Soil Series 84

A Report on Field Research in Soils

(A compilation of recent experimental results by personnel of the Department of Soil Science, Extension Specialists and Agronomists at St. Paul and the Branch Stations at Crookston, Grand Rapids, Lamberton, Morris, Rosemount, and Waseca).

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Some of the results herein reported are from experiments carried on during 1968 only, and should not be regarded as the results obtained over a number of years. The investigations are those of a more prectical nature, and do not include some of the more theoretical problems presently under study in greenhouse and in the laboratory. Because these are largely results of one year they should not be considered as conclusive and are not for further publication.

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Some Climatological Notes, Fall 1968

by Donald G. Baker (Feb. 1969)

A. Summary of the 1968 Soil Water Survey

The Fall, 1968, soil water results are shown in table 1. Unlike several previous years, and 1967 in particular, the soils almost everywhere contain an abundance of water. With an average available water content of around 9 inches the soils are thus capable of sustaining crops from planting in mid-May to the end of June without additional precipitation.

The relatively high soil moisture reserves do pose two possible handicaps over more normal seasons. One is that due to such high soil water reserves the soil cannot absorb as much spring runoff and precipitation as usual. And this leads to a greater possibility of spring flooding. A second handicap is that with more water in the soil than usual the soils will be slower to warm unless there is a higher than usual evaporation rate this spring.

There were a number of sites where the soils were simply too wet to obtain samples. This, of course, was a direct result of the most unusual precipitation distribution, particularly at the end of the growing season. Figure 1 contrasts the 1968 season with the average for 1961-67 at Lamberton. The difference begins in the early spring with the very low water reserves. And then with hardly a pause the reserves continue to increase even through the growing season, which is just the opposite of the normal course of events. No measurements were made after September 13, 1968, but the soil water undoubtedly continued to increase as shown by the dashed line.

Table 1. Fall, 1968, soil water survey results (from sampling to a depth of 5 feet).

County	Nearby Town	Operator	Soil Type	Crop	Total Available Water, Inches	% of Possible Water	Inches Difference Fall '68-Fall '67	Water Used In Season, Inches	
Big Stone	Ortonville	H.Dimberg	Barnes c.l.	Small grain	2.6	22.8	+ 1.8	16.9 (4/12-11/6)	OG
Big Stone	Beardsley	Wright	Barnes si.l.	Alfalfa	0.5	4.9	+ 0.1	19.1 (4/12-11/6)	OG
Chippewa	Milan (Big Bend)	H.Olson	Rothsay si.l.	Small grain	7.3	50.7	+ 2.6	22.8 (4/12-11/6)	OG
Chippewa	Montevideo	Sederstrom	Barnes	Corn	6.0	45.8	+ 5.4	19.2 (4/12-11/6)	OG
Dodge	Dodge Center	Sutherland	Kasson si.l.	Corn	8.0	76.1	+ 4.8	21.2 (4/30-12/4)	SCS
Jackson	Lakefield	Pietz	Primghar si. c.l.	Corn	Too wet to sample	-	-	-	GH
Kandiyohi	Pennock	Giese	Clarion si.l.	Soil bank	7.8	57.8	+ 7.6	28.0* (4/11-11/6)	OG
Kandiyohi	Kandiyohi	Arvidson	Nicollet	Corn	Too wet to sample	-	-	-	OG
Lac Qui Parle	Bellingham	Glasser	Aastad si.c.l.	Small grain	9.7	59.1	+ 2.8	24.1* (4/12-11/6)	OG
Lac Qui Parle	Lac Qui Parle	Heimdahl	Rothsay si.l.	Corn	5.3	39.0	+ 4.3	22.6* (4/12-11/6)	OG

Table 1. (Continued)

Lac Qui Parle	Marietta	Aebli	Rothsay si.l.	Corn	9.3	72.1	+ 5.0	20.4 (4/12-11/6)	OG
Lac Qui Parle	Dawson	Nelson	Aastad si.c.l.	Corn	9.8	90.7	+ 3.6	20.6 (4/12-11/6)	OG
Lincoln	Arco	Madsen	Barnes c.l.	Corn	6.3	49.2	+ 5.2	33.4* (4/13-11/4)	GH
Lincoln	Porter	Boulton	Barnes si.c.	Flax	8.9	69.0	+ 5.2	19.4 (4/13-11/4)	GH
Lyon	Marshall	Boerboom	Vallers	Corn	Too wet to sample	-	-	-	GH
Murrey	Slayton	Larson	Barnes si. c.l.	-	Too wet to sample	-	-	-	GH
Mille Lacs	Milaca	Nichols	Mora si.l.	Hay	11.8	118.0	+ 8.3	28.4* (4/25-11/8)	SCS
Nobles	Fulda	Horn	Primghar	Corn	Too wet to sample	-	-	-	GH
Polk	Crookston	U of M	Hegne si.c.l.	Corn (#1)	9.8	57.3	+ 8.1	19.6 (5/17-10/31)	OS
Polk	Crookston	U of M	Hegne si.c.l.	Wheat (#4)	6.9	40.3	+ 6.3	19.0 (5/20-10/31)	OS
Polk	Crookston	U of M	Hegne si.c.l.	Sugarbeets (#5)	7.9	46.2	+ 0.2	20.0 (6/5-10/31)	OS
Pipestone	Pipestone	Bucher	Kranzburg si.l.	Corn	9.9	73.3	+ 8.6	25.7* (4/15-11/12)	GH

Table 1. (Continued)

Ramsey	St. Paul	U of M	Waukegan si.l.	Sod	12.1	147.5	+12.1	23.7* (5/2-11/8)	DGB
Ramsey	St. Paul	U of M	Waukegan si.l.	Soy	12.8	156.0	+12.8	25.4* (5/2-11/8)	DGB
Ramsey	St. Paul	U of M	Waukegan si.l.	Bare of vegetation	10.8	131.7	+10.8	25.5* (5/2-11/8)	DGB
Redwood	Belview	Anderson	Nicollet c.l.	Corn	Too wet to sample	-	-	-	GH
Redwood	Lamberton	U of M	Webster c.l.	Corn	3.5 Too wet to sample after Sept. 13	35.3	+ 0.4	19.8 (3/26-9/13)	WN
Redwood	Wabasso	Kuehn	Nicollet	Corn	7.0	53.8	+ 6.3	25.6* (4/15-11/4)	GH
Redwood	Morgan	Prokosch	Nicollet c.l.	-	Too wet to sample	-	-	-	GH
Rock	Hardwick	Hengeveld	Kranzburg si.l.	Corn	13.0	92.9	+ 6.0	21.1 (4/15-11/12)	GH
Sibley	Winthrop	Woods	Nicollet c.l.	Corn	Too wet to sample	-	-	- (5/2-11/13)	SCS
Stevens	Morris	U of M	Aastad	Corn	3.4	27.0	+ 2.1	18.3 (4/11-11/6)	OG
Swift	Danvers	Stubbs	Barnes c.l.	Small grain	4.8	33.6	+ 3.7	21.2 (4/11-11/6)	OG
Swift	Murdock	Tucker	Vallers si.c.	Soybeans	15.4	106.2	+ 6.0	(4/11-11/6)	OG

Table 1. (Contimued)

Todd	Long Prairie	C.Hartung	Blowers l. f.s.	Oats	8.3	96.5	-	13.8 (5/21-9/30) AF
Wabasha	Kellogg	Zickrick	Fayette si.l.	Corn	13.5	93.1	+ 5.6	34.1* (4/13-11/4) SCS
Watonwan	Butterfield	Hanson	Nicollet c.l.	-	Too wet to sample	-	-	- SCS
Watonwan	Lewisville	Tilney	Kingston si.l.	Corn	11.1	91.7	+ 6.4	(4/16-11/26) SCS
Watonwan	Lewisville	Tilney	Medelia si.l.	Sugarbeets	6.6	48.9	+ 0.5	(4/16-11/26) SCS
Yellow Medicine	Granite Falls	Velde	Aastad si.c.l.	Corn	8.8	58.3	+ 4.7	22.3 (4/16-11/8) GH

*Excessive seasonal precipitation, some of which was lost directly as runoff, gives a false figure as to the quantity of water consumed by the crop.

Dr. Olaf Soine of the Northwest Experiment Station at Crookston has obtained similar data under various crops that he sampled during the 1968 season. Data from his corn plot are shown in figure 2. Unlike much of the state the northwest did not receive the heavy autumn rains (see figure 3) but did receive a good snowfall and above average spring precipitation. The result was an earlier increase in soil water reserves. Like Lamberton the Crookston soil water reservoir continued to increase during the growing season—a rare event indeed.

Figure 3 shows the September and October precipitation totals which explain the late summer and autumn soil reservoir increases. A high of 18 inches was recorded at Tracy with secondary highs in east-central and south-central Minnesota.

Table 2 lists the average fall soil water content at the various sampling sites.

Fig. 1

Comparison of the 1968 soil water season at Lamberton corn plots with the 1961-67 average

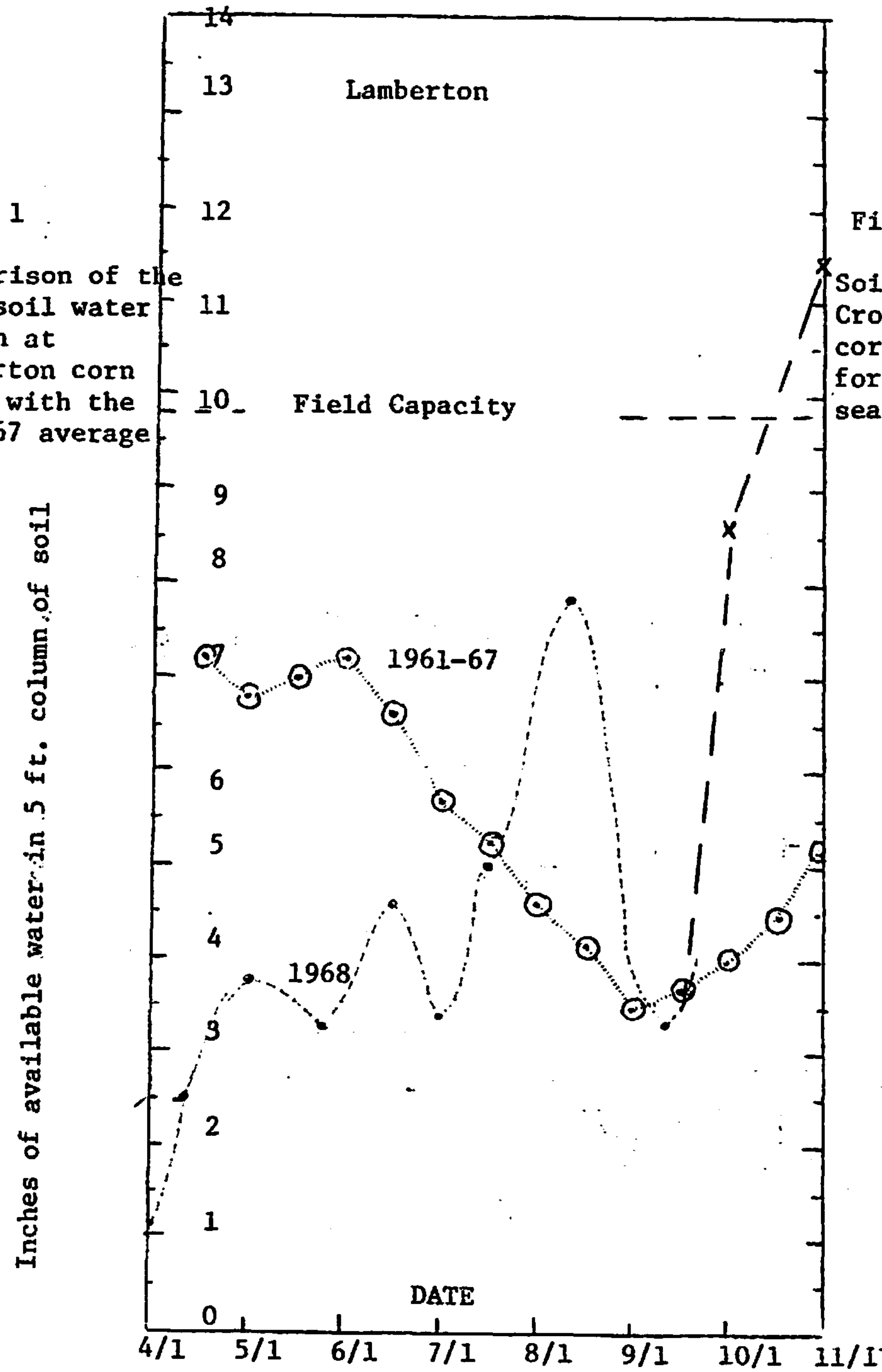
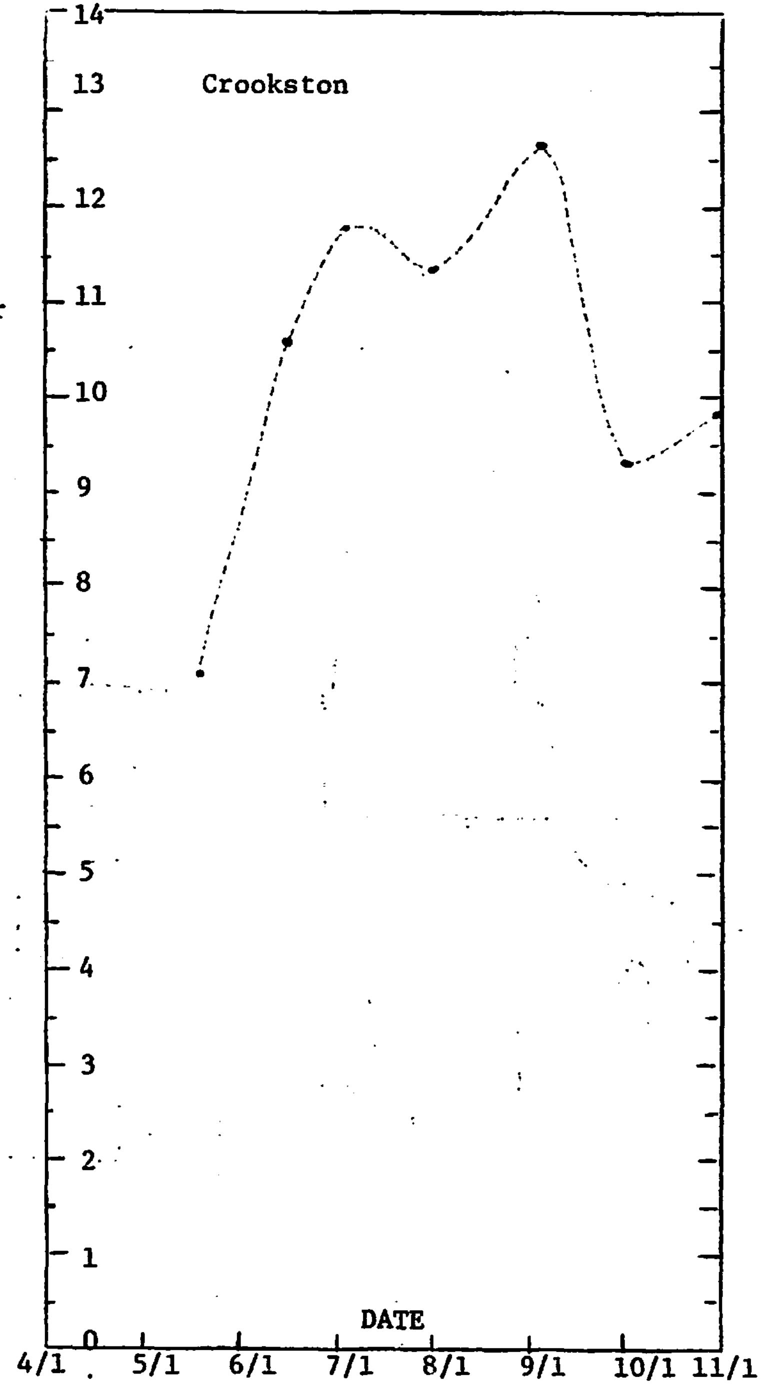


Fig. 2

Soil water at Crookston under corn in site 1 for the 1968 season.



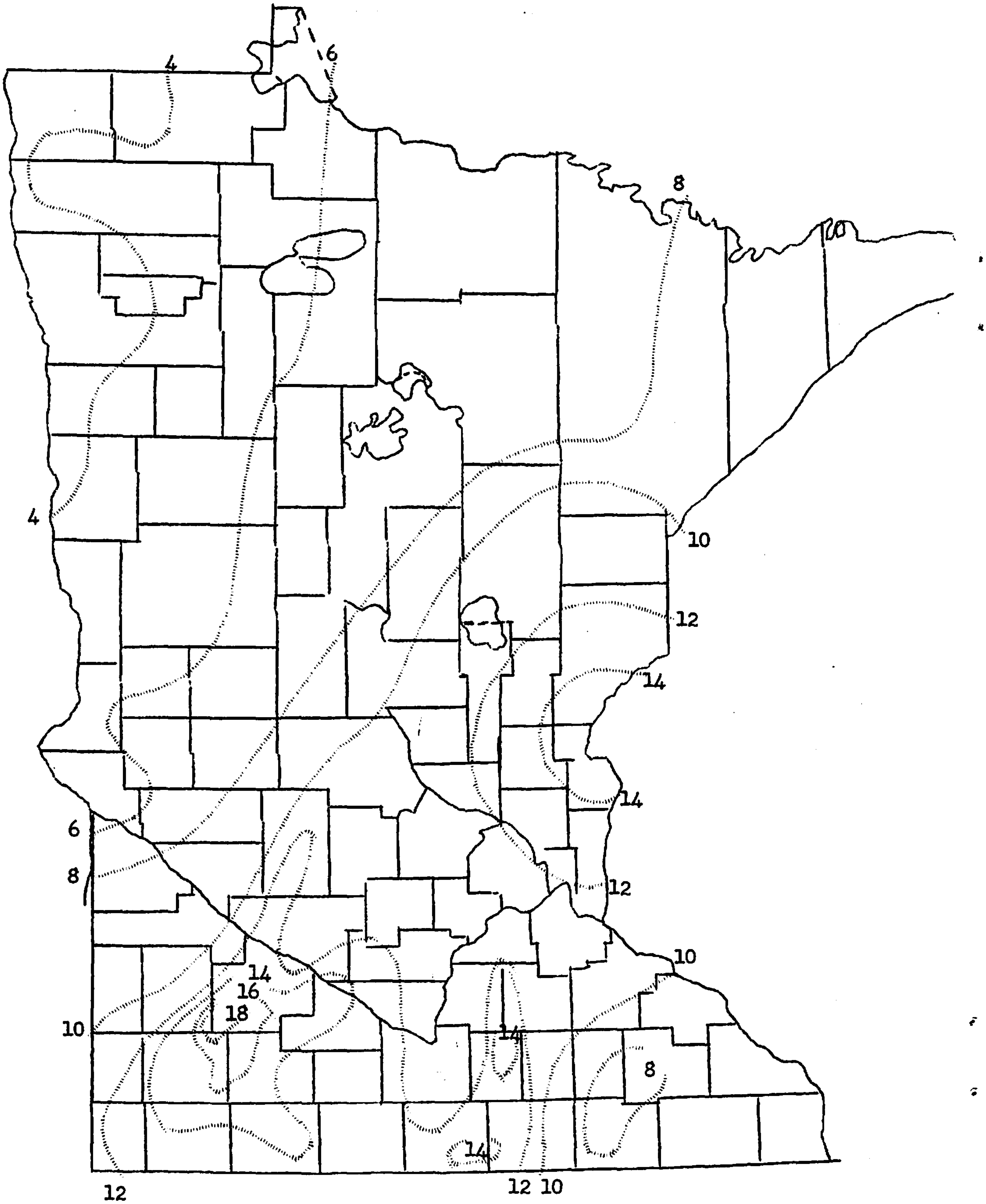


Fig. 3. Total September and October Precipitation for 1968.

Prepared by Weather Bureau Office of Climatology.

Table 2. Average fall soil water reserves in inches of available water in a 5 foot column of soil

County	Nearby Town	Ave. Water Content (in.)	Years of Data
Big Stone	Ortonville	1.7	3 (1966-68)
"	Beardsley	0.3	3 (1966-68)
Chippewa	Milan (Big Bend)	6.5	6 (1962-68) '65 msg
"	Montevideo	3.7	4 (1965-68)
Dodge	Dodge Center	4.8	9 (1960-68)
Jackson	Lakefield	3.7	1 (1967)
Kandiyohi	Pennock	2.3	5 (1963-68) '65 msg
"	Kandiyohi	1.4	4 (1963-68) '65 msg
Lac Qui Parle	Bellingham	9.1	6 (1962-68) '65 msg
"	Lac Qui Parle	3.1	4 (1965-68)
"	Marietta	6.2	6 (1962-68) '65 msg
"	Dawson	6.8	5 (1963-68) '65 msg
Lincoln	Asco	3.3	6 (1963-68)
"	Porter	5.1	6 (1963-68)
Lyon	Marshall	5.7	4 (1963-67) '66,'68 msg
Murray	Slayton	1.1	1 (1967) '68 msg
Mille Lacs	Milaca	6.7	8 (1961-68)
Nobles	Fulda	3.1	1 (1967)
Polk	Crookston	5.6 (Plot 1)	8 (1961-68)
"	"	3.7 (Plot 4)	3 (1964-68) '66 msg
"	"	7.9 (Plot 5)	4 (1964-68) '66 msg
"	"	5.8 (Plot 6)	3 (1964-66) '67,'68 msg
"	"	2.9 (Plot 7)	2 (1966-67) '68 msg
Pipestone	Pipestone	5.6	2 (1967-68)

Table 2. (Continued)

County	Nearby Town	Ave. Water Content (In.)	Years of Data
Ramsey	St. Paul	6.9 (Sod Plot)	4 (1965-68)
"	"	6.4 (Soy Plot)	6 (1962-68)'64,'67 msg
"	"	8.3 (Base Plot)	3 (1965-68) '67 msg
Redwood	Belview	5.5	6 (1962-68) '68 msg
"	Lamberton	5.2	7 (1961-68) '68 msg
"	Morgan	7.6	3 (1965-68) '68 msg
"	Wabasso	5.2	5 (1963-68)
Rock	Hardwick	10.0	2 (1967-68)
Sibley	Winthrop	8.5	7 (1961-68) '68 msg
Stevens	Morris	2.3	2 (1967-68)
Swift	Danvers	4.6	5 (1963-68)
"	Murdock	10.1	5 (1963-68)
Todd	Long Prairie	8.3	1 (1968)
Watonwan	Butterfield	7.4	7 (1961-68) '68 msg
"	Lewisville (Mad)	7.6	3 (1966-68)
"	Lewisville (King)	8.1	3 (1966-68)
Wabasha	Kellogg	9.5	8 (1961-68)
Yellow Medicine	Granite Falls	9.3	6 (1963-68)

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Weather Summary - 1968
Southwest Experiment Station, Lamberton

Wallace W. Nelson, Supt.

Month	Period	Precipitation Inches	Air Temperature Ave.Max.	Air Temperature Ave.Min.	Soil Temperature Ave.2"	Soil Temperature Ave.12"
January	1-31	0.45	27	7	27	29
February	1-29	0.08	27	5	25	26
March	1-31	0.88	57	26	37	34
April	1-10	2.21	58	33	42	39
	11-20	1.32	69	43	51	45
	21-30	0.92	65	38	50	46
	Total	4.45				
May	1-10	0.47	69	41	54	51
	11-20	0.55	68	40	56	51
	21-31	0.68	68	56	57	52
	Total	1.70				
June	1-10	1.87	91	63	71	61
	11-20	0.25	82	53	70	64
	21-30	1.84	80	54	68	63
	Total	3.96				
July	1-10	0.71	82	56	73	65
	11-20	3.32	89	67	80	71
	21-31	5.60	81	59	80	69
	Total	9.63				
August	1-10	1.45	85	62	74	69
	11-20	0.28	82	55	71	67
	21-31	0.30	81	59	74	68
	Total	2.03				
September	1-10	1.61	73	49	64	63
	11-20	1.63	75	54	63	62
	21-30	4.42	72	47	60	59
	Total	7.66				
October	1-31	7.88	63	40	50	52
November	1-30	0.72	42	27	37	41
December	1-31	1.46	24	9	30	34
(Growing Season) April 1-September 20		29.43	76	51	64	59
(Annual) January 1-December 31		40.90	58	35	49	48

Method of Corn Planting Study

Lancaster, Wisconsin - University of Wisconsin Experiment Farm

Arthur Peterson, James Swan and William Paulson, Supt.

The following field experiment was conducted near Lancaster, Wisconsin during the 1968 growing season.

Soil: Fayette silt loam, 6 to 8% south slope, previously in corn

Fertilizer: 250 to 300 lbs/acre of 6-24-24

100 lbs of N as anhydrous ammonia

Population planted 22,000 plants/acre; depth of planting 1½ to 2 inches on wheeltrack planting and 2 to 2½ inches on coulter planting.

Corn: Wisc. 601, 110 days

Experimental design for final yield - 4 x 4 latin square (plot size was 18 x 50 feet with alleys of 15 to 50 feet). Soil temperature and early growth cannot be analyzed in the latin square design.

Treatments: 1 Plow-disk-harrow

2 Plow

3 Chisel

4 None

Tillage and planting on May 8. All treatments were chisel plowed in early April 1968.

Yield determinations were made on the wheeltrack treatment only.

Each plot consisted of six 36-inch rows 50 feet long. Each plot was divided into three 2-row subplots with the following types of planting: coulter, wheeltrack, and combined wheeltrack and coulter.

Soil temperature measurements

Soil temperature was measured on the following treatments:

1 Plow-disk-harrow (coulter)

2 Plow (coulter)

2 Plow (wheeltrack)

4 None (coulter)

No temperature measurements were made on the chisel treatment. One set of thermocouples was placed in a chemically killed sod plot.

Soil temperatures were measured by thermocouples on 2 reps (only one rep was part of the 4 x 4 latin square). Thermocouples were placed at the 3-inch depth in the row. Four couples were used in parallel in each treatment.

Final stand and yield

Treatments	Population at harvest plants/acre	Yield bu/acre at 15.5% moisture
Plow-disk-harrow	21,200 a	130 a
Plow	17,500 b	128 a
Chisel	19,500 a	126 ab
None	19,400 a	121 b

Significant at 5% level by Duncans New Multiple Range test.
Above yield and stand measurements were taken from the wheeltrack treatments.

1968 Weather Record at Lancaster

	Air Temperature				Precipitation	
Month	Avg.	Max.	Min.	Departure from Normal	Inches	Departure from normal Inches
May	55.0°F	79°F	32°F	-4.1°F	2.42	-1.43
June	68.2	89	49	-0.3	7.47	+2.54
July	70.4	89	48	-3.0	5.51	+1.78
August	70.1	91	50	-1.6	3.94	+0.11
September	60.8	83	38	-2.5	4.12	+0.44

Early growth was measured on June 17 on two reps not included in the 4 x 4 latin square. Later infiltration measurements were taken on these reps and final yields could not be taken.

Treatment	Early Growth
Plow-disk-harrow	42 gms
Plow	32 "
Chisel	33
None	31
(Sod)	(12)

Conclusions:

1) Differences in early growth on the 2 reps measured were not significantly different at the 10 percent level for either the 4 tillage treatments or the 3 types of planting. (The sod treatment was not included in the analysis.)

2) Compared to the plow-disk-harrow (coulter) treatment, small reductions in soil temperature were measured for coulter planting on the plow and none treatments. Small increases in soil temperature were measured for the plow (wheeltrack) treatment. On the sod (coulter) treatment decreases in soil temperature of up to 5°F were measured. Early growth was greatly reduced on the sod treatment.

3) Final yields were significantly lower at the 5 percent level on the "none" tillage treatment. Similar results were reported from Ohio. Research in Ohio in which conventional and "no tillage" systems were compared, indicated yields decreased on "no tillage" trials on crusting soils with 5 percent cover. There was no difference in yields at 50 percent cover and yields increased with "no tillage" at 90 and 100 percent cover. N. Rask, G. B. Triplett, D. M. VanDoren, Jr. (Ohio Report, January-February 1967, page 14, 15). Plant populations varied on the tillage treatments and were significantly lower on the wheeltrack-plow treatment.

4) Average air temperature in May was 4°F below the normal. Rainfall was above normal in June and July.

Soil temperatures at three-inch depth under designated tillage treatments

(average of 2 reps - only one rep was in the 4 x 4 latin square)

Dates	Plow-Disk-Harrow (coulter) (conventional)			Difference in Soil Temperature for NONE(coulter)-conv.			Difference in Soil Temperature for Plow(wheel track)-conv.			Difference in Soil Temperature for Plow(coulter)-conv.			Difference in Soil Temperature for Sod(coulter)-conv.		
	AM °F	PM °F	AVG °F	AM °F	PM °F	AVG °F	AM °F	PM °F	AVG °F	AM °F	PM °F	AVG °F	AM °F	PM °F	AVG °F
May 9-11	48.7	60.8	54.8	+0.4	-0.3	+0.1	-0.4	+1.8	+0.7	+0.1	+0.1	+0.1	-	-	-
12-18	53.9	62.0	58.0	-0.3	-0.1	-0.2	-0.1	+1.3	+0.6	-0.3	-0.1	-0.2	-0.4	-2.8	-1.6
19-25	53.1	61.5	57.0	-0.3	-0.7	-0.5	-0.3	+0.9	+0.3	-0.5	-0.2	-0.4	+0.3	-2.7	-1.2
May 26 June 1	55.3	62.0	58.7	-0.1	-0.4	-0.3	+0.1	+0.4	+0.3	-0.1	-0.3	-0.2	+0.3	-1.4	-0.6
June 2-8	66.3	79.4	72.7	-0.8	-1.4	-1.1	+0.5	+1.3	+0.9	-0.3	-0.6	-0.5	-3.0	-7.5	-5.2
9-15	66.7	73.4	70.1	-0.3	-0.8	-0.6	+0.1	0	+0.1	-0.1	-0.6	-0.4	+0.2	-0.9	-0.4

Note - Read to nearest 0.5°F so differences less than 0.5°F are within the error of measurement. Average readings are for days with both AM and PM readings.

AM readings taken 0900 DST ± 2 hours
PM readings taken 2000 DST ± 2 hours

Land Forming Experiment
Northwest Experiment Station, Crookston - 1968

Olaf C. Soine, Soil Scientist

This experiment was laid out in the fall of 1965 to study the effect of 5 different methods of land forming on crop yields in a rotation of corn, wheat, barley, and alfalfa. A fertilizer trial was included in the experiment.

The wheat yields in 1968 were good, but lower than those of 1967. The lowest yields were on the .02 and .01 percent and level treatments plots, partly because the soil was most disturbed here during the initial land forming. The 40+40+20 fertilizer gave the largest yield increases on all treatments in 1968 and also for the 3-year averages.

The barley yields were average and the 40+40+20 fertilizer increased the yields from 10 to 16 bu. on all treatments over the check plot. The 0+40+20 fertilizer gave 4-6 bu. increases over the 0+40+0 application in 1968. In the 3-year averages, the 40+40+20 fertilizer showed 20 and 17 bu. increases over the check on the .02 and .01 percent slope treatments, respectively.

The 1968 corn yields were very high and there were very little differences between the fertilizer applications.

There were no alfalfa yields in 1966 and the drought of 1967 hed a severe effect on the new seedings. On the "Land Smoothing" plots the alfalfa stands were too poor to harvest. The yields were variable on all treatments in 1958 and no definite trends were evident from the various fertilizer applications.

Effect of 5 different methods of "Land Forming" on the yield of corn, wheat, barley and alfalfa.

Land Forming Treatments	Fertilizer lbs/acre	Corn* (bu/acre) 1968	Corn* (bu/acre) Av 1966-68	Wheat (bu/acre) 1968	Wheat (bu/acre) Av 1966-68	Barley (bu/acre) 1968	Barley (bu/acre) Av 1966-68	Alfalfa** (lbs/acre) 1968	Alfalfa** (lbs/acre) Av 1967-68
CHECK	0+0+0	102	83	41	38	57	51	4670	3807
	0+40+0	100	83	41	37	63	55	4927	3855
	0+40+20	105	79	40	36	58	48	4402	3593
	40+40+20	111	87	49	39	67	57	4015	3378
.02% SLOPE	0+0+0	107	84	36	35	52	41	4417	3911
	0+40+0	100	81	33	35	56	45	5116	4386
	0+40+20	105	77	30	34	62	49	5353	4410
	40+40+20	100	86	43	40	68	61	4474	4088
.01% SLOPE	0+0+0	100	75	32	32	61	43	4242	3610
	0+40+0	93	74	30	31	61	42	5255	4012
	0+40+20	93	78	35	34	62	47	5903	4363
	40+40+20	96	81	48	40	72	60	4599	4126
LEVEL	0+0+0	100	82	33	35	56	53	2689	3284
	0+40+0	100	86	35	35	56	56	2784	3040
	0+40+20	90	80	36	34	62	50	2025	2764
	40+40+20	102	88	46	39	68	61	2899	2974
LAND SMOOTHING	0+0+0	100	87	41	38	57	56	2623	
	0+40+0	104	87	47	39	57	52	2071	
	0+40+20	93	85	41	39	61	61	2033	
	40+40+20	97	83	45	39	74	62	2044	

*15.5% Moisture, 22-inch rows

**15.5% Moisture, 2 cuttings

Field Experiments with Asphalt Soil Barriers (22" deep) on Sandy Soils in Sherburne County in 1968

George R. Blake

Precipitation Record
Elk River Experiment Station
1968

June date	Ppt. Inches	July date	Ppt. Inches	August date	Ppt. Inches	September date	Ppt. Inches
14	1/	1	.21	5	.05	3	.49
17	2/	13	.63	7	.16	4	.21
18	1/	15	1.87	8	2.92	9	.37
20	1/	17	.07	16	.26	16	.12
21	0.73	18	.13	19	.06	17	1.52
24	TR	22	Tr	26	.15	18	.67
26	0.40	26	Tr			19	.11
27	TR	29	.07			20	.02
		31	.81				

1/ Amount unknown. Raingauge installed June 21.

2/ Rain over weekend preceding 17th unknown amount.

TR indicates trace, less than 0.01 inch.

Asphalt Barriers
1968 Potato Yields
Elk River Experiment Field

Item	Irrigated		Not Irrigated		Significance
	Barrier	No Barrier	Barrier	No Barrier	
Yield #1 cwt/A	218.7	203.6	124.5	85.8	I*
Knobs cwt/A	8.0	6.6	34.1	43.8	I*
Sp. Gravity	1.0070	1.0773	1.0742	1.0727	NS

Asphalt Barriers
1968 Snap Beans Yield, lbs/A
Elk River Experimental Field

Size	Not Irrigated		Irrigated		Statistical Significance
	No Barrier	Barrier	No Barrier	Barrier	
1	116.7	196.0	264.3	204.9	NS
2	249.9	201.7	392.6	339.4	NS
3	300.0	313.5	508.1	563.2	NS
4	847.0	970.5	1240.6	1247.0	NS
5	1958.4	2071.4	2890.1	2510.0	NS
5	2008.6	3268.7	2841.0	2407.2	NS
1 + 2	366.5	397.7	656.9	544.3	NS
3,4 + 5	3105.3	3355.5	4638.8	4320.1	NS
1,2 + 6	2375.1	3666.4	3497.9	2951.5	Irr. x B*
Total	5480.4	7021.9	8137.0	7271.6	NS

Asphalt Barrier Experiment
1968 Sweet Corn Data 1/
Elk River Satellite Farm

	Asphalt Barrier Application Rate (gal/A)			
	0	800	1100	1600
Corn height, inches	47.6a	52.0b	52.2b	52.9b
Weight of ears, lbs	7,620a	8,805ab	9,066bc	10,112c
Number of ears, lbs	21,390	21,353	21,698	24,012
Immature ears, lbs	1,010	908	968	1,127
No. immature ears	6,843	5,999	6,244	6,743
Gross wt - immature	6,610a	7,897b	8,098b	8,985b
Gross No. - immature	14,547	15,355	15,455	17,270
Mean wt/ear,lbs	0.46	0.48	0.52	0.52
Ears with smut, lbs	156a	584b	873b	857b
No. ears w/smut	245a	871b	1180b	1298b
Ditto 99% lebel	245a	871ab	1180b	1298b
Missing kernels, rows 2/	7.1	7.1	7.2	7.3
Filled ear ends 2/	5.4	5.7	5.9	6.0
Overall visual quality 2/	5.7	6.4	6.4	6.6

1/ Values are on acre basis except as noted. Values with like letters are statistically equal; with unlike letters different by DMR test at 95% probability level unless noted. Values without letters not different at 95% probability level.

2/ Mean of arbitrary 1 to 10 scale rating on random subsample from each plot where 10 was best, 1 poorest.

1968 Sweet Corn Yields with Asphalt Barriers
Elk River Experimental Field

	Irrigated		Not Irrigated		Statistical
	Barrier	No Barrier	Barrier	No Barrier	Significance[2]
Weight lbs./A.	14,932	13,768	13,225	11,269	Barrier*
No. ears/A	24,682	23,386	22,841	20,896	NS
Quality rating[1]	7.14	7.52	7.10	6.77	NS
Weight/ear	0.61	0.59	0.60	0.54	Barrier*, Irrigation*
No. ears smut/ total ears	0.028	0.020	0.018	0.024	NS
Filled ends of ears[1]	5.88	6.09	6.21	5.76	NS
Missing rows & kernels	8.55	7.87	8.19	7.83	Barrier*

[1]Overall quality, filled ear tips, and missing rows or kernels: weighted rating based on examination of about 36 randomly selected ears per plot separated to good, medium and poor.
Values are derived from good = 10, medium = 6, and poor = 2.

[2]Single asterisk is 95% level; NS means difference not significant. None of the barrier x irrigation interactions was significant.

Date of Irrigation
Asphalt Barrier
Elk River Experimental Field
Data Book 41
1968

Water was added at the rate of about 0.4 to 0.5 inches per hour. This varied slightly depending on other irrigation systems using the source. Amounts added are nominal being approximated by placing cans at random on plot being irrigated.

Date	Setting	Amount in inches
July 2	West half	1
July 3	East half	1
July 11	Both halves	1
July 25	Both	1
July 30	Both	.75
August 5	Both	1
August 15	Both	.9
August 21	Both	.9

Water Content
30 inch free darining profile
Hubbard Loamy Coarse Sand
Elk River, Minnesota
1968

Depth in inches	Map Location M5	K4	M3	L2	Mean
	Water Content by Weight				
0-3	14.73	15.06	12.34	13.16	13.82
3-6	12.16	10.87	8.65	11.71	10.85
6-9	6.88	7.55	6.04	14.34	8.70
9-12	5.71	6.11	5.95	11.67	7.36
12-15	8.63	6.31	6.49	17.71	9.79
15-18	8.78	7.02	13.14	16.44	11.35
18-21	14.26	11.00	11.27	15.56	13.02
21-24	13.52	10.39	15.24	15.48	12.93
24-27	13.46	10.29	14.37	13.52	12.91
27-30		9.64		13.42	11.53
	Water Content by Volume				
0-3	18.71	21.84	18.63	17.63	19.20
3-6	15.44	15.76	13.06	15.69	14.99
6-9	9.29	11.33	9.12	19.26	12.25
9-12	8.28	9.78	9.40	16.92	11.20
12-15	13.81	11.23	10.64	27.10	15.70
15-18	14.05	11.93	21.68	25.15	18.20
18-21	23.53	18.15	18.60	24.90	21.30
21-24	22.31	17.14	25.15	25.54	22.54
24-27	22.21	16.98	23.71	22.31	21.30
27-30		15.91		22.14	19.03

Water Content
30 inch free draining profile
Zimmerman fine sand 1/
Elk River Satellite Station, Minnesota
1968

	Location		
Depth in inches	A	B	Mean
	Water Content by Weight		
0-4	11.85	11.69	11.77
4-8	13.47	13.44	13.46
8-12	12.81	15.91	14.36
12-16	14.54	17.58	16.06
16-20	19.52	20.21	19.87
20-24	20.78	21.16	20.97
24-28	21.95	20.50	21.23
28-30	20.89	23.15	22.02
	Water Content by Volume		
0-4	18.37	18.12	18.25
4-8	20.88	20.83	20.86
8-12	19.86	24.66	22.26
12-16	22.54	27.25	24.90
16-20	30.26	31.33	30.80
20-24	32.21	32.79	32.50
24-28	34.02	31.78	32.90
28-30	32.38	35.88	34.13

1/ Composited soil 8-30 inches was used since texture and density do not vary in this soil.

Soil Pesticide Residue Studies

Russell S. Adams, Jr.

Simulated atrazine residue plots were continued at Lamberton, Morris, and Waseca in 1968. Again "residue" rates of atrazine were incorporated in the spring prior to seeding of oats and soybeans. Yields for 1968 and averages for the three year study are shown in Table 1. Field plots in 1968 were subject to severe extremes of weather. Oat plots at Lamberton and Waseca experienced hail, winds and late freezes. These weather factors apparently were additive to the atrazine injury as the 1/4 lb rate of atrazine at both locations was sufficient to reduce oats stands by more than 50%. At Morris between 1/4 and 1/2 lb was necessary for 50% stand reduction. Recovery was good at Lamberton and oat yields were not appreciably affected by 1/2 lb of atrazine at Lamberton or at Morris. Between 1/2 and 1 lb/A was required at all locations to reduce yields by 50%. Considering a 20% yield loss as severe, approximately 55% reduction in stand can be tolerated when normal recovery is taken into account. In the three year study approximately 0.6 lb/A of atrazine was required to produce 55% reduction in stand.

The season was such that severe atrazine injury occurred in soybeans at the 1/2 and 1 lb/A rates at Morris. Little affect on stand was observed at the other locations. Weeds in the row were a problem at both Lamberton and Morris. Soybeans have little capacity to compete with weeds. Only a few in the row can reduce yields. In 1968, grasses seriously infested the rows in plots where only simulated atrazine "residues" treatments were applied. A small amount of atrazine resulted in some weed control which offset the atrazine injury where no other herbicide treatment was used. Wherever weed free checks were successfully established yields in those checks have generally been as high or higher than the highest yielding chemical treatments.

Table 1. Stand and Yield of Oats and Soybeans When Atrazine Was Incorporated

Atrazine treatment lb/A	Lamberton Stand, % Control 1968	Lamberton Stand, % Control 3 year Avg.	Lamberton Yield, bu/A 1968	Lamberton Yield, bu/A 3 year Avg.	Morris Stand, % Control 1968	Morris Stand, % Control 3 year Avg.	Morris Yield, bu/A 1968	Morris Yield, bu/A 3 year Avg.	Waseca Stand, % Control 1968	Waseca Stand, % Control 3 year Avg.	Waseca Yield, bu/A 1968	Waseca Yield, bu/A 3 year Avg.
Lodi Oats, average 5 replications												
0	100	100	32.8	44.5	100	100	75.8	77.5	100	100	56.4	68.2
1/4	44	73	37.6	46.0	75	78	79.9	86.8	46	66	42.6	59.5
1/2	40	56	29.3	43.7	32	48	59.6	71.8	46	47	35.5	46.7
1	30	22	16.8	23.2	17	26	28.9	52.0	17	28	17.0	34.3
1 1/2	11	18	7.5	16.1	6	17	4.2	31.7	7	15	14.8	23.5
Chippewa 64 Soybeans, average 4 replications												
0	100	100	10.2	16.1	100	100	6.2	15.2	100	100	35.6	33.8
1/4	83	85	11.0	16.0	101	101	8.4	18.5	108	105	35.3	35.1
1/2	85	88	11.1	15.9	48	84	6.4	17.2	105	100	37.5	30.7
1	80	86	11.3	14.9	43	71	2.7	14.2	90	81	33.4	28.6

Field data for 1968 and cumulative three year averages are given for the herbicide interaction plots in Table 2. In these plots atrazine was incorporated in a split plot design across plots containing no chemical, linuron (2 1/2 lb/A), CDAA (5 lb/A), amiben (3 lb/A), and trifluralin (1 lb/A). As in previous years atrazine-linuron and atrazine-amiben plots appeared to suffer the greatest physical injury. This has not been reflected in the three-year average yields because of the additional weed control obtained in all the herbicide-atrazine treatments. However, with atrazine-linuron plots 1 1/2 lb/A or less atrazine was required to reduce yields (compared to the linuron control) by 50%. All other herbicide-atrazine combinations required 1 1/2 lb/A or more atrazine to reduce yields by 50%. Consistently atrazine-trifluralin treatments gave the least reduction in yield from atrazine. Caution should be exercised in interpreting these data broadly. The soil characteristics in the plots at these three stations were similar in texture (all clay loams), organic matter content and pH. Consequently, results observed there might not be duplicated in coarse textured soils or soils low in organic matter. Furthermore, one cannot be certain that applying atrazine in "residual" amounts near the time of application of the other herbicides would give the same results as residual atrazine. Atrazine was applied in the spring in order to have a reasonably reproducible amount of atrazine from year to year. Carryover of atrazine from the previous year will vary widely, depending upon weather conditions during the growing season after application of the herbicide, and cannot be relied upon to be present in sufficient amounts to give injury.

Table 2. Yield of Chippewa 64 soybeans as affected by herbicide treatments and residue amounts of atrazine. Four replications.

"Residual" atrazine lb/A	No chemical 1968	No chemical 3 yr. Avg.	Linuron 1968	Linuron 3 yr. Avg.	CDDA 1968	CDDA 3 yr. Avg.	Amiben 1968	Amiben 3 yr. Avg.	Trifluralin 1968	Trifluralin 3 yr. Avg.
	bu/A									
Lamberton										
0	10.2	16.4	20.0	19.4	20.8	20.7	18.0	20.2	19.6	20.4
1/4	11.0	16.0	20.5	20.3	19.5	19.9	17.4	19.0	19.6	19.7
1/2	11.1	15.9	15.3	17.4	17.4	20.3	13.1	17.7	16.8	19.5
1	11.3	14.9	12.5	13.8	13.3	16.5	9.1	16.3	15.0	18.6
Morris										
0 (weed-free check)		17.4								
0	6.2	15.2	14.9	23.0	9.9	19.7	17.7	23.4	17.7	23.8
1/4	8.4	18.5	17.1	24.4	12.0	22.2	16.6	24.3	19.2	26.1
1/2	6.4	17.2	4.8	19.7	6.9	18.5	11.8	20.5	16.6	23.8
1	2.7	14.2	3.8	14.3	3.8	17.8	3.9	18.2	11.6	22.5
Waseca										
0 (weed-free check)		37.8								
0	35.6	33.8	35.1	34.2	35.2	34.9	33.8	34.9	34.1	33.5
1/4	35.3	33.8	37.0	35.1	35.3	34.3	35.2	33.7	33.4	33.2
1/2	37.5	30.7	36.5	30.8	35.9	33.5	35.0	33.1	33.5	32.3
1	33.4	27.4	30.9	28.3	33.1	30.2	31.5	29.1	35.4	29.4

Lime Plots, Lamberton, 1968

J. Grava, W. W. Nelson and G. W. Randall

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, and (b) corn (1966 and 1968) and Chippewa soybeans (1967) in a sequence. Yield, plant and soil analytical data were reported in the "Bluebooks" of Feb. 1967, pp. 69-70, and March 1968, pp. 38-41.

Since the initial lime treatments had not raised the soil pH to the desired levels additional amounts were applied in spring of 1968 and worked in soil by disking (corn-soybeans series), or disking and plowing (alfalfa series). Alfalfa was seeded in 1968, stand established but no yields were obtained.

Corn was grown in 30-inch rows; population: 21,000 plants/A; herbicide: Ramrod; all plots received 115+135+22 lb./A of plant nutrients, expressed as N, P_2O_5 and K_2O.

Corn yield and moisture content were not affected by lime treatments (Table 1). The first increment of lime increased the magnesium and copper contents, and decreased the manganese content of sixth corn leaf at silking (Table 2).

Table 1. Yield and Moisture Content of Corn, Lamberton Lime Plots, 1968.

Rate of Lime To./Acre	Corn Yield Bu./Acre	Moisture %
0	148	37.6
3*	144	38.4
6*	156	37.6
Significance	N.S.	N.S.
CV	6	3

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

Table 2. Chemical Composition of Sixth Corn Leaf at Silking, Lamberton Lime Plots, 1968.

Lime Treatment To./acre	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B	Fe	Sr
	Percent in Dry Matter				Parts per million in Dry Matter						
0	.28	1.96	.67	.53a	17	6a	.95	36b	7	131	21
3	.27	1.91	.67	.61b	23	8b	.99	32a	7	155	23
6	.28	1.81	.69	.62b	19	7ab	1.1	32a	7	144	24
Significance	N.S.	N.S.	N.S.	**	N.S.	*	N.S.	*	N.S.	N.S.	N.S.
CV	6	6	6	6	26	15	14	6	10	33	8

FERTILIZER AND LIME TRIALS AT PIERZ, MORRISON CO., MINNESOTA 1968

C. J. Overdahl, G. W. Randall

This experiment was initiated in the fall of 1962. Lime applications of 5 tons per acre were made at that time for the potassium experiment, bringing the average pH to 6.72. Seeding time treatments of K in the spring of 1963 consisted of 0, 60, 120, 180 and 240 pounds per acre of K_2O. Soil tests, tissue analysis and yields in 1967 showed no evidence of the 1963 K treatments remained in the soil.

Annual topdressing treatments of 0, 120 and 240 pounds per acre of K_2O were started in the fall of 1964. All seeding time treatments were split three ways. This amounted to 20 plots of each topdressing rate. These plot numbers were reduced to 10 each, (except for check plots) in 1968 when the topdressing treatments were omitted on half of them.

Comparison is made in Table 1 of the yield differences, as well as tissue analyses, between four years of annual topdressing with plots where the fourth annual topdressing was omitted. There was a significant drop in alfalfa yield, even with the 240 pound treatment. There was also a significant drop of %K in the tissue.

The topdressings were made the previous fall after the third cutting had been removed. Table 1 shows a serious drop in %K by cuttings which might indicate insufficient K levels or that topdressing should be done in early summer, perhaps after the first cutting.

Of further interest in the 1968 results were the yield-soil test relationships for pH, phosphorus and potassium. Phosphorus soil tests from the 48 plots that had adequate lime were compared to the 1968 alfalfa yield. These relationships are shown by curves in Figure 1. The one year's data indicate no further yield increase beyond a P soil test of approximately 50 lbs. per acre of extractable phosphorus (Bray's P_1).

Similar comparisons were made with the 1968 pH versus 1968 alfalfa yields and the 1967 soil K tests with the 1967 alfalfa yields. These are shown in Figures 2 and 3, respectively. Again, with one year's data, the optimum pH appears to be about 6.7 and the optimum soil K level appears to be approximately 300 pounds of exchangeable K.

Table 1. Effect of omitting last of 4 annual fall K topdressings on yield and %K of alfalfa the following year. (Morrison Co., Pierz, Minn., Brainerd Sandy Loam soil.)

	Cutting	Annual treatments of K_2O, lbs/A				
		0	120		240	
Yields T/A	1	.67	2.02	1.70*	2.23	2.05*
	2	.62	2.01	1.68*	2.03	2.05*
	3	.12	.85	.60*	1.20	.99*
	Total	1.41a	4.88c	3.98*b	5.46d	5.09*c
% K, tissue 1968	1	.93	1.96b	1.48*a	3.12c	2.21*b
	2	--	1.44b	.90*a	2.24c	1.74*b
	3	--	.89a	.68*a	1.90c	1.21*b

* Topdressing omitted for 1968 crop after 3 previous applications.

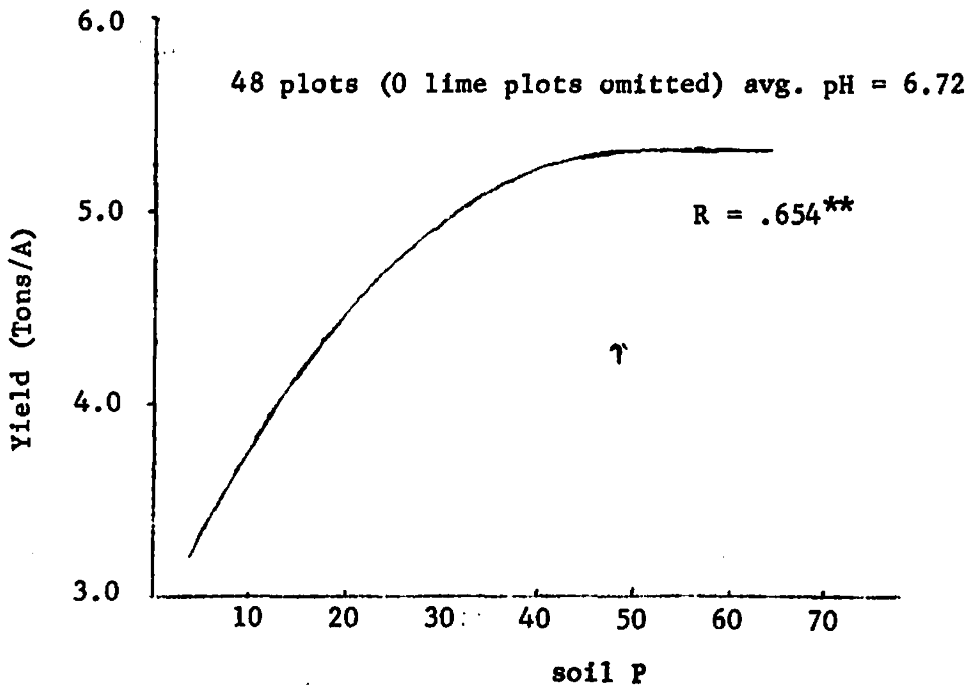


Figure 1. Relationship of soil test P and alfalfa yield, 1968.

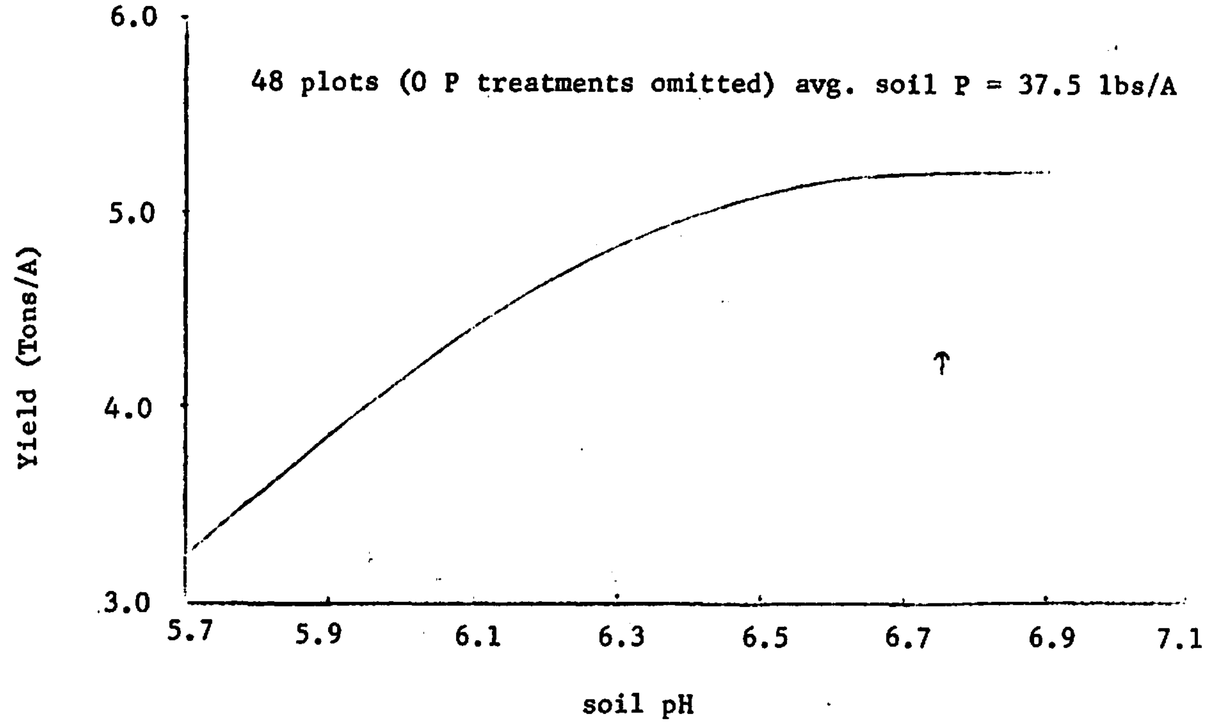


Figure 2. Relationship of soil pH and alfalfa yield, 1968.

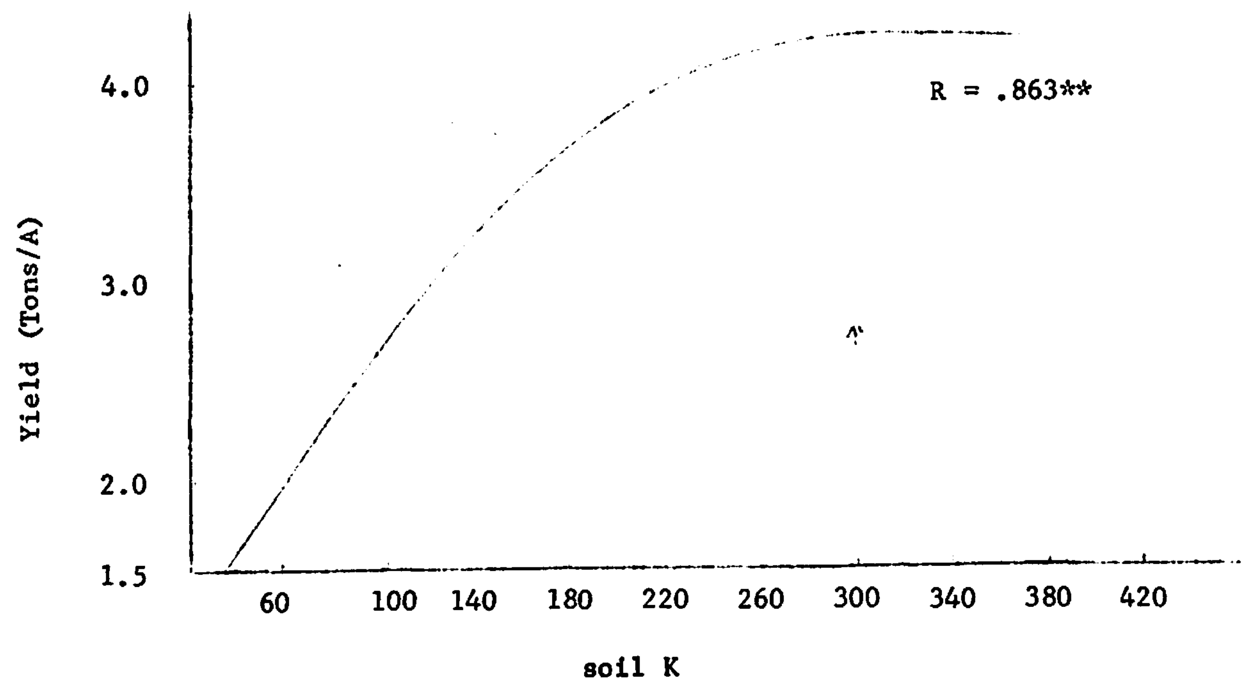


Figure 3. Relationship between soil K and alfalfa yield, 1967.

ROSEMOUNT SOILS FARM

Rosemount Agricultural Experiment Station
1968

Paul M. Burson

GENERAL CONDITIONS AND RESULTS

The year 1968 was another unusual year as far as moisture conditions were concerned. The moisture range was from one extreme to the other. The first 2 weeks of May were dry, followed by a high intensity rain on May 15 of 1.13 inches and May 27 of 1.17 inches, making a total of 2.30 inches for the 2 days out of a total of 3.85 inches for the month. The months of September and October were very wet in most of southern Minnesota as well as at Rosemount. A total of over 5.00 inches for each month with a total of 10.95 inches for the 2 months. This condition caused poor ripening and drying conditions for the corn and soybeans. Some plots were too wet to harvest. Moisture content in the grain ran high because of the poor drying weather. After plots were harvested, it was impossible to harvest parts of some of the remaining fields because the soils were too wet to operate the heavy harvesting equipment. From March 15 through October 31, there was a total of 31.16 inches of rain. June had the highest rainfall for a single month of 7.45 inches.

All corn and soybeans were planted in 30 inch rows with a final average stand of 22,000 plants per acre for the corn. The planting rate for corn was 26,000 kernels per acre. The final stand was about 15 percent less than the planting rate. On the fertilized corn the stand was much better than on the checks. The difference in stand of corn for many years has been 2,000 more plants per acre on the fertilized as compared to the check areas.

Weed sprays have been used every year for the last several years. At the present time practically no cultivation is being done on corn and soybeans. As the weed spray program continues from year to year on corn, soybeans and the year alfalfa is seeded, grassy weeds are becoming a rather minor problem. On some fields mustard and Canadian thistles are still causing some trouble.

40 INCH VS. 30 INCH VS. 20 INCH ROW SPACINGS FOR CORN

In 1968 all the corn and soybeans on the Soils Farm were planted in 30 inch rows with a John Deere 4-row Flexi Intergal Toolbar planter. This planter can be adjusted for any row width down to 20 inches. Comparisons were made on both corn and soybeans at 40, 30 and 20 inch row spacing.

The results for corn are given in Table 1. The rate of planting was 26,000 kernels per acre with a final stand of 22,000 plants per acre regardless of the row width which would provide for different spacing between plants in the row. The general trends for 1968 was an increase in yield from the 40 inch row to the 20 inch row regardless of the fertilizer treatment. In all row widths there was an increase in yield of corn from the use of band fertilizer and band plus sidedressed nitrogen placement.

With soybeans where row spacing was compared, two rates of planting of 45 and 60 lbs. per acre were also compared. Differences in row spacing, as reported in Table 2, compared with different spacing of plants in the row along with the placement of fertilizer in a band and starter (Pop-Up). In the case of starter (Pop-Up), both liquid and dry materials were used. There was practically no difference in yield between the 60 lb. and the 45 lb. rates of planting. Injury to germination was noted on the dry starter (Pop-Up) but none on the liquid which was the same as reported in 1967. May was comparable to the moisture conditions in 1967 which were also very dry. During the growing season the band placement showed the best growth but the yields in the fall did not indicate this seasonal

TABLE 1. ROW WIDTH FOR CORN - 40-30-20 INCH SPACING.

Rosemount Soils Farm
1968

Field 18

Fertilizer Treatments	Yield in Bu. per acre		
	40 inches	30 inches	20 inches
Check	99.0	105.0	111.0
Band (1)	102.0	111.0	121.0
Band + N (2)	119.0	130.0	153.0

(1) 300 lbs. per acre of 4-12-24

(2) 160 lbs. of actual N broadcast and disked in before planting.

Atrazine for weed control - no cultivation

Planted May 28, 1968

Limed 3 tons per acre November, 1964

Continuous corn since 1952

Soil Type - Clyde silty clay loam

TABLE 2. ROW SPACING AND PLANTING RATE FOR FERTILIZED SOYBEANS.

Rosemount Soils Farm
1968

Field 37

Fertilizer Treatments	Yield in Bu. per Acre: 40 inch rows, No Broadcast	40 inch rows, (1) Broadcast	30 inch rows, No Broadcast	30 inch rows, (1) Broadcast	20 inch rows, No Broadcast	20 inch rows, (1) Broadcast
Planting Rate 60 lbs. per Acre						
Check	20.0	21.6	23.3	26.6	23.3	25.0
Band	21.6	21.6	23.3	26.6	25.0	26.6
Starter (Pop-Up)-Dry(3)	25.0	20.0	28.3	28.3	28.3	30.0
Starter (Pop-Up)-Liquid(4)	25.0	23.0	25.0	30.0	30.0	30.0
Planting Rate 45 lbs. per Acre						
Check	23.3	20.0	25.0	20.0	25.0	25.0
Band	28.3	23.3	21.6	23.3	30.0	26.6
Starter (Pop-Up)-Dry(2)	21.6	20.0	23.3	25.0	30.0	26.6
Starter (Pop-Up)-Liquid(3)	23.3	23.3	21.6	23.3	33.3	31.6

Planted June 4

Continuous soybeans for 5 years

(1) Residual broadcast and plowed down 800 lbs. of 4-12-14 in 1966.

(2) Band of 4-12-24 at 300 lbs. per acre.

(3) 10-30-12 dry fertilizer with seed at 10 lbs. total N + K per acre.

(4) 7-21-7 liquid fertilizer with seed at 10 lbs. total N + K per acre.

Variety - Chippewa 64

Weed control - Lorox and Ramrod after planting

Limed 3 tons per acre 1953

Soil type - Port Byron & Judson silt loam.

growth difference. The residual broadcast fertilizer did not seem to show any carry-over from the 1966 application. The 20 inch row spacing as compared to the wider row spacings were generally a little better in yield. The 40 inch spacing was lower in yield than the 20 and 30 inch spacing in both rates of planting.

EARLY BERSUS LATE PLANTING FOR CORN

Questions are raised by farmers about planting corn early. What is early in Minnesota may be a question. Some say May 1 and others say May 10th to May 15th. Trials were run in 1968 considering May 1 as early planting and May 10 as late planting. In 1968, May 1 was too early because the corn was damaged and set back by frost, while no injury to the May 10th planting. Each planting date received the same fertilizer treatments and the same methods of placement as given in Table 3. This field had never received a basic broadcast plow-down fertilizer treatment. For that reason, the combination of starter (Pop-Up) plus band gave the better yields. In general, for this particular field from year to year, May 1 planting can be considered too early because the chance of a frost injury is always possible. In talking to farmers in the cornbelt area of southern Minnesota, they generally agree May 1st is too early. They feel, as the results indicate in Table 3, that probably May 10 might be the date to consider as early planting from year to year and possibly May 20th as late planting. Under Minnesota spring weather conditions, planting by calendar is usually not satisfactory. In the over-all yields for the trials the later planting was the most favorable.

TABLE 3. EARLY PLANTING VERSUS LATE PLANTING OF CORN

Rosemount Soils Farm
1968

Field 17E

Fertilizer Treatments	Percent Moisture	Yield in Bu. per Acre Early[1]	Late[2]	Percent Moisture
Check	26.1	95.0	109.0	25.7
Band[3]	25.3	104.0	128.0	25.9
Band + N[4]	24.6	132.0	135.0	25.5
Starter (Pop-Up)[5]	25.7	131.0	132.0	27.7
Starter (Pop-Up) + N	25.0	142.0	139.0	26.6

(1) Early planting May 1

(2) Lake planting May 10

(3) 300 lbs. per acre 4-12-24

(4) 160 lbs. of actual N per acre sidedressed with planter after corn emergence

(5) 10-30-12 with total of 15 lbs. N & K

Atrazine for weed control - no cultivation

Continuous corn since 1952

Soil type - Clyde silty clay loam

Planting rate 26,000

Final stand 22,000 plants

CONTINUOUS CORN CROPPING SYSTEM

There are 4 fields on the Rosemount Soils Farm that have been in continuous corn from 8 to 16 years. These fields in 1968 did not produce quite as well as the field that have been in a regular rotation system. This has been true for both corn and soybeans. Not all the fields were harvested in 1968 because of lack of help and funds.

Tables 1, 3, 4 and 8 are fields that have been in continuous corn for 16 years with only commercial fertilizer treatments (no manure), while Table 7 gives the results on field 48 that has been in corn for 16 years but has received manure at the rate of 10 to 20 tons per acre per year with only banded placed fertilizer. The soil types on fields reported in Tables 1, 3 and 7 are Clyde silty clay loam.

CORN AND SOYBEANS IN A CROP ROTATION SYSTEM

Trials were contimued in 1968 where a basic broadcast plow-down placement of fertilizer has been made every three years, beginning in 1959, regardless of the crop that appeared in that particular year of the rotation system. The grade of fertilizer used was based on soil test. The rotations used are as follows:

1. Corn - Alfalfa seeded - Alfalfa hay (2 years).
2. Corn - Soybeans - Alfalfa seeded - Alfalfa hay (1 year).
3. Corn - Soybeans - Alfalfa seeded (green manure) - Corn - Alfalfa seeded - Alfalfa hay (1 year).

Table 5 gives the yields of corn on Field 22 following 1 year in alfalfa hay. Fertilizer was broadcast plowed-down every 3 years with band and starter (Pop-Up) placement at corn planting time. Yields were generally somewhat higher in 1968 over 1967, but were not as high as has usually been in previous years. Table 5 gives the yields of corn in rotation with broadcast plow-down, band and starter (Pop-Up) placement.

TABLE 4. BROADCAST-BAND-STARTER (POP-UP) FERTILIZER PLACEMENT FOR CONTINUOUS CORN

Rosemount Soils Farm
1968

Field 10

Yields in Bu. per Acre

Plot No.	Fertilizer Treatments	Check	Years and Broadcast Fertilizer Rates (1) 1959 1962 1965 1968		1960 1963 1966 1969		1961 1964 1967 1970	
			300	600	300	600	300	600
1.	Check	54.0	73.0	74.0	74.0	73.0	72.0	70.0
2.	Check + N(2)	83.0	94.0	91.0	88.0	89.0	75.0	76.0
3.	Starter (Pop-Up) Fertilizer Shoe(3)	93.0	118.0	114.0	104.0	112.0	103.0	99.0
4.	Starter (Pop-Up) Fertilizer Shoe + N(2)	116.0	114.0	116.0	107.0	117.0	107.0	101.0
5.	Starter (Pop-Up) with seed(4)	117.0	108.0	110.0	108.0	112.0	102.0	108.0
6.	Starter (Pop-Up) with seed + N(2)	119.0	112.0	110.0	111.0	119.0	110.0	113.0
7.	Band + Starter (Pop-Up)	118.0	114.0	112.0	109.0	115.0	108.0	110.0
8.	Band-Starter (pop-Up) + N(2)	123.0	115.0	114.0	113.0	129.0	122.0	127.0
9.	Band (5)	113.0	110.0	112.0	109.0	116.0	113.0	114.0
10.	Band + N(2)	116.0	114.0	114.0	111.0	124.0	121.0	115.0

Planted May 11, 1968

(1) Broadcast plow-down of 0-20-20 through 1966, 0-12-36 at 500 and 1000 lbs per acre in 1967 and 4-12-24 at 500 and 1000 lbs per acre in 1968. Based on soil test.

(2) Actual N at 160 lbs per acre sidedressed at first cultivation on all plots.

(3) Starter (Pop-Up) placed with fertilizer shoe ahead of planter shoe and at the same depth as the seed. 10-30-12 at 15 lbs total N+K per acre.

(4) Starter (Pop-Up) placed directly with the seed. 10-30-12 at 15 lbs total N+K per acre.

(5) Band of 4-12-24 at 300 lbs per acre.

Limed 3 tons per acre July 1951.

Continuous corn since 1952.

Soil type - Port Byron Silt Loam.

TABLE 5. BROADCAST-BAND-STARTER (POP-UP) FERTILIZER PLACEMENT ON 1ST YEAR CORN IN CROP ROTATION (1)

Rosemount Soils Farm
1968

Field 22

Yields in Bu. per Acre

Plot No.	Fertilizer Treatments	Check	Years and Broadcast Fertilizer Rates(2) 1959 1962 1965 1968		1960 1963 1966 1969		1961 1964 1967 1970	
			300	600	300	600	300	600
1.	Check	92.0	104.0	106.0	73.0	90.0	92.0	114.0
2.	Chech + N(3)	100.0	104.0	106.0	108.0	93.0	108.0	117.0
3.	Starter (Pop-Up) Fertilizer shoe(4)	123.0	127.0	127.0	118.0	113.0	135.0	128.0
4.	Starter (Pop-Up) Fertilizer shoe + N(3)	128.0	124.0	127.0	122.0	123.0	139.0	137.0
5.	Starter (Pop-Up) with seed(5)	124.0	130.0	135.0	122.0	123.0	127.0	126.0
6.	Starter (Pop-Up) with seed +N(3)	142.0	139.0	137.0	130.0	132.0	142.0	137.0
7.	Band(6)	139.0	128.0	129.0	118.0	119.0	141.0	143.0
9.	Band + N(3)	139.0	127.0	127.0	114.0	115.0	146.0	142.0

Planted May 11, 1968

(1) Corn-soybeans-alfalfa seeded-alfalfa hay-corn etc.

(2) Broadcast plow-down of 0-20-20 through 1966, 0-12-36 at 500 and 1000 lbs. per acre in 1967 and 4-12-24 at 500 and 1000 lbs. per acre in 1968. Based on soil test.

(3) Actual N at 100 lbs. per acre sidedressed at 1st cultivation.

(4) Starter (Pop-Up) placed with fertilizer shoe ahead of planter shoe and at the same depth as the seed. 10-30-12 at 15 lbs. total N + K per acre.

(5) Starter (Pop-Up) placed directly with the seed. 10-30-12 at 15 lbs. total N + K per acre.

(6) Band of 4-12-24 at 300 lbs. per acre

Limed 3 tons per acre July 1952.

Soil Type - Port Byron Silt Loam.

Table 6 gives the yields of soybeans in rotation with broadcast plow-down, band and starter (Pop-Up) placement.

LIME ON CONTINUOUS CORN

The results from use of lime on continuous corn are reported in Tables 7 and 8. Field 48, as reported in Table 7, has been in corn since 1952. This field was limed at 3.0 tons per acre in the fall of 1961 as determined by the soil test. This field has also received from 10 to 20 tons of manure per acre per year. Field 44, as reported in Table 8, has been in corn for the same period and was limed at 3.0 tons per acre in the fall of 1964. No manure has ever been applied, but instead trials are being run on methods of N placement which includes plow-down, sidedressing, disked in after plowing and all the N applied in a band at planting time. Tables 7 and 8 are on following pages.

FERTILIZED ALFALFA YIELDS

Trials were continued on alfalfa production in the various crop rotation systems of landuse on cropland. Broadcast fall plow-down was made every three years regardless of the crop that appeared in that particular year of the rotation. The year that the field was in alfalfa the fertilizer was broadcast on the alfalfa. The grades and rates per acre of the fertilizer are given in the footnotes of Table 9.

In this table, the yields are given for 2 cuttings of alfalfa for each of the 4 fields and the average yields per acre for all fields. These results show the difference in yields of the 1968 application as compared to when the fertilizer was applied in 1967 and as far back as 1966. Also, there is the comparison of the residual band-placed fertilizer applied on the corn with and without broadcast. In all cases the residual band-placed fertilizer has given some increase in yield. This indicates that the

TABLE 6. BROADCAST-STARTER (POP-UP)-BAND FERTILIZER PLACEMENT FOR SOYBEANS GROWN IN A CROP ROTATION (1)

Rosemount Soils Farm
1968

Field 32

Yields in Bu. per Acre

Fertilizer Treatments	Check	Years and Broadcast Fertilizer Rates (2)					
		1959 1962 1965 1968		1960 1963 1966 1969		1961 1964 1967 1970	
		300	600	300	600	300	600
Check	25.0	30.0	26.0	---	31.6	---	---
Band (3)	28.3	31.6	31.6	---	31.6	---	---
Starter (Pop-Up) (4)	26.6	30.0	31.6	---	28.3	---	---
Starter (Pop-Up) (5)	26.6	28.0	30.0	---	30.0	---	---

Variety - Chippewa 64

(1) Corn-soybeans-alfalfa (GM)-C-alfalfa seeded-hay.

(2) Broadcast plow-down of 0-20-20 through 1966, 0-12-36 at 500 and 1000 lbs per acre in 1967 and 4-12-24 at 500 and 1000 lbs per acre in 1968. Based on soil test.

(3) Band of 4-12-24 at 300 lbs per acre.

(4) Starter (Pop-Up) placed with seed. 10-30-12 at 10 lbs total N + K per acre.

(5) Starter (Pop-Up) placed with fertilizer shoe ahead of planter shoe and at the same depth as seed. 10-30-12 at 10 lbs total N + K per acre.

Weed control - Lorox and Ramrod after planting.

Planted June 4, 1968.

Limed 3 tons per acre November 1964.

Samples were not taken on 3 sets of plots because we lost student help followed by bad weather.

Soil Type - Port Byron Silt Loam.

TABLE 7. LIME VS NO LIME FOR CONTINUOUS CORN

Rosemount Soils Farm

1968

Field 48

Fertilizer Treatments	Yield in Bu. per Acre		
	No lime	Lime	Increase for lime
Manure	114.0	138.0	24.0
Band + Manure	120.0	139.0	19.0
Band	--	118.0	--
Starter (Pop-Up) + Manure	--	140.0	--
Starter (Pop-Up) + Band + Manure	--	141.0	--

Limed 3 tons per acre in 1961

Manure at 10 tons per acre per year

Band - 6-24-12 at 175 lbs per acre

Atrazine for weed control. Part of field was cultivated in 1968 because of a few wet areas

Pop-Up - 10-30-12 at 15 lbs per acre of total N and K

Planting rate 26,000 per acre

Final stand 22,000 per acre

Planting date - May 3, 1968

Continuous corn since 1952

Soil Type - Clyde silty clay loam

TABLE 8. LIME VS NO LIME FOR CONTINUOUS CORN

Rosemount Soils Farm
1968

Field 44

	Yield in Bu. per Acre			
Fertilizer Treatments	No lime	Percent Moisture	Lime	Percent Moisture
Check	66.0	29.5	71.0	29.1
Band (1)	86.0	26.1	85.0	25.9
Band + N	107.0	26.0	119.0	25.6
500 Bc. Plowed (2) + N (3)	112.0	26.4	108.0	26.1
Band + N Plowed (4)	107.0	28.2	116.0	27.9
Band + N Disked (5)	102.0	27.7	114.0	27.6
Band blend (6)	--	--	114.0	28.1

Planted May 27

Planting rate 26,000

Final stand 22,000

Weed control - atrazine broadcast before planting with no cultivation in 1968

Spring plowed

Continuous corn since 1952

(1) Band 4-12-24 at 300 lbs per acre

(2) 4-12-24 Broadcast and plowed under

(3) N sidedressed at 160 lbs of actual N per acre

(4) N broadcast and plowed under at 160 lbs of actual N per acre

(5) N broadcast and disked in at 160 lbs of actual N per acre

(6) N mixed with band fertilizer and all placed in a band

Limed 3 tons per acre in 1964

Soil Types - Judson Silty Clay Loam and Clyde Silty Clay Loam.

TABLE 9. FERTILIZED ALFALFA HAY YIELDS

Rosemount Soils Farm
1968

Yields in Tons per Acre

Cuttings of Hay	Check	Years and Broadcast Fertilizer Rates: 1959(1) 1962 1965 1968		1960(1) 1963 1966 1969		1961(1) 1964 1967 1970	
		300	600	300	600	300	600
Field 20							
No Banded Residual Fertilizer							
1st Cutting	1.96	2.39	2.07	2.20	1.69	2.09	2.01
2nd Cutting	1.96	2.77	2.36	2.12	1.99	1.99	1.80
Total	3.95	5.16	4.43	4.32	3.68	4.08	3.81
Banded Residual Fertilizer							
1st Cutting	2.12	2.44	1.85	2.23	2.17	1.85	2.09
2nd Cutting	2.09	2.71	2.65	2.07	2.41	1.96	2.17
Total	4.21	5.15	4.50	4.30	4.58	3.81	4.26
Field 25							
No Banded Residual Fertilizer							
1st Cutting	1.91	2.44	2.17	2.85	2.60	1.64	2.12
2nd Cutting	1.27	2.15	1.85	2.01	1.96	2.33	1.75
Total	3.08	4.59	4.03	4.86	4.56	3.97	3.87
Banded Residual Fertilizer							
1st Cutting	2.09	2.83	2.93	2.79	2.33	1.91	2.20
2nd Cutting	2.15	2.12	2.17	2.07	1.80	1.93	1.59
Total	4.24	4.95	5.10	4.86	4.13	3.84	3.79
Field 27							
No Banded Residual Fertilizer							
1st Cutting	1.45	1.53	1.96	1.80	2.09	2.33	2.15
2nd Cutting	1.61	1.91	2.04	1.88	1.91	1.85	1.88
Total	3.05	3.44	4.00	3.68	4.00	4.18	4.03

Table 9. Continued.

	Banded Residual Fertilizer						
1st Cutting	1.61	1.53	2.07	2.01	2.23	2.49	2.55
2nd Cutting	1.69	2.07	2.44	2.12	2.31	2.12	2.01
Total	3.30	3.60	4.51	4.13	4.54	4.61	4.56
	Field 35						
	No Banded Residual Fertilizer						
1st Cutting	1.56	2.33	1.93	1.93	1.61	--	--
2nd Cutting	1.88	1.88	2.39	2.28	1.85	--	--
Total	3.44	4.21	4.32	4.21	3.46	--	--
	Banded Residual Fertilizer						
1st Cutting	1.80	2.44	2.44	2.09	1.99	--	--
2nd Cutting	1.93	2.52	2.31	2.28	2.12	--	--
Total	3.73	4.96	4.75	4.37	4.11	--	--
	Averages for 4 Fields						
	No Banded Residual Fertilizer						
1st Cutting	1.72	2.17	2.03	2.20	1.89	2.02	2.09
2nd Cutting	1.68	2.18	2.16	2.07	1.92	2.05	1.81
Total	3.40	4.35	4.19	4.27	3.81	4.07	3.90
	Banded Residual Fertilizer						
1st Cutting	1.90	2.31	2.32	2.28	2.18	2.08	2.61
2nd Cutting	1.96	2.35	2.39	2.14	2.16	2.00	1.92
Total	3.86	4.96	4.69	4.42	4.34	4.08	4.53

(1) Broadcast fall plow-down based on soil tests.
0-20-20 from 1959 through 1966 at 300 and 600 lbs. per acre.
0-12-36 for 1967 at 500 and 1000 lbs. per acre.
4-12-24 for 1968 at 500 and 1000 lbs. per acre.
All fertilizer was applied every 3 years.

Residual fertilizer is the carry-over from 4-12-24 banded on corn at 300 lbs. per acre and sidedressed with 100 lbs. of actual N per acre.

Variety - Vernal

Seeding rate - 16 lbs. per acre.

over-all fertility level is being increased from year to year from the residual band-placed fertilizer for both corn or soybeans. Over the years since 1959, the 300 lbs. per acre of broadcast plow-down placed fertilizer has been as good as the 600 lb. rate per acre. The 500 and 1,000 lbs. per acre did not add enough of an increase in yields to merit the added cost.

ALFALFA VERSUS BIRDSFOOT TREFOIL IN PASTURE MIXTURES

Considerable support has been given Birdsfoot Trefoil as the basic legume to use in a pasture mixture as compared to other perennial legumes such as alfalfa. Questions have been raised about Trefoil as to its yield, its carrying capacity, its uniform seasonal production as a pasture legume and its palatability as compared to other legumes. On pastures G Birdsfoot Trefoil was compared to alfalfa. Seedings in 2 replications were made in the summer of 1967 after the pastures had been sprayed to control the grass so a direct comparison could be made between the 2 legumes. Each pair of replications had the same fertilizer treatments, as shown in Table 10, so the alfalfa and the trefoil could be compared with the same fertility levels. The results show the alfalfa to be far superior to the trefoil in yield per acre on the basis of 2 cuttings. The cuttings were made at the time recommended for hay. There is a very striking difference in yield of alfalfa over the trefoil for the second cutting. This would indicate the yield and the carrying capacity as a pasture legume would not keep up the summer production as would be the case in favor of the alfalfa. The results of this test are shown in Table 10.

TABLE 10. ALFALFA VS BIRDSFOOT TREFOIL IN PASTURE MIXTURES

Rosemount Soils Farm
1968

Pastures G

Yield in Tons per Acre(1)

Cuttings of Hay	Check		Manure		Nitrogen		Renovation	
	Alfalfa	Trefoil	Alfalfa	Trefoil	Alfalfa	Trefoil	Alfalfa	Trefoil
First	2.33	2.60	3.68	3.95	3.65	3.04	3.79	3.20
Second	2.71	1.64	3.73	1.91	3.52	1.96	3.97	1.91
Total	5.15	4.24	7.41	5.86	7.17	5.00	7.76	5.11

Alfalfa and Trefoil seeded in July 1967

No manure after fall of 1964 for 1965 pastures

Manured pastures received annual fall applications of 8 tons per acre beginning in fall of 1957.

No nitrogen fertilizer after spring of 1965.
Nitrogen applied annually in spring at 80 lbs. of actuan N per acre.

All pastures limed at 3.0 tons per acre September 1956.

Average of All Residual Manure and All Fertilizer Treatments on Alfalfa(1)

Cuttings of Hay	Yield tons per acre
First	3.36
Second	3.48
Total	6.84

Average of All Residual Manure and All Fertilizer Treatments on Birdsfoot Trefoil(1)

Cuttings of Hay	Yield tons per acre
First	3.19
Second	1.85
Total	5.04

(1) All pastures received a basic treatment (except check) of 300 lbs. per acre of 0-20-20 as based on soil test followed by annual spring application of 200 lbs. per acre through 1965.

All pastures (including check) received 200 lbs. per acre of 0-20-20 at seeding time in 1967.

FALL VERSUS SPRING PASTURE RENOVATION

Questions have been raised by farmers as to when is the best time to renovate pasture sods for the purpose of establishing a legume with the old grass sod. If the renovation is started in late August or early September, all the desirable pasture grasses are killed and the cost of renovation in time and power is greater because the soil is dryer and more difficult to prepare a seedbed as compared to the spring renovation. When renovation is done in early spring before the frost is entirely out of the soil, the job can be completed before soil conditions are ready for the preparation of the regular field cropland. In the early spring the soil is not so compact as a result of the freezing and thawing and the grass sod will not be destroyed or killed out as in the case of the fall renovation. There also has to be additional cultivation in the spring for the final seedbed preparation on the fall renovation. It is not necessary to kill out all the pasture grasses and then buy new grass seed for reseeding. As in the case of spring renovation, a good seedbed can be prepared for the new legume seeding. Early spring renovation merely sets back the pasture grasses so the new legume seeding and the old pasture sod will start growth at the same time. At both times of renovation the seedbed must be a thoroughly prepared seedbed. Fertilizer can be applied in the spring for both situations. Plots were set up in the fall of 1967 to compare fall renovation with plots that were renovated in the spring of 1968. Table 11 shows the comparison of the estimated percentages of alfalfa, grass and weeds at both times of renovation with the estimates made on June 10th and September 23rd.

TABLE 11. FALL VS SPRING PASTURE RENOVATION

Rosemount Soils Farm
1968

PERCENT OF TOTAL PASTURE COMPOSITION[1]

Fertilizer Treatments[2]	Fall Renovation[3]						Spring Renovation[4]					
	June(7)			Sept. (7)			June (7)			Sept. (7)		
	Alf.	Grass	Weeds	Alf.	Grass	Weeds	Alf.	Grass	Weeds	Alf.	Grass	Weeds
Check (5)	65	5	30	40	10	50	47	48	5	25	75	Trace
0+80+0	69	2	30	50	10	40	55	40	5	40	60	Trace.
0+80+80	65	5	30	75	5	20	47	48	5	40	60	Trace
20+80+80	65	5	30	60	20	20	47	48	5	30	70	Trace
Check (5)	65	5	30	50	20	30	4	48	5	30	70	Trace
0+80+0	65	5	30	75	5	20	47	48	5	40	60	Trace
0+80+80	65	5	30	70	10	20	47	48	5	40	60	Trace
20+80+80	65	5	30	60	20	20	47	48	5	40	60	Trace
Check (6)	20	75	5	5	90	5	25	75	0	5	90	5

(1) Pasture composition includes alfalfa, bromegrass, timothy and weeds.

(2) Alfalfa was seeded at 16 lbs. per acre on all renovated plots. All fertilizer applied in early spring before final seedbed preparation.

(3) Renovated in the fall, starting in late Aug. 1967 with no fertilizer applied until spring 1968.

(4) Renovated in the spring on March 24 and 25 and seeded March 26, 1968.

(5) Same as (3) and (4). Renovated but no fertilizer.

(6) No renovation and no fertilizer.

(7) Pasture composition estimates were made June 10 and Sept. 23, 1968.

Taller grass on 20+80+80 ---- 15" ---- June 10 reading.
Weed growth greater on fall renovation, because of less grass.
Weed growth less on spring renovation on all plots.
Weed growth same at September reading.
Bare spots on spring renovation. Trace to 5 percent.
Bare spots on fall renovation - 20 to 30 percent.

CONTINUOUS CORN - HIGH FERTILITY EXPERIMENT

Rosemount Soils Farm
Established 1953
Fields 42 and 43

W. P. Martin, P. M. Burson and G. W. Randall

This experiment was established in 1953. Yields have been harvested annually for 16 years. During this time, soil and plant samples have been taken and analyzed. Yield results from past years may be found in the mimeographed "Bluebook" for 1963, 1964, 1965, 1966, 1967 and 1968. Fertilizer rates, ratios and stand populations have been changed in recent years. Since the amount of K per acre has been increased the yields have been increasing.

The corn was first planted in 30 inch rows in 1967. Atrazine was used in 1968 with no cultivation and resulted in good weed control. Final stands were 26,000 plants for the high population rate and 20,000 plants for the low population rate. The check yields are still very high. This area has a deposition from surrounding land of 4 feet or more.

TABLE 12. HIGH FERTILITY CORN YIELDS FOR 1968

Plot No.	Fertilizer Treatment (2)	Av. Yields in Bu. per Acre (1) High (3)	Low (4)
1	Check	128.0	123.0
2	12 + 36 + 108	133.0	118.0
3	112 + 36 + 108	143.0	125.0
4	212 + 36 + 108	148.0	132.0
5	28 + 84 + 252	138.0	113.0
6	128 + 84 + 252	142.0	124.0
7	228 + 84 + 252	146.0	122.0
8	44 + 132 + 296	136.0	119.0
9	144 + 132 + 396	143.0	126.0
10	244 + 132 + 396	146.0	119.0
Av. yields for high and low populations		140.3	122.1

(1) Average for 4 replications.

(2) Pounds of N + P_2O_5 + K_2O per acre for 1968.

(3) High population 26,000 plants per acre.

(4) Low population 20,000 plants per acre.

Weather Summary - 1968

West Central Experiment Station - Morris

Samuel D. Evans

		Precipitation			Air Temperature			Temp.
Month	Period	1968	Average 1930-59	Deviation from Nor.	1968	Average 1930-59	Deviation from Nor.	Soil(10cm.) 1968
January	1-31	.70	.56	+.14	8.4	10.1	-1.7	12.1
February	1-29	.11	.67	-.56	10.1	14.7	-4.6	17.6
March	1-31	.48	1.11	-.63	35.3	27.5	+7.8	31.5
April	1-10	1.55			38.0	37.3		37.9
	11-20	1.33			48.8	43.5		45.0
	21-30	2.00			46.0	48.6		44.9
Total or Average		4.88	2.05	+2.83	44.3	43.1	+1.2	42.6
May	1-10	.81			52.3	53.0		52.0
	11-20	.86			48.8	56.3		50.1
	21-31	.55			54.2	60.2		55.8
Total or Average		2.22	3.07	-.85	51.8	56.5	-4.7	52.7
June	1-10	1.25			72.6	63.6		69.8
	11-20	1.46			61.3	66.3		65.0
	21-30	.80			64.6	68.4		67.4
Total or Average		3.51	3.79	-.28	66.2	66.1	+0.1	67.4
July	1-10	.08			64.9	70.4		70.2
	11-20	.37			75.5	72.0		78.2
	21-31	.61			68.2	72.6		74.8
Total or Average		1.06	3.25	-2.19	69.6	71.7	-2.1	74.4
August	1-10	1.26			73.5	72.3		77.8
	11-20	1.21			63.8	70.1		70.4
	21-31	.49			67.6	66.7		74.8
Total or Average		2.96	2.87	+.09	68.3	69.7	-1.4	72.5
September	1-30	3.46	1.94	+1.52	58.2	59.7	-1.5	60.3
October	1-31	4.12	1.44	+2.68	46.7	48.9	-2.2	48.3
November	1-30	.70	1.09	-.39	32.0	30.4	+1.6	34.3
December	1-31	3.48	.59	+2.89	12.1	17.0	-4.9	25.1
April 1-August 31 (Growing Season)		14.63	15.03	-.40	60.1	61.7	-1.6	62.0
Jan. 1-Dec. 31 (Annual)		27.68	22.43	+5.25	42.0	43.0	-1.0	45.0

Use of Varying Rates of Nitrogen & Starter on Corn in 1968
West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1967 an experiment was initiated on Doland silt loam to determine the effect of varying rates of nitrogen and starter on corn yields.

Table 1. The yield of ear corn in 1968 at Morris with varying rates of nitrogen and starter fertilizer.

	Starter (6-24-24) applied (lbs./acre)				
Nitrogen lbs./acre	0	50	100	200	average
0	68.8	56.7	64.7	66.0	64.0
50	58.8	65.1	65.6	70.1	64.9
150	50.0	63.2	59.3	66.6	59.8
Average	59.2	61.7	63.2	67.5	

Nitrogen significantly decreased yields and starter had no effect. There was a highly significant starter x nitrogen interaction.

Variety - DeKalb XL 304 Planting date - May 2

Use of Seed Incorporated (Pop-up) Fertilizer
West Central Experiment Station - Morris

Samuel D. Evans

In the spring of 1967 an experiment was initiated to determine the effect of small amounts of seed incorporated fertilizer on early growth and yield of corn. The experiment was set up on a Doland silt loam on which various broadcast rates were applied annually.

Broadcast fertilizer did not significantly increase yield. Placement of fertilizer either with the seed or in the "2 x 2" position increased yields significantly, but placement was not important. It was the amount of starter used that was of greatest significance. None of the fertilizer treatment had any effect on early growth.

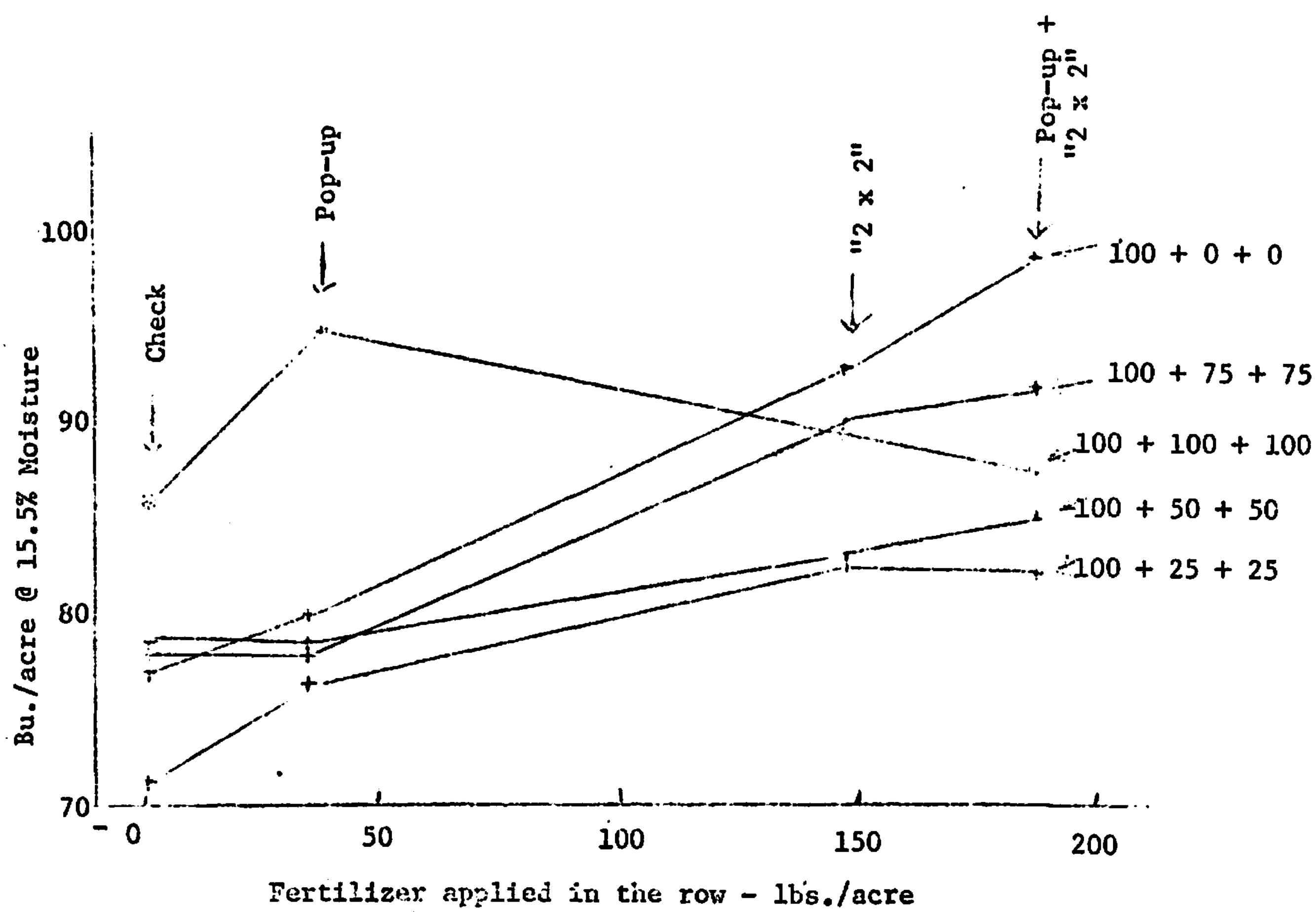
Variety - DeKalb XL 304 Planting date - May 2

Table 1. The effect of fertilizer placement at different broadcast rates on corn yields at Morris in 1968.

	Row Treatment (Yield in bu./acre @ 15.5% moisture)				
Broadcast Treatment	Check	Pop-up(1)	Starter(2)	Pop-up+ Starter	Average
100 + 0 + 0	76.0	79.1	92.6	97.8	86.4
100 + 25 + 25	70.7	75.8	82.0	81.5	77.5
100 + 50 + 50	78.4	77.7	82.6	84.6	80.8
100 + 75 + 75	77.2	76.1	89.8	91.6	83.7
100 + 100 + 100	85.4	94.7	89.3	87.2	89.2
Average	77.5	80.7	87.3	88.6	

(1) Pop-up - 37.5 lbs. of 8-32-16
(2) Starter - 150 lbs. of 8-32-16

Figure 1. The effect of starter rate & placement at five broadcast rates.



Effect of High Rates of Phosphorus With and Without Zinc on Corn Yields
West Central Experiment Station - Morris

Samuel D. Evans

High rates of phosphorus were applied to a Doland Silt loam in the fall of 1967 to simulate phosphorus induced zinc deficiency on corn. The application of phosphorus increased yields and there was no indication of a phosphorus induced zinc deficiency.

Table 1. Soils tests of the experimental area.

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K (lbs./A)
1	6.9	5.5	12	310
2	6.7	5.5	9	260

Table 2. Yield in bu./acre @ 15.5% moisture for 1968.

Treatment	Yield
Check	91.6
60 lbs. P_2O_5	97.1
120 lbs. P_2O_5	95.0
240 lbs. P_2O_5	98.2
10 lbs. Zinc as zinc sulfate	97.7
240 lbs. P_2O_5 - 10 lbs. Zinc as zinc sulfate	98.7

Variety - DeKalb XL 304 Planting date - May 2

Phosphorus Fertilization of Continuous Corn
West Central Experiment Station - Morris

Samuel D. Evans

In 1965 a phosphorus experiment was set up 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 phosphorus application on the zinc content of corn leaves and corn yields.

All plots received a uniform row application of 10 + 0 + 20. Nitrogen at 120 lbs./acre and potash at the rate of 60 lbs. of K_2O/acre were plowed down in the fall of 1967.

1968 Yield

Broadcast P trt. (lbs./acre)	Row Phosphorus treatment (lbs./acre) 0 P	15 P	30 P	45 P	45 P + 10 Zn	Average
0 P	66.4	68.5	72.5	68.7	70.9	69.4
45 P	74.4	71.6	65.5	62.6	68.2	68.5
Average	70.4	70.0	69.0	65.7	69.5	

There was no significant effect of either row or broadcast phosphorus in 1968.

Variety - DeKalb - Xl 304 Planting date - May 1

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 fertilizers on continuous corn. The plots were set up on Forman clay loam and corn grown previously on this soil had not previously shown zinc deficiency, even though leaf samples indicated the zinc content to be below 20 ppm zinc.

Treatment	When Applied	Yield Bushels/acre @ 15.5% moisture
Check	----	71.1
5 lbs. zinc as $ZnSO_4$	1965	64.4
10 lbs. zinc as $ZnSO_4$	1965	67.6
10 lbs. zinc as $ZnSO_4$	yearly	68.2
20 lbs. zinc as $ZnSO_4$	1965	58.4
0.5 lbs. zinc as ZnChel.	yearly	73.3
45 lbs. P broadcast	yearly	69.0
45 lbs. P broadcast - 10 lbs. zinc as $ZnSO_4$	yearly 1965	68.9

As in the past there was no significant differences due to zinc application, but again the annual treatment of 10 lbs. of zinc as $ZnSO_4$ gave the highest yield. The last two years the lowest yielding treatment has been the one receiving the 0.5 lbs. of zinc as zinc chelate.

Variety - DeKalb XL 304 Planting date - April 30

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.

1968 Silage Yields
Dry matter, tons/acre

On plots harvested as grain 1965-68:
Low fertility (74 + 48 + 48) - 4.60
High fertility (148 + 96 + 96) - 5.04

On plots harvested as silage 1965-68:
Low fertility (74 + 48 + 48) - 4.60
High fertility (148 + 96 + 96) - 5.00

1968 Grain Yields
Bushels/acre @ 15.5% moisture

On plots harvested as grain 1965-68:
Low fertility (74 + 48 + 48) - 55.43
High fertility (148 + 96 + 96) - 65.16

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

Grain (0 + 0 + 0) - 34.26 bushels/acre

Silage (0 + 0 + 0) - 3.74 tons/acre

There appears to be no reduction in corn yields after removing silage for 4 years. Higher fertility increased silage yields by 0.4 tons/acre and grain yields by 10 bushels/acre. Yields on fertilized plots were significantly higher than on unfertilized plots.

Variety - Pioneer 3681 Planting date - May 10

Corn Irrigation Experiment
West Central Experiment Station - Morris

L. K. Lindor, S. D. Evans, and R. E. Smith

In the spring of 1967 an experiment was initiated at the station on a Sioux sandy loam (15-18 inches to gravel) to determine the effect of irrigation on corn yields at three populations and three nitrogen levels. Results from the first two years indicate that irrigation of this soil is economically feasible. Irrigation water needed to maintain the soil at 50 percent of field capacity was 11 inches in 1967 and 9 inches in 1968. At a cost of $1.00 per acre inch these amounts are reasonable considering the yield increase obtained. In 1967 the yield on an unirrigated plot at the low population and the 60-pound nitrogen rate was 18.7 bushels per acre. The yield when the same treatment was irrigated was 92.6 bushels per acre. In 1968 the yield on the same treatment unirrigated was 26.2 bushels per acre. When irrigated the yield was 109.3 bushels per acre. So the yield increase on the lowest cost treatment in 1967 was 73.9 bushels per acre and in 1968 it was 83.1 bushels per acre. In 1967 there was a further yield increase due to nitrogen application and in 1968 there was a yield increase due to higher population.

Details of the 1967 treatments are given in Soil Series 82 (March 1968). In 1968 the hybrid used was DeKalb XL 306. The entire plot was fertilized with 0 + 100 + 100 in the fall of 1967 before plowing. Starter fertilizer was used on the entire experiment at the rate of 150 lbs. of 8-32-16 per acre. Yields and measurements made in 1967 and 1968 are given in table 1 and 2 respectively. The corn was planted on May 22 in 1967 and on May 2 and 3 in 1968.

Table 1. Irrigated corn at Morris - 1967

Population Trt.	Yield (Bu/A)	Plants/acre	% Moisture at Harvest	% Barren Stalks	Ear Wt. (lbs.)
Low	99.0a	22,085a	31.0b	7.4a	.418b
Medium	105.1a	25,178b	33.0a	7.9a	.398b
High	105.3a	26,855c	31.1b	6.9a	.368a
Significance	NS	**	*	NS	**
Nitrogen Trt.					
60 lbs.	97.7a	24,459a	31.6a	9.4a	.386a
120 lbs.	106.4b	24,633a	31.2a	5.6a	.402a
180 lbs.	105.3b	25,025a	32.3a	7.2a	.397a
Significance	*	NS	NS	NS	NS
Pop. x Nit. Interaction					
Low x 60	92.6	22,717	31.2	12.4	.411
Low x 120	103.8	21,845	30.5	4.9	.427
Low x 180	100.7	21,715	31.2	4.9	.416
Med. x 60	96.7	24,655	34.7	8.1	.374
Med. x 120	109.9	25,265	32.2	8.6	.421
Med. x 180	108.6	25,592	32.2	7.0	.400
High x 60	103.7	25,984	28.9	7.6	.372
High x 120	105.6	26,789	30.9	3.3	.358
High x 180	106.6	27,770	33.5	9.8	.374
Significance	NS	NS	NS	NS	NS
Unirr. ck. (60# N)	18.7	17,751	29.8	49.7	.176

* Significantly different at the 5% level.
** Significantly different at the 1% level
NS Not significantly different.

Note: Values followed by different letters are significantly different at the level specified by the stars (*).

Table 1a. Soil test results - Fall 1967

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K (lbs./A)
1	7.3	over 8.5	3	240
2	7.0	over 8.5	3	200

Table 2. Irrigated corn at Morris - 1968

Population Trt.	Yield (Bu/A)	Plants/acre	% Moisture at Harvest	% Barren Stalks	Ear Wt. (lbs.)
Low	110.8a	22,094a	36.8a	16.2c	.420c
Medium	121.6b	25,178b	37.0a	9.2b	.368b
High	123.9b	29,812c	37.6a	4.8a	.307a
Significance	**	**	NS	**	**
Nitrogen Trt.					
60 lbs.	118.2a	25,735a	37.1a	10.0a	.364a
120 lbs.	118.2a	25,596a	37.2a	9.3a	.360a
180 lbs.	119.8a	25,753a	37.0a	11.0a	.371a
Significance	NS	NS	NS	NS	NS
Pop. x Nit. Interaction					
Low x 60	109.3	21,989	36.8	17.9	.424
Low x 120	112.3	22,094	36.9	13.5	.413
Low x 180	110.6	22,216	36.5	17.2	.422
Med. x 60	122.2	24,951	36.8	6.5	.368
Med. x 120	121.9	25,038	37.0	9.4	.364
Med. x 180	120.6	25,561	37.2	11.5	.374
High x 60	123.2	30,283	37.8	5.5	.302
High x 120	120.5	29,673	37.8	4.9	.302
High x 180	128.0	29,481	37.1	4.1	.317
Significance	NS	NS	NS	NS	NS
Unirr. ck. (60# N)	26.2	20,857	45.1	28.7	.189

** Significantly different at the 1% level.
NS Not significantly different.

Note: Values followed by different letters are significantly different at the 1% level.

Table 2a. Soil test results - Fall 1968

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K(lbs/A)	ppm Zn
1	7.8	high	13	250	2.0
2	7.6	high	16	230	----

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). Two cuttings were made in 1967 and 1968. Yields were quite low in both years due to a shortage of moisture.

Table 1. Initial soil test data of the experimental area.

Sample No.	pH	O.M.%	Ext. P (lbs./A)	Exch. K (lbs./A)
1	7.2	5.7	24	370
2	7.2	5.6	13	480

Table 2. First cutting yields - 1968

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Lbs. alfalfa hay/A @ 15% moisture					
0	3850	4050	3850	3550	3600	3780
57	3950	3750	3950	4050	4200	3980
114	4000	4000	4100	4200	4450	4150
229	4100	4050	4150	4150	4400	4170
458	4150	4250	4050	4300	4300	4210
Average	4010	4020	4020	4050	4190	

Table 3. Second cutting yields - 1968

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Lbs. alfalfa hay/A @ 15% moisture					
0	1450	1250	1200	1100	1400	1280
57	1150	1250	1100	1300	1200	1200
114	1150	1350	1400	1250	1250	1280
229	1200	1350	1200	1100	1500	1270
458	1250	1400	1350	1450	1550	1400
Average	1240	1320	1250	1240	1380	

Table 4. Total 1968 yields

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Lbs. alfalfa hay/A @ 15% moisture					
0	5300	5300	5050	4650	5000	5060
57	5100	5000	5050	5350	5400	5180
114	5150	5350	5500	5450	5700	5430
229	5300	5400	5340	5250	5900	5440
458	5400	5650	5400	5750	5850	5610
Average	5250	5340	5270	5290	5570	

Table 5. Analysis of Variance

	1st cutting	2nd cutting	Total
Reps	NS	NS	NS
Phosphorus rates	**	NS	*
Potassium rates	NS	NS	NS
P x K interaction	NS	NS	NS

There was a small significant response to phosphorus in 1968 in the first cutting, but the increase was too small to pay for the added fertilizer.

Foliar Application of Micronutrients
Southern Experiment Station - Waseca

Russell D. Frazier

Several micronutrients were applied to the leaves of soybeans growing in production fields at the Experiment Station and on The Tilney Farms near Lewisville. Treatments included metallic sulfates, chelates, mixtures of chelates and a zinc-containing fungicide. Four replicates of 9 treatments were made in a randomized complete block design. Foliar analysis of the plants is in progress.

Table 1. Foliar Application of Micronutrients--Lewisville, and Waseca.

	Treatment	Rate of material applied per acre, pounds	Yields, bushels per acre	
			Lewisville	Waseca
1.	$CuSO_4$	8	45.5	30.1
2.	$ZnSO_4$	15	47.4	32.7
3.	Zn Chelate	2	47.7	36.4
4.	$FeSO_4$	10	49.3	32.0
5.	Fe 138 Chelate	2	46.8	33.2
6.	$MnSO_4$	8	47.1	38.8
7.	Mn Chelate	1	55.0	36.2
8.	Zn-fungicide	6	52.4	36.9
9.	[Trt 5+3+7]	1 each	49.3	40.9

Analysis of variance using class comparisons as described by LeClerg and others indicated the following information.

Source	df	MS Lewisville	MS Waseca
Treatments:	8	36.21*	48.32**
Comparisons:			
2, 3:1	1	11.34	53.40*
2, 3:4, 5	1	.81	15.41
2, 3:6, 7	1	48.65+	33.93+
2:3	1	.21	28.13+
2:8	1	5.00	35.70+
4:5	1	12.75	3.00
6:7	1	123.25**	13.26
2:9	1	7.41	133.66**
Error	24	12.51	9.51

From this one year's preliminary date it appeers that the chelates heve a more favorable effect on soybean yield then do the sulfates used. This may be due to rates of sulfates used as much as the nature of the compounds. The information tends to indicate that consideration should be given to both zinc and manganese nutrition.

1968 Zinc Sources Trial for Field Corn
Southern Experiment Station - Waseca

Russell D. Frazier

Various sources and carriers of zinc were applied broadcast to the soil in a randomized block design. Five treatments and 5 reps were used. Pioneer 3582 seed was planted May 2, 1968 at a population of about 25,000 kernels per acre. Soil pH was 6.1, P test 17, K test 230. Since one of the treatments contained ammonium nitrate, all other treatments received an equivalent amount of ammonium nitrate to compensate. Since this soil is slightly acid, a deficiency of available Zn would not be normally expected.

Treatment results are shown in the accompanying table. These data are inconclusive as far as comparing treatments is concerned, but do puzzle one in interpreting the seeming difference in favor of no treatment. There were no significant treatment effects. Further work is anticipated for 1969.

Table I. Treatments and results, Waseca Zn source trial, 1968.

Treatment	Bu/Ac Corn
Liquid	
1. 10 lb. Zn/Ac as $ZnSO_4$	187.4
2. 10 lb. Zn/Ac as $ZnNO_3$ and NH_3 in H_2O	186.8
3. 2.5 lb. Zn/Ac as Na_2Zn	186.4
Granular	
4. 10 lb. Zn/Ac as $ZnSO_4$	183.6
5. No zinc	203.1

Fertilizer Placement Study on Corn, Waseca 1968
Southern Experiment Station, Waseca

Russell D. Frezier

A randomized block design with a split plot feature was used to investigate the effects of broadcast, row and "popup" placement of fertilizer as well as date of planting. Treatments were chosen to dovetail into those of the larger corn management studies begun in 1967. Plots were established in 1968, so broadcast treatment did not have much opportunity to be evident. It is anticipated to continue these plots on the same location for several years to ascertain broadcast effect as well as interactions with row placement.

Table 1. Results of Fertilizer Placement Studies on Corn, Waseca, 1968

	No Broadcast		Broadcast 0+100+100		
	May 2	May 25	May 2	May 25	Ave.
Row: Check	192.0	155.1	233.2	166.6	186.7
2X2 (21+55+72)	223.0	144.1	214.9	170.9	188.2
Seed placement (4+9+12)	237.2	146.7	219.3	153.0	189.0
Ave.	217.4	148.6	222.5	163.5	

Ammonium nitrate was used overall at 150 lb. N rate per acre.

Soil test information:	pH	P	K
	5.5	72	260

Minnhybrid 4201 was seeded at rate of 25,000.

Detailed statistical analysis has not been completed as of January 30, 1969, so specific statements can not be made as to treatment effects. At this point it appears that there is a considerable effect in favor of early planting, and perhaps also in favor of the broadcast fertilization. Little can be said at this point with regards to placement effect.

The Effect of Nitrogen Source, Placement and Time of Application to a Webster Clay Loam at Lamberton on 1960-68 Corn Yields and the Nitrogen Content of the Corn Grain

John M. MacGregor, Wallace W. Nelson, and Gyles W. Randall

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 nine years of continuous corn growing to N application of this experiment, with results reported each year in Soil Series 76-82.

The 1968 growing season at Lamberton was characterized by a relatively dry spring and early summer, but with an extremely wet late summer and fall. Yield samples were taken from 30 feet of row on October 10th and the calculated data are shown in Table 1. Since nitrogen concentrations in the corn grain were determined on only one replication, it was not possible to statistically analyze the amounts of nitrogen and crude protein actually removed.

Table 1. The Effect of Rate, Kind, Time, and Placement of Fertilizer Nitrogen on the 1968 Corn Yield, Nitrogen, and Crude Protein Content of the Grain at Lamberton.

Trt. No.	Annual Treatment Lbs N/A[a]	1968 Bu/A	1968 N in Corn Grain %	1968 N in Corn Grain Lbs/A	1968 Crude Protein in Grain %	1968 Crude Protein in Grain Lbs/A
1	Check	102.4 a	1.12	54.3	7.0	339
2	40 NH_4NO_3 P.D[b] fall	131.6 bcd	1.30	82.7	8.1	517
3	40 urea " "	132.5 bcd	1.29	82.6	8.1	516
4	40 NH_4NO_3 Top[c] "	135.2 bcd	1.23	80.4	7.7	502
5	40 urea " "	134.0 bcd	1.27	82.2	7.9	514
6	80 NH_4NO_3 P.D. "	131.2 bc	1.34	85.0	8.4	531
7	80 urea P.D. "	142.6 bcd	1.47	101.3	9.2	633
8	160 NH_4NO_3 P.D. "	140.2 bcd	1.46	98.9	9.1	618
9	160 urea " "	149.9 d	1.42	102.9	8.9	643
10	40 NH_4NO_3 T.D. spring	128.0 b	1.21	74.8	7.6	468
11	40 urea " "	140.5 bcd	1.22	82.8	7.6	518
12	80 NH_4NO_3 " "	144.7 bcd	1.40	97.9	8.8	612
13	80 urea " "	138.7 bcd	1.46	97.9	9.1	612
14	40 NH_4NO_3 S.D.[d]	133.4 bcd	1.26	81.2	7.9	508
15	40 urea "	132.2 bcd	1.31	83.9	8.2	523
16	80 NH_4NO_3 "	137.7 bcd	1.39	92.5	8.7	578
17	80 urea "	146.9 cd	1.43	101.5	8.9	634
18	160 NH_4NO_3 "	141.5 bcd	1.45	99.1	9.1	620

a approximately 14 lbs/A additional N is applied annually in the starter fertilizer (175 lbs of 8-24-12 per acre).

b P.D. = plowed down
c T = topdressed
d S.D. = sidedressed

It is evident that all of the annual nitrogen treatments significantly increased corn yields, but with little or no significant effect on increasing N rates, time of application, or of placement of the N fertilizer.

The application of NH_4NO_3 for the four placement or time of application (fall plow down, fall on top of plowed soil, at spring planting, or as a mid-June sidedressing) produced an average increase over the no N treatment of 21.6 bu/A (19.3%), whereas the same treatments as urea yielded an average of 22.5 bu/A (20.1%).

The three times of applying 80 lbs N/A as NH_4NO_3 increased average corn yield 24.9 bu/A (22.2%), with equivalent rates of urea N producing 30.9 bu/A (a 27.6% increase).

The fall and sidedressed NH_4NO_3 treatments supplying 160 lbs. N/A increased average corn yield 28.4 bu/A (25.3%), whereas the one fall applied 160 lb N rate as urea increased yields by 37.7 bu/A (a 33.7% increase).

When field corn is grown each year with annual fertilizer N application, it is also important to determine long term average annual corn grain yields. The nine year annual corn yield averages are shown in Table 2. All of the N treatments have significantly increased ear corn yield averages over the 9 year period.

Table 2. The Effect of Rate, Time, Kind, and Placement of Fertilizer Nitrogen on Ear Corn Production from a Webster Clay Loam at Lamberton for Nine Years (1960-68).

Trt. No.	Treatment (lbs N/A)	Year 1960	1961	1962	1963	1964	1965	1966	1967	1968	9 Yr. Avg.
		Bushels of ear corn per acre @ 15.5% moisture									
1	Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	63.3 a
2	40 NH_4NO_3 P.D. fall	42.3	87.5	30.9	148.6	88.3	34.9	26.8	75.7	131.6	74.1 b
3	40 urea " "	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	76.6 bc
4	40 NH_4NO_3 Top "	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	77.4 bc
5	40 urea " "	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	81.6 bcd
6	80 NH_4NO_3 P.D. "	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.8	131.2	90.7 defg
7	80 urea P.D. "	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	89.5 defg
8	160 NH_4NO_3 " "	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	93.3 efg
9	160 urea " "	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	98.1 g
10	40 NH_4NO_3 T.D. spring	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	85.5 cdef
11	40 urea " "	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	82.7 bcd
12	80 NH_4NO_3 " "	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	83.6 bcde
13	80 urea " "	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	95.1 fg
14	40 NH_4NO_3 S.D. "	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	84.2 cde
15	40 urea "	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	81.3 bcd
16	80 NH_4NO_3 "	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	88.9 defg
17	80 urea "	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	94.7 fg
18	160 NH_4NO_3 "	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	96.4 g
Yearly Average		58.6	93.3	39.4	146.7	101.3	60.3	36.3	101.8	135.7	

NH_4NO_3 versus urea N

The four NH_4NO_3 treatments at the rate of 40 lbs N/A annually averaged 80.3 bu/A of corn over the 9 years, whereas similar treatments as urea N averaged 80.6 bu/A.

The three NH_4NO_3 times of application at 80 lbs of N/A averaged 87.7 bu/A, and the comparative urea N average was 93.1 bushels.

The two 160 lbs of N/A rates as NH_4NO_3 averaged 94.9 bu/A, with the one similar rate urea fall treatment 98.1 bu/A.

It would appear that over the nine year period, urea N is fully as effective as NH_4NO_3 - N in continuous corn production at Lamberton.

Rates of N application (40, 80, & 160 lbs/A)

The eight 40 lb N/A treatments averaged 80.4 bushels (17.4 bu increase), the six 80 lb N/A rates produced a 9 year average of 90.4 bu/A and the three annual 160 lbs N/A averaged 95.9 bu/A, showing that the lower N application rates produced proportionally larger yield increases.

Time of N application and Placement (over nine years)

Forty lbs of N/A plowed down in the fall averaged 75.4 bushels, whereas similar amounts spread and left on the surface over winter averaged 79.5 bushels. Similar treatments made in the spring however, averaged 84.1 bu/A and June sidedressing yielded an 82.8 bushel average.

Eighty pounds of N/A plowed down in the fall averaged 85.1 bushels, compared to 89.4 bushels with spring application, and 91.8 bu/A when side-dressed.

The two 160 lbs N/A rates plowed down in the fall averaged 95.7 bu/A, whereas the lone NH_4NO_3-160 lb N/A June sidedressing averaged 96.4 bushels over the 9 years.

There appears to be a small advantage for spring over fall application at the 40 and 80 lb N/A rates but this is not apparent where 160 lbs N were broadcast annually.

The Effect of Eleven Years of Annual Application of Nitrogen for Continuous Corn on Soil Reaction and on Zinc Concentration in the Sixth Corn Leaf at Silking in 1968 (Barnes loam-Morris)

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

Commencing in 1957, corn has been grown each year on a Barnes loam at Morris, with annual applications of 0, 40, 80 and 240 pounds of fertilizer N as NH_4NO_3 or as urea. P_2O_5, and K_2O were also applied each year at the rate of 40 pounds per acre.

During the summer of 1967, laboratory analyses of the 0"-6" depth soil indicated a significant lowering of pH with the heaviest N application. Although there was some decrease in the pH of the subsoils with the heavy annual N application, this was not significant.

Since a decrease in soil pH (increase in soil acidity) frequently increases zinc availability, samples of the sixth corn leaves were obtained in 1968 from the five replications of each of the five N treatments and these were analyzed for zinc concentration. The pH of the 0"-6" soil samples collected in 1967 and the zinc concentrations of the 1968 corn leaves are shown below.

The pH of Surface Soil in 1967 and Zinc Concentration in 1968 Corn Leaves at Morris

Annual fertilizer treatment (Lbs/A) (1957-1968)	pH of 0"-6" soil (1967)	Leaf zinc in ppm (1968)
N + P_2O_5 + K_2O		
0 + 40 + 40 (applied in spring)	7.26 a	16.4 a
40 + 40 + 40 (applied in fall)	7.28 a	15.9 a
40 + 40 + 40 (applied in spring)	7.14 a	16.6 a
80 + 40 + 40 (" " ")	7.11 a	21.2 b
240 + 40 + 40 (" " ")	6.50 b	22.2 b

It is apparent that the 240 pound rate of N application every year eventually significantly depressed the pH of the surface soil. The much lower 80 lb N/A annual fertilization depressed soil pH, but not significantly so, but both of the two heavier rates of N significantly increased zinc concentrations in the 1968 corn leaves.

Concentrations of Nitrate Nitrogen (NO_3-N) in Free Soil Water in Webster Clay Loam Subsoil at Lamberton Under and Adjacent to Continuous Corn With Annual Nitrogen Fertilization

J. M. MacGregor and W. W. Nelson

Early in 1968, a study of the NO_3-N content of free soil water underlying the continuous corn fertilized annually with 0, 40, 80, and 160 pounds per acre of NH_4NO_3 or urea nitrogen was initiated. Approximately 14 lbs N/A is applied annually with ample P_2O_5 and K_2O (175#/A of 8-24-12) in the starter fertilizer over the entire experimental area. Aluminum tubes 3" in diameter and 30, 42, 54, 66, and 78 inches in length were stoppered at one end and a ring of small holes drilled through in a ring around each cylinder 6" from the stoppered end. These cylinders were then sunk some 20 feet inside four of the no nitrogen and within four of the annual 80 lb NH_4NO_3 -N/A plots, so that the ring of small holes would be 2', 3', 4', 5', and 6' from the surface of the soil. These tubes were then also capped at the soil surface end to prevent soil or other materials from falling down these "wells." Free water could then enter through the ring of drilled holes and would be collected in the 6" reservoir below the holes at the lowered stoppered end.

To determine NO_3-N concentrations and possible NO_3-N movement between the ends of the plots and a tile drain some 12 feet distant in the surface roadway, a number of similar wells having the ring of holes 42 inches from the soil surface were sunk midway between the ends of three check, three 40 lb N/A plots, four 80 lb N/A plots, and four plots receiving 160 lbs of NH_4NO_3 annually.

Since 1968 at Lamberton was relatively dry until late in July, there was no water accumulation in any of the wells and the first sampling was available on July 29th. Samples collected were chilled or frozen immediately until NO_3 analysis. A study on sample temperature storage effect prior to NO_3 analyses, when frozen, refrigerated or maintained at room temperature (for 10 days) showed a small and variable effect, so all samples were then frozen until analysis was possible. A total of five samplings were made from late July to early in November. The results are shown in Tables 1 and 2.

It is obvious that the NO_3-N content of free water in the subsoil of the check plots is relatively low under the continuous corn, since they receive only some 14 lbs N/A annually in the NPK starter fertilizer used. It is doubtful if a lateral movement of N into the subsoil of the plots has occurred from the two adjoining plot treatments, although this may have occurred in Plot 7 where the NO_3-N concentration of the water at 6 feet is considerably more than the same level in the other three check plots. NO_3-N concentrations at the 42" depth midway between the ends of the check plots and the tile lines are higher than within the plots, indicating either some accumulation or a possible movement of the NO_3 toward the tile drains. While there was no increase in NO_3-N concentrations in the wells outside the 40 lb N/A plots, this would not be expected, since most of this N added in such small amounts would be normally removed by the growing corn.

Table 2 shows that the annual application of 80 lbs N/A has increased the NO_3-N concentrations of the free water in the subsoil (Plots 2, 25, 60, and 78) even with much higher corn yields on these plots. Since the NO_3-N content of the wells outside the 80 lb-N/A plots is somewhat higher than those reported in Table 1, it is probable that this rate of N application has resulted in some lateral movement of NO_3-N to the tile drains, which are some 12.5' from the end of each of these plots. Since even higher N concentrations occur in the wells adjacent to the 160 lb rate of N/A treatment, it appears that some NO_2-N is probably being lost in the drainage waters at these higher rates of N application.

Whereas lateral movement of NO_3-N between plot treatments is probably small or non-existent, (the plots are 20' in width), it is apparent that some NO_3-N of the annual 80 and 160 lb N/A treatments is being carried away by the tile drains in the free water in the subsoil and is thus lost to crop production.

Table 1. Treatment, Nitrate N Concentrations in Soil Free Water, Stalks, Ears, and Corn Yield per Acre in 1968 on NH_4NO_3-Urea Treated Continuous Corn at Lamberton. (Webster Clay Loam)

Plot No.	Annual N/A Rate, time & placement	Plot treatment west side Lbs N/A[a]	Plot treatment east side Lbs N/A	Well depth (feet)	NO_3-N in ppm in H_2O 7/29	7/31	9/25	10/22	11/2	Stalks/A	Ears/A	Ear Corn Bu/A
				Wells within plots								
7	None	160 NH_4NO_3-N(SD)	80 urea-N(fall)	2	—	—	—	1.32	—	22,070	20,328	108.3
				3	—	0.73	0.13	0.53	4.03			
				4	2.44	0.99	0.26	0.46	0.20			
				5	4.55	3.96	1.25	1.45	0.66			
				6	10.69	17.02	6.01	9.97	3.10			
32	None	40 NH_4NO_3-N(SD)	160 urea-N(fall)	2	—	—	—	2.90	—	19,747	19,166	106.3
				3	—	—	—	1.22	—			
				4	—	—	0.73	0.46	0.99			
				5	—	5.94	0.66	0.46	0.79			
				6	—	4.09	1.52	1.25	1.19			
46	None	80 urea-N)SD)	40 NH_4NO_3-N(fall)	2	—	—	—	0.46	—	20,909	18,005	107.8
				3	—	1.12	0.79	0.53	2.18			
				4	5.61	1.06	0.53	1.06	2.24			
				5	2.18	1.91	1.39	1.25	1.91			
				6	2.44	2.84	2.71	1.12	1.98			
73	None	80 urea-N(fall)	80 NH_4NO_3-N(fall)	3	—	—	—	0.59	—	18,005	15,101	87.4
				4	—	0.14	0.07	0.13	1.32			
				5	0.59	0.59	0.07	0.53	0.73			
				6	1.25	1.06	0.20	0.92	0.79			
				Wells at outer end of plots (12 feet distant from tile drain)								
4	None	40 urea-N(fall)	40 NH_4NO_3-N(fall)	3.5	—	1.58	—	8.78	1.98	18,005	18,005	113.6
54	None	40 urea-N(fall)	160 NH_4NO_3-N(fall)	3.5	—	—	—	11.09	22.58	20,909	19,747	110.5
79	None	None	80 NH_4NO_3-N(spring)	3.5	12.41	14.45	—	—	—	19,166	19,166	119.8
15	40 NH_4NO_3-N(SD)	80 urea-N(spring)	40 urea-N(fall)	3.5	—	—	—	7.26	10.43	17,424	17,424	136.9
33	40 NH_4NO_3-N(SD)	160 NH_4NO_3-N(SD)	None	3.5	—	0.73	—	9.04	—	17,424	17,424	135.1
49	40 NH_4NO_3-N(SD)	160 NH_4NO_3-N(SD)	40 NH_4NO_3-N(fall)	3.5	—	—	—	16.17	—	16,843	16,262	110.0

[a]SD = sidedressed

Table 2. Treatment, NO_3-N Concentrations in Soil Free Water, Stalks, Ears, and Corn Yield per Acre in 1968 in NH_4NO_3-Urea Continuous Corn at Lamberton. (Webster Clay Loam)

Plot No.	Annual N/A Rate, time & placement	Plot treatment west side Lbs N/A	Plot treatment east side Lbs N/A	Well Depth (feet)	NO_3-N in ppm in H_2O 7/29	7/31	9/25	10/22	11/2	Stalks/A	Ears/A	Bu/A
				Wells within plots								
2	80 NH_4NO_3-N (spring)	40 NH_4NO_3-N(fall)	40 NH_4NO_3-N (spring)	2	--	16.36	--	15.70	--	21,490	19,166	134.9
				3	15.97	19.94	22.58	21.12	13.66			
				4	18.94	18.74	15.32	20.20	16.56			
				5	11.62	14.52	11.22	15.58	13.13			
				6	15.71	18.48	20.60	17.68	14.19			
25	80 NH_4NO_3-N (spring)	80 Urea-N(spring)	160 NH_4NO_3-N(fall)	2	--	--	--	12.67	--	19,747	18,586	141.6
				3	--	--	--	13.13	14.00			
				4	--	--	6.07	16.50	14.26			
				5	--	4.42	6.47	13.79	13.60			
				6	8.05	5.81	6.47	13.86	16.64			
60	80 NH_4NO_3-N (spring)	40 NH_4NO_3-N(fall)	40 urea-N (spring)	2	--	--	--	1.98	--	21,490	19,747	147.5
				3	--	--	2.57	3.50	5.68			
				4	--	6.53	5.48	5.02	4.42			
				5	5.74	5.54	3.63	3.96	4.22			
				6	6.34	7.06	5.35	6.80	2.77			
78	80 NH_4NO_3-N (spring)	None	80 urea-N(spring)	2	--	3.82	0.79	2.71	--	23,813	21,490	169.3
				3	9.31	8.32	1.45	4.69	2.57			
				4	6.80	10.09	4.36	4.49	2.11			
				5	6.34	10.75	4.95	4.22	2.84			
				6	5.54	5.74	5.21	5.08	5.02			
				Wells at outer end of plots (12 feet distant from tile drains)								
11	80 NH_4NO_3-N(SD)	None	40 urea-N(spring)	3.5	--	1.39	--	12.61	17.16	22,070	22,070	141.6
38	80 NH_4NO_3-N(SD)	None	40 urea-N(SD)	3.5	10.76	14.98	--	--	--	20,909	19,166	140.5
58	80 NH_4NO_3-N(SD)	40 urea-N(spring)	80 urea-N(spring_	3.5	--	--	--	27.46	20.72	20,909	19,166	138.7
63	80 NH_4NO_3-N(SD)	40 urea-N(spring)	40 NH_4NO_3-N(fall)	3.5	--	--	--	28.52	--	19,747	17,424	130.1
8	160 NH_4NO_3-N(SD)	80 NH_4NO_3-N(fall)	None	3.5	--	--	--	39.46	87.64	20,909	19,166	139.5
34	160 NH_4NO_3-N(SD)	40 urea-N(spring)	40 NH_4NO_3-N(SD)	3.5	--	19.40	--	17.16	--	19,747	19,166	150.2
50	160 NH_4NO_3-N(SD)	80 urea-N(fall)	40 NH_4NO_3-N(SD)	3.5	--	--	--	47.52	39.46	19,747	18,586	132.6
68	160 NH_4NO_3-N(SD)	40 urea-N(fall)	160 urea-N)fall)	3.5	--	--	--	71.28	--	23,813	21,490	143.7

Soybean Nitrogen Fertilization Study

G. E. Ham, R. H. Anderson, S. D. Evans, W. W. Nelson
R. D. Frazier and J. R. Lofgren

At the 30 to 60 bushel level, one-third to one-half of the nitrogen in the soybean plant is taken from the soil in the form of ammonium and nitrate ions. A considerable amount of this nitrogen is taken up during the last month of the growing season when the seeds are filling. At about the same time the seeds are filling, the nitrogen fixing ability of the nodules decreases. These facts would seem to indicate that nitrogen fertilization of soybeans should increase seed yield, but such is not the case. Nitrogen applications at planting time or sidedress applications during the growing season have not significantly increased seed yields.

Ammonium nitrate, urea, urea plus sulfur and sulfur-coated urea sources of nitrogen were compared at Lamberton, Waseca and Morris with nonnodulating and nodulating isolines of Chippewa maturity and Chippewa 64 soybeans. The same sources of nitrogen were compared at Crookston and Grand Rapids with Altona, Norman and Portage soybeans. The yields from Grand Rapids, Lamberton and Morris are shown in Table 1, 2 and 3.

The yields from Waseca were erratic due to the effects of phytophthara root rot. The yields from Crookston were low and erratic due to the cool, wet season and a wet spot in the plots,

Table 1. Effect of nitrogen fertilizer additions on 1968 soybean seed yield at Grand Rapids, Minnesota when different sources of nitrogen fertilizers at the rate of 150 pounds of N per acre were disced into the soil in the spring of 1968

Nitrogen source	Soybean variety Altona bu/acre	Portage bu/acre	II-55-14 bu/acre
Check	27.5	29.8	31.3
Ammonium nitrate	31.7	30.6	32.2
Urea	33.2	32.6	31.9
Urea + sulfur[a]	34.6	32.6	30.0
Sulfur-coated urea[b]	33.7	32.8	33.5

[a] Treatment had some N and S as sulfur-coated urea
[b] Provided by Dr. H. L. Meredith, Agronomist, TVA

Table 2. Effect of nitrogen fertilizer additions on 1968 soybean seed yield at Lamberton, Minnesota when different sources of nitrogen fertilizers at the rate of 150 pounds of N per acre were disced into the soil in the spring of 1968.

Nitrogen source	Soybean variety Nonnods[a] bu/acre	Nods[a] bu/acre	Chippewa 64 bu/acre
Check	24.6	30.1	28.2
Ammonium nitrate	29.3	28.9	27.7
Urea	29.1	28.5	27.9
Urea + sulfur[b]	29.0	27.2	28.2
Sulfur-coated urea[c]	30.6	29.5	29.1

[a] Nonnods and nods are isolines of Chippewa maturity. The isolines are very similar in all respects except for the inability and ability to form nodules when the plants are grown in the presence of most strains of Rhizobium japonicum

[b] Treatment has same N and S as sulfur-coated urea.

[c] Provided by Dr. H. L. Meredith, Agronomist, TVA.

Table 3. Effect of nitrogen fertilizer additions on 1968 soybean seed yield at Morris, Minnesota when different sources of nitrogen fertilizers at the rate of 150 pounds of N per acre were disced into the soil in the spring of 1968

Nitrogen Source	Soybean variety		
	Nonnods[a]	Nods[a]	Chippewa 64
	bu/acre	bu/acre	bu/acre
Check	16.9	19.6	17.7
Ammonium nitrate	22.1	21.4	19.4
Urea	24.3	25.6	23.7
Urea + sulfur[b]	21.7	20.4	21.2
Sulfur-coated urea[c]	21.8	22.1	20.9

[a] Nonnods and nods are isolines of Chippewa maturity. The isolines are very similar in all respects except for the inability and ability to form nodules when the plants are grown in the presence of most strains of Rhizobium japonicum

[b] Treatment has same N and S as sulfur-coated urea.

[c] Provided by Dr. H. L. Meredith, Agronomist, TVA

1968 Polyphosphate Investigations

A. C. Caldwell
and
R. C. Leslie

Field trials comparing the effects of polyphosphates and orthophosphates on 1) early growth, 2) elemental uptake and 3) yields of soybeans were run at Rosemount, Lamberton, and Morris Experiment Stations. Three different phosphate treatments at two placements were employed at all stations with two rates included at Rosemount as shown in Table 1.

Table 1. Phosphate Treatments

Phosphate Material	Experiment Station	Rate # P_2O_5/A	Application
Check			
Ortho. Dry 11-48-0	L-R-M	62.5*	2 x 2
Ortho. Dry 11-48-0	L-R-M	62.5	Pop-up
Ortho. Dry 11-48-0	R	125.0	2 x 2
Ortho. Dry 11-48-0	R	125.0	Pop-up
Ortho. Liq. 8-24-0	L-R-M	125.0	2 x 2
Ortho. Liq. 8-24-0	L-R-M	125.0	Pop-up
Ortho. Liq. 8-24-0	R	250.0	2 x 2
Ortho. Liq. 8-24-0	R	250.0	Pop-up
Poly. Liq. 11-37-0	L-R-M	81.1	2 x 2
Poly. Liq. 11-37-0	L-R-M	81.1	Pop-up
Poly. Liq. 11-37-0	R	162.2	2 x 2
Poly. Liq. 11-37-0	R	162.2	Pop-up

* 98 # P_2O_5/Acre at Lamberton

At Rosemount and Morris, treatments were replicated five times, with six replications at Lamberton. All locations used Chippewa-64 soybeans. In addition to the phosphate treatments at Lamberton, 200 # N/Acre was broadcast before planting as processed feathers and disked in.

The plants in the non-nitrogen fertilized plots were randomly sampled at two different growth stages, whereas whole plants 5-7 inches high and uppermost fully matured trifoliate leaves were sampled at pod stage.

Total dry matter was determined for both samplings. Elemental analyses were run on all plots, except nitrogen fertilized plots. Yields were determined on all plots.

Results

Yields

Yield data at Lamberton and at Rosemount (Tables 2 and 4 respectively) indicate a response to phosphorus fertilization. Morris yield data, Table 3, show no response to phosphorus fertilization because of atrazine carry-over damage. The only significant difference among treatments was the 2 x 2, 8-24-0 application at 60#/A. The 11-48-0 applied as pop-up reduced yields at Rosemount. Nitrogen fertilization increased Lamberton yields.

Table 2. Effect of Phosphate Fertilizers on Soybean Yields at Lamberton

		Treatments					
		Ortho. Dry		Ortho. Liq.		Poly. Liq.	
Treatment (lbs/A)	Check	2 x 2	Pop-up	2 x 2	Pop-up	2 x 2	Pop-up
	Bu/Acre						
No Nitrogen	25.9a	30.4b	30.6b	29.1bc	28.8c	29.9bc	29.2bc
200 lbs. Nitrogen	27.5	33.6	33.3	31.6	29.7	31.0	30.3

*Values followed by same letter not significantly different at 5% level

Table 3. Effect of Phosphate Fertilizers on Soybean Yields at Morris

Treatments						
	Ortho. Dry		Ortho. Liq.		Poly. Liq.	
Check	2 x 2	Pop-up	2 x 2	Pop-up	2 x 2	Pop-up
Bu/Acre						
26.8	25.6	24.3	25.9	25.1	27.7	25.6

Treat. - N.S.

Table 4. Effect of Phosphate Fertilizers on Soybean Yields at Rosemount

Treatment (lbs/A)	Check	Treatments: Ortho. Dry 2 x 2	Ortho. Dry Pop-up	Ortho. Liq. 2 x 2	Ortho. Liq. Pop-up	Poly. Liq. 2 x 2	Poly. Liq. Pop-up
		Bu/Acre					
30# P_2O_5/A	26.1a	33.9b	27.0a	33.2b	33.4b	31.5b	32.5b
60# P_2O_5/A		30.8b	*	38.3c	31.1b	33.0b	33.5b

*Values followed by same letter not significantly different at 5% level.

* Salt damage too extensive for yield determination.

ELEMENTAL ANALYSIS

Elemental uptake data on soybean tissue from Rosemount, Table 5, show increases in P uptake by young soybean plants when liquids were applied at rates to supply 60# P_2O_5/A. Significant differences in K, Ca, Mg, Mn and B uptake among treatments were found. Lamberton elemental uptake data, Table 6, show significantly greater uptake of all elements by soybeans fertilized with 11-37-0 applied as pop-up. Morris elemental uptake data showed no significant differences among all treatments. Differences in elemental content of tissue at both Rosemount and Lamberton appeared to have no significant effect on soybean yields.

Table 5. Effect of Phosphorus Sources on Element Uptake by Soybeans at Rosemount

Material	Treatment Rate $\#P_2O_5/A$	Placement	First Sampling Elements P	K	Ca	Mg	Fe	Al	Zn	Cu	Mo	Mn	B
			--Milligrams/Plant--				--Micrograms/Plant--						
Check			1.03a	3.02a	5.24a	3.66a	161	205	22.9	7.21	1.12	17.3a	14.6a
11-48-0	30	2 x 2	1.33a	3.08a	5.46a	4.08ab	146	168	28.8	6.93	1.00	18.7abc	14.6a
11-48-0	30	Pop-up	2.56cd	3.51a	7.29ab	5.52b	160	169	21.6	6.01	1.27	30.7c	18.3abc
11-48-0	60	2 x 2	1.64ab	3.03a	6.01ab	4.44ab	144	164	22.0	7.24	1.18	22.5abc	15.8abc
11-48-0	60	Pop-up		Salt Damage									
8-24-0	30	2 x 2	1.84bc	4.18ab	7.52ab	5.14ab	188	224	28.1	8.63	1.45	25.2abc	21.2bc
8-24-0	30	Pop-up	1.65ab	4.04ab	6.92ab	4.95ab	164	182	27.9	7.79	1.29	26.5bc	18.8abc
8-24-0	60	2 x 2	2.34bcd	5.36b	8.27b	5.60b	174	198	30.1	7.26	1.39	30.4bc	21.9c
8-24-0	60	Pop-up	2.55cd	5.34b	7.65ab	5.11ab	158	172	26.2	7.78	1.32	32.5c	20.0abc
11-37-0	30	2 x 2	1.66ab	3.37a	6.62ab	4.89ab	161	188	20.8	7.91	1.35	23.0abc	18.1abc
11-37-0	30	Pop-up	1.63ab	3.04a	6.18ab	4.61ab	158	174	21.2	6.84	1.17	22.5abc	16.8abc
11-37-0	60	2 x 2	2.38bcd	3.53a	7.66ab	5.52b	177	196	25.7	6.57	1.44	31.3c	20.4abc
11-37-0	60	Pop-up	2.31bcd	3.43	6.91ab	4.89ab	185	207	20.3	7.87	1.37	32.1c	18.9abc
	Significance		*	*	*	*	N.S.	N.S.	N.S.	N.S.	N.S.	*	*

Table 5. (Continued)

Material	Treatment Rate #P_2O_5/A	Placement	Second Sampling Elements										
			P	K	Ca	Mg	Fe	Al	Zn	Cu	Mo	Mn	B
			-----Milligrams/Plant-----				------------------Micrograms/Plant------------------						
Check			26.5	126.2ab	91.6	45.3	1237.9	342.7	561.1	205.3	11.2	448.5a	461.8
11-48-0	30	2 x 2	29.3	125.3ab	86.8	44.1	1284.0	336.8	542.1	205.9	10.7	458.8a	468.3
11-48-0	30	Pop-up	35.9	147.1ab	103.7	57.2	1666.4	358.2	582.1	198.5	13.1	615.3ab	553.0
11-48-0	60	2 x 2	28.4	117.4a	80.1	40.6	1199.6	223.6	485.4	163.7	11.7	454.1a	446.4
11-48-0	60	Pop-up		Salt Damage									
8-24-0	30	2 x 2	37.3	157.0ab	112.4	56.3	1632.6	396.3	701.9	239.8	12.9	607.2ab	602.7
8-24-0	30	Pop-up	29.6	138.6ab	93.2	44.5	1248.1	317.6	566.5	201.5	11.5	509.2ab	493.3
8-24-0	60	2 x 2	37.8	155.2b	109.5	51.9	1740.8	331.7	632.5	225.4	15.2	589.7b	600.1
8-24-0	60	Pop-up	38.3	172.0ab	119.9	57.4	1690.4	398.2	655.9	238.6	13.9	686.1ab	634.1
11-37-0	30	2 x 2	35.6	157.8ab	107.2	54.4	1472.8	395.3	654.7	224.2	14.0	578.6ab	581.0
11-37-0	30	Pop-up	38.3	164.3ab	115.2	57.7	1642.0	356.1	665.3	233.1	14.9	615.2ab	623.8
11-37-0	60	2 x 2	33.1	142.8ab	101.0	50.0	1434.7	296.8	550.8	181.5	12.7	593.8ab	519.6
11-37-0	60	Pop-up	37.1	155.5ab	108.2	54.2	1536.0	371.7	596.1	212.7	14.4	604.9ab	584.7
	Significance		N.S.	*	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	*	N.S.

*Values followed by the same letter not significantly different at the 5% level

Table 6. Effect of Phosphorus Sources on Element Uptake by Soybeans at Lamberton

Treatments		First Sampling Elements										
Material	Placement	P	K	Ca	Mg	N	Al	Zn	Mo	Mn	B	Fe
		Milligrams/Plant					Micrograms/Plant					
Check		1.77a	13.2bc	8.6bc	3.6bc	30.5bc	919bc	68.8b	2.4bc	25.0a	21.9cd	582bc
11-48-0	2 x 2	1.19a	8.2ab	5.7a	2.5a	20.0a	598ab	39.5ab	1.6ab	16.8a	15.6ab	381ab
11-48-0	Pop-up	1.40a	8.1ab	6.1ab	2.8ab	21.5a	671	34.9ab	1.7ab	19.9a	16.2abc	439abc
8-24-0	2 x 2	1.63a	10.1ab	7.0ab	3.2abc	26.2ab	637ab	42.3ab	1.8abc	25.4a	17.2abc	414abc
8-24-0	Pop-up	1.31a	7.0a	5.5a	2.7ab	21.3a	393a	24.6a	1.2a	20.4a	13.9a	263a
11-37-0	2 x 2	1.83ab	11.6abc	8.7bc	4.0cd	29.5bc	811bc	57.1ab	2.2bc	26.8a	20.3bcd	538abc
11-37-0	Pop-up	2.43b	15.6 c	10.6c	4.8d	36.7c	1075c	68.6b	2.7c	36.9b	25.4d	681c
Significance		*	*	*	*	*	*	*	*	*	*	*
		Second Sampling										
Check		46.3ab	202.4ab	98.9ab	46.9ab	705.0ab	178.6a	782.4abc	11.6ab	361.1ab	522.0ab	1147ab
11-48-0		35.8a	164.4a	75.7a	37.4ab	575.0a	198.4a	631.6ab	9.4b	269.4a	404.0a	934a
11-48-0		50.2ab	215.1ab	95.7ab	49.3ab	729.6ab	404.7b	844.1bc	12.7ab	386.2ab	537.0ab	1501b
8-24-0		51.9ab	208.2ab	93.2ab	48.1ab	712.3ab	247.3ab	767.4abc	12.2ab	362.1ab	530.0ab	1207ab
8-24-0		32.3a	131.4a	60.6a	32.1a	456.1a	190.3a	486.8a	7.8b	248.6a	336.0a	814a
11-37-0		47.4ab	205.1ab	96.7ab	47.4ab	717.6ab	222.0ab	756.1abc	11.3ab	357.4ab	522.0ab	1189ab
11-37-0		67.4b	272.6b	131.0b	61.7b	967.2b	254.1ab	1008.7bc	16.2a	491.0b	719.0b	1513b
Significance		*	*	*	*	*	*	*	*	*	*	*

*Values followed by the same letter not significantly different at 5% level.

Effect of Potassium Fertilizer Sources and Rates on Soybeans

George E. Ham

The plots were located on the University of Minnesota Sand Plain Experimental Field near Elk River in Anoka County. The soil was a Hubbard loamy coarse sand with 0-2% slope. Soil test results are given below:

pH	Extractable phosphorus pp2m	Exchangeable potassium pp2m	Sulfur pp2m	Zinc pp2m
5.6	200(VH)[a]	200(M)	3(L)	2.6(H)
5.9	200(VH)	220(M)	5(L)	2.0(M)
5.1	200(VH)	180(M)	5(L)	2.8(H)
5.3	200(VH)	180(M)	5(L)	3.2(H)

[a]VH=very high, H=high, M=medium, L=low

All plots were treated uniformly with 0+40+0 (elemental basis) and 3 tons of limestone. Then, the potassium treatments were applied, the area was plowed about 12 inches deep and three tons of limestone were applied and disced into the soil.

A split-plot design was used with six replicates and the treatments were applied as outlined in Table 1. Individual plots were six 24-inch rows (12 feet) wide and 30 feet long. Treflan was applied at the rate of one-half pound per acre. Chippewa 64 variety soybeans were planted with a tractor-mounted four row cone planter on May 10, 1968 at the rate of 10 germinable seeds per foot of row. The plots were irrigated as needed with two exceptions when the plot areas became dry enough such that moisture stresses were apparent.

Leaf samples for foliar analysis were taken when the plants were in mid-bloom. The last fully matured leaf from about 25-30 plants in a plot were taken per sample. The leaves from replicates I and II were combined as were the leaves from replicates II and IV. The leaves were dried, ground and analyzed for P, K, Ca, Sr, Na, Fe, Mg, Zn, Cu, Mo, Mn, B and S by emission spectrograph. The results are shown in Table 2.

Plots were harvested for seed yield on October 10, 1968. A 16-foot section of one of the two center rows was cut, threshed with a small plot thresher, cleaned and weighed. Yields for statistical analysis were based on bushels of soybeans per acre on the basis of 12.0% moisture. The yields are shown in Tables 3 and 4.

The lack of significant yield increases of soybeans when potassium fertilizers were applied to soil in the field at this location this year does not necessarily mean that potassium additions do not effect seed yield. The yields were generally too low and variable due to irrigation problems to measure the effect of added potassium on soybean seed yield.

Summary

The addition of K to soybeans grown in the field had little affect on soybean seed yields. The %K in the leaves was increased somewhat but the increases were not significant at the .05 level of significance. Only %P in the leaves was increased significantly when K_2HPO_4 was added.

Table 1. Amount of nutrients contained in added potassium fertilizers.

Potassium source	Analysis of fertilizer added	Fertilizer Rate in Pounds Per Acre			
		100 K_2O	200 K_2O	400 K_2O	800 K_2O
	N - P_2O_5 - K_2O-S	N P K S	N P K S	N P K S	N P K S
KCl	0+0+60+0	0+0+83+0	0+0+166+0	0+0+332+0	0+0+664+0
KNO_3	13+0+44+0	30+0+83+0	60+0+166+0	90+0+332+0	180+0+664+0
K_2SO_4	0+0+50+17.6	0+0+83+35	0+0+166+70	0+0+332+140	0+0+664+280
K_2HPO_4	0+44+48+0	0+34+83+0	0+68+166+0	0+136+332+0	0+272+664+0
Sul-Po-Mag	0+0+22+22.7	0+0+83+103 +49 Mg	0+0+166+206 +98 Mg	0+0+332+412 +196 Mg	0+0+664+824 +392 Mg
K_2CO_3	0+0+64+0	0+0+83+0	0+0+166+0	0+0+332+0	0+0+664+0
KCl+S(K_2SO_4)			0+0+166+70		
KCl+Mg(Sul-Po-Mag)			0+0+166+206 +98 Mg		
KCl+N(KNO_3)			60+0+166+0		
KCl+P(K_2HPO_4)			0+68+166+0		

Table 2. Effect of potassium sources and levels on the nutrient content of field grown Chippewa 64 soybeans. (Emission spectrograph analysis)

Potassium source	K_2O level	P	K	Ca	Sr	Fe	Mg	Zn	Cu	Mo	Mn	B	S
	lb/A	%	%	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%
Check	0	.489	1.97	.704	21.3	182	.317	53.8	11.0	1.01	109	49.6	.339
K_2CO_3	100	.451	2.13	.678	20.0	226	.277	49.1	10.7	1.06	100	43.3	.341
"	200	.462	2.30	.658	19.1	169	.291	52.3	10.5	0.74	96	40.5	.327
"	400	.445	2.26	.655	19.3	175	.262	48.4	11.4	0.82	94	41.5	.305
"	800	.450	2.43	.629	20.1	182	.268	52.3	11.3	0.79	93	40.7	.345
K_2HPO_4	100	.486	2.17	.650	18.4	206	.289	49.2	20.5	0.95	96	42.5	.322
"	200	.520	2.26	.683	17.5	239	.311	51.5	11.7	1.05	101	46.3	.336
"	400	.540	2.25	.647	17.5	249	.276	45.1	7.3	1.04	99	42.0	.342
"	800	.623	2.39	.616	17.0	205	.267	50.7	7.4	0.75	96	40.2	.351
K_2SO_4	100	.483	2.24	.683	19.5	164	.286	55.1	12.7	1.05	113	48.2	.348
"	200	.464	2.29	.714	19.1	180	.306	62.6	12.9	0.83	120	47.5	.347
"	400	.471	2.35	.683	16.8	179	.298	58.4	12.7	0.96	122	47.9	.338
"	800	.437	2.33	.654	16.7	184	.281	59.3	13.1	0.88	117	47.0	.350
$K_2SO_4 \cdot MgSO_4$	100	.479	2.19	.710	21.2	186	.325	57.4	12.1	0.96	116	48.4	.352
"	200	.438	2.27	.633	16.0	166	.301	54.7	12.0	0.97	109	44.7	.362
"	400	.465	2.30	.642	14.7	195	.311	54.2	11.9	1.14	114	49.7	.350
"	800	.466	2.38	.618	13.4	200	.318	59.6	27.5	1.19	130	50.1	.355
KNO_3	100	.484	2.14	.715	21.2	181	.301	48.0	10.6	1.13	105	46.7	.327
"	200	.513	2.24	.724	20.8	185	.319	52.7	10.8	1.03	110	45.2	.330
"	400	.493	2.15	.731	23.5	204	.315	54.8	11.3	0.94	108	45.2	.349
"	800	.486	2.17	.694	21.1	173	.286	48.7	10.2	0.99	100	44.7	.324
KCl	100	.488	2.24	.720	21.5	251	.333	52.0	11.9	1.03	111	47.3	.337
"	200	.498	2.19	.684	20.0	238	.299	49.5	12.6	1.02	98	47.7	.330
"	400	.443	2.16	.621	35.3	234	.265	48.5	10.6	1.08	107	44.4	.336
"	800	.464	2.37	.623	18.0	234	.277	51.9	11.9	0.87	104	42.5	.331
"	1600	.478	2.50	.629	19.0	174	.274	53.9	11.8	0.88	105	46.7	.345
KCl-N	200	.463	2.28	.708	20.4	215	.295	52.4	11.4	1.02	112	46.4	.322
KCl-S	200	.454	2.18	.662	18.2	176	.294	53.5	13.2	0.90	115	42.3	.355
KCl-S-Mg	200	.470	2.14	.673	18.5	220	.285	52.9	11.8	1.24	113	48.4	.345
KCl-P	200	.544	2.30	.735	20.0	212	.312	49.2	8.9	0.93	113	48.8	.347

Table 3. Effect on 1968 soybean seed yield at Elk River, Minnesota when different rates and sources of potassium fertilizer were plowed down in the spring of 1968.

Potassium sources	Pounds K_2O per acre				Means of all rates
	100	200	400	800	
	Bu/acre	Bu/acre	Bu/acre	Bu/acre	
K_2HPO_4	27.4	31.0	26.1	27.1	27.9
K_2SO_4	30.1	28.4	27.8	28.2	28.6
K_2CO_3	33.0	34.3	28.7	30.2	31.5
$K_2SO_4 \cdot MgSO_4$	26.5	32.4	29.5	29.9	29.6
KNO_3	29.3	28.4	30.4	30.4	29.6
KCl	32.1	30.9	30.3	30.7	31.0
Average of all sources	29.7	30.9	28.8	29.4	29.7

Check plot average (5 replicates) 29.6 bu/acre

Coefficient of variation: 12.6

Analysis of Variance for Data of Table 3

Source of variation	Degrees of freedom	Mean square	F value
Replicates (R)	3	88.95	2.13
K sources (S)	5	30.69	0.73
Error (a)	15	41.77	
K rates (Ra)	3	18.26	1.44
Ra x S	15	11.71	0.92
Error (6)	54	12.70	

Coefficient of variability (a): 21.8

(b): 12.0%

Table 4. Effect on 1968 soybean seed yield at Elk River, Minnesota when different sources of potassium fertilizers at the rate of 200 pounds K_2O per acre were plowed down in the spring of 1968.

Potassium sources	Seed yield
	Bu/acre
K_2HPO_4	27.4
K_2SO_4	30.1
K_2CO_3	33.0
$K_2SO_4 \cdot MgSO_4$	26.5
KNO_3	29.3
KCl	32.1
KCl + P (equivalent to K_2HPO_4)	26.6
KCl + S (" " K_2SO_4)	31.1
KCl + N (" " KNO_3)	30.0
KCl + S + Mg (equivalent to $K_2SO_4 \cdot MgSO_4$)	27.8
Average of all sources	29.4
Check plot average	29.6
Coefficient of variation: 10.6%	

Analysis of Variance for Date of Table 4

Source of variation	Degrees of freedom	Mean square	F value
Replicates	3	28.24	1.34
K sources	9	20.74	0.98
Error	27	21.15	

Soybean Fertilizer Placement Study

G. E. Ham, S. D. Evans, R. D. Frazier, and W. W. Nelson

Fertilizer treatments consisting of banded starter, starter in contact with the seed and a combination of banded and seed placement were superimposed on broadcast fertilizer treatments at Lamberton, Morris, Waseca, and Rosemount. The treatments and rates are shown in Tables 1, 2, 3, and 4. The analysis of variance is shown in Tables 5, 6, 7 and 8.

Seed yields of all varieties were increased by broadcast fertilizer applications at Lamberton and Morris where soil test levels of P and K were low. Foliar analyses indicated that the response was due largely to P. At Waseca and Rosemount, seed yields were not increased by fertilizer applications when the soil test levels of P and K were medium or high.

These studies showed that seed placement (or pop-up) fertilizer placement can be used with soybeans without significantly decreasing seed yield or stand. However, even with soils testing low in P and K, broadcast applications of fertilizer had a more marked effect on soybean seed yield. Under conditions of low P and K soil test levels, seed placement or band placements may be utilized if small amounts of fertilizer are used. If maximum yields are a goal, larger amounts of broadcast fertilizer should be plowed down, preferably, or disced into the soil before planting.

Table 1. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Soybeans Grown at Morris, Minnesota in 1968.

Starter Fertilizer	Variety: Chippewa '64 No broadcast bu/acre	Chippewa '64 Broadcast bu/acre	Merit No broadcast bu/acre	Merit Broadcast bu/acre	Traverse No broadcast bu/acre	Traverse broadcast bu/acre	All varieties No broadcast bu/acre	All varieties broadcast bu/acre	Average of all varieties over no broadcast and broadcast bu/acre
Check	21.4	22.9	18.3	21.0	18.1	21.2	19.3	21.7	20.5
Band (2x2)	19.9	26.2	19.8	23.6	21.2	22.1	20.3	24.0	22.1
Seed placement	20.3	24.7	18.5	23.4	20.7	22.6	19.8	23.5	21.7
Band & seed placement	21.9	25.1	19.5	24.6	20.7	22.3	20.7	24.0	22.3
Average of all starter fertilizer	20.9	24.7	19.0	23.2	20.2	22.0	20.0	23.3	21.7

Coefficient of variation: 8.[illegible]%

Fertilizer rates: Band 10+20+10
Seed placement 4+8+4
Broadcast 0+60+30 (broadcast to surface in spring 1968)

Table 2. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Soybeans Grown at Lamberton, Minnesota in 1968.

Starter Fertilizer	Variety: Chippewa '64, No broadcast	Variety: Chippewa '64, Broadcast	Variety: Corsoy, No broadcast	Variety: Corsoy, Broadcast	Variety: Hark, No broadcast	Variety: Hark, Broadcast	Variety: All varieties, No broadcast	Variety: All varieties, Broadcast	Average of all varieties over no broadcast and broadcast
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	28.0	32.4	31.1	36.5	28.7	34.0	29.2	34.3	31.8
Band (2x2)	28.1	31.8	30.2	35.5	30.6	33.0	29.6	33.5	31.5
Seed placement	28.6	33.4	33.6	34.8	32.5	33.6	31.5	33.9	32.7
Band & seed placement	31.4	31.4	32.8	33.9	31.4	31.7	31.9	32.3	32.1
Average of all starter fertilizer	29.0	32.3	31.9	35.2	30.8	33.1	30.6	33.5	32.0

Coefficient of variation: 8.7%

Fertilizer rates: Band 10+20+10
Seed placement 4+8+4
Broadcast 0+60+30 (plowed down in fall 1967)

Table 3. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Soybeans Grown at Waseca, Minnesota in 1968.

Starter Fertilizer	Variety: Chippewa '64 No broadcast	Chippewa '64 Broadcast	Corsoy No broadcast	Corsoy Broadcast	Hark No broadcast	Hark Broadcast	All varieties No broadcast	All varieties Broadcast	Average of all varieties over no broadcast and broadcast
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	36.5	35.4	40.6	39.6	42.5	41.3	39.9	38.8	39.3
Band (2x2)	37.9	34.5	43.1	38.4	39.6	41.3	40.2	38.0	39.1
Seed placement	35.4	33.5	40.8	38.3	42.2	40.0	39.4	37.3	38.3
Band & seed placement	37.2	33.7	39.5	41.1	36.3	37.0	37.7	37.3	37.5
Average of all starter fertilizer	36.8	34.3	41.0	39.4	40.2	39.9	39.3	37.8	38.5

Coefficient of variation: 5.0%

Fertilizer rates: Band 16+40+53
Seed placement 4+8+12
Broadcast 0+100+150 (broadcast to surface in spring 1968)

Table 4. Effect on Soybean Seed Yield When Different Fertilizer Placements Were Applied to Chippewa 64 Soybeans Grown at Rosemount, Minnesota in 1968.

Starter Fertilizer	Fertilizer rate lb/acre N-P-K	No broadcast bu/acre	Broadcast[a] bu/acre	Average of no broadcast and broadcast bu/acre
Check	0-0-0	33.4	32.2	32.8
Seed placement	4+8+4	35.9	31.1	33.5
Band 2" x 2"	10+20+10	35.4	32.2	33.8
Band 3" below seed	10+20+10	34.3	33.1	33.7
Band 2" x 2" + seed placement	10+20+10 4+8+4	34.2	30.6	32.4
Band 3" below seed + seed placement	10+20+10 4+8+4	36.1	33.2	34.7
Band 2" :- 2"	(0+40+40)	32.5	31.3	31.9
Average of all starter fertilizer		34.5	32.0	

Coefficient of variation:

[a]Broadcast consisted of 0+40+40 applied in spring and disced in about 2 weeks before planting.

Table 5. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Morris, Minnesota in 1968.

Source of variation	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	22.77	1.56 NS
Varieties (V)	2	30.21	2.08 NS
R x V (error a)	6	9.83	
Broadcast (B)	1	259.87	17.86 **
V x B	2	11.76	0.81 NS
R x V x B (error b)	9	14.55	
Starter (S)	3	16.10	5.32 **
V x S	6	21.69	0.72 NS
B x S	3	1.36	0.45 NS
V x B x S	6	4.93	1.63 NS
R x V x B x S (error c)	54	3.02	

Table 6. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Lamberton, 'Iinnesota in 1968.

Source of varieties	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	5.57	0.57 NS
Varieties (V)	2	67.93	6.99 *
R x V (error a)	6	9.71	
Broadcast (B)	1	203.53	43.50 **
V x B	2	2.49	0.53 NS
R x V x B (error b)	9	4.68	
Starter (S)	3	6.59	2.38 NS
V x S	6	2.34	0.84 NS
B x S	3	23.74	8.57 **
V x B x S	6	3.84	1.39 NS
R x V x B x S (error c)	54	2.77	

Table 7. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Waseca, Minnesota in 1968.

Source of variation	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	23.64	1.55 NS
Varieties (V)	2	220.53	1.45 NS
R x V (error a)	6	15.21	
Broadcast (B)	1	49.16	2.32 NS
V x B	2	9.79	0.46 NS
R x V x B (error b)	9	21.20	
Starter (S)	3	17.02	4.61 *
V x S	6	16.53	4.48 *
B x S	3	4.31	1.17 NS
V x B x S	6	9.28	2.52 *
R x V x B x S (error c)	54	3.69	

Table 8. Analysis of Variance for Soybean Seed Yield When Starter Fertilizer Was Superimposed on Broadcast Fertilizer at Rosemount, Minnesota in 1968.

Sources of variation	Degrees of freedom	Mean square	Calculated F value
Replicates (R)	3	6.51	1.42 NS
Broadcast (B)	1	20.64	4.52 **
B x R (error a)	3	4.57	
Starter fertilizer (S)	6	7.20	1.27 NS
B x S	6	15.84	2.79 *
B x S x R (error b)	36	5.67	

Effect of Winter Versus Spring Fertilization on 1968 Corn Yield

J. M. MacGregor, W. W. Nelson and P. M. Burson

Since there is considerable interest in broadcasting commercial fertilizer for corn during the winter months and the comparative yield with similar applications made a few months later in the spring, a field experiment was designed to determine any marked fertility differences which might occur on three fields, two being on the Soils Unit of the Experiment Station, Rosemount, one located on Ostrander silt loam having a 5% slope (fall plowed) and the second on Judson silt loam with a 1% slope (spring plowed). A third field was located on an essentially level Webster silty clay loam on the Southwest Experiment Station, Lamberton. Four replications of randomized paired time of fertilization plots were measured out, each being approximately 50 feet long and 20 feet wide. The Rosemount treatments included N, P_2O_5 and K_2O at 40 pounds of each per acre, but the K_2O was omitted at Lamberton.

The winter of 1967-68 was characterized by little snowfall, snow depth being approximately 6 inches when the winter fertilization treatments were broadcast on January 17 and 18, 1968. The comparable spring treatments were broadcast at Lamberton on April 2nd and on the two fields at Rosemount on April 26th. Suitable corn hybrids were planted early in May to obtain a population of approximately 20,000 plants per acre.

Precipitation during the 1968 growing season at Rosemount was higher than normal, with the month of June being extremely wet. Rainfall at Lamberton was limited, until late July with an extremely wet late summer and fall. The corn was harvested in late October and ear corn yields are shown in the following three tables.

Table 1: The Yield of 1968 Ear Corn at Rosemount on Ostrander Silt Loam When Fertilized in Mid-January or in Late April

Treatment (lbs/A)	Time fertilizer broadcast	Bushels ear corn/A @ 15.5% moisture I	II	III	IV	Average	Sig.
None		100.1	110.6	116.9	107.7	108.8	a
40+0+0	January 18	109.2	124.6	103.9	113.5	112.8	a
40+0+0	April 26	112.1	99.1	119.8	127.9	114.7	a
0+40+0	January 18	95.2	110.1	108.7	125.5	109.9	a
0+40+0	April 26	112.6	111.6	117.8	119.3	115.3	a
0+40+40	January 18	97.2	115.9	109.7	121.2	111.0	a
0+40+40	April 26	109.2	113.5	127.5	111.6	115.5	a
40+40+40	January 18	116.4	106.8	109.7	117.8	112.7	a
40+40+40	April 26	110.6	118.8	129.4	105.3	116.0	a

It is evident that none of the fertilizer treatments significantly increased corn yields and this renders time of application meaningless.

Table 2: The Yield of 1968 Ear Corn at Rosemount on Judson Silt Loam When Fertilized in Mid-January or in Late April

Treatment (lbs/A)	Time fertilizer broadcast	Bushels ear corn/A @ 15.5% moisture I	II	II	IV	Average	Sig.
None		110.6	124.6	135.6	141.9	128.2	a
40+0+0	January 19	123.6	89.9	146.7	160.7	130.2	a
40+0+0	April 26	115.9	129.9	124.6	147.7	129.5	a
0+40+0	January 19	148.2	139.5	115.4	118.8	130.5	a
0+40+0	April 26	137.6	115.9	122.7	151.0	131.8	a
0+40+40	January 19	148.1	136.1	114.5	151.0	137.4	a
0+40+40	April 26	131.8	147.2	142.4	124.1	136.4	a
40+40+40	January 19	133.7	144.8	132.3	133.2	136.0	a
40+40+40	April 26	140.0	139.0	157.3	137.1	143.4	a

Again it is obvious that none of the fertilizer treatments significantly increased 1968 corn yield.

Table 3: 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 corn yield, with no significant difference between the different times of fertilizer application.

It is unfortunate that the two experimental corn fields at Rosemount failed to significantly respond to any of the four fertilizer treatments since it precludes the possibility of drawing any conclusions at these locations.

Summary

Many factors affect the relative efficiency of fertilizer applied during the winter,—such as steepness and length of slopes; soil type; snow depth; plowed or unplowed land; type, amount, and forms of nutrient elements applied; and weather during the late winter and early spring. In years of limited snow cover there is little or no mechanical problem in winter fertilization, but a heavy snow cover may seriously limit such an operation.

The limited results obtained in 1968 are promising, but are obviously insufficient to generalize on the relative merits of winter fertilization in comparison to similar treatments applied just before spring planting. This investigation is being repeated on the same experimental areas to provide a more definite answer on the feasibility of winter fertilization in Minnesota.

Sulfur Investigations on Soils and Plants in Minnesota

A. C. Caldwell, E. C. Seim and G. W. Rehm

Studies on S in soils and crops were continued in the field, greenhouse and laboratory in 1968. New investigations included NXS interactions, evaluation of a NH_4NO_3-K_2SO_4 fertilizer and the absorption of SO_2 by soils.

Sulfur in the air and in precipitation

The measurement of SO_2 in the atmosphere and precipitation was terminated in September 1968. Over 5 years of data on the possible atmospheric contribution to the S economy of 4 areas in Minnesota are now available. For the 5 year period, S in the atmosphere (H_2S and SO_2 absorbed by a PbO_2 surface) ranged from 5.8 lb/A of exposed surface at Park Rapids, Minnesota to 36.4 lb/A at St. Paul, Minnesota (two sampling sites about 200 miles apart). Absorption in an industrial area like St. Paul increased in the winter months to 14 times the Park Rapids values and dropped in the summer months to 3 times the Park Rapids values. Sulfur in precipitation ranged from an average of 3.6 lb S/A/yr. at Park Rapids to 14.7 lb S/A/yr. at St. Paul. If it is assumed that on the average soils will absorb only 22% as much S from the air as the PbO_2 surface (Alway, 1937), the average annual contribution of S to the soil from atmospheric sources (precipitation and direct absorption) was 4.9 lb S/A/yr. at Park Rapids and 22.7 lb S/Ayr. at St. Paul.

N:S ratios in alfalfa, red clover, corn and timothy

N:S ratios in first cutting red clover ranged from a 17:1 when the clover and the preceding small grain crop had received 50 lb S/A as gypsum to 22.8:1 when no S was applied. A N:S ratio of 17:1 is considered normal for rapidly growing clover.

An analysis of the second cutting of an alfalfa crop for N indicated there was no significant effect of S on the N content of established 5 year old alfalfa. N:S ratios, however, ranged from 16.9 to 1 where no S was applied to 7.4:1 when 100 lb S/A was applied annually.

N:S ratios in corn ranged from 20:1 in the 6th leaf of corn which received no S to 18.4:1 when 10 lb S/A as Na_2SO_4 was applied. N:S ratios in the corn grain were much higher, averaging 29:1 when no S was applied and 23:1 when the corn received 10 lb S/A as Na_2SO_4.

N:S ratios of timothy hay grown on organic and mineral soils in northern Minnesota ranged from 9.5:1 to 17.8:1.

<u>Sulfate-sulfur in small grain and alfalfa</u>

Small grain and alfalfa grown on the experimental field at Park Rapids were analyzed for SO_4-S. Ten lb S/A significantly increased SO_4-S in the whole plant at the rootstage from 0.020 to 0.034% in oats; from 0.019 to 0.028% in barley; and from 0.007 to 0.041% in wheat. In alfalfa, SO_4-S ranged from 0.004% when no S was applied, to 0.168% when 1000 lb S/A as gypsum had been applied 4 years previously.

<u>The effect of new S assemblages on alfalfa</u>

A study of S assemblages was initiated in 1967 involving the effect of powdered elemental S, prilled elemental S, 90% elemental S plus 10% bentonite, and 80% elemental S plus 10% bentonite plus 10% Na_2SO applied at the rate of 50 lb S/A. All of the treatments increased yields of alfalfa, although that treated with the prilled S was not significantly different from the check yields at the .05 probability level. Powdered S and the bentonite mixtures significantly increased alfalfa yields, but there was no significant difference between these materials. Yields ranged from 1.46 tons/A on the check plots to over 3 tons/A for the effective S applications

Evaluation of a NH_4NO_3-K_2SO_4 fertilizer

During the summer of 1968 field experiments were conducted to evaluate the effectiveness for corn of an IMC fertilizer product consisting of 75% NH_4NO_3 and 25% K_2SO_4. In this study the effectiveness of the new product was compared to equal amounts of N, P, and K applied as S-free materials. The IMC material did not significantly influence the yield, moisture content or shelling percentage of the corn. Corn receiving the IMC fertilizer averaged 130.9 bu/A, the S-free fertilized corn 118.7 bu/A, but this difference was not significant at the 5% probability level. There was a significant difference in the S content of the corn plants at the 5-8 inch, and 24 inch growth stages and in the 6th leaf at tasseling. Sulfur content of the tissue decreased with increasing maturity. The S containing fertilizer significantly decreased the N, P and Mo content of the 6th leaf at tasseling, but the reduced levels did not appear to be critical. N:S ratios ranged from 15:1 in the young corn plants receiving the S-free fertilizer to 11.5:1 in the 6th leaf tissue of the plants fertilized with the IMC material. N:S ratios decreased with age of plants for both S-free and S containing fertilizer treatments.

In a greenhouse experiment the growth of barley was significantly increased by N-K-S treatments at early stages of growth. In general, withholding N from the fertilizer produced a great reduction of growth and a reduction in the content and uptake of N, K, S and P. Withholding S or K from the fertilizer treatment resulted in reduction in the content and uptake of these elements respectively.

Effect of source of sulfur on yield and nutrient content of corn in a K rate study

There was no significant difference in the yield or in the nutrient content of corn to which varying levels of K were applied as K_2SO_4 or as KCl plus Na_2SO_4. Increasing rates of K application from 100 to 400 lb K/A increased the yield of corn from 111 to 132 bu/A, but these differences were not significant at the 5% confidence level.

N x S interactions

The effect of the NH_4+ and NO_3- ions on $SO_4=$ uptake by corn was studied in the field as well as in the greenhouse and growth chamber. Uptake of the $SO_4=$ ion was traced with 35-S and in some experiments the uptake of the N source was followed with 15-N.

When both the N and S sources were applied as a starter to corn in the field, the uptake of SO_4 was significantly increased when NH_4 rather than NO_3 was used as the N source. This effect was observed in young plants up to 7 weeks old. More N was absorbed by the corn when NH_4 rather than NO_3 was the N source. The uptake of fertilizer SO_4 was significantly correlated to the uptake of N from the starter. The N source, however, had no effect on the total S, SO_4-S or total N content of corn tissue. The N source also had no effect on corn yield.

Zinc Trials on Sugarbeets - 1968
Northwest Experiment Station, Crookston, Minnesota

Olaf C. Soine, Soil Scientist

Some interest has developed concerning the effect of zinc on sugarbeets on the highly calcareous soils of Western Minnesota, especially on soils where high rates of phosphate fertilizers are being used. Zinc deficiencies in corn have been observed in this part of the state and the application of this element has given increases of 10-20 bushels of corn per acre. Although no deficiencies have been observed in sugarbeets, it seemed worth while to set up a zinc experiment on this crop.

Two rates of zinc sulfate (36% zinc) were broadcast prior to planting and the same rates were applied in a band after planting. Samples of the leaf blade, petiole and roots were taken on July 3 and September 19 for zinc analysis. The beets were harvested on September 26 for yield, and analyzed for sucrose, purity, sodium, potassium and amino nitrogen.

Table 1 gives the field and laboratory data for the roots at harvest time.

Table 1. Effect of zinc on the yield, percent sucrose, purity and content of sodium, potassium, and amino N., 1968.

Treatment	Yield	Sucrose	Purity	Sodium	Potassium	Amino N.
	T./A.	%	Index			
Check	16.35	12.85	904	666	1595	528
Broad. 30 lb.	18.02	13.25	877	634	1673	523
Broad. 120 lb.	18.56	13.40	824	617	1554	498
Band 30 lb.	18.41	13.18	799	514	1625	464
Band 120 lb.	18.32	13.55	794	580	1681	451
L.S.D.	2.05	0.60	109	N.S.	N.S.	N.S.

The yield of beets varied from 16.35 to 18.56 tons per acre for the check and 120 lb. broadcast treatments, respectively. There were no significant differences in yield between the zinc treatments.

The sucrose content was increased by the zinc treatments when compared to the check, but only the 120 lb. band treatment was significantly different from all the others.

The purity index gives some information about the processing of the beets and the higher the index the more difficult it is to extract all the sugar. The highest index in Table 1 is for the check plot and the zinc treatments were lower but only the 120 lb. band treatment was significant. There were no significant differences between the treatments for potassium and amino nitrogen.

The zinc content of the blades, petioles and roots are given in Table 2 for the 2 sampling dates. The zinc content for the July 3

Table 2. Zinc content of leaf blade, petiole and roots of sugarbeets, 1968.

	Sampled July 3			Sampled Sept. 19		
Treatment	Leaf	Petiole	Root	Leaf	Petiole	Root
		P.P.M.			P.P.M.	
Check	364	131	124	119	8.6	35
Broad. 30 lb.	325	114	90	82	10.8	54
Broad. 120 lb.	362	110	106	205	10.8	48
Band 30 lb.	2.51	87	88	86	10.8	67
Band 120 lb.	300	113	98	291	9.4	63

sampling is very high and also erratic when compared to the sampling on September 19. The above normal rainfall in June and July may have had some effect on the zinc uptake, while the latter sampling gives the zinc content of a more mature beet. This is only one year's data and needs to be substantiated with more field trials at other locations.

The source of zinc used in this trial was zinc sulfate which contains 36% zinc and 12.5% sulfur. The 2 rates, 30 and 120 lbs. per acre, added 3.75 and 15 lbs., respectively, of sulfur to the soil. The question has been asked about the addition of sulfur to the soils in this area and it seemed desirable to run sulfur determinations of the leaf blade, petiole, and roots. The results are given in Table 3.

Table 3. Sulfur content of leaf blade, petiole, and roots of sugarbeets, sampled September 19, 1968.

Treatment	Rate lbs./acre	Percent sulfur Leaf	Petiole	Root
Check	0	0.71	0.13	0.06
Broadcast	30	0.91	0.13	0.06
Broadcast	120	0.88	0.14	0.07
Band	30	0.79	0.14	0.06
Band	120	0.78	0.14	0.06
L.S.D. 5%		N.S.	N.S.	N.S.

There was a slight increase in the sulfur content of the leaf blades when compared to the check plot but the increases were not significant. There were no significant increases in the sulfur content of the petioles and roots.

The soils of this area contain substantial amounts of sulfur in the form of gypsum ($CaSO_4$) and other soil minerals and from the decay of organic matter. The addition of sulfur is not recommended for crop production in this area.

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Effects of the Application of Iron and Zinc Chelates to Flax at Crookston, Minnesota in 1968

James R. Lofgren - Agronomist - N. W. School and Experiment Station

Yellowing of flax has occurred frequently in the Red River Valley. This yellowing has been noted to be associated with cooler temperatures and higher moisture conditions. The condition has been noted on numerous horticultural crops and ornamentals. The yellowing was believed to be an iron deficiency or inavailability of iron to plants associated with cool temperatures. To determine if iron would correct the symptoms on flax and to determine if the symptoms were due to an iron or zinc deficiency the following experiment was performed in 1968.

Methods and Materials

Zinc and iron chelate compounds were provided by Giegy Chemical Co. Four cultivars 'Nored,' 'Bolley,' 'B5128' and 'Summit' were selected so as to span the general range of maturity for flax. Two rates of each chelate were used: ten and five pounds per acre for iron and five and two and one-half pounds per acre for zinc. Plots were ten feet long and consisted of four rows spaced one foot apart. The design of the experiment was a split-plot with treatments as whole plots and cultivars as sub-plots. Four replications were grown on Bearden soil. The plots were seeded on May 13 and the treatments applied on June 5 when the plants were 3-4 inches tall. All plots were harvested on October 10 (killing frost occurred on October 4).

Results and Discussion

Yield data are summarized in Table 1. No significant differences

Table 1. Performance of iron and zinc chelates on flax at Crookston, Minnesota in 1968

	Check	Fe 10#	Fe 5#	Zn 5#	Zn 2.5#	Ave.
	Yield, bushels per acre					
Nored	9.5	9.6	6.2	9.6	8.1	8.6
Bolley	7.7	7.3	6.4	9.1	8.1	7.7
B5128	13.1	10.8	9.3	14.8	10.3	11.7
Summit	12.2	10.8	9.7	14.4	16.7	12.8
Ave.	10.6	9.6	7.9	12.0	10.8	

Analysis of variance indicated treatments were not statistically different. Cultivars and treatment x cultivar mean squares were highly significantly different. The standard error (S.E.) for cultivarial means was 0.6 bu. The S.E. for the difference between cultivars within one treatment was 1.3 bu.

were noted between treatments. The cultivars reacted differently when averaged over the treatments. Further differences can be noted for the treatment x cultivar interaction. The cultivar Summit responded to both rates of zinc chelate and B5128 and Bolley responded to the high rate of zinc. The yield of B5128 and Summit was significantly depressed by iron chelate at both rates. Other differences were slight depressions of yield for certain treatments over the check.

Conclusions

These results alone do not lead to any definite conclusions. Some cultivars were found to respond to zinc and not to iron. The treatments were not significantly different. This study should be continued at least one more year.

The Effect of High Rates of Zinc Application to a Zinc Deficient Soil in Swift County on Corn Growth and Leaf Zinc Concentration in 1968

O. M. Gunderson and J. M. MacGregor

Since the effect of relatively heavy applications of zinc as granular $ZnSO_4 \cdot H_2O$ were not known, an experiment was initiated on a zinc deficient calcareous loam. Three four row plot replications were treated with granular $ZnSO_4 \cdot H_2O$ to supply 10, 40, 80 and 160 pounds of zinc per acre for continuous corn. The treatments were broadcast and plowed down.

Growth observations were periodically made and there were no apparent differences in either rate of growth, or appearance of the corn plants. Sixth leaves were sampled during early silking, and these were analyzed for both Zn and P content. The results are shown in the following table.

The Effect of Heavy Zinc Applications on Corn Leaf Zinc Concentrations to a Zinc Deficient Soil Near Benson, Swift County, Minnesota.

Rate of Zinc Application (lbs/A)	Replicate 1	Replicate 2	Replicate 3	Average
	Corn leaf zinc in parts per million			
10 as $ZnSO_4 \cdot H_2O$	14.5	12.3	17.0	14.6
40 as $ZnSO_4 \cdot H_2O$	17.0	19.7	18.8	18.8
80 as $ZnSO_4 \cdot H_2O$	21.5	18.2	29.0	22.9
160 as $ZnSO_4 \cdot H_2O$	40.5	31.4	32.8	34.9

Increasing the rate of zinc application to the soil from 10 to 40 pounds per acre increased average leaf zinc about 4 ppm, while the 80 pounds per acre rate produced a further increase. Increasing the zinc application rate to 160 pounds per acre more than doubled leaf zinc, but even this corn leaf zinc concentration is relatively common in corn leaves grown on many Minnesota soils where no presently recognized Zn deficiency occurs.

Since the heavier rates of Zn application had neither apparent beneficial nor detrimental effect on corn growth, and leaf zinc concentrations were not abnormally high, yield samples were not taken in this experiment.

The 1966-67-68 Experiments on Effect of Zinc Sources and Zinc Phosphate Interaction on Corn Leaf Composition and Grain Yield on a Calcareous Loam in Swift County

O. M. Gunderson, J. M. MacGregor, S. D. Evans & G. W. Randall

In the spring of 1966, a project was commenced to study:

1. The effect of several commercial zinc fertilizer materials, and
2. The effect of increasing amounts of phosphate fertilization on the zinc and phosphorus content of the sixth corn leaf and on the resulting ear corn yield.

Two randomized block experimental areas were established in mid-May of 1966 on the Richard Mikkelson farm some 2 to 3 miles north of Benson in Swift County. Each experiment consisted of 7 treatments replicated 4 times. All zinc treatments except one chelated zinc source (which was row applied each year) and all P treatments were broadcast and then plowed down. The farm operator also applied a total of 100 + 40 + 40 per acre as a blanket broadcast application before plowing. In 1966 the spring was late, so 90 day maturity corn was planted. Atrazine was applied on June 1st and leaf samples were taken in early September. In 1967, the planting season was earlier and a 100 day corn maturity was used. A mid-September frost materially decreased the 1967 ear corn yield. The 1968 growing season was more normal.

One of the problems in field experiments with zinc fertilization is the extreme variability of soils in their response to zinc applications. For this reason, large apparent differences may not be statistically significant.

The initial soil pH was 8.2, and soil P using Bray No. 1 extractant (1:10) varied from 3 to 50 pounds per acre.

Visual Zn Deficiency Symptom Rating and Zn Content of 6th Corn Leaf

In each of the three years of the study, visual estimates of severity of zinc deficiency symptoms have been made about silking time. A scale of 0 to 10 was used by two individuals making independent ratings with the lower value representing the most severe symptoms on the four replications of each treatment. The two ratings of the four plot averages were then averaged and 10 of the 6th corn leaves from the ground on each plot were then collected, washed, dried, ground and analyzed for zinc content. Both the visual ratings and leaf zinc concentrations for the three years are shown in Table 1.

It is obvious that a close relationship exists between the visual Zn deficiency symptoms exhibited by the corn plants and the zinc content present in the leaves at that (silking) time. It would appear that there is little additional value in determining leaf zinc content by chemical methods when visual deficiency symptoms are so well correlated.

The Effect of Zinc and Phosphate Applications on Corn Leaf Composition

Corn leaves were analyzed for both Zn and P during each of the three growing seasons and the values obtained are shown in Table 2.

In the zinc source study, increasing rates of Zn as granular $ZnSO_4 \cdot H_2O$ (36% Zn) have significantly increased zinc leaf content in each of the three years and depressed leaf phosphorus in 1966 and 1967, but not in 1968. The effect of ZnMNS on leaf zinc was intermediate, with the chelated zinc (Na_2Zn) showing the least increase in leaf zinc, with a variable but generally lesser effect on leaf phosphorus.

The addition of phosphate to the soil, especially at the higher rates, depressed leaf zinc in 1966 and 1967, but resulted in no significant depression in 1968. Higher phosphate applications increased leaf P, but

Table 1. Visual Ratings of Zinc Deficiency in Growing Corn Plants and Zinc Content of Sixth Corn Leaves.

1966 Treatment (lbs/A)	1966 Visual rating[a]	1966 Leaf Zn ppm	1967 Visual rating[a]	1967 Leaf Zn ppm	1968 Visual rating[a]	1968 Leaf Zn ppm
No zinc	5.1	7.2c	3.2	9.2d	3.0	14.8a
10 as $ZnSO_4$(P.D.1966)	7.9	11.7bc	7.1	13.8c	6.5	16.4ab
20 " "	8.7	14.0b	8.6	18.2b	8.7	23.4bc
40 " "	9.0	18.0a	8.5	26.5a	9.0	29.4c
10 as ZnMNS(")	8.7	9.3bc	8.0	12.8cd	7.5	15.3[illegible]
0.5 Zn as Zn 45 (row annually)	2.6	8.6c	6.4	11.8cd	6.0	12.1a
2.5 Zn as Zn 45 (P.D. 1966)	6.0	8.3c	3.9	11.5cd	3.0	12.7a
Phosphate-Zinc Interaction						
40 P_2O_5 (P.D. in 1966)	7.0	10.0ab	7.5	10.2abc	7.0	13.3
80 " (")	7.0	10.2ab	7.0	12.5ab	5.7	16.1a
160 " (")	5.7	8.4bc	8.0	10.5abc	6.2	13.1a
320 " (")	3.9	7.5c	5.0	9.0bc	3.2	12.7a
640 " (")	2.7	7.3c	3.5	8.2c	2.5	9.3a
320 " + 10 Zn as SO_4 (P.D. in 1966)	8.5	12.4a	8.4	13.2a	8.7	15.4a
640 P_2O_5 + 10 Zn as SO_4 (P.D. in 1968)	7.9	11.0a	8.5	12.0ab	8.2	17.3a

[a] 0 = severe zinc deficiency symptoms, 10 = essentially normal corn growth

P.D. = plowed down

Table 2. The Effect of Zinc & Phosphate Treatments on the Zinc & Phosphorus Content of the Sixth Corn Leaf (1966-1968)

	Ppm leaf zinc			% leaf phosphorus		
Treatment (lbs/A)	1966	1967	1968	1966	1967	1968
No zinc	7.2c	9.2d	14.8c	0.400a	0.367a	0.410cd
10 as $ZnSO_4$(P.D.[a] 1966)	11.7bc	13.8c	16.4bc	0.297bc	0.304bc	0.338d
20 " "	14.0b	18.2b	23.4ab	0.259c	0.273c	0.462bc
40 " "	18.0a	26.5a	29.4a	0.259c	0.281bc	0.511b
10 as ZnMNS(P.D.1966)	9.3bc	12.8cd	15.3c	0.326abc	0.285bc	0.630a
0.5 Zn as Na_2Zn (row annually)	8.6c	11.8cd	12.1c	0.394a	0.331ab	0.351d
2.5 Zn as Na_2Zn (P.D. 1966)	8.3c	11.5cd	12.7c	0.372ab	0.323abc	0.458bc
<u>Phosphate-Zinc Interaction</u>						
40 P_2O_5 (P.D. in 1966)	10.0ab	10.2abc	13.3a	0.351bc	0.317c	0.410
80 " "	10.2ab	12.5ab	16.1a	0.313bc	0.312c	0.338
160 " "	8.4bc	10.5abc	13.1a	0.359bc	0.323c	0.462
320 " "	7.5c	9.0bc	12.7a	0.400b	0.436b	0.510
640 " "	7.3c	8.2c	9.3a	0.486a	0.570a	0.630
320 P_2O_5 + 10 Zn as SO_4 (P.D. in 1966)	12.4a	13.2a	15.4a	0.325bc	0.308c	0.351
640 P_2O_5 + 10 Zn as SO_4 (P.D. in 1966)	11.0a	12.0ab	17.3a	0.304c	0.310c	0.458

[a] P.D. = plowed down

the addition of 10 pounds of zinc per acre generally increased leaf zinc and lowered P levels. Since the effect of added Zn and P_2O_5 significantly affected leaf Zn and P in the first two years of this study and with no significant effect in the third year (1968), it is possible that these two element additions made early in 1966 are becoming less effective on the third corn crop.

The effects of the 1966 zinc and phosphate soil treatments on ear corn yields during the three years and amounts of available soil zinc as determined by the Institute of Agriculture Soil Testing Laboratory on 1968 samplings are shown in Table 3.

It is obvious that the zinc soil test is extracting the zinc applied to this calcareous loam more than two years earlier, with a general direct relationship to the amount of zinc applied.

The great variability in the severity of zinc deficiency exhibited by corn plants growing on this soil is well illustrated by the large differences in ear corn yield following fertilization with the different zinc sources, but these were not mathematically significant in either 1967 or in 1968. The general trend is shown by the three year yield averages.

Heavier P_2O_5 applications made in 1966 appeared to depress the amount of zinc extracted by test and significantly depressed corn yields in 1966 and in 1968. The 1966 addition of 10 lbs. of Zn/A increased the amount of zinc extracted from soils sampled in 1968 and also ear corn yields in the two more favorable growing seasons (1966 and 1968).

Table 3. The Effect of 1966 Zinc & Phosphate Fertilization on 1968 Available Soil Zinc, and on 1966, 1967 and 1968 Ear Corn Yield

Soil Treatment (lbs/A)	1968 Soil Test (lbs Zn/A)					Ear Corn @ 15.5% moisture(Bu/A)			
	Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg.	1966	1967	1968	Avg.
No zinc	1.6	1.6	0.9	0.9	1.2	92.0bc	56.1a	71.3a	73.1
10 as $ZnSO_4$(P.D.[a] 1966)	0.9	1.8	1.8	1.9	1.6	115.4a	77.5a	92.4a	95.1
20 " (")	3.6	2.9	4.6	2.5	3.4	111.8a	75.6a	94.8a	94.1
40 " (")	5.0	5.6	3.3	5.7	4.9	109.3a	81.7a	88.8a	93.3
10 as ZnMNS(")	2.2	2.0	2.4	1.6	2.1	103.8ab	79.2a	86.9a	90.0
0.5 as Na_2Zn (row annually)	1.5	1.1	1.1	2.0	1.4	85.5c	69.7a	93.4a	82.9
2.5 as Na_2Zn (P.D. in 1966)	4.1	1.9	1.1	1.4	2.1	93.3bc	58.4a	79.0a	76.9
Phosphate-Zinc Interaction									
40 P_2O_5 (P.D.[a] 1966)	0.8	1.7	1.6	1.3	1.3	98.4ab	68.5a	86.9abc	84.6
80 " "	1.0	1.1	3.8	2.1	2.0	96.9ab	65.8a	94.5bc	85.7
160 " "	1.0	1.6	1.0	1.5	1.3	96.3ab	60.8a	100.0c	85.7
320 " "	0.9	1.3	1.2	1.6	1.2	96.8ab	50.2a	81.4ab	76.1
640 " "	0.9	1.4	0.8	1.3	1.1	83.4b	34.3a	72.0a	63.2
320 " + 10 Zn as SO_4 (1966)	3.9	3.9	2.2	3.0	3.2	113.6a	74.8a	92.6bc	93.7
640 " "	4.5	2.6	7.7	2.6	4.3	107.6a	74.7a	100.6c	94.3

[a] P.D. = plowed down

The 1968 corn grain was analyzed for zinc concentrations, and the individual analyses for each plot are shown in Table 4. The average concentrations were then calculated and the actual zinc removed in the 1968 corn grain was determined on the dry grain basis, assuming 56 pounds of corn grain per bushel at zero moisture content.

Table 4. Zinc in 1968 Corn Grain at Benson. Mickelson-Swift County.

Soil Treatment (lbs/A)	Zinc in 1968 Corn Grain (ppm) 1	2	3	4	Average	1968 Yield Bu/A	Pounds of Zn removed per acre
No zinc	26.4	17.0	20.9	7.3	17.9	71.3	0.060
10 as $ZnSO_4 7H_2O$ (P.D.[a] 1966)	18.3	16.3	22.5	14.4	17.9	92.4	0.078
20 " (")	18.0	16.5	11.0	20.7	16.6	94.8	0.075
40 " (")	31.8	34.8	27.8	26.0	30.1	88.8	0.127
10 as ZnMNS (")	23.5	16.3	12.9	18.0	17.7	86.9	0.073
0.5 as Na_2Zn (row annually)	14.5	16.2	15.2	9.4	13.8	93.4	0.061
2.5 as Na_2Zn (P.D. in 1966)	21.3	16.2	16.4	14.8	17.2	79.0	0.064
Phosphate-Zinc Interaction							
40 P_2O_5 (P.D.[a] 1966)	15.4	13.5	12.4	14.8	14.0	86.9	0.058
80 " "	9.3	11.5	17.3	13.8	13.0	94.5	0.045
160 " "	11.5	10.4	13.5	12.0	11.9	100.0	0.056
320 " "	6.0	8.5	12.4	9.9	9.7	81.4	0.037
640 " "	7.0	11.4	9.9	7.9	9.1	72.0	0.031
320 "+ 10 Zn(")	19.4	15.2	13.5	15.5	15.9	92.6	0.070
640 "+ 10 Zn(")	11.7	15.8	12.0	14.4	13.5	100.6	0.064

[a] P.D. = plowed down

It is evident that only the 40 pound rate of zinc application (made in 1966) produced a marked increase in zinc present in the corn grain. Phosphate treatments produced a steady decrease in the zinc concentrations in the grain, but this was remedied by treating with 10 lbs of Zn/A.

It is evident that relatively small amounts of zinc per acre are being removed in the corn grain.

Effect of Micronutrient Additions to Soybeans on Seed Yield

G. E. Ham, R. D. Frazier, W. W. Nelson and S. D. Evans

The seed treatments outlined in Table 1 were applied to Chippewa 64 soybean seed before planting at Big Lake, Lamberton, Waseca, Morris and Rosemount. Foliar analyses indicated that the concentrations of nutrients added were normal or above normal on the check plots and the addition of these nutrients did not significantly affect the concentration of the element in the leaves.

Table 1. Effect on Soybean Seed Yield When Different Micronutrients were Added to Chippewa Soybeans in 1968

	Location					Average of all locations
	Big Lake bu/acre	Lamberton bu/acre	Morris bu/acre	Rosemount bu/acre	Waseca bu/acre	
Check	15.1	34.3	23.0	28.9	42.7	28.8
Mo 50gm/acre	13.4	35.4	27.2	28.7	44.1	29.8
Mo 100gm/acre	11.7	34.3	26.9	28.2	41.8	28.6
Co 30gm/acre	13.3	35.2	26.8	25.9	40.6	28.4
Co 30gm/acre	14.3	31.6	25.4	24.4	42.4	27.6
Fe 2 lbs/acre	16.3	36.5	26.9	25.6	41.5	29.4
Fe 4 lbs/acre	13.0	37.3	27.2	26.9	41.5	29.2
Zn 2 lbs/acre	14.5	38.7	27.1	29.4	43.0	30.5
Zn 4 lbs/acre	15.9	37.8	27.1	26.9	43.1	30.1
Mn 2 lbs/acre	16.2	37.5	25.1	26.4	44.6	29.9
Mn 4 lbs/acre	14.1	37.6	27.0	28.1	42.3	29.8
Molycofix [a]	14.9	33.0	26.1	24.4	41.7	28.0
Polyplex - 2	16.[illegible]	33.6	35.4	25.3	42.2	28.5
Polyplex - 4	14.4	31.4	23.9	22.9	42.9	27.1
Cu 1 lb/acre	15.6	31.4	25.0	24.8	45.1	28.4
Cu 2 lbs/acre	16.4	33.5	24.4	24.6	44.6	28.7
Molynoc [b]	13.9	34.7	26.9	29.2	43.1	29.6

[a] Obtained from W. R. Grace Co., Princeton, Illinois and added at recommended rate

[b] Obtained from Kolo Inoculant Co., Quincey, Illinois and added at recommended rate

The Effect of Zinc and Phosphate Applications on Zinc and Phosphorus Concentrations in Corn Leaves and Ear on Corn Yield of Two Farm Fields in Western Minnesota in 1968

Orville M. Gunderson and John M. MacGregor

Two western Minnesota corn fields were selected for Zn:P interaction investigations late in 1967. Three replications, each consisting of six 15' x 40' plots were treated in a randomized block; the treatments being; check, 60 lbs P_2O_5/A, 120 lbs P_2O_5/A, 240 lbs P_2O_5/A, 10 lbs Zn/A, and 240 lbs P_2O_5 + 10 lbs Zn/A. These were applied and plowed down in the fall and field corn was planted in 30" rows in the spring of 1968.

Hot and very dry weather occurred during tasselling and silking and this greatly reduced ear corn yields and the possibilities of zinc or phosphate effect. The two field results are best considered individually. Applied Zn was granular $ZnSO_4.H_2O$ and superphosphate was the P source.

The Eldren Lichtsinn Farm Experiment - Dumont, Traverse County

Corn had been grown on this Bearden silt loam in 1967. Soil pH averaged 7.4, available P was 10 lbs/A, K was 200 lbs/A, and available soil zinc test showed 2.2 lbs/A (high). Table 1 shows the 1968 corn leaf zinc and phosphorus concentrations at silking (under drowth conditions) and the eventual yield of ear corn.

Table 1. Fertilizer Treatment, Concentrations of Leaf Zinc, Phosphorus, and the Ear Corn Yield in 1968 on the Eldren Lichtsinn Field. (Bearden silt loam)

Treatment (lbs/A)	Leaf zn (ppm)	% Leaf P	Yield of ear corn (bu/A @ 15.5% moisture)
Check	21.0	0.289	102.9
60 P_2O_5	23.0	0.280	92.5
120 P_2O_5	26.8	0.286	111.0
240 P_2O_5	17.9	0.303	100.0
10 Zn	20.7	0.284	103.9
240 P_2O_5 + 10 Zn	19.4	0.283	106.4

The results show no consistent relationship in leaf Zn, P, or corn yields to the applied phosphate or zinc treatments. The low soil test value for soil P of 10 pounds per acre would indicate a probable phosphate yield response, but this did not occur. The relatively high test for available soil zinc is more consistent with the erratic yield results, but zinc applications to this soil failed to increase corn leaf zinc which might be normally expected.

The Charles Burmeister Farm Experiment - Chokio, Stevens County

This was a Hamerly clay loam having a pH of 7.4, extractable P was 13 lbs/A, an exchangeable K level of 370 (high), with a low available zinc test of only 1.2 ppm. Due to a drainage problem, only two replications of this field were harvested. The results are shown in Table 2.

Table 2. Fertilizer Treatment, Concentrations of Leaf Zinc, Phosphorus, and the Ear Corn Yield in 1968 on the Charles Burmeister Farm. (Hamerly clay loam)

Treatment (lbs/A)	Leaf Zn (ppm)	% Leaf P	Yield of ear corn (bu/A @ 15.5% moisture)
Check	19.5	0.239	66.6
60 P_2O_5	18.2	0.245	80.2
120 P_2O_5	14.3	0.266	71.3
240 P_2O_5	16.6	0.241	67.5
10 Zn	21.4	0.206	73.3
240 P_2O_5 + 10 Zn	34.0	0.241	73.9

With data from only two replications, and with all values being quite erratic, it is not possible to draw any valid conclusions from the results on this experimental field.

In conclusion, the extremely dry soil conditions at silking time when leaf sampling was done, may have seriously affected the leaf Zn:P balance and nullified the possibility of obtaining the usual Zn:P interaction previously observed in the corn growing on zinc deficient soils of western Minnesota. Corn yields were apparently independent of the applied mineral treatments.

A Survey of Micronutrient Additions to Corn In Southwest Minnesota

G. D. Holcomb and H. L. Meredith [1]

Situation Statement

During recent years there has been considerable concern of the need for the addition of micronutrients. As corn yields increase, it has frequently been suggested that the absence of one or more of the micronutrients may limit yield. Results in many areas of the nation have shown a profitable yield response to the application of a micronutrient. For clarity, N, P, and K, nutrients required in larger amounts, are referred to as the major nutrients or macronutrients. The nutrients required in trace amounts are referred to as minor or micronutrients.

There has been only limited research with micronutrients in southwest Minnesota. These results plus a general knowledge of micronutrients have served as the basis for recommendation of micronutrient needs in this part of the state.

Procedure for Demonstration Plots

To evaluate the need and to obtain leaf values for nutrients, demonstration plots were established in Cottonwood, Jackson, Nobles, and Rock Counties during May of 1968.[2] The indicator crop was corn. The micronutrients consisted of zinc, copper, manganese and iron. Plots were established in cooperation with the Tennessee Valley Authority, the

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[2]The cooperating county agricultural agents of these counties were respectively Paul Sandager, Ray Palmby, Robert Koehler, and Kent Ringkob and this investigation was made possible largely through their active participation.

Treatment (lbs. material per acre)	Yield, Bu/A at 15.5% Moisture
No starter	119.7
Starter only	118.3
2 lbs. zinc + starter	114.4
2 lbs. zinc, 2 lbs. manganese + starter	107.0
2 lbs. zinc, 2 lbs. manganese, 1 lb. copper + starter	107.3
4 lbs. zinc + starter	114.7
2 lbs. iron + starter	117.8
Starter only	112.0

Jackson County--Curtis Pietz farm. Planted May 3. Hybrid, Pioneer 3582. Insecticide, Thimet. Fertilizer: broadcase 0+97+65 per acre; preplant 160 pounds nitrogen per acre; with seed, 60 pounds 7-24-3 per acre. Harvested December 6. Stand, 21,500.

Treatment (lbs. material per acre)	Yield, Bu/A at 15.5% Moisture
1 lbs. zinc + starter	124.9
Starter only	127.3
1 lb. zinc, 1 lb. iron, 3/4 lb. manganese, 1/2 lb. copper + starter	127.4
Starter only	119.2
2 lbs. zinc + starter	124.5

Nobles County--Joel McCarvel farm. Planted May 10. Hybrid, Funks G18A. Fertilizer: 110 lbs. nitrogen per acre preplant; 96 pounds 7-21-7 per acre with planter. Harvested November 26. Stand, 18,000.

Treatment (lbs. material per acre)	Yield, Bu/A at 15.5% Moisture			
	I	II	III	Average
2 lbs. zinc + starter	89.7	84.6	--	87.1
Starter only	92.6	84.7	83.3	86.9
2 lbs. zinc, 1 lb. copper, 1.5 lbs. manganese, + starter	81.4	86.7	--	84.0
4 lbs. zinc + starter	86.4	78.6	--	82.5

Table 1. Analyses of corn plants at 15 to 24 inches height (leaves extended) from Jackson, Cottonwood, Nobles and Rock Counties, Minnesota, 1968.

	Percent				Parts Per Million				
	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B
C. Pietz, 2 lbs. Zn	.47	3.5	.60	.30	30	12	1.8	53	12
Pieta, Zn,Fe,Mn,Cu	.49	3.23	.70	.33	27	14	1.9	61	13
Pietz, check #1 (W)	.44	3.6	.59	.29	24	13	1.5	54	11
Pietz, #1 Zn	.54	3.5	.66	.33	33	14	1.6	64	12
J.McCarvel, 2 Zn	.43	3.4	.49	.40	44	12	2.2	49	13
J.McCarvel, E. Ck.	.37	3.2	.46	.38	27	11	2.0	40	12
McCarvel, Zn,Mn,1 Cu	.39	3.8	.48	.36	39	15	1.4	45	10
McCarvel, W. Ck.	.34	3.6	.42	.36	35	12	1.4	35	10
McCarvel, 4 Zn	.43	3.2	.47	.36	40	11	2.3	39	14
R. O'Toole, 4 Zn	.40	3.1	.49	.37	32	12.9	2.1	51	9.9
R. O'Toole, Check	.39	3.0	.56	.47	33	12	1.8	58	9.4
R. O'Toole, Zn,Fe,Mn,Cu	.36	3.4	.46	.40	36	13	1.2	54	7.0
R. O'Toole, 2 Zn	.40	3.2	.58	.49	33	14	1.8	59	8.8
R. O'Toole, Starter	.40	3.2	.52	.47	34	14	1.6	53	7.5
W. Turner, Pop-up	.37	3.0	.56	.38	40	11	1.4	39	10
W. Turner, 2 Zn	.39	3.2	.66	.38	30	12	1.8	45	12
W. Turner, 2 Zn-Mn	.40	3.1	.68	.43	33	13	1.7	44	11
W. Turner, Zn,Mn,Cu	.42	2.8	.57	.34	31	12	1.9	41	13
W. Turner, 4 Zn	.40	3.3	.54	.39	38	11	1.4	35	10
W. Turner, Fe	.39	3.0	.53	.36	39	11	1.2	42	9.7
J. Hedquist, Zn	.42	3.6	.47	.27	37	8.2	1.1	45	9.1
J. Hedquist, Cu	.46	3.5	.50	.27	33	9.1	1.4	48	10
J. Hedquist, Check	.46	3.2	.46	.24	32	9.5	1.4	48	11
J. Hedquist, Mn	.47	3.5	.50	.30	30	8.5	1.4	51	10

No nutrient deficiency symptoms were observed throughout the growing season. There did not appear to be any yield response to starter fertilizer in these comparisons. None of the micronutrients added appeared to effect the final yield. The micronutrient solutions did not appear to consistently alter the composition of a particular micronutrient in the plant. Although these data are not conclusive, indications are that in 1968 yields were not increased by the micronutrient additions under the conditions studied on the farms represented in the southwest counties of Minnesota.

The above tissue data may be used as composition references for normal or near-normal corn plants in this part of the state at this stage of development. The comparison of tissue P and soil test P on yield appears in Table 2. The soil test results are shown in Table 3. Soil tests of the farm in Jackson and part of the samples from Cottonwood County are fairly high. Samples from Nobles, Rock and part of Cottonwood County reflected low phosphorus soil tests. The highest corn yields were made on the Hedquist farm in Cottonwood County (high soil tests - 127 bu/A) and the Pietz farm in Jackson County (high soil tests - 125 bu/A).

Table 2. Comparison of tissue P and soil test P with yield of corn, southwest Minnesota, 1968.

Farmer	County	Average Tissue P %	Average Soil Test P lbs/A	Average pH	Average Corn Yield Bu/A
Pietz	Jackson	.485	39.5	6.0	124.8
Turner	Cottonwood	.395	15.6	6.5	113.9
Hedquist	Cottonwood	.452	51.8	6.1	127.3
McCarvel	Nobles	.392	13.2	6.1	85.1
O'Toole	Rock	.390	10.4	6.6	109.2

Table 3. Soil tests of soils used in survey of micronutrient deficiencies in southwest Minnesota, 1968.

Sample Number	County	Farmer	pH	P[1]	K[2]	Treatment
S-25	Jackson	Pietz	6.0	37	300	1 lb. Zn
S-26	Jackson	Pietz	5.7	54	330	2 lb. Zn
S-27	Jackson	Pietz	6.1	40	300	Check
S-28	Jackson	Pietz	6.0	27	280	2 lb. Zn, 2 lb. Mn, 1 lb. Cu, 2 lb. Fe
S-29	Cottonwood	Turner	6.4	12	200	2 lb. Zn, 2 lb. Mn, 1 lb. Cu
S-30	Cottonwood	Turner	6.7	14	220	Pop-up
S-31	Cottonwood	Turner	6.6	12	230	2 lb. Zn, Mn
S-32	Cottonwood	Turner	6.5	15	230	2 lb. Zn
S-33	Cottonwood	Turner	6.3	23	210	2 lb. Fe
S-34	Cottonwood	Turner	6.0	17	200	4 lb. Zn
S-36	Cottonwood	Hedquist	5.9	58	390	Check
S-37	Cottonwood	Hedquist	6.2	48	360	1 lb. Cu
S-38	Cottonwood	Hedquist	6.2	62	400	2 lb. Zn
S-39	Cottonwood	Hedquist	6.1	45	330	2 lb. Mn
S-40	Cottonwood	Hedquist	6.3	46	300	Starter only
S-41	Nobles	McCarvel	6.6	12	300	Check
S-42	Nobles	McCarvel	6.4	20	360	4 lb. Zn
S-43	Nobles	McCarvel	6.4	8	280	2 lb. Zn
S-44	Nobles	McCarvel	6.6	9	270	2 lb. Zn, 1 lb. Cu, 1.5 lb. Mn
S-45	Nobles	McCarvel	6.6	17	410	Check
S-46	Rock	O'Toole	6.6	8	250	Starter only
S-47	Rock	O'Toole	6.7	8	210	2 lb. Zn
S-48	Rock	O'Toole	6.7	9	240	Check
S-49	Rock	O'Toole	6.6	12	300	2 lb. Zn, 2 lb. Fe, 1.5 lb. Mn, 1 lb. Cu
S-50	Rock	O'Toole	6.5	15	280	4 lb. Zn

[1]Bray No. 1 extracting solution, soil-solution ratio of 1:10.

[2]Neutral 1 N ammonium acetate extracting solution and Perkin-Elmer flame photometer.

Interpretation of phosphorus and potassium contents of Minnesota soils.

Relative Level	Extractable Phosphorus (P) Lbs. Per Acre	Exchangeable Potassium (K) Lbs. Per Acre
Low	0-10	0-100
Medium	11-20	101-200
High	21-30	201-300
Very high	Over 30	Over 300

<u>Summary and Conclusions</u>

A demonstration was conducted in southwest Minnesota to delineate the response of the addition of micronutrients on the growth of corn. No micronutrient deficiencies were noted throughout the growing season. No response to micronutrients was noted visually or reflected in corn yields. No leaf analyses were particularly low in any of the elements measured.

Tissue P and soil test P values corresponded to corn yields. The higher P values were grouped with the highest yield.

The results of this demonstration help to emphasize the need for maintaining soils at a desirable fertility level as determined by soil test.

Zinc deficiency typically occurs on soils with high pH and low organic matter levels. Since all of these soils were below 7.0 in pH, it is not surprising that a zinc response was not noted. Manganese and iron are seldom limiting except on soils with a pH above 7.5. Additions of copper to mineral soils have previously been observed to have little or no influence on tissue Cu or on yield when applied at the rate used in this study.

Cobalt Content of Minnesota Soils, Legumes, and Grasses

J. M. MacGregor and J. L. Keogh

In the mid-1940's, a cobalt deficiency in calves was reported near the town of Dundas, in Rice County, Minnesota. Feeding experiments conducted by the late Dr. Thor W. Gullickson of the then Department of Dairy Husbandry, established that the inclusion of cobalt in the diet of the unhealthy animal resulted in apparently normal health and subsequent growth. Since very little was known of the cobalt status of Minnesota soils or of the pasture or hay plants growing on different soils, a study was commenced in the late summer of 1948 on this problem.

Bulk soil samples were collected from 11 representative soil types at locations from Beltrami County in the north to Fillmore County in the southeast. Samples of the grasses growing in these soils were also collected for analysis. The soils were potted in the greenhouse in triplicate and seeded to meadow fescue in February, 1949. A solution of cobalt sulfate ($CoSO_4 \cdot 7H_2O$) was added to the potted soils to supply 0.0, 0.5, 1.0, and 5.0 pounds of cobalt per acre. To avoid contamination and maintain natural growth as much as possible, no other fertilizer materials were added. The grasses were harvested when heading out and analyzed for cobalt concentrations. The sampling location, soil type, pH, total soil cobalt, cobalt content of native grass and of the meadow fescue grown in the greenhouse with the cobalt-treated soils are shown in Table 1.

Table 1. Cobalt Content of Some Minnesota Soils, Native Grasses and of Meadow Fescue.

	County	Soil Type	Soil pH	Total soil Co. (ppm)	Co. in native grasses (ppm)	Meadow fescue grown in greenhouse; Cobalt applied in lbs/A: 0.0	0.5	1.0	5.0
						ppm cobalt at heading of meadow fescue			
9	Fillmore	Kenyon Si.L.	6.8	1.3	0.18	0.14	0.10	0.22	0.33
6	Renville	Nicollet L.	7.6	1.8	0.16	0.09	0.06	0.20	0.10
7	Fillmore	Tama Si.L.	5.7	2.1	0.18	0.12	0.20	0.16	0.18
5	Mille Lacs	Milaca VFSL	5.5	3.2	0.14	0.14	0.10	0.22	0.31
4	Sherburne	Zimmerman LFS	5.4	3.3	0.13	0.08	0.16	0.12	0.16
2	Stevens	Nutley Si. C.	6.3	4.4	0.12	0.08	0.09	0.10	0.36
3	Clay	Fargo Si. C.L.	6.2	5.3	0.15	0.08	0.10	0.11	0.33
8	Wabasha	Fayette Si.L	6.8	5.4	0.18	0.10	0.10	0.10	0.15
10	Martin	Clarion	7.5	5.8	0.15	0.05	0.10	0.10	0.19
1	Beltrami	Si.L.	5.9	6.5	0.20	0.14	0.29	0.18	0.86
11	Rice	Clarion L.	5.9	7.0	0.11	0.15	0.14	0.07	0.15

The lack of correlation between total soil cobalt, the cobalt concentration in the grasses growing on the sample sites, and the concentrations in the meadow fescue grown in the greenhouse where cobalt had been added at different rates was interesting but inconclusive, and since funds were not available to continue this study, the investigation was temporarily discontinued.

Precipitation in many areas of Minnesota during 1951 was exceptionally heavy, with a moisture excess of 10 to 12 inches on the annual basis being relatively common. At this time Dr. William Andberg, a veterinarian located at Anoka, observed several cases of what he considered to be cobalt deficiency in dairy cattle on some farms of the area. These farm soils are quite sandy in nature, the most common soil type being Zimmerman loamy sand. Dr. Andberg's observations (which continued into 1952) were reported to this department and it was decided to apply cobalt sulfate ($CoSO_4 \cdot 7H_2O$) spray at to pastures on several farms where possible cobalt nutritional deficiencies had been observed. The rates of cobalt application were to be the same as those used on the 11 soils of the 1948-49 greenhouse study at 0.0, 0.5, 1.0 and 5.0 pounds per acre.

Pastures on four Anoka County farms received cobalt sprays (in quadruplicate) early in May and a bluegrass and a legume pasture on the problem farm near Dundas in Rice County (Clarion loam) were also treated at the same time. None of the plot areas were fenced and these were grazed with the remainder of the pastures. Forage samples were harvested where possible from each plot, both in mid-June and again in early August for cobalt analysis. The forage samples were dried, ground and stored until late in 1968, at which time improved analytical equipment and methods were available for cobalt analyses.

The cobalt content of the two 1953 forage cuttings are shown in Table 2. In some instances, the pastures were grazed too closely and forage samples were not obtainable.

Table 2. The Cobalt Content of 1953 Pasture Forage on Five Minnesota Farms Following Soluble Cobalt Applications in Early May.

Soil type	County	Farm operator	Total Soil Co ppm	Forage type	Cutting	Rates of cobalt application to soil (lbs/A) 0.0	0.5	1.0	5.0
						Parts per million of Co in forage			
Zimmerman loamy sand	Anoka	Paul Paulson	1.19	alfalfa	First	----	----	----	2.09
" " "	"	" "		"	Second	0.15	0.18	0.38	0.88
" " "	"	" "		timothy	First	----	----	----	0.81
" " "	"	" "		"	Second	0.13	0.18	0.38	----
" " "	"	Peter Sortberg	0.56	alfalfa	First	0.30	0.98	0.78	1.88
" " "	"	" "		"	Second	0.15	0.23	0.38	1.38
" " "	"	" "		brome	First	0.15	0.53	0.17	0.31
" " "	"	George Giddings	1.65	brome	First	0.13	0.70	1.00	2.22
" " "	"	" "		"	Second	0.13	0.18	0.23	----
" " "	"	Peter Georges	0.72	alfalfa	Second	0.28	----	0.28	0.88
" " "	"	" "		brome	Second	----	----	----	1.63
" " "	"	" "		timothy	Second	0.23	0.13	0.18	0.75
Clarion loam	Rice	Don Fergason	2.26	legume mix.	First	0.28	1.50	2.50	7.13
" "	"	" "		" "	Second	0.15	0.23	0.38	0.18
" "	"	" "	2.49	bluegrass	First	0.08	----	----	9.50
" "	"	" "		"	Second	1.00	----	----	1.63

Dashes (--) indicate where close grazing eliminated sampling.

Although the cobalt concentrations of the different forage species are quite variable, it is apparent that applications of soluble cobalt to these soils results in some increase in Co concentration of the forage plants on these soils. There appears to be little difference between cuttings, and the legumes tend to be somewhat higher in cobalt content. However, it would seem to be more practical to supply cobalt directly in animal feeds rather than to soils of pasture or haylands.

1968 Soybean Inoculant Testing Program

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The plots were located at Rosemount, Waseca, Lamberton, Morris and Big Lake, Minnesota. The soil test results for soil samples taken at these locations are shown below:

Location	Soil pH	Soil texture	Extractable phosphorus pp2m	Exchangeable potassium pp2m	Sulfur pp2m	Zinc pp2m
Big Lake	5.9	loamy sand	200(VH)[a]	200(M)	5(L)	2.6(H)
Lamberton	6.0	silty clay loam	13(M)	210(H)	3(L)	1.3(M)
Morris	7.8	silt loam	13(M)	220(H)	7(M)	1.1(L)
Rosemount	6.1	loam	28(H)	250(H)	8(M)	2.1(H)
Waseca	5.8	loam	40(VH)	310(VH)	10(M)	2.9(H)

[a]VH=very high, H=high, M=medium, L=low

Materials and Methods

Inoculants applied by the inoculant companies and humus inoculants applied soon before planting to Chippewa 64 soybean seeds were evaluated for influence on soybean seed yield. The seed was supplied by the University of Minnesota and all seed was from one source. The planting dates were as follows: Big Lake, May 10; Lamberton, May 14; Morris, May 21; Rosemount, May 23; Waseca, May 25. The border rows of the three-row plots were planted with a tractor-mounted cone planter while the treatment or center row (including checks) was planted by opening a furrow with a wheel hoe, shaking the seeds from a coin envelope and covering with a garden rake. Seedling emergence was as good or better in the hand-planted rows as in the mechanically planted border rows.

Foliar analyses of leaf samples taken during the summer showed that the concentration of P, K, Ca, Sr, Na, Fe, Mg, Zn, Cu, Mo, Mn and B in the leaves was normal. The center row of each plot was harvested for seed yield. A 15-foot section of the center row was cut, threshed with a small plot thresher, cleaned and weighed. Yields for statistical analyses were based on bushels of soybeans per acre on the basis of 12.0% moisture. The yields are shown in Table 1. Yields from Grand Rapids and Crookston are not included due to the adverse growing season at these two locations which resulted in unsuitable testing conditions.

Results and Discussion

Inoculation of soybeans did not significantly affect soybean seed yields. The analysis of variance for all locations is shown in Table 2. The only significant effect was location. The reason for the significant location effect is obvious from the data since the average yield varied from about 15 bushels per acre at Big Lake to over 40 bushels per acre at Waseca. The analysis of variance for each location by itself showed no significant F values at the .10 level of significance.

The failure of inoculation to increase soybean seed yields confirms studies conducted by the University of Minnesota during 1967 and studies reported by other researchers in other states.

The samples of seed from the Morris and Waseca inoculation plots are being submitted to the U.S. Regional Soybean Laboratory at Urbana, Illinois for oil and protein analysis.

Summary and Future Plans

The 1968 soybean inoculation test results confirm the opinios expressed and the position taken in Soils Fact Sheet Number 9, "Inoculation Problems of Soybeans." The inoculation test will be discontinued unless the various companies wish to finance additional tests.

Table 1. Effect of Inoculation on Soybean Seed Yields (Bu/A) at Various Locations in Minnesota in 1968

Inoculant brand	Type inoculant	Location: Big Lake bu/acre	Morris bu/acre	Rosemount bu/acre	Waseca bu/acre	Lamberton bu/acre	Average of all locations bu/acre
A	Humus 1	15.8	24.1	27.1	42.7	37.4	29.4
A	Humus 2	15.9	25.2	26.8	41.6	35.0	28.9
B	Check	15.0	23.0	28.9	42.7	34.3	28.9
B	Research 1	15.6	25.7	27.1	42.9	38.0	29.9
B	Research 2	16.4	27.1	26.0	39.8	37.1	29.3
B	Humus 1	13.8	28.1	28.8	43.5	35.8	30.0
B	Humus 2	12.8	28.8	26.5	39.9	34.8	28.6
C	Check	17.1	25.4	26.4	43.9	36.4	29.8
C	Research A	15.4	25.2	24.6	44.0	32.3	28.4
C	Research B	12.2	26.0	26.8	42.5	37.1	28.9
C	Humus 1	13.6	25.7	27.3	41.3	30.8	27.7
C	Humus 2	13.6	26.0	26.0	43.9	40.5	30.0
C	Preinoc. Check	12.9	27.6	27.5	42.7	35.6	29.3
C	Preinoculated	16.5	27.0	27.0	42.1	39.2	30.4
D	Check	14.0	25.8	26.5	41.5	34.9	28.5
D	Research A	14.2	26.3	27.9	41.3	35.2	29.0
D	Research B	14.0	25.6	27.4	44.0	32.5	28.7
D	Humus 1	15.3	25.9	26.0	41.7	34.9	28.8
D	Humus 2	15.6	26.9	28.4	43.3	34.8	29.8

Table 1

E	Check	15.9	24.3	26.1	40.0	38.7	29.0
E	Research 1	15.0	28.1	23.0	41.1	37.0	28.8
E	Research 2	16.2	24.8	24.7	43.3	33.1	28.4
E	Humus 1	15.6	26.1	24.5	41.7	33.0	28.2
E	Humus 2	16.3	25.1	25.3	43.3	33.2	28.6
F	Check	15.6	27.9	27.8	43.5	37.6	30.5
F	Research 1	16.0	27.6	27.0	41.6	38.2	30.1
F	Research 2	13.1	26.1	26.0	40.4	35.8	28.3
F	Humus 1	14.8	26.8	29.2	43.1	34.7	29.7
F	Humus 2	17.2	26.4	29.8	39.9	38.4	30.3
U of M	Check	15.4	24.9	27.8	43.2	39.2	30.1
U of M	Strain 1	15.5	25.2	26.5	43.0	38.0	29.9
U of M	Strain 2	13.4	26.2	27.3	42.7	37.8	29.5
U of M	Strain 3	14.4	27.2	26.9	42.3	38.0	29.8
Nodulating isoline		14.1	28.2	31.6	44.8	37.0	31.1
Nonnodulating isoline		8.8	17.7	18.6	33.5	29.3	21.7
Average of all checks		15.5	25.2	27.3	42.5	36.9	29.5
Average of all inoculants		14.9	26.3	26.7	42.2	37.1	29.4
Coefficient of variation		19.6%	9.7%	10.3%	6.5%	12.1%	10.7%

Table 2. Analysis of Variance for Soybean Seed Yield (bu./Acre) When Uninoculated and Inoculated Seeds Were Compared at Big Lake, Lamberton, Morris, Rosemount and Waseca, Minnesota in 1968.

Source of Variation	Degrees of Freedom	Mean Square	F Value[a]
Location (L)	4	14,372.50	419.39**
Replicates (R)	3	34.95	1.02 NS
R x L (error a)	12	34.27	
Inoculation (I)	32	10.30	1.06 NS
L x I	128	9.66	0.99 NS
R x I	96	7.94	0.82 NS
Error (error b)	384	9.72	0.82 NS

[a]**indicates significant at the .01 level of significance; NS indicates not significant at the .10 level of significance

Soybean Variety - Rhizobium Japonicum Interaction Studies

G. E. Ham, R. H. Anderson and J. R. Lofgren

Seven strains of Rhizobium japonicum (soybean rhizobid) obtained from the U.S.D.A. Beltsville collection were used to inoculate three different varieties of soybeans at Crookston and Grand Rapids in 1968. The peat-based inoculants were applied to the seed the night before planting and kept refrigerated until planted. The replications with three row plots in 24-inch rows were utilized with the center row of each plot inoculated. The growing season was cooler than normal at both locations.

Few or no nodules were present on the roots of the uninoculated plants at both locations. Yields at Grand Rapids were increased by as much as 7.8 bushels per acre by inoculations while yields were increased by as much as 5.9 bushels per acre at Crookston (Tables 1 and 2). The effects of rhizobia strains and the strain x variety interaction were significant as indicated in Tables 3 and 4. This indicates that rhizobia strains increased yields significantly and the effect of a strain was not the same on all varieties. However, sorting out the best strain (s) for each variety is virtually impossible due to year variation and also due to location, i.e., the best strain on a variety may not be the best strain on this variety at another location or in another year.

Table 1. Effect on Soybean Seed Yield When Different Strains of <u>Rhizobium Japonicum</u> Were Applied to Soybean Seeds Planted at Crookston, Minnesota in 1968

Rhizobium Japonicum strain	Soybean Variety Altona bu/acre	Soybean Variety Portage bu/acre	Soybean Variety II-55-14 bu/acre	Average of all varieties bu/acre
Check	15.4	16.7	16.1	16.1
38	21.3	20.2	17.5	19.7
110	17.7	21.8	19.5	19.7
122	16.0	19.1	20.7	18.9
123	16.8	20.6	17.0	18.1
126	19.9	20.8	17.6	19.4
135	16.3	17.8	16.8	17.0
138	18.4	20.0	21.4	19.9
Average of all strains	17.8	19.6	18.3	18.6

Table 2. Effect on Soybean Seed Yield When Different Strains of <u>Rhizobium Japonicum</u> Were Applied to Soybean Seeds Planted at Grand Rapids, Minnesota in 1968

Rhizobium Japonicum strain	Soybean Variety Altona bu/acre	Soybean Variety Portage bu/acre	Soybean Variety II-55-14 bu/acre	Average of all varieties bu/acre
Check	27.6	30.0	29.8	29.2
38	31.2	34.2	37.0	34.1
110	32.5	32.1	35.6	33.4
122	33.3	34.3	32.0	33.2
123	30.8	31.7	31.3	31.3
126	35.3	34.1	34.4	34.6
135	30.6	32.8	32.3	31.9
138	32.3	36.4	37.6	35.4
Average of all strains	33.2	31.7	33.8	

Table 3. Analysis of Variance for Soybean Seed Yield When Soybean Seeds Were Inoculated at Planting Time at Crookston, Minnesota in 1968

Source of Variation	Degrees of Freedom	Mean Square	Calculated F Value
Replicates (R)	2	7.10	0.83 NS
Varieties (V)	2	6.75	0.79 NS
R x V	4	8.55	
Strain (S)	7	20.73	4.68**
V x S	14	9.24	2.09*
	42	4.43	

Table 4. Analysis of Variance for Soybean Seed Yield When Soybean Seeds Were Inoculated at Planting Time at Grand Rapids, Minnesota in 1968

Source of Variation	Degrees of Freedom	Mean Square	Calculated F Value
Replicates (R)	2	2.50	0.99 NS
Varieties (V)	2	26.34	10.48**
R x V	4	2.52	
Strain (S)	7	36.69	9.94**
V x S	14	6.75	1.83T
R x V x S	42	3.69	

Sugarbeet Rotation Study - 1968
Northwest Experiment Station, Crookston, Minnesota

Olaf C. Soine, Soil Scientist

This is the second year of this rotation study, but no definite trends are visible at this time. The yields of all crops were good. The sugarbeet yields are approximately 38 percent higher in 1968 than they were in the drought year of 1967. The beet plots follow the last crop in each rotation as given in table (e.g., Rotation 1, beets follow sw. cl. fallow; Rotation 2, beets follow the oats crop, etc.). The wheat yields in 1968 were similar to those in 1967. The barley yields were about 25% below last year's yields.

The crop yields for the 6 rotations for 1968 with 1967-68 averages are given in Table 1.

Table 2 gives the 1967 crop, yield, percent sugar, purity index, and sodium, potassium, and amino-N. in parts per million for the 6 rotations. The beets were harvested on September 23, and this early date may in part account for the low percentages of sugar and the high purity indexes. The percent sugar varied from 11.90 to 13.20 for the beets from Rotation 1 and 6, respectively. Rotation 1 beets had the highest purity index and sodium content, but the differences were not significant. The rotations did not show any significant differences in the potassium content of the beets. The beets that followed the sweet clover and the black fallow treatments contained the highest amount of amino nitrogen.

Table 1. Crop yields for 6 rotations for 1968 with 1967-68 averages.

	1968	1967-68	1968	1967-68	1968	1967-68	1968	1967-68
Rotation 1	Beets		Wheat		Barley		Sw. cl. fallow	
	21.44 T	17.28 T	54.4 bu.	55.1 bu.	65.0 bu.	83.1 bu.	-----	-----
Rotation 2	Beets		Wheat		Barley		Oats	
	18.76	16.24	53.6	54.6	77.9	89.4	114.0	125.4
Rotation 3	Beets		Potato*		Wheat		Barley	
	19.29	16.21	309	282.5	49.4	50.6	75.2	83.4
Rotation 4	Beets		Wheat		Barley		Alf. hay fallow**	
	20.19	16.11	56.1	52.9	73.6	89.6	2495 lb.	-----
Rotation 5	Beets		Wheat		Barley		Bl. fallow	
	22.23	17.78	57.3	58.7	75.2	87.8	-----	-----
Rotation 6	Beets		Wheat		Barley		Soybeans	
	20.36	16.88	57.8	57.7	75.3	83.2	21.4	27.5

* No. 1 Potato
** Moisture content 20%

Table 2. The 1967 crop, yield, percent sugar, purity index, and sodium, potassium and amino-nitrogen for the 6 rotations, 1968.

Rotation No.	1967 Crop	Yield T./A.	Sugar %	Purity Index	Sodium P.P.M.	Potassium P.P.M.	Amino-N. P.P.M.
1	S. cl. F.	21.44	11.90	1076	1034	1542	528
2	Oats	18.76	12.50	811	792	1543	351
3	Barley	19.29	13.03	763	705	1226	439
4	Alfalfa	20.19	12.86	911	792	1483	517
5	Bl. fallow	22.23	12.23	971	862	1323	552
6	Soybeans	20.36	13.20	787	592	1555	438
L.S.D.		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Alfalfa Removal vs Plow-Under for Sugarbeets in 1968
Northwest Experiment Station, Crookston, Minnesota

Olaf C. Soine, Soil Scientist

In this study, a 21-acre field of old alfalfa was used to evaluate the effect of removing the first crop versus plowing it under for sugarbeets the following year. This field had been in alfalfa for 3 crop years and the stand was medium. The treatments were randomized and laid out in 100 ft. strips across the field. The first crop of alfalfa was removed for hay from 4 strips and the remaining 4 strips were left and the field was plowed on June 28-29, 1967. It was fertilized with 250 lbs/acre of 0-46-0 in the fall and 100 lbs/acre of 5-42-0 at planting time.

The beets were mechanically thinned and no hand labor was used.

The beets were harvested September 20, 1968. Table 1 gives the field data.

Table 1. Yield of beets, percent sucrose, purity index and number of beets harvested.

Treatment	Yield	Sucrose	Sucrose	Purity	No. beets harvested
	tons/A	lbs/A	percent	index	/80 ft. row
Alfalfa removed	15.45	3930	12.72	766	64
Alfalfa plowed under	15.90	3892	12.24	864	70

Alfalfa Yields: Yields were taken from each plot and the average for all plots was 1858 lbs of dry matter per acre. This is equivalent to 1.1 tons of alfalfa hay at 15% moisture content. Figuring alfalfa hay at $16.50 per ton, the value of alfalfa would be $18.65 per acre.

Soil Fertility Experiments on Potatoes

C. J. Overdahl, G. W. Randall and C. P. Klint

The following tables are a summary of fertility trials on sandy soils with irrigated potatoes the past 3 years (1966, 1967 and 1968).

It is of interest to note a slight reduction in the K soil test from a 600+ to 435 lbs. on plots that were untreated with potassium for three years. There is an apparent corresponding yield response to potassium.

Reduction of magnesium levels in the potato petiole is directly related to the increase in potassium levels. Thus far no response has been measured in potato yield from magnesium treatments, either as dolomitic limestone, magnesium sulfate or magnesium chloride, even when petioles from untreated magnesium plots were as low as .15%.

With the Norland variety at the Gray farm, yields from 300 pounds of nitrogen were superior to those from 150 pounds N. At the Sand Plain farm, with the Russet Burbank variety, 150 pounds of nitrogen gave potato yields that were significantly higher than 75 pounds, but 300 pounds was not significantly higher than 150 pounds. The low total yield perhaps accounts for the lack of increase beyond 150 lbs. of N. The plan is to use a different variety in 1969.

Table 1. Effect of potassium on potato yield, % K and % Mg in petiole. Tessman Farm, Hennepin County, Minnesota.

	1966		1967		1968	
	CWT/A		CWT/A		CWT/A	
200 + 150 + 0	332		206		178	
200 + 150 + 150	325		225		280	
200 + 150 + 500	277		222		271	
	% K	% Mg	% K	% Mg	% K	% Mg
200 + 150 + 0	11.6	.14	8.0	.22	6.8	.35
200 + 150 + 150	12.7	.12	8.0	.20	7.6	.23
200 + 150 + 500	12.8	.14	7.9	.20	7.9	.14

K soil test = 600+ in spring of 1966, in fall of 1968 200+150+500 plot tested 600+ but 200+150+0 plots averaged 435 lbs. of exchangeable K.
Slightly lower N & P rates were used in 1966.
Variety - Norland

Table 2. Effect of dolomitic limestone on yield of potatoes (CWT) and % magnesium in tissue. Tessman Farm, Hennepin County, Minnesota.

Lime rate lbs/A	1966 Yield	1966 % Mg	1967 Yield	1967 % Mg	1968 Yield	1968 % Mg
0	344	.21	276	.20	322	.16
1000	368	.18	193	.17	323	.17
2000	377	.21	224	.17	326	.20
4000	354	.21	243	.23	328	.19
8000	-		227	.22	300	.23

Soil pH 5.4. Lime had no effect on soil pH or yield.

Table 3. Effect of magnesium ($MgSO_4$) on yield of potatoes and % Mg in petiole. Tessman Farm, Hennepin County, Minnesota.

Mg lbs/A	1967 Yield Cwt.	1967 Mg %	1968 Yield Cwt.	1968 Mg %
0	339	.22	371	.15
25	328	.23	362	.15
50	341	.26	370	.17
75	344	.25	373	.17
300	322	.23	346	.20**

Average of 5 reps. 200+150+500 applied on all plots both years, 75+150+150 in the row.

Magnesium applied in the row in 1967; same rates were broadcast in 1968.
Magnesium was significantly higher in petiole from 300 pound treatment in 1968.
There was no response to applications of magnesium.
Variety - Norland

Table 4. Effect of potassium on potato yield, % K and % Mg in petiole. Gray Farm, Sherburne County, Minnesota.

	1966 CWT/A	1967* CWT/A	1968 CWT/A
200 + 150 + 0	207	111	252
200 + 150 + 150	232	194	336
200 + 150 + 250	313	198	332
200 + 150 + 500	338	199	347
200 + 150 + 1000	341	203	329

	1966 % K	1966 % Mg	1967 % K	1967 % Mg	1968 % K	1968 % Mg
200 + 150 + 0	-	-	4.5	.49	4.9	.72
200 + 150 + 150	8.3	.55	7.6	.22	7.5	.32
200 + 150 + 250	10.0	.38	9.0	.15	7.8	.26
200 + 150 + 500	11.8	.31	9.0	.13	7.6	.20
200 + 150 + 1000	11.3	.37	9.0	.15	7.8	.17

* Yield reduced by severe hail damage.
Petiole analysis in 1966 at Ohio, 1967 & 1968 at U. of Minn.
Variety - Norland

Table 5. Effect of phosphorus on potato yield, % P in petiole. Gray Farm, Sherburne County, Minnesota.

	1966		1967		1968	
	CWT/A	% P	CWT/A	% P	CWT/A	% P
200 + 0 + 500	255	.29	145	.20	213	.21
200 + 150 + 500	325	.26	258	.51	318	.33

N & P treatments were slightly lower in 1966.
Variety - Norland

Table 6. Effect of nitrogen on potato yield. Gray Farm, Sherburne County, Minn.

1966	Yield Cwt.	1968	Yield Cwt.
50 + 100 + 500	228	75 + 150 + 500	317
100 + 100 + 500	307	150 + 150 + 500	331
200 + 100 + 500	346	300 + 150 + 500	368

No N yields taken 1967 due to hail and plot damage.
Variety - Norland

Table 7. Effect of nitrogen on potato yield. Sand Plain Experiment Farm, Sherburne County, Minnesota.

1968	Yield Cwt.
75 + 150 + 500	139a
150 + 150 + 500	204b
300 + 150 + 500	216b

4 replications
Variety - Russet Burbank

Table 8. Effect of potassium and magnesium treatments ($MgCl_2$) on yield of potatoes, % K and % Mg in petiole. Sand Plain Experiment Farm, Sherburne County, Minnesota 1968.

5

Treatment		Yield Cwt.		%	%
K_2O	Mg	A+B	A	K	Mg
0	0	158	81	5.8	.31
150	0	170	91	6.0	.26
500	0	189	126	6.7	.17
0	50	195	118	6.0	.36
150	50	199	115	6.2	.30
500	50	183	102	6.9	.19

$N + P_2O_5 + K_2O$ lbs/A	Potash Effect CWT/A	Mg lbs/A	Magnesium Effect CWT/A
200 + 150 + 0	176	0	172
200 + 150 + 150	185	50	192
200 + 150 + 500	186		

There were no significant differences in yield from either K or Mg. Yields were very low with many B size potatoes. 1968 soil test pH = 5.5, P = 200^+, K = 190. Variety - Russet Burbank

Fertilizer Trials on Oil Crops
Northwest Experiment Station, Crookston, 1968

Olaf C. Soine, Soil Scientist

Tame Mustard: This completes a 3-year fertilizer study on tame mustard and the yield results are given in the following table.

The 1966 growing season was favorable with above normal precipitation during June, July, and August, and above normal temperatures during April and May. The summer drought of 1967 reduced the yielding potential of the crop. The excessive rainfall, cool and cloudy weather during the 1968 growing season were not too favorable for mustard.

The highest yields were obtained in 1966 but there were no significant differences between the treatments. The 20+40+0** (20 lb. N broadcast, 40 lb. P applied with drill) gave the highest yield response.

In 1967, 20+40+0* treatments produced the highest yields but the yield differences were not significant in this trial.

There were no significant yield differences in the 1968 trial. The 40+80+40 treatment gave the best yield differences in the 1968.

The 3-year average yields varied from a low of 855 to a high of 1071 lbs. per acre but the differences between the treatments were not significant. The 30+40+20* treatment gave the highest 3-year average yield, but it was not the highest yielder each year. The higher rates like 40+80+40 and 80+160+80 did not increase the yields when compared to the other rates.

Fertilizer Trial on Tame Mustard
Yield in lbs/acre, 1966-68

Treatment N-P-K-	1966	1967	1968	Avg. 1966-68
		lbs/acre		
0+0+0	1028	852	812	897
10+0+0*	1030	814	729	858
20+0+0**	1171	735	683	863
0+40+0	1095	860	703	886
10+40+0*	1228	918	727	958
20+40+0**	1363	820	748	977
10+40+0	1057	835	981	958
20+40+0*	988	1046	740	925
30+40+0**	1128	905	806	946
20+40+20	1119	861	895	958
30+40+20*	1200	1055	959	1071
40+40+20**	1097	840	786	908
40+80+40	--	852	1078	965
80+160+80	--	791	919	855
L.S.D.	N.S.	N.S.	N.S.	N.S.

10+0+0* and 20+0+0**, 10 and 20 lbs. N. respectively, broadcast prior to seeding.
10+40+0* and 20+40+0*, 10 and 20 lbs. N. broadcast, 0+40+0 applied in band with drill at seeding time.
Avg. date of seeding - May 2
Avg. date of harvest - August 7

Sunflowers: The following table gives the yield, bushel weight, and oil content of sunflowers for the past 3 years.

In general, the highest yields were obtained in 1967 and 1968. The fertilizer treatments varied from year to year and no single treatment gave a consistent high yield each year. The 40+80+0 treatment gave the highest average yield response for the 3-year period. The 0+0+40 treatment gave the lowest average yield for the 3-year period.

There was very little variance in the average bushel weights for the 3-year period.

The average oil content for 1966-67 varied from 40.2 to 45.8% for the 80+160+80 and 0+40+20 treatments, respectively, compared to 44.6% for the check plot.

Fertilizer Trial on Sunflowers

Treatment	Yield lbs/acre				Bu.wt.	Percent oil
N P K	1966	1967	1968	Avg.1966-68	Avg.1966-68	Avg.1966-67
40+80+0	1670	2094	1894	1886	29	44.2
20+40+0	1582	2205	1529	1772	28	45.0
80+160+80*	--	1390	2126	1758	28	40.2
40+80+40	1664	1711	1830	1735	29	44.7
0+0+20	1550	1791	1768	1703	28	45.2
20+0+0	1465	1626	2002	1698	28	45.5
20+40+20	1527	1971	1553	1684	29	44.8
0+40+20	1505	1754	1620	1626	29	45.8
40+0+0	1621	1319	1879	1606	29	44.4
0+0+0	1397	1578	1844	1606	29	44.6
0+80+40	1412	1638	1723	1591	28	45.1
0+80+0	1450	1680	1555	1562	29	45.3
0+40+0	1515	1393	1570	1493	29	45.1
0+0+40	1288	1290	1684	1421	28	44.0

* 2-year data
Avg. date of seeding - May 7
Avg. date of harvest - October 5

Summary of 1968 Soil Fertility Work on Sunflowers from the Department of Agronomy and Plant Genetics

R. G. Robinson[1]
Dept. of Agronomy and Plant Genetics

No fertilizer trials were conducted in 1968. However, within trials of row widths, plant populations, varieties, and crop sequence, comparisons were made of very high rates of N-P-K versus no fertilizer. The yield data in Table 1 are the grand averages of many treatments and represent the average response to fertilizer in these trials.

Table 1. Effect of fertilizer on soil test results and sunflower performance at four locations.

		Soil tests, July 1968, lb/A				Sunflower			
	Soil	Fertilizer		No fertilizer		Yields, lb/A		Date bloom	
Location	texture	P	K	P	K	Fert.	No fert.	Fert.	No fert.
Rosemount	silt loam	66	210	44	190	1249	1062	7-25	7-28
Rosemount	silt loam	48	290	26	230	1808	1488	7-26	7-29
Elk River	sandy loam	200	280	200	180	576	692	7-25	7-28
Grand Rapids	loamy sand	114	270	75	150	1614	1594	8-10	8-13

On the basis of these soil tests and previous experience with sunflowers, yield increases from P or K would not be expected even though the fertilizer applications greatly increased available P and K. All of the soil tests were rated high or very high in P and medium to very high in K.

In all tests, visual response to the N-P-K fertilizer was obvious--greener leaves, increased vigor, more rapid growth. This was probably due to the high rates of N--120 to 300 lb/A/.

Fertilizer decreased seed yield at both 30,000 and 60,000 populations and in 3 of 4 varieties at Elk River. The populations were too high but were chosen in expectation of irrigation which was not available when needed. Stalk and leaf growth were obviously greater on the fertilized plots, at least until bloom stage. One inch of irrigation water was applied to one replicate at bloom stage July 25 (too late). On this one replicate, irrigation alone increased yield to 851 lb/A and irrigation plus fertilizer to 1212 lb/A.

[1]Field work at Grand Rapids was conducted by Agronomist R. H. Anderson.

Yield Potentials on a Dorset Sandy Loam, Park Rapids, 1968

G. W. Rehm, E. C. Seim and A. C. Caldwell

In order to determine the yield potential of the soils in the Park Rapids area with maximum fertility levels, yield production trials were carried out for corn, soybeans, potatoes, and sunflowers. The production trials for corn are reported separately. The yields for each crop are shown in Table 1.

Table 1. The Yield of Potatoes, Soybeans and Sunflowers From the Yield Potential Trials at Park Rapids 1968.

Crop	Variety	Yield
Potatoes	Norgold	554 bu./A
	Burbank	670 bu./A
Soybeans	Portage	23.9 bu./A
	Clay	36.0 bu./A
	Grant	34.8 bu./A
Sunflowers	Paradovich	1542 lb./A

<u>Potatoes:</u>

Both Norgold and Burbank russets were grown in this study. The seed pieces were planted approximately 1 foot apart in the row in 24 inch rows. The fertility program was: 500 lb. K/A as 0-0-60 and K_2SO_4, 50 lb. P/A as 0-46-0, 200 lb. N/A as 33-0-0 and 50 lb. S/A as K_2SO_4. In addition, 200 lb. N/A was sidedressed in 2 separate applications. Chlordane at 16 lb./A was applied at 50 lb./A to provide a systemic insect control. These two materials were disced in at planting time. The natural rainfall was supplemented with approximately 10 in. of water by weekly irrigation from July 13 to August 13. After each irrigation the plants were sprayed with 1 1/2 lb./A of Polyram 80-W to prevent both early and late blight.

Soybeans:

The three varieties of soybeans were planted in 24 in. rows at a rate of approximately 90 lb./A. The fertilizer applications included: 200 lb. K/A as 0-0-60 and K_2SO_4, 50 lb. S/A as K_2SO_4, 30 lb. P/A as 0-46-0, and 100 lb. N/A as 33-0-0. These materials were disced in at planting time. Randox at 10 lb./A was also disced in to control the perennial grasses. The soybeans received approximately 12 inches of supplemental irrigation throughout the summer.

Sunflowers:

The sunflowers were planted in 24 inch rows with a spacing between the seeds in the row of approximately 6 inches. The fertilizers applied included: 300 lb. K/A as 0-0-60, 30 lb. P/A as 0-46-0, 50 lb. S/A as gypsum, 200 lb. N/A as 33-0-0 and 1 lb. B/A as fertilizer borate. Chlordane was applied at 16 lb./A to control soil insects. All of these materials were disced in at planting time. A sidedress application of 100 lb. N/A was made when the plants were approximately 2 feet tall. Approximately 12 inches of supplemental irrigation was supplied throughout the summer.

Discussion:

It should be pointed out that the yield of the Burbank russets was significantly greater than the yield of Norgold russets. With regard to the soybeans, the yields of the Clay and Grant varieties were not significantly different from each other but were significantly different from the yield of the Portage variety. However, at the time of frost the Grant variety was not mature and as a result the harvested soybeans were of poor quality.

The Effect of Variety and Population on Corn Yield at Park Rapids

G. W. Rehm, E. C. Seim and A. C. Caldwell

As part of an overall production study, the effect of plant population on the yield of 7 corn varieties was studied during the summer of 1968. Both 65-68 and 75-85 day hybrids were included. The short season varieties were the Trojan TX-68 and Pioneer PXE-1 hybrids. The longer season varieties were Pioneer 3985, Trojan TX-80, Jacques JX-21, Northrup King PX-417 and Minnesota Hybrid 806. The short season varieties were planted to give approximately 30,50, and 100 thousand plants per acre. The longer season hybrids were planted to give approximately 20, 30, and 40 thousand plants per acre. All varieties were planted in 24 inch rows. All populations of each variety were replicated 5 times.

Fertilizer applications were constant for all populations of all varieties. The nutrients applied included: 300 lb. K/A as 0-0-60, 50 lb. P/A as 0-46-0, 50 lb. S/A as Na_2SO_4, 10 lb. Zn/A as $ZnSO_4.7\ H_2O$, 1 lb. B/A as fertilizer borate and 150 lb. N/A as 33-0-0. These materials were plowed down and worked in at planting time. In addition, 150 lb./A of a 5-15-10 liquid fertilizer were applied as a starter and 150 lb. N/A were sidedressed when the corn was approximately 24 inches high. Corn rootworms were controlled by applying 4 lb. actual chlordane per acre and perennial grasses were controlled by applying 10 lb. Randox/A. The corn was sprayed with 1.5 lb. Sevin per acre to control corn borer. The rainfall for the summer amounted to 12.68 inches with 9.98 inches falling during June. From July 13 to August 31, 14 inches of supplemental irrigation were applied.

The sixth leaf at silking was taken for nutrient analysis in the laboratory. The total S content was determined by wet digestion and subsequent turbidimetric analysis. The remainder of the elements reported here were determined by emission spectrographic analysis.

The yield data for the very short season hybrids are presented in Table 1. The values reported are averages of the 5 replications. In general, the yields were not as high as expected and there was no significant difference among the varieties or populations. It should be pointed out that in this table and all subsequent tables, treatment means followed by the same letter are not significantly different at the 5% level. Although yield differences were not significant, the average yields were higher for the lower plant populations. It is interesting to note the high precentage of barren stalks at the higher populations. This is probably a significant factor leading to the yield reductions.

Table 1. The Yield, Moisture Content, Shelling % and % Barren Stalks of Short Season Corn Hybrids Grown at Park Rapids in 1968

Variety	Population	Yield	Shelling	H_2O	Barren Stalks
	Plants/A.	Bu/A.	%	%	%
Trojan TX-68	30,000	72.1	74.4	32.9 b	14.7 b
Trojan TX-68	50,000	66.4	72.1	36.1 ab	27.4 ab
Trojan TX-68	100,000	63.7	72.1	38.4 a	26.7 ab
Pioneer PXE-1	50,000	62.2	77.1	33.0 b	32.5 ab
Pioneer PXE-1	100,000	53.6	77.8	32.6 b	43.1 a
		N.S.	N.S.		

The nutrient content of the short season hybrids at the various populations is given in Table 2. Although there are significant differences among varieties and populations for various elements, no general trend is evident from the data presented. In general, there is a reduction in the tissue content of several of the nutrients with an increase in the plant population.

Table 2. Nutrient Content of Short Season Corn Hybrids Grown at Park Rapids in 1968

Variety	Population	S	P	K	Mg	Ca	Sr	Fe	Zn	Cu	Mo	Mn	B
	Plants/A.	%					ppm						
Trojan TX-68	30,000	.244a	.420	2.07a	.402	.720	17.3	926.8	36.7a	8.18	6.8	49.5ab	8.3
Trojan TX-68	50,000	.221ab	.307a	1.90ab	.385	.654	16.1	748.5	30.8ab	8.09	9.3	38.6c	6.4
Trojan TX-68	100,000	.205b	.296a	1.42c	.471	.697	17.4	884.5	25.1bc	7.74	7.4	35.2c	7.2
Pioneer PXE-1	50,000	.221ab	.321a	1.92ab	.410	.720	17.3	787.3	24.6bc	7.02	9.4	54.8a	6.9
Pioneer PXE-1	100,000	.204b	.284a	1.63bc	.492	.717	17.6	835.4	20.3c	6.84	9.0	47.5b	6.1
					N.S.	N.S.	N.S.	N.S.		N.S.	N.S.		N.S.

The yield data for the 75-85 day hybrids are presented in Table 3. The highest average yield was produced by the Pioneer 3985 hybrid planted at 40,000 plants per acre. The smallest average yield was produced by the Trojan TX-80 variety planted at 20,000 plants per acre. The highest individual plot yield was 144.4 bu./A produced by the Pioneer 3985 variety at 40,000 plants per acre. The values reported in Table 3 are averages of 5 replications.

Table 3. The Yield, Moisture Content, Shelling Percentage and Percent Barren Stalks of 75-85 Day Corn Hybrids at Various Populations

Variety	Population	Yield	Moisture Content	Shelling Percentage	Barren Stalks
	Plants/A.	Bu/A.	%	%	%
Pioneer 3985	20,000	*103.5 bcd	45.3	82.6	13.4
Pioneer 3985	30,000	98.8 bcd	43.4	83.1	9.5
Pioneer 3985	40,000	122.3 a	43.3	82.4	4.7
Minnesota 806	20,000	108.5 abc	39.8	78.1	4.8
Minnesota 806	30,000	111.0 abc	41.4	76.5	9.7
Minnesota 806	40,000	106.6 abc	41.4	77.9	7.5
Jacques JX-21	20,000	112.9 ab	42.6	81.8	5.8
Jacques JX-21	30,000	110.7 abc	43.0	82.7	15.4
Jacques JX-21	40,000	113.9 ab	44.6	82.8	10.8
Northrup King PX-417	20,000	101.0 bcd	37.3	80.2	10.1
Northrup King PX-417	30,000	111.5 abc	37.0	79.8	5.4
Northrup King PX-417	40,000	122.2 a	35.4	79.6	5.3
Trojan TX-80	20,000	88.4 d	39.9	82.2	2.3
Trojan TX-80	30,000	100.3 bcd	41.2	82.7	6.2
Trojan TX-80	40,000	93.8 cd	41.8	82.3	13.8

*Treatment means followed by the same letter are not significantly different at the 5% level.

The effects of variety as well as population can be separated and analyzed statistically. The effect of population on corn yield is shown in Table 4. The values reported are averages of all varieties at any one population. The yield at the 40 thousand population was significantly higher than the yield at the 20 thousand population but was not significantly different from the average yield of all varieties planted at 30,000 plants per acre. There was no significant yield increase when the population was increased from 20 to 30 thousand plants per acre. In addition, population had no significant effect on the moisture content, shelling percentage or percent barren stalks of these 75-85 day hybrids.

Table 4. The Effect of Population on Yield, Moisture Content, Shelling Percentage and Percent Barren Stalks of 75-85 Day Corn

Population	Yield	Moisture Content	Shelling	Barren Stalks
Plants/A.	Bu/A.	%	%	%
20,000	102.9 a	41.0	81.0	7.3
30,000	106.5 ab	41.2	81.0	6.5
40,000	111.8 b	41.3	80.9	8.4
		N.S.	N.S.	N.S.

The effect of variety on corn yield is shown in Table 5. The values reported in this table are averages for all populations of any one variety. Considering all populations of each variety, the average yield of Trojan TX-80 was significantly lower than the average yields for the Jacques and Northrup King hybrids but was not significantly different from the average yield of either the Pioneer or Minnesota hybrids. Likewise, there were no significant differences among the yields for the Pioneer, Minnesota, Jacques, and Northrup King varieties when all populations were considered.

It should also be noted that the moisture content of the Northrup King variety was significantly lower than any of the other four varieties at all populations. There was no variety-population interaction for any of the variables listed in Table 5.

Table 5. The Effect of Corn Variety on the Yield, Moisture Content, Shelling Percentage and Percent Barren Stalks of 75-85 Day Corn

Variety	Yield	Moisture Content	Shelling Percentage	Barren Stalks
	Bu/A	%	%	%
Pioneer 3985	108.2 ab	44.0 a	82.7 a	9.2
Minnesota 806	108.7 ab	40.9 a	77.5 b	7.3
Jacques JX-21	112.5 a	43.4 a	82.2 a	6.0
Northrup King PX-417	111.6 a	36.6 b	79.9 b	7.0
Trojan TX-80	94.2 b	41.0 a	82.4 a	7.4
				N.S.

The effects of population and variety on the nutrient composition of corn plants are shown in Tables 6 and 7. The data in Table 6 show that plant population had no effect on the tissue content of any of the nutrients measured. The content of nutrients was, however, influenced by variety (Table 7). Again the results are variable and there is no distinct pattern. It is interesting that the Trojan variety has a distinctly lower sulfur content. This occurred even though 50 lb. of S/A was applied at planting time. Again there was no variety-population interaction for any of the nutrients studied. (See Tables 6 & 7 on following page.)

In general, the yield of the 75-85 day varieties increased with increasing population and some varieties proved to be superior to others. The yields of the 65 day hybrids were, however, much lower than expected. In addition, there was no consistent effect of either population or variety on the nutrient content of the corn tissue.

The results of this study show that very respectable, but not exceedingly high, corn yields can be obtained in the Park Rapids area. The data from the 65 and 68 day varieties points out the need for more study of these hybrids.

Table 6. The Effect of Population on the Nutrient Content of 75-85 Day Corn

Population	S	P	K	Ca	Mg	Sr	Fe	Zn	Cu	Mo	Mn	B
Plants/A.	%					ppm						
20,000	.260	.365	1.97	.667	.300	17.6	893.4	31.8	9.8	.89	61.6	8.4
30,000	.258	.369	2.24	.656	.254	16.8	865.0	32.3	9.6	.74	66.3	9.0
40,000	.249	.355	2.11	.644	.274	18.2	745.2	30.4	8.6	.75	63.[illegible]	8.4
	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 7. The Effect of Variety on the Nutrient Content of 75-85 Day Corn

Variety	S	P	K	Ca	Mg	Sr	Fe	Zn	Cu	Mo	Mn	B
	%					ppm						
Pioneer 3985	.282 a	.397 b	2.14 ab	.657	.265 bc	17.1	811.0	30.6	9.1	.77	64.1 a	7.8
Minnesota 806	.273 a	.376 a	2.15 ab	.661	.304 ab	17.2	933.6	34.1	10.9	.92	73.3 a	9.7
Jacques JX-21	.257 b	.362 a	2.44 a	.640	.210 c	16.7	781.3	29.9	8.6	.67	64.4 a	8.7
Northrup King PX-417	.250 b	.351 a	1.86 b	.655	.339 a	17.4	812.4	28.8	9.2	.88	54.7 b	8.0
Trojan TX-80	.218 c	.330 a	1.94 b	.667	.262 bc	19.2	834.3	33.9	8.8	.73	61.6 a	8.6
				N.S.		N.S.	N.S.	N.S.	N.S.	N.S.		

The Effect of Salt Applications to an Ostrander Silt Loam at Rosemount and to a Webster Clay Loam at Lamberton on Soil Conductivity, Plant Population, and Yields of Hark and Chippewa 64 Soybeans in 1968

J. M. MacGregor, P. M. Burson, W. W. Nelson and G. W. Randall

Since earlier studies of soybean chlorosis in Minnesota indicated that soluble salt concentrations in the soil were probably a contributing factor, it was decided to apply chemical salts to the soil at two locations in quantities sufficient to artificially increase saturation extract electrical conductivities of 2, 4, and 6 millimhos per centimeter in order to study the effect of such treatments on soybean growth and yield. Two varieties were to be grown - Hark, which has a low chlorosis tolerance and the more chlorosis tolerant variety Chippewa 64 using four replications in a randomized block, with each plot being fifteen feet wide and twenty feet in length.

Soil samples of the 0"-6" depth were collected at the two locations early in 1968 and these were studied in the laboratory to determine the approximate salt quantities required to induce the desired conductivities for the 6" soil depth. Two salt treatments were employed - $MgSO_4$ alone, and a mixture of $CaSO_4 \cdot 2H_2O$, $MgSO_4$, K_2SO_4 and Na_2SO_4, the relative proportions of the latter based on the cation distribution reported in the Profile 5 of the Soil Survey of the Southwest Experiment Station at Lamberton.

The calculated salt treatments were applied April 30 to May 3 and disked in before the two soybean varieties were planted. The Lamberton experiment soybean plants were severely damaged by hail in early May. This planting was then disked and replanted, but the new stand proved too variable and uneven, independent of the salt treatments applied. The yellowing which later developed in these soybeans showed no visual relation to soil salt treatment but followed the characteristic varietal effect, being much more severe on the Hark than on the Chippewa 64 plants.

Soil of the surface 6 inches was sampled on half of the 72 plots of each field in early July and the electrical conductance of the saturated soil extract determined. Population counts were also made in early July. The Rosemount field was harvested by mowing two of the six 30-inch rows for 10 feet. Due to a saturated soil condition on the Lamberton field from September until snow in November, yield samples were not obtained. Soil samples of the first and second 6" depths on all plots were collected early in November, and these are being analyzed for electrical conductance for possible repetition of this study during the 1969 growing season.

The 1968 results are shown in Tables 1 and 2.

Table 1. Soil Treatment and Electrical Conductivity, Soybean Population, and 1968 Yield of Hark and Chippewa 64 Soybeans on an Ostrander Silt Loam at Rosemount.

	Treatment and desired conductivity	Sat. extract conductivity mmho/cm (actual)	Soybean population 1,000's/A		Yield (bu/a)	
			Hark	Chippewa 64	Hark	Chippewa 64
1	Check	0.72 a	133.8 b	114.5 b	28.8 a	20.3 a
2	2mmho $MgSO_4$	1.46 b	147.4 b	121.6 b	29.6 a	25.7 a
3	2mmho Salt Mix	1.38 b	135.4 b	113.4 b	33.2 a	25.5 a
4	4mmho $MgSO_4$	3.54 c	138.8 b	110.4 b	31.6 a	23.2 a
5	4mmho Salt Mix	2.93c	125.4 ab	119.4 b	28.4 a	26.6 a
6	6mmho $MgSO_4$	4.56 d	104.4 a	77.2 a	28.0 a	25.2 a
7	6 mmho Salt Mix	3.41 c	137.1 b	115.2 b	31.6 a	28.0 a
	F Value	42.6	5.11	6.60	0.91	2.46
	Significance	**	**	**	N.S.	N.S.
	CV	16.8	13.0	15.0	13.7	12.8

Table 2. Soil Treatment and Electrical Conductivity and Populations of Hark and Chippewa 64 Soybeans on a Calcareous Webster Clay Loam at Lemberton.

	Treatment and desired conductivity	Sat. extract conductivity mmho/cm (actual)	Plant population 1000's/A Hark	Chippewa 64	
1	Check	1.08 a	121.9 a	73.2 a	
2	2mmho $MgSO_4$	1.44 a	111.5 a	71.5 a	Too wet
3	2mmho Salt Mix	1.58 a	121.5 a	89.9 a	for
4	4mmho $MgSO_4$	2.96 b	99.4 a	95.1 a	yield
5	4mmho Salt Mix	3.02 b	120.5 a	63.4 a	sampling
6	6mmho $MgSO_4$	4.10 c	124.0 a	97.2 a	
7	6mmho Salt Mix	3.45 bc	113.5 a	98.9 a	
	F Value	17.4	0.51	0.94	
	Significance	**	N.S.	N.S.	
	CV	21.8	29.7	50.1	

Although there was a significant increase in the conductance of the soil of both fields with increasing salt treatments, the salt effect was not as large as that desired. Since the $MgSO_4$ was more soluble than the salt mixture, this salt produced the maximum conductivity of 4.56 mmhos/cm on the Rosemount field.

Plant populations of both varieties at Rosemount were significantly depressed by maximum conductivity with the highest rate of $MgSO_4$ application. There was no apparent characteristic chlorosis effect observed by the plants of either variety at any time on the Ostrander silt loam.

There was little difference in yield of the Hark variety on the various salt treated plots, and though the Chippewa 64 yields increased they were not significant, the untreated yield was considerably less than that on some of the salt treatments. It is possible that soybean yields might be responsive to some component of one or more of the added salts.

It is apparent that factors other than high soluble salt concentrations in the soil such as temperature, moisture, aeration, etc., are probably important contributors to soybean chlorosis.

Trace Element Study with Kentucky Bluegrass and Timothy - 1968

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Four field experiments with Kentucky bluegrass and timothy were conducted to study the effects of trace element applications. All materials were top-dressed on established stands of grasses on growers' fields. General information on the experimental sites is given in Table 1.

Table 1. Location, soil type and other information concerning the experiments

Field No.	Location	Species, variety	Age of stand	Soil type
1.	E. Helmstetter Lake of the Woods County	K. bluegrass Park	1965 seeding	Rocksbury loam
2.	Ed. Baumgartner Roseau County	K. bluegrass Park	Renovated 1965	Bearden silty clay loam
3.	D. Habstritt Roseau County	K. bluegrass Park	Renovated 1966	Peat
4.	Al. Ravendalen Lake of the Woods County	Timothy Climax	1965 seeding	Unidentified loam

A Latin square design was used with six treatments replicated six times. Following amounts and sources of trace elements were used:

	Treatment	Rate
1.	None	--
2.	Boron (B)	2 lb./acre boron
3.	Copper (Cu)	50 lb./acre $CuSO_4 \cdot 5H_2O$
4.	Manganese (Mn)	25 lb./acre $MnSO_4$
5.	Zinc (Zn)	25 lb./acre $ZnSO_4 \cdot H_2O$
6.	B, Cu, Mn, Zn	Same as above

All treatments received a uniform application of N, P and K. All materials were applied on October 10, 1967.

The individual plots were 10 feet wide and 20 feet long. Plant tissue samples were collected at the beginning of heading out from fields 1, 2 and 4. No plant samples, at this stage of development, could be collected on the peat (field 3) because the field was inundated by flood. Nitrogen content was determined by the micro-Kjeldahl procedure. Contents of the other chemical elements were determined in the multielement emission spectrophotometer. A strip 17 feet long and 34 inches wide up the center of each plot was cut for seed yields.

Adjacent to each of the four main experiments with trace elements, six additional plots were established to measure the effects of fertilization with N, P and K on seed yields. Increases in seed yields, ranging from 120 to 460 pounds per acre, resulted from application of the three major nutrient elements (Table 2).

Trace element treatments did not increase seed yields of the two grasses (Table 3). Applications of boron and zinc resulted in significantly lower seed yields of Kentucky bluegrass on mineral soil (Field 1).

Effects of trace element treatments on the chemical composition of grass tissue on mineral soils are shown in Tables 4, 5 and 6. Increases in boron content of the tissue resulted from B applications on all fields. Manganese content in Kentucky bluegrass was increased only on field 1. Copper and zinc contents were not affected by trace element treatments.

Table 2. Effect of Fertilization on the Seed Yield of Park Kentucky Bluegrass and Climax Timothy, 1968.

Plant Nutrients Applied N P_2O_5 K_2O	Field 1 Bluegr. Rocksbury 1 (E.H.)	Field 2 Bluegr. Bearden sicl (E.B.)	Field 3 Timothy Unident. 1 (A.R.)	Field 4 Bluegr. Peat (D.H.)
Lbs./Acre	Yield of seed, lbs./acre			
None	232	171	43	422
60 + 30 + 30	591	387	270	-
90 + 45 + 45	693	500	368	-
20 + 40 + 40	-	-	-	583
30 + 40 + 40	-	-	-	543

Fertilizer treatments were made on October 10, 1967.

Table 3. Effect of Trace Element Applications on the Seed Yields of Kentucky Bluegrass and Timothy, 1968.

Treatments of Trace Elements	Field 1 Bluegr. Loam (E.H.)	Field 2 Bluegr Sicl (E.B.)	Field 3 Timothy Loam (A.R.)	Field 4 Bluegr. Peat (D.H.)
	Yield of seed, lbs./acre			
None	621 c	350	375	602
B (Boron)	524 a	367	353	600
Cu (Copper)	612 c	332	373	599
Mn (Manganese)	596 bc	316	370	597
Zn (Zinc)	550 ab	307	388	625
B, Cu, Mn, Zn	591 bc	387	368	583
Significance	**	N.S.	N.S.	N.S.
CV(%)	7	20	10	11

All plots received following amounts of plant nutrients: Field No. 1 and 2 60+30+30; field No. 3 90+45+45; field No. 4 20+40+40. All fertilizer materials were applied on October 10, 1967.

Table 4. Effect of Trace Element Applications on the Chemical Composition of Kentucky bluegrass tissue, 1968. Field 1. E.H. Lake of the Woods County, Rocksbury loam.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	5 a	10	30 b	28
B	8 b	10	20 ab	29
Cu	5 a	10	29 ab	28
Mn	5 a	11	33 c	30
Zn	5 a	9	27 a	34
B, Cu, Mn, Zn	7 b	11	31 bc	32
Significance	**	N.S.	**	N.S.
CV (%)	11	17	7	13

Table 5. Effect of Trace Element Application on the Chemical Composition of Kentucky bluegrass, 1968. Field 2. E.B., Roseau County, Bearden Sicl

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	5 a	13	25	23
B	7 b	9	26	20
Cu	5 a	11	23	21
Mn	5 a	12	25	22
Zn	5 a	17	24	27
B, Cu, Mn, Zn	7 b	17	27	27
Significance	**	N.S.	N.S.	N.S.
CV (%)	11	71	13	23

Table 6. Effect of Trace Element Applications on the Chemical Composition of Timothy Tissue, 1968.
Field 3. A.R., Lake of the Woods County, Unidentified loam.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	9 a	11	32	39
B	12 b	12	26	39
Cu	8 a	11	30	37
Mn	8 a	11	30	37
Zn	8 a	12	35	42
B, Cu, Mn, Zn	12 b	12	30	41
Significance	**	N.S.	N.S.	N.S.
CV (%)	17	15	11	12

Soil Testing

John Grava

Soil testing entered a new phase on September 13, 1968, when the soil testing laboratory of the University of Minnesota started making fertilizer and lime recommendations with a computer. Computerized recommendations can be made for 72 different crops.

A complete updating of the soil testing laboratory has also taken place. The improvements include: (a) hiring of two full-time junior scientists, (b) introduction of tests for sulfur, zinc and soluble salts (conductivity), (c) adoption of the SMP buffer as a lime requirement test, and (d) speeded-up service.

The laboratory processed a total of 25,339 samples. The number of various types of samples analyzed during 1968 is shown by the following data:

Regular farm, garden and lawn samples	20,962
Specials (S 689, Zn 818, S.S. 372, L.R. 351)	2,230
Florist (Greenhouse) samples	1,438
Limestone	35
Departmental research samples	674
Total	25,339

Heavy rainfall and extremely wet soil conditions made sample collection most difficult. Because of that, the expected sample pick-up promoted by the improved service did not materialize. In fact, 7500 less soil samples were submitted for testing during the last four months of 1968 than during the same period in 1967. The monthly distribution of regular soil samples received by the laboratory is shown in Table 1.

Table 1. Monthly Distribution of Regular Soil Samples Received by the University of Minnesota Soil Testing Laboratory During 1968.

Month	Number of Samples
January	1585
February	1570
March	2952
April	2815
May	1012
June	369
July	462
August	1027
September	2432
October	3492
November	2248
December	1506