YIELDS OF FIELD CORN GROWN EACH OF FIFTEEN YEARS (1957-1971) WITH VARYING RATES OF NITROGEN FERTILIZER AT MORRIS

J. M. MacGregor, S. Evans and G. R. Blake

A continuous corn fertilizer experiment was commenced in 1957 on a non-tiled Barnes loam at the West Central Experiment Station at Morris. Adequate amounts of phosphate and potash were applied annually with four rates of N application. Although a plant population of 16-18,000 corn plants per acre was desired, this was not always obtained, since different methods of seedbed preparation were employed until 1968. For the past four cropping seasons, the seedbed of the entire experimental area has been prepared on all treatments by the method commonly used in the area - fall plowing and disking. All vegetative residues remained on the field, either being plowed down or worked into the surface. Residues have been fall plowed down over the entire experimental plot since late 1967. Ear corn yields and the average for the fifteen years are shown in Table 1. Relatively dry soil conditions have frequently limited corn yields during the years of this study.

It is evident that the annual 40 pound per acre N fertilization rate increased average corn yields approximately 10 bushels per acre and also that further increases in annual N fertilization rate failed to further increase corn yields. Soil analyses have shown some accumulation of nitrate nitrogen to a 24 foot depth, although major concentrations occur in the upper 8 foot depth.

Corn grain from all plots was sampled in 1971 and analyzed for nitrogen content. The ear corn yields over the fifteen year period and 1971 N content and removal are shown in the following table.

It is evident that during the 15 year period, the 40 pound rate of fertilizer N application has increased average corn yields by approximately 10 bushels per acre, with no additional increase with increased rates of N fertilization.

Assuming that the N content of the grain has been relatively constant during the 15 year period, total N removal and balance in the soil is also shown, with little utilization where heavy N fertilization occurred.

YIELD OF EAR CORN DURING FIFTEEN YEARS (1957-71) WITH DIFFERENT RATES OF ANNUALLY APPLIED NITROGEN, WITH N CONCENTRATIONS AND REMOVAL IN THE CORN GRAIN
(average of 15 replications)

Annual fertilization rate in lbs/A

Year	0+40+40(S)	40+40+40(F)	40+40+40(S)	80+40+40(S)	240+40+40(S)
	(Bushels of corn per acre @ 15.5% moisture)				
1957	65.2	71.0	69.4	72.1	71.3
1958	73.2	81.5	81.0	82.4	80.3
1959	36.1	40.9	41.5	39.7	36.8
1960	53.3	48.2	55.0	53.7	52.5
1961	32.3	48.3	47.6	45.0	46.1
1962	38.1	59.0	62.0	65.3	67.1
1963	62.7	80.9	83.5	77.4	79.5
1964	33.2	34.1	29.6	29.1	24.7
1965	50.4	68.3	75.3	80.8	82.8
1966	49.0	63.7	66.3	75.9	33.1
1967	66.8	69.2	71.2	69.7	71.3
1968	64.1	79.6	70.2	78.5	76.0
1969	76.4	58.0	60.2	59.9	58.7
1970	59.2	66.9	70.2	78.5	76.0
1971	64.2	79.9	82.6	83.6	85.4
15 Year Average (bu/A)	54.3	64.0	64.8	66.1	62.8
%N in 1971 corn grain	1.15	1.32	1.47	1.60	1.81
Pounds N/A in 1971 grain	32.8	50.9	60.0	67.0	75.7
N applied in 15 years (lbs/A)	--	600	600	1200	3600
Approx. N removed grain (lbs/A)	444	599	671	751	807
N balance in soil	-444	-599	-671	+449	+2793

(S) - Fertilizer broadcast in spring
(F) - Fertilizer broadcast in fall

PHOSPHORUS FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

A phosphorus fertilization experiment on continuous corn was set up in 1965 on Forman clay loam to determine (1) the interaction of row and broadcast levels of phosphorus on corn yields, and (2) the effect of high rates of phosphorus on the zinc content of corn leaves and on corn yields.

All plots received a uniform row application of 10 + 0 + 20. Nitrogen was plowed down in the fall of 1970 at the rate of 120 lbs. of N per acre. Reps 3 and 4 were severely damaged by standing water in late June.

1971 Variety - Pioneer 3956 Planting date - May 5, 1971

Table 1. 1971 yields in Bu/acre at 15.5% moisture (Reps 1, 2, 5 and 6 only)

Broadcast P Treatment (lbs/acre)	Row Phosphorus Treatments (lbs/acre)					
	Ck	15 P	30 P	45 P	45 P + 10 Zn	Average
0	97.3	98.4	100.0	105.1	108.9	102.0
45 P	110.6	100.4	96.9	91.9	105.4	101.0
Average	104.0	99.4	98.5	98.5	107.2	

Table 2. Average yield in bu/acre at 15.5% moisture for 1965-71.

Broadcast P Treatment (lbs/acre)	Ck	15 P	30 P	45 P	45 P + 10 Zn	Average
0	78.0	77.4	79.0	78.5	82.5	79.1
45 P	82.6	79.4	76.4	74.3	82.4	79.1
Average	80.3	78.4	77.7	76.4	82.4	79.0

As shown in Table 1, yields were reduced slightly by very high rates of phosphorus. This depression in yield is less than in some previous years. This may be due to the fact that the growing season was favorable and yields were higher than in any year of this experiment. At the higher yield level there is probably a need for more phosphorus. As in past years, the addition of 10 lbs. of zinc at the highest phosphorus level increased yields.

In Table 2 are the 7-year average yields. Statistical analysis has not been done over years but it again appears that there is a slight reduction in yield at very high phosphorus rates; i.e., 30 P and 45 P in the row at the 45 P broadcast level. There is also a significant increase in yield from the addition of zinc at the 45 P row rate.

POTASSIUM FERTILIZATION OF CORN

Walt Heideman Farm - Benson

S. D. Evans, J. Edman, and O. Gunderson

A potassium experiment on corn was set up southeast of Benson in the spring of 1971. The initial soil tests are given in Table 1. Rates of potassium in addition to combinations with nitrogen and phosphorus were used.

Table 1. Soil test values on the Heideman farm, Spring 1971.

Section of plot area	Soil Texture	pH	Organic Matter	Phosphorus (lbs/A.)	Potassium (lbs/A.)	Zinc (ppm)
Northeast	silt loam	7.9	High	9	250	2.9
Southeast	silt loam	8.1	High	5	280	3.2
Southwest	silt loam	8.0	High	4	240	3.5
Northwest	silt loam	7.7	High	5	260	3.3

The field was in alfalfa in 1970 and was fall plowed. Treatments were applied on May 3 and the corn was planted and taken care of by the farmer. A starter fertilizer of 100 lbs/acre of 8-32-16 was used. Leaf samples were taken on July 30 and the results are shown in Table 2. The only nutrients which were significantly different between treatments were manganese and boron. Potash appeared to lower the leaf manganese. The addition of nitrogen or nitrogen and phosphorus at the high potassium level raised the leaf manganese. The variation in leaf boron did not appear to be related to treatment. At no time during the summer was there a visual difference between treatments.

Table 2. Nutrient content of leaves at silking.

Treatment N	Treatment P_2O_5	Treatment K_2O	P %	K %	Ca %	Al ppm	Fe ppm	Mg %	Zn ppm	Cu ppm	Mo ppm	Mn[a] ppm	B[a] ppm
(lbs/A)													
0	0	0	.26	1.37	.58	60	179	.54	23	10.0	18.4	85bc	9.7bc
0	0	100	.27	1.43	.57	62	182	.53	18	9.8	17.3	78ab	7.1a
0	0	300	.26	1.43	.55	56	173	.54	18	8.9	18.0	77ab	8.6abc
0	0	600	.26	1.54	.54	60	174	.46	20	10.0	16.3	76a	9.2bc
100	0	600	.26	1.52	.60	61	175	.48	19	10.6	15.7	83abc	8.4ab
100	100	600	.26	1.50	.54	48	159	.49	18	9.4	17.3	88c	10.2c
Treatment Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*

[a] Treatments followed by the same letter are not significantly different at the 5% level.

The plots were harvested on October 7 and the harvest data is given in Table 3. There were no significant effects of any of the treatments.

Table 3. Harvest data on Potash Plots at Benson

N	P_2O_5	K_2O	Yield Bu/A @ 15.5% M	Number of ears harvested on an acre basis	Ear moisture at harvest %
	(lbs/A)				
0	0	0	111.5	22,500	30.1
0	0	100	109.1	22,600	31.0
0	0	300	107.6	22,300	32.0
0	0	600	111.1	22,100	31.8
100	0	600	105.9	22,500	32.6
100	100	600	109.2	22,400	31.2
Treatment Significance			NS	NS	NS

Statistical Analysis done by Dean Fairchild.

ZINC FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1965 an experiment was initiated involving the use of zinc fertilizer on continuous corn. The plots were set up on Forman clay loam and corn grown previously on this soil had not shown zinc deficiency, even though leaf samples indicated the zinc content was below 20 ppm zinc.

Table 1. Yields for 1971 and 1965-71.

Treatment* (lbs/acre)	When Applied	Yield in bu/acre at 15.5% moisture 1971**	Average 1965-71
Check	- -	121.9	88.3
5 lbs. zinc as zinc sulfate	1965	114.0	86.3
10 lbs. zinc as zinc sulfate	1965	118.6	86.7
10 lbs. zinc as zinc sulfate	yearly	118.2	89.0
20 lbs. zinc as zinc sulfate	1965	118.5	88.2
0.5 lbs. zinc as Zn chel.	yearly	118.7	84.5
45 lbs. P broadcast	yearly	120.4	84.2
45 lbs. P broadcast + 10 lbs. zinc as zinc sulfate	yearly 1965	112.0	85.2

* All plots received a uniform application of 120 lbs. of N in the fall of 1970 and 125 lbs. of 8-32-16 starter.

**Reps 1, 2, 3, and 6 only.

Yields (Table 1) in 1971 were very high. The highest yielding treatment was the check at 121.9 bu/acre. All other treatments were lower with 5 lbs. zinc as zinc sulfate and the 45 P + 10 zinc treatments being substantially lower. The 7-year average yields show no differences between zinc treatments and the check. The treatments with phosphorus are slightly lower.

NPK FERTILIZATION OF SOYBEANS

West Central Experiment Station - Morris

S. D. Evans and G. E. Ham

A series of plots was established on Forman clay loam in the fall of 1967 to determine the optimum fertilization rates for sugar beets. The project was discontinued after one cropping year, so these plots were put in soybeans in 1969, 1970, and 1971. Yields were taken in 1969 and 1971. Fertilizer rates used are given in table 1.

Table 1. Fertilizer rates used in the experiment (rates are lbs/acre in the elemental form).

Nitrogen	Phosphorus	Potassium
N_0 - 0	P_0 - 0	K_0 - 0
N_1 - 70	P_1 - 25	K_1 - 25
N_2 - 140	P_2 - 50	K_2 - 50

Two separate experiments were carried out each year. On one experiment fertilizer was applied the fall before yields were measured (direct fertilization). On the other experiment there was no fertilizer applied in the fall immediately before yields were measured (residual fertilization). The elements were applied in all combinations of a 3 x 3 x 3 factorial of 2 replications. Chippewa 64 soybeans were used in 1969 and Clay soybeans in 1971. The initial soil tests are given in table 2.

Table 2. Initial soil test values - Fall 1967.

Sample No.	pH	O.M.	P	K
1	7.0	5.7	24	370
2	6.7	6.0	26	370

In 1969 yields averaged about 30 bushels per acre (table 3). In 1971 with more moisture, yields averaged about 37 bushels per acre (table 4). The summary of the statistical analysis of the data (table 5) shows very little effect of any treatments. In the 1971 data phosphorus and potassium have a slight effect on yield. This shows up as a quadratic effect with both elements reaching a maximum yield at the middle level of each; i.e., P_1 or K_1. The effect is very small, however, with $P_1 - P_0 = 1.1$ bushels per acre and $K_1 - K_0 = 2.2$ bushels per acre.

A 10-lb. zinc treatment with zinc supplied in zinc sulfate was included as an extra treatment each year. In no case (table 6) was there a significant positive effect of the zinc application.

Table 3. 1969 soybean yields on NPK factorial experiment.

Bushels/Acre

Residual Fertilization (Fertilizer applied in fall of 1967)

	N_0	N_1	N_2	Aver.		N_0	N_1	N_2	Aver.		P_0	P_1	P_2	Aver.
P_0	30.8	31.5	31.7	31.3	K_0	29.2	30.6	30.3	30.0	K_0	30.4	28.7	31.0	30.0
P_1	28.6	30.7	32.2	30.5	K_1	30.1	31.2	32.5	31.3	K_1	31.8	32.2	29.9	31.3
P_2	31.3	30.2	30.2	30.6	K_2	31.5	30.7	31.4	31.2	K_2	31.9	30.8	30.8	31.2
Aver.	30.3	30.8	31.4	--	Aver.	30.3	30.8	31.4	--	Aver.	31.3	30.5	30.6	--

Direct Fertilization (Fertilizer applied in fall of 1968)

	N_0	N_1	N_2	Aver.		N_0	N_1	N_2	Aver.		P_0	P_1	P_2	Aver.
P_0	30.3	30.6	30.4	30.4	K_0	27.5	30.0	29.2	28.9	K_0	30.6	28.2	27.8	28.9
P_1	29.8	30.0	30.0	30.0	K_1	31.4	31.0	30.7	31.0	K_1	31.8	30.5	30.8	31.0
P_2	27.7	31.0	30.4	29.7	K_2	29.0	30.6	30.8	30.2	K_2	28.8	31.3	30.5	30.2
Aver.	29.3	30.6	30.3	--	Aver.	29.3	30.6	30.3	--	Aver.	30.4	30.0	29.7	--

Table 4. 1971 soybean yields on NPK factorial experiment.

Bushels/Acre

Residual Fertilization (Fertilizer applied in fall of 1969)

	N_0	N_1	N_2	Aver.		N_0	N_1	N_2	Aver.		P_0	P_1	P_2	Aver.
P_0	39.6	37.6	37.1	38.1	K_0	37.3	36.0	37.2	36.8	K_0	38.4	35.5	36.6	36.8
P_1	35.1	36.6	38.8	36.8	K_1	37.3	37.7	38.4	37.8	K_1	38.4	38.9	36.2	37.8
P_2	35.5	36.6	36.2	36.1	K_2	35.6	37.1	36.5	36.4	K_2	37.6	36.0	35.6	36.4
Aver.	36.7	36.9	37.4	--	Aver.	36.7	36.9	37.4	--	Aver.	38.1	36.8	36.1	--

Direct Fertilization (Fertilizer applied in fall of 1970)

	N_0	N_1	N_2	Aver.		N_0	N_1	N_2	Aver.		P_0	P_1	P_2	Aver.
P_0	35.4	38.2	37.0	36.9	K_0	35.8	36.0	37.6	36.5	K_0	35.6	38.2	35.6	36.5
P_1	38.1	37.4	38.4	38.0	K_1	37.6	38.8	38.4	38.3	K_1	37.8	39.2	37.8	38.3
P_2	35.2	35.7	36.8	35.9	K_2	35.3	36.4	36.2	36.0	K_2	37.2	36.5	34.2	36.0
Aver.	36.2	37.1	37.4	--	Aver.	36.2	37.1	37.4	--	Aver.	36.9	38.0	35.9	--

Table 5. Summary of ANOVA on 1969 and 1971 soybean yields.

Source of Variation	Degrees of Freedom	1969 Residual	1969 Direct	1971 Residual	1971 Direct
N	2	NS	NS	NS	NS
Linear	1	NS	NS	NS	NS
Quadratic	1	NS	NS	NS	NS
P	2	NS	NS	NS	NS
Linear	1	NS	NS	NS	NS
Quadratic	1	NS	NS	NS	+
K	2	NS	NS	NS	+
Linear	1	NS	NS	NS	NS
Quadratic	1				
NP	4	NS	NS	NS	NS
L x L	1	NS	NS	NS	NS
Rest	3	NS	NS	NS	NS
NK	4	NS	NS	NS	NS
L x L	1	NS	NS	NS	NS
REST	3	NS	NS	NS	NS
PK	4	NS	NS	NS	NS
L x L	1	NS	NS	NS	NS
REST	3	NS	NS	NS	NS

Note: NS - Non significant, + - significant at the 10% level,
* - significant at the 5% level.

Table 6. Effect of 10 lbs. zinc on soybean yields.

Treatment	1969 Residual	1969 Direct	1971 Residual	1971 Direct
	Bushels/acre			
N_1 P_1 K_1	31.8	30.8	38.6	39.6
N_1 P_1 K_1 + 10 Zn	25.4	28.8	38.8	39.6

SMALL GRAIN FERTILIZATION

West Central Experiment Station - Morris

S. D. Evans

Field experiments were carried out on Tara silt loam in 1971 to study the response of wheat, oats, and barley to nitrogen fertilization. The nitrate nitrogen level in the 0-24 inch soil zone was 70 lbs/acre as determined by the University of Minnesota Soil Testing Laboratory. Soil test levels of P and K were very high.

A. Oats

1. Nitrogen study

Main plots - Varieties (1) Lodi (2) Otter (3) Diana

Sub plots - Nitrogen levels of 0, 30, 60, and 90 lbs. of actual nitrogen.

A uniform starter application of 100 lbs. of 10-20-20 was used.

Seeding date - April 7, 1971

Table 1. Yield of Oats, Morris, 1971.

Nitrogen Applied lbs/A	Variety: Lodi	Otter	Diana	Average
		Bu/A		
0	46.6	69.3	76.6	64.2
30	109.5	108.2	92.5	103.4
60	106.2	115.3	108.8	110.1
90	73.0	109.3	119.7	100.7
Average	83.8	100.5	99.4	

Table 2. Lodging Score, Oats, Morris, 1971.

Nitrogen Applied lbs/A	Variety: Lodi	Otter	Diana	Average
		Lodging[a]		
0	1.0	1.0	1.0	1.0
30	2.0	2.0	1.7	1.9
60	2.3	2.0	2.0	2.1
90	2.7	2.0	2.3	2.3
Average	2.0	1.8	1.8	

[a] 1-Erect, 9-Flat

Table 3. Groat Percentage, Oat Fertility Study - Morris, 1971

Nitrogen Applied lbs/A	Variety Lodi	Otter	Diana	Average
		Groat %		
0	73.3	74.0	72.0	73.1
30	74.7	75.0	72.3	74.0
60	75.0	75.7	73.3	74.7
90	75.0	76.3	73.0	74.8
Average	74.5	75.2	72.7	

Table 4. Analysis of Variance

Source of Variation	Significance Yield	Heading Date	Pl.Ht.	Lodging	Groat %
Varieties	NS	**	**	NS	NS
Nitrogen	**	NS	**	**	**
Varieties x Nitrogen	NS	NS	NS	NS	NS

Table 5. Chemical Analyses of Oat Leaves Samples at Heading (Reps combined).

Variety	Nitrogen Applied lbs/A	N %	P %	K %	Ca %	Fe ppm	Mg %	Zn ppm	Cu ppm	Mo ppm	Mn ppm	B ppm
Lodi	0	3.10	.22	1.57	.46	75	.23	8.1	1.5	7.8	35	3.6
	30	2.58	.22	1.76	.38	60	.24	7.4	1.8	7.9	28	3.9
	60	4.11	.25	1.30	.52	92	.26	11.1	1.7	8.2	48	5.1
	90	3.16	.22	1.66	.45	74	.22	9.0	2.0	7.6	37	4.0
Otter	0	2.84	.24	1.69	.42	61	.20	7.8	1.8	6.9	28	3.2
	30	4.12	.28	1.42	.54	82	.24	12.1	1.6	7.9	32	4.5
	60	3.41	.26	1.66	.40	77	.23	8.5	1.3	7.5	27	4.8
	90	3.99	.26	1.60	.46	77	.24	10.3	1.3	7.8	26	5.0
Diana	0	3.67	.22	1.38	.52	79	.23	12.6	1.0	7.5	34	7.5
	30	3.29	.22	1.51	.45	70	.25	9.7	0.7	8.1	25	6.8
	60	2.98	.20	1.59	.42	59	.26	9.4	1.0	7.3	24	8.2
	90	3.99	.23	1.37	.55	95	.24	13.4	1.1	8.4	36	8.8

B. Barley

1. Nitrogen Study

Main plots - Varieties (1) Dickson (2) Larker (3) 64-76

Sub plots - Nitrogen levels of 0, 30, 60, and 90 lbs. of actuan nitrogen.

A uniform starter application of 100 lbs. of 10-20-20 was used.

Seeding date - April 7, 1971

Table 6. Yield of Barley - Morris, 1971

Nitrogen Applied Lbs/Acre	Variety Dickson	Larker	64-76	Average
		Bu/Acre		
0	43.4	35.7	46.7	41.9
30	62.7	49.7	58.5	57.0
60	70.1	54.5	65.7	63.4
90	63.7	54.1	69.4	62.4
Average	60.0	48.5	60.1	

Table 7. Lodging Score, Barley - Morris, 1971

Nitrogen Applied Lbs/Acre	Variety Dickson	Larker	64-76	Average
		Lodging[a]		
0	2.0	5.0	1.7	2.9
30	3.0	6.3	2.0	3.8
60	2.7	6.0	2.0	3.6
90	5.0	7.3	2.0	4.8
Average	3.2	6.2	1.9	

[a]1-Erect, 9-Flat

Table 8. Analysis of Variance.

Source of Variation	Significance Yield	Heading Date	Pl. Ht.	Lodging
Varieties	NS	**	**	**
Nitrogen	*	NS	**	**
Nitrogen x Varieties	NS	NS	*	NS

Table 9. Chemical Analyses of Barley Leaves Sampled at Heading (Reps combined)

Variety	Nitrogen Applied Lbs/Acre	N %	P %	K %	Ca %	Fe ppm	Mg %	Zn ppm	Ca ppm	Mo ppm	Mn ppm	B ppm
Dickson	0	2.70	.26	.77	.69	51	.35	13.5	4.0	9.6	51	6.4
	30	3.12	.27	.85	.85	57	.37	16.4	4.1	10.6	54	6.2
	60	2.98	.27	.82	.83	89	.36	15.6	4.0	10.4	50	6.0
	90	3.81	.28	.87	.99	60	.37	20.3	4.7	10.3	66	6.6
Larker	0	3.42	.28	.66	1.50	63	.43	19.4	3.6	12.0	61	7.5
	30	3.43	.27	.74	1.39	62	.39	21.1	3.3	11.3	53	7.5
	60	2.51	.28	.70	1.05	57	.36	13.4	3.8	9.5	60	7.6
	90	3.51	.29	1.02	.96	58	.42	22.8	5.0	11.0	76	6.1
64-76	0	3.28	.30	.86	.57	50	.32	19.5	4.4	11.2	51	7.5
	30	3.85	.29	1.00	.84	56	.39	28.2	5.4	10.4	73	5.0
	60	3.37	.28	.94	.75	51	.36	22.4	4.6	10.3	55	5.5
	90	3.26	.26	.93	.69	61	.36	21.8	4.5	10.3	60	5.1

C. Wheat

1. Nitrogen Study

Main plots - Varieties (1) Ciano 67 (2) Chris (3) Era

Sub plots - Nitrogen levels of 0, 40, 80, and 120 lbs. of actual nitrogen.

A uniform application of 100 lbs. of 10-20-20 was used.

Seeding date - April 7, 1971

Table 10. Yield of Wheat - Morris, 1971

Nitrogen Applied Lbs/Acre	Variety Ciano 67	Chris	Era	Average
		Bu/Acre		
0	44.9	35.0	34.5	38.1
40	47.2	41.3	46.0	44.8
80	46.2	42.7	43.6	44.2
120	47.1	34.3	47.2	42.9
Average	46.4	38.3	42.8	

Table 11. Lodging Score, Wheat - Morris, 1971

Nitrogen Applied Lbs/Acre	Variety Ciano 67	Chris	Era	Average
		Lodging[a]		
0	1.0	1.3	1.0	1.1
30	1.0	2.7	1.3	1.7
60	1.0	5.0	2.0	2.7
90	1.0	7.0	2.3	3.4
Average	1.0	4.0	1.7	

[a] 1-Erect, 9-Flat

Table 12. Analysis of Variance

Source of Variation	Significance			
	Yield	Heading Date	Pl. Ht.	Lodging
Varieties	NS	**	**	**
Nitrogen	*	NS	**	**
Nitrogen x Varieties	NS	NS	**	**

Table 13. Chemical Analysis of Wheat Leaves Sampled at Heading (Reps Combined)

Variety	Nitrogen Applied lbs/Acre	N %	P %	K %	Ca %	Fe ppm	Mg %	Zn ppm	Cu ppm	Mo ppm	Mn ppm	B ppm
Ciano 67	0	3.35	.24	1.00	.40	69	.32	12.9	1.6	10.6	37	3.0
	40	3.64	.25	1.16	.49	72	.34	15.0	1.5	11.3	39	3.0
	80	3.92	.28	1.07	.57	76	.39	16.8	1.5	13.2	51	3.2
	120	3.20	.25	1.07	.37	68	.33	12.0	1.5	10.0	39	4.0
Chris	0	2.97	.24	1.05	.30	62	.27	13.9	2.3	8.9	42	2.3
	40	3.63	.25	1.01	.42	77	.30	15.8	2.3	10.7	52	3.0
	80	3.94	.25	1.02	.45	74	.33	17.0	2.1	10.3	58	2.7
	120	3.39	.24	.95	.34	66	.28	15.3	2.2	11.5	49	3.3
Era	0	3.20	.28	1.20	.29	62	.25	20.4	2.0	9.8	42	2.1
	40	3.56	.27	1.07	.31	59	.26	21.0	1.9	9.2	44	2.2
	80	2.81	.27	1.20	.25	54	.19	17.4	1.8	8.6	27	1.6
	120		.27	1.20	.36	66	.25	22.1	2.2	8.4	45	1.3

This work was done in cooperation with the following staff of the Department of Agronomy and Plant Genetics:

Oats - D. D. Stuthman

Barley - D. C. Rasmusson

Wheat - R. E. Heinen

Statistical analysis was done by Dean Fairchild, Department of Soil Science.

THE EFFECT OF HEAVY APPLICATIONS OF ANIMAL MANURES ON BOTH THE CROP (CORN) AND THE SOIL
1970 and 1971
West Central Experiment Station - Morris

Samuel D. Evans, J. M. MacGregor, R. C. Hunter, and P. R. Goodrich

Experimental Design

Main treatments arranged in three replications of a complete randomized block design. Each plot is split into two parts for sub-plot treatments.

Treatments

Main plots:

1. No manure or fertilizer.
2. Recommended amounts of inorganic fertilizer.
3. Solid manure from a conventional beef feeding facility (manure + straw).
4. Liquid beef manure from a slatted floor feeding barn.
5. Liquid hog manure from a slatted floor hog finishing barn.

Sub-plots:

A. Corn treated at planting with insecticide for corn rootworm control.

B. No rootworm control.

Main Plot Size

60 feet wide by 120 feet long.

Soil Type

Tara and Doland silt loams.

Initial Soil Sampling

Dates - September 25, 28, and 29, 1970.

Soil samples frozen immediately and then transferred to St. Paul.

Initial Tillage

Ran field cultivator over plots to receive liquid manure.

Initial Manure Application

Treatment 3 - September 30

Treatment 4 - September 30, October 1

Treatment 5 - October 2

Plowing

October 5 at a depth of 4-5 inches.

Second Manure Application

Treatment 3 - October 8

Treatment 4 - October 7

Treatment 5 - October 6

Plowing

All plots plowed 8-10 inches deep on October 16.

Total Manure Application (Fall 1970)

Treatment 3 - 100 tons/acre

Treatment 4 - 284 tons/acre (2 1/2 acre inches)

Treatment 5 - 284 tons/acre (2 1/2 acre inches)

Table 1. Manure Analyses (Fall 1970)

	Solid Beef	Liquid Beef	Liquid Hog
Total Solids	31.35%	10.82%	1.24%
Total Volatile Solids (from total solids)	78.30%	8.43%	99.51%
B.O.D.	4,066 mg/l	124,800 mg/l	11,340 mg/l
C.O.D.	46,695 mg/l	62,960 mg/l	26,400 mg/l
Total N	11,200 ppm	2,018,470 ppm	2,335,920 ppm
NO_3-N	2,819 ppm	156,000 ppm	135,600 ppm
PO_4	2,880 ppm	633,000 ppm	125,500 ppm

May 6 - Sampled plots which were to receive inorganic fertilizer.

Table 2. Soil Test Results

Sample	pH	Organic Matter	P	K	Zinc
Rep 1	7.1	H	19	200	1.9
Rep 2	7.2	H	21	240	1.7
Rep 3	7.4	H	17	230	3.7

May 6 - Applied 109 lbs/A of actual N as ammonium nitrate to treatment 2 plots.

May 7 - Planted plots in 30-inch rows with Pioneer 3956A(N) @ 20,000 seed/acre. Four rows in each plot were left without insecticide. Remaining 16 rows received 10 lbs/A of Furadan (10% granule). Plots of treatment 2 received 154 lbs/A or 7-26-26 as a starter (11 + 40 + 40). None of the other treatments received any fertilizer.

May 10 - Sprayed all plots with 2 1/2 lbs/A of Lasso broadcast.

May 24 - Corn just emerging. No apparent differences between treatments.

June 15 - Cultivated all plots.

June 17 - Observed wilting in liquid beef plots.

June 28 - Cultivated all plots.

July 6 - Took 3 soil samples to an 8-inch depth for conductivity measurements.

Area in Rep 1 Only	Electrical conductivity on a saturations extract mmhos/cm
Liquid beef plot where corn was stunted and wilted	6.5
Liquid beef plot where corn was normal	1.3
Check plot	0.2

July 22 thru July 31 - Took notes on pollen shed and silking. On the day following silking took leaf samples in the A parts of all main plots.

There were significant changes in all elements except nitrogen. (Table 3). Manure treatments increased P and K and lowered Ca and Mg. Liquid beef manure drastically increased Zn, Mn, and B in the leaves.

August 4 - Pulled 5 plants in each plot, made a visual rating of root-worm damage, and took pictures of roots. (Dallas Rasmusson, Department of Entomology, Fisheries and Wildlife).

September 15 - Sampled main plots; collected ear, plant, and root samples.

The dry matter production per acre is given in Table 4. The liquid beef plots were highest in above ground D.M. production, while the liquid hog plots were highest in total D.M. production. Chemical analyses of the fodder, grain, and roots is given in Table 5.

September 16 - Took soil samples in plot area to investigate arthropod population. (John Mihm, Department of Entomology, Fisheries, and Wildlife).

September 21 - Took plant counts and lodging notes.

September 23 - Took silage and grain yields and fodder and grain samples.

Harvest data is given in Table 6.

Plants per acre at harvest varied from 18,500 to 21,500. Plants root lodged were quite high in the check and fertilized plots without insecticide. Lodging in all other plots was below 10%. Grain yields ran from 83.52 bu/A on the fertilized plot without insecticide to 116.63 bu/A on the liquid beef plot with insecticide. There was no significant difference between main plot treatments, but there was a significant increase in yield from using insecticide. There was a significant effect of main plot treatments on silage yield, but no effect of insecticide. Nitrogen analyses of the fodder and grain is given in Table 7.

October 4 - Harvested the bulk of the experimental area as shelled corn.

October 9 and 11 - Sampled all plots to a 4-foot depth (3 sub-samples per plot).

A summary of the soil sample analyses is given in Table 8. Nitrate-nitrogen increased in all plots receiving manure. The biggest change occurred with liquid beef manure. In the 3- to 4-foot zone all plots are quite similar in nitrate-nitrogen content.

The treatments receiving either solid or liquid beef manure show chloride levels much above those a year earlier. Liquid hog manure shows an increase in chloride but the increase is less than with the beef manures.

Electrical conductivity measured on a soil filtrate is higher on all plots receiving manure. Again there is a bigger increase with the beef manures than with the hog manure.

October 13 and 14 - Installed permanent neutron access tubes to an 8-foot depth in all plots in rep 1 (3 tubes per lot).

October 14 and 15 - Spread 100 tons/acre of solid beef manure on appropriate plots.

October 15 - Plowed solid beef plots to a 10-inch depth. Had difficulty plowing area in that coulters would not cut thru the material and it would pile up in front of plow. Finally removed coulters and this worked better. There was still some manure left on the surface.

October 15 - Spread 30 lbs. zinc sulfate on fertilized plots.

October 21 - Ran field cultivator thru all plots to receive liquid manure.

October 21 - Applied 1 1/4" hog manure.

October 25 - Applied 1 1/4" liquid beef manure.

Plowed liquid hog manure plots.

Applied 1 1/4" liquid hog manure.

November 3 - Plowed all but solid beef plots.

Applied 1 1/4" liquid beef manure.

November 10 - Plowed east 1/2 of liquid beef manure plot, rep 1. Still too wet, surface soil frozen, wheels slip on a layer about 10 inches deep.

November 12 - Finished plowing liquid beef plots.

November 23 and 24 - Took neutron probe readings in rep 1.

February 9 and 10 - Took neutron probe readings in rep 1.

Table 3. Summary of Leaf Analysis of Corn Leaves (Sampled at Silking)

Treatment	N %	P %	K %	Ca %	Mg %	Al ppm	Fe ppm	Zn ppm	Cu ppm	Mn ppm	B ppm
Check	2.84	.25	1.40	.66	.45	165	152	13.2	10.3	87	4.2
Fertilized	2.70	.36	1.81	.71	.55	174	186	12.2	11.6	107	4.5
S. Beef	2.95	.40	2.43	.52	.24	131	149	13.4	8.8	87	5.6
L. Beef	2.99	.36	2.04	.73	.23	115	127	27.3	7.0	258	13.0
L. Hog	3.10	.34	2.38	.63	.27	154	154	15.4	9.0	102	6.3
LSD (5%)	----	.08	.48	.12	.09	13	25	5.1	3.0	36	6.6
Significance[a]	NS	*	**	*	**	*	*	**	*	**	**

[a]NS is non-significant, + is significant at the 10% level, * is significant at the 5% level, **is significant at the 1% level.

Table 4. Dry Matter Production (Sampled September 15)

Treatment	Forage Lbs/A of Dry Matter	Forage Roots* Lbs/A of Dry Matter
Check	6,742	15,365
Fertilized	7,550	16,192
S. Beef	6,948	18,171
L. Beef	7,863	17,954
L. Hog	7.472	18,629

*Assuming only 42% of roots harvested on all plots.

Table 5. Chemical Analysis of the Samples Collected on September 15.

Treatment	Cl ppm	N %	P %	K %	Ca %	Mg %	Al ppm	Fe ppm	Zn ppm	Cu ppm	Mn ppm	B ppm
						FODDER						
Check	1795	.63	.11	.93	.34	.40	49	287	7.2	5.5	53	11.3
Fertilized	2785	.76	.13	1.03	.34	.43	43	126	6.2	6.2	50	18.5
S. Beef	5397	.80	.22	1.74	.25	.25	42	113	6.4	5.3	46	5.4
L. Beef	5508	1.07	.28	1.99	.48	.28	49	140	8.6	5.2	142	6.2
L. Hog	2591	.87	.14	1.83	.31	.24	40	110	7.0	4.2	50	4.4
						GRAIN						
Check		1.48	.47	.52	Less	.20	14	36	24.9	2.4	7	3.4
Fertilized		1.56	.50	.56	than	.22	7	41	27.4	1.9	10	8.1
S. Beef		1.70	.64	.63	.02%	.24	12	47	34.6	1.7	13	6.5
L. Beef		1.75	.63	.59		.25	4	36	33.0	1.0	15	5.1
L. Hog		1.73	.57	.55		.23	5	33	37.3	3.7	12	7.6
						ROOTS						
Check		.71	.17	.63	.23	.21	2024	2322	12.9	6.4	70	3.8
Fertilized		.63	.15	.71	.21	.24	1559	1797	10.2	4.7	56	3.1
S. Beef		.87	.17	1.37	.26	.20	1791	1930	10.6	7.0	60	2.9
L. Beef		.92	.17	1.48	.31	.25	1361	1523	9.8	3.8	61	2.6
L. Hog		.91	.23	1.18	.31	.24	2414	2675	13.5	5.1	85	4.3

Table 6. Harvest Data.

Treatment	Insecticide	Plants per Acre	Root Lodged 30° or more %	Broken Above Ear %	Broken Below Ear %	Broken if Pushed to Arms Length %	Grain: No. of Ears per Acre	Grain: Nubbins %	Grain: % Ear Moisture at Harvest	Grain: Grain Yield Bu/Ac @ 15.5% Mois.	Silage: Lbs/Ac on Dry Matter Basis	Silage: Ears as a % of the Total	Silage: Dry Matter at Harvest %
Check	W	19500	4.0	13.1	2.5	17.1	19500	4.5	38.2	96.88	11700	59.2	54.6
	W/O	18500	56.2	11.5	1.2	3.3	18800	7.0	38.8	92.86	11200	58.7	54.2
Fertilized	W	20700	1.4	18.1	3.5	20.1	19900	6.8	38.2	110.72	13900	54.7	51.3
	W/O	19400	41.8	25.5	2.7	9.4	19700	5.6	36.7	83.52	12100	53.4	57.9
S. Beef	W	21000	0.2	32.5	4.4	19.4	19300	5.0	36.4	103.60	13700	54.9	49.2
	W/O	19300	5.5	28.8	3.0	21.1	18200	9.2	35.9	98.78	13000	54.0	50.9
L. Beef	W	21500	1.8	20.9	4.0	11.9	20400	7.6	38.4	116.63	14800	53.4	45.6
	W/O	21500	3.4	22.1	4.5	11.5	20000	8.2	39.6	102.78	13400	49.5	47.7
L. Hog	W	20300	0.7	23.5	9.6	17.7	19800	8.1	32.5	101.71	14700	55.4	55.4
	W/O	19200	8.6	34.1	1.7	14.3	18900	7.9	35.2	97.54	13400	52.9	54.4

Table 7. Nitrogen in the Fodder and Grain at Final Harvest on September 23.

Treatment	Insecticide	Fodder N %	Grain N %
Check	W	.56	1.41
	W/O	.64	1.43
Fertilized	W	.71	1.65
	W/O	.70	1.62
S. Beef	W	.74	1.72
	W/O	.82	1.85
L. Beef	W	1.04	1.80
	W/O	1.07	1.85
L. Hog	W	.92	1.70
	W/O	.91	1.91

Table 8. Analyses of Soil Samples Taken in Morris Animal Manure Plots.

Nitrate (NO_3-N)

ppm in Soil

Depth (ft.)	Check A	Check B	Fertilized A	Fertilized B	Solid Beef A	Solid Beef B	Liquid Beef A	Liquid Beef B	Liquid Hog A	Liquid Hog B
0-1/2	12	10	12	10	16	44	18	100	13	22
1/2-1	12	6	18	9	15	56	14	165	21	71
1-2	13	4	13	11	15	41	12	196	14	106
2-3	11	16	14	31	15	37	14	63	10	62
3-4	4	21	5	22	8	25	7	20	5	25

Chloride

ppm in Soil

Depth (ft.)	Check A	Check B	Fertilized A	Fertilized B	Solid Beef A	Solid Beef B	Liquid Beef A	Liquid Beef B	Liquid Hog A	Liquid Hog B
0-1/2	22	10	11	8	13	15	9	30	7	8
1/2-1	12	5	6	6	9	18	5	41	6	6
1-2	13	4	6	3	8	82	8	104	7	18
2-3	15	10	15	15	15	155	17	168	11	81
3-4	12	23	13	18	16	76	13	58	10	30

Electrical Conductivity on Soil Filtrate

(20 g. air dried soil + 50 ml. H_2O mmhos/cm)

Depth (ft.)	Check A	Check B	Fertilized A	Fertilized B	Solid Beef A	Solid Beef B	Liquid Beef A	Liquid Beef B	Liquid Hog A	Liquid Hog B
0-1/2	.17	.14	.17	.13	.23	.30	.18	.41	.16	.16
1/2-1	.15	.13	.16	.13	.10	.24	.14	.50	.16	.31
1-2	.18	.12	.16	.17	.20	.29	.17	.60	.15	.40
2-3	.19	.17	.21	.26	.20	.34	.19	.44	.18	.40
3-4	.17	.20	.18	.24	.19	.24	.18	.21	.16	.22

Note: A - Readings on Soil Samples taken in fall of 1970 before manure application.

B - Readings on Soil Samples taken in fall of 1971 before manure application.

1971 Corn Tillage Experiment - Waseca

Wm. Lueschen, J. Swan, J. True

Tillage Treatments		Early Plant Growth Grams Dry Weight/10 plants					Final Stand 1000
Primary	Secondary	Rep 1	Rep 2	Rep 3	Rep 4	Avg.	plants/acre
1. Spring Plow	None	51	47	34	40	43 d	20.8
2. Spring Plow	Conventional	39	32	32	29	44 d	23.5
3. Spring Plow	Field Cultivate	37	38	41	39	39 cd	22.3
4. Spring Plow	Conventional	66	55	57	46	--	21.4
5. Spring Chisel	Conventional	36	43	22	21	31 bc	23.6
6. Spring Chisel	Field Cultivate	29	33	29	17	27 ab	22.1
7. Spring Chisel	Zero	20	27	19	16	21 a	21.5
8. Spring Chisel	Conventional	49	24	38	18	--	21.6
9. Spring Chisel	Disk	35	31	39	19	31 bc	21.8
10. None	None	22	17	19	17	19 a	22.1
11. None	Disk	48	40	49	24	40 d	21.5

4 reps (30 feet x 125 feet)

11 treatments - Randomized complete block

Hybrid - Funks 4444

Date Planted and Secondary Tillage-5/4/71

Date of Spring Primary Tillage-4/23-26

All planting done with AC-No Till planter

Bdcst fertilizer-175 lbs/A N (NH_4NO_3) + 50 lbs/A P_2O_5 + 50 lbs/A K_2O

Insecticide: Furadan 1 lb. banded

Herbicide: Ramrod pre-emergence + Atrazine and oil post

Coulters removed on 8 rows/plot on all plots except 10 zero primary and zero secondary where coulters removed for 4 rows.

4-inch soil temperature measurements were made using thermocouples in all 4 reps of treatment.

In 1970, no fall tillage was done for the 1971 season due to tiling operations.

In each comparison treatment means with the same letter are not significantly different at the 5 percent level by Duncan Multiple Range Test.

Plots were in corn in 1970 and received the same tillage treatments except that in 1971 spring primary tillage replaced fall primary tillage.

1971 Corn Tillage Experiment - Waseca

Tillage Treatments		Corn Yield Bu/Acre 15.5% Moisture										Average
		Rep 1		Rep 2		Rep 3		Rep 4		Avg.		F & C
Primary	Secondary	Conv.	Flute	Conv.	Flute	Conv.	Flute	Conv.	Flute	Conv.	Flute	
1. Spring Plow	None	123.1	123.5	104.5	125.1	92.4	101.6	127.3	121.1	111.8	117.8	114.8 b
2. Spring Plow	Conv.	100.9	108.0	114.7	110.5	99.8	92.3	103.5	107.9	104.7	104.7	102.6 ab
3. Spring Plow	Field Cult.	103.0	95.5	99.0	104.6	96.6	93.8	104.4	125.5	100.8	104.9	102.8 ab
4. Spring Plow	Conv.	97.1	99.2	99.2	87.7	104.9	100.3	112.3	104.0	103.4	97.8	--
5. Spring Chisel	Conv.	100.4	111.0	94.2	98.6	97.5	115.1	114.8	121.0	101.7	111.4	103.3 ab
6. Spring Chisel	Field Cult.	112.4	103.9	93.9	107.3	112.5	121.4	109.8	122.9	107.2	113.9	110.5 ab
7. Spring Chisel	Zero	114.4	122.2	111.6	107.3	118.7	131.8	114.3	109.5	114.6	117.7	116.2 b
8. Spring Chisel	Conv.	90.7	94.4	103.8	110.8	76.0	87.4	117.7	120.2	97.1	103.2	--
9. Spring Chisel	Disk	123.6	123.8	107.2	121.1	100.2	95.3	97.0	113.8	107.0	113.5	110.3 ab
10. None	None	88.7	93.3	90.8	87.2	91.3	100.7	107.4	109.9	94.6	97.8	96.2 a
11. None	Disk	108.8	100.0	103.5	111.8	82.7	99.5	113.6	112.7	102.2	106.0	104.1 ab
								Average		104.1	108.6	106.7

1971 Mulch Rates Tons/Acre

Treatment	Rep 1	Rep 2	Rep 3	Rep 4	Avg.
Plow	Trace	Trace	Trace	Trace	Trace
Chisel	1.56	1.41	1.48	1.31	1.44
Zero	2.55	3.03	3.65	2.80	3.01

Measurements made just after planting.

Corn Tillage - Waseca, 1971

Treatments		Reps 1	2	3	4	Days to 50% Emergence Total	$\bar{X}$
Fall Plow	Zero	16	17	16	16	65	16
Fall Plow	Conv.	15	16	15	16	62	16
Fall Plow	Field Cult.	16	16	16	16	64	16
Spring Plow	Conv.	15	15	15	15	60	15
Fall Chisel	Conv.	17	16	17	19	69	17
Fall Chisel	Field Cult.	18	18	17	19	72	18
Fall Chisel	None	19	19	19	19	76	19
Spring Chisel	Conv.	16	18	16	17	67	17
Spring Chisel	Disk	17	17	16	19	69	17
Zero Tillage	Zero	19	20	19	19	77	19
Zero	Disk	16	18	16	18	68	17
	Total	184	190	182	193	749	187
	$\bar{X}$	17	17	17	18	68	17

1971 Corn Yield - ANOVA

	dF	MS	F
Rep	3	461.2770	11.99*
Fluting	1	329.3889	8.56 N.S.
Error	3	38.47185	--
Tillage	8	344.9869	3.92**
Interaction	8	20.13983	0.23 N.S.
Error	48	87.94476	--
Total	71		

Coefficient of variation = 8.78 percent

Treatment Comparisons (Array test)

Primary tillage		Secondary tillage	
Plow	106.8 ab	No Spring Tillage	109.0 N.S.
Chisel	110.0 b	Conventional	103.0
No Plow	100.1 a	Field Cultivate	106.7
		Disk	107.2

Linear regression of yield and early growth had an r value of 0.003 indicating little relationship between early growth and final yield.

Corn Early Growth - ANOVA

	dF	MS	F
Rep	3	238.6944	8.20 **
Tillage	8	354.5486	12.20 **
Error	24	29.04861	
Total	35		

C.V. = 16.48 percent

Primary tillage		Secondary tillage	
Plow	41.9 b	No Spring tillage	27.4 a
Chisel	27.4 a	Conventional	37.5 b
No plow	29.5 a	Field Cultivate	32.9 ab
		Disk	35.6 ab

Population - ANOVA

	dF	MS	F
Reps	3	27.03065	10.88 **
Tillage	8	1.930069	0.78 N.S.
Error	24	2.484606	
Total	35		

CV = 7.28 percent

RELATIVE EARLY CORN GROWTH

Waseca Tillage Trials

Primary Tillage	Secondary Tillage	Time of Primary Tillage	Percent of Highest Treatment 1970	1971
Plow	Conv.	Fall	100	--
		Spring	94	100
	Zero	Fall	74	--
		Spring	--	98
	Field Cultivate	Fall	83	--
		Spring	--	89
Chisel	Conv.	Fall	74	--
		Spring	77	71
	Zero	Fall	57	--
		Spring	--	48
	Field Cultivate	Fall	74	--
		Spring	--	61
	Disk	Spring	71	71
No tillage	Disk	--	71	91
	Zero	--	54	43

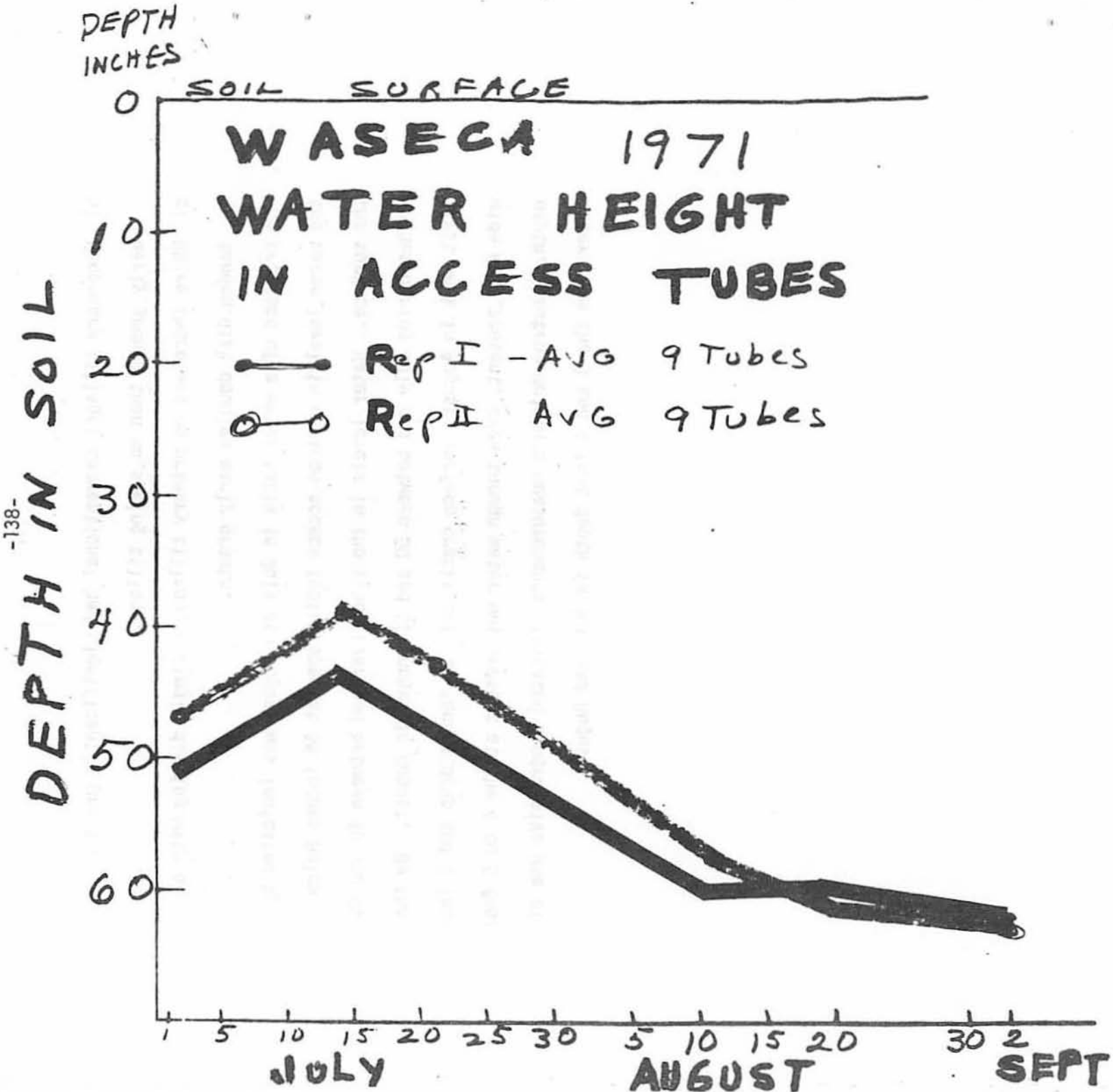
Conclusions:

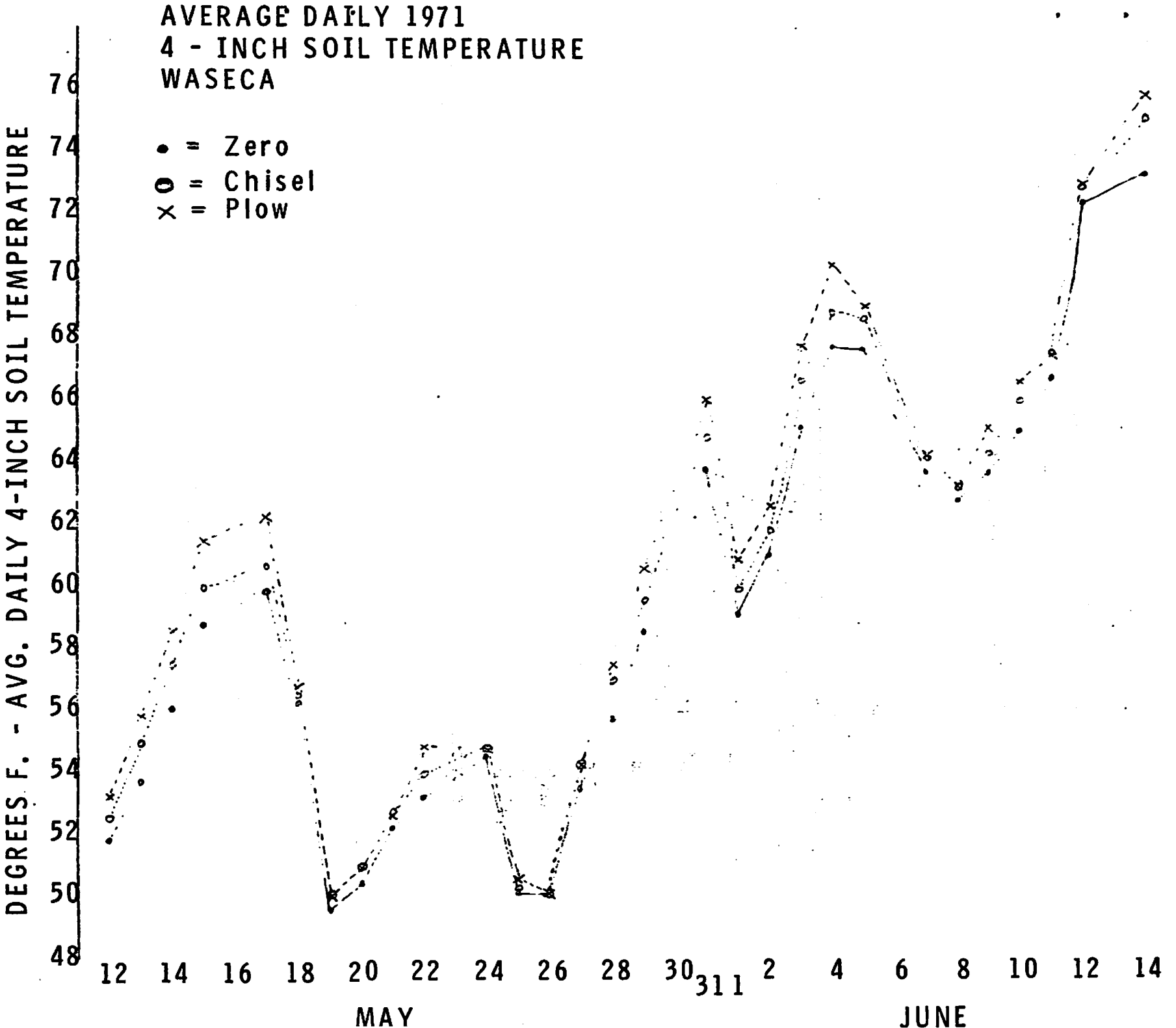
1. Corn yield factorial effects:
   a) In the primary tillage treatment group, chisel yielded significantly greater than No-Plow. The comparison of plow and no-plow approached significance.
   b) In the secondary tillage treatments, there were no significant yield differences.
2. The F test of all treatments showed that significant yield differences were present (at the 5% level). Both the plow and chisel treatments with no secondary tillage (114.8 and 116.2 Bu/A, respectively) were significantly different compared to the no-till treatment with no secondary tillage (96.2 Bu/A). There were no other significant differences.
3. Corn yields were much lower in 1971, averaging only 107 Bu/A compared to 160 Bu/A in 1970. The decrease in yield was due to a severe drought in July and August; between July 9 and August 30 only 1.27 inches of rain fell.
4. There was no significant difference in yield due to use of the fluted coulter.
5. Large significant differences in early growth were measured. Growth differences generally agreed with the growth differences expected based on soil temperature measurements. Soil temperature decreased as mulch rate increased. However, differences in early growth were not correlated with yield.
6. Early growth factorial effects:
   a) Primary tillage: plowing had significantly greater early growth than either the chisel or no-plow treatments.

b) Secondary tillage: conventional had significantly greater early growth than no spring tillage.

c) Where there was no primary tillage, a single disking with a tandem disk doubled early growth.

7. The presence of a water table in July and August was indicated by the water level in neutron access tubing open at 66 inches below the surface. Water levels in the tubes averaged between 40 and 50 inches during July and between 50 and 60 inches in August. By the first week in August, surface cracks over 20 inches deep and 1 inch wide were present, even though water was present at the 4 to 5 foot depth. Neutron moisture measurements indicated progressive use of water from the 3 and 4 foot depth in July and August.


DEPTH INCHES
SOIL SURFACE
WASECA 1971
WATER HEIGHT
IN ACCESS TUBES
Rep I - AVG 9 Tubes
Rep II AVG 9 Tubes
DEPTH IN SOIL
0
10
20
30
40
50
60
1 5 10 15 20 25 30 5 10 15 20 30 2
JULY
AUGUST
SEPT


AVERAGE DAILY 1971
4 - INCH SOIL TEMPERATURE
WASECA
• = Zero
O = Chisel
X = Plow
DEGREES F. - AVG. DAILY 4-INCH SOIL TEMPERATURE
76
74
72
70
68
66
64
62
60
58
56
54
52
50
48
12 14 16 18 20 22 24 26 28 30 31 1 2 4 6 8 10 12 14
MAY
JUNE

LIME PLOTS, WASECA 1971

J. Grava, C. J. Overdahl, D. S. Fairchild,
B. D. McCaslin, R. H. Anderson

A field experiment was established in spring of 1971 at the Southern Experiment Station to study the effects of liming on yield and chemical composition of corn, and chemical properties of soil. The soil type is Le Sueur silty clay loam. The plot had been used for a corn management study, 1967-1970. Average soil tests of samples collected prior to the establishment of the experiment are given in Table 1.

Table 1. Soil test results.

Soil pH	SMP Buffer Index	P Lb/A	K Lb/A	Zn ppm	S ppm	Lime Requirement - Tons/A
5.7	6.1	85	400	1.9	14	5.5 -- 7.0

Dolomitic limestone, used in this experiment, had the following quality characteristics:

Passing 8-mesh sieve	97.3%
Passing 60-mesh sieve	51.7%
Calcium carbonate equivalent	96.1%

The lime rates used were as follows: 0, 2.5, 5.0, 7.5, 10.0 tons per acre. The treatments were replicated six times. Limestone was applied on April 20, 1971. Individual plots are 20 feet wide (8-30" rows) and 60 feet long. All plots received the following: (a) 154 + 128 + 136 lb/A of plant nutrients, expressed as N, P_2O_5, K_2O; (b) herbicide: 1 1/2 lb/A Atrazine, 2 lb/A Lasso; (c) insecticide: 3/4 lb/A Furadan. Pioneer 3582 Hybrid was planted on April 26; planting rate: 26,000. Corn was cultivated on May 29.

The yields of corn and chemical composition of sixth leaf at tasseling are given in Tables 2 and 3. Lime treatment had no effect on corn yields but liming did increase the molybdenum content of leaf tissue.

Table 2. Yield of corn, Waseca lime plots, 1971.

Rate of Lime	Yield
Tons/Acre	Bu/Acre
0	140
2.5	129
5.0	131
7.5	138
10.0	137
Significance	NS*
CV%	12

*N.S. -- Treatment means not significantly different at the 5.0% level.

Table 3. Chemical composition of sixth corn leaf at tasseling, Waseca lime plots, 1971.

Rate of Lime	N	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B	Fe	Al
Tons/Acre	----- Percent in dry matter ------					--------- Parts per million in dry matter -------						
0	2.79	.30	2.00	.49	.17	36	6	7.0a[2]	93	8	131	41
2.5	2.84	.29	1.91	.48	.17	37	5	8.3b	86	7	138	45
5.0	2.90	.30	1.96	.51	.19	37	6	8.6b	86	8	139	44
7.5	2.90	.30	1.99	.51	.17	37	6	8.9b	91	8	137	40
10.0	2.69	.29	1.87	.48	.18	37	6	9.2b	81	7	137	43
Significance	NS[1]	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS
CV%	8	5	6	7	9	17	25	10	17	8	9	17

[1]N.S. -- Treatment means not significantly different at the 5.0% level.

[2]Treatment means followed by different letters are significantly different at the 5.0% level.

NITROGEN EXPERIMENTS WITH CORN

W. E. Fenster and C. J. Overdahl

In the fall of 1969, nitrogen experiments were established to determine the rates of nitrogen that would result in the highest economic yields of corn on highly productive land. The soils on which the experiments were conducted are fine textured, high in organic matter, high in P and K, and have reasonably good drainage. Another dimension has been added to these experiments whereby the nitrate-nitrogen in the soil is being monitored to ascertain the downward movement with time as it relates to the rate of application of nitrogen.

Table 1. Corn yields as influenced by nitrogen treatments (3 locations 8 replications).

N (lbs/A) annually	Martin Co. Continuous corn 1970	Martin Co. Continuous corn 1971	Martin Co. Virgin soil 1971	Waseca Co. Continuous corn 1970	Waseca Co. Continuous corn 1971
	yield (bu/A)				
0	120 a	130 a	179 a	82 a	43 a
50	128 ab	142 b	190 bc	109 b	63 b
100	140 c	151 b	187 bc	143 c	93 c
150	132 bc	144 b	183 b	153 cd	131 d
200	131 abc	147 b	194 c	163 d	144 e
400	135 bc	153 b	190 bc	169 d	151 f

Where letters differ at each location, yields are statistically different at the 10% level.

All plots received a basic treatment of 0+150+200+20 Zn annually.

The soils were classified as Webster silty clay loams.

Table 2. Percentage nitrogen in tissue* (July) as related to fertilizer nitrogen application.

N (lbs/A)	Martin Co. Continuous corn 1971 %	Martin Co. Virgin soil 1971 %	Waseca Co. Continuous corn 1970 %	Waseca Co. Continuous corn 1971 %
0	2.5	2.8	1.9	1.5
50	2.7	2.7	2.2	1.7
100	2.6	2.8	2.5	2.2
150	2.9	2.8	2.7	2.6
200	2.9	2.8	2.8	2.9
400	2.9	2.9	3.0	3.0

* sixth leaf at tasseling

In order to determine the amount of nitrate-nitrogen in the soil profile, soil cores were taken to a depth of 6 feet in Martin County and 5 feet in Waseca County. It is our intent to monitor these nitrates and their movement in the soil for at least 5 years. Preliminary data on the soil nitrate regimes are given in the following tables:

Table 3. Amount of nitrate-nitrogen in the soil profile* on continuous corn in Martin County (average of 4 replicates). Parts per million (ppm) Nitrate-Nitrogen (NO_3-N)

Soil Depth (ft.)	Treatment - lbs N/A applied annually: 0		50		100		150		200		400	
	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
0-1	8	9	7	9	6	9	8	12	9	23	12	60
1-2	6	5	5	5	6	8	6	17	6	23	9	45
2-3	6	5	9	13	7	13	13	43	7	26	19	30
3-4	12	6	17	15	9	15	44	30	22	20	28	20
4-5	12	7	21	14	11	14	29	28	24	17	18	18
5-6	7	10	20	13	13	14	24	23	17	17	14	18

* soils sampled after corn harvested

Table 4. Amount of nitrate-nitrogen in the soil profile on virgin soil planted to corn in Martin County (average of 4 replicates).

Soil Depth (ft.)	Virgin soil fall 1970	ppm NO_3-N Treatment - lbs N/A applied - 1971					
		0	50	100	150	200	400
0-1	6	17	19	24	15	31	40
1-2	4	10	23	32	29	47	32
2-3	5	7	9	8	14	14	11
3-4	3	3	5	4	5	4	5
4-5	3	3	3	4	5	6	3
5-6	3	4	3	4	4	6	4

Table 5. Amount of nitrate-nitrogen in the soil profile on continuous corn in Waseca County (average of 4 replicates).

Soil Depth (ft.)	ppm NO_3-N Treatment - lbs N/A applied - 1971					
	0	50	100	150	200	400
0-1	4	4	6	6	5	17
1-2	2	2	3	4	3	12
2-3	3	3	3	3	3	27
3-4	2	2	2	3	3	17
4-5	3	2	3	4	4	10

OBSERVATIONS AND SUMMARY

1. In Martin County on continuous corn in 1970 and 1971, significant yield increases were not realized where rates of nitrogen greater than 100 pounds of N/acre were applied.
2. In Martin County on the virgin soil in 1971, the 50 pound N rate was adequate to produce a significant increase in corn yields. Higher rates of N produced no additional increases in corn yields.
3. In Waseca County, the highest significant increases in corn yields were obtained in 1970 with 150 pounds of N/acre and in 1971 with

400 pounds of N/acre. The University still recommends between 150 and 200 pounds of N/acre, however, as the farmer realizes his highest economic yield at these rates.

4. The percentage N in the sixth leaf at tasseling stage correlated very well with amounts of N/acre applied and the corn yields. In general, when 2.7 percent or greater was noted in the plant tissue, yield increases were not realized from additional N applications.
5. The soil nitrates at the three plot sites varied markedly. In general, however, the highest nitrate levels were found in the top 2 or 3 feet of soil at all locations. The highest levels of NO_3-N were observed in Martin county on the continuous corn plots receiving an annual application of 400 pounds of N/acre.
6. At the Martin county location, nitrogen applications in excess of 100 pounds of N/acre on continuous corn appears to result in NO_3-N levels in the soil which may be of concern from an environmental quality standpoint. More years of data are needed to verify these results. Further study is also needed to see if the NO_3-N moves downward in th soil profile with time and further applications of nitrogen.
7. On the virgin soil in Martin county, the applied nitrogen is reflected in the top 2 feet of soil after one year. The levels of accumulation would appear to be in relation to the rates of nitrogen applied. Unlike the continuous corn in Martin county, where the NO_3-N levels are confounded with many years of fertilizer nitrogen and manure applications, the virgin soil profile indicates no additional accumulation of NO_3N from the fertilizer applications in the 3 to 6 foot depth after one year.

8. The NO_3N levels at the Waseca location are relatively low at all nitrogen fertilizer rates except that receiving the 400 pounds of N. It is interesting to note that the soils at Waseca and Martin counties are classified as Websters, since they have quite different nitrogen regimes. This difference may be due in a large measure to differences in rainfall and perhaps other climatic conditions. Of equal importance, perhaps, is the fact that the Waseca location has not received any barnyard manure for at least 20 years, whereas, the Martin county continuous corn site has received several manure applications in recent years.

9. Based on these preliminary data, it would appear that serious consideration should be given to adjusting nitrogen fertilizer recommendations for corn, based on the NO_3-N level on soil samples taken from perhaps 0 to 3 feet in depth.

PHOSPHORUS AND POTASSIUM NEEDS FOR HIGH CORN YIELDS

C. J. Overdahl and W. E. Fenster

To study rates of P and K broadcast or in the row sounds like repetition of corn fertility research done during the past 50 years. Advances in research with corn hybrids, weed control and insect control, however, causes fertilizer research to become out of date rapidly.

In the fall of 1969, we established trials in Martin and Waseca counties to determine broadcast needs of P and K when corn yields are in the range of 150 to 200 bushels per acre. Earlier work of this nature was carried out where yields were in the range of 80 to 100 bushels. The question is whether increased rates of fertilizer should be in proportion to the higher yield goals, or perhaps much higher, and how high should a soil test be before no more broadcast fertilizer is needed.

Broadcast phosphorus applications were made annually at 0, 50, 100, 150 and 200 pounds per acre of P_2O_5 with a blanket treatment of about 200+0+300+20 Zn each year. The annual broadcast potassium applications were made at 0, 50, 100, 200 and 400 pounds per acre of K_2O with a blanket treatment of 200+150+0+20 Zn.

Farmer cooperators were selected on the basis of ability to produce 200 bushels per acre on occasion where great attention is paid to details of tillage and controlling insects and weeds, plus early planting with good hybrids.

The soils were fine textured, high in organic matter, high in P and K, and had reasonably good drainage. Tables 1 through 4 show yields, along with related soil and tissue tests. They also show details about pH, zinc levels in soil and leaves, as well as

nitrogen in leaves.

In 1970, there were no significant increases from either broadcast P or K, but significant responses were obtained from starter fertilizer. In 1971 in Martin county, there was a significant response to broadcast phosphate when the soil phosphorus test was 37 pounds of P in the check plot. Phosphorus in the leaf opposite and below the ear sampled July 21 during silking was increased from .28 to .30 percent by the application of 100 pounds of P_2O_5. Results in 1972 and perhaps 1973 will be necessary before one could safely say that 37 pounds of soil P and .28 percent P in the leaves was not high enough. To complicate our thinking, Waseca county results show that raising leaf P from .28 to .30 percent and soil P from 27 to 45 pounds per acre gave no yield increase in 1971. Rainful was more limiting in August at this site and yields were about 15 bushels per acre less than in Martin county. We need yields close to 200 bushels per acre before we can learn about yield differences when soil tests are this high.

Some surprises were encountered. Originally, the zinc levels were moderately low on the Martin county trial, so 20 pounds of actual zinc as zinc sulfate were incorporated for the 1970 crop and again for 1971. Table 1 shows that zinc in the leaves is below 20 ppm, but that zinc soil tests are very high. Zinc research by Dr. MacGregor of the Soil Science Department at the University, shows that zinc applications increase leaf zinc, but often maximum corn yields were reached when leaf content was still below 20 ppm. We are quite sure that 20 pounds of zinc per acre two consecutive years prevented zinc from being a limiting factor in these trials.

Another surprise was the small increase of P and K in plant