silking and was analyzed for N. Silage and grain yields were taken at physiological maturity by hand harvesting 30 and 60' of row, respectively, from each plot.

Tile lines began flowing in March, 1983 and continued to flow intermittently until mid July. Conditions were extremely dry in late July, August and September and no tile flow was recorded during this period. Tile lines commenced flowing again in October through early December. When tile lines were flowing, flow rates were measured daily and samples taken on Monday, Wednesday and Friday for NO_3-N analysis. All analyses were done by the Research Analytical Lab.

Soil NO_3-N in the 0-6' profile was determined from two cores/plot taken in 1-foot increments on October 17, 1983.

RESULTS

Early plant growth with moldboard plow tillage was significantly greater than with no tillage (Table 1). This was probably due to cooler soil temperatures and slower emergence rates under no tillage. Leaf N was also significantly greater with moldboard plow tillage. Corn silking on no tillage plots was delayed approximately one week.

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

No significant differences (p>95%) were found between tillage systems in silage yield, silage N uptake, grain yield, grain N or grain N uptake in 1983. A slight trend toward higher silage yield and silage N uptake was observed with moldboard plow however.

Precipitation for 1983 was 46% above the 30-year normal and resulted in high amounts of tile flow in 1983. Tile flow for the period (March-December) was approximately 9% higher with the no tillage treatment (Table 2). Nitrate-N concentration in the tile water averaged 0.82 mg/L higher with no tillage which was probably not a significant difference. Total NO_3-N loss, a function of both tile flow and NO_3-N concentration, averaged 7.4 lb NO_3-N/A higher with no tillage primarily due to the high tile flow from this treatment.

Residual NO_3-N in the 0-6' profile after harvest was not significantly affected by the two tillage treatments (Table 3).

Table 1. Influence of tillage system on corn production and N utilization at Waseca in 1983.

Tillage system	Early plant growth	Leaf N	Silage Yield	Silage N uptake	Grain Yield	Grain N	Grain N removal
	g/plant	%	T DM/A	lb N/A	bu/A	%	lb N/A
Mb. Plow	34.7	2.69	4.95	103.3	105.8	1.45	73.0
No Tillage	17.7	2.50	4.70	97.5	102.3	1.50	72.4
Signif. Level (%):	99	94	75	80	47	28	08
CV (%) :	10.5	3.4	5.2	5.0	6.8	10.8	12.5

Table 2. Influence of tillage system on tile flow, NO_3-N concentration and NO_3-N loss at Waseca in 1983.

Tillage system	Tile flow[1/]	Nitrate-N Concentration	Nitrate-N Loss
	acre-inches	mg/L	lb NO_3-N/A
Mb. Plow	20.55	7.88	36.70
No Tillage	22.39	8.70	44.10

1/ March-December, 1983

Table 3. Influence of tillage system on residual NO_3-N in the soil profile in November, 1983.

Profile depth	Tillage System: Mb. Plow	Tillage System: No Tillage
feet	-------NO_3-N (lb/A)------	
0-1	12.8	14.4
1-2	14.8	8.0
2-3	14.0	12.0
3-4	11.6	15.6
4-5	11.2	14.8
5-6	11.2	16.0
Total (lb NO_3-N/A 0-6')	75.6	80.8

NITROGEN EFFICIENCY AS AFFECTED BY RIDGE-PLANTING

Waseca, 1983

G. W. Randall

As conservation tillage systems become more popular there are numerous questions regarding proper fertilization practices. Ridge planting, a system where no preparatory tillage is done but the seeds are planted on a preformed ridge, has attracted much attention in the last few years. The purpose of this study was to determine the influence of N source, N rate and method-time of N application on the N needs of continuous corn grown in a ridge-plant system so as to improve N efficiency with conservation tillage.

EXPERIMENTAL PROCEDURES

Nineteen treatments, involving a factorial with 3 method-times of application, 3 sources of N and 2 rates of N plus a check treatment, were replicated five times and applied to a Webster clay loam. All treatments were completely randomized. Each individual plot measured 10' wide (4 rows) by 60' in length.

The plots in 1983 were planted on the same plots as in 1981 and 1982; thus, the treatments were continuous. The previous crop of corn was ridged in July of 1982. In the fall of 1980, P and K were broadcast at a rate of 30 + 120 lb P_2O_5+K_2O/A. Soil tests averaged: pH = 7.4 Bray P_1 = 41 lb/A (Very High) and exchangeable K = 325 lb/A (Very High). Response to additional fertilizer P and K would not be expected at these soil test levels; hence no P or K was applied for 1983.

Corn (Pioneer 3732) was planted with a Buffalo till-planter at 27000 plants/A with 1 lb Furadan (a.i.)/A on May 18. No starter fertilizer was used. Weeds were chemically controlled with Lasso (4 lb/A) + Bladex (3½ lb/A) applied preemergence on May 23. All plots were cultivated and ridged on July 14.

One-third of the N treatments was applied preplant on May 18. The urea was broadcast on the surface by hand while the urea-ammonium nitrate (UAN) solution (28% N) was broadcast with a motorized bicycle sprayer. The planting operation which removes the top of the ridge and deposits the soil in the interrow valleys was done within 6 hours of N application and should have incorporated most of the N. Anhydrous ammonia (AA) was knifed-in between the ridges with an anhydrous tool bar equipped with coulters ahead of the knives.

Another one-third of the treatments was applied just as the corn was emerging (June 3). Application techniques were the same as at preplanting. The last one-third of the treatments was sidedress-applied at the 10-leaf stage (July 8). This delay from the intended 8-leaf stage was due to an extended wet period from June 30 to July 7. The urea and UAN materials were banded 4-6 inches to the side of each row and covered slightly with soil. This simulated N application with a cultivator.

The percent of the soil surface covered by corn residue from the 1981 crop was measured prior to planting and again at emergence by the line-intercept method.

Leaf samples were taken at silking from 10 random plants in the center two rows of each plot. Final population was determined from 120' of row prior to harvest. Grain yield, grain moisture and grain N (protein) were determined on corn harvested from the center two rows of each plot with a modified JD 3300 plot combine on October 6.

Two separate analyses of variance statistical tests were conducted on the data. The first was a two-way ANOVA with all treatments including the check. A second analysis, with the check treatment omitted, was made to estimate the influence of each of the main factors (method-time, N source, and N rate) and the interactions among these factors.

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

RESULTS AND DISCUSSION:

Surface residue. Residue accumulation measurements across both the ridge and inter-ridge areas of all treatments showed that 70% of the soil surface was covered by residue from the previous crop prior to planting (May 18). At the emergence stage (June 3) this had dropped to 27% as a result of residue incorporation by the planter.

Plant height. Plant heights were measured at two stages: 13-14 leaf (July 20) and after tasseling (August 9). Prior to tasseling all N treatments applied at the preplant (PP) and emergence (EM) stages increased the plant height above the check (Table 1). Apparently the N from the sidedress (SD) treatments applied 12 days prior to taking the measurements had not been utilized yet. Thus, the plants were still somewhat stunted. When averaged over N source and rate, the factorial analysis indicated the PP application to have slightly taller plants than the EM application with both the PP and EM plants being substantially taller than the SD plants (Table 2). There was no significant difference among N sources when averaged over N rate and method-time. The difference in plant height between the N rates was not significant (90% level) when averaged over method-time and source. The highly significant interaction between method-time and N source (98% level) indicates that the plants were somewhat smaller with AA compared to the UAN and urea materials when applied PP and EM, while at the SD stage the largest plants were associated with the AA source. The reversal was probably due to the injection of the AA into the moist soil at the SD stage where the NH_3 could be nitrified quickly and taken up by the plants. Whereas, the UAN and urea were applied near the soil surface and probably were not moved into the rooting zone for rapid uptake.

Table 1. Plant height, final plant population, and leaf N as influenced by method-time, source, and rate of N fertilizer applied to a ridge-plant system at Waseca in 1983.

Treatments						
Method[1/] -Time	N Source[2/]	N Rate	Plant Height 7/20	Plant Height 8/9	Final population	Leaf N
		lb N/A	-----cm-----		x 10^{-3}	%
PP	UAN	75	145	225	25.8	2.25
PP	UAN	150	153	222	27.0	2.66
PP	Urea	75	142	219	26.5	2.27
PP	Urea	150	145	222	26.5	2.51
PP	AA	75	134	216	26.4	2.27
PP	AA	150	148	228	25.7	2.71
EM	UAN	75	141	219	26.4	2.11
EM	UAN	150	141	220	25.9	2.45
EM	Urea	75	137	221	25.9	2.30
EM	Urea	150	147	222	25.7	2.76
EM	AA	75	135	218	26.6	2.35
EM	AA	150	134	216	25.5	2.76
SD	UAN	75	123	208	26.1	1.64
SD	UAN	150	116	203	25.6	1.89
SD	Urea	75	119	203	25.7	1.60
SD	Urea	150	116	202	25.1	1.89
SD	AA	75	125	215	25.9	2.36
SD	AA	150	128	221	26.7	2.64
	Check		116	201	25.3	1.56
	Significance Level (%):		99	99	95	99
	BLSD (.05)	:	11.	10.	1.5	.23
	CV (%)	:	6.7	3.8	3.3	8.8

1/ PP=preplant, EM=emergence, SD=sidedress at 8-leaf stage

2/ UAN=28% N solution, AA=anhydrous ammonia

3/ Probability level of significance

Table 2. Factorial analyses of plant height, plant population and leaf N as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1983.

	Plant Height 7/20	Plant Height 8/9	Final population	Leaf N
	-----cm-----		x 10^{-3}	%
Main Treatments				
Method-Time				
PP	144	222	26.3	2.44
EM	139	219	26.0	2.46
SD	121	209	25.9	2.00
Signif. Level (%):	99	99	84	99
BLSD (.05) :	4	4		.09
N Source				
UAN	136	216	26.1	2.17
Urea	134	215	25.9	2.22
AA	134	219	26.1	2.51
Signif. Level (%):	48	85	49	99
BLSD (.05) :				.09
N Rate				
75	133	216	26.1	2.13
150	136	217	26.0	2.47
Signif. Level (%):	88	52	63	99
Interactions				
Meth-Time x Source				
PP UAN	149	224	26.4	2.45
PP Urea	143	221	26.5	2.39
PP AA	141	222	26.0	2.49
EM UAN	141	219	26.1	2.28
EM Urea	142	221	25.8	2.53
EM AA	135	217	26.0	2.56
SD UAN	119	206	25.9	1.77
SD Urea	117	203	25.4	1.74
SD AA	126	218	26.3	2.50
Signif. Level (%):	98	99	78	99
			Significance Levels (%)	
Method-Time x Rate	94	45	77	57
Source x Rate	43	80	40	11
M-T x S x R	58	45	97	24

After tasseling height measurements also showed significantly taller plants with the PP and EM applications compared to the check (Table 1). However, the SD applications of UAN and urea were not different from the check. Factorial analysis of the data (Table 2) indicate an almost identical pattern as with the pre-tassel data. No appreciable rain occurred in the 32-day period between the SD application and the post-tassel measurement. During this time it appears as though the SD-applied UAN and urea, which were placed on the soil surface and covered slightly, remained near the upper-part of the rooting profile and were positionally unavailable.

Final population. Final population was significantly different (95% level) among the treatments but no relationship could be ascribed to method-time, N source or N rate (Tables 1 and 2). This was in contrast to previous years when populations were decreased by the application of AA at the EM stage. Improved coulters which penetrated the soil ahead of the new anhydrous knives (without sealing wings) aided the 1983 application of the AA under soil conditions which were ideal.

Leaf N. Nitrogen concentration in the earleaf at silking was increased significantly over the check by all of the N treatments except the SD applied 75-lb rate of UAN and urea (Table 1). Factorial analysis showed a significant effect of method-time (PP = EM > SD) when averaged over N source and rate, N source (AA > urea = UAN) when averaged over method-time and N rate, and N rate (150 > 75) when averaged over method-time and N source (Table 2). The significant interaction (99% level) between method-time and N source is shown by the low N concentrations with the SD applied UAN and urea treatments (probably for the same reason as discussed for plant height) and the UAN applied at the EM stage. Perhaps some of the UAN was volatilized from this high pH soil (7.4) which was 27% covered with plant residues from the 1982 crop. This did not occur with urea, however.

Grain yield. Grain yields were extremely low due to the 7-week dry period (July 5-August 24) and the accompanying very hot temperatures which placed tremendous stress on the corn. However, all N treatments except the 75-lb rate of urea SD applied at the 10-leaf stage resulted in yields greater than the check (Table 1). Factorial analysis showed significant differences among method-time (PP > EM >> SD), between N rates (150 > 75) and a slight advantage for AA compared to UAN and urea (significant at the 91% level) (Table 2). The significant method-time x N source interaction is again shown by the (1) little difference among N sources when applied PP, (2) slightly lower yield with UAN when broadcast-applied to the soil surface at the EM stage, and (3) substantially lower yields obtained with UAN and urea compared to AA when SD applied at the 10-leaf stage.

Nitrogen applied prior to planting offered no problems. Apparently the UAN and urea were incorporated satisfactorily by the planter and the AA went on very easily. The residue was easily cut by the coulters and ammonia vapors were not observed. Ammonia application at the 10-leaf stage went very smoothly and resulted in higher yields than with either UAN or urea. This was probably due to positional unavailability of the UAN and urea which were only incorporated about 1 inch deep. After application to the slightly dry surface soil, rainfall totaled only 1.80" over the next 7 weeks. This did not allow for adequate movement of the N down into the soil where most of the root activity and nutrient uptake was occurring. On the other hand the AA was injected about 7" deep into the moist soil where nitrification could take place, hence, greater N uptake.

Grain moisture. With the exception of three SD treatments grain moisture was reduced significantly from the check by all of the N treatments (Table 3). Factorial analysis showed lower grain moistures to be associated with the earlier N application times (PP < EM < SD) and with the higher N rate (Table 4). Grain moisture was not significantly affected (95% level) by source of N; however, the method-time x source interaction was highly significant. This is illustrated by the slightly lower moisture levels with UAN and urea compared to AA at the PP and EM stages as contrasted to the higher moistures with UAN and urea compared to AA at the SD stage.

Protein. Protein percentage of all treatments was generally low but was increased over the check by all of the 150-lb N treatments except the SD application of UAN at the 10-leaf stage (Table 3). Factorial analysis indicated an effect of N source (AA > Urea = UAN) and N rate (150 > 75) on protein percentage (Table 4). Protein levels were not influenced by the method-time factor or the interaction between method-time and N source. However, the highly significant interaction between method-time and N rate is shown by protein being increased from 7.79% to 8.83% by the higher N rate with the PP application, from 7.79% to 8.57% with the EM application, but only from 8.00% to 8.16% with the SD application at the 10-leaf stage.

N removal. Grain N removal is the product of grain yield times grain N percentage and thus parallels the yield and protein responses very closely. All N treatments significantly improved N removal (uptake) over the check (Table 3). Factorial analyses indicated less grain N removed with delayed N application time, with UAN and urea compared to AA, and with the 75-lb N rate (Table 4).

Nitrogen efficiency. The N efficiency, as calculated from grain N removal minus that of the check and then divided by the N application rate, was extremely low in 1983 due to the low yields (Table 3). The lowest values were generally obtained with the SD applied UAN and urea materials and with UAN applied at the EM stage.

Weather conditions could have been conducive to volatilization of the surface-applied UAN and urea following the EM application as shown in Table 5. Although precipitation totaled only 0.09" in the 10-day period, measurable rainfall occurred on 3 days with trace amounts occurring on 4 other days. This amount of rain would not have been enough to move the N into the soil, but the rather humid and warm conditions may have resulted in some volatilization.

Table 3. Grain yield, moisture, protein, N removal, and N efficiency as influenced by method-time, source and rate of fertilizer N applied to a ridge-planted system at Waseca in 1983.

Treatments			Grain				
Method-Time	N Source	N Rate	Yield	Moisture	Protein	N removal 1/	N efficiency 2/
		lb N/A	bu/A	%	%	lb N/A	%
PP	UAN	75	86.3	20.8	8.05	52.7	26
PP	UAN	150	101.2	19.9	8.64	66.2	22
PP	Urea	75	86.9	21.0	7.71	50.7	24
PP	Urea	150	97.1	20.2	8.79	64.4	21
PP	AA	75	80.6	22.4	7.61	46.5	18
PP	AA	150	98.2	20.4	9.06	67.0	23
EM	UAN	75	80.5	21.7	7.71	47.0	19
EM	UAN	150	84.1	21.6	8.49	53.7	14
EM	Urea	75	86.4	21.8	7.67	50.2	23
EM	Urea	150	99.0	20.3	8.41	63.1	20
EM	AA	75	85.3	22.6	8.00	51.5	25
EM	AA	150	87.7	21.6	8.80	58.3	17
SD	UAN	75	71.5	23.3	7.77	42.2	12
SD	UAN	150	75.6	22.8	7.87	44.9	08
SD	Urea	75	64.9	23.5	7.95	39.4	09
SD	Urea	150	70.1	23.3	8.20	43.7	07
SD	AA	75	83.2	22.9	8.27	52.2	26
SD	AA	150	91.8	21.5	8.41	58.3	17
	Check		58.2	24.1	7.44	32.8	
Significance Level (%):			99	99	99	99	
BLSD(.05) :			9.7	1.1	.51	6.3	
CV(%) :			9.8	4.4	5.1	10.5	

1/ Yield times grain N

2/ (Grain N removed from trt. - Grain N removed from check) ÷ N Rate

Table 4. Factorial analyses of grain yield, moisture, protein and N removal as influenced by method-time, source and rate of N fertilizer applied to a ridge-plant system at Waseca in 1983.

	Grain			
	Yield	Moisture	Protein	N removal
	bu/A	%	%	lb N/A
Main Treatments				
Method-Time				
PP	91.7	20.8	8.31	57.9
EM	87.2	21.6	8.18	53.9
SD	76.2	22.9	8.08	46.8
Significance Level (%):	99	99	88	99
BLSD (.05) :	3.9	.4		2.6
N Source				
UAN	83.2	21.7	8.09	51.1
Urea	84.1	21.7	8.13	51.9
AA	87.8	21.9	8.36	55.6
Significance Level (%):	91	36	97	99
BLSD (.05) :			.23	2.8
N Rate				
75	80.6	22.2	7.86	48.0
150	89.4	21.3	8.52	57.7
Significance Level (%):	99	99	99	99
Interactions				
Meth-Time x Source				
PP UAN	93.7	20.3	8.34	59.4
PP Urea	92.0	20.6	8.25	57.5
PP AA	89.4	21.4	8.34	56.8
EM UAN	82.3	21.7	8.10	50.3
EM Urea	92.7	21.0	8.04	56.6
EM AA	86.5	22.1	8.40	54.9
SD UAN	73.5	23.0	7.82	43.6
SD Urea	67.5	23.4	8.09	41.6
SD AA	87.5	22.2	8.34	55.3
Significance Level (%):	99	99	67	99
		Significance Level (%)		
Meth-Time x Rate	90	39	99	99
Source x Rate	12	86	63	55
M-T x S x R	49	49	49	51

Table 5. Air temperature and precipitation in the 10-day period following the emergence stage application of N in 1983.

Day	Air Temperature Max.	Air Temperature Min.	Precipitation
	-------°F------		inches
1 (N applied)	72	47	T
2	67	46	T
3	58	39	.05
4	71	44	---
5	77	50	---
6	81	53	.01
7	78	60	---
8	87	61	T
9	82	64	.03
10	82	65	T

SUMMARY

Application of N at PP regardless of N source resulted in the highest yields, protein level, and N removal, tallest plants at both the pre and post tassel stages, and the lowest grain moisture. Application at the emergence stage to the 27% residue covered soil surface resulted in similar results as with the PP application except with UAN. Leaf N and grain yield was lower with UAN compared to urea and AA. This could have been due to volatilization loss since significant rainfall did not occur until 11 days after application. The SD applications of all materials at the 10-leaf stage gave the lowest yields. This was especially true for UAN and urea. Because of the extremely dry conditions from the time of sidedressing until late August, positional unavailability of the UAN and urea was thought to be the primary factor.

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SOIL TEST COMPARISON STUDY

Waseca, 1983

G. W. Randall and P. L. Kelly

Soil testing is one of the best and most economical methods of ascertaining the nutrient status of the soil. The test then serves as the basis for fertilizer recommendations for crops. Many private and public laboratories provide that service to Corn Belt farmers. The purpose of this study is to compare the soil analyses and fertilizer recommendations given by five regional laboratories for corn production in Southern Minnesota. Working with the laboratories in this comparison study we should be able to improve and standardize fertilizer recommendations for corn production.

PROCEDURES

Two experimental sites measuring 150' by approximately 300' were selected for sampling in October 1979. One of the sites had a history of high P and K fertilization while the other had not received P or K since 1974. The soil type in the former is a Nicollet clay loam while that in the latter is primarily Webster clay loam with some Nicollet clay loam. Both sites have been cropped to continuous corn. Tile lines spaced at 75' intervals provide excellent drainage at both sites. Neither site can be irrigated.

Four samples consisting of approximately 35 cores each from a 0-7" depth were taken from each site. All samples were oven dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent to five laboratories which test the majority of the soil samples from Southern Minnesota. Soil analyses requested consisted of pH, OM, extractable P_1, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. Based on the results from the U of M laboratory these two sites were then classified as being initially "very high" and "medium-high". The fertilizer recommendations given by the five laboratories were then applied as five treatments in the spring of 1980 for corn. An additional check (no fertilizer) treatment was included in the randomized, complete-block design with six replications.

After the 1980 crop, soil samples (5 cores/plot times 6 replications yielding 30 cores per treatment) were taken yearly from each treatment and sent to the respective laboratory. This allows us to follow the buildup or decline of nutrients in the soil as affected by the recommendations of a particular laboratory over a continuous, long period of time.

Soybeans were initiated into this study in 1982 after nine years continuous corn at the very high testing site and after seven years at the medium-high testing site and will again be planted in 1984.

Fertilizer amounts based on the analyses and recommendations from the summer 1982 samples were applied in the fall to the appropriate plots and incorporated by field cultivation. Lab nitrogen recommendations were spread in the following spring and also field cultivated. These fertilizer recommendations were based on a yield goal of 160 bu/A of corn following soybeans. Corn (Pioneer 3732) was planted at 27,700 ppA in 30" rows on May 9 with neither insecticide nor starter fertilizer. Chemical weed control consisted of 3½ qt. Lasso and 3½ qt. Bladex/A applied preemergence.

On July 25 the leaf opposite and below the ear at 50% silking was randomly sampled from ten plants and submitted for analyses. Final populations were determined from 70' of row. Grain yield and moisture were determined on corn harvested from the center two rows of each plot with a modified JD 3000 plot combine. Grain yields were converted to 15.5% moisture.

In August 1983, 0-7" soil samples were taken from each treatment of each of the two sites and were sent to the laboratory of the respective treatment. The recommendations obtained from these samples will be used for the 1984 soybean crop.

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

RESULTS

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. While the numeric values of the five laboratories were generally similar, the interpretations (whether the soil tests high, low, medium, deficient, etc.) varied significantly. As a result N, P and K recommendations among the laboratories were substantially different. Various micronutrients and sulfur were recommended by two of the four private labs. Three of the four private labs recommended liming the soil.

Table 1. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1983.

	Soil Test Results[1/]				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	5.9	6.0	6.2	6.0	5.9
pH (buffer)	6.7	6.6	6.7	6.5	6.2
Phosphorus	29 H	26 D	26 VH	36 H	23 VH
Potassium	178 H	162 L	130 H	175 H	125 MH
Organic Matter (%)	3.2 H	3.9 A	3.2 M	3.9	H
Calcium	1860 M	2437 A	4000	3030 M	---
Magnesium	405 VH	466 A	500	500 M	413 A
Sulfur	8 M	24 A	19 H	26 VH	10 MH
Iron	80 VH	86 E	8	5.6 VH	---
Manganese	35 VH	25 E	2	2 VH	---
Zinc	1.9 M	1.6 A	1.6 H	1.4 M	1.0 M
Copper	1.1 M	.9 A	.4	---	---
Boron	1.7 H	.8 A	1.3	---	---
ENR (lb/A)	94	---	---	50	---
C.E.C. (meq/100g)	15.8	21.5	24.8	26.9	---

1/ All soil test results are stated in ppm unless noted otherwise.

	Recommended Fertilizer Program[2/]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	200	160	167	244	130
Phosphorus (P_2O_5)	50	70	12	75	---
Potassium (K_2O)	90	135[3/]	61	112	90
Sulfur	14	---	---	---	---
Iron	---	---	---	.12[4/]	---
Manganese	---	---	---	.12[4/]	---
Zinc	2.5	---	---	.62[4/]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.5	2	.8	---	---

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 160 bushels of corn per acre.

3/ Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

4/ As 5 qt/A of a material weighing 9.9 lb/gal and containing 5% Zn, 1% Fe, 1% Mn.

Grain yields were significantly affected by the fertilizer treatments (Table 2). All fertilizer recommendations resulted in higher yields than the unfertilized check. There was no significant difference between grain yield, grain moisture nor final population among the five laboratory treatments.