Table 2. Leaf N and various corn grain parameters as influenced by 150 lbs N/A as urea treated with nitrification inhibitors or slow release urea nitrogen sources.

Treatment[1/]	Leaf N	Grain			
		Yield	Moisture	N	N Removal
	%	bu/A	%	%	lb N/A
Control	1.10	23.4	38	1.30	13.2
Urea	1.99	110.1	27	1.51	77.7
Urea+N-Serve[2/]	1.89	109.4	27	1.37	69.2
Urea+Terrazole[3/]	2.06	121.2	30	1.40	80.2
Urea Formaldehyde	1.51	56.4	32	1.38	36.2
Sulfur Coated Urea	1.49	61.9	31	1.31	38.2
Significance	**	**	**	NS	**
BLSD (.05)	.41	47.5	4	--	26.2
C.V.	13.5	38.8	9.6	10.6	34.0

1/ All treatment received 150 lb N/A except the control.

2/ 0.5 lb/A N-Serve (active ingredient) coated onto urea.

3/ 0.5% Terrazole coating onto urea.

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1976 WEATHER SUMMARY

Below normal precipitation for the second consecutive year highlights weather conversation about the 1976 weather at the Northwest Experiment Station. Total precipitation for the year was more than seven inches below normal, and for the growing season, April to September, it was six inches below normal.

January, March and June were the only months recording above normal precipitation, with the largest increase only 15% above normal in June. The precipitation for September was the smallest amount ever recorded in the 86-year history of the weather station. The new "all-time" September low of 0.24 inch was only 11% of the normal 2.26 inches. May and November were also very close to breaking the all-time low for their respective months. The precipitation of 0.04 inch in November was the third lowest ever recorded while May's precipitation of 0.38 inch was the fourth lowest in the history of the Northwest Experiment Station. For the 1976 growing season, the average precipitation per month was one inch below normal.

Total precipitation for the year was 13.48 inches which is 7.25 inches less than the 85-year average. Of this 13.48 inches, 10.88 inches fell as rain and the remaining 2.60 inches were received as 46.0 inches of snow. The moisture content of the snow for 1976 (0.057 in./1 in. snow) was less than the long time average of 0.077 in./1 in. of snow. Table 1 shows the weather summary data for 1976 including precipitation, mean temperature, and long-time averages.

The last spring frost occurred May 17 when the temperature dropped to 32°F. The first fall frost occurred on September 21 with a temperature of 31°F. The first killing frost came on the 23rd of September with a reading of 25°F. The frost-free period of 127 days during 1976 was only 21 days longer than average.

The temperatures at the station for 1976 were 1.5°F. warmer than average.

With the exception of March, the average monthly temperatures from January through September were above normal. October, November, and December also recorded below normal temperatures. February and August both ranked fourth as being the warmest February and August in the weather history at Crookston.

Six new "all-time" maximum daily temperature records were set in the month of August. For four consecutive days, August 18, 19, 20 and 21, the respective temperatures reached were 100, 100, 99 and 99°F. August 24 and 25 set the remaining two records with 97°F. readings. September 3, September 30 and October 4 also set new "all-time" daily maximum temperature records with their respective readings of 95, 86 and 83°F.

Three "all-time" minimum daily temperature records were also set in 1976. On the dates May 7, June 16 and December 30, the new record low temperatures were 18, 37 and -32°F. respectively.

Table 1. Weather Summary for 1976 with Averages for Precipitation and Mean Temperatures for 1890-1973.

	Precipitation, Inches					Mean Temperature ----degrees-----	
	Snow Inches	Precip. Inches	Rain	Total	1890-1973	1976	1890-1973
Jan.	18.2	.95	.00	.95	.56	6.0	3.9
Feb.	8.4	.38	.00	.38	.54	19.8	8.2
Mar.	12.1	.97	.04	1.01	.85	20.6	23.0
Apr.	0.0	.00	.74	.74	1.53	47.0	41.4
May	0.0	.00	.38	.38	2.61	55.0	54.5
June	0.0	.00	4.18	4.18	3.61	68.3	64.5
July	0.0	.00	1.91	1.91	3.13	70.8	69.4
Aug.	0.0	.00	2.77	2.77	2.88	72.2	67.5
Sept.	0.0	.00	.24	.24	2.26	61.0	57.4
Oct.	T	T	.61	.61	1.39	40.9	45.4
Nov.	0.8	.03	.01	.04	.76	24.3	26.9
Dec.	6.5	.27	.00	.27	.61	5.7	11.5
TOTAL	46.0	2.60	10.88	13.48	20.73	41.0	39.5

NITROGEN RATE AND CARRIER COMPARISONS ON WHEAT

G. W. Wallingford and R. K. Severson

Nitrogen is usually the largest fertilizer input for wheat production in northwestern Minnesota. Ammonium nitrate has traditionally been the most common carrier of nitrogen used in this area but nitrogen solutions and anhydrous ammonia have recently been taking over a larger share of the nitrogen market. A fourth nitrogen source, urea, has seen only limited use but should occupy a larger share of the market in the future.

An experiment which compared the four nitrogen materials at three nitrogen rates was established at two locations in 1976. One location was on a coarse-textured soil located east of Thief River Falls and the other was on a fine-textured soil north of Stephen. The location at Stephen was lost due to the extreme dry weather which caused uneven germination and extremely poor plant populations. Soil test results are listed below for the Thief River Falls site.

SOIL TEST RESULTS

NO_3-N	P	K	OM	pH	Soil Type
104	22	140	H	7.1	Sandy loam

The experimental design used in 1975 was used again in 1976. Nitrogen rates of 30, 60 and 90 lbs N/A were used in a randomized complete block design with four replications. All materials were applied preplant and were incorporated after application. Plots were planted on April 28 and harvested for grain on August 5.

RESULTS

Table 2 contains the dry matter and grain yields harvested from the Thief River Falls location in 1976. There were no significant differences between any of the treatments. A relatively high nitrate content of the soil was sufficient to satisfy the nitrogen requirement of the crops through the growing season. According to the Minnesota soil test recommendations, no response is expected at a nitrate-N level of 104 lbs N/A and no response was found.

Table 2. Wheat dry matter (soft-dough stage) and grain yields as affected by nitrogen material and rate at Thief River Falls in 1976.

Material	N Rate	Yield	
		Dry Matter	Grain
	lbs/A	lbs/A	bu/A
Control	0	6241	63.9
Ammonium	30	6223	65.1
Nitrate	60	6007	57.6
(34-0-0)	90	6835	66.4
Urea	30	5980	63.2
(46-0-0)	60	6794	59.0
	90	5833	59.0
Urea-Ammonium	30	6302	65.8
Nitrate Solution	60	6234	67.9
(28-0-0)	90	6390	68.5
Anhydrous	30	5382	60.1
Ammonia	60	5946	58.1
(82-0-0)	90	6027	61.8
Significance		N.S.	N.S.
CV (%)		9.2	16.0

FALL VS. SPRING NITROGEN APPLICATIONS FOR WHEAT

G. W. Wallingford and R. K. Severson

Losses of nitrogen by denitrification or by leaching can influence the efficiency of applying nitrogen in the fall. The fine-textured, high organic matter, poorly drained soils of the Red River Valley have potential for denitrification losses in late, wet springs that frequently occur in northwestern Minnesota.

A study was initiated in the fall of 1975 to compare fall vs. spring nitrogen applications, nitrogen carriers and rates of nitrogen on the yield of wheat. The study was located on the Northwest Experiment Station on a Wheatville loam soil. The soil test results are given below. A previous nitrate survey of the field showed the chosen location to be low in nitrate, but the sample taken in fall 1975 was high in nitrate.

SOIL TEST RESULTS

NO_3-N	P	K	OM	pH	Soil Type
134	20	150	H	7.9	Wheatville loam

Fall applications were made on October 22, 1975 and spring applications on April 19, 1976. Plots were planted on April 23 to Profit 75 and were harvested on August 13 for grain yield. Eighty pounds of phosphate and 120 lbs of K_2O were applied to all plots.

RESULTS

The grain yields are given in Table 3. The extremely dry conditions during the spring stunted the growth of the plants and caused early maturity. The plants were already heading by the middle of June when the only substantial rain of the season occurred. The rain did not come in time to allow the plants to recover and the resulting yields were very low.

The extremely low yields due to the drought and the initial high nitrate level in the soil prevented any treatment differences from occurring. The experiment is being continued in the same form for the 1977 season.

Table 3. Wheat grain yields in 1976 as affected by nitrogen material, rate, and time of application.

Material	N Rate	Yield	
		Fall	Spring
	lbs/A	bu/A	bu/A
Control	0	19.7	19.7
Ammonium	30	15.8	15.2
Nitrate	60	17.1	14.4
(34-0-0)	90	17.4	20.8
Urea	30	17.6	20.8
(46-0-0)	60	25.1	20.2
	90	20.9	15.0
Urea-Ammonium	30	20.4	16.7
Nitrate Solution	60	18.4	24.8
(28-0-0)	90	15.0	18.6
Anhydrous	30	20.7	18.7
Ammonia	60	18.1	18.6
(82-0-0)	90	15.2	21.3
Significance		N.S.	N.S.
CV (%)		27.2	27.2

PHOSPHORUS FERTILIZATION OF WHEAT IN THE RED RIVER VALLEY

G. W. Wallingford and C. A. Simkins

Fine-textured soils of the Red River Valley used for sugar beet production have been receiving large applications of phosphorus for many years. On soils testing medium to high in available phosphorus, it is becoming questionable whether wheat will respond to additional phosphorus applications. Data is needed to update wheat response to phosphorus applied either banded or broadcast.

Three experimental locations were established in 1976 at Crookston, Shelly and Stephen. The location at Stephen was lost due to extremely poor germination resulting from the dry spring. The soil test results for the Crookston and Shelly locations are given below.

SOIL TEST RESULTS

	NO_3-N	P	K	OM	pH	Soil Type
Crookston	134	58	310	H	7.9	Wheatville loam
Shelly	137	38	600+	H	7.1	Fargo silty clay

A randomized complete block design with four replications and ten treatments was used. The ten treatments consisted of one control and three rates of phosphorus (20, 40 and 60 lbs P_2O_5/A) applied as triple superphosphate (0-44-0) with three banded and three broadcast treatments, and as ammoniated superphosphate (18-46-0) with three banded treatments only. The fertilizer was placed with the seed in the banded treatments while the broadcast treatments were applied preplant and incorporated.

Additional nitrogen was applied so that all plots received a total of 60 lbs N/A and 60 lbs of K_2O/A. The treatments were applied and the plots planted with 1.5 bu/A of Era wheat on April 22 at Crookston and on April 26 at Shelly.

RESULTS

The grain yields from the two locations are given in Table 4. There were no significant differences between any of the treatments at either location. There were also no visible growth differences between treatments any time during the season.

The spring of 1976 was early, dry and warm. Response of small grains to phosphorus applications are most likely in wet, cool springs. The springs of both 1975 and 1976 were not conducive, therefore, to phosphorus response. Several more years of data are needed so that the wheat response to phosphorus can be measured under different weather conditions.

Table 4. Wheat grain yield as affected by phosphorus rate and method of application at two locations in 1976.

Material[a]	Rate	Method	Crookston	Shelly
	lbs P_2O_5/A			
			Grain bu/A	Grain bu/A
Control	0	--	31.5	61.4
TSP	20	Banded	32.4	65.4
TSP	20	Bd'cst	33.1	63.8
ASP	20	Banded	28.6	64.8
TSP	40	Banded	30.9	60.9
TSP	40	Bd'cst	23.3	60.4
ASP	40	Banded	33.0	62.8
TSP	60	Banded	32.8	64.7
TSP	60	Bd'cst	29.8	63.0
ASP	60	Banded	32.7	62.0
Significance			N.S.	N.S.
CV (%)			17.8	7.5

[a] TSP = Triple Superphosphate (0-44-0)
ASP = Ammoniated Superphosphate (18-46-0)

CORN FERTILITY IN NORTHWESTERN MINNESOTA

G. W. Wallingford and R. K. Severson

The area of corn production in Minnesota is moving steadily northward. In 1975 there were 47,000 acres of corn grown in Polk, Norman and Mahnomen counties. Most corn in this area is grown on the coarse-textured soils east of the Red River Valley basin. Research on nitrogen, phosphorus and potassium fertility of corn has been very limited in this area.

Two experimental locations were established in 1976 in Norman county north and east of Ada. The soil test results and soil types of the two locations are listed below. The experimental design used in 1975 was followed again in 1976. The studies included a nitrogen rate study, a phosphorus rate and material study and a potassium rate study. A randomized complete block design with four replications was used. All fertilizer materials were applied preplant and incorporated. The nitrogen and potassium materials were urea and potassium chloride. The phosphorus rates were duplicated by using both triple superphosphate and a nitrogen-polyphosphate solution (10-34-0) as phosphorus materials. The fertilizer was applied on May 1 at the Berglind location and on May 3 at the Gill location. Planting was done within one week after fertilizer applications were made. At the Berglind farm, the same location was used in 1976 as was used in 1975 and the treatments were superimposed on the exact same plot area. The plots were hand harvested on September 28 at the Gill location and on September 30 at the Berglind location by harvesting two thirty-foot sections of each plot.

SOIL TEST RESULTS

	NO_3-N	P	K	OM	pH	Soil Type
Berglind (1975)	59	27	150	M	8.1	Ulen fine sandy loam
Gill	51	14	150	H	8.1	Ulen fine sandy loam

RESULTS

There were no significant differences due to treatment at either location in the phosphorus and potassium studies (Table 5). In the nitrogen study, maximum yields were obtained at the 100 lbs N/A rate.

The growing season in 1976 was unusually good for corn production from the standpoint of growing degree days. Although limited rainfall caused poor germination and erratic stands in the plots as well as many other fields in the area, the long growing season caused the yields to be higher than average. The lack of rainfall probably made the broadcast fertilizer applications positionally unavailable throughout most of the season because the soil surface remained dry and fertilizer incorporation was shallow. Phosphorus and potassium were probably affected the most by positional unavailability which could explain the lack of response to these nutrients even though soil tests and previous cropping history (corn) indicated a likely response.

Table 5. Corn yields as influenced by nitrogen, phosphorus and potassium at two locations in 1976.

N Rate lbs N/A	Yield bu/A		P Rate[a] lbs P_2O_5/A	Yield bu/A		K Rate lbs K_2O/A	Yield bu/A	
	Berglind	Gill		Berglind	Gill		Berglind	Gill
0	59.3	64.8	0	84.9	78.9	0	94.9	83.8
20	67.4	77.3	20 TSP	83.6	80.9	40	95.7	74.2
40	69.5	65.3	20 Poly	87.3	82.9	80	97.9	76.5
60	65.6	70.0	40 TSP	85.0	81.6	120	95.2	77.3
80	80.2	79.0	40 Poly	82.7	74.5	160	99.1	83.1
100	85.9	92.2	60 TSP	92.7	75.0			
			60 Poly	83.6	81.5			
			80 TSP	86.9	72.4			
			80 Poly	88.8	84.7			
Significance	**	*		N.S.	N.S.		N.S.	N.S.
BLSD (0.05)	14.2	16.1						
CV (%)	12.6	13.5		9.2	15.4		6.5	10.7

[a] TSP = Triple superphosphate (0-44-0), Poly = Polyphosphate (10-34-0)

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1976

Month	Period	Precipitation 1976	Precipitation 89-yr. av.	Precipitation Dev. from av.	Air Temperature 1976	Air Temperature 89-yr. av.	Air Temperature Dev. from av.	Soil (10 cm) Temperature 1976	Soil (10 cm) Temperature 9-yr. av.
January	1-31	.98	.65	+ .33	7.1	8.3	- 1.2	13.6	21.8
February	1-29	.61	.66	- .05	23.2	12.7	+10.5	23.2	24.5
March	1-31	1.23	1.04	+ .19	26.0	26.8	- 0.8	29.0	29.2
April	1-10	.02	.58	- .56	45.4	38.1	+ 7.3	42.2	
	11-20	.33	.65	- .32	54.1	44.3	+ 9.8	49.8	
	21-30	.12	1.10	- .98	47.0	48.2	- 1.2	49.2	
Total or av.		.47	2.33	-1.86	48.9	43.6	+ 5.3	47.1	40.9
May	1-10	.05	.79	- .74	46.5	52.0	- 5.5	49.2	
	11-20	0	.99	- .99	58.4	55.6	+ 2.8	61.8	
	21-31	.34	1.23	- .89	61.0	60.0	+ 1.0	63.5	
Total or av.		.39	3.01	-2.62	55.5	56.0	- 0.5	58.4	55.8
June	1-10	.10	1.32	-1.22	72.8	63.1	+ 9.7	72.8	
	11-20	.24	1.20	- .96	67.2	66.5	+ 0.7	70.4	
	21-30	1.29	1.36	- .07	68.8	68.2	+ 0.6	71.0	
Total or av.		1.63	3.88	-2.25	69.6	66.0	+ 3.6	71.4	69.4
July	1-10	0	1.52	-1.52	72.9	69.9	+ 3.0	78.0	
	11-20	.25	1.07	- .82	72.2	71.4	+ 0.8	78.6	
	21-31	.82	1.03	- .21	74.3	71.5	+ 2.8	79.0	
Total or av.		1.07	3.61	-2.54	73.2	71.0	+ 2.2	78.6	76.7
August	1-10	.13	1.08	- .95	70.2	70.4	- 0.2	78.7	
	11-20	1.30	.89	+ .41	72.2	69.3	+ 2.9	74.0	
	21-31	.33	.98	- .65	74.4	66.9	+ 7.5	77.5	
Total or av.		1.76	2.95	-1.19	72.4	68.8	+ 3.6	76.8	74.4
September	1-30	.57	2.22	-1.65	58.9	59.1	- 0.2	63.4	61.5
October	1-31	.08	1.61	-1.53	40.4	47.5	- 7.1	44.8	48.0
November	1-30	.14	.94	- .80	23.3	29.9	- 6.6	28.3	33.8
December	1-31	.46	.68	- .22	9.2	15.6	- 6.4	15.4	24.3
April-August Growing Season		5.32	15.78	-10.46	64.0	61.2	+ 2.8	66.6	63.5
January-December Annual		9.39	23.58	-14.19	42.3	42.1	+ 0.2	45.9	46.8

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

West Central Experiment Station - Morris

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

The experiment initiated in 1970 was continued. Treatments and results in previous years are given in Soil Series 88, 89, 91, 95, and 97. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year. In 1975 and 1976 the comparison of Furadan vs. no Furadan was dropped and the no Furadan sub-plots were planted to soybeans.

I. Planting Information

Sixteen rows of each plot were planted to corn (var. Trojan TXS99) and eight rows to soybeans (var. Clay) on May 5, 1976. Furadan at 10 lbs./acre (1 lb./acre active ingredient) was applied to the corn. Starter fertilizer consisting of 154 lbs./acre of 8-33-17 was applied to both the corn and soybeans in the fertilized treatment. Nitrogen in the form of ammonium nitrate was applied to the fertilized plots to provide 110 lbs./acre of N on October 14, 1975. All plots were plowed on October 15, 1975. Lasso (2) + Bladex (2) were applied to the corn and Lasso (2) + Lorox (1) were applied to the soybeans. All materials were broadcast applied on May 6, 1976. The corn was sprayed with 2,4-D LV ester @ 1/2 lb./acre on June 8, 1976.

II. Soil Sampling and Analysis

A. 1975 measurements

The results of the analysis of the soil samples collected to a depth of 16 feet are given in Table 1. Other measurements not included in this report are Bray #1 P 1:10 and 1:50, Na, K, and electrical conductivity of the top 4 feet and Mn in the top foot only.

1. $(NO_3 + NO_2)$-N - All manure treatments had higher values than the two check treatments at all depths. There was substantial nitrogen movement to the 10-foot depth with all manures and to the 14-foot depth with the liquid beef manure.

2. Chloride - In most cases the chloride content of the soil in the manured treatments was higher than in the check treatments. Chloride had increased to the 16-foot depth with the two beef manures and to the 12-foot depth with the hog manure.

3. Chloride/$(NO_3 + NO_2)$-N Ratio - Below the 4-foot depth the ratio is generally constant indicating the chloride and the $(NO_3 + NO_2)$-N were moving thru the profile together and denitrification was not taking place.

B. 1976 measurements

The soils were sampled to a depth of 4 feet in the fall of 1976 but the results are not yet available.

Table 1. Effect of high rates of manure and commercial fertilizer five years (fall 1975) after application on the $(NO_3 + NO_2)$-N and Cl content of a Tara soil profile.

Depth	CK	FE	SB	LB	LH
			$(NO_3 + NO_2)$-N, ppm		
0-1'	4.9	7.8	24.7	25.7	13.2
1-2'	0.6	27.7	70.2	114.9	40.6
2-3'	1.8	31.4	101.8	160.0	105.1
3-4'	4.2	8.8	66.5	98.0	57.7
4-6'	6.7	4.2	41.1	68.8	42.1
6-8'	5.6	2.2	20.4	45.9	16.3
8-10'	2.8	2.0	10.0	34.1	9.4
10-12'	2.2	1.3	5.3	21.2	7.2
12-14'	1.9	1.3	4.7	13.9	4.9
14-16'	1.6	0.8	4.0	8.4	3.9
			Cl, ppm		
0-1'	1.5	6.5	8.2	8.4	8.8
1-2'	3.1	31.8	84.7	82.8	33.5
2-3'	8.5	31.1	152.6	160.0	79.7
3-4'	7.6	14.7	117.7	104.1	41.5
4-6'	5.3	6.8	106.8	75.0	25.6
6-8'	6.6	3.5	58.2	57.6	14.3
8-10'	5.6	12.7	26.1	42.1	10.8
10-12'	4.4	4.2	13.6	27.2	6.6
12-14'	4.6	4.5	10.3	17.2	4.8
14-16'	4.9	2.4	10.2	14.2	3.2
			$Cl^-/(NO_3 + NO_2)$-N Ratio		
0-1'	0.3	0.8	0.4	0.4	0.6
1-2'	4.7	1.2	1.6	2.6	1.0
2-3'	4.8	1.0	1.6	1.0	0.8
3-4'	1.8	1.7	2.0	1.1	0.7
4-6'	0.8	1.6	2.8	1.1	0.7
6-8'	1.2	1.6	2.9	1.3	0.9
8-10'	2.4	9.4	2.6	1.4	1.4
10-12'	2.1	3.3	2.8	1.4	1.0
12-14'	2.4	3.8	2.3	1.3	1.3
14-16'	3.2	3.1	3.1	2.4	0.9

III. Plant Tissue Analysis

Stands were very poor and plants stunted by the dry weather, but plant samples were taken as in previous years.

A. Early whole corn plants (Table 2)

The manure treatments were significantly higher in K and lower in Mg than the CK and FE treatments. The SB and LB treatments were lower than FE in Ca, Zn, and Mn. The LH treatment was significantly lower than SB and LB in K and higher in Zn. The LH treatment was higher than LB in Mn. The CK treatment was significantly lower than the manure treatments in P and K and higher in Ca and Mg.

B. Corn leaves at silking (Table 3)

The manure treatments were significantly higher than the FE treatment in K and lower in Mg. The CK treatment was significantly lower than all other treatments in N. The FE and LH treatments were significantly higher than all other treatments in Zn.

C. Soybean leaves at mid-bloom (Table 4)

The manure treatments were generally higher than the CK and FE treatments in P and K and lower in Ca, Mg, and Cu. The CK treatment was much higher than all other treatments in Cu.

IV. Field and Plant Measurements (Table 5)

Stands in all plots were very poor due to the dry conditions during the planting season. The plants that were left were severely stunted by the dry weather during the summer and were further damaged by a severe hail storm on the evening of August 10, 1976. Therefore, only a limited number of measurements were made.

A. Early plant height - All manures increased the early plant height as compared to the CK.

B. Early plant dry weight - The SB and LB treatments were significantly heavier than all other treatments. The FE and LH treatments were not different, but LH was heavier than CK.

C. Ear moisture at harvest - There were no significant differences.

D. Corn grain yield - The FE treatment was significantly higher yielding than all other treatments.

E. Soybean yield - There were no significant differences in yield.

Table 2. Summary of analysis of early corn plant samples[1] - 1976.

Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B
	%				ppm			
CK	.38	1.81	.69	.70	39.8	8.8	98	7.4
FE	.43	2.93	.58	.62	57.0	7.9	104	8.3
SB	.45	3.98	.44	.37	36.3	6.6	82	7.6
LB	.50	4.08	.45	.38	35.4	6.6	76	8.5
LH	.46	3.54	.52	.42	53.3	7.8	92	8.2
Significance:	**	**	**	**	**	NS	**	NS
BLSD (.05)	.05	.35	.12	.09	10.9	-	13	-

[1] Sampled June 16, 1976.

Table 3. Summary of analysis of corn leaves at silking - 1976.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.22	.23	1.25	.78	.64	223	14.1	12.9	67	13.7
FE	2.60	.28	1.36	.86	.75	224	23.9	11.0	85	17.7
SB	2.61	.36	2.30	.86	.47	237	15.8	10.2	97	18.8
LB	2.62	.34	2.16	.81	.48	240	16.3	9.2	86	21.3
LH	2.74	.35	2.09	.85	.51	235	24.8	10.7	87	22.9
Significance:	**	+	*	NS	*	NS	*	+	NS	NS
BLSD (.05)	.20	-	.74	-	.15	-	7.0	-	-	-

Table 4. Summary of analysis of soybean leaves[1] - 1976.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	4.41	.24	1.00	2.08	.88	310	40.4	8.5	80	49.3
FE	3.92	.23	.98	2.55	.90	349	54.9	5.8	100	49.4
SB	4.13	.28	1.44	2.67	.71	267	29.7	3.6	108	51.1
LB	4.33	.29	1.52	2.72	.73	343	39.6	4.4	108	51.1
LH	4.29	.27	1.49	2.65	.76	321	48.5	3.8	98	50.2
Significance:	NS	*	**	**	*	NS	NS	**	+	NS
BLSD (.05)	-	.04	.18	.29	.12	-	-	1.9	-	-

[1] Sampled July 26, 1976.

Table 5. Summary of plant measurements - 1976.

Treatment	Early plant height inches	Early plants (10) Dry wt. grams	Corn Grain Ear moisture at harvest %	Corn Grain Yield @ 15.5% M. Bu/Ac	Soybean yield Bu/Ac
CK	19.6	36.5	39.0	15.0	8.6
FE	21.7	50.6	29.3	28.9	11.9
SB	23.9	70.7	27.6	13.3	7.3
LB	24.4	69.9	28.7	7.4	5.9
LH	22.3	54.7	25.6	18.1	6.1
Significance:	*	**	NS	*	NS
BLSD (.05)	2.8	17.2	-	13.4	-

THE RESIDUAL EFFECT OF RATES OF SOLID BEEF MANURE ON CORN GROWTH AND YIELD

West Central Experiment Station - Morris

S. D. Evans

The experiment which was initiated in 1971 was continued. Only one application of manure was made. Treatment descriptions and results in previous years are given in Soil Series 88, 91, 95, and 97.

I. Planting Information

The plots were planted to corn (var. Trojan TXS 99) on May 5, 1976. All plots were treated with Furadan at 10 lbs./acre (1 lb./acre active ingredient). Starter fertilizer consisting of 154 lbs./acre of 8-33-17 was applied to the fertilized plots only. Nitrogen in the form of ammonium nitrate was applied to the fertilized plots to provide 110 lbs./acre of N on October 14, 1975. All plots were plowed on October 15, 1976. Lasso (2) + Bladex (2) were applied broadcast on May 6. The corn was also sprayed with 2,4-D LV ester @ 1/2 lb./acre on June 8.

II. Plant Tissue Analysis

Stands were very poor and plants stunted by the dry weather, but plant samples were taken as in previous years.

A. Early whole plants (Table 1)

The only significant differences were in Ca and Mg. The highest rate of manure had lower contents than all other treatments. The Mg content of the plants from FE were higher than from all other treatments.

B. Leaf samples at silking (Table 2)

The only significant differences were at the 10% level with K and Mg. The K level increased and the Mg level decreased as manure was increased above the fertilized treatment.

III. Yield and Plant Measurements (Table 3)

Stands in all plots were very poor due to the dry conditions during the planting season. The plants that were left were severely stunted by the dry weather during the summer and were further damaged by a severe hail storm on the evening of August 10, 1976.

There were no significant differences in any of the measurements.

Table 1. Summary of analysis of early plant samples - 1976.[1]

Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B
	%				ppm			
Fertilized	.40	2.82	.55	.66	49.8	7.4	80	7.5
Solid Beef @ 33 1/3 T/A	.44	3.10	.56	.55	46.0	7.0	89	6.8
Solid Beef @ 66 2/3 T/A	.42	3.30	.56	.55	35.8	7.6	90	6.8
Solid Beef @ 100 T/A	.43	3.64	.49	.45	31.3	7.6	86	7.0
Significance:	NS	+	**	**	NS	NS	NS	NS
LSD (.05)	-	-	.02	.07	-	-	-	-

[1] Two reps only.

Table 2. Summary of analysis of leaf samples at silking - 1976.[1]

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
Fertilized	2.46	.27	1.09	.98	.90	224	18.8	8.5	88	13.6
Solid Beef @ 33 1/3 T/A	2.38	.30	1.48	.85	.65	220	14.4	7.4	74	13.0
Solid Beef @ 66 2/3 T/A	2.46	.33	1.70	.86	.65	222	16.4	7.8	90	16.3
Solid Beef @ 100 T/A	2.48	.34	1.90	.91	.59	248	15.3	8.2	84	14.2
Significance:	NS	NS	+	NS	+	NS	NS	NS	NS	NS

[1] Two reps only.

Table 3. Summary of plant measurements - 1976.[1]

Treatment	Early plant height inches	Early plants (10) dry wt. grams	Corn Grain: Ear moisture at harvest %	Corn Grain: Yield @ 15.5% M. Bu/A
Fertilized	25.6	71.0	26.8	32.8
Solid Beef @ 33 1/3 T/A	24.0	57.0	29.8	31.0
Solid Beef @ 66 2/3 T/A	23.9	61.8	30.2	22.0
Solid Beef @ 100 T/A	23.4	60.6	26.2	18.2
Significance:	NS	NS	NS	NS

[1] Two reps only.

MANURE RATE STUDY

West Central Experiment Station - Morris

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

Solid and liquid beef manures were applied and the effects were compared against check plots. Treatments and results from previous years are given in Soil Series 91, 95, and 97.

I. Manure Application and Analysis

Manure was applied for the fourth time in the fall of 1975. Samples were taken at the time of application and were analyzed by the Animal Waste Laboratory in the Department of Agricultural Engineering. The amounts are given in Table 1. The chemical analysis of each manure is given in Table 2. Using these figures, the amount of each nutrient applied to each manure treatment was calculated and is given in Table 3.

II. Planting Information

The plots were planted to Trojan TXS99 on May 5, 1976. Furadan was applied at 10 lbs./acre (1 lb./acre active ingredient) to one-half of each main plot and the other half was left untreated. Starter fertilizer (consisting of 154 lbs./acre of 8-33-17) was used only on the fertilized treatment. Nitrogen had been applied to the fertilized treatment in the fall prior to plowing at a rate to give 110 lbs./acre of N. Lasso (2) + Bladex (2) were applied broadcast on May 6. The corn was sprayed with 2,4-D LV ester on June 8.

III. Soil Sampling and Analysis

A. 1975 measurements

The results of some of the analysis are given in Table 4. Other measurements made on the upper 4 feet of soil were Bray #1 P 1:10 and 1:50, Na, K, and pH. These latter measurements are not included in this report.

1. $(NO_3 + NO_2)$-N - The fertilized treatment was higher than the check down to 4 feet. SB1 and LB1 treatments have levels similar to those in the fertilized treatment. The heavier manure treatments have high levels and there was some movement into the 4th and 5th foot.

2. Chloride - Increased manure applications resulted in higher chloride values. The only treatment with any substantial chloride movement below 5 feet was SB3.

3. Conductivity - The increases were associated with an increase in manure rates. There was an increase in chloride to the 4-foot depth with SB2 and SB3.

B. 1976 measurements

The soils were sampled to a depth of 4 feet in the fall of 1976 but the results are not yet available.

IV. Plant Sampling and Analysis

Stands were very poor and plants stunted by the dry weather, but plant samples were taken as in previous years.

A. Early whole plants (Table 5)

There were no significant differences due to treatment.

B. Corn leaves at silking (Table 6)

1. Nitrogen - There was a significant difference between the CK and all other treatments.

2. Phosphorus - The manure treatments were significantly higher than CK and FE. Increased manure rates caused slight increases in P content of the leaves.

3. Potassium - FE was significantly higher than CK and lower than all manure treatments in K.

4. Magnesium - In general the manure reduced the Mg content.

5. Zinc - All manure treatments were significantly higher in Zn than CK. The FE treatment was significantly higher than all SB treatments and LB1.

6. Manganese - The Mn content of the leaves increased with increasing manure applications.

V. Yield and Plant Measurements (Table 7)

Stands were very poor due to the dry conditions during the planting season. The plants that were left were severely stunted by the dry weather during the summer and were further damaged by a severe hail storm on the evening of August 10. Therefore, only a limited number of measurements were made.

A. Early plant height - The higher rates of manure (SB2, SB3, and LB3) were slightly smaller.

B. Early plant dry weight - There were no significant differences.

C. Ear moisture at harvest - There were no significant differences.

D. Grain yield - There were no significant differences. However, the manured treatments were slightly lower in yield.

Table 1. Actual amounts of manure applied in the fall of 1975.

Treatment	Dry Weight	Wet Weight
	- tons/acre -	
SB1	8.063	33.333
SB2	16.127	66.667
SB3	24.190	100.000
LB1	1.913	18.844
LB2	3.825	37.687
LB3	5.738	56.531

Table 2. Average* analysis of manure samples applied in the fall of 1975.

Measurement	Unit†	Type of Manure SB	Type of Manure LB
pH	-	6.3	7.4
Total solids	%	24.2	10.2
Electrical conductivity	mmhos/cm	1.88	3.67
Total Kjeldahl N	%	3.5	8.3
NH_4^+-N	%	2.1	5.3
Organic N	%	1.4	3.0
Phosphates (PO_4-P)	%	.72	1.31
Emission Spectrograph			
P	%	.86	1.55
K	%	2.15	2.76
Ca	%	1.39	1.89
Mg	%	.62	.76
Na	%	.67	1.02
Fe	ppm	2444	964
Al	ppm	2056	655
Mn	ppm	141	136
Zn	ppm	132	147
Cu	ppm	29	20
B	ppm	37	28

* Values based on three samples each of SB and LB manure.

† Dry weight basis.

Table 3. Nutrients applied in 1975 for the 1976 crop year.

Element	SB1	SB2	SB3	LB1	LB2	LB3
			- lbs./acre -			
Total Kjeldahl N	564	1129	1693	318	635	952
NH_4-N	339	677	1016	203	405	608
Org-N	225	452	677	115	230	344
PO_4-P	116	232	348	50	100	150
P	139	277	416	59	119	178
K	347	693	1040	106	211	317
Ca	224	448	673	72	145	217
Mg	100	200	300	29	58	87
Na	108	216	324	39	78	117
Fe	39	79	118	3.7	7.4	11.1
Al	33	66	99	2.5	5.0	7.5
Mn	2.3	4.5	6.8	0.5	1.0	1.6
Zn	2.1	4.3	6.4	0.6	1.1	1.7
Cu	0.5	0.9	1.4	0.08	0.15	0.23
B	0.6	1.2	1.8	0.11	0.21	0.32

Table 4. Effect of two types of beef cattle manure and commercial fertilizer (fall 1975) on the NO_3 + NO_2)-N content, chloride content, and conductivity.

Depth	CK	FE	SB1	SB2	SB3	LB1	LB2	LB3
				(NO_3 + NO_2)-N, ppm				
0-1'	6.5	6.9	19.3	68.8	85.7	17.5	30.6	57.9
1-2'	2.7	29.1	18.8	75.6	108.8	29.2	58.3	107.0
2-3'	5.4	38.1	19.6	56.4	76.2	15.7	44.2	69.4
3-4'	8.1	13.9	12.4	30.2	29.5	8.9	20.7	13.4
4-5'	8.7	9.0	9.6	11.2	21.0	8.9	14.7	8.0
5-6'	7.8	8.1	6.6	8.4	12.8	7.5	8.5	6.6
6-7'	6.0	6.0	4.7	6.6	9.8	6.3	5.9	6.4
7-8'	5.1	4.6	4.9	5.0	6.8	5.1	3.9	5.2
8-9'	4.3	3.3	3.3	3.7	5.2	3.8	3.9	4.5
9-10'	3.8	2.9	2.8	2.9	4.6	3.5	3.3	3.5
				Cl,ppm				
0-1'	5.7	15.2	9.8	42.6	53.0	9.5	13.8	16.6
1-2'	12.6	21.3	43.9	149.0	145.2	41.3	50.5	99.2
2-3'	13.0	20.1	35.2	137.8	116.1	23.0	49.1	76.1
3-4'	11.0	11.2	15.6	72.2	44.1	12.1	24.9	14.9
4-5'	11.7	12.5	10.5	18.8	30.0	12.3	18.3	8.0
5-6'	10.0	5.9	6.9	8.6	16.0	11.6	11.9	9.5
6-7'	8.1	5.3	7.0	6.9	11.2	9.3	7.9	6.2
7-8'	7.5	4.8	6.1	7.0	7.3	12.1	6.0	5.7
8-9'	6.7	5.2	5.5	4.8	5.3	8.7	6.8	6.6
9-10'	6.9	6.0	3.9	3.7	5.0	8.9	4.5	4.8
				Conductivity (mmhos/cm)				
0-1'	.153	.188	.276	.510	.557	.278	.302	.343
1-2'	.232	.293	.307	.590	.660	.331	.460	.613
2-3'	.240	.317	.320	.523	.527	.235	.433	.480
3-4'	.219	.215	.230	.363	.317	.195	.313	.215

Table 5. Summary of analysis of early plant samples - 1976.

Treatment	P	K	Ca	Mg	Zn	Cu	Mn	B
	%				ppm			
CK	.41	2.61	.60	.64	39.5	7.9	101	8.0
FE	.45	3.23	.65	.55	44.4	7.9	119	9.6
SB1	.45	3.71	.53	.45	42.0	7.9	108	8.4
SB2	.45	3.47	.69	.50	47.3	7.8	117	9.9
SB3	.53	3.43	.59	.52	45.6	6.9	113	10.4
LB1	.45	3.26	.62	.56	38.3	9.0	105	8.5
LB2	.45	3.15	.63	.54	38.4	8.1	107	8.4
LB3	.49	3.68	.56	.45	40.0	6.8	118	11.2
Significance:	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Summary of analysis of corn leaves at silking - 1976.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	1.20	.26	1.13	.80	.75	222	15.1	8.7	64	13.3
FE	1.35	.25	1.48	.81	.67	212	23.7	9.8	89	17.6
SB1	1.39	.31	1.88	.78	.56	240	18.8	10.1	96	18.2
SB2	1.41	.32	1.93	.74	.46	217	19.2	8.3	122	20.5
SB3	1.48	.34	1.89	.74	.43	216	18.1	7.9	123	18.8
LB1	1.42	.32	1.71	.82	.63	217	19.5	11.0	100	17.7
LB2	1.40	.33	1.68	.82	.64	231	21.1	9.9	111	22.2
LB3	1.38	.36	1.94	.83	.57	245	22.1	10.2	147	25.4
Significance:	**	**	**	NS	+	NS	*	NS	**	NS
BLSD (.05)	0.11	.03	.26	-	-	-	2.9	-	16	-

Table 7. Summary of 1976 measurements.

Treatment	Early plant height inches	Early plant (10) dry wt. grams	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M. Bu/Ac
CK	10.6	20.8	33.2	24.6
FE	10.0	20.0	33.7	25.8
SB1	10.8	26.4	30.3	16.8
SB2	7.4	13.7	36.6	13.6
SB3	8.1	16.6	31.5	22.4
LB1	9.6	19.2	33.2	19.2
LB2	10.0	23.6	32.3	19.9
LB3	8.9	19.9	26.9	14.6
Significance:	+	NS	NS	NS
+ Insecticide	N.M.[1]	N.M.	32.1	18.8
- Insecticide	N.M.	N.M.	32.3	20.5
Significance:			NS	NS
Interaction Significance:	N.M.	N.M.	NS	NS

[1] N.M. = Not measured on the (-) insecticide treated portion of each main plot.

Table 8. Plant measurements - 1976.

Main plot treatment	Insecticide	Grain: Ear moisture at harvest %	Grain: Yield @ 15.5% M. Bu/Ac
CK	W	33.7	25.6
	W/o	32.8	23.7
FE	W	36.5	25.1
	W/o	30.8	26.6
SB1	W	28.2	15.5
	W/o	32.4	18.1
SB2	W	34.7	11.4
	W/o	38.4	15.9
SB3	W	27.6	28.8
	W/o	35.4	15.9
LB1	W	36.1	15.7
	W/o	30.3	22.8
LB2	W	29.3	17.5
	W/o	35.3	22.2
LB3	W	31.0	10.7
	W/o	22.9	18.4

NITROGEN FERTILIZATION OF WHEAT

West Central Experiment Station - Morris

S. D. Evans, G. L. Malzer, and R. L. Thompson

I. Plot Description and Planting Information

The experiment initiated in 1975 was continued on a new site. The soil type was again Doland silt loam. Soil test information in the fall of 1975 is given in Table 1.

Table 1. Soil test information for the 1976 plots.

Sample	pH	Organic matter	Phosphorus (lbs/Ac)	Potassium (lbs/Ac)	NO_3-N (lbs/Ac)
1	7.8	H	5*	220	29
2	8.0	H	8*	200	23

* 1:50 soil:solution ratio.

Prior to plowing in the fall of 1975, 100 lbs. of P_2O_5 and 100 lbs. of K_2O were broadcast. Samples were taken in each replicate to a 2-foot depth for NO_3-N. Results showed 70, 78, and 53 lbs. NO_3-N/acre in replicates 1, 2, and 3, respectively. The wheat was seeded on April 14 and the nitrogen was applied as topdressed ammonium nitrate on April 15.

The rates of nitrogen used were based on the average NO_3-N in the fall of 1975. The two tests averaged 26 lbs./acre so the recommended N application for a yield goal of over 60 bu./acre would be 120 lbs./acre. Rates of 90 and 150 lbs. N/acre in addition to a check were included.

II. Yield Results

The 1976 yields are given in Table 2.

Table 2. Effect of N rate and variety on yield of wheat at Morris, 1976.

	N Rate - lbs./Acre				
Variety	0	90	120	150	Average
	- Bu./Acre -				
Era	17.3	21.1	19.2	20.0	19.4
Olaf	13.8	17.1	19.6	18.1	17.2
Kitt	19.8	21.8	22.8	19.8	21.0
Waldron	20.3	19.4	23.6	20.1	20.8
Crosby	16.4	18.3	18.7	19.3	18.2
Botno	17.2	18.2	18.8	17.3	17.9
Average	17.5	19.3	20.5	19.1	

	Significance	BLSD (.05)
Varieties	NS	-
N Rates	*	1.8 Bu./Acre
Interaction	NS	-

The varieties were not significantly different. The 90-lb. and 120-lb. N rates were significantly different from the 0-lb. rate. Four of the six varieties reached maximum yield at the 120-lb. rate which was the recommended rate. Based on the spring NO_3-N test the recommended rate was 70 lb./acre. There was no interaction between varieties and N.

III. Protein Results

The protein percentages from the 1976 plots are given in Table 3. Varieties and N rates were both highly significant. Era had the lowest protein of the hard red spring wheat varieties, with Olaf being the highest. The percent protein increased up to the 120-lb. rate with all varieties and to the 150-lb. rate with Kitt, Waldron, and Botno. The interaction was not significant.

Table 3. Effect of N rate and variety on percent protein of wheat at Morris, 1976.

Variety	N Rate - lbs./Acre				
	0	90	120	150	Average
	- % Protein -				
Era	15.87	17.02	17.31	16.68	16.71
Olaf	18.34	18.86	19.15	18.63	18.73
Kitt	17.42	18.86	18.11	19.03	18.35
Waldron	16.85	17.65	18.28	18.86	17.92
Crosby	17.08	18.05	18.63	18.17	17.98
Botno	15.64	16.79	16.68	17.08	16.54
Average	16.86	17.87	18.03	18.07	

	Significance	BLSD (.05)
Varieties	**	.63%
N Rate	**	.32%
Interaction	NS	

IV. Bushel Weight

The test weight values are given in Table 4. There was a significant difference between varieties with Olaf, Kitt, and Waldron being significantly lower in test weight than Era, Crosby, and Botno. There was no significant effect of the N and the interaction was not significant.

Table 4. Effect of N rate and variety on test weight of wheat at Morris, 1976.

Variety	N Rate - lbs./Acre 0	90	120	150	Average
	- lbs./bu. -				
Era	65.9	66.0	65.9	66.2	66.0
Olaf	64.2	63.7	64.1	63.5	63.9
Kitt	63.9	63.1	63.6	63.7	63.6
Waldron	64.1	63.5	63.6	63.7	63.7
Crosby	65.8	65.6	65.7	65.4	65.6
Botno	65.4	64.9	65.2	64.7	65.0
Average	64.9	64.5	64.7	64.5	

	Significance	BLSD (.05)
Varieties	**	1.0 lb./Bu.
N Rate	NS	-
Interaction	NS	-

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

Samuel D. Evans

I. Experimental Description

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

II. 1976 Operations

In 1976 the variety used was Trojan TXS99. Furadan was applied at 1 lb./acre (active ingredient) at planting on May 3. Lasso at 2 lbs./acre and Bladex at 2 lbs./acre were applied broadcast on May 4. Silage yields were taken on September 2 and grain yields on September 16. Yields were very low due to drouth and hail damage.

III. Silage Yields - Dry matter; tons/acre.

A. On plots harvested as grain 1965-76:

	1976 Yield	1966-76 Yield
Low fertility (74 + 48 + 48)	2.35	5.44
High fertility (148 + 96 + 96)	1.61	5.84

B. On plots harvested as silage 1965-76:

Low fertility (74 + 48 + 48)	2.81	5.27
High fertility (148 + 96 + 96)	2.52	5.68

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

A. On plots harvested as grain 1965-76:

	1976	1966-76
Low fertility (74 + 48 + 48)	28.68	86.50
High fertility (148 + 96 + 96)	14.78	91.12

V. Check Yields

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

	1976	1966-76 Average
Grain (0 + 0 + 0)	7.10 Bu/A	48.88 Bu/A
Silage (0 + 0 + 0)	1.65 tons/A	3.71 tons/A

VI. Discussion

A. In 1976 silage yields were reduced slightly by fertilization on areas that had been harvested either for grain or for silage for 11 years. There was also a slight reduction in yield where continuous silage was grown compared to continuous grain. Grain yields were lower under the high fertility conditions.

B. The 11-year average yields show essentially no difference between growing continuous grain and continuous corn silage.

SULFUR FERTILIZATION OF FIELD CROPS UNDER IRRIGATION AT PARK RAPIDS IN 1976

A.C. Caldwell and R.P. Schoper

Sulfur is an essential element for plant growth and is required in relatively large amounts by some crops such as alfalfa. Since there are extensive areas in Minnesota where sulfur deficiencies do occur, investigations on sulfur needs by crops in this state were conducted quite a few years ago, and then more recently by the Department of Soil Science.

In 1976, studies were continued both on and off the Park Rapids Experimental Field on a wide range of crops including alfalfa, potatoes, corn, wheat, barley and navy beans. The soil on which the studies were conducted is a Dorset sandy loam testing 7 and 2 ppm available S on the experimental field and the Monico farm, respectively.

ALFALFA

A trial started in 1974 was continued into 1976. It consisted of S rates of 25, 50 and 100 lbs/A applied as either elemental sulfur or gypsum in a single application at the initiation of the experiment. The results shown in Table 1 reflect a substantial increase in yield and S concentration in the plant tissue. It is interesting to note that even a modest application of S after 2 years is maintaining the S concentration within the alfalfa tissue well above the 0.25% critical level.

POTATOES

Russet Burbank potatoes were grown under irrigation at both the experimental field and the Monico farm. At both locations tuber yield and S concentration in the potatoe petioles were increased (Tables 2 and 3). In addition, analysis indicated that 100 lbs S/A could increase the %S in the tuber on the Monico farm from 0.126 to 0.157 and on the station with 50 lbs S/A from 0.128 to 0.163. This certainly suggests that applied S may be valuable in improving the nutritional value of potatoe tubers. Visually, the potatoes at the farm site were chlorotic and showed reduced vegetative growth, a further indication of an S deficiency situation.

CORN, SMALL GRAIN AND NAVY BEANS

Excellent yields of corn, wheat, barley and navy beans were obtained under irrigation at the experimental farm, however, no consistent yield increases due to the use of sulfur were noted. In all cases, as with alfalfa and potatoes, the application of sulfur significantly increased the S concentration in the plant tissue.

Table 1. Yield and S content of alfalfa tissue under irrigation at Park Rapids in 1975 and 1976.

Sulfur Treatment	1975 1st cutting T/A	1975 1st cutting %S	1975 2nd cutting T/A	1975 2nd cutting %S	1976 1st cutting T/A	1976 1st cutting %S	1976 2nd cutting T/A	1976 2nd cutting %S
0	1.2	.212	1.1	.176	1.2	.179	1.2	.188
25 (elem.)	1.5	.294	1.5	.258	1.6	.224	1.8	.240
25 (gypsum)	1.4	.325	1.5	.297	1.4	.246	1.7	.229
50 (elem.)	1.5	.326	1.6	.288	1.6	.259	2.0	.276
50 (gypsum)	1.3	.358	1.4	.361	1.6	.314	1.8	.293
100 (elem.)	1.6	.365	1.5	.385	1.7	.347	2.1	.364
100 (gypsum)	1.5	.393	1.5	.409	1.8	.351	2.0	.342

Table 2. Tuber yield and S content of potatoe petioles under irrigation at Park Rapids in 1976.

Sulfur Treatment	Yield cwt/A	Petiole %S
0	386	.331
25 (gypsum)	416	.385
25 (elemental)	420	.354
*25 (fortified gyp.)	410	.360
50 (gypsum)	407	.377
50 (elemental)	403	.373
*50 (fortified gyp.)	413	.388

* Fortified gypsum is a mixture containing approximately 2/3 gypsum and 1/3 elemental S.

Table 3. Tuber yield and S content of potatoe petioles under irrigation at the Monico farm in 1976.

Sulfur Treatment	Yield cwt/A	Petiole %S
0	372	.321
* 50 (gypsum)	440	.353
50 (elemental)	362	.351
*100 (gypsum)	401	.379
100 (elemental)	450	.363

* Due to the variable stand on portions of the experimental area gypsum and fortified gypsum treatments were averaged.

PESTICIDE INTERACTION PLOTS AT ROSEMOUNT

Russell S. Adams, Jr.

An experiment studying the effects of combinations of the insecticide Furadan, the herbicide Atrazine, and soil pH in continuous corn culture was established for the fourth year in 1976. Treatments included five residual lime treatments, Furadan at 0, 1/2 and 2 pounds per acre, Atrazine at 0, 2, 4 and 8 pounds per acre and their combinations. Each treatment was replicated four times. The plots have been managed so as to maximize both weed and corn rootworm infestation.

The 1976 season was extremely dry, as was 1974. Consequently the study is becoming something of a drought study. Severe drought effects occurred in 1976. The soil was so dry in early spring that neither the herbicide nor the insecticide were activated and pest control was ineffective. Weeds in the chemically treated plots contributed to reduced yields under the drought stress even though the plots were cultivated three times.

We previously reported evidence of an herbicidal effect of Furadan. This was particularly pronounced in 1976 and appeared to be selective. These effects are now reflected in the four year averages at the 0 and 2 pounds per acre Atrazine rate. Data are given in Tables 1 and 2.

Corn yields generally reflected chemical treatments, particularly in 1976. Yields in the no lime, no chemical treatments were lowest being 15 bushels per acre in 1976 and 47 bushels per acre for the four year acreage. In the high lime, high Atrazine, high Furadan treatments yields were highest being 67 bushels per acre in 1976 and averaging 95 bushels per acre over the four years.

Two changes in response became apparent in 1976. Data are given in Tables 3 and 4. In 1973 when lodging was compared with the untreated check the 2 pound per acre treatment of Furadan decreased lodging as soil pH increased. However, in 1976, and to a lesser extent in 1975, the high lime treatments showed little or no lodging control with 2 pounds per acre Furadan. These results could be due to a highly selective corn rootworm resistence, which seems unlikely, or to increasingly more rapid decay of Furadan in the high lime soils. Some difficulty with alleged Furadan resistance in corn rootworm has been reported. These observations indicate that the question needs more study.

Finally, in 1973, 1974 and 1975 broadleafed weeds made up 10% or less of the total weed population. Most of these were velvet leaf. In 1976 broadleafed weeds, again largely velvet leaf, made up about one-third of the population. Whether this is due to a toxin liberated by velvet leaf (which we have confirmed in laboratory studies), to the extremely dry season, to a greater competitive ability under drought stress of velvet leaf with giant foxtail, or merely to a cyclic fluctuation in velvet leaf populations remains to be determined.

Table 1. The amount of lodging, weed growth, and corn yields in Atrazine-Furadan --soil pH studies at Rosemount, Minnesota, 1976.

Rate of Furadan lbs/A, and lime status	Atrazine applied, lbs/A: None			2.0			4.0			8.0		
	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A
No lime-somewhat (~ pH 5.4)												
Furadan 0 lbs/A	68	1.10	15	65	1.47	25	58	0.69	37	60	0.59	36
1/2	30	1.28	29	22	0.85	43	20	0.85	44	28	0.31	55
2	28	0.85	47	45	0.76	44	43	0.91	50	38	0.19	53
Moderate lime-slightly acid (~ pH 6.3)												
Furadan 0 lbs/A	50	1.29	34	45	1.26	33	50	0.48	49	60	0.30	48
1/2	65	0.84	34	42	1.21	34	22	0.95	58	40	0.48	55
2	50	0.82	44	10	0.96	44	18	0.55	50	25	0.59	46
Well limed-near neutral (~ pH 6.8)												
Furadan 0	52	1.08	32	58	1.17	26	40	0.49	44	42	0.21	62
1/2	37	0.57	51	42	0.86	43	53	1.06	46	45	0.17	56
2	48	0.32	35	50	0.54	44	40	0.32	60	30	0.29	56
Heavily limed-slightly Calcareous (~ pH 7.2)												
Furadan 0 lbs/A	72	0.98	22	62	0.83	45	40	0.50	66	45	0.12	58
1/2	48	1.02	45	68	0.49	45	42	0.20	69	32	0.09	70
2	52	0.92	36	72	0.54	51	62	0.28	67	58	0.09	67

Table 2. The amount of lodging, weed growth and corn yields in Atrazine-Furadan soil pH studies at Rosemount, Minnesota, 4 year average.

Rate of Furadan lbs/A, and lime status	Atrazine applied, lbs/A: None			2.0			4.0			8.0		
	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A	Lodging %	Weeds Tons/A	Corn bu/A
No lime-somewhat acid (~pH 5.4)												
Furadan 0 lbs/A	54	1.50	47	51	0.98	69	54	0.45	75	39	0.25	79
1/2	25	1.86	57	33	0.65	78	33	0.65	73	32	0.21	85
2	18	1.17	69	39	0.80	78	15	0.66	75	36	0.16	84
Moderate lime-slightly acid (~pH 6.3)												
Furadan 0 lbs/A	43	1.89	61	51	0.70	67	42	0.33	80	52	0.08	86
1/2	46	1.33	55	36	0.66	76	26	0.54	89	40	0.20	83
2	24	1.61	65	22	0.88	75	16	0.31	83	21	0.22	86
Well limed-near neutral (~pH 6.8)												
Furadan 0 lbs/A	48	1.28	55	36	0.83	70	45	0.24	79	44	0.10	91
1/2	40	1.25	72	34	0.87	71	37	0.48	84	48	0.09	90
2	25	1.00	67	20	0.74	87	27	0.40	92	25	.11	89
Heavily limed-slightly calcareous (~pH 7.2)												
Furadan 0 lbs/A	61	1.48	56	58	0.34	79	52	0.17	82	50	0.05	80
1/2	36	1.36	73	42	0.42	84	38	0.16	89	38	0.05	93
2	40	0.84	75	43	0.35	83	30	0.18	90	38	0.02	95

Table 3. Lodging in the 2 lb/A Furadan treatments as a percentage of the untreated check. 100% would be lodging in cultivated check the same as in 2 lb/A Furadan treatment.

Lime Treatment	1973	1974	1975	1976
		% of check		
No lime-somewhat acid ~pH 5.4	63	39	53	60
Moderate lime-slightly acid ~pH 6.3	68	33	59	51
Well limed-near neutral ~pH 6.8	26	50	68	88
Heavily limed-slightly calcareous ~pH 7.2	25	57	112	111

Table 4. Ratio of Broadleaf weeds: grasses in cultivated checks. A number of 1.0 would mean equal dry weights of both.

Lime Treatment	1973	1974	1975	1976
No lime-somewhat acid ~pH 5.4	0.109	0.025	0.092	0.275
Moderate lime-slightly acid ~pH 6.3	0.027	0.043	0.052	0.448
Well limed-near neutral ~pH 6.8	0.203	0.037	0.144	0.354
Heavily limed-slightly calcareous ~pH 7.2	0.490	0.093	0.128	0.332

ALFALFA AND RED CLOVER POTASSIUM AND COPPER TRIALS

Staples, Minnesota - 1976
C. J. Overdahl, Melvin Wiens, R. Schoper and J. Lensing

POTASSIUM TREATMENT EFFECT (ALFALFA AND RED CLOVER)

Plots were established in July of 1970. Experiments on phosphorus, lime and sulfur were discontinued after 1974. No significant effect from these treatments were noted. Phosphorus and sulfur tested high in all of these trials. The soil pH was originally low, but it was determined that irrigation water had a calcium carbonate content of 280 ppm. This resulted in over 1,000 pounds of lime equivalent added annually. The check plots in 1974 had a pH of 7.1, making the lime experiment meaningless. Very high water rates were applied in 1976 (38 inches). The average pH in October was 7.8, indicating a potential problem.

POTASSIUM TREATMENTS ON RED CLOVER AND ALFALFA

	Annual treatments of K_2O in lbs/A and time of application						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
			Yields Tons/Acre at 15% Moisture				
Alfalfa							
1972	3.4	3.6	3.8	3.5	3.4	3.6	ns
1973	4.0a	4.8bc	4.6bc	4.6bc	4.3ab	4.8c	5%
1974	5.1a	6.5b	6.4b	6.4b	6.3b	6.5b	5%
1975	5.1a	6.4bc	6.6c	6.1b	6.2b	6.4bc	1%
1976	4.5a	6.2c	6.1c	5.8b	5.6b	5.7b	1%
Red Clover							
1972	4.2	5.0	4.5	4.7	4.7	4.7	ns
1973	3.3	3.6	3.3	3.4	3.6	3.7	ns
1974*	-	-	-	-	-	-	
1975	5.0a	6.0b	5.8b	5.8b	5.6b	6.0b	5%
1976*	2.8a	3.2b	3.3b	3.2b	3.1b	3.2b	5%
			Soil Test K lbs/A				1976
Alfalfa							
1972	92	258	322	160	165	185	Avg. pH=7.8
1973	85	290	210	150	140	195	
1974	60	175	240	95	75	200	Avg. P=60
1975	48	178	160	75	63	135	
1976	40	210	145	68	68	128	
Red Clover							
1972	107	262	230	182	167	162	
1973	90	290	240	160	190	310	
1974	135	180	200	150	155	180	
1975	60	180	83	108	60	115	

* red clover failed in 1974, was reseeded August 1, 1974 and a good stand was established for 1975. Red clover in 1976 was plowed and reseeded after two cuttings.

	Plant Analysis %K						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	Significance
Alfalfa							
1972							
1st cut	2.05	2.76	2.89	2.20	2.74	2.65	
2nd cut	2.00	2.50	2.46	2.27	1.92	2.34	
3rd cut	2.52	3.44	3.08	2.94	2.85	3.18	
1973							
1st cut	1.74a	2.74b	2.88b	2.40b	2.45b	2.47b	5%
2nd cut	1.58a	2.76b	2.76b	2.48b	2.39b	2.65b	1%
3rd cut	1.64a	2.60b	2.57b	2.45b	2.17b	2.56b	5%
1974							
1st cut	1.37	3.08	3.59	2.17	2.32	3.21	
2nd cut	1.29	2.40	2.85	2.25	1.89	2.60	
3rd cut	1.11	2.18	2.48	2.08	1.62	2.36	
1975							
1st cut	1.24a	2.19c	2.67d	1.67b	2.15c	2.31c	1%
2nd cut	1.39a	2.74c	2.49bc	2.27b	1.93a	2.67c	1%
3rd cut	1.23a	2.60c	2.85c	2.15b	1.72a	2.45bc	1%
1976							
1st cut	1.24a	3.66f	3.26de	1.55b	2.38c	2.99d	5%
2nd cut	1.45a	2.98d	2.83d	2.68c	2.02b	2.90d	5%
3rd cut	1.49a	2.78cd	2.86d	2.26b	2.03b	2.68c	5%
Red Clover							
1972							
1st cut	2.14	3.05	2.83	3.02	2.61	3.04	
2nd cut	2.20	2.86	2.60	2.51	2.21	2.44	
3rd cut	2.65	3.54	2.98	3.32	2.87	2.98	
1973							
1st cut	1.76a	2.63b	2.65b	2.56b	2.42b	2.66b	5%
2nd cut	2.03a	2.84c	2.97c	2.65bc	2.48b	2.92c	1%
3rd cut	1.81a	3.00d	2.53c	2.40c	2.10b	2.66c	1%
1974							
none							
1975							
1st cut	1.55a	2.59d	2.33cd	2.01bc	1.87ab	2.45d	1%
2nd cut	1.69a	3.00c	2.18b	2.80c	2.05b	2.89c	1%
3rd cut	1.78a	3.12d	2.37b	2.68c	2.25b	2.87c	1%
1976							
1st cut	1.43	2.96	3.18	2.08	2.37	2.80	5%
2nd cut	1.70a	3.09c	2.67b	2.66b	2.47b	3.05c	5%

The potassium (K) experiment has provided useful data on differences between alfalfa and red clover K needs.

In 1976, the 240 pound potash treatments gave yields significantly higher than for the 120 pounds per acre for alfalfa, but not for red clover. There has been no significant difference in yield between October or June application. Each year plant analyses show higher K content from October treatments at the first cutting time. This is prior to the June K applications. K content in plants from the 120 pound rate, at time of the last cutting, is higher from June treatments. This is generally true for all years of the experiment. Check plots after the first year show plant K to be less than 2 percent in both alfalfa and red clover. Potassium soil tests are unusually low. The basic difference between alfalfa and red clover so far is the loss of red clover stand and the necessary reseeding of this crop every year. Alfalfa is still grown from the seeding of 1970.

COPPER OBSERVATIONS

	Lbs/acre of copper applied as copper sulfate		
	0	10	Sig. 5%
		Tons/Acre	
Alfalfa			
1972	0.52	0.60	3rd cutting only
1973	5.3	5.4	ns
1974	6.4	6.9	ns

In 1972 to 1974, copper treatments were made on a special area of alfalfa adjacent to the alfalfa-red clover site. There was a slightly higher yield from copper treatments, but this was not significant at the 5 percent level.

In 1975 and 1976, two of the four replicates in the alfalfa-red clover trials had 10 pounds per acre of copper.

	Lbs. of copper applied as copper sulfate annually		
	0	10	Sig.
		Tons/Acre	
Alfalfa			
1975	5.8	6.1	ns
1976	5.5	5.8	10%
Red Clover			
1975	5.6	5.8	ns
1976	3.1	3.2	ns

				ppm Cu plant tissue			
Cuts	1	2	3	1	2	3	
Alfalfa							
1975	0.8	-	-	2.2	-	-	1%
1976	1.2	2.2	2.1	4.5	6.5	6.4	1%
Red Clover							
1975	4.5	-	-	4.3	-	-	ns
1976	3.5	3.7	-	6.7	8.6	-	1%

Added copper had a highly significant effect on copper content in both alfalfa and red clover tissue. Copper is always higher in red clover, particularly without added copper. There is no copper effect on yield with red clover, but there was an indication of some copper effect on alfalfa yield in 1976. Trials will be continued in 1977 with newly seeded red clover.