planting to ensure uniform germination. Lasso herbicide was applied on April 30 at the rate of 1.5 lbs/A and the corn was cultivated once on June 11, 1970. Natural rainfall from April 13 to November 2, 1970 totaled 25.87 inches and 14.05 inches of water was applied to the field by periodic supplemental irrigation. The corn was mature and harvested in early October. The 1969 and 1970 fertilizer treatments and the resulting corn yields are shown in the following table.

Table 1. The 1969 and 1970 Fertilizer Treatments and Subsequent Corn Yields on an Irrigated Hubbard Loamy Coarse Sand in Sherburne County (average of 5 replications).

1969				1970				1969+ 1970
Soil treatment (lbs/A)			Corn yield (bu/A)	Soil treatment (lbs/A)			Corn yield (bu/A)	yield (bu/A)
N	P	K		N	P	K		
0	43	0	19.9a[1]	0	0	0	18.5a[1]	38.4
0	43	75	25.4a	0	0	0	24.5a	49.9
0	43	150	37.9a	0	0	0	39.7a	77.6
100	43	0	90.5b	100	0	0	99.8b	190.3
100	43	150	98.3b	100	0	0	110.7b	209.0
100	43	75	98.9b	100	0	0	120.5b	219.4
200	43	150	104.5bc	200	0	0	107.7b	212.2
400	43	300	119.1cd	0	0	0	39.3a	158.4
200	43	0	121.8cd	200	0	0	113.3b	235.1
200	43	75	128.9d	200	0	0	122.7b	251.6

[1] Numbers followed by the same letter are not significantly different at the 5.0% level (Duncan's New Multiple Range Test).

The very large (but transient) response of corn yield to N fertilization was significant when applied at either 100 or 200 lbs per acre. The N was applied each year as a split treatment (at seeding and again in late June) and even greater yield increases might be obtained with equivalent amounts separated into lesser, but more frequent treatments. The corn plants in the 400 lb/A N treatment (200 lbs/A in 1969 at seeding and 200 lbs in late June of 1969) were burned by the late June treatment and even the 1969 yields were no greater than the 200 lb treatment. Apparently the applied excess N was rapidly leached beyond plant root depth and essentially lost to crop production.

The soil was initially medium to high in exchangeable potassium, and therefore the lack of a significant response to the 1969 potassium treatments in both 1969 and 1970 would be expected.

Frequent N fertilization at relatively low rates combined with frequent irrigation appear to be the major requirements for maximum corn production on these sandy soils. Potassium fertilization would be expected to be a necessity relatively soon although phosphate is apparently ample for some time.

The experiment will be repeated in 1971 with varying rates of N being applied at several times during the growing season.

THE RELATIVE EFFECT OF SULFUR COATED UREA AND OTHER FORMS OF NITROGEN ON 1970 CORN YIELD AND COMPOSITION WHEN GROWN ON AN IRRIGATED HUBBARD LOAMY COARSE SAND IN SHERBURNE COUNTY

J. M. MacGregor, R. C. Munter, D. S. Fairchild and B. D. McCaslin

Since sulfur-coated urea developed by the Tennessee Valley Authority is designed to lengthen the period of N availability over longer periods, an experiment was designed to determine this effectiveness for corn production on this sandy soil in comparison to equivalent N fertilization as urea alone, urea + equivalent sulfur (as flowers) and as ammonium nitrate N.

Since the soil was very sandy and porous, the sulfur-coated urea having the slowest availability (3.2% in 3 days, 10.4% in 7 days or 1.8% daily) was selected. Corn had been grown in 1969 using only 43 lbs/A of planter applied P per acre with no additions of N or of K--with resultant 1969 corn yields of less than 20 bushels per acre. Soil pH varied from 5.0 to 5.1, organic matter medium (M), extractable P (Bray No. 1) was 200 lbs/A, with exchangeable K varying from 210 to 320 lbs/A. The corn hybrid grown in 1970 was Trojan TXS102 (110 day maturity) planted on April 29 in 30-inch rows with a population of nearly 30,000 plants per acre. Lasso herbicide was applied on the day following seeding at the rate of 1.5 lbs/A. Natural rainfall in the period April 13--November 2 totaled 25.87 inches and a total of 14.05 inches by sprinkler irrigation was also applied at suitable intervals. Five replications of 5 treatments were used in a randomized block design; each plot was 6 rows (15 feet) by 50 feet in length. All 4 treatments were broadcast on June 16 to supply N at the rate of 100 lbs/A. Five index leaves were sampled from each plot on July 28 and again on August

28 and analyzed for percentage N (by Kjeldahl) and for 12 other elements on an emission spectrograph (Jarrel Ash 1.5 meter Atom-Counter). The corn was mature and harvested in early October.

Results

It was evident within 10 days following the N sidedressing treatments that the sulfur-coated urea was releasing the N at a slower than desirable rate since corn growth during most of the growing season was only slightly better than corn growing with no N fertilization.

The analyses of the sixth corn leaf at the 2 sampling dates are shown in Table 1 and Table 2.

It is evident that the sulfur-coated urea was being released much too slowly in comparison to the 3 other N treatments. Marked differences in the other elements were evident, especially in the concentrations of the same elements at the 2 stages of growth. In general, the N fertilization appeared to increase concentrations of total N, K, Ca, Sr, Zn and Mn and to decrease P levels in the corn leaves. (See Table 2)

Ear corn yields, N content and N removal in corn grains per acre are shown in Table 3. (See Table 3)

It is evident that the slightly soluble sulfur-coated urea used in this experiment released N much too slowly for maximum corn production in comparison to yields of 3 other N treatments which received equivalent (but more soluble) amounts of N (100 lbs/A). It is possible that the S-coated urea would have been much more productive if applied 1 1/2 months earlier at the time of seeding. This will be studied in 1971 along with possible residual effects of the 1970 S-urea treatments.

The relative efficiency of the 3 soluble N fertilizers in corn production is excellent, since in most Minnesota soils 50% or even 40% removal of the amounts of N applied would be considered more normal.

This experiment will be modified and repeated in 1971, since it is evident that sulfur-coating of the urea delays solubility and probably increases the length of time that fertilizer N remains available to the corn plants. Residual effect of the 1970 S-coated urea and the application of more soluble forms of this fertilizer for corn will be studied on these sandy irrigated soils.

Table 1. Analyses of the Sixth Corn Leaves on N Treated Hubbard Loamy Coarse Sand. (1970)

Treatments:	% N (Kjeldahl)	% P	% K	% Ca	PPM Sr	PPM Fe	% Mg	PPM Zn	PPM Cu	PPM Mo	PPM Mn	PPM B
	(Analyses of 6th corn leaves sampled July 28, 1970)											
CHECK	1.17	.408b	1.75a	.335a	9.64a	45.6	.136	13.3a	7.60	3.46	37.4a	5.80
100# N/A as S-Urea	1.12	.276a	1.88ab	.506b	15.2b	41.5	.144	13.7a	9.14	3.12	41.9a	5.18
100# N/A as Urea + S	2.55	.341ab	2.11ab	.637b	19.5c	35.0	.190	20.46	12.7	3.72	60.7b	6.12
100# N/A as Urea	2.48	.289a	2.03ab	.583b	18.2bc	35.0	.156	18.9b	9.96	2.74	53.0b	5.92
100# N/A as NH_4NO_3	2.49	.365ab	2.30b	.713b	20.6c	39.6	.235	22.66	13.6	4.38	59.3b	7.46
Significance		*	*	**	**	NS	NS	*	NS	NS	**	NS
Coefficient of Variation		18.7	13.1	21.3	14.6	17.2	49.1	25.5	44.5	44.5	14.3	30.7

Table 2 Analyses of the Sixth Corn Leaves on N Treated Hubbard Loamy Coarse Sand (1970)

Treatments:	% P	% K	%Ca	PPM Sr	PPM Fe	% Mg	PPM Zn	PPM Cu	PPM Mo	PPM Mn	PPM B
	(Analyses of 6th corn leaves sampled August 28th 1970)										
CHECK	.592b	1.74a	1.12a	30.7a	140	.422	19.2a	3.90a	11.0	135a	21.5
100# N/A as S-Urea	.242a	2.06a	1.62b	45.6b	147	.414	19.3a	9.26b	11.7	164ab	25.5
100# N/A as Urea + S	.309a	4.00b	1.67b	48.2b	126	.466	28.4b	19.2c	10.6	194b	23.6
100# N/A as Urea	.235a	3.75b	1.64b	48.9b	129	.404	23.9ab	19.2c	9.2	166ab	22.4
100# N/A as NH_4NO_3	.232a	3.66b	1.74b	52.6b	147	.428	24.9ab	18.0c	9.3	155ab	23.1
Significance	**	**	**	**	NS	NS	*	**	NS	*	NS
Coefficient of Variation	32.8	22.4	10.7	9.03	18.4	18.3	20.5	26.5	17.4	16.6	10.5

Table 3 The 1970 Yield of Ear Corn Grown On Hubbard Loamy Coarse Sand in Sherburne County, Nitrogen Content of Grain, & N Removal per Acre

(Average of 5 replications)

Soil Treatment	Bu corn/A	% N in grain	lbs N removed/A
None	13.4 a	1.08	6.9
S-coated urea (100# N/A 1/	60.2 b	0.98	27.9
Urea + S (100# N/A) 2/	141.0 C	1.18	78.7
Urea (100# N/A) 2/	144.8 C	1.10	75.3
NH_4 NO_3 (100# N/A) 2/	150.0 C	1.14	80.9

1/ Contains 90 lbs sulfur/A

2/ Flowers of sulfur applied at 90 lb/A rate.

EXPERIMENTS WITH NITROGEN SOURCE, PLACEMENT AND TIME OF NITROGEN APPLICATION TO A WEBSTER-CLAY LOAM AT LAMBERTON FROM 1960 - THROUGH - 1970

John M. MacGregor, Wallace W. Nelson and Robert G. Munter

A field fertilizer experiment for continuous corn was commenced in the spring of 1960 to determine the relative effectiveness of annually applied N as either ammonium nitrate or as urea. The nitrogen was broadcast and plowed down or simply broadcast and left on the plowed surface over winter, or broadcast in the spring and worked in during the usual seedbed preparation, or broadcast as a sidedressing in late June. Four replications of 18 different annual treatments were applied as a randomized block, each plot being 20 feet wide and 77.5 feet long. A starter fertilizer such as 8-24-12 is applied over the entire field at planting at approximately 175 pounds per acre. The corn seed for several years was drilled lengthwise over each plot at a 40 inch row spacing to obtain about 18,000 - 20,000 plants per acre, but later the row direction was reversed with a 30 inch row spacing to supply the same population. Many different studies have been made during the ten years of continuous corn growing to N application of this experiment, with results reported each year in Soil Series 76-84. The entire field was tiled in 1963.

Total precipitation during 1970 was 25.3" which is approximately normal for the area. Less than an inch (0.91") of rain fell during the entire month of August but the corn crop weathered this minor drought well. Ear corn yields during the 11 year period are shown in Table 1.

Table 1. Eleven Year Yield of Ear Corn on a Tiled Webster Clay Loam Near Lamberton with Annual Applications of NH_4NO_3 or Urea Nitrogen at Different Rates, Times and Placement.

(Average of 4 Replications)

N applied annually in lbs/A[1]	Years											
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	Average
	Ear corn yield in bushels per acre											
1) Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	92.8	85.7	68.0a
2) 40 as NH_4NO_3 - fall plow down	42.3	87.5	30.9	148.6	88.3	34.9	26.8	75.7	131.6	109.3	96.3	79.3b
3) 40 " urea - " " "	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5	120.4	84.9bc
4) 40 " NH_4NO_3- fall plow - surface	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	124.6	122.5	85.9bcd
5) 40 " urea - " " "	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1	121.2	90.2cde
6) 80 " NH_4NO_3 = " " down	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.8	131.2	146.8	134.7	99.8fgh
7) 80 " urea " " "	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3	141.4	99.1fgh
8) 160 as NH_4NO_3 " " "	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	158.7	141.7	103.7gh
9) 160 as urea - " " "	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0	140.4	107.6h
10) 40 " NH_4NO_3 - spring topdress	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	142.0	125.6	94.4def
11) 40 " urea " "	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4	118.9	91.7cdef
12) 80 " NH_4NO_3 " "	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	159.5	140.4	103.6gh
13) 80 " urea " "	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9	146.2	105.2gh
14) 40 " NH_4NO_3 sidedress	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	142.3	127.1	93.4cdef
15) 40 " urea "	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3	117.7	90.3cde
16) 80 " NH_4NO_3 "	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	140.3	127.7	97.2efg
17) 80 " urea "	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2	140.5	105.4gh
18) 160 " NH_4NO_3 "	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	148.3	136.9	104.8gh
Average annual corn yield in bu/A	58.6	93.3	39.4	147.7	101.3	60.3	36.3	101.8	135.7	140.9	127.0	

[1]. The entire area received an additional 14 lbs N/A as starter fertilizer annually (8-24-12 @ 175 lbs/A)

All of the broadcast fertilizer N treatments have significantly increased the average 11 year yield of corn grain above the plots receiving only the 14 lbs N/A in the starter fertilizer. No significant differences in corn yield resulted following urea or ammonium nitrate application and yields show that these two forms of N are both effective and equivalent.

Plowing down 40 lbs of N/A each fall has produced corn yields which were not significantly different to fall broadcasting immediately following fall plowing and allowing the ammonium nitrate or urea to remain on the plowed soil surface overwinter. However, corn yields where 40 lbs N/A as ammonium nitrate was fall plowed down were significantly lower than where the same amount of urea N was fall applied and left on the plowed surface (79.3 bu compared to 90.2 bu). This indicates that laboratory experiments indicating substantial N losses to the atmosphere as ammonia from surface applied urea are apparently not valid under actual field conditions of corn production. One hazard of plowing fall applied N down is, in the event of heavy late fall and early spring rains, N removal downward by leaching may be substantial, before it can be utilized by the following corn crop. Surface applied N may be lost from urea to the air as ammonia, or from ammonium nitrate as N_2 or as the various N oxides. While plowing limited amounts of N under in the fall may increase crop residue decomposition, it is apparent that this theory is not entirely justified, and fall applied N fertilizers allowed to remain on plowed surfaces overwinter may produce larger corn yields than those plowed under at the same time. Apparently overwinter losses of N to the atmosphere may be comparatively less than overwinter and early spring losses downward by leaching. During the 11 year period of this experiment 40 lbs of N left on the surface overwinter has produced an annual average of 6 more bushels of corn per acre (88.1 versus 82.1).

Comparing 11 year corn yield averages where 40 lbs of N/A (in addition to the 14 lbs N/A in the starter) was applied in the fall, winter, or as a June sidedressing, the surface fall treatments averaged 88.1 bushels, those applied at seeding averaged 93.0 bushels whereas those broadcast as a late June sidedressing averaged 91.9 bushels/A. The maximum difference is less than 5 bu of corn per acre, which may not be mathematically significant, but over the 11 years this would mean more than a 50 bushel advantage for the N fertilization at seeding, compared to the fall spreading on plowed ground. Where compared to plow down N fall fertilization, the total 11 year difference in N at seeding yield would exceed 100 bushels of corn per acre.

Where 80 lbs of N were broadcast in the fall, spring, or as a June sidedressing. The 11 year corn yields averaged 99.5, 104.4, and 101.3 bushels respectively, or another 5 bushel advantage of the spring treatment over the fall fertilization.

The N fertilization at the 160 lb N/A rate in the fall averaged 105.7 bushel, whereas the June sidedressing produced an average of 104.8 bu/A. Apparently this heavy rate of N fertilization compensates for any overwinter losses of applied N.

When rate of N fertilization is considered, the 8 fall surface treatments of 40 lbs (+14 lbs N in starter) averaged 88.8 bu., and the six 80 lb rate treatments averaged 105 bu/A during the 11 year period. The first 40 lbs of N increased average corn production by 21 bushels; whereas doubling the rate of N produced a 34 bushel increase;the 174 lb rate of N application produced 37 bushels more corn per acre.

Nitrogen Removal in Corn Grain

The amount of nitrogen removed in the corn grain is of interest. In Table 1 it was shown that little increase in corn yield could be expected over several years where total applied N exceeded 94 pounds per acre. The 1970 yields and relative utilization of N at different fertilization rates is shown in Table 2.

Table 2. Yield of Dry Shelled Corn, Percentage Nitrogen and Nitrogen Removal in Corn Grain per acre from NH_4NO_3 - Urea Treated Continuous Corn on Webster Clay Loam at Lamberton in 1970.

Treatment (lbs N/A)[1]	Yield in bu/A (15.5% moisture)	Dry shelled corn (lbs/A)	% N (in grain)	lbs N removed / A	Fertilizer N applied (lbs/A)	Soil N[2] status
1) Check	85.7 a	4055	1.13a	45.8	14	-31.8
2) 40 as NH_4NO_3 - fall plow down	96.3 a	4557	1.17 ab	53.3	54	+ 0.7
3) 40 " urea - " " "	120.4 bcd	5697	1.17 ab	66.7	54	-12.7
4) 40 " NH_4NO_3 - " " surface	122.5 cde	5797	1.18 ab	68.4	54	-14.4
5) 40 " urea - " " "	121.2 cde	5735	1.20 abc	68.8	54	-14.8
6) 80 " NH_4NO_3 - " " down	134.7 cdef	6374	1.22 abcd	77.8	94	+16.2
7) 80 " urea - " " "	141.4 ef	6691	1.22 abcd	81.6	94	+12.4
8) 160 " NH_4NO_3 - " " "	141.7 ef	6705	1.24 abcd	83.1	174	+90.9
9) 160 " urea - " " "	140.3 def	6639	1.24 abcd	82.3	174	+91.7
10) 40 " NH_4NO_3 - spring topdress	125.6 ede	5943	1.25 abcd	74.3	54	-20.3
11) 40 " urea - " "	118.9 bc	5626	1.28 bcde	72.0	54	-18.0
12) 80 " NH_4NO_3 - " "	140.4 def	6644	1.28 bcde	85.0	94	+ 9.0
13) 80 " urea - " "	146.2 f	6918	1.29 bcdef	89.2	94	+ 4.8
14) 40 " NH_4NO_3 - sidedress	127.1 cdef	6014	1.32 cdef	79.4	54	-25.4
15) 40 " urea "	117.7 bc	5570	1.34 def	74.6	54	-20.6
16) 80 " NH_4NO_3 - "	127.7 cdef	6043	1.33 ef	83.4	54	+10.6
17) 80 " urea - "	140.5 def	6649	1.39 ef	92.4	94	+ 1.6
18) 160 " NH_4NO_3 - "	136.9 cdef	6478	1.41 f	91.3	94 174	+82.7

1. The entire area received an additional 14 lbs N/A annually as starter fertilizer (8-24-12 @ 175 lbs/A).
2. Fertilizer N minus N removal in corn grain in lbs/A.

It is evident that the heavier rates of N fertilization produced comparatively small increases in corn grain protein, the greatest increases in protein apparently taking place with the later N treatments. The N fertilization at planting time appears to result in the more efficient combination of corn yield and corn protein.

Nitrogen removal in the grain increases with rate of N application, but the heavier treatments result in a lowered uptake by the growing corn. Nitrogen removal in the corn grain shows a proportional decrease that applied as fertilizer N added as the rate increases. Nitrogen removal in the grain is efficient up to the 94 lb N rate, but above this it decreases rapidly at the higher rate, with nearly 100 lbs of N/A remaining where 174 lbs of N were applied per acre.

Analysis of Subsoil Waters of N Plots.

Several wells for the collection of free subsoil waters to a depth of 72 inches were located on several plots. Water was present in a few of these allowing a mid-June sampling. The analytical results were closely related to the rates of N fertilization and N removal in the corn grain. These are shown in Table 3.

Table 3. Analyses of Subsoil Free Water in a Webster Clay Loam Near Lamberton Under N Fertilized Continuous Corn Mid-June sampling 1970

Plot Number	Treatment Number	Soil Treatment	Sample depth	NO_3-N	NH_4-N	PO_4-P	K	Cond.
73	1	Check (14# N/A)	4'	1.8	1.0	0.013	1.8	1.0
7	1	" " "	6'	3.0	2.0	-	-	2.8
38	16	80 N sidedressed (+14# N/A)	3'	17.0	0.6	0.030	1.1	0.8
38	16	" " " " "	5'	7.3	10.0	0.227	2.0	0.9
38	16	" " " " "	6'	15.0	4.0	0.025	2.8	1.5
58	16	" " " " "	2'	5.3	2.0	0.000	4.2	2.5
58	16	" " " " "	4'	9.1	2.0	0.074	3.0	3.4
63	16	" " " " "	6'	9.5	2.0	0.056	2.0	2.8
34	18	160 N sidedressed (14# N/A)	4'	49.0	2.0	0.155	2.5	1.7
34	18	" " " " "	5'	9.9	4.0	0.080	3.1	1.1
34	18	" " " " "	6'	39.0	10.0	0.050	4.7	1.9
68	18	" " " " "	5'	22.0	8.0	0.116	4.9	2.7

Nitrogen Fertilization and Silking and Pollination of Corn.

It appeared that N fertilization had some effect on corn pollen shedding and silking. Data were collected and subjected to statistical analyses and found to be non-significant.

Analyses of the Sixth "Index" Corn Leaves

Leaf samples from all plots were taken at silking and analyzed using a Jarrel Ash 1.5 Meter Atom-Counter Emission Spectrograph. Since the differences occurring are complex and not entirely clear, these data will not be included in this report.

LIME PLOTS, LAMBERTON, 1970

J. Grava, W. W. Nelson, D. S. Fairchild
and B. D. McCaslin

A field experiment was established in the fall of 1965 to study the effects of liming on crop yields, chemical composition of plant tissue, and chemical properties of soils. The crops grown were: (a) Vernal alfalfa in series 4, and (b) in series 5, corn (1966, 1968 and 1970) and Chippewa soybeans (1967) and Hark soybeans (1969) in a sequence. Data on crop yields, soil and plant analyses were reported in the "Bluebooks" of Feb. 1967, pp. 69-70; March 1968, pp. 38-41; March 1969, pp. 30-31; March 1970, pp. 66-69.

Since the initial lime treatments (3 and 6 tons per acre of Dolomitic limestone applied in the fall of 1965) had not raised the pH to the desired levels, additional amounts were applied in spring of 1968 and worked in soil by disking (corn-soybean series), or disking, plowing and disking (alfalfa series). Alfalfa was reseeded in 1968.

Soil samples were collected during the summer of 1969. Lime treatments had increased the soil pH in alfalfa series from 5.7 to 6.1 with the 4 ton rate, and to 6.8 with 10 tons per acre. In the corn-soybean series, the check plots had soil pH values of 6.1 while the pH was raised to 6.6 with the 3 ton treatment and to 6.9 with the application of 6 tons per acre of limestone. The subsoil is alkaline at a depth of 12 inches in the corn-soybean series and at 24 inches in the alfalfa series.

In 1970, corn received 180 lbs. / acre of 8-24-12 starter, plus 100 lbs. / acre of N (33.5-0-0) or a total of 114 + 43 + 22 lbs. / acre of plant nutrients, expressed as N. P_2O_5 and K_2O. Corn was grown in 30-inch rows. All plots received ramrod herbicide applied in rows at a rate of 5 lbs. / acre. Alfalfa series received a broadcast application of 0 + 60 + 30 in the fall of 1969.

Corn yield was not affected by lime treatments (Table 1).

Table 1. Yield of corn, Lamberton lime plots, 1970.

Rate of Lime	Yield of Shelled Corn (15.5% Moisture)
tons / acre	bu. / acre
0	112
3*	120
6*	116
Significance	NS
CV %	8

*3 or 6 tons/acre applied in the fall of 1965 and again in the spring of 1968.

Three cuttings of alfalfa were taken in 1970 yielding four tons of hay per acre (Table 2). Liming had no effect on the yield of alfalfa.

Table 2. Yield of alfalfa, Lamberton lime plots, 1970.

Rate of Lime	1st Cutting	2nd Cutting	3rd Cutting	Total
		Hay, tons/acre		
0	2.2	1.1	0.6	3.9
4*	2.3	1.1	0.7	4.1
10**	2.3	1.1	0.6	4.0

* 3 tons/acre applied in fall of 1965 and 4 tons/acre applied in spring of 1968.

** 6 tons/acre applied in fall of 1965 and 10 tons/acre applied in spring of 1968.

Chemical composition was not affected by lime treatments (Table 3).

Table 3. Chemical composition of sixth corn leaf at silking, Lamberton lime plots, 1970.

Lime Treatment	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B	Fe	Sr
TO./acre	Percent in dry matter				Parts per million in dry matter						
0	.25	1.46	.55	.50	17	7	1.3	35	12	115	21
3	.26	1.31	.55	.57	18	9	2.0	33	13	123	23
6	.27	1.39	.55	.58	18	9	2.0	32	13	119	23
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV	5	11	9	15	13	20	24	10	12	10	12

The chemical composition of alfalfa is given in Table 4. Manganese content of alfalfa was decreased by liming consistently in all cuttings. The concentrations of other nutrient elements were not affected by liming.

Table 4. Chemical composition of alfalfa, Lamberton lime plots, 1970.

Lime Treatment	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B	Fe	Sr
	Percent in dry matter				Parts per million in dry matter						
					(a) First Cutting						
0	.23	1.15	1.35	.37	19	7	.97	24b	38	74	67b
4	.23	1.15	1.26	.37	18	7	1.22	16a	34	66	60a
10	.22	1.06	1.43	.41	18	9	1.09	18a	37	71	65ab
Significance	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	*
CV	13	6	9	9	9	38	16	12	8	8	5
					(b) Second Cutting						
0	.26	1.21	1.30	.44	21	8	1.14	27b	42	89	64
4	.26	1.17	1.31	.47	19	8	1.27	17a	42	95	64
10	.24	1.10	1.36	.48	20	9	1.20	16a	40	102	66
Significance	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
CV	8	8	4	6	8	24	15	16	6	22	9
					(c) Third Cutting						
0	.20	1.33	1.31	.47	21	8	1.07	31b	50	103	71
4	.21	1.29	1.29	.48	20	7	1.14	20a	49	111	69
10	.21	1.30	1.38	.48	21	8	1.12	19a	48	112	71
Significance	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
CV	5	9	9	6	12	15	14	13	9	17	11

SMALL GRAIN FERTILIZATION

Southwest Experiment Station - Lamberton

W. W. Nelson and S. D. Evans

Field experiments were established on Nicollet clay loam in the spring of 1970 to study the response of wheat, oats, and barley to nitrogen fertilization. A second objective was to determine the need for starter fertilizer on these crops. Three varieties of each crop were grown at three applied nitrogen levels. The nitrate nitrogen level in the 0-24 inch soil zone was 101 lbs/acre as determined by the North Dakota Soil Testing Laboratory; P tested high, K very high.

A. Oats

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

Sub plots - No starter vs. starter (100 lbs. 10-20-20)

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

Seeding Date - April 27, 1970

Table 1. Yield of oats - Lamberton, 1970.

Variety	Nitrogen Applied lbs/acre	No Starter	Starter	Average
		- Bu/acre -		
Lodi	0	58.0	68.8	63.4
	30	56.8	65.4	61.1
	60	62.1	59.9	61.0
	90	62.7	58.2	60.5
Variety Average		59.9	63.1	61.5
Otter	0	71.7	69.5	70.6
	30	65.6	66.6	67.8
	60	68.7	68.0	68.4
	90	72.2	64.5	68.3
Variety Average		69.6	68.0	68.8
Diana	0	58.4	54.2	56.3
	30	62.1	64.2	63.2
	60	52.6	67.9	60.2
	90	55.3	54.9	55.1
Variety Average		57.1	60.3	58.7
Overall Average		62.2	63.8	

Table 2. Groat Percentage, Oat Fertility Study - Lamberton, 1970.

Variety	Nitrogen Applied lbs/acre	No Starter	Starter	Average
		- Groat % -		
Lodi	0	66.9	58.7	62.8
	30	67.6	66.0	66.8
	60	65.8	68.7	67.2
	90	69.6	66.9	68.2
Variety Average		67.4	65.1	66.3
Otter	0	71.3	70.9	71.1
	30	69.5	66.0	68.1
	60	70.0	68.7	69.3
	90	69.8	64.0	66.9
Variety Average		70.2	67.4	68.8
Diana	0	63.0	67.1	65.2
	30	64.5	62.6	63.6
	60	66.7	65.5	66.1
	90	67.5	67.1	67.3
Variety Average		65.5	65.2	65.4
Overall Average		67.7	65.9	

Table 3. Analysis of Variance, Yield of Oats.

Source of Variation	Significance
Reps	* (5% level)
Varieties (V)	** (1% level)
Starter (S)	NS
V x S	NS
Nitrogen (N)	NS
N x V	NS
N x S	NS
N x V x S	NS

B. Barley

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

Sub plots - No starter vs. starter (100 lbs. 10-20-20)

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

Seeding Date - April 27, 1970

Table 4. Yield of Barley - Lamberton, 1970.

Variety	Nitrogen Applied lbs/acre	No Starter	Starter	Average
		- Bu/acre -		
Dickson	0	48.8	46.0	47.4
	30	49.5	43.9	46.7
	60	44.2	46.8	45.5
	90	48.5	45.6	47.0
Variety Average		47.7	45.6	46.7
Larker	0	56.9	58.5	57.7
	30	58.1	62.5	60.3
	60	57.1	56.1	56.6
	90	65.7	59.4	62.6
Variety Average		59.5	59.1	59.3
64-76	0	50.0	52.3	51.1
	30	52.4	54.4	53.4
	60	49.7	49.1	49.4
	90	42.8	45.8	44.3
Variety Average		48.7	50.4	49.6
Overall Average		52.0	51.7	

Table 5. Analysis of Variance, Yield of Barley.

Source of Variation	Significance
Reps	NS
Varieties (V)	** (1% level)
Starter (S)	NS
N x S	NS
Nitrogen (N)	NS
N x V	+ (10% level)
N x S	NS
N x V x S	NS

C. Wheat - Data for wheat not completed as of 1/28/71.

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. F. Heinen

WINTER VERSUS SPRING FERTILIZATION ON 1968, 1969 and 1970 CORN YIELDS AT LAMBERTON

W. W. Nelson and J. M. MacGregor

This experiment was conducted during the late winter, spring, and summer of 1968 and 1969 on two sloping fields (1% and 5%) on the Soils Unit of the Minnesota Agricultural Experiment Station near Rosemount, and on a nearly level, untiled Webster clay loam at the Southwest Experiment Station near Lamberton in 1968, 1969, and 1970. Four replications of randomized paired plots 50 ft. long and 20 ft. wide were broadcast fertilized in mid-January (on snow) or in early April, using N, P_2O_5 and K_2O and combinations of these at Rosemount, but only N and P_2O_5 combinations near Lamberton.

Snow during the three winters was not sufficiently deep to prohibit the operation of large fertilizer spreading trucks. Although all of the fertilizer was broadcast by hand, the granules appeared to sink a short distance into the snow almost immediately with resultant little movement into adjoining areas.

Results

Unfortunately, both of the sloping fields near Rosemount failed to show significant increases in corn yields from any of the fertilizer applications, making it impossible to determine the relative effects of winter or spring broadcasting of fertilizer. Since these yields have previously been reported in Soil Series 84 and 86, the results will not be included here.

Table 2 THE 1969 YIELD OF SILAGE CORN FROM WEBSTER SILTY CLAY LOAM NEAR LAMBERTON FOLLOWING FERTILIZATION IN JANUARY OR IN MAY

Treatment (Lbs/A)	Time of Fertilization	Yield of silage corn (Tons/A) I	II	III	IV	AVERAGE
None	-	8.09	8.24	8.67	6.55	7.89 ab
40+0+0	January	10.88	8.79	10.59	7.57	9.46 bc
40+0+0	May	10.85	12.76	13.40	7.74	11.17 c
0+40+0	January	10.03	7.28	8.29	7.71	8.33 ab
0+40+0	May	8.50	7.60	6.84	5.97	7.23 a
40+40+0	January	9.98	11.14	8.70	8.32	9.54 bc
40+40+0	May	9.98	11.02	7.48	8.35	9.19 b

The 1969 silage yield results were rather inconclusive and it was decided to repeat the experiment in the following year. The 1970 yields of ear corn are shown in Table 3.

Table 3 THE YIELD OF 1970 EAR CORN AT LAMBERTON GROWN ON A WEBSTER SILTY CLAY LOAM FERTILIZED IN MID-JANUARY OR EARLY APRIL

Treatment (Lbs/A)	Fertilizer broadcast in:	I	II	III	IV	AVERAGE	SIG.
None	-	61.2	68.8	60.6	66.2	64.2	a
40+0+0	January	94.4	87.3	90.3	90.3	90.6	b
40+0+0	April	94.9	94.5	93.1	97.0	94.9	b
0+40+0	January	63.6	82.3	63.8	68.2	69.5	a
0+40+0	April	51.4	79.6	64.9	70.2	66.5	a
40+40+0	January	105.1	94.9	96.6	115.5	103.0	c
40+40+0	April	102.9	110.6	102.4	105.3	105.3	c

Conclusions

From the results obtained during the 3 years of experiments on the relatively level Webster silty clay loam near Lamberton, the spreading of either nitrogen fertilizer alone or in combination with phosphate in mid-January on the snow results in essentially equivalent increases in corn yield to similar rates applied in the following May.

The relatively level Webster soil at Lamberton produced significantly more corn with fertilization and the results are shown in the three following tables.

Table 1. The Yield of 1968 Ear Corn at Lamberton on a Webster Silty Clay Loam When Fertilized in Mid-January or in Early April

Treatment (lbs/A)	Time fertilizer broadcast	Bushels ear corn/A @15.5% moisture I	II	III	IV	Average	Sig.
None		105.1	104.1	99.1	67.0	93.8	a
40+0+0	January 17	110.2	109.1	127.8	94.8	110.5	b
40+0+0	April 2	114.4	117.9	113.1	121.5	116.7	b
0+40+0	January 17	97.1	104.3	102.8	102.0	101.6	ab
0+40+0	April 2	105.0	93.2	103.1	71.6	93.2	a
40+40+0	January 17	110.2	118.0	118.1	112.4	114.7	b
40+40+0	April 2	112.0	122.6	104.8	106.4	111.5	b

The N (40+0+0) and the NP (40+40+0) resulted in significant increases in 1968 corn yield, with no significant difference between the different times of fertilizer application.

The autumn of 1968 and spring of 1969 were extremely wet and it was not possible to plow this untiled silty clay loam until the end of May. The 1969 corn was planted so late that it was decided to base 1969 yields on silage corn rather than the usual corn grain and these are shown in Table 2.

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

Samuel D. Evans

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

Silage Yields - Dry matter, tons/acre	1970	Average 1966-70
On plots harvested as grain 1965-70:		
Low fertility (74 + 48 + 48)	5.58	5.32
High fertility (148 + 96 + 96)	4.92	5.48
On plots harvested as silage 1965-70:		
Low fertility (74 + 48 + 48)	5.51	5.33
High fertility (148 + 96 + 96)	5.73	5.64

Grain Yields - Bushels/acre @ 15.5% moisture	1970	Average 1966-70
On plots harvested as grain 1965-70:		
Low fertility (74 + 48 + 48)	92.36	85.85
High fertility (148 + 96 + 96)	89.18	86.56

In addition an unfertilized, unreplicated check adjacent to the experimental area yielded as follows:

	1970	Average 1966-70
Grain (0 + 0 + 0)	81.20 bushels/acre	56.85 bushels/acre
Silage (0 + 0 + 0)	4.84 tons/acre	4.23 tons/acre

There appears to be no reduction in corn yields after removing silage for 6 years. Higher fertility did not increase silage yields or grain yields.

Variety - Pioneer 3956 Planting date - May 13

Leaf samples were taken on all plots in 1970 when the plants were 50% silked. The average values for the various treatments are given in Table 1.

Table 1. Average Nutrient Content of Leaf Opposite and Below the Ear when the Plants were 50% Silked (average of 4 reps).

	Continuous Silage Plots		Continuous Grain Plots	
	Low Fertility	High Fertility	High Fertility	Low Fertility
P%	.24	.29	.24	.29
K%	1.10	1.41	1.47	1.77
Ca%	.64	.56	.50	.52
Fe ppm	100	203	95	105
Mg %	.84	.73	.68	.69
Zn ppm	24.3	17.2	24.0	17.1
Cu ppm	13.7	10.2	12.0	10.1
Mo ppm	11.6	10.7	9.4	9.3
Mn ppm	86	94	68	91
B ppm	6.5	6.6	5.8	6.7

CORN IRRIGATION EXPERIMENT

West Central Experiment Station - Morris

S.D. Evans, D.D. Warnes, L.K. Lindor, & R.E. Smith

This experiment was continued as reported in Soil Series 82 (March 1968 and March 1969). Variety - Pioneer 3956 was planted on May 9, 1970. Atrazine and Ramrod were applied preemergence. Eleven and one half inches of water was applied between June 23 and August 24. Rainfall from planting through August 31 was 9.94 inches. The corn was harvested on October 15.

Table 1. Irrigated corn at Morris - 1970 and 1967-70 average.

	Yield (Bu/A)	
Population treatment	1970	1967-70
Low	118 a	108
Med	127 b	116
High	113 a	116
Nitrogen treatment		
60 lbs.	112 a	110
120 lbs.	121 b	115
180 lbs.	124 b	115
Pop. X Nit. Interaction		
Low x 60	112	104
Low x 120	120	111
Low x 180	120	108
Med x 60	118	112
Med x 120	131	120
Med x 180	134	119
High x 60	106	114
High x 120	113	115
High x 180	119	118

Fertilizer applied before planting in the spring of 1970 consisted of 400 lbs. of 0-25-25 and 9 lbs. of zinc as zinc sulfate. Starter fertilizer in 1970 was 110 lbs. of 9-36-18.

Leaf samples were taken on selected plots when the plants were 50% silked and are presented in Table 2.

Table 2. Summary of 1970 Leaf Analysis on Corn Irrigation Plot.

Element	Range of Values
N %	1.95 - 2.79
P %	0.21 - 0.33
K %	1.55 - 2.63
Ca %	0.49 - 0.98
Fe ppm	92 - 183
Mg %	0.35 - 0.67
Zn ppm	7.3 - 15.8
Cu ppm	3.6 - 12.6
Mo ppm	5.0 - 12.3
Mn ppm	49 - 85
B ppm	4.6 - 8.7

PHOSPHORUS AND POTASSIUM FERTILIZATION OF ALFALFA

West Central Experiment Station - Morris

Samuel D. Evans

In the fall of 1966 an alfalfa fertility experiment was established at the station on Forman clay loam (formerly Barnes). Three cuttings were made in 1970 and there was a significant effect of phsophorus on the first crop.

Table 1. First Cutting Yields - 1970

P_2O_5 Applied (lbs./acre)	K_2O Applied (lbs./acre) 0	60	120	240	480	Average
	Tons alfalfa hay/A @ 15% moisture					
0	1.6	1.8	1.8	1.9	1.8	1.8
57	2.0	2.1	2.0	2.1	2.0	2.0
114	2.2	2.2	2.1	2.2	2.0	2.2
229	1.9	2.2	2.4	2.2	2.4	2.2
458	2.1	2.0	2.0	2.2	2.1	2.1
Average	2.0	2.1	2.1	2.1	2.1	

Table 2. Total of 3 cuttings - 1970

P_2O_5 Applied (lbs./acre)	K_2O Applied (lbs./acre) 0	60	120	240	480	Average
	Tons alfalfa hay/A @ 15% moisture					
0	4.0	3.8	4.0	4.2	4.2	4.0
57	4.2	4.2	4.0	4.2	4.6	4.2
114	4.4	4.6	4.2	4.6	4.2	4.4
229	4.0	4.5	4.6	4.2	4.9	4.4
458	4.4	4.3	4.0	4.6	4.3	4.3
Average	4.2	4.3	4.2	4.4	4.4	

Table 3. Analysis of Variance - 1970 Yields

	1st Cutting	2nd Cutting	3rd Cutting	1970 Total
Reps	NS	NS	NS	NS
Phosphorus rates	**	NS	NS	*
Potassium rates	NS	NS	NS	NS
P x K interaction	NS	NS	NS	NS

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 1969 at the rate of 220 lbs. of N per acre.

In 1970 there were no significant treatment effects.

1970 Variety - Pioneer 3956 Planting date - May 20, 1970

Table 1. 1970 yields in Bu/acre at 15.5% moisture.

Broadcast P Treatment (lbs./acre)	Row Phosphorus Treatment (lbs./acre)					
	ck	15P	30P	45P	45P+10Zn	Average
ck	76.0	82.1	81.8	76.3	84.0	80.0
45P	84.1	81.1	76.5	73.5	88.4	80.7
Average	80.0	81.6	79.2	74.9	86.2	

Table 2. Average yield in bu/acre at 15.5% moisture for 1965-70.

Broadcast P (lbs./acre)	Row Phosphorus Treatment (lbs./acre)					
	ck	15P	30P	45P	45P+10Zn	Average
ck	75	74	75	74	78	75
45P	78	77	73	72	78	76
Average	77	75	74	73	78	

POTASSIUM FERTILIZATION OF CORN

Walter Flowers Farm - Benson

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

A potassium experiment on corn was set up south of Benson in the spring of 1970. The initial soil test is given in Table 1. Rates of potassium in addition to combinations with nitrogen and phosphorus were used. Zinc sulfate was applied uniformly over the area.

Table 1. Soil Test Values on the Flower's Farm.

pH	Organic Matter	P	K	Zn	S
7.8	H	16	420	1.0	9

Fertilizer was spread on the field on May 7. The corn was planted and taken care of by the farmer. The farmer used a basic fertilizer treatment on the entire area. The plots were thinned to a uniform stand on June 23. Leaf samples were taken and the averages are shown in Table 2.

Table 2. Average Nutrient Content in Leaves when the Plants were 50% Silked.

Treatment			(Average of 4 Reps)									
			P	K	Ca	Fe	Mg	Zn	Cu	Mo	Mn	B
N	P_2O_5	K_2O	%	%	%	ppm	%	ppm	ppm	ppm	ppm	ppm
	lbs/acre											
0	0	0	.34	1.44	.48	103	.58	9.6	13.7	10.6	68	12.1
0	0	100	.36	1.64	.44	110	.52	10.8	17.7	9.7	70	12.0
0	0	300	.34	1.69	.44	95	.46	9.4	13.0	9.6	66	12.0
0	0	600	.31	1.54	.47	95	.46	10.8	12.3	8.9	69	10.6
100	0	600	.32	1.70	.46	94	.46	14.2	17.1	9.4	70	13.4
100	100	600	.33	1.73	.42	114	.48	12.7	19.1	10.1	70	11.0

The plots became very weedy but yields were taken on October 1. The average yields are shown in Table 3. There were no significant statistical differences between treatments.

Table 3. Yields in Bu/Acre @ 15.5% moisture (Average of 4 reps).

N	P_2O_5	K_2O	Yield
	lbs/acre		
0	0	0	102
0	0	100	114
0	0	300	113
0	0	600	109
100	0	600	109
100	100	600	111

SMALL GRAIN FERTILIZATION

West Central Experiment Station - Morris

S. D. Evans

Field experiments were established on Forman clay loam in the spring of 1970 to study the response of wheat, oats, and barley to nitrogen fertilization and to study starter response on wheat and barley. The nitrate nitrogen level in the 0-24 inch soil zone was 48 lbs./acre as determined by the North Dakota 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 - May 1, 1970

Table 1. Yield of Oats, Morris, 1970.

Nitrogen	Variety			
Applied lbs/A	Lodi	Otter	Diana	Average
		Bu/A		
0	67.5	68.3	54.6	63.5
30	78.9	77.5	81.2	79.2
60	81.9	79.9	86.5	82.7
90	94.6	100.8	92.8	96.1
Average	80.7	81.6	78.8	

Table 2. Analysis of Variance, Oat Yields

Source of Variates	Significance
Reps	NS
Varieties	NS
Nitrogen	** (1% level)
Varieties x Nitrogen	NS

Table 3. Groat Percentage, Oat Fertility Study - Morris, 1970

Nitrogen Applied lbs/A.	Variety Lodi	Otter	Diana	Average
		Groat %		
0	62.4	67.8	63.8	64.7
30	61.1	67.7	62.4	63.8
60	63.1	66.0	62.7	63.9
90	62.0	66.9	62.0	63.6
Average	62.2	67.1	62.7	

Table 4. Chemical Analyses of Oat Leaves Samples at Heading (one sample per treatment)

Variety	Nitrogen Applied lbs/A	N %	P %	K %	Ca %	Fe ppm	Mg %	Zn ppm	Cu ppm	Mo ppm	Mn ppm	B ppm
Lodi	0	2.49	.25	3.38	.63	104	.24	10.8	4.3	4.1	15	9.4
	30	2.53	.23	2.99	.63	154	.21	13.6	7.6	6.3	25	9.8
	60	2.91	.21	2.78	.63	94	.23	12.9	5.0	4.3	24	10.1
	90	3.28	.22	3.41	.58	111	.24	17.5	11.5	5.7	22	8.4
Otter	0	2.38	.37	2.72	.48	127	.21	14.6	15.6	5.7	21	9.8
	30	3.57	.25	3.05	.70	107	.30	14.6	5.8	4.3	32	11.0
	60	2.94	.29	2.94	.63	139	.22	15.6	10.4	3.9	46	9.3
	90	3.32	.31	3.05	.63	140	.22	18.1	7.9	4.7	36	10.7
Diana	0	2.07	.29	2.66	.56	76	.19	10.9	5.4	3.5	18	8.8
	30	2.70	.30	3.20	.56	127	.20	21.1	27.3	5.1	16	8.7
	60	3.12	.27	3.13	.63	147	.21	15.6	8.1	3.9	16	8.3
	90	2.39	.31	2.87	.58	96	.22	12.3	10.9	5.9	33	13.3

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 actual nitrogen

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

Seeding date - May 1, 1970

Table 5. Yield of Barley in Response to Nitrogen - Morris, 1970

Nitrogen Applied lbs/acre	Variety			Average
	Dickson	Larker	64-76	
		Bu./Acre		
0	39.0	39.3	38.0	38.8
30	52.0	52.7	53.7	52.9
60	59.1	60.5	61.6	60.5
90	70.0	68.5	59.1	65.9
Average	55.1	55.3	53.1	

Table 6. Analysis of Variance, Yields on Barley Nitrogen Study

Source of Variates	Significance
Reps	NS
Varieties	NS
Nitrogen	** (1% level)
Nitrogen x Varieties	NS

Table 7. Chemical Analyses of Barley Leaves Sampled at Heading (one sample per treatment)

Variety	Nitrogen Applied lbs/Acre	N %	P %	K %	Ca %	Fe ppm	Mg %	Zn ppm	Ca ppm	Mo ppm	Mn ppm	B ppm
Dickson	0	2.79	.40	1.76	.52	67	.21	22.7	6.3	6.7	19	7.8
	30	2.60	.35	2.18	.50	120	.21	17.0	8.9	6.9	19	9.8
	60	2.83	.36	2.47	.61	92	.23	16.4	6.8	7.1	22	7.2
	90	3.33	.46	2.91	.58	73	.28	20.9	7.4	6.3	31	7.9
Larker	0	2.44	.39	1.96	.77	67	.23	14.1	2.5	5.9	25	7.0
	30	2.37	.38	2.03	.83	69	.25	15.3	8.1	7.5	23	9.7
	60	3.12	.37	1.96	1.08	71	.25	19.7	5.3	6.7	28	9.8
	90	3.84	.41	2.07	1.24	87	.27	23.0	5.3	7.3	34	9.3
64-76	0	2.65	.38	2.06	.47	52	.28	18.6	3.6	5.7	22	6.2
	30	3.07	.44	2.70	.63	66	.32	19.7	7.6	5.9	35	6.2
	60	2.97	.34	1.33	.76	73	.24	22.5	9.1	10.1	27	10.2
	90	3.19	.48	3.02	.60	1775	.29	23.8	43.1	10.1	57	8.8

2. Starter Fertilizer on Barley

Main plots - Nitrogen levels of 30 and 60 lbs. of nitrogen

Sub plots - Varieties (1) Larker (2) 64-76

Sub-sub plots - Starter treatments

Seeding date - May 1, 1970

Table 8. Yield of Barley on Response to Starter - Morris, 1970

	30 lbs.N/Acre		60 lbs.N/Acre		
	Larker	64-76	Larker	64-76	Average
	Bu/Acre				
10 + 0 + 0 Bcst	54.0	48.7	62.8	65.8	57.8
10 + 0 + 0 Row	49.3	52.8	61.1	62.5	56.4
10 + 20 + 0 Row	56.5	52.9	60.1	61.7	57.8
10 + 20 + 20 Row	56.2	54.5	66.5	68.5	61.4
Variety Average	54.0	52.2	62.6	64.6	
Nitrogen Average	53.1		63.6		

Table 9. Analyses of Variance, Barley Starter Plots

Source of Variates	Significance
Reps	NS
Nitrogen (N)	+ (10% level)
Varieties (V)	NS
N x V	NS
Starter trts. (S)	+ (10% level)
N x S	NS
V x S	NS
N x V x S	NS

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 - May 1, 1970

Table 10. Yield of Wheat on Response to Nitrogen - Morris, 1970

Nitrogen Applied lbs/Acre	Variety			
	Ciano 67	Chris	Era	Average
	Bu/Acre			
0	19.2	19.4	21.7	20.2
40	29.0	26.3	37.4	30.9
80	31.6	30.6	40.3	34.2
120	31.0	29.8	39.1	33.4
Average	27.8	26.6	34.7	

Table 11. Analysis of Variance, Wheat Yields

Source of Variates	Significance
Reps	NS
Varieties	* (5% level)
Nitrogen	** (1% level)
Varieties x Nitrogen	NS

Table 12. Protein Levels of Era Wheat

Nitrogen Applied lbs/Acre	% Protein
0	10.3
40	10.8
80	12.2
120	13.0

Table 13. Chemical Analysis of Wheat Leaves Samples at Heading (one sample per treatment)

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	3.07	.31	1.93	.42	97	.24	17.6	5.8	6.9	18	4.9
	40	3.09	.31	2.07	.52	108	.24	22.0	10.2	7.3	22	5.7
	80	3.93	.34	1.39	.67	151	.29	26.7	7.3	9.3	31	6.2
	120	4.28	.31	1.63	.73	136	.34	27.3	10.1	6.9	37	5.4
Chris	0	2.93	.29	1.51	.34	95	.18	23.1	9.9	7.7	25	4.2
	40	3.61	.26	1.64	.41	239	.23	23.8	6.4	3.5	32	2.8
	80	4.12	.32	1.61	.54	101	.25	22.4	- -	7.5	47	5.8
	120	4.16	.32	1.69	.58	167	.24	25.5	4.0	5.9	51	5.8
Era	0	2.67	.35	2.10	.31	113	.12	25.9	11.0	5.1	20	3.5
	40	3.39	.32	1.99	.40	93	.16	27.9	7.4	7.1	27	4.9
	80	3.75	.32	1.57	.55	89	.19	31.5	8.7	7.1	39	6.2
	120	3.96	.33	1.69	.63	105	.21	29.1	4.5	7.5	42	5.9

2. Starter Fertilizer on Wheat

Main plots - Nitrogen levels of 40 and 80 lbs. of N

Sub plots - Varieties (1) Chris (2) Era

Sub sub plots - Starter treatments

Seeding date - May 2, 1970

Table 14. Yield of Wheat in Response to Starter - Morris, 1970.

	40 lbs. N/Acre		80 lbs. N/Acre		
	Chris	Era	Chris	Era	Average
		- Bu./Acre -			
10 + 0 + 0 Bcst.	37.0	40.7	42.1	50.1	42.5
10 + 0 + 0 Row	36.2	45.6	44.3	52.5	44.7
10 + 20 + 0 Row	39.1	46.7	45.5	49.8	45.3
10 + 20 + 20 Row	32.9	45.4	42.2	52.7	43.4
Variety Average	36.4	44.6	43.6	51.3	
Nitrogen Average	40.5		47.5		

Table 15. Analysis of Variance, Wheat Starter Plots

Source of Variates	Significance
Reps	NS
Nitrogen (N)	NS
Varieties (V)	* (5% level)
N x V	NS
Starter trts. (S)	NS
N x S	NS
V x S	NS
N x V x S	NS

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

Weather Summary - 1970

West Central Experiment Station - Morris

Samuel D. Evans

Month	Period	PRECIPITATION 1970	PRECIPITATION 84 yr Ave	Deviation from Ave	AIR TEMPERATURE 1970	AIR TEMPERATURE 84 yr Ave	Deviation from Ave	SOIL Soil (10cm) Temp 1970	3 yr. Ave
Jan	1-31	.24	.66	-.42	0.4	8.6	-8.2	28.0	22.2
Feb	1-28	.35	.65	-.30	11.3	12.8	-1.5	28.0	24.2
March	1-31	1.52	1.04	+.48	21.2	26.8	-5.6	28.0	2[illegible]3
April	1-10	16	.60	-.44	33.8	38.3	-4.5	32.2	41.1
	11-20	2.58	.63	+ 1.95	38.2	44.3	-6.1	35.4	
	21-30	2.09	1.10	+.99	47.9	48.4	-0.5	43.1	
						43.7	-3.7	36.9	
Total or Average		4.83	2.33	+ 2.50	40.0				56.1
May	1-10	.03	.81	-.78	51.3	52.1	-0.8	54.8	
	11-20	.30	1.01	-.71	53.8	55.6	-1.8	55.6	
	21-31	2.15	1.18	+.97	57.6	60.0	-2.4	58.6	
Total or Average		2.48	3.00	+.52	54.4	56.0	-1.6	56.4	67.8
June	1-10	.01	1.34	- 1.33	68.5	62.9	+5.6	71.0	
	11-20	3.02	1.16	+ 1.86	67.0	66.6	+0.4	71.1	
	21-30	.07	1.41	- 1.34	69.0	68.2	+0.8	73.8	
Total or Average		3.10	3.91	.81	68.4	65.9	+2.5	72.0	76.1
July	1-10	.00	1.57	- 1.57	70.6	69.9	+0.7	79.3	
	11-20	.72	1.06	-.34	73.7	71.4	+2.3	80.0	
	21-31	3.42	.94	+ 2.48	74.2	71.7	+2.5	79.5	
Total or Average		4.14	3.57	+.57	72.9	71.0	+1.9	79.6	75.3
August	1-10	.11	1.10	-.99	69.0	70.6	-1.6	75.7	61.8
	11-20	.05	.91	-.86	71.4	69.1	+2.3	78.0	46.7
	21-31	.09	.96	-.87	69.6	66.8	+2.8	74.0	34.2
Total or Average		.25	2.97	-2.72	70.0	68.8	+1.2	75.8	75.8
Sept.	1-30	2.55	2.26	+.29	58.9	59.3	-0.4	61.8	61.8
Oct.	1-31	4.11	1.52	+ 2.59	45.9	47.5	-1.6	47.1	46.[illegible]
Nov.	1-30	3.66	.88	+ 2.78	27.4	29.9	-2.5	33.7	34.2
Dec.	1-31	.10	.69	-.59	12.5	15.8	-3.3	21.0	24.4
April-Aug	Growing Season	14.80	15.78	-.98	70.4	68.6	+1.8	64.1	63.[illegible]
Jan-Dec	Annual	27.33	23.46	+ 3.87	40.3	42.2	-1.9	47.4	46.6

YIELDS OF FIELD CORN GROWN EACH OF FOURTEEN YEARS (1957-1970) 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 three cropping seasons, the seedbed has been prepared on all treatments by the method commonly used in the area - plowing and disking. All vegetative residues remained on the field, either being plowed down or worked into the surface. Ear corn yields and the average for the fourteen years are shown in Table 1. Soil moisture appears to frequently a limiting factor in corn production in this area.

During the fourteen years of continuous corn, it is evident that while the annual 40 pound per acre N fertilization rate increased ear corn yields approximately 10 bushels per acre, further increases in the rate of annual N fertilization rate failed to result in a further increase in corn yields. Soil analyses have shown some accumulation of nitrate nitrogen to a 24 foot depth, although the major portion is present in the upper 8 foot depth.

The sixth corn leaf on all plots were sampled in 1970 at silking and analyzed for nitrogen content. The ear corn yields over the fourteen year period and 1970 leaf nitrogen are shown in the following table.

It is evident that all N treatments increased the N content of the corn leaves, but the more economic rate of N fertilization for the immediate corn crop is apparently the 40 lb/A rate. Heavy rates of N fertilization were not effective for increasing yields and would not be recommended.

YIELD OF EARN CORN DURING FOURTEEN YEARS (1957 - 70) WHEN GROWN EVERY YEAR WITH DIFFERENT RATES OF NITROGEN FERTILIZATION

AND PERCENTAGE N IN "INDEX" LEAVES IN 1970

(Average of 15 replications)

N Appl. (lbs/A)	(a)	Bushels of ear corn per acre at 15.5% moisture															
		YEAR															
		1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	14 yr. Ave.	1970 % leaf N
0	(S)	65.2	73.2	36.1	53.3	32.3	38.1	62.7	33.2	50.4	49.0	66.8	64.1	47.4	59.2	52.2 a	1.45
40	(F)	71.0	81.5	40.9	48.2	48.3	59.0	80.9	34.1	68.3	63.7	69.2	79.6	58.0	76.9	62.8 b	1.95
40	(S)	69.4	81.0	41.5	55.0	47.6	62.0	83.5	29.6	75.3	66.3	71.2	70.2	60.2	70.2	63.8 b	1.89
80	(S)	72.1	82.4	39.7	53.7	45.0	65.3	77.4	29.1	80.8	75.9	69.7	78.5	59.9	78.5	65.1 b	2.31
240	(S)	71.3	80.3	36.8	52.5	46.1	67.1	79.5	24.7	82.8	33.1	71.3	76.0	58.7	76.0	61.4 b	2.38

(a) 40 pounds of both phosphate and potash were applied annually to all plots at time of N application.
(S) = Spring
(F) = Fall

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 1970 and 1965-70.

Treatment (lbs./A)	When applied	Yield in bu/acre at 15.5% moisture 1970	1965-70 average
Check	- -	90.3 ab*	83
5 lbs zinc as zinc sulfate	1965	94.3 ab	82
10 lbs zinc as zinc sulfate	1965	96.0 b	82
10 lbs zinc as zinc sulfate	yearly	97.4 b	84
20 lbs zinc as zinc sulfate	1965	99.9 b	83
0.5 lbs zinc as Zn chel.	yearly	85.9 ab	79
45 lbs P broadcast	yearly	80.9 a	78
45 lbs P broadcast + 10 lbs zinc as zinc sulfate	yearly 1965	91.2 ab	81

1970 Variety - Pioneer 3956 Date Planted - May 19, 1970

* Yields followed by different letters are significantly different at the 5.0% level population (Duncan's new multiple Range test).

1970 Corn Tillage Experiment - Waseca
Wm. Leuschen, R. Frazier, J. Swan, J. True

Treatments		Early Plant Growth Grams Dry Weight / 12 plants 6/8/70					Corn Yield Bu/Acre 15.5% Moisture					Final Stand Plants Acre
Primary tillage	Secondary tillage	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg	
1. Fall Plow	None	26.0	24.8	33.7	20.1	26.2	173.4	166.6	157.2	161.4	164.7	21,100
2. Fall Plow	Conventional	31.0	43.8	37.5	25.8	34.5	175.9	163.0	160.1	168.2	166.8	21,900
3. Fall Plow	field Cultivate	29.0	30.3	29.2	25.7	28.6	168.9	167.6	161.5	156.9	163.7	21,900
4. Spring Plow	Conventional	34.3	30.3	36.7	30.7	33.0	160.2	169.7	154.6	161.6	161.5	21,000
5. Fall Chisel	Conventional	29.5	26.9	29.2	20.1	26.4	162.8	178.5	153.5	162.0	164.2	22,400
6. Fall Chisel	Field Cultivate	29.0	27.8	19.5	28.3	26.2	165.8	152.4	154.9	153.6	156.7	21,600
7. Fall Chisel	Zero	22.0	23.2	17.7	15.8	19.7	175.9	163.7	149.6	155.2	161.1	21,600
8. Spring Chisel	Conventional	26.3	29.7	23.5	26.5	26.5	143.5	159.5	142.5	155.3	150.2	23,600
9. Spring Chisel	Disk	23.6	27.9	29.4	18.4	24.8	168.5	158.6	149.0	161.9	159.5	22,300
10. None	None	19.9	21.2	15.5	20.3	19.2	157.8	156.8	154.7	154.1	155.9	22,900
11. None	Disk	24.6	27.2	25.2	22.1	24.8	158.9	155.6	156.9	160.0	157.9	24,000

4 Reps (30 feet wide by 125 feet long)

11 Treatments Randomized Complete Block

Hybrid Minhybrid 4201, Population 22,200 (Range 21,000-24,000)

Date Planted - April 29-30 on corn ground

Date of Spring Tillage - April 29

All planting done with Ac-No till planter

Fertilizer : 175 lbs/A N (NH_4No_3) + 100 lbs/A P_2O_5 +100 lbs/A K_2O

Insecticide : Furadan

Herbicide: Ramrod Pre-emergence + Atrazine and oil post

Coulters removed on 8 rows per plot on all plots except (10) zero primary - zero secondary where coulters were removed for 4 rows.

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

CORN YIELD ANOVA

	dF	SS	MS	F
Rep	3	732.3298	244.1099	
Treatment	10	937.8519	93.7852	2.74* sig. at 5% level
Error	30	1025.1427	34.1714	
Total	43			

Coefficient of variation = 3.640 percent

LSD = 8.43 Bu/A
Duncans Multiple Range Test (for 10) = 9.85 Bu/A

Treatment Comparisons

None of the following factorial effects were significantly different at 5% level

Primary Tillage	Means	Time of Primary Tillage	Means
Plow	164 Bu/A	Fall	163 Bu/A
Chisel	158	Spring	157
No Plow	157		

Secondary Tillage	Means	Fall plow vs. everything	Means
No spring tillage	161 Bu/A	Fall Plow	165 Bu/A
Conventional	161	All other treatments	158
Field Cultivate	160		
Disk	159		

Linear regression of yield and early growth was negative with an r value of 0.04 indicating little relationship between early growth and final yield.

Corn Early Growth ANOVA

	DF	SS	MS	F
Total	43	81,473	1,910.9	
Treatment	10	19,109	1,910.9	6.80 ** Sig. at 1% level
Reps	3	53,936	17,978.7	64.0 **
Error	30	8,428	280.9	

CV = 63.62

Treatment Comparisons:

Primary tillage	Means	Time of primary tillage	Means
Plow	30.55 b gms/12 plants	Fall	26.9 gms/12 plants
Chisel	24.71 a	Spring	28.1
No Plow	22.00 a		N.S.

Secondary tillage	Means
No spring tillage	21.68 a gms/12 plants
Conventional	30.11 c
Field cultivate	27.35 bc
Disk	24.80 b

Fall plow vs. Everything	Means
Fall plow	29.74 b gms/12 plants
All other treatments	25.07 a

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

CONCLUSIONS:

1. None of the factorial effects were significantly different concerning final corn yield. That is, there was no significant difference (at 5% level) in yield between any of the primary treatment group or any of the secondary treatment group. The comparison of fall plowing vs. all other treatments most closely approached significance at the 5% level.

2. The F test of all treatments showed that significant differences were present (at the 5% level). However, most of this difference can be attributed to the spring chisel + conventional treatment which had 5.7 Bu/acre lower yield than any other treatment. Since spring chisel-disk was almost identical with only a drag harrow operation left out, it is difficult to explain this result. More years of data are required before any stress can be placed on this observed difference.

3. The coefficient of variation was very low, 3.6.

4. Early growth differences were observed. These growth differences generally agreed with the growth differences one would expect based on soil temperature measurements. Soil temperature decreased as amount of mulch increased (see the figure). Treatments with lower soil temperatures generally had reduced early growth. The differences in early growth were not reflected in final yields.

5. Differences between treatments and between reps were significant at the 1 percent level.

   a. Primary tillage - plow treatments had significantly greater early growth than chisel and no-plow treatments.

   b. Secondary tillage - conventional tillage gave significantly greater early growth than disk or no spring tillage treatments. No spring tillage had significantly lower early growth than conventional, field cultivate, and disk treatments.

   c. Time of Primary Tillage - fall plowing was not significantly different from spring plowing.

   d. Fall plow vs. Everything - fall plowing had significantly greater early growth than the average of all other treatments.

FERTILITY EXPERIMENTS WITH CORN ON HIGH FERTILITY SOILS (1970)[1]

C.J. Overdahl, W.E. Fenster, R.D. Frazier[2]

In the fall of 1969, we established plots at two locations to measure feasibility rates of N, P, and K on highly productive land. Tables 1 to 4 show the 1970 yields, soil tests and tissue tests, according to N,P,K treatments.

Table 1. 1970 corn yields at 2 locations according to nitrogen treatments (Adequate P, K, and Zn on all plots)

N lbs/A	Martin County	Waseca County
	bu/Acre	
0	120a	82 a
50	128 ab	109 b
100	140 c	143 c
150	132 bc	153 cd
200	131 abc	163 d
400	135 bc	169 d

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

Table 2. 1970 corn yields at 2 locations according to phosphate and potast broadcast treatments (all phosphate plots received a basic treatment of 200+0+200+20 Zn and all potash plots has 200+150+0+20 Zn)

P_2O_5 lbs/A	Martin Co.	Waseca Co.*	K_2O lbs./A	Martin Co.	Waseca Co*
	Yields bu./acre			yields bu./acre	
0	155	133	0	156	134
50	151	136	50	147	129
100	162	132	100	152	139
150	146	136	200	147	132
200	145	138	400	160	134
Avg. Starter increase	4	13		16	10

There were no significant differences in corn yields from any of the broadcast P and K treatments. Starter fertilizer response significant at all locations, but no significant interaction between broadcast rates and starter

* Research at Waseca under direction of Dr. R.D. Frazier.

(1) reprinted from Special Report no. 12. 1971 Minnesota Retail Dealer's conference handbook

(2) Efforts of Dean Fairchild on plot work and statistical analysis greatfully acknowledged.