SOIL SERIES 86

A REPORT ON FIELD RESEARCH IN SOILS

The 1970 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science, Extension Soil Specialists and Agronomists at St. Paul and the branch stations at Crookston, Grand Rapids, Lamberton, Morris, Rosemount and Waseca, and Soils and Crops agents.

Some of the results are from 1969 experiments only and should be regarded on this basis. The investigations are those of a more applied nature, and exclude some of the more theoretical laboratory, greenhouse and growth chamber studies. Since considerable amounts of data includes only one years study, it should not be considered as conclusive and not for further publication.

Sincere appreciation is expressed for materials and/or financial assistance contributed by several organizations including: Amchem Products; American Oil Company; Chevron Chemical Company; CIC Biometeorology Graduate Program, College of Environmental Sciences, University of Wisconsin; Conwed Corporation; Custom Farm Services; DuPont Chemical Company; Eagle-Picher Company; Elanco Products Company; Farmers Union Central Exchange; Geigy Agricultural Chemical Corporation; Gulf Oil Company; International Harvester Company; Jacques Seed Company; MacAndrews and Forbes Company; Midland Cooperatives; Minnesota Crop Improvement Association; Minnesota Limestone Producers Association; Minnesota Plant Food Association; Monsanto Chemical Corporation; Montana Sulphur and Chemical Company; St. Paul Ammonia Products; Tennessee Corporation; and U. S. Borax and Chemical Corporation.

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SOME CLIMATOLOGICAL NOTES, FALL 1969

by Donald G. Baker

A. Summary of the 1969 Soil Water Survey.

The fall 1969 soil water results are shown in Table 1. Following the exceptionally high precipitation of fall 1968, which was centered over an area a bit west of Lamberton where a total of 18 inches was recorded in September and October, the 1969 soil water reservoirs are returning to normal. This is why most of the soils show a decrease in water content between fall of 1968 and 1969 (column 8 in table 1).

The return to normality of the water content in south-central and southwestern Minnesota was in part hastened by the departure of the April 1-August 31, 1969, precipitation from normal, Fig. 1. In all of central and southern Minnesota, except a relatively small area in the southwest and extreme south-central, the precipitation was below normal. The deviation reached a maximum departure of at least 8 inches below normal in a small area south of the Twin Cities.

The 1968 and 1969 soil water reservoirs during the growing season at Southwest Experiment Station, Lamberton, are shown in Fig. 3. By the end of the 1969 season the reservoir was about back to normal.

The 1968 and 1969 seasons at the Northwest Experiment Station, Crookston, are shown in Fig. 4. It is interesting to note the difference in water content due to plant cover.

In summary the soil water reservoir in the state seems to be as follows:

1. Average in the south-central and southwest. For the 1970 crop year only a normal seasonal precipitation is required.

2. The same is true for northeastern, north-central and northwestern (except the exterme northwestern tip) Minnesota.
3. Soil moisture reserves are probably somewhat below normal in the west-central and extreme southeastern parts of the state. Normal to somewhat above normal precipitation is required for the 1970 season.
4. Soil reserves are probably quite low in the extreme northwestern tip and in a relatively large area in central and east-central Minnesota. Well above normal precipitation will be necessary to sustain crops in the 1970 season.

Table 2 shows the average soil water content at a number of sites.

B. Average Winter Snow and Soil Conditions at St. Paul.

While the following data are derived only from the Twin Cities area they may be of general interest to those concerned with the winter climate. Table 3 shows that on the average the snow depth reached a maximum in February, although there was a slightly greater liklehood of snow cover in January (78.8% of the days) than in February (75.7% of the days). For the winter period of December-March the snow cover persisted about 82 days (67.6% of the days) with the daily snow depth averaging 4.3 inches.

The average progression of the 32°F isotherm into and out of the soil at the St. Paul campus weather station is shown in Fig. 4.

Also shown in Fig. 4 is what is believed to be typical patterns of frozen soil when a deep snow cover is present and when there is relatively little snow cover (a so-called "open" winter). Of particular importance

Table 3. Long-term mean monthly snow depth and percent of possible days with snow cover.*

	Nov	Dec	Jan	Feb	Mar	Apr	Mean (Dec-Mar)
Depth (In.)	0.67	2.95	4.90	5.71	3.64	.T	4.3
Possible Days (%)	25.7	65.1	78.8	75.7	51.5	1.5	67.6

*Based upon snow depth values on the 10th, 20th and 30th day of each month. Data from the Minneapolis-St. Paul Weather Bureau airport station. T signifies a trace.

with respect to early spring drainage problems is the fact that a frozen layer often persists at intermediate depths (centered between 60-80 cm, 24-31 in.) for about 10 days after thawing has occurred both above and below this level.

Table 1. Fall 1969 soil water survey results (soils sampled to a depth of 5 feet).

County	Nearby Town	Operator	Soil Type	Crop	Total Available Water, Inches	% of Possible Water	Inches Difference Fall '69-Fall '68	Water Used In Season, Inches	
Big Stone	Ortonville	H. Dimberg	Barnes c.l.	Alf-brome	1.9	13.9	-0.7	21.4 4/25-11/10	OG
Big Stone	Beardsley	Wright	Barnes si.l.	Soybeans	4.7	40.1	+4.2	11.6 4/25-11/10	OG
Chippewa	Milan	H. Olson	Rothsay si.l.	Soybeans	5.1	38.3	-2.2	21.9 5/6-11/10	OG
Chippewa	Montevideo	Sederstrom	Barnes si.l.	Corn	2.8	21.2	-3.2	20.0 5/6-11/10	OG
Grant	Barrett	H. Hubbard	---	Wheat	2.0	15.2	----	14.1 5/12-11/10	OG
Jackson	Lakefield	Pietz	Primghar si.l.	Alfalfa	8.9	93.6	*	5/26-10/27	GH
Kandiyohi	Pennock	G. Geise	Clarion si.l.	Alf-brome	1.9	13.9	-5.9	M-11/10	GH
Lac Qui Parle	Bellingham	Glasser	Aastad si.c.l.	Corn	9.9	61.8	+0.2	M-11/10	OG
Lac Qui Parle	Lac Qui Parle	Heimdahl	Rothsay si.l.	Small grain	1.5	11.0	-3.8	21.6 5/6-11/10	OG
Lac Qui Parle	Marietta	Aebli	Rothsay si.l.	Small grain	8.0	59.7	-1.3	22.0 5/6-11/10	OG

Table 1. (Continued)

Lac Qui Parle	Dawson	M. Nelson	Aastad si.c.l.	Soybeans	5.6	51.8	-4.2	21.4 5/6-11/10	OG
Lincoln	Porter	R. Boulton	Barnes si.l.	Corn	3.7	47.4	-5.2	22.1 5/23-10/28	GH
Lyon	Marshall	Boerboom	Vallers c.l.	Corn	15.6	125.8	*	5/24-10/29	GH
Murray	Slayton	A. Larson	Barnes si.c.l.	Alfalfa	3.3	25.8	*	16.5 5/26-10/27	GH
Murray	Fulda	R. Horn	Primghar si.l.	Oats	5.3	30.6	*	18.0 5/26-10/27	GH
Polk	Crookston	U. of M.	Hegne si.c.l.	Barley (#1)	11.3	66.4	+1.5	15.2 6/8-10/31	OS
Polk	Crookston	U. of M.	Hegne si.c.l.	Wheat (#5)	7.1	41.7	-0.8	16.2 5/30-11/4	OS
Polk	Crookston	U. of M.	Hegne si.c.l.	Sugarbeets (#6)	5.0	29.4	----	15.4 6/3-10/31	OS
Pipestone	Pipestone	Bucher	Kranzburg si.l.	Corn	8.4	61.7	-1.5	20.1 5/23-10/27	GH
Ramsey	St. Paul	U. of M.	Waukegan si.l.	Sod	1.4	17.3	-3.5	14.1 5/4-10/23	DB
Ramsey	St. Paul	U. of M.	Waukegan si.l.	Soybeans	1.5	18.5	-4.7	15.3 5/4-10/23	DB
Ramsey	St. Paul	U. of M.	Waukegan si.l.	Bare soil	1.1	13.6	-3.7	14.3 5/4-10/23	DB

Table 1. (Continued)

Redwood	Belview	V. Anderson	Nicollet c.l.	Corn	8.4	67.2	*	12.6 5/20-10/29	GH
Redwood	Lamberton	U. of M.	Webster c.l.	Corn	4.8	48.9	**	14.9 6/20-10/18	WN
Redwood	Morgan	N. Prokosch	Nicollet c.l.	Alfalfa	1.5***	33.3***	*	17.4 5/24-10/29	GH
Redwood	Wabasso	D. Kuehn	Nicollet	Corn	4.1	31.3	-2.9	5/24-10/29	GH
Rock	Hardwick	Hengeveld	Kranzburg si.l.	Corn	4.8	44.8	-8.2	M-10/27	GH
Stevens	Alberta	R. Cook	---	Alfalfa	2.5	17.5	---	14.9 5/12-11/10	OG
Stevens	Morris	U. of M.	Aastad si.c.l.	Corn	3.0	23.8	-0.4	16.8 5/12-11/10	OG
Swift	Danvers	Stubbs	Barnes c.l.	Corn	2.7	18.8	-2.1	22.2 5/6-11/10	OG
Swift	Murdock	Tucker	Vallers si.c.	Corn	12.1	79.0	-3.3	M-11/10	OG

*Too wet for fall samples in 1968.
**Compared to 9/13/68 sample; too wet for later sampling in fall, 1968.
***Includes only first 3 feet.
NOTE: S.C.S. sites not sampled because sampling materials not sent out.

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	4 (1966-69)
"	Beardsley	1.4	4 (1966-69)
Chippewa	Milan (Big Bend)	6.3	7(1962-69) '65 msg
"	Montevideo	3.5	5 (1965-69)
Dodge	Dodge Center	4.8	9 (1960-69) '69 msg
Grant	Barrett	2.0	1 (1969)
Jackson	Lakefield	6.3	2 (1967-69) '68 msg
Kandiyohi	Pennock	2.2	6 (1963-69) '65 msg
"	Kandiyohi	1.4	4 (1963-68) '65 msg
Lac Qui Parle	Bellingham	9.21	7 (1962-68) '65 msg
"	Lac Qui Parle	2.8	5 (1965-69)
"	Marietta	6.5	7 (1962-69) '65 msg
"	Dawson	6.6	6 (1963-69) '65 msg
Lincoln	Arco	3.3	6 (1963-69) '69 msg
"	Porter	4.9	7 (1963-69)
Lyon	Marshall	7.7	5 (1963-69) '66,'68 msg
Murray	Slayton	2.2	2 (1967-69) '68 msg
Mille Lacs	Milaca	6.7	8 (1961-69) '69 msg
Nobles	Fulda	3.2	2 (1967-69) '68 msg
Polk	Crookston	6.2 (Plot 1)	9 (1961-69)
"	"	3.7 (Plot 4)	3 (1964-69) '66,'69 msg
"	"	7.7 (Plot 5)	5 (1964-69) '66 msg
"	"	5.6 (Plot 6)	4 (1964-69) '67,'68 msg
"	"	2.9 (Plot 7)	2 (1966-67) '68,'69 msg

Table 2. (Continued)

County	Nearby Town	Ave. Water Content (in.)	Years of Data
Pipestone	Pipestone	6.5	3 (1967-69)
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	5.9	7 (1962-69) '68 msg
"	Lamberton	5.1	8 (1961-69) '68 msg
"	Morgan	7.6	3 (1965-68) '68,'69 msg
"	Wabasso	5.0	6 (1963-69)
Rock	Hardwick	8.3	3 (1967-69)
Sibley	Winthrop	8.5	7 (1961-69) '68,'69 msg
Stevens	Alberta	2.5	1 (1969)
"	Morris	2.5	3 (1967-69)
Swift	Danvers	4.3	6 (1963-69)
"	Murdock	1.0	6 (1963-69)
Todd	Long Prairie	8.3	1 (1968) '69 msg
Watonwan	Butterfield	7.4	7 (1961-69) '68,'69 msg
"	Lewisville (Mad)	7.6	3 (1966-68)
"	Lewisville (King)	8.1	3 (1966-68)
Wabasha	Kellogg	9.5	8 (1961-69) '69 msg
Yellow Medicine	Granite Falls	9.3	6 (1963-68)

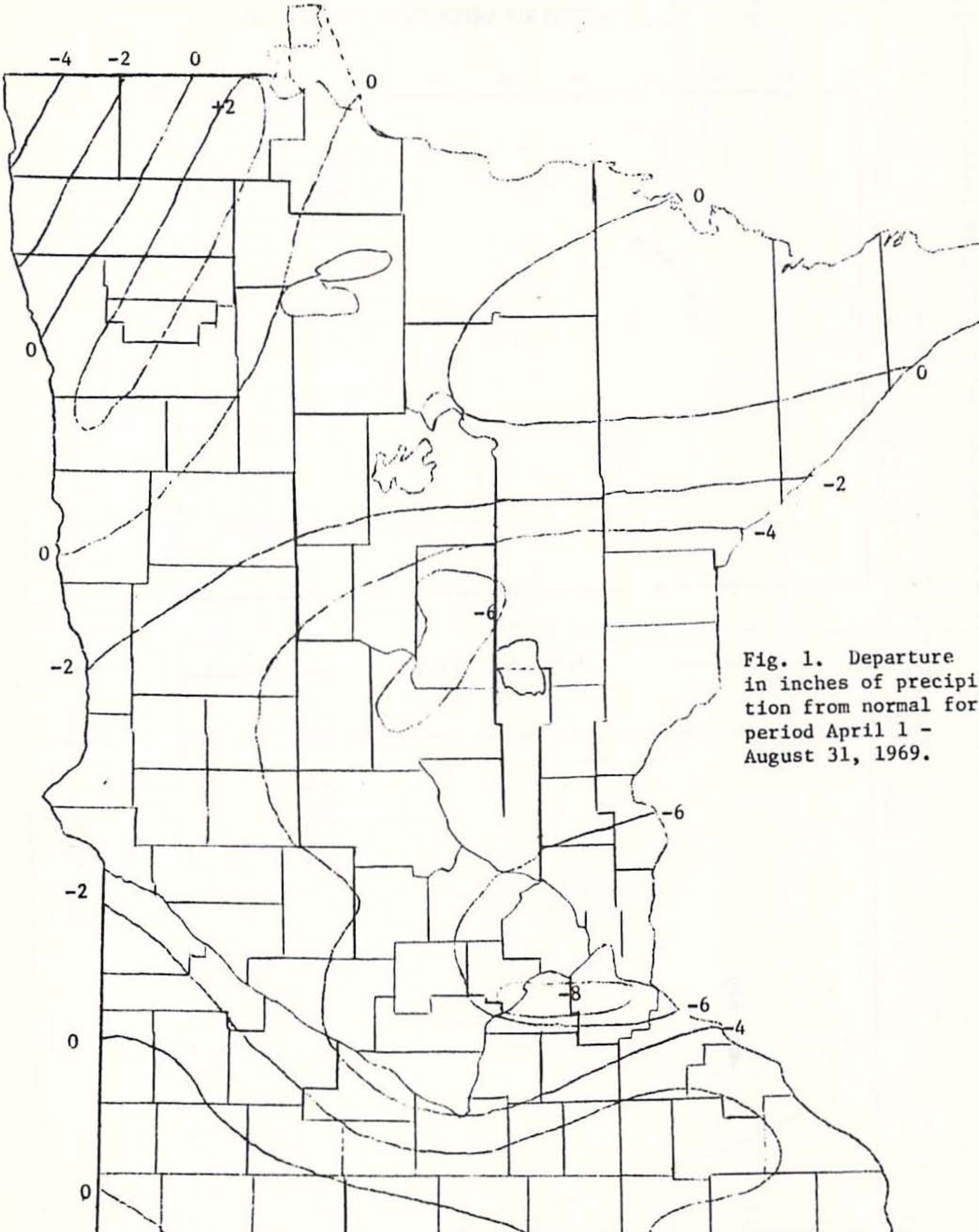

Fig. 1. Departure in inches of precipitation from normal for period April 1 - August 31, 1969.

D. G. Baker, Soil Science
E. L. Kuehnast, ESSA
9/24/69

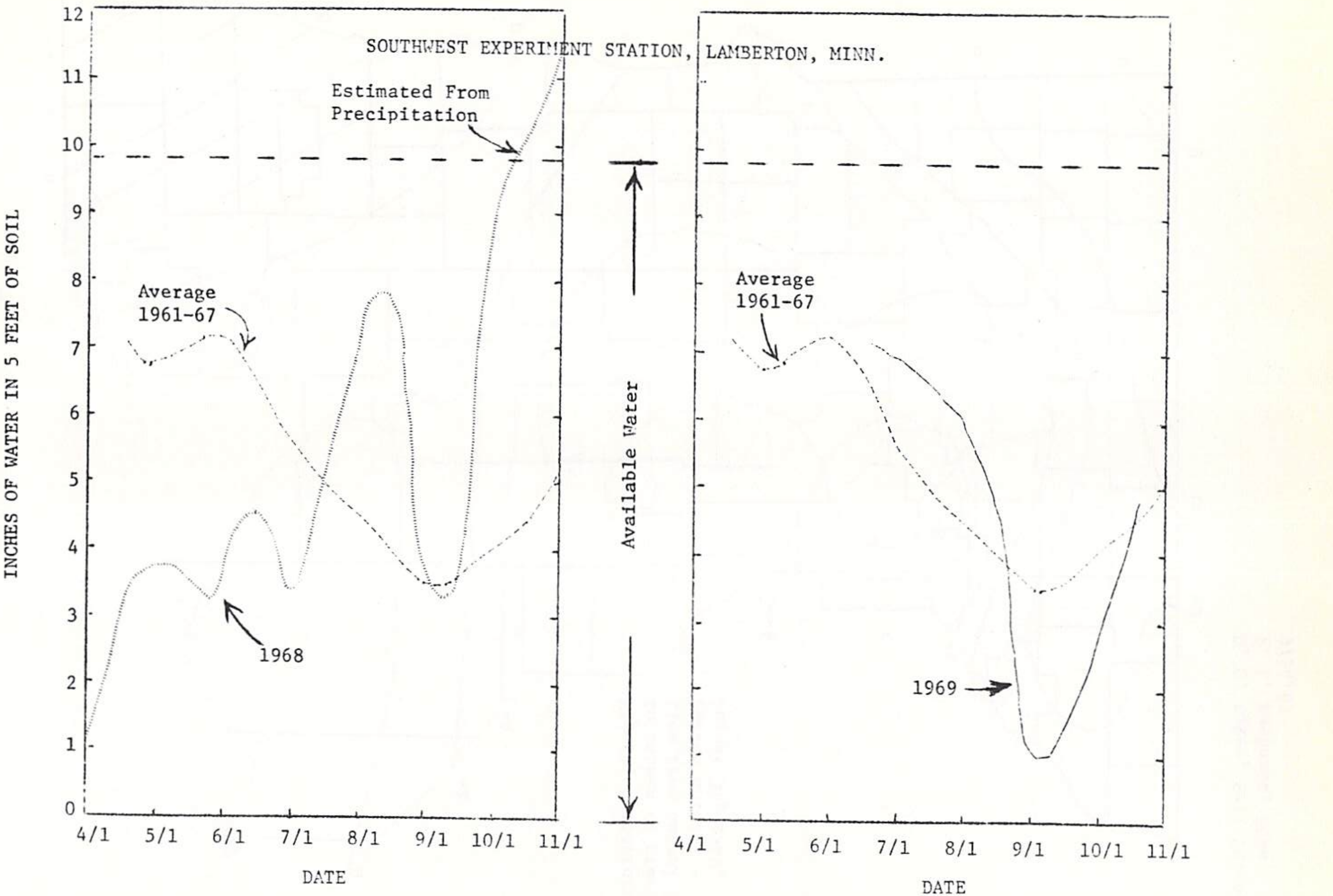

Fig. 2. Soil water conditions under continuous corn at Southwest Agricultural Experiment Station, Lamberton, Minn.

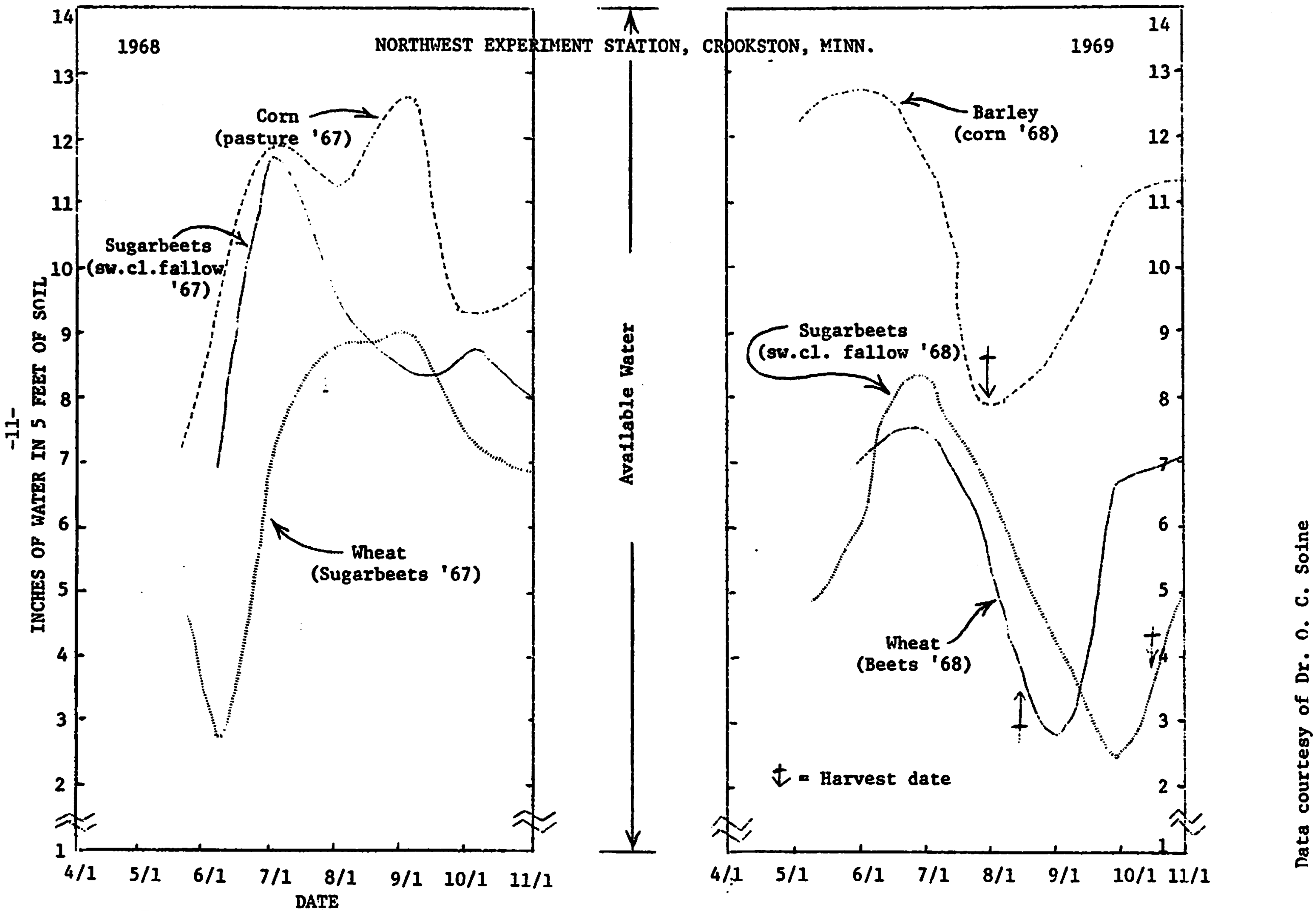

Fig. 3. Soil Water Conditions at the Northwest Agricultural Experiment Station, Crookston.

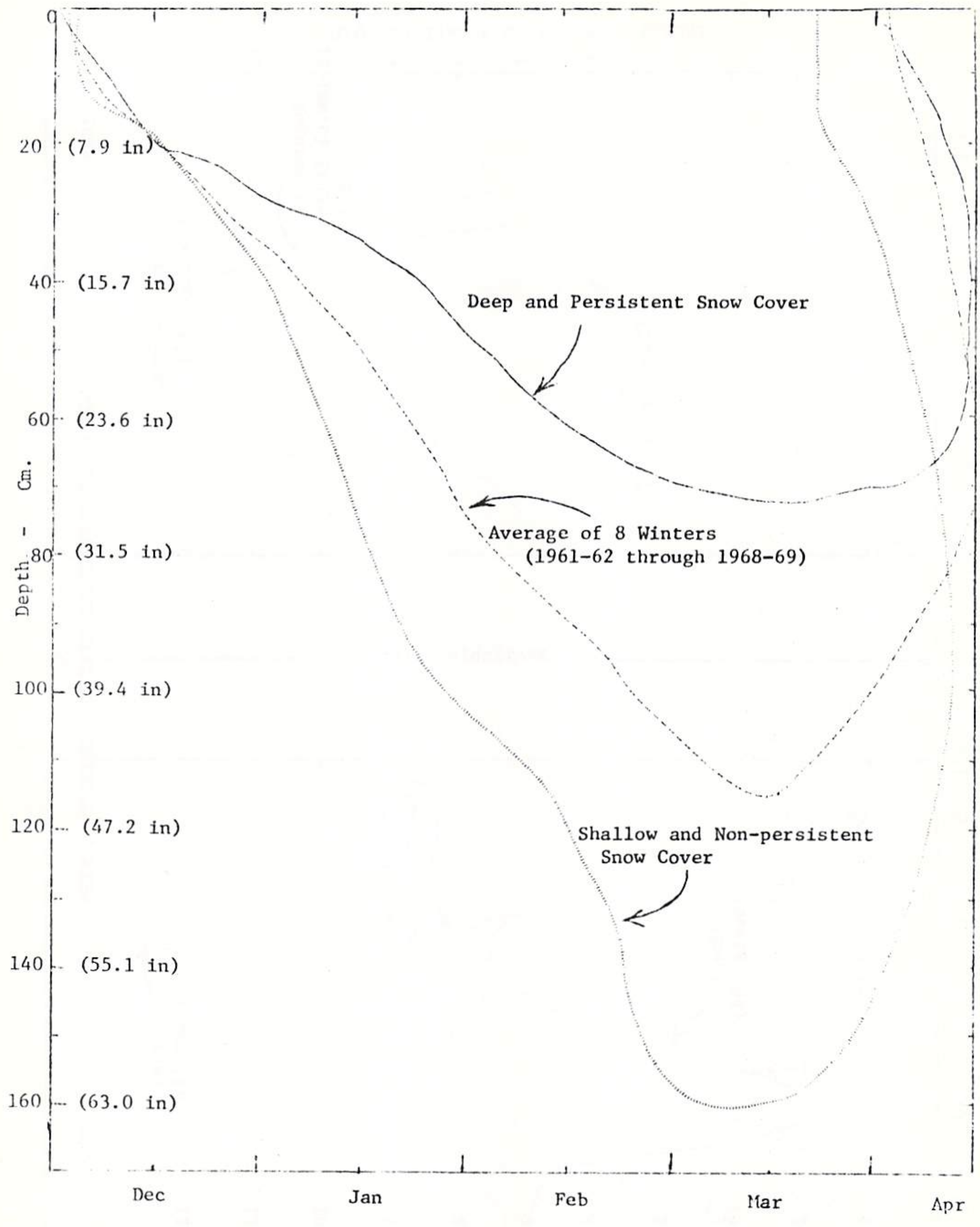

Fig. 4. Average soil freezing depth at St. Paul, Minn., 1961-62 through 1968-69. Freezing depth under deep and shallow snow cover is also shown.

Those to whom I am indebted for obtaining the soil samples or supplying soil water data are the following:

Mr. C. L. Robeck, District Conservationist, S.C.S., U.S.D.A.; Gaylord

Mr. A. N. Fischer, District Conservationist, S.C.S., U.S.D.A.; Long Prairie

Mr. Orville Gunderson, Area Soils Agent, U. of M.; Morris

Mr. George Holcumb, Area Soils Agent, U. of M.; Marshall

Mr. William M. Kalton, District Conservationist, S.C.S., U.S.D.A.; Milaca

Mr. Patrick N. Kennedy, District Conservationist, S.C.S., U.S.D.A.; St. James

Dr. W. W. Nelson, Southwest Experiment Station, U. of M.; Lamberton

Mr. G. J. Stickeler, District Conservationist, S.C.S., U.S.D.A.; Kellogg

Dr. Olaf C. Soine, Northwest Experiment Station, U. of M.; Crookston

EFFECT OF ZINC ON THE YIELD AND QUALITY OF SUGARBEETS, 1969

Northwest Experiment Station, Crookston

Olaf C. Soine, Soil Scientist

This is the second year for this trial and in 1969 there were plots at four locations throughout the Red River Valley. Table 1 gives the location of these plots, the previous crops, and the fertilizer treatments prior to planting. Two rates of zinc, 10 and 40 lbs. per acre, were broadcast prior to planting and placed in a band after planting.

Table 1. Location, 1968 crop and fertilizer treatment.

Location	1968 Crop	Fertilizer Applied
Sabin	Durum wheat	100 lb. N, 160 lb. P_2O_5 broadcast prior to planting
Crookston	Sw. cl. fallow	250 lb. P_2O_5 fall applied, 100 lb. 5-42-0 applied at planting
E. Grand Forks	Sw. cl. fallow	200 lb. 5-42-0 applied at planting
Auburn, North Dakota	Potato	50 lb. N, 160 lb. P_2O_5 broadcast prior to planting

Table 2 gives the soil analysis for the four locations. These samples were taken prior to the fertilizer application and planting. The soil at all sites was alkaline, high in organic matter, and high in potash. The phosphorus tested very high at Crookston, high at Auburn and Sabin, but low at East Grand Forks. The zinc content of the soil was medium at all locations.

Table 2. Soil analysis for each location, 1969.

Soil texture	pH	Organic matter	P lbs/A	K lbs/A	Zn P.P.M.	S P.P.M.
Auburn, No. Dak. Sil	7.9	H	40	410	1.9	40
E. Grand Forks, Minn. Sil	8.0	H	13	450	1.9	21
N.W. Experiment Station, Crookston L	8.1	H	92	540	2.0	28
Sabin, Minn. SiCl	7.9	H	37	600	1.6	14

Table 3 gives the treatment, yield, percent sugar, impurity index, and sugar per acre. Yields at Sabin and Auburn were low because of poor stands and insufficient rainfall during the growing season. Yields at Crookston and E. Grand Forks were good. Although there were no significant yield increases at any of the locations, there were increases of 1.41 tons at Crookston, 1.20 tons at Sabin, and 0.90 tons at Auburn. There were no significant differences between rates or methods of application, impurity index, percent sugar, and sugar per acre.

Samples of the blade, petiole, and roots were taken in mid-July and September for zinc analysis from the Crookston and E. Grand Forks plots. These two plots had the same land preparation and previous crop management. The data is given in Tables 4 and 5.

Table 3. Effect of zinc on yield, percent sugar, purity, and sugar at four locations, 1969.

Auburn, N. Dakota

Treatment	Rate lbs/A	Yield t/A	Sugar %	Impurity index	Sugar lbs/A
Check	0	14.61	14.30	1145	4,160
Zn broadcast	10	15.10	14.30	1089	4,320
Zn broadcast	40	14.67	14.92	936	4,380

E. Grand Forks, the zinc content of the roots was higher at the first sampling date than at Crookston, but not at the later date.

Table 4. Zinc content of blade, petiole and root in parts per million (ppm), 1969.

Treatment	Rate	Crookston			E. Grand Forks		
	lbs/A	blade	petiole	root	blade	petiole	root
Check	--	30.4b[1]	11.1a	11.6a	36.5a	14.5a	15.2c
Broadcast	10	34.4ab	14.5a	13.4a	37.6a	15.0a	17.8b
Broadcast	40	39.2a	13.9a	13.5a	40.9a	18.6a	19.9a
Band	10	31.8b	12.8a	13.0a	37.4a	16.5a	17.4b
Band	40	37.2ab	15.8a	13.5a	40.3a	16.6a	17.2b

Plots sampled July 7 and 17 at Crookston and E. Grand Forks, respectively.

[1]Any two averages followed by the same letter do not differ at the 5% level of significance according to Duncan's New Multiple Range Test.

Table 5. Zinc content of blade, petiole and root in parts per million (ppm), 1969

Treatment	Rate	Crookston			E. Grand Forks		
	lbs/A	blade	petiole	root	blade	petiole	root
Check	--	28.3b[1]	18.9a	9.3b	32.2a	13.6a	8.2b
Broadcast	10	36.8a	14.7a	13.6a	39.0a	16.5a	12.2a
Broadcast	40	39.1a	14.9a	12.9ab	37.7a	11.3a	11.9ab
Band	10	33.1ab	19.2a	10.9ab	35.8a	17.5a	9.6ab
Band	40	37.9a	15.8a	11.8ab	39.5a	15.9a	8.8ab

Plots sampled September 18 and 22 at Crookston and E. Grand Forks, respectively.

[1]See footnote Table 4.

LAND FORMING EXPERIMENT

Northwest Experiment Station, Crookston - 1969

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.

There were variations in the yields of all crops on the various land forming treatments. The lowest yields occurred on the 0.2% and 0.1% slopes, especially on the lower half of these plots because most of the top soil was removed from this area during construction. The least soil movement took place on the Level and Land Smoothing plots, and here the yields were more indicative of the fertilizer treatments. On the check plot, there were two low areas where water tended to accumulate, which caused some crop damage.

The corn yields in 1969 were good but no definite results from the fertilizer applications were noted on the check, 0.2%, and 0.1% slope plots. On the Level and Land Smoothing plots, the 40+40+20 fertilizer application gave the highest yields. Although there were some variations in the 4-year averages, the 40+40+20 increased the yields on three of the land treatment plots.

Wheat production in 1969 was good and yields were above those in 1968 and the 4-year averages. The 40+40+20 fertilizer gave the most consistent and largest yield increase on each land treatment.

The barley yields on the 0.2% and 0.1% slope treatments were very low because of the soil disturbance on these plots during construction. The best yield increases came from the 40+40+20 fertilizer application in 1969 and also for the 4-year averages.

The alfalfa yields in 1969 were variable and no definite trends were established. The best yields were on the 0.1% slope treatment, and the highest increase came from the 40+40+20 fertilizer application.

This study will be summarized and prepared for publication.

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

Land Forming	Fertilizer	Corn[a] bu/acre		Wheat bu/acre		Barley bu/acre		Alfalfa[b] lbs/acre	
Treatments	lbs/acre	1969	Avg.1966-69	1969	Avg.1966-69	1969	Avg.1966-69	1969	Avg.1967-69
	0+0+0	85	84	47	40	53	51	6799	5785
Check	0+40+0	80	82	47	40	50	53	6504	5666
	0+40+20	74	78	47	39	53	49	6424	5464
	40+40+20	75	84	49	42	66	59	6315	5272
	0+0+0	88	85	40	37	26	37	6233	5833
0.2%	0+40+0	86	83	42	37	25	40	6479	6301
Slope	0+40+20	89	80	40	35	24	43	6088	6124
	40+40+20	81	85	44	41	39	56	5871	5916
	0+0+0	84	78	39	34	38	42	7119	5771
0.1%	0+40+0	84	77	43	34	26	38	7163	5985
Slope	0+40+20	80	79	48	37	38	45	7056	6201
	40+40+20	84	82	50	42	68	62	7379	6427
	0+0+0	88	84	43	37	45	51	6791	5742[c]
Level	0+40+0	95	88	46	38	46	53	6514	5363
	0+40+20	90	83	42	36	46	56	6239	5089
	40+40+20	98	90	43	40	57	60	6293	5096
	0+0+0	87	87	42	40	50	54	6779	4701[d]
Land	0+40+0	80	85	39	39	47	51	7065	4568
Smoothing	0+40+20	80	84	41	40	46	57	6858	4456
	40+40+20	88	85	48	41	60	62	6504	4274

[a] 15.5% Moisture, 22-inch rows
[b] 15.5% Moisture, 2 cuttings
[c] Only 1 crop in 1967 on Level Treatment
[d] No crop in 1967 and 1st crop in 1968 on Smoothing Treatment

SUGARBEET ROTATION STUDIES - 1969

Northwest Experiment Station, Crookston

Olaf C. Soine, Soil Scientist

This trial was initiated in 1967 to study the effect of different cropping systems on the yield and quality of beets. Cost of production and net return per acre are also included.

The following 4-year rotations are being used:

1. Beets, wheat, barley, legume fallow
2. Beets, wheat, barley, oats
3. Beets, potato, wheat, barley
4. Beets, wheat, barley, alf. hay-fallow
5. Beets, wheat, barley, bl.fallow
6. Beets, wheat, barley, soybeans

Table 1 gives the average yields for 1967-69 for the six rotations. Rotation 1, with the required year of a legume fallow, has been the common type of cropping for beets throughout the Red River Valley. This requirement has been lifted and growers will now be looking for information about different cropping systems for beets.

The yield of beets and all other crops has been good in all the rotations. The highest average beet yield of 18.49 tons was obtained with Rotation 5 and the lowest yield of 16.99 tons with Rotation 2.

Table 1. Average yields of crops for 1967-69 for six sugarbeet rotations.

Rotation 1	Beets 18.19 T	Wheat* 50.5 B	Barley 80.6 B	Sw. C. Fallow ----
Rotation 2	Beets 16.99 T	Wheat 52.2 B	Barley 83.5 B	Oats 116.7 B
Rotation 3	Beets 17.45 T	Potato** 327 B	Wheat 49.3 B	Barley 82.8 B
Rotation 4	Beets 17.36 T	Wheat 50.9 B	Barley 82.1 B	Alf-hay Fallow*** 2134 lbs.

Table 1. (Continued)

Rotation 5	Beets 18.49 T	Wheat 53.3 B	Barley 83.6 B	Bl. Fallow ---
Rotation 6	Beets 17.42 T	Wheat 51.8 B	Barley 79.9 B	Soybeans 26.8 B

* All grain yields on pure seed basis
** No. 1 potato
*** 1st. crop alfalfa removed. Moisture content 20%

The effect of the 1967-69 crop on the 3-year average yield of beets, percent sugar, impurity index, and pounds of sugar per acre is given in Table 2. The data in this table shows the effect of the previous cropping on beets. For example, in Rotation 1, beets always follow the sw. clover fallow.

There are some interesting variations in the percent sugar for the various rotations. The black, sw. clover, and alfalfa fallow rotations have the lowest percent sugar, while Rotations 2 and 6 have the highest. This same result occurred in 1968.

The impurity index gives some indication of the quality of the beets and the lower this figure is the better the processing quality. The three fallow rotations have the highest impurity indexes while the oats and soybean rotations, Rotations 2 and 6, have the lowest.

Table 2. Effect of 1967-69 crop on 1967-69 yield, percent sugar, impurity index and yield of sugar.

Rotation	1967-69 crop	Yield T/A	Sugar %	Impurity index	Sugar T/A
1	Sw.cl. fallow	18.19	13.57	2768	2.47
2	Oats	16.99	14.72	2021	2.50
3	Barley	17.45	13.92	2370	2.43
4	Alf-hay fallow	17.36	13.96	2459	2.42
5	Bl. fallow	18.49	13.48	2715	2.49
6	Soybeans	17.42	14.38	2247	2.50

It is interesting to note that the amount of sugar per acre for Rotations 2 and 6 are higher than that from the three fallow rotations.

Table 3 gives the average net income for 1967-68. These figures include a land cost of $20.00 per acre and $5.00 per acre for taxes. If a grower owns his land, the $20.00/A would not be "out of pocket" cost.

Table 3. Average net income from six sugarbeet rotations, 1967-68.

Rotation 1	Beets $184.84	Wheat $48.34	Barley $45.29	Sw.cl.fallow $-25.11	Total $253.36
Rotation 2	Beets $169.38	Wheat $47.73	Barley $49.97	Oats $36.35	$303.43
Rotation 3	Beets $168.55	Potato $294.15	Wheat $42.32	Barley $43.52	$548.54
Rotation 4	Beets $166.14	Wheat $44.81	Barley $50.32	A.Hay fallow $-13.68	$247.59
Rotation 5	Beets $196.22	Wheat $53.66	Barley $48.69	Bl.Fallow $-23.63	$274.94
Rotation 6	Beets $178.00	Wheat $41.98	Barley $43.85	Soybeans $33.48	$297.31

Tables 4 and 5 give a breakdown for cost of production for beets for 1967. The calculations for all crops follow this pattern and the rates for all farm operations are based on two publications[1] by the Extension Service, University of Minnesota, and North Dakota Crop and Livestock Reporting Service.

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[1] Custom Rates for Farm Operation. Extension Pamphlet 134 - Revised 1969 - Agricultural Extension Service, University of Minnesota.

Custom Farm Work Rates. Jan. 8, 1969. North Dakota Crop and Livestock Reporting Service, North Dakota State University, Fargo, North Dakota.

The net return from beets varies, depending on the type of rotation, but the important figure becomes the total return from all the crops in each rotation. The highest income came from Rotation 3 which included potatoes, while the lowest came from Rotation 4. In general, the net returns from the three fallow rotations were the lowest.

Table 4. Production worksheet for sugarbeets, 1967.

	Exp.	Seed bed	Har.	Land	Mkt.
Seed	$2.00				
Fertilizer	3.00				
Chemicals	3.60				
*Risk	0.75				
F. culti.		$1.00			
Harrow		0.50			
Plant		2.00			
Culti (4)		6.00			
Lift			$25.00		
Haul					$18.87
H. Labor		22.00			
R. tax				$ 5.00	
*Land				20.00	
Total	$9.35	$31.50	$25.00	$25.00	$18.87

Price. $16.74/ton
Yield. . . . . . 13.11 ton

1. Gross per acre. $219.46
2. Total production cost. 109.72
3. Profit or loss. 109.74
4. Spendable income per acre. 20.75
5. Total spendable income. 130.49

Table 5. Production worksheet for Sw. clover fallow.

	Exp.	Seed bed	Land
Seed	$ 3.00		
Fert.	9.63		
Plow		$3.00	
Disk		1.00	
F. culti. (3)		3.00	
Harrow		1.50	
R. Estate tax			$ 5.00
*Land use			20.00
Total	$12.63	$8.50	$25.00

1. Total production cost. $46.13
2* Spendable income per acre. 20.00
3. Total production cost. . . . . -26.13

FERTILIZING ALFALFA AT ELK RIVER, SHERBURNE COUNTY, 1969

C.J. Overdahl, C.P. Klint, D.S. Fairchild, B.C. McCaslin

This experiment was initiated in April of 1968. Lime applications of 8 tons per acre were made at that time, bringing the average pH to 6.2 on the irrigated plots and an average pH to 5.5 on the non-irrigated plots (Table 1). Seeding time treatments consisted of corrective and topdressing treatments of K_2O. The following treatment combinations were used on 16 irrigated plots and 16 non-irrigated plots:

(1) 0 lbs/A K_2O corrective + 0 lbs/A K_2O topdress

(2) 0 lbs/A K_2O corrective + 240 lbs/A K_2O topdress

(3) 480 lbs/A K_2O corrective + 0 lbs/A K_2O topdress

(4) 480 lbs/A K_2O corrective + 240 lbs/A K_2O topdress

Borate gypsum and phosphorus were applied to the entire experiment.

Comparisons are made in Table 1 of the pH differences between the irrigated and non-irrigated plots. Without irrigation, 8 tons/acre of lime over 1 1/2 years raised the pH by 0.1 compared with the irrigated plot with the same rates of lime raised the pH 0.8. This significant change in pH indicates the importance of lime quality and water in entering into the soil reaction in producing a pH change.

Comparisons are made in Table 2 of the yield differences, plant tissue contents and soil tests of the various treatments. There is the expected large difference between irrigated and non-irrigated plots. There was only a 0.2 tons/acre yield response over the check from the 240 lbs/A/K_2O top-dress treatment without irrigation. The irrigated plots indicated a 0.9 tons/acre yield increase between the check plot versus the highest potash treatment. The small differences in yields may be the result of the relatively high initial K soil tests (190 lbs/A/K). With additional crop removal, the soil test and plant tissue contents of K will likely be reduced resulting in greater yield differences between K treatments.

Future plans for this experiment include increasing the number of cuttings from 3 to four and the application of the 240 K_2O topdress treatment as a split application. One-half of the topdress rate will be applied in April, with the remainder being applied in July after removal of the 2nd cutting.

Table 1. Effect of 8 tons/acre of lime* on soil-water pH with irrigated and non-irrigated alfalfa. (Sherburne Co., Hubbard Loamy Coarse Sand).

Lime Treatment	April 1968	September 1969
Tons/A	(Initial pH)	
0	5.4	5.2
8	-	6.2
Irrigated plots		
8	-	5.5
Non-irrigated plots		

*Lime quality-92.0% C.C.E.

92.8% Pass 8 mesh screen
24.2% Pass 60 mesh screen

Table 2. Elk River alfalfa yields and plant tissue contents, 1969.

Unirrigated

	Corrective K_2O lbs/A	0		480	
	Topdressed K_2O lbs/A	0	240	0	240
		Tons/A			
Cuttings					
1	May 28	1.1	1.2	1.2	1.1
2	July 9	0.6	0.6	0.7	0.7
3	August 14	0.9	1.0	1.0	1.0
	Total yield	2.6	2.8	2.9	2.8
K soil test Sept. 69 (lbs/A/K)		150	272	242	367
Tissue test	May %K	2.10			2.62
" "	Aug. %K	2.39	2.23	2.70	2.39

Irrigated

	Corrective K_2O lbs/A	0		480	
	Topdressed K_2O lbs/A	0	240	0	240
		Tons/A			
Cuttings					
1	May 28	1.1	1.2	1.2	1.1
2	July 9	2.4	2.5	2.4	2.6
3	August 14	1.8	1.7	1.8	2.5
	Total yield	5.3	5.4	5.4	6.2
K soil test Sept. 69 (lbs/A/K)		150	272	277	480
Tissue test	May %K	2.04			2.65
" "	Aug.%K	1.86	2.20	2.69	2.57

IRRIGATION
AMB PLOTS

ELK RIVER
1969

Plots were irrigated when tensiometers on potatoes at 12 inch depth were between 0.4 and 0.5 atmospheres. If 41-42 waited one more day; If >43 irrigated that day. Tensiometers read between 8 AM and 10 AM each morning.

Date	Barrier	No Barrier
May 29*	0.5	0.5
May 30*	0.5	0.5
July 21	1.0	1.0
August 4		1.0
August 8	1.0	1.0
August 12		1.0
August 15	1.0	
August 18	1.0	1.0
August 22	1.0	1.0
August 27		1.0
August 29	1.0	1.0
Totals	7.0	9.0

*Irrigated both non-irrigated and irrigated plots these dates to insure onion germination.

IRRIGATION
AMB - TURF

ELK RIVER
1969

Date	Water Added, inches
May 27	1.0
June 10	0.6
June 13	0.6
June 17	0.6
June 20	0.5
July 7	0.5
July 12	0.5
July 22	1.0*
August 6	1.0
August 11	1.0
August 19	1.0
August 25	1.0
August 29	1.0
September 1	1.0
Total	

* All plots irrigated alike except on July 22 south plot was not irrigated as tensiometer showed no need.

ASPHALT BARRIER STUDY

Potatoes

ELK RIVER EXPERIMENTAL FIELD

1969

	No Irrigation		Irrigation		Statistical
	No Barrier	Barrier	No Barrier	Barrier	Significance
No. 1's	9,899.5	10,804.0	22,749.3	20,524.6	Irr*
Knobby	5,360.4	4,226.5	7,715.6	6,172.8	NS
Total No. 1 Size	15,259.9	15,030.5	30,464.9	26,697.4	Irr*
No. 2's	8,055.9	6,225.9	5,798.4	5,014.7	NS
Total 1 & 2	23,315.8	21,256.3	36,263.3	31,712.1	Irr*
Specific Gravity	1.076	1.079	1.071	1.072	Irr*

All values except specific gravity are in pounds per acre

ASPHALT BARRIER STUDY

ONIONS

Elk River, 1969

	No Irrigation		Irrigation		Statistical Significance		
	No Barrier	Barrier	No Barrier	Barrier	Irrig.	Bar.	I + B
Number of Onions per acre							
Total	35,780	41,914	42,156	42,108	NS	NS	NS
Rots	920	871	920	775	NS	NS	NS
No. 3 size	21,587	13,696	35,330	9,293	*	NS	NS
No. 2 size	14,859	25,120	22,312	23,038	NS	*	*
No. 1 size	726	2,323	15,391	13,745	*	NS	NS
Weights per acre (Pounds)							
Total	6,016	8,673	16,621	15,686	*	NS	NS
No. 3 size	2,057	1,142	397	445	*	*	*
No. 2 size	3,591	6,345	7,110	7,023	*	*	*
No. 1 size	368	1,186	9,114	8,214	*	NS	NS

NOTE: Weights per acre include big necks, doubles and rots in their proper size classification.

ASPHALT BARRIER PROJECT

SNAP BEANS

ELK RIVER EXPERIMENTAL FIELD

1969

	BARRIER	NO BARRIER	STATISTICAL SIGNIFICANCE
Size #1 lbs/A	213.0	260.9	NS
Size #2 lbs/A	1553.6	1346.5	NS
Size #3 lbs/A	3083.6	2753.5	NS
Size #4 lbs/A	3344.4	3675.5	NS
Size #5 lbs/A	143.9	244.9	NS
Sizes 2,3,4 lbs/A	7981.7	7776.3	Rep*
Total lbs/A	8373.2	8310.8	NS

NOTE: Snap beans were not irrigated in 1969.

SWEET CORN YIELDS

Elk River Experimental Field

1969

	Not Irrigated		Irrigated	
	No Barrier	Barrier	No Barrier	Barrier
Numbers of Ears per acre				
Total	39,704	43,124	45,109	45,835
Sucker	11,240	13,381	9,883	13,678
Smut	958	366	1,272	489
Marketable	27,506	29,377	33,953	31,668
Weights of Ears per acre				
Total	19,144	20,889	22,810	22,512
Sucker	1,881	2,609	1,376	2,507
Smut	576	177	1,184	189
Marketable	16,686	18,103	20,250	19,815
Quality Factors				
Weight/Ear	0.61	0.62	0.59	0.62
Rows Missing	6.91	7.19	7.89	7.26
Over-all Quality	6.32	6.71	6.66	6.35
Maturity	4.04	3.98	4.25	4.04
Filled Ends	6.58	6.48	7.01	6.57

Differences not significant except for REP on total number and total weight of ears per plot and weight of sucker ears.

ASPHALT BARRIER STUDY

NO_3, NO_2, K, H_2O

Elk River, 1969

	No Irrigation		Irrigated	
	No Barrier	Barrier	No Barrier	Barrier
NO_3-N, ppm				
0-6"	12.3	16.8	9.0	12.6
6-12"	28.3	26.5	25.2	18.2
12-20"	19.6	16.9	15.5	10.9
Total	60.3	60.3	49.9	41.7
K, ppm				
0-6"	20.7	20.3	17.7	18.4
6-12"	13.2	11.8	11.3	14.7
12-20"	6.9	7.1	6.3	6.5
Total	40.9	39.2	35.3	39.7
Water, Percent Weight				
0-6"	10.7	10.9	10.6	9.8
6-12"	9.7	9.5	10.8	10.9
12-20"	11.5	10.2	9.2	9.7
Average	10.7	10.2	10.1	10.1

NOTE: (1) Differences not significant, except average water content for Rep.
(2) NO_2-N ppm was 0.4 ppm for all plots at all depths.

ASPHALT BARRIER STUDY

SWEET CORN

Elk River Satellite, 1969

	Gallons of Asphalt Acre			
	0	750	950	1,500
Number of Ears per acre				
Total Marketable	12187a	15033b	15096b	15324b
Smutty	253	0	0	0
Weights per acre (Pounds)				
Total Marketable	6859a(a)	8840b(b)	9202b(bc)	9449b(c)
Smutty	242	0	0	0
Quality rating on basis of 10 as perfect				
Maturity	4.44	4.44	4.36	4.11
Missing Rows	9.22	8.86	8.70	9.11
Ends filled	6.06	6.58	7.11	7.17
Overall Quality	6.34	7.19	7.19	7.60
Mean weight per ear	0.55	0.58	0.60	0.61

NOTE: Duncan's MRT values are given at the 99% level. In addition, on weights of marketable ears per acre Duncan's MRT values are given in parenthesis for the 95% level.

ASPHALT BARRIER STUDY

SWEET CORN

Elk River Satellite, 1969

		Gallons of Asphalt / Acre			
		0	750	950	1,500
Nitrates, ppm	0-6"	3.60	2.62	2.57	4.25
"	6-12"	2.45	1.97	1.90	1.90
"	12-20"	2.95	2.53	3.20	2.92
"	0-20"	9.00	8.10	7.67	9.07
Nitrites, ppm	0-6"	0.60a	0.65a	0.45a	1.15b
"	6-12"	0.32	0.30	0.30	0.32
"	12-20"	0.25	0.30	0.30	0.30
"	0-20"	1.17a	1.25a	1.05a	1.77b
Potassium, ppm	0-6"	15.65	17.20	13.60	15.65
	6-12"	6.90	8.00	6.45	7.10
	12-20"	5.90	6.10	6.05	6.17
	0-20"	28.45	31.30	31.10	28.92
Water, Ow,	0-6"	7.07a	7.92b	6.90a	7.72b
	6-12"	7.40	7.17	5.90	7.27
	12-20"	7.20	7.32	7.12	6.55
	Average	7.20	7.45	6.72	7.12

NOTE: Duncan's MRT values are at 95% level.

Soil Fertility Trials on Potatoes

C. J. Overdahl and C. P. Klint

Field trials were initiated in the spring of 1966 to evaluate potato nutrient needs on loamy sands and sandy loams under intensive irrigation.

Objectives of the trials included:

1. To determine rates of potassium that must be applied annually to maintain high yields on soils that have been built to very high fertility levels.
2. To determine how fast potassium in soils will build up from average soil tests to very high levels.
3. To determine the extent of the effect of very high potassium rates on magnesium levels in potatoes on acid soils.
4. To determine the extent magnesium additions will have on soils where high potassium rates have reduced the magnesium levels in potato petioles.
5. To study how important annual phosphorus additions are.
6. To observe how much nitrogen is needed for most practical yields.

A complete analysis of soil and plant tissue samples, yields and N, P, K recommendations for potatoes can be obtained from Soil Series No. 85 "Soil Fertility Trials on Potatoes" by C. J. Overdahl and C. P. Klint, November 1969.

THE EFFECT OF NITROGEN AND POTASSIUM RATES ON CORN YIELDS ON AN IRRIGATED HUBBARD LOAMY COARSE SAND IN SHERBURNE COUNTY

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

In the spring of 1969, a project was initiated to study:

1. The effects of different rates of nitrogen and potassium, with sufficient phosphorus, on corn yields on a course textured soil with optimum irrigation,

2. The accumulation of nitrate nitrogen in the subsoils which may cause pollution of subterranean water supplies, and

3. The effect on the protein content of corn grain when additional amounts of potassium are added with adequate nitrogen and phosphorus fertility.

Objectives two and three were unable to be completed because of our inability to soil sample past 24", and the lack of funds to run amino acids to determine protein contents.

Six replications of 10 treatment combinations were applied as a randomized complete block design, each plot being 15 feet wide and 50 feet long. The potassium treatments (75, 150, 300 lbs K/A) and one half of the nitrogen treatments (100, 200, 400 lbs N/A) were broadcast on May 26. The variety Minhybrid 5301 was planted on May 27 with a starter fertilizer application of 0 + 100 + 0 (43 lb. P/A) over the entire experimental site. The final one half of the nitrogen treatments were broadcast on June 26. The corn was planted in 30 inch rows at 23,000 plants per acre.

The 1969 growing season at Elk River was characterized by a relatively wet spring and early summer, but with an extremely dry late summer and fall. A total of 11.5 inches of precipitation was recorded during the growing season at the station. An additional 14 3/4 inches of water was added periodically by irrigation. The irrigation water unfortunately was not always applied uniformly to all plots, since some jets clogged at times.

The experimental site is located on a Hubbard loamy coarse sand, with an initial pH of 5.4. No lime was applied to the plot. Soil test indicated a very high extractable phosphorus level (200 + lbs/A) with a exchangeable potassium at 210 lbs/A.

Table 1. Corn Yields with Varying Rates of Nitrogen and Potassium on a Hubbard Loamy Coarse Sand in Sherburne County.

Fertilizer Treatments*	1969 Yield 15.5%
	bu/A
0 + 43 + 0	19.9 a**
0 + 43 + 75	25.4 a
0 + 43 + 150	37.9 a
100 + 43 + 0	90.5 b
100 + 43 + 150	98.3 b
100 + 43 + 75	98.9 b
200 + 43 + 150	104.5 bc
400 + 43 + 300	119.1 cd
200 + 43 + 0	121.8 cd
200 + 43 + 75	128.9 d

* Pounds per acre of N + P + K. Applied in 1969.

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

<u>Rates of Nitrogen Application</u> (0, 100, 200, 400 lbs/A)

It is evident that the addition of 100 and 200 lbs of N produced highly significant yield increases with the first 100 lbs of N increasing average corn yields by 70.6 bu/A. The 200 lbs of N treatment further increased average corn yields by 31.3 bu/A. The addition of 400 lbs of N produced no additional yield increase, but this might have been partly due to plant burning damage when the second half of the N (as ammonium nitrate) was broadcast on June 26.

<u>Rates of Potassium Application</u> (0, 75, 150, 300 K/A)

No significant yield responses resulted with the addition of increased rates of K with only a 7.0 bu/A average increase with the addition of the first 75 lbs/A of K. No yield advantages were shown with the 150 or 300 of K. This small K response might be expected with the relatively high initial potassium soil test (210 lbs/A).

<u>Conclusion</u>

Corn yields with adequate irrigation on a coarse textured soil showed a tremendous yield response to the addition of 100 and 200 lbs. of N/A. Though no significant yield responses occurred with increasing rates of K, in this field experiment the addition of this element to coarse textured soils is still important for maintaining a balance of major nutrients. It would appear that the optimum rates of fertilizer nitrogen and potassium for this experiment were 200 and 75 lbs/A.

Future plans on this experimental area may include:

(1) Rates of N-P-K for optimum corn production of irrigated coarse textured soils,

(2) Placement and number of applications of N, and

(3) Sources of nitrogen.

SAND PLAIN EXPERIMENT FIELD

ELK RIVER

WEATHER DATA 1969

Recorded 0800 Mon-Fri.

Date	Temperature °F Max.	Min.	Prec. inches
4/24	67	—	
25	74	40	
26	71	38	
27	38	31	
28	50	28	1.28*
29	59	30	
30	64	40	
5/1	66	50	
2	68	48	.23
3	70	40	
4	83	52	
5	81	48	.29
6	74	57	.31
7	72	44	
8	62	43	
9	56	38	
10	53	40	
11	54	32	
12	64	28	
13	76	35	
14	81	46	
15	83	60	
16	68	48	
17	63	42	
18	67	38	
19	61	48	
20	61	36	.03
21	56	40	
22	59	35	.18
23	69	37	
24	73	49	.20
25	72	38	
26	82	53	
27	98	69	
28	94	66	
29	83	55	
30	83	56	

Date	Temperature °F Max.	Min.	Prec. inches
5/31	86	52	
6/1	52	41	
2	51	38	.80
3	67	38	.02
4	72	51	.05
5	83	52	.02
6	62	48	
7	74	42	
8	74	49	
9	80	41	
10	79	53	
11	67	49	.52
12	59	44	
13	62	34	
14	67	41	.02
15	75	42	
16	68	55	.03
17	71	56	.03
18	74	56	
19	84	66	
20	70	60	
21	78	57	
22	76	60	
23	81	52	.32
24	75	52	.34
25	80	53	.37
26	67	47	1.22
27	65	37	
28	61	50	
29	62	50	
30	69	48	.10
7/1	76	40	
2	77	55	.20
3	86	49	
4	84	64	
5	72	55	
6	76	50	

Denotes Snow*

SAND PLAIN EXPERIMENT FIELD

ELK RIVER

WEATHER DATA 1969

Date	Temperature °F Max	Min.	Prec. inches	Date	Temperature °F Max.	Min.	Prec. inches
7	69	57		13	88	66	
8	81	57	1.39	14	85	54	
9	86	66	.02	15	90	58	
10	86	59		16	91	62	
11	89	60		17	93	64	
12	97	65		18	85	58	
13	90	68		19	81	49	
14	90	73	.40	20	87	54	
15	89	70	.22	21	87	51	
16	86	69		22	88	54	
17	77	63		23	87	54	
18	86	57		24	88	53	
19	88	64		25	90	54	
20	78	55		26	90	58	
21	85	53		27	89	64	
22	82	57		28	94	73	
23	80	60		29	95	75	
24	85	53		30	81	55	.10
25	84	60	.22	31	81	53	
26	85	57		9/1	--	50	.36
27	70	51		2	84	--	
28	84	55	2.62	3	84	54	
29	90	59		4	81	60	
30	89	63	.29	5	--	--	.31
31	76	55		6	--	--	
8/1	78	50		7	--	--	
2	87	54		8	64	46	.15
3	87	56		9	65	41	
4	86	63		10	75	40	
5	93	63		11	74	50	
6	91	69		12	88	53	
7	81	60		13	85	56	
8	85	55		14	89	62	
9	80	62		15	81	61	
10	89	56		16	73	50	
11	94	61		17	70	41	
12	94	68		18	64	52	

Denotes Snow*

SAND PLAIN EXPERIMENT FIELD

ELK RIVER

WEATHER DATA 1969

Date	Temperature °F Max.	Min.	Prec. inches
19	73	55	
20	78	48	
21	79	50	
22	70	55	
23	56	45	.05
24	63	34	
25	72	46	.03
26	67	42	
27	64	38	
28	71	32	
29	72	42	.03
30	62	36	
10/1	72	50	
2	77	41	
3	79	48	
4	86	60	
5	65	41	
6	62	39	.15
7	56	41	.03
8	58	36	.01
9	73	45	
10	64	42	
11	51	34	
12	38	32	
13			.57*
14			.02

Data By Month	May	June	July	Aug.	Sept.
Total Prec. "	1.24	3.84	5.36	.10	.93
Mean Max. Temp.	71.6	70.2	83.0	87.6	73.2
Median Max. Temp.	75.5	67.5	83.0	86.5	72.5
Mean Min. Temp.°	45.9	48.7	58.7	58.9	47.7
Median Min. Temp.	48.5	50.0	56.5	62.0	47.0
Mean Temp.°	58.7	59.5	70.8	73.2	60.4
Median Temp.°	63.0	59.0	68.5	72.0	60.5
Max. Temp.°	98	84	97	95	89
Min. Temp.°	28	34	40	50	32

EXPERIMENTS WITH NITROGEN SOURCE, PLACEMENT AND TIME OF NITROGEN APPLICATION TO A WEBSTER-CLAY LOAM AT LAMBERTON FROM 1960 THROUGH 1969

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

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

The 1969 growing season was extremely wet in early spring with progressively less precipitation as the summer progressed. Soil moisture was very limited in August and September, but no really serious drowth occurred. Ear corn yields during the 10 year period are shown in Table 1.

Each of the nitrogen treatments significantly increased corn yields over the 10 year period, with no significant differences between NH_4NO_3 and urea nitrogen sources. Where only 40 pounds of nitrogen were applied annually (+ 14 pounds N in the starter fertilizer) spring treatments averaged 95.1 bushels per acre, sidedressing in late June averaged 88.8 bushels, with fall applications averaging 81.4 bushels per acre. The overall 40 pound N treatments averaged 85.3 bushels per acre.

The 80 lb N/A fall treatments averaged 95.7 bushels with similar treatments applied in spring averaging 100.6 bu/A and late June sidedressing producing a 98.0 bu/A. The average of all 80 lb treatments was 98.1 bu/A. The three 160 lb/A rates of N application (or 174 lbs N/A including starter N) produced an average annual yield of 102 bushels per acre.

It is apparent that over the 10 year period, the minimum rate of 40 lbs N/A annually (actually a total of 54 lbs N with starter N) is most effective when applied at planting time and least effective with fall application, being more noticeable in years when corn planting was delayed. Fall application and remaining on the plowed surface over winter (treatments 4 and 5) appear to be equal or possibly better than fall plowdown (Treatments 2 and 3).

As might be expected, smaller differences in corn yield occurred with the 80 or 160 pound N rates in the fall, spring or as a sidedressing.

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

N applied annually in lbs/A[1]	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	Average
	Ear corn yield in bushels per acre										
1) Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	92.8	66.2 a
2) 40 as NH_4NO_3-fall plow down	42.3	87.5	30.9	148.6	88.3	34.9	26.8	75.7	131.6	109.3	77.6 b
3) 40 " urea - " " "	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5	81.4 bc
4) 40 " NH_4NO_3-fall plow surface	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	124.6	82.2 bcd
5) 40 " urea - " " "	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1	84.1 cde
6) 80 " NH_4NO_3- " " down	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.8	131.2	146.8	96.3 efghi
7) 80 " urea - " " "	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3	95.0 efghi
8) 160 as NH_4NO_3 " " "	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	158.7	99.9 fghi
9) 160 " urea - " " "	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0	104.4 i
10) 40 " NH_4NO_3-spring topdress	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	142.0	91.3 defg
11) 40 " urea - " "	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4	88.8 cde
12) 80 " NH_4NO_3- " "	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	159.5	99.9 ghi
13) 80 " urea - " "	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9	101.2 hi
14) 40 " NH_4NO_3-sidedress	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	142.3	90.1 cdefg
15) 40 " urea - "	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3	87.5 cde
16) 80 " NH_4NO_3- "	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	140.3	94.1 efgh
17) 80 " urea - "	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2	101.9 hi
18) 160 " NH_4NO_3- "	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	148.3	101.6 hi
Average annual corn yield in bu/A	58.6	93.3	39.4	146.7	101.3	60.3	36.3	101.8	135.7	140.9	

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

Nitrogen Removal in Corn Grain

The amounts of nitrogen removed per acre in the corn grain is of interest, as well as the increase in percentage N of the corn grain by the different N fertilizer treatments. These are shown in Table 2.

The 40 pound (or a total of 54 pound) rate of N per acre annually had the least effect on N concentration in the corn grain, and increasing rates of N fertilization raised N levels in the grain 40% or more. Increasing corn yields increased nitrogen removal from a low of 18% increase (Treatment 2) to 143% increase (Treatment 9). In general, where less than 100 pounds of N per acre was annually applied, N removal in grain approximates fertilizer N applied. The highest rate of N application resulted in a considerably lower proportion of applied N removal in the corn grain. This is shown in the following section.

The Nitrate-N Content of Soil After Ten Years of N Fertilization

Since this field experiment had been conducted over a 10 year period, in late 1969 all plots were sampled in late October to an 84 inch depth (7 feet) in two 6 inch depths for the surface foot, and in foot increments beyond.

These samples were then analyzed for NO_3-N content and the results are reported in Table 3 in parts per million for each depth. Pounds per acre of nitrate N were computed by assuming that each acre 6 inches of soil weighed approximately 2 million pounds. The average amounts of NO_3-N present in the four replicates of each treatment to a 7 foot depth were then computed to determine nitrate accumulations under the different treatments during the 10 years and their possible relationship to N fertilization and N removal by cropping.

It is obvious that there is little accumulation of NO_3-N to the 7 foot depth with the two lower rates of N fertilization (40 and 80 lbs/A) when applied in the fall one year before sampling. This might be expected by the N removal in the corn grain as shown in Table 2. However, where the 160 lb/A (actually 174 lb/A) annual N application was applied each fall, the NO_3-N content of the soil has been more than doubled, especially where urea was the N source.

Spring N applications at the two lower rates show slightly more NO_3-N in the soil than similar rates applied in the fall, with the late June sidedressing resulting in somewhat more NO_3-N residue remaining. However, the late June sidedressing at the highest rate (Treatment 18) indicates a very large amount of NO_3-N in the 7 foot depth of soils sampled, being largely concentrated in the surface foot. It is evident that fertilization at the rate of 160 lbs N/A (or a total of 174 lbs) annually results in high soil concentrations of NO_3-N, which is unlikely to be completely utilized by the growing corn. Much of this excess N may be removed from the soil in drainage waters of the tiling system, and be lost for crop production. There is also the hazard of needless possible pollution of stream waters draining the area.

To determine the amount of movement of NO_3-N to depths greater than 84 inches, four of the plots (3,7,9, and 13) representing treatments 1,2,6 and 8 were sampled to an 18 foot depth and analyzed for nitrate-nitrogen content. The NO_3-N present in the entire 18 foot depth is shown in Table 4.

It is evident that the plot treated with 54 pounds of N/A annually over the 10 year period has no greater NO_3-N accumulation than soil where the 14 pounds of N was annually applied in starter fertilizer. However, with increasing rates of N application, (94 or 174 lbs of N/A annually) there is an apparent increase in NO_3-N content, especially in the upper 7 foot soil depth (see Table 4).

This would indicate that the percolating water removed by the 48 inch deep tile drainage system is removing considerable amounts of the applied fertilizer nitrogen, but there is some accumulation deep in subsoils where large amounts of N fertilizer have been applied.

The maximum water soluble potassium content of all samples in the 0 to 7 foot depth was 37 ppm, and 42 ppm level was detected in one 13 to 14 foot soil depth.

1969 Concentrations of Nitrate Nitrogen (NO_3-N) and Other Components in Free Soil Water

The experiment described on page 78 of Soil Series 84 was repeated in 1969. As in 1968, the wells were pumped free of all water 24 hours before removing the water samples to be analyzed. This allowed minimum time for the sample to remain in the well with possible chemical change. It was found that some wells failed to hold water because of the rubber stoppers being dislodged.

The spring of 1969 was extremely wet at Lamberton and it was not convenient to reinstate the wells until late in June. Three samplings were made during July and early August (before dry soil conditions eliminated free water accumulations) and the analyses are shown in Table 5(a,b,c and d).

Table 5a indicates a probable lateral movement of NO_3-N at depths of several feet, since the NO_3-N accumulations are somewhat higher than would normally be expected from the application of only 14 lbs of N/A annually, and with a plot width of 20 feet, some of the wells would be only some 8 feet from adjoining plots receiving up to 174 pounds of fertilizer N annually. Also the wells in the roadways (nearer to the tile line) at the end of each plot (No. 7 and 79) indicate movement of additional NO_3-N toward the tile line at the 42 inch sampling depth.

Nitrate-N (NO_2-N) was low in all samplings but there was considerable variation in the PO_4-P in the well waters at the different depths. Since some 18 pounds of P is applied annually in the starter fertilizer to the surface soil of all plots, it would be reasonable to expect some P accumulation in the waters of the more shallow wells. Moderate quantities of potassium (K) were found at all sampled depths. Electrical conductance (an indicator of soluble salt content) increased with depth as expected.

Table 5b shows water analyses from the wells located on plots receiving 54 and 94 lbs N/A annually for 10 years. Nitrate-N is somewhat higher and the deeper NO_2-N samples considerably higher than in plots receiving less N. The PO_4-P content is less, with K and soluble salt content being considerably higher with higher N treatments.

Table 5c indicates that the annual 174 lb N/A treatment is substantially increasing NO_3-N levels in the free water of these plots with some increase in NO_2-N levels as well. The PO_4-P content is again relatively low (probably because of increasing P removal during higher crop production) with K and soluble salt content being much the same as in Table 5b.

Table 5d shows that some of the wells outside the plots toward the tile in the middle of the uncropped roadway contain waters with high levels of NO_3-N. Some of this accumulation may be attributed to normal nitrate production in the soil and the uncropped and weed-free roadway allows essentially no NO_3-N removal by growing plants. However, it is probable that some of these dissolved nitrates are the result of heavy N fertilization of the adjoining nitrates; PO_4-P, K, and salt concentrations were not remarkable on plots outside these wells.

It must be concluded that heavy N fertilization of continuous corn results in considerable increase in NO_3-N in soil water of the upper 6 feet of the soil profile. The NO_2-N and PO_4-P content of these waters remains relatively low but with a substantial dissolved potassium (K). Soluble salts normally increase with depth on these calcareous soils.

Corn Leaf Zinc and Nitrogen Fertilization

The sixth corn leaves of all treated plots were sampled during silking and analyzed for zinc content to determine if there was any marked effect between continued N fertilization and leaf zinc. The results are shown in Table 6.

Corn leaf zinc varied from 17 to 25 parts per million, with leaves on only the 3 heaviest N treatments containing significantly more zinc than the check treatment.

Since it is known that continued high rates of N fertilization with either ammonium nitrate or urea reduce soil pH, and thus increase soil zinc availability, the pH of each of the four plot-soils where corn had the lowest and highest zinc concentrations was also determined. The averages obtained are shown at the base of Table 6. Although the average soil pH difference is not marked, the trend of lower soil pH and greater zinc concentrations in the corn leaves is apparent.

Table 2. Yield of Dry Shelled Corn, Percentage Nitrogen and Nitrogen Removal in Corn Grain per acre From NH_4NO_3-Urea Treated Continuous Corn on Webster Clay Loam at Lamberton in 1969.

Treatment (lbs N/A)[1]	Dry shelled corn lbs/A				% N					lbs N removed per acre				
	1	2	3	4	1	2	3	4	Average	1	2	3	4	Average
1) Check	4159	4893	3724	4789	1.09	1.14	0.93	0.99	1.04 a	45.3	55.8	34.6	47.4	45.8 a
2) 40 as NH_4NO_3-fall plow down	5546	5158	4292	5683	1.04	1.02	1.09	1.05	1.05 ab	57.7	52.6	46.8	59.7	54.2 ab
3) 40 " urea - " " "	6171	5906	5096	6384	1.11	1.06	1.11	1.04	1.08 abc	68.5	62.6	56.6	66.4	63.5 bc
4) 40 " NH_4NO_3-" " surface	6407	4595	6152	6431	1.16	1.04	1.08	1.12	1.10 abc	74.3	47.8	66.4	72.0	65.1 bcd
5) 40 " urea - " " "	6066	5352	7216	7126	1.09	0.99	1.12	1.22	1.11 abc	66.1	53.0	80.8	86.9	71.7 cde
6) 80 " NH_4NO_3-" " down	6492	6899	7089	7311	1.05	1.30	1.22	1.23	1.20 cde	68.2	89.7	86.5	89.9	83.6 ef
7) 80 " urea - " " "	5962	7259	6989	7108	1.02	1.30	1.29	1.20	1.20 cde	60.8	94.4	90.2	85.3	82.7 ef
8) 160 " NH_4NO_3-" " "	6809	8139	7604	7481	1.40	1.30	1.39	1.51	1.40 gh	95.3	105.8	105.7	113.0	104.9 hi
9) 160 " urea - " " "	7912	6814	7387	8366	1.37	1.41	1.51	1.55	1.46 h	108.4	96.1	111.5	129.7	111.4 i
10) 40 " NH_4NO_3-spring topdress	5551	7382	6814	7126	1.26	1.12	1.16	1.15	1.17 bcd	69.9	82.7	79.0	82.0	78.4 de
11) 40 " urea - " "	6847	6880	6828	6582	1.22	1.02	1.16	1.33	1.18 bcde	83.5	70.2	79.2	87.5	80.1 ef
12) 80 " NH_4NO_3- " "	7472	7803	6909	8011	1.33	1.33	1.44	1.26	1.34 fgh	99.4	103.8	99.5	100.9	100.9 gh
13) 80 " urea - " "	7112	6630	6942	8820	1.19	1.19	1.34	1.29	1.25 def	84.6	78.9	93.0	113.8	92.6 fgh
14) 40 " NH_4NO_3-sidedress	6928	6535	6630	6847	1.11	1.16	1.26	1.27	1.20 cde	76.9	75.8	83.5	87.0	80.8 ef
15) 40 " urea - "	6890	5958	7585	6691	1.12	1.15	1.26	1.32	1.21 cdef	77.2	68.5	95.6	88.3	82.4 ef
16) 80 " NH_4NO_3- "	6454	5451	6857	7789	1.29	1.13	1.40	1.40	1.31 efg	83.3	61.6	96.0	109.0	87.5 fg
17) 80 " urea - "	8257	7983	8248	6970	1.33	1.40	1.32	1.54	1.40 gh	109.8	111.8	108.9	107.3	109.5 i
18) 160 " NH_4NO_3- "	6932	6256	7992	7320	1.48	1.48	1.43	1.43	1.46 h	102.6	92.6	114.3	104.7	103.6 hi

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

Table 3. Nitrate Nitrogen Content of Webster Clay Loam Near Lamberton in November, 1969, Following 10 Years of Continuous Corn Under Different Nitrogen Fertilization.

Plot nos.	Total N applied/A	Soil depth in inches 0-6	6-12	12-24	24-36	36-48	48-60	60-72	72-84
		ppm NO_3-N							
(1)	Check								
7	0 + 140# starter	1.3	1.1	1.7	1.1	1.1	2.7	2.0	2.5
32	" " "	1.7	4.2	1.2	1.5	1.0	2.8	2.8	2.6
46	" " "	1.0	1.0	1.3	0.9	1.1	1.8	1.2	2.0
73	" " "	4.4	2.3	1.7	1.1	1.1	1.8	1.4	2.3
	Average ppm	2.1	2.2	1.5	1.2	1.1	2.3	1.9	2.4
	" lbs/A	2.1	2.2	3.0	2.4	2.2	4.6	3.8	4.8
	Total - 25.1 lbs/A								
(2)	40 N - F (PD)								
3	400 + 140# starter	2.3	1.8	2.3	1.0	1.9	1.0	2.1	2.5
21	" " "	1.0	2.7	1.7	1.1	3.5	1.5	1.5	1.5
45	" " "	2.3	1.0	1.5	1.0	0.9	1.3	1.6	1.3
62	" " "	5.0	3.9	1.7	2.5	1.1	2.3	3.2	1.7
	Average ppm	2.7	2.4	1.8	1.4	1.9	1.5	2.1	1.8
	" lbs N/A	2.7	2.4	3.6	2.8	3.8	3.0	4.2	3.6
	Total - 26.1 lbs/A								
(3)	40 urea F (PD)								
14	400 + 140# starter	6.6	3.3	2.7	2.4	2.6	3.3	2.6	2.2
22	" " "	0.8	0.7	1.2	1.4	1.8	3.0	2.3	4.8
43	" " "	1.2	2.9	1.3	1.1	1.7	1.5	1.3	1.7
75	" " "	2.3	2.1	0.3	2.1	2.5	2.9	2.8	5.3
	Average ppm	2.7	2.3	1.4	1.8	2.2	2.7	2.3	3.5
	" lbs N/A	2.7	2.3	2.8	3.6	4.4	5.4	4.6	7.0
	Total - 32.8 lbs/A								

(Table 3. continued)

Plot nos.	Total N applied/A	Soil depth in inches 0-6	6-12	12-24	24-36	36-48	48-60	60-72	72-84
		ppm NO_3-N							
(4)	40 N - F (top)								
17	400 + 140# starter	5.6	2.5	2.7	2.6	1.9	2.5	3.0	2.5
27	" " "	2.7	1.8	2.5	1.7	1.3	1.8	3.6	1.8
48	" " "	2.7	1.8	1.0	1.1	1.2	2.0	1.5	1.3
61	" " "	3.5	2.1	1.9	1.0	2.3	2.1	3.5	3.0
	Average ppm	3.6	2.1	2.0	1.6	1.7	2.1	2.9	2.2
	" lbs/A	3.6	2.1	4.0	3.2	3.4	4.2	5.8	4.4
	Total - 30.7 lbs/A								
(5)	40 urea F (top)								
5	400 + 140# starter	2.2	2.2	1.9	1.2	1.5	1.7	2.3	1.9
36	" " "	1.9	1.4	1.7	1.7	1.2	2.3	2.7	2.3
55	" " "	2.9	3.6	2.1	3.8	2.8	3.8	2.3	2.8
69	" " "	5.6	3.3	1.3	1.7	1.7	3.1	1.3	1.9
	Average ppm	3.2	2.6	1.8	2.2	1.8	2.7	2.2	2.2
	" lbs N/A	3.2	2.6	3.6	4.4	3.6	5.4	4.4	4.4
	Total - 31.6 lbs/A								
(6)	80 N - F (PD)								
9	800 + 140# starter	2.7	1.0	1.9	1.0	1.9	2.6	1.9	2.2
30	" " "	3.3	1.9	2.1	2.5	2.9	1.9	1.7	1.5
56	" " "	4.2	2.7	1.9	2.1	4.2	3.2	3.5	3.0
72	" " "	2.1	1.9	1.3	2.2	2.5	2.8	4.2	5.6
	Average ppm	3.1	1.9	1.8	2.0	2.9	2.6	2.8	3.1
	" lbs N/A	3.1	1.9	3.6	4.0	5.8	5.2	5.6	6.2
	Total - 35.4 lbs/A								
(7)	80 urea F (PD)								
6	800 + 140# starter	4.4	2.5	1.7	1.2	1.5	1.5	2.1	1.7
23	" " "	1.1	2.5	1.6	1.9	3.7	4.5	2.9	1.4
51	" " "	5.3	1.9	2.3	1.5	2.2	3.5	1.3	3.5
74	" " "	2.4	1.6	1.4	1.7	2.6	2.1	3.6	2.8
	Average ppm	3.3	2.1	1.8	1.6	2.5	2.9	2.5	2.4
	" lbs N/A	3.3	2.1	3.6	3.2	5.0	3.8	5.0	4.8
	Total - 30.8 lbs/A								

(Table 3. continued)

Plot nos.	Total N applied/A	0-6	6-12	12-24	24-36	36-48	48-60	60-72	72-84
		Soil depth in inches							
		ppm NO_3-N							
(8)	160 N - F (PD)								
13	1600 + 140 starter	3.7	1.4	3.6	6.6	8.2	8.4	6.6	3.3
24	" " "	2.2	2.3	1.0	0.7	1.3	3.0	1.1	6.2
53	" " "	5.2	6.4	2.9	2.0	3.3	3.2	1.6	2.4
66	" " "	0.6	2.7	2.6	1.9	10.4	10.1	7.9	10.1
	Average ppm	2.9	3.2	2.5	2.8	5.8	6.2	4.3	5.5
	" lbs N/A	2.9	3.2	5.0	5.6	11.6	12.4	8.6	11.0
	Total - 60.3 lbs/A								
(9)	160 urea F (PD)								
18	1600 + 140# starter	1.5	3.8	1.2	2.7	4.0	3.0	4.5	4.4
31	" " "	3.3	3.5	2.2	1.1	8.1	9.2	8.7	8.0
42	" " "	4.2	5.4	7.4	5.0	4.4	4.4	2.9	4.4
67	" " "	0.8	3.8	3.7	4.7	19.8	8.8	11.4	13.7
	Average ppm N	2.5	4.1	3.6	3.4	9.1	6.4	6.9	7.6
	" lbs/A N	2.5	4.1	7.2	6.8	18.2	12.8	13.8	15.2
	Total - 80.6 lbs/A								
(10)	40 N - S								
1	400 + 140# starter	2.9	2.9	2.1	1.9	1.0	1.5	1.7	1.9
29	" " "	3.1	2.3	1.1	2.8	1.6	1.3	3.1	3.1
44	" " "	1.2	2.3	0.9	0.9	1.1	2.3	1.5	1.5
71	" " "	1.2	1.4	1.7	2.9	2.8	2.5	1.6	1.7
	Average ppm N	2.1	2.2	1.5	2.1	1.6	1.9	2.0	2.1
	" lbs/A N	2.1	2.2	3.0	4.2	3.2	3.8	4.0	4.2
	Total - 26.7 lbs/A								
(11)	40 urea S								
10	400 + 140# starter	8.8	1.9	2.5	2.9	2.1	2.8	2.3	3.7
35	" " "	3.8	2.9	2.0	2.1	0.9	2.3	1.6	2.3
59	" " "	2.4	1.0	2.5	3.0	2.1	3.7	1.5	2.8
64	" " "	3.6	3.5	0.7	2.3	3.9	2.4	3.3	2.4
	Average ppm N	4.7	2.3	1.9	2.6	2.3	2.8	2.2	2.8
	" lbs/A N	4.7	2.3	3.8	5.2	4.6	5.6	4.4	5.6
	Total - 36.2 lbs/A								

(Table 3. continued)

Plot nos.	Total N applied/A	0-6	6-12	12-24	24-36	36-48	48-60	60-72	72-84
		Soil depth in inches							
		ppm NO_3-N							
(12)	80 N - S								
2	800 + 140# starter	2.3	1.9	1.5	1.9	1.7	1.3	1.7	1.6
25	" " "	1.4	2.9	2.9	1.1	1.5	2.7	1.9	2.8
60	" " "	2.3	3.5	1.9	3.4	3.7	3.9	1.7	3.7
78	" " "	3.0	1.9	1.3	1.9	2.1	2.7	2.3	3.4
	Average ppm N	2.3	2.6	1.9	2.1	2.3	2.7	1.9	2.9
	" lbs/A N	2.3	2.6	3.8	4.2	4.6	5.4	3.8	5.8
	Total - 32.5 lbs/A								
(13)	80 urea S								
16	800 + 140# starter	10.8	3.3	3.2	2.5	2.9	3.0	3.2	3.7
26	" " "	1.8	2.8	2.3	1.9	2.9	3.6	1.9	2.4
57	" " "	2.8	2.5	2.9	2.5	3.6	3.8	3.0	2.6
77	" " "	3.6	7.4	3.4	1.8	3.7	2.7	2.5	1.2
	Average ppm N	4.8	4.0	3.0	2.2	3.3	3.3	2.7	2.5
	" lbs/A N	4.8	4.0	6.0	4.4	6.6	6.6	5.4	5.0
	Total - 42.8 lbs/A								
(14)	40 N - SD								
15	400 + 140# starter	3.1	2.3	1.9	2.6	2.6	3.0	2.4	3.5
33	" " "	2.5	1.6	2.0	1.9	1.5	1.9	2.3	2.5
49	" " "	1.3	1.7	1.7	1.3	2.8	3.6	4.3	1.9
70	" " "	1.4	2.9	2.1	2.1	2.6	3.4	2.5	1.5
	Average ppm N	2.1	2.1	1.9	2.0	2.4	3.0	2.9	2.4
	" lbs/A N	2.1	2.1	3.8	4.0	4.8	6.0	5.8	4.8
	Total - 33.4 lbs/A								
(15)	40 urea SD								
19	400 + 140# starter	8.4	2.3	2.3	2.6	3.5	2.4	3.5	2.4
37	" " "	2.3	1.9	1.9	2.1	1.7	1.9	2.7	1.7
52	" " "	6.7	2.5	3.2	3.3	5.3	4.6	4.2	1.9
65	" " "	3.3	5.4	1.0	3.7	3.5	1.9	2.2	1.9
	Average ppm N	5.2	3.0	2.1	2.9	3.5	2.7	3.2	2.0
	" lbs/A N	5.2	3.0	4.2	5.8	7.0	5.4	6.4	4.0
	Total - 41.0 lbs/A								

(Table 3. continued)

Plot nos.	Total N applied/A	0-6	6-12	12-24	24-36	36-48	48-60	60-72	72-84
		Soil depth in inches							
		ppm NO_3-N							
(16)	80 N - SD								
11	800 + 140# starter	6.1	5.6	2.5	2.5	3.0	3.7	4.2	3.1
38	" " "	10.1	3.7	1.2	2.3	2.7	2.7	1.9	2.3
58	" " "	3.6	4.2	2.5	1.9	3.2	4.4	3.3	4.2
63	" " "	8.2	3.7	2.5	2.4	2.4	3.0	3.7	2.4
	Average ppm N	7.0	4.3	2.2	2.3	2.8	3.5	3.3	3.0
	" lbs/A N	7.0	4.3	4.4	4.6	5.6	7.0	6.6	6.0
	Total - 45.5 lbs/A								
(17)	80 urea - SD								
20	800 + 140# starter	3.1	1.4	2.5	1.7	3.2	2.4	2.7	1.5
28	" " "	2.0	2.1	1.1	1.3	2.6	2.1	2.2	1.5
47	" " "	2.7	4.1	2.1	3.6	2.2	2.6	3.1	3.0
76	" " "	4.1	13.1	6.5	3.6	5.3	5.7	3.4	5.5
	Average ppm N	3.0	5.2	3.1	2.6	3.3	3.2	2.9	2.9
	" lbs/A N	3.0	5.2	6.2	5.2	6.6	6.4	5.8	5.8
	Total - 44.2 lbs/A								
(18)	160 N - SD								
8	1600 + 140# starter	202.0	13.6	18.4	8.4	2.7	11.1	3.1	2.5
34	" " "	0.6	4.6	2.3	8.7	4.2	9.9	10.2	6.8
50	" " "	23.5	61.6	16.0	13.2	10.3	10.9	4.6	6.1
68	" " "	36.8	80.0	11.5	1.2	5.6	11.5	4.4	10.9
	Average ppm N	65.7	40.0	12.1	7.9	5.7	10.9	5.6	6.6
	" lbs/A N	65.7	40.0	24.2	15.8	11.4	21.8	11.2	13.2
	Total - 203.3 lbs/A								

Table 4. The NO_3-N Content of Webster Clay Loam Near Lamberton Following 10 Years of Continuous Corn and N Fertilization.

Plot No.	7	3	9	13
Treat. No.	1	2	6	8
Lbs N/A in 10 years	140	540	940	1740
Soil depth in feet	NO_3-N in parts per million			
0.5	1.3	2.3	2.7	3.7
0.5 - 1	1.1	1.8	1.0	1.4
1 - 2	1.7	2.3	1.9	3.6
2 - 3	1.1	1.0	1.0	6.6
3 - 4	1.1	1.9	1.9	8.2
4 - 5	2.7	1.0	2.6	8.4
5 - 6	2.0	2.1	1.9	6.6
6 - 7	2.5	2.5	2.2	3.3
7 - 8	2.6	1.3	10.8	2.4
8 - 9	1.3	1.5	1.8	1.5
9 - 10	0.8	1.1	3.1	1.5
10 - 11	0.9	1.3	0.7	1.4
11 - 12	0.8	1.2	3.3	0.9
12 - 13	0.7	0.6	0.8	1.0
13 - 14	1.2	0.8	0.9	1.1
14 - 15	1.4	1.7	0.6	0.8
15 - 16	0.4	1.1	1.7	2.3
16 - 17	2.5	0.9	1.9	1.0
17 - 18	2.3	0.7	1.2	0.7
Total NO_3-N in lbs/A	56.8	50.1	80.3	107.7

Table 5(a)
(N in starter only)

Analyses of Soil Waters Under 1969 Continuous Corn at Lamberton
Tiled Webster clay loam-starter fertilizer of 8-24-12@175#/A.

Plot (yield bu/A)	Depth in feet	lbs N/A annually			NO_3-N in ppm			NO_2-N in ppm			PO_4-P in ppm			K in ppm			Conductance (mmhos/cm)		
		Central	East	West	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5
(87)																			
4	2	14	54	54	3.1	1.2	1.5	0.2	0.1	1.0	1.08	0.05	0.10	2.76	2.91	1.4	0.34	0.22	0.24
"	3	"	"	"	3.6	-	1.7	0.2	-	0.1	0.17	-	0.03	1.13	-	4.6	0.37	-	0.70
"	4	"	"	"	3.7	1.4	-	0.2	0.1	-	0.11	0.01	-	4.09	1.37	-	1.30	1.38	-
"	5	"	"	"	2.3	1.7	3.2	0.2	0.1	0.2	0.05	0.01	0.01	1.51	1.42	1.4	1.72	1.78	1.80
"	6	"	"	"	3.0	2.1	3.4	0.1	0.1	0.1	0.05	0.03	0.01	1.78	1.42	1.8	1.65	1.65	1.64
(88)																			
7	6	14	94	174	53.0	-	-	0.3	-	-	0.01	-	-	2.29	-	-	2.14	-	-
(103)																			
32	3	14	174	54	6.1	-	-	0.1	-	-	1.06	-	-	1.73	-	-	0.35	-	-
"	4	"	"	"	7.1	5.8	-	0.1	1.0	-	0.23	0.02	-	0.73	0.76	-	0.48	0.78	-
"	5	"	"	"	12.0	4.7	3.7	0.1	0.2	9.0	2.30	0.01	0.01	1.64	2.83	5.9	0.42	0.94	0.86
(101)																			
73	3	14	94	94	3.6	-	1.1	0.5	-	0.1	0.21	-	0.06	6.10	-	5.1	0.96	-	0.58
"	4	"	"	"	7.9	2.5	0.9	0.1	2.0	0.1	0.05	0.01	0.01	1.07	3.63	2.1	0.46	1.40	0.59
"	5	"	"	"	1.0	1.3	-	0.1	0.3	-	0.05	0.18	-	12.0	8.90	-	1.90	1.76	-
								Water outside plots - toward drain tile											
(88)																			
7	3.5	0 (14)	0 (94)	0 (174)	24.4	-	7.9	0.4	-	1.0	0.13	-	0.18	1.56	-	3.8	0.71	-	0.84
(77)																			
79	3.5	0 (14)	0 (94)	0 (14)	8.1	-	-	0.2	-	-	0.01	-	-	1.36	-	-	0.49	-	-

Table 5(b)
54 & 94# N/A

Analyses of Soil Waters Under 1969 Continuous Corn at Lamberton
Tiled Webster clay loam-starter fertilizer of 8-24-12@175#/A

Plot (yield bu/A)	Depth in feet	lbs N/A annually			NO_3-N in ppm			NO_2-N in ppm			PO_4-P in ppm			K in ppm			Conductance (mmhos/cm)		
		Central	East	West	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5
									Wells within plots										
(130)																			
48	3	54	94	54	4.3	-	-	0.2	-	-	0.06	-	-	1.56	-	-	0.56	-	-
"	4	"	"	"	3.9	-	-	0.1	-	-	0.01	-	-	2.66	-	-	1.20	-	-
(136)																			
11	2	94	54	14	-	3.8	1.5	-	0.1	0.2	-	0.08	0.08	-	5.10	1.6	-	0.98	0.25
"	3	"	"	"	22.9	-	1.9	5.0	-	0.5	0.08	-	0.06	0.94	-	1.3	1.80	-	0.51
"	4	"	"	"	16.0	7.4	-	0.3	8.0	-	0.09	0.01	-	3.14	6.95	-	1.73	2.50	-
"	5	"	"	"	-	-	4.3	-	-	0.5	-	-	0.01	-	-	11.0	-	-	2.58
"	6	"	"	"	-	5.7	7.7	-	4.0	6.0	-	0.01	0.01	-	6.90	6.2	-	3.00	3.00
(115)																			
38	5	94	54	14	-	8.0	11.3	-	0.8	0.7	-	0.01	0.01	-	1.89	2.4	-	0.85	0.98
"	6	"	"	"	-	7.6	11.5	-	2.0	2.0	-	0.01	0.01	-	2.69	5.4	-	1.31	1.35
(145)																			
58	3	94	94	54	14.5	2.9	-	0.4	2.0	-	0.05	0.01	-	3.48	7.30	-	1.66	1.50	-
"	4	"	"	"	6.7	1.2	1.7	2.0	1.0	0.1	0.01	0.01	0.01	8.70	9.05	10.9	3.40	3.50	3.60
"	5	"	"	"	4.3	2.3	2.0	6.0	4.0	0.2	0.04	0.01	0.02	9.10	6.71	10.6	3.25	2.40	3.40
(165)																			
63	3	94	54	54	32.2	-	-	0.1	-	-	0.04	-	-	2.88	-	-	0.84	-	-
"	6	"	"	"	14.9	-	-	0.1	-	-	0.03	-	-	3.05	-	-	2.60	-	-

Table 5(c)
174# N rate

Analyses of Soil Waters Under 1969 Continuous Corn at Lamberton
Tiled Webster clay loam-starter fertilizer of 8-24-12 at 175#/A

Plot (yield bu/A)	Depth in feet	lbs N/A annually			NO_3-N in ppm			NO_2-N in ppm			PO_4-P in ppm			K in ppm			Conductance (mmhos/cm)		
		Central	East	West	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5
								(Wells within plots)											
(147)																			
8	3	174	14	94	-	27.5	-	-	10.0	-	-	0.03	-	-	4.67	-	-	0.91	-
"	4	"	"	"	-	36.5	-	-	14.0	-	-	0.04	-	-	9.50	-	-	0.62	-
"	5	"	"	"	-	55.0	56.0	-	5.0	0.4	-	0.04	0.01	-	4.28	3.2	-	0.63	3.70
"	6	"	"	"	-	71.0	-	-	0.8	-	-	0.01	-	-	2.26	-	-	0.58	-
(132)																			
34	2	174	54	54	8.8	-	-	0.2	-	-	0.39	-	-	3.98	-	-	0.42	-	-
"	3	"	"	"	11.2	3.6	1.4	0.2	0.1	0.7	0.32	0.09	0.05	1.10	1.13	0.5	0.32	0.28	0.19
"	4	"	"	"	37.2	-	-	0.2	-	-	0.27	-	-	2.40	-	-	0.67	-	-
(156)																			
42	4	174	14	54	-	2.3	-	-	0.4	-	-	0.01	-	-	3.41	-	-	1.62	-
(169)																			
50	2	174	54	94	36.1	-	1.2	0.2	-	0.3	0.08	-	0.05	2.50	-	1.9	0.71	-	0.22
"	3	"	"	"	7.0	11.4	4.2	0.1	0.2	0.2	0.36	0.16	0.04	1.51	5.40	1.3	0.24	1.14	0.35
"	4	"	"	"	35.7	47.0	-	0.2	3.0	-	0.02	0.01	-	3.12	4.72	-	1.84	0.36	-
(146)																			
68	2	174	174	54	11.0	-	-	0.4	-	-	0.08	-	-	4.39	-	-	0.50	-	-
"	3	"	"	"	10.0	-	1.5	0.1	-	0.2	0.07	-	0.03	1.33	-	1.8	0.36	-	0.43
"	4	"	"	"	26.9	14.6	17.9	6.0	6.0	2.0	0.01	0.01	0.02	4.08	5.60	1.2	2.40	1.97	1.60
"	5	"	"	"	30.8	33.2	-	0.2	0.8	-	0.03	0.01	-	1.60	1.56	-	1.53	1.08	-
"	6	"	"	"	44.5	62.0	47.7	4.0	5.0	10.0	0.05	0.01	0.01	7.60	6.15	7.2	2.17	0.37	2.28

Table 5(d)
Wells outside plots

Analyses of Soil Waters Under 1969 Continuous Corn at Lamberton
Tiled Webster clay loam-starter fertilizer of 8-24-12 at 175#/A

Plot (yield bu/A)	Depth in feet	lbs N/A annually			NO_3-N in ppm			NO_2-N in ppm			PO_4-P in ppm			K in ppm			Conductance (mmhos/cm)		
		Central	East	West	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5
Wells outside plots (12' from tile line)																			
(88) 7	3.5	0 14	0 94	0 174	24.4	-	1.3	0.4	-	0.1	0.13	-	0.02	1.56	-	6.4	0.71	-	0.84
(77) 79	3.5	0 14	0 94	0 14	8.1	-	-	0.2	-	-	0.01	-	-	1.36	-	-	0.49	-	-
(146) 15	3.5	0 54	0 54	0 94	19.2	-	-	0.2	-	-	0.05	-	-	0.98	-	-	0.43	-	-
(138) 33	3.5	0 54	0 14	0 174	19.2	-	-	0.1	-	-	0.06	-	-	0.51	-	-	0.30	-	-
(145) 70	3.5	0 54	0 54	0 54	4.7	-	-	0.1	-	-	0.04	-	-	0.79	-	-	0.26	-	-
(115) 38	3.5	0 94	0 54	0 14	-	9.6	-	-	0.5	-	-	0.01	-	-	0.80	-	-	0.44	-
(145) 58	3.5	0 94	0 94	0 54	19.3	-	-	0.1	-	-	0.05	-	-	0.96	-	-	0.72	-	-
(147) 8	3.5	0 174	0 14	0 94	107.0	-	7.9	0.3	-	1.0	0.20	-	0.18	5.60	-	3.8	1.45	-	0.84

(Table 5d. continued)

Plot (yield bu/A)	Depth in feet	lbs N/A annually			NO_3-N in ppm			NO_2-N in ppm			PO_4-P in ppm			K in ppm			Conductance (mmhos/cm)		
		Central	East	West	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5	July 2	July 17	Aug 5
Wells outside plots (12' from tile line)																			
(132)		0	0	0															
34	3.5	174	54	54	11.7	-	-	0.1	-	-	0.08	-	-	0.27	-	-	0.23	-	-
(146)		0	0	0															
68	3.5	174	174	54	23.8	8.7	-	0.2	0.1	-	0.05	0.01	-	1.34	5.10	-	0.43	0.67	-

Table 6. Zinc Concentrations of the Sixth Corn Leaf at Silking in 1969 in the Tenth Year of Continuous Corn and Different N Fertilization of a Webster Clay Loam at Lamberton.

	[1] Zinc in leaves as ppm				
Annual N (lbs/A)	1	2	3	4	Average
1) Check	24.7	21.7	15.2	17.2	19.7 abc
2) 40 as NH_4NO_3-fall plow down	18.8	15.9	16.5	17.5	17.2 ab
3) 40 " urea - " " "	19.4	21.7	22.0	15.0	19.5 abc
4) 40 " NH_4NO_3-fall plow surface	17.1	20.1	16.7	15.7	17.4 ab
5) 40 " urea - " " "	20.1	14.9	21.9	16.4	18.3 abc
6) 80 " NH_4NO_3-" " down	21.1	20.1	17.8	20.3	19.8 abc
7) 80 " urea - " " "	23.2	21.4	23.7	18.1	21.6 bcd
8) 160 as NH_4NO_3-" " "	22.4	-	36.2	17.4	25.4 d
9) 160 " urea - " " "	18.6	28.3	24.3	20.7	23.0 cd
10) 40 " NH_4NO_3-spring topdress	21.1	21.0	17.8	18.1	19.5 abd
11) 40 " urea - " "	22.1	14.8	16.4	15.5	17.2 ab
12) 80 " NH_4NO_3- " "	23.1	20.2	18.1	15.2	19.2 abc
13) 80 " urea - " "	20.4	18.3	24.1	15.0	19.5 abc
14) 40 " NH_4NO_3-sidedress	19.6	18.4	17.6	19.1	18.7 abc
15) 40 " urea - "	17.1	16.3	17.8	16.7	17.0 a
16) 80 " NH_4NO_3- "	23.0	17.5	19.6	16.6	19.2 abc
17) 80 " urea - "	18.1	18.9	18.7	18.1	18.5 abc
18) 160 " NH_4NO_3- "	23.4	21.1	21.5	19.1	21.3 bcd

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

Average soil pH of treatment 15(lowest leaf zinc) = 6.2
" " " " " 8(highest " ") = 5.8

LIME PLOTS, LAMBERTON, 1969

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

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

Since the initial lime treatments (3 and 6 tons per acre of dolomitic limestone applied in fall of 1965) had not raised the pH to the desired levels, additional amounts were applied in spring of 1968 and worked in soil by disking (corn-soybean series), or disking, plowing and disking (alfalfa series). Alfalfa was seeded in 1968, stand established but no yields were obtained.

Soybeans, in 1969, were grown in 30-inch rows; herbicide: Treflan; fertilizer: none. Alfalfa received in 1969: 0 + 60 + 30 lb/A of plant nutrients, expressed as P_2O_5 and K_2O. Soybean yield was not affected by lime treatments (Table 1).

Table 1. Yield of soybeans, Lamberton lime plots, 1969.

Rate of lime tons/acre	Yield bu/acre
0	45
3*	45
6*	45

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

Five tons per acre of alfalfa were harvested in three cuttings (Table 2). Liming had no effect on the hay yields.

Table 2. Yield of alfalfa, Lamberton lime plots, 1969.

Rate of lime	1st cutting	2nd cutting	3rd cutting	Total
		Hay, tons/acre		
0	2.5	1.4	0.9	4.8
4*	2.7	1.3	1.0	5.0
10**	2.6	1.4	1.0	5.1

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

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

The effect of dolomitic limestone applications on soil pH is shown in Tables 3 and 4. Phosphorus and potassium soil test values for the two crop areas are given in Tables 5 and 6.

Table 3. Effect of liming on soil pH, alfalfa area (series 4), Lamberton, 1969.

Depth inches	Lime treatment tons/acre		
	0	4	10
		soil pH	
0-3	5.7 a*	6.1 b	6.8 c
3-6	5.7 a	6.1 b	6.6 c
6-9	5.8 a	6.3 b	6.5 b
9-12	6.1	6.1	6.3
12-18	6.4	6.3	6.4

* Means in horizontal rows followed by different letters are significantly different at 5% level.

Table 4. Effect of liming on soil pH, corn-soybean area (series 5), Lamberton, 1969.

Depth inches	Lime treatment tons/acre		
	0	3	6
		Soil pH	
0-3	6.1 a	6.6 a	6.9 b
3-6	6.1 a	6.7 b	6.8 b
6-9	6.1 a	6.6 b	6.7 b
9-12	6.2	6.7	6.7
12-18	6.6 a	7.0 b	6.9 b

Table 5. Phosphorus and potassium soil tests, alfalfa area, Lamberton lime plots, 1969.

Depth inches	Lime rate tons/acre 0	4	10	Lime rates tons/acre 0	4	10
	Extr. P, pp2m			Exch. K, pp2m		
0-3	82	75	78	304	284	266
3-6	62	76	86	206	210	214
6-9	53	68	60	210	208	202
9-12	8	10	12	190	186	178
12-18	4	3	4	176	172	160

Table 6. Phosphorus and potassium soil tests, corn-soybean area, Lamberton lime plots, 1969.

Depth inches	Lime rate tons/acre 0	3	6	Lime rates tons/acre 0	3	6
	Extr. P, pp2m			Exch. K, pp2m		
0-3	49	43	55	290	270	270
3-6	54	50	40	320	270	250
6-9	42	43	27	230	230	210
9-12	9	8	5	215	200	180
12-18	4	3	3	190	190	170

THE EFFECT OF HEAVY SULFATE SALT APPLICATIONS TO AN OSTRANDER LOAM AT ROSEMOUNT AND TO A CALCAREOUS WEBSTER CLAY LOAM AT LAMBERTON ON SOIL EXTRACT CONDUCTIVITY, PLANT POPULATIONS AND YIELDS OF HARK AND OF CHIPPEWA 64 SOYBEANS IN 1969.

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

The 1968 results were reported in Soil Series 84 (pp 168-171) and the experiment was described at that time. The 1968 electrical conductivities of the soil extracts were somewhat less than desired and resulted in no visual chlorosis of the soybean plants, but the heavier salt applications decreased soybean germination. It was decided to broadcast a second salt treatment sometime before planting in 1969, similar to that made in 1968. No additional fertilizer, other than the salts, was applied in 1969. Hark and Chippewa 64 soybean varieties were again planted as in the previous year of the study. Soil samples from the 0"-6" and 6"-12" depths were collected from each plot near Rosemount on July 11, 1969 and from the Lamberton field on August 5th, and electrical conductivities of the saturated extracts were determined.

Plant population counts and observations for plant chlorosis were made periodically during the summer. At Rosemount, there was no evidence of chlorosis from any of the treatments on either soybean variety, but the heaviest soluble salt treatments seriously reduced plant population. Chlorosis, especially of the Hark variety, was evident over much of the experimental area during the entire growth period, but there was no consistent effect of the salt treatments and appeared to be caused by natural differences in the soil itself. Populations were highly variable on the Lamberton field and, therefore, no harvest yields were obtained. The 1969 results obtained are shown in Tables 1 and 2.

Table 1. Soil Treatment, Extract Electrical Conductivity, Plant Population and 1969 Yields of Hark and Chippewa 64 Soybeans on an Ostrander Silt Loam Near Rosemount.

Treatment & desired conductivity	Sat'd extract conductivity (actual) mmhos/cm 0"-6"	6"-12"	Soybean population 1000's/A Hark	Chippewa 64	Yield (bu/A) Hark	Chippewa 64
1) Check	1.26	0.85	129.8 d	130.3 cd	24.4 b	27.6 b
2) 2 mmho $MgSO_4$	2.12	0.99	121.0 bcd	138.0 d	25.5 b	26.9 b
3) 2 mmho salt mix	2.60	1.15	126.5 cd	130.5 cd	31.8 b	26.3 b
4) 4 mmho $MgSO_4$	3.46	1.72	108.5 b	99.3 b	27.5 b	23.5 b
5) 4 mmho salt mix	3.15	1.69	124.3 bcd	133.0 cd	31.5 b	25.7 b
6) 6 mmho $MgSO_4$	5.43	2.95	10.5 a	16.0 a	12.5 a	7.4 a
7) 6 mmho salt mix	3.56	2.50	111.8 bc	115.8 bc	31.3 b	27.7 b
	Sampled 7/11/69		Counted 7/3/69		Harvested 10/28/69	

Table 2. Soil Treatment, Extract Electrical Conductivity, and Plant Population in 1969 of Hark and Chippewa 64 Soybeans on a Calcareous Webster Clay Loam Near Lamberton. (Sampled 8/5/69)

Treatment & desired conductivity	Sat'd extract conductivity (actual) mmhos/cm 0"-6"	6"-12"	Soybean population 1000's/A Hark	Chippewa 64
1) Check	3.1	3.0	68.5	55.0
2) 2 mmho $MgSO_4$	3.4	4.2	70.8	59.2
3) 2 mmho salt mix	3.6	3.1	67.1	48.5
4) 4 mmho $MgSO_4$	3.6	3.5	75.6	57.3
5) 4 mmho salt mix	3.4	3.3	67.5	42.3
6) 6 mmho $MgSO_4$	4.1	3.4	73.6	44.8
7) 6 mmho salt mix	3.6	3.5	70.2	48.1

On the heaviest salt treatment where an electrical conductivity of the saturated soil extract of 6 mmhos was desired, the highly soluble magnesium sulfate was spread at the rate of 24,248 pounds per acre or a two year total of over 48 tons at Rosemount, and 16,408 pounds at Lamberton (or a two year total of some 32.8 tons). This salt was soluble and dissolved on the soil surface within a few minutes and would certainly increase the osmotic pressure of the soil solution.

On the other hand, the salt mix consisting largely of gypsum ($CaSO_4$ $2H_2O$ - which is only slightly soluble) and lesser amounts of magnesium, potassium, and sodium sulfates, although applied in larger amounts - 35,066 pounds per acre at Rosemount and 17,584 pounds at Lamberton in each of the two years - was relatively slightly soluble and evidently had a lower activity and effectiveness to increase electrical conductivity of the soil solution.

At Rosemount, the 4 mmho $MgSO_4$ treatment significantly lowered germination and plant populations of both varieties, although soybean yields were not significantly depressed. The 4 mmho salt mix was considerably less effective for increasing conductivity and yields were somewhat (but not significantly) better than the 4 mmho $MgSO_4$ treatment. However, the 6 mmho $MgSO_4$ treatment almost eliminated soybean stand, with resulting serious yield reduction. Although the 6 mmho salt mix significantly lowered soybean population, soybean yields apparently were not affected. There was no evidence of plant chlorosis in either variety during the entire growing season, although the more moderate salt treatments appeared to increase the height of the Hark variety some six inches.

The untreated calcareous and evidently salty Webster clay loam near Lamberton had an initial high electrical conductivity and the relatively heavy salt treatments apparently increased this only slightly. Plant chlorosis was evident over much of the experimental area (especially in the Hark variety) but was largely independent of the applied salt treatments. The plant populations were low and highly variable with no evident correlation with salt treatment and, as in 1968, yields were not secured because of this variability.

Conclusions

This experiment was designed to study the effect of soluble salt concentrations in the soil on the incidence of the so-called "iron chlorosis" of soybeans. It is well known that soluble salt concentrations are only one of the soil factors contributing to the chlorotic conditions since excessive soil moisture, low soil temperature, and high soil pH are also involved.

It is apparent that soybean chlorosis does not develop, even where low tolerance varieties such as Hark are grown, unless more of the causative soil factors can be controlled along with increasing soluble salt content. Since varying levels of soil moisture and the depression of soil temperatures are presently not practical in field experiments, this phase of the chlorosis investigation will be discontinued in 1970.

WINTER VERSUS SPRING FERTILIZATION ON 1969 CORN YIELD

J. M. MAC GREGOR, W. W. NELSON AND P. M. BURSON

This experiment was first conducted during the late winter, spring and summer of 1968 with two fields at Rosemount (a fall plowed Ostrander silt loam having a 5% slope, and a spring plowed Judson silt loam having a 1% slope). The third field was located on an essentially level untiled Webster clay loam at Lamberton. Four replications of randomized paired plots 50 feet long and 20 feet wide received broadcast mid-January or early April applications of N, P_2O_5, and K_2O at Rosemount, but only N and P_2O_5 applied at Lamberton.

The winters of 1967-68 and 1968-69 had moderate amounts of snowfall and large fertilizer spreading trucks could have operated fairly well during the winter months. However, as reported in Soil Series 84 (pp 105-7), fertilizer applications were not effective on the two Rosemount fields. Significant fertilizer effect at Lamberton showed both winter or spring treatments to be equally effective for increasing 1968 corn yield.

The fall of 1968 and spring of 1969 were extremely wet and the experimental field at Lamberton remained too wet to plow until late May of 1969. Fertilizer was broadcast on the three fields as in the previous year, but the corn at Lamberton remained immature and only silage weights were obtained. The results are shown in the following tables.

TABLE 1

THE 1969 YIELD OF EAR CORN AT ROSEMOUNT ON OSTRANDER SILT LOAM

FOLLOWING FERTILIZATION IN MID-JANUARY OR IN MAY

Treatment (Lbs/A)	Time of Fertilizer Broadcast	Bushels of ear corn/A @ 15.5% moisture				
		I	II	III	IV	Average
None	-	67.5	84.6	101.8	118.4	93.1
40+0+0	January	81.9	91.4	67.8	61.5	75.7
40+0+0	May	79.4	80.0	81.3	108.7	87.4
0+40+0	January	66.5	81.4	97.3	103.9	87.3
0+40+0	May	65.9	84.8	91.3	84.9	81.7
0+40+40	January	64.9	87.4	121.6	117.2	97.8
0+40+40	May	67.0	62.5	126.2	70.6	81.6
40+40+40	January	84.8	66.3	96.4	125.6	93.3
40+40+40	May	76.1	92.9	89.8	132.2	97.8

Fertilizer treatments not significant

TABLE 2

THE 1969 YIELD OF EAR CORN ON JUDSON SILT LOAM AT ROSEMOUNT.

FOLLOWING FERTILIZATION IN MID-JANUARY OR MAY

Treatment (Lbs/A)	Time of Fertilization	Bushels of ear corn /A @ 15.5% moisture				
		I	II	III	IV	Average
None		65.7	89.5	72.1	73.3	75.2
40+0+0	January	67.4	92.2	96.7	84.6	85.2
40+0+0	May	77.2	96.1	105.6	97.9	94.2
0+40+0	January	81.9	82.0	86.2	98.0	87.0
0+40+0	May	73.5	86.6	101.3	91.8	88.3
0+40+40	January	84.3	92.3	74.9	77.0	82.1
0+40+40	May	113.7	87.4	80.1	109.8	97.8
40+40+40	January	79.1	91.5	92.2	74.7	84.4
40+40+40	May	103.4	85.4	97.9	74.5	90.3

Fertilizer treatments not significant

TABLE 3

THE 1969 YIELD OF SILAGE CORN FROM WEBSTER CLAY LOAM NEAR LAMBERTON

FOLLOWING FERTILIZATION IN JANUARY OR IN MAY

Treatment (Lbs/A)	Time of Fertilization	Yield of silage corn (Tons/A) I	II	III	IV	Average
None	-	8.09	8.24	8.67	6.55	7.89 ab
40+0+0	January	10.88	8.79	10.59	7.57	9.46 bc
40+0+0	May	10.85	12.67	13.40	7.74	11.17 c
0+40+0	January	10.03	7.28	8.29	7.71	8.33 ab
0+40+0	May	8.50	7.60	6.84	5.97	7.23 a
40+40+0	January	9.98	11.14	8.70	8.32	9.54 bc
40+40+0	May	9.89	11.02	7.48	8.35	9.19 b

As in 1968 the fertilized corn on the two soil types at Rosemount (Tables 1 & 2) produced an extremely variable yield and there was no significant effect of the fertilizers on either field, and hence time of application effect was not measurable.

The late spring plowed Webster clay loam at Lamberton (Table 3) also failed to produce a clear cut fertilizer effect making the effect of fertilization time relatively inconclusive.

Although these studies on winter versus spring fertilization for corn production have not resulted in clear and definite answers to possible yield differences, these experiments will not be continued in 1970, largely because of the deep snow cover in January 1970. One of the main difficulties in such a study is to locate experimental areas which are uniformly low in fertility.

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.

1969 Silage Yields
Dry matter, tons/acre

On plots harvested as grain 1965-69:

Low fertility	(74 + 48 + 48)	- 4.88
High fertility	(148 + 96 + 96)	- 5.68

On plots harvested as silage 1965-69:

Low fertility	(74 + 48 + 48)	- 4.74
High fertility	(148 + 96 + 96)	- 5.07

1969 Grain Yields
Bushels/acre @ 15.5% moisture

On plots harvested as grain 1965-69:

Low fertility	(74 + 48 + 48)	- 79.08
High fertility	(148 + 96 + 96)	- 80.19

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

Grain (0 + 0 + 0) - 57.16 bushels/acre

Silage (0 + 0 + 0) - 3.34 tons/acre

There appears to be no reduction in corn yields after removing silage for 5 years. Higher fertility increased silage yields by 0.3 tons/acre, but did not increase grain yields. Yields on fertilized plots were significantly higher than on unfertilized plots.

Variety - Pioneer 3681 Planting date - May 22

CORN IRRIGATION EXPERIMENT

West Central Experiment Station - Morris

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

This experiment was continued as reported in Soil Series 82 (March 1968 and March 1969). Variety - Dekalb XL 306 was planted on May 22, 1969. Atrazine was applied preemergence. Ten inches of water was applied between June 16 and August 29. Rainfall from planting through August 31 was 5.90. inches. The corn was harvested on October 24.

Table 1: Irrigated corn at Morris - 1969

Population treatment	Yield (Bu/A)
Low	103
Med	113
High	120
Nitrogen treatment	
60 lbs.	111
120 lbs.	115
180 lbs.	110
Pop. X Nit. Interaction	
Low x 60	101
Low x 120	108
Low x 180	102
Med x 60	111
Med x 120	116
Med x 180	111
High x 60	121
High x 120	122
High x 180	116

Table 2: Soil test results - Fall 1969

Sample No.	pH	O.M.	P.	K.	Zn	S	Sol. Salts
1	7.7	Hi	12	210	1.8	22	0.8

EFFECT OF HIGH RATE 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 and again in 1968 to simulate phosphorus induced zinc deficiency on corn. The application of both phosphorus and zinc increased yields and there was no apparent interaction.

Yield in bu./acre @ 15.5% moisture for 1969

Treatment	Yield
check	77.9
60 lbs. P_2O_5	90.4
120 lbs. P_2O_5	92.4
240 lbs. P_2O_5	86.0
10 lbs. zinc as zinc sulfate	94.2
240 lbs. P_2O_5 + lbs. zinc as zinc sulfate	86.3

Variety - Dekalb XL 304 Planting date - May 22

PHOSPHORUS FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

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

All plots received a uniform row application of 10 + 0 + 20. Nitrogen was plowed down in the fall of 1968 at the rate of 120 lbs. of N per acre.

Variety-Dekalb XL 304 Planting date - May 12

Table 1: 1969 yields in bu/acre at 15.5% moisture.

Broadcast P Treatment (lbs./acre)	Row Phosphorus Treatment (lbs./acre)					
	ck	15P	30P	45P	45P+10Zn	Average
ck	48.5	43.0	44.9	40.7	44.8	44.4
45P	42.7	50.8	40.6	44.2	49.2	45.5
Average	45.6	46.9	42.8	42.4	47.0	

Table 2: % Phosphorus and ppm zinc in corn leaves at silking for 1969. Phosphorus is the upper number and zinc is the lower number.

Broadcast P (lbs./acre)	Row Phosphorus Treatment (lbs./acre)				
	ck	15P	30P	45P	45 + 10Zn
ck	.24 / 16	.24 / 16	.26 / 12	.28 / 11	.26 / 26
45P	.28 / 10	.31 / 10	.31 / 11	.31 / 10	.27 / 21
Average	.26 / 13	.28 / 13	.28 / 12	.30 / 10	.26 / 24

Table 3: Phosphorus - Zinc ratio of corn leaves analyzed from 1969 plots.

Broadcast P (lbs./acre)	Row Phosphorus Treatment (lbs./acre)				
	ck	15P	30P	45P	45 + 10Zn
ck	152	144	218	259	98
45P	282	306	277	318	129
Average	217	225	248	288	114

Table 4: Average yield in bu/acre at 15.5% moisture for 1965-69.

Broadcast P (lbs./acre)	Row Phosphorus Treatment (lbs./acre)					
	ck	15P	30P	45P	45P+10Zn	Average
ck	74	72	74	74	77	75
45P	77	76	72	71	76	74
Average	76	74	73	72	76	

PHOSPHORUS AND POTASSIUM FERTILIZATION OF ALFALFA

West Central Experiment Station - Morris

Samuel D. Evans

In the fall of 1966 an alfalfa fertility experiment was established at the station on Forman clay loam (formerly Barnes). Three cuttings were made in 1969 and yields were higher than in previous years, but there were no significant treatments.

Table 1: First Cutting yields - 1969

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Tons alfalfa hay/A @ 15% moisture					
0	2.3	2.1	2.6	2.4	2.6	2.4
57	2.3	2.5	2.5	2.4	2.5	2.4
114	2.4	2.6	2.3	2.8	2.3	2.5
229	2.4	2.7	2.6	2.6	2.9	2.6
458	2.2	2.7	2.5	2.7	2.8	2.6
Average	2.3	2.5	2.5	2.6	2.6	

Table 2: Total of 3 cuttings - 1969

P_2O_5 Applied	K_2O Applied 0	60	120	240	480	Average
	Tons alfalfa hay/A @ 15% moisture					
0	4.3	3.7	4.4	3.9	4.8	4.2
57	4.0	4.3	4.0	4.1	4.5	4.2
114	4.2	4.4	4.0	4.7	4.2	4.3
229	4.1	4.7	4.5	4.4	5.0	4.6
458	4.2	4.8	4.3	4.9	5.0	4.6
Average	4.2	4.4	4.3	4.4	4.7	

Table 3: Analysis of variance - 1969 yields

	1st Cutting	2nd Cutting	3rd Cutting	1969 Total
Reps	NS	*	**	**
Phosphorus rates	NS	NS	NS	NS
Potassium rates	NS	NS	NS	NS
P x K interaction	NS	NS	NS	NS

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.

Table 1: The effect of fertilizer placement at different broadcast rates on corn yields at Morris in 1969.

Broadcast treatment	Row Treatment (Yield in bu./acre @ 15.5% moisture)				
	check	Pop-up(1)	Starter(2)	Pop-up + Starter	Average
100+0+0	82.7	82.3	77.7	80.7	80.8
100+25+25	57.4	67.6	67.6	73.0	66.4
100+50+50	70.7	69.9	64.4	73.0	69.5
100+75+75	67.5	68.9	70.7	70.3	69.4
100+100+100	72.8	78.7	81.3	81.6	78.6
average	70.2	73.5	72.3	75.7	

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

(2) Starter - 150 lbs. of 8-32-16

Yields were quite low due to dry weather and the highest yield was on the treatment with no broadcast P_2O_5 or K_2O and no starter

USE OF VARYING RATES OF NITROGEN & STARTER ON CORN IN 1969

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 1969 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
	(Yield in bu./acre @ 15.5% moisture)				
0	56.3	45.2	52.5	48.3	54.9
50	61.0	43.7	45.6	59.1	59.0
150	63.4	49.6	50.2	55.0	65.1
average	60.2	59.4	56.9	62.0	

Yields were quite variable due to dry weather, but there was a significant effect of nitrogen fertilization. There was no starter effect on nitrogen x starter interaction.

Variety - Dekalb XL 304 Planting date - May 22

YIELDS OF FIELD CORN GROWN EACH OF THIRTEEN YEARS (1957-69) WITH VARYING RATES OF NITROGEN FERTILIZATION AT MORRIS

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

A continuous corn fertilizer experiment was commenced in 1957 on a non-tiled Barnes loam at the West Central Experiment Station at Morris. Adequate amounts of phosphate and potash were applied annually with four rates of N application. Although a plant population of 16-18,000 corn plants per acre was desired, this was not always obtained, since different methods of seed-bed preparation were employed until 1968. For the past two cropping seasons, the seedbed has been prepared on all treatments by the common method. All vegetative residues remained on the field, either being plowed down or worked into the surface. Ear corn yields and the average for the thirteen years are shown in Table 1. Soil moisture appears to be a limiting factor in corn production.

During the thirteen years of continuous corn, it is evident that while the annual 40 pound per acre N fertilization rate increased ear corn yields approximately 10 bushels per acre, further increases in the rate of annual N fertilization rate did not result in a further increase in corn yields. Soil analyses have shown some accumulation of nitrate nitrogen to a 24 foot depth, although the major portion is present in the upper 8 foot depth.

The sixth corn leaf on all plots were sampled in 1969 at silking and while leaf zinc varied from 30 to 37 ppm on the different treatments, there was no significant treatment affect.

Table 1. Yield of Earn Corn During Thirteen Years (1957-69) When Grown Every Year With Different Rates of Nitrogen Fertilization.

N Appl. (lbs/A)	(a)	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	13 yr Average
		Bushels of ear corn per acre at 15.5% moisture													
0	(S)	65.2	73.2	36.1	53.3	32.3	38.1	62.7	33.2	50.4	49.0	66.8	64.1	47.4	51.7
40	(F)	71.0	81.5	40.9	48.2	48.3	59.0	80.9	34.1	68.3	63.7	69.2	79.6	58.0	61.7
40	(S)	69.4	81.0	41.5	55.0	47.6	62.0	83.5	29.6	75.3	66.3	71.2	70.2	60.2	62.5
80	(S)	72.1	82.4	39.7	53.7	45.0	65.3	77.4	29.1	80.8	75.9	69.7	78.5	59.9	63.8
240	(S)	71.3	80.3	36.8	52.5	46.1	67.1	79.5	24.7	82.8	33.1	71.3	76.0	58.7	60.0

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

(S) = Spring

(F) = Fall

NPK FERTILIZATION OF SOYBEANS

West Central Experiment Station - Morris

S. D. Evans and G. E. Ham

A series of plots was established in the fall of 1967 to determine the optimum fertilization rates for sugar beets. The project was discontinued after one cropping year so these plots were put into soybeans in 1969. Chippewa 64 soybeans were planted on one set of plots that had fertilizer in the fall of 1967 and on another set that had fertilizer in the fall of 1968. Fertilizer rates used are given in table 1.

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

Nitrogen	Phosphorus	Potassium
N_o - 0	P_o - 0	K_o - 0
N_1 - 70	P_1 - 25	K_1 - 25
N_2 - 140	P_2 - 50	K_2 - 50

The elements are applied in all combinations in a 3 X 3 factorial of 2 replications. The soybeans were planted on May 28 and were harvested on October 9.

The experiment was analyzed and there were no significant main effects or interactions. The main effect yields are given in Tables 2 and 3.

Table 2: Yields of soybeans on plots that received fetilizer in the fall of 1967.

N_o 30.3	P_o 31.3	K_o 30.0
N_1 30.8	P_1 30.5	K_1 31.3
N_2 31.4	P_2 30.6	K_2 31.2

Table 3: Yields of soybeans on plots that received fertilizer in the fall of 1968.

N_o 29.3	P_o 30.4	K_o 28.9
N_1 30.6	P_1 30.0	K_1 31.0
N_2 30.3	P_2 29.7	K_2 30.2

Leaves were sampled but they have not yet been analyzed.

Table 4: Soil test results - Fall 1967

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

ZINC FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station - Morris

Samuel D. Evans

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

Table 1: Yields for 1969 and 1965-69.

Treatment	When applied	Yield in bu./acre at 15.5% moisture 1969	1965-69 aver.
Check	--	54.9	81
5 lbs zinc as zinc sulfate	1965	51.4	79
10 lbs zinc as zinc sulfate	1965	49.3	79
10 lbs zinc as zinc sulfate	yearly	57.3	82
20 lbs zinc as zinc sulfate	1965	50.0	82
0.5 lbs zinc as Zn chel.	yearly	45.1	74
45 lbs P broadcast	yearly	44.9	78
45 lbs P broadcast + 10 lbs zinc as zinc sulfate	yearly 1965	53.6	79

Table 2: Summary of phosphorus and zinc leaf analysis for 1969.

Treatment	When applied	%P	ppm Zinc	P/Zn Ratio
Check	--	.26	12	228
5 lbs zinc as zinc sulfate	1965	.23	14	169
10 lbs zinc as zinc sulfate	1965	.24	16	148
10 lbs zinc as zinc sulfate	yearly	.25	24	102
20 lbs zinc as zinc sulfate	1965	.25	20	128
0.5 lbs zinc as Zn chel.	yearly	.24	15	164
45 lbs P broadcast	yearly	.29	10	301
45 lbs P broadcast + 10 lbs zinc as zinc sulfate	yearly 1965	.26	12	225

1965 Variety-Dekalb XL 304 Date Planted - May 13, 1969

WEATHER SUMMARY - 1969

West Central Experiment Station - Morris

Samuel D. Evans

		Precipitation			Air Temperature			Temp. Soil(10 CM)
Month	Period	1969	Average 1930-59	Deviation from Nor.	1969	Average 1930-59	Deviation from Nor.	1969
January	1-31	2.17	.56	+1.60	0.6	10.1	-9.5	26.6
February	1-28	1.02	.67	+0.35	12.4	14.7	-2.3	27.0
March	1-31	0.68	1.11	-0.43	15.9	27.5	-11.6	28.5
April	1-10	1.77			35.3	37.3	-2.0	34.2
	11-20	.23			49.0	43.5	+5.5	46.4
	21-30	.97			48.2	48.6	-0.4	51.2
Total or Average		2.97	2.05	+0.92	44.2	43.1	+1.1	43.9
May	1-10	2.32			54.6	53.0	+1.6	54.2
	11-20	1.97			53.4	56.3	-2.9	57.0
	21-31	.14			63.0	60.2	+2.8	65.9
Total or Average		4.43	3.07	+1.36	57.2	56.5	+0.7	59.3
June	1-10	.27			58.3	63.6	-5.3	65.1
	11-20	.54			57.6	66.3	-8.7	65.0
	21-30	1.22			61.0	68.4	-7.4	62.8
Total or Average		2.03	3.79	-1.76	59.0	66.1	-7.1	64.3
July	1-10	.86			64.5	70.4	-5.9	68.0
	11-20	.67			75.5	72.0	+3.5	79.0
	21-31	1.99			70.0	72.6	-2.6	76.1
Total or Average		3.52	3.25	+0.27	70.0	71.7	-1.7	74.4
August	1-10	.13			70.9	72.3	-1.4	77.0
	11-20	.04			72.6	70.1	+2.5	79.3
	21-31	.04			72.1	66.7	+5.4	77.1
Total or Average		.21	2.87	-2.66	71.8	69.7	+2.1	77.8
September	1-30	2.81	1.94	+0.87	60.3	59.7	+0.6	63.5
October	1-31	2.83	1.44	+1.39	42.4	48.9	-6.5	44.9
November	1-30	.85	1.09	-0.24	30.5	30.4	+0.1	34.8
December	1-31	1.95	.59	+1.36	17.3	17.0	+0.3	27.2
April 1-Aug. 31		13.16	15.03	-1.87	60.6	61.7	-1.1	64.1
Jan. 1 - Dec. 31		25.47	22.43	+3.04	40.3	43.0	-2.7	47.8

1968 CLIMATIC STUDIES AT THE PARK RAPIDS SULFUR EXPERIMENTAL FIELD

J. B. Swan, A. C. Caldwell, G. W. Rehm, E. Seim, D. G. Baker

Past research at the Park Rapids experimental field has indicated that climatic conditions commonly imposed limitations on yields. The drought limitation has been eliminated by irrigation. However, other climatic limitations remain, including the normally short growing season and low air temperatures as illustrated by only 1766 GDD on the average (base temperature 50°F) for the average warm season period at Park Rapids. Low soil temperatures may also constitute a severe limitation. Measurements in 1967 indicated that in irrigated corn the soil temperatures throughout the growing season were well below the optimum. During 1968, soil temperatures were measured at the 2-and 12-inch depths under widely varying populations of irrigated corn and also under potatoes, bare soil and sod. Daily pan evaporation and maximum and minimum air temperatures were recorded.

Table 1 reports the weekly soil temperature at the 2-and 12-inch depths in the row for irrigated corn at populations of 30,000 and 100,000 plants. Measurements were made by using 4 thermocouples placed in parallel for each treatment. Readings were taken at 8:15 AM CDST ± 90 minutes and 5:10 PM CDST ± 40 minutes to approximate the daily minimum and maximum soil temperatures, respectively. The varieties of corn used were Pioneer PXEI for the 100,000 population and Trojan TX68 for the 30,000 population. The soil temperatures reported are the weekly means of the average daily temperatures.

As in 1967, soil temperatures for irrigated corn were well below optimum in 1968. Sizeable differences in weekly average maximum 2-inch soil temperature were recorded between populations of 30,000 and 100,000. However, data from a single year must be judged with caution due to wide fluctuations likely to occur between years.

Greatest temperature difference between the two populations for both maximum and average 2-inch soil temperatures occurred during late June and early July and was probably caused by the more dense shading during this period in the 100,000 plant population treatment. Differences in weekly mean afternoon temperatures were as great as 7°F. Figure 1 shows the weekly mean of the average and maximum 2-inch soil temperatures never exceeded 74°F or 81°F for the 100,000 plant or the 30,000 plant population treatments, respectively. Weekly measurements of average 2-inch soil temperatures were lower and did not rise above 71°F for the 100,000 plant population treatment or 73°F for the 30,000 plant population. These temperatures were generally well below the optimum for corn which is of the order of 85°F. Weekly values of the average 2-inch soil temperature exceeded 70°F for only 1 week for the 100,000 plant population treatment and for 2 weeks for the 30,000 plant population treatment.

Figure 2 and Table 2 show the 2-inch soil temperatures measured by maximum-minimum type mercury-in-steel soil thermometers for populations of 20,000, 40,000 and 50,000 plants.

Weekly mean soil temperatures recorded for bare soil and sod at the 2-, 4-and 12-inch depths are reported in Table 3. Soil temperatures measured by the mercury-in-steel type maximum and minimum thermometers at the 4 and 12-inch depths under potatoes and maximum and minimum air temperatures are shown in Table 4.

Measurement of the evaporation from a Class A type pan and the estimated evapotranspiration are listed in Table 5. The ratios of the two evapotranspiration estimates to the measured values of pan evaporation would indicate, for 1968, that pan evaporation in this locality overestimates evapotranspiration by about 15-20%. The potential evapotranspiration estimate by the Penman method for the growing season (defined as period when probability of occurrence of 32°F or less remains less than 50%) is about 16.5 inches of water. The Thornthwaite method estimate amounts to about 17.8 inches per season. Thus, an average of about 17 inches might be assumed.

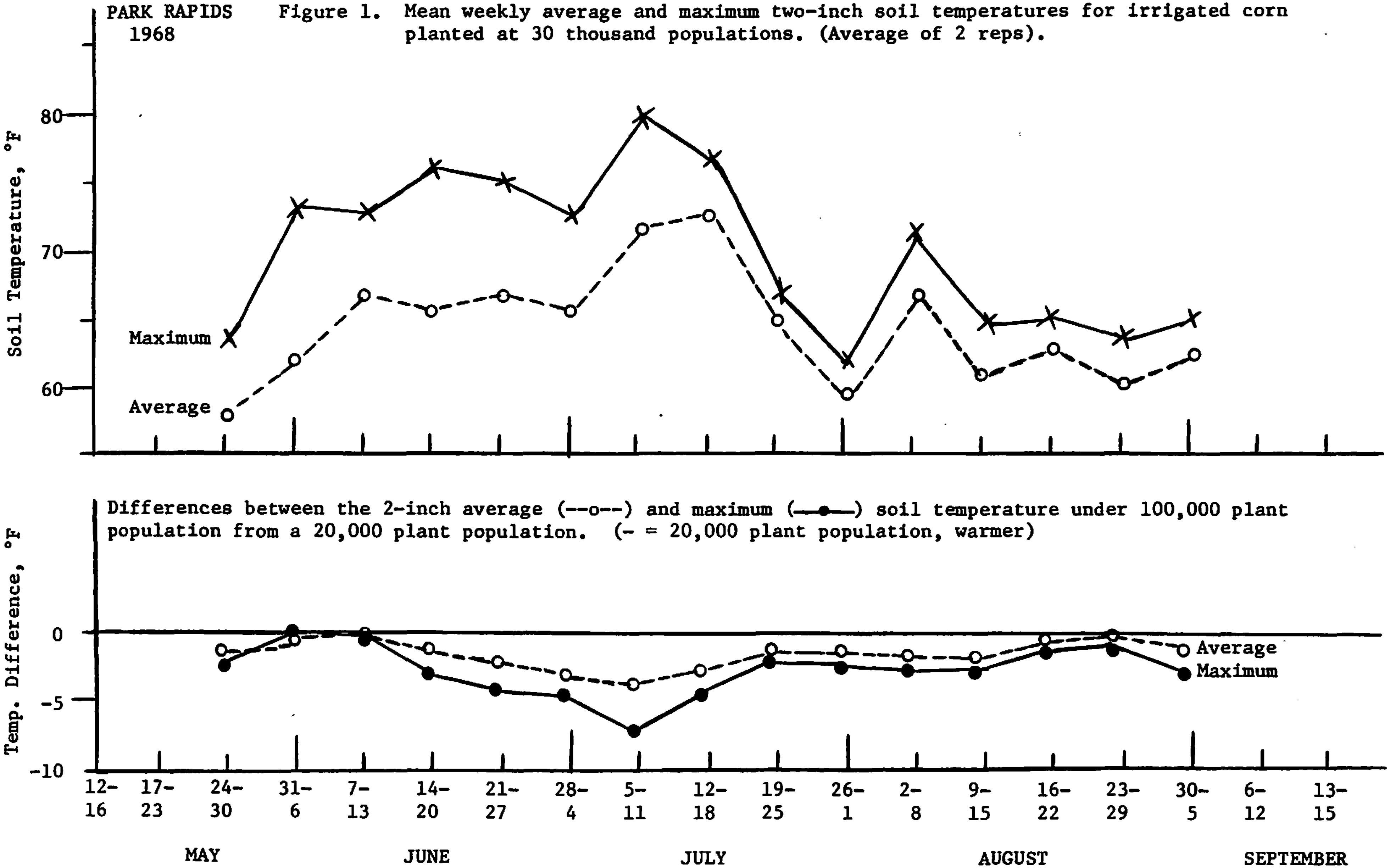

Figure 1. Mean weekly average and maximum two-inch soil temperatures for irrigated corn planted at 30 thousand populations. (Average of 2 reps).

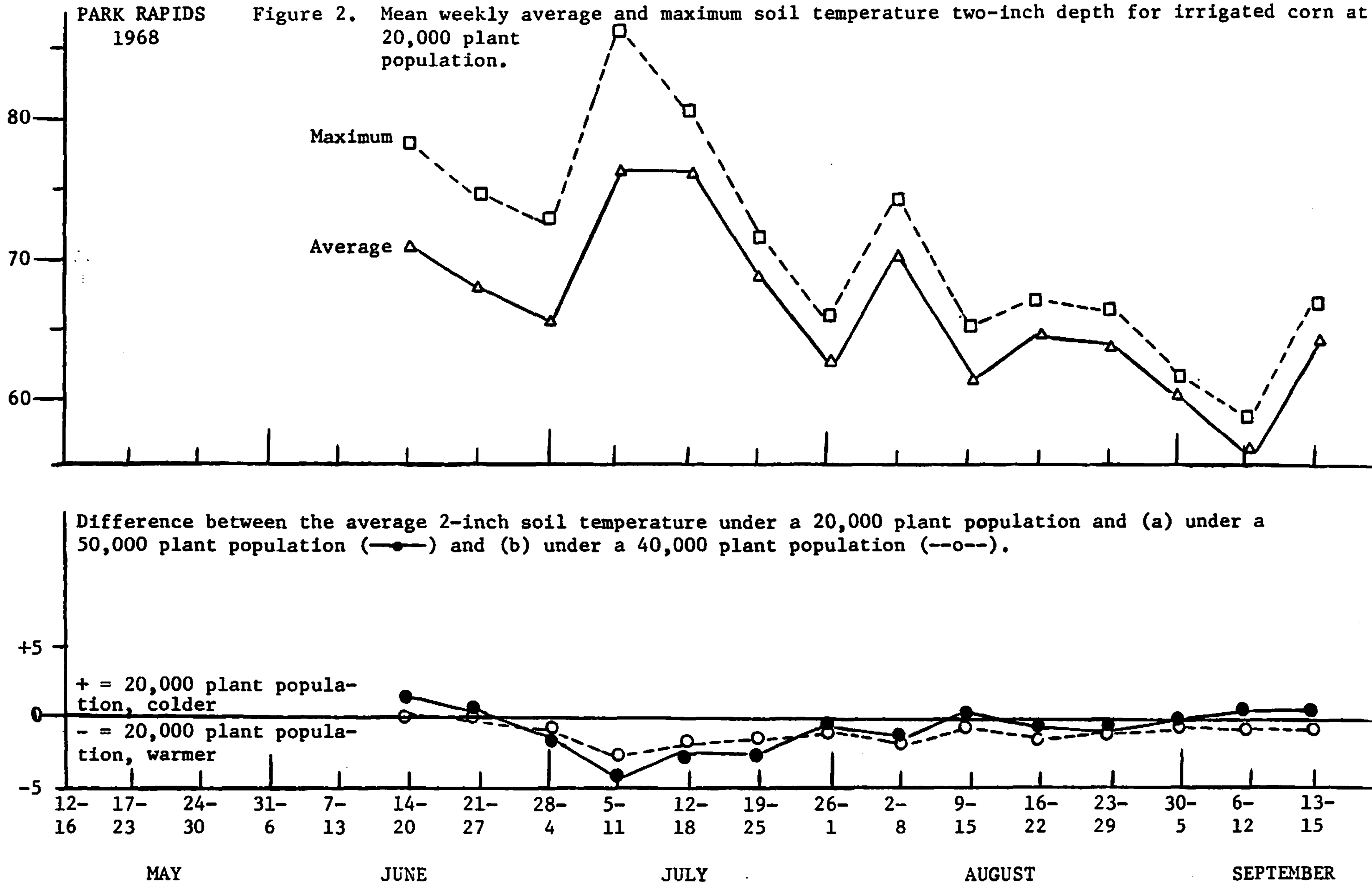

Figure 2. Mean weekly average and maximum soil temperature two-inch depth for irrigated corn at 20,000 plant population.

Table 1. Mean Weekly Soil Temperature (°F) at 2 and 12-inch Depths Under Irrigated Corn for Two Populations, Park Rapids, 1968.

Period	Climatological Week Number	100,000 POPULATION-(Plot 5) 2-Inch Depth AM °F	PM °F	AVG. °F	100,000 POPULATION-(Plot 5) 12-Inch Depth AM °F	PM °F	AVG. °F	30,000 POPULATION-(Plot 6) 2-Inch Depth AM °F	PM °F	AVG. °F	30,000 POPULATION-(Plot 6) 12-Inch Depth AM °F	PM °F	AVG, °F	Aug. 2-inch ΔT (30-100) °F
May 24-May 30	13	49.7	62.0	57.2	52.4	52.6	53.4	49.9	64.2	59.4	51.7	53.3	53.4	+2.2
May 31-June 6	14	55.2	71.7	59.3	56.6	57.9	53.8	54.7	71.4	58.8	55.0	57.8	53.7	-0.5
June 7-June 13	15	61.1	72.2	66.7	64.2	64.1	64.2	61.2	73.0	67.1	63.4	63.8	63.7	+0.4
June 14-June 20	16	56.6	74.3	65.5	59.6	60.6	60.1	55.4	76.4	65.9	59.5	61.0	60.3	+0.4
June 21-June 27	17	58.8	72.2	65.4	61.7	61.4	61.5	59.2	74.8	66.7	61.7	61.9	61.8	+1.3
June 28-July 4	18	56.4	68.4	63.0	61.1	60.4	60.3	57.0	72.0	65.9	61.6	61.4	61.2	+2.9
July 5-July 11	19	62.3	74.9	68.7	65.5	64.7	65.3	62.8	78.9	70.8	65.9	66.7	66.7	+2.1
July 12-July 18	20	68.5	73.3	70.5	68.6	68.0	68.7	68.7	75.4	71.8	69.3	69.0	69.0	+1.3
July 19-July 25	21	60.9	65.9	63.4	64.0	63.6	63.9	61.2	67.1	64.3	63.6	65.0	64.3	+0.9
July 26-August 1	22	56.9	60.3	58.5	59.8	59.3	59.8	56.7	62.0	59.3	60.0	60.7	60.5	+1.2
August 2-August 8	23	62.7	69.2	65.6	62.5	62.7	61.9	62.6	70.4	66.5	63.0	63.8	62.3	+0.9
August 9-August 15	24	57.5	63.8	60.6	61.1	60.6	60.8	57.8	65.3	61.6	60.4	60.5	60.5	+1.0
August 16-August 22	25	59.2	64.8	62.3	60.5	60.6	60.7	59.3	64.9	62.3	60.7	59.7	60.6	0
August 23-August 29	26	57.6	63.2	60.4	60.2	60.4	60.5	56.9	64.8	61.1	60.2	59.5	60.2	+0.7
August 30-August 31	27	59.2	64.2	62.2	60.9	62.0	60.9	58.7	66.8	62.7	59.9	61.0	60.8	+0.5

100,000 Population Pioneer PXE-1
30,000 Population Trojan TX68
24 inch row width

Four thermocouples were placed in parallel in the row in each treatment
AM readings taken about 8:15 DST± 90 minutes (approximates daily minimum temp.)
PM readings taken about 5:10 DST± 40 minutes (approximates daily maximum temp.)

Average temperatures were calculated from weekly averages of daily average temperatures. Where either AM or PM readings were missing, these data were not included in the averages.

Table 1 (continued).

Period	Climatological Week Number	100,000 POPULATION-(Plots 22)						30,000 POPULATION-(Plot 25)						Avg.2-inch ΔT (30-100)
		2-Inch Depth			12-Inch Depth			2-Inch Depth			12-Inch Depth			
		AM °F	PM °F	AVG. °F	AM °F	PM °F	AVG. °F	AM °F	PM °F	AVG. °F	AM °F	PM °F	AVG. °F	°F
May 24-May 30	13	50.7	61.5	56.6	52.8	51.3	51.2	50.7	63.3	57.3	52.3	51.6	51.9	+ .7
May 31-June 6	14	57.2	74.3	63.8	55.7	57.5	56.1	57.0	75.2	65.5	56.3	58.7	57.2	+1.7
June 7-June 13	15	60.9	72.9	66.9	62.8	63.0	63.0	60.4	72.9	66.7	63.4	63.7	63.6	-0.2
June 14-June 20	16	56.5	72.7	64.6	59.1	60.1	59.6	56.1	76.3	66.3	58.9	60.8	59.9	+1.7
June 21-June 27	17	59.0	70.1	64.4	61.2	61.8	61.4	58.9	75.8	67.2	61.6	62.3	61.9	+2.8
June 28-July 4	18	56.1	68.0	62.8	59.7	60.6	59.6	56.4	73.6	66.2	60.2	61.9	60.6	+3.4
July 5-July 11	19	61.4	71.9	66.7	63.6	62.8	63.3	62.9	82.0	72.5	66.8	66.9	67.0	+5.8
July 12-July 18	20	67.1	71.3	70.0	66.7	67.3	66.9	68.4	78.0	74.0	68.6	69.7	69.0	+4.0
July 19-July 25	21	60.3	64.3	62.4	62.9	62.8	63.0	61.7	67.7	64.8	65.8	65.1	65.5	+2.4
July 26-August 1	22	56.1	60.2	57.9	58.6	58.4	58.8	56.6	63.1	59.8	60.3	60.3	60.5	+1.9
August 2-August 8	23	61.8	67.5	64.4	62.7	62.1	61.9	63.5	72.6	67.8	64.0	64.7	63.8	+3.4
August 9-August 15	24	55.8	60.4	58.1	59.0	59.1	59.0	57.6	65.4	61.5	62.0	61.2	61.6	+3.4
August 16-August 22	25	59.4	63.7	61.8	59.6	58.5	59.1	60.0	66.2	63.3	62.4	61.2	62.0	+1.5
August 23-August 29	26	56.9	62.9	60.0	58.7	58.7	58.8	57.1	63.4	60.1	62.2	59.6	59.8	+0.1
August 30-August 31	27	59.2	60.8	59.5	60.0	60.1	60.0	59.1	64.4	61.7	60.1	61.3	60.6	+2.2

Table 2. Mean Weekly Soil Temperature (°F) at 2-inch Depth Under Irrigated Corn with Populations of 50, 40, and 20 thousand Plants/Acre, Park Rapids, 1968.

Period	Climatological Week Number	50,000 POPULATION 2-Inch Depth (Plot 3)			40,000 POPULATION 12-Inch Depth (Plot 40)			20,000 POPULATION 2-Inch Depth (Plot 41)			Colder or warmer than 2-inch temp. under 20,000 pop.	
		MIN. °F	MAX. °F	AVG. °F	MIN. °F	MAX. °F	AVG. °F	MIN. °F	MAX. °F	AVG. °F	50,000 °F	40,000 °F
June 18-June 20	16	62.7	81.3	72.0	61.3	80.0	70.7	63.0	78.0	70.5	+1.5	+0.2
June 21-June 27	17	60.0	76.0	68.0	60.0	75.1	67.6	60.7	74.4	67.6	+0.4	0.0
June 28-July 4	18	55.3	72.0	63.6	57.7	70.0	63.9	57.7	72.3	65.0	-1.4	-1.1
July 5-July 11	19	64.3	78.4	71.4	64.6	81.6	73.1	65.6	85.9	75.7	-4.3	-2.6
July 12-July 18	20	69.3	77.1	73.2	69.0	78.6	73.8	71.1	80.1	75.6	-2.4	-1.8
July 19-July 25	21	63.1	67.7	65.4	63.9	68.9	66.4	64.0	70.7	68.0	-2.6	-1.6
July 26-August 1	22	59.4	63.0	61.2	59.1	63.1	61.1	58.7	64.9	61.8	-0.6	-0.7
August 2-August 8	23	63.7	71.4	67.6	63.4	71.3	67.4	65.0	73.4	69.2	-1.6	-1.8
August 9-August 15	24	57.7	63.9	60.8	57.3	62.1	59.7	56.7	63.6	60.1	+0.7	-0.4
August 16-August 22	25	60.0	65.6	62.8	60.1	63.4	61.8	60.7	66.1	63.4	-0.6	-1.6
August 23-August 29	26	59.3	64.7	62.0	59.6	64.3	61.9	60.0	65.6	62.8	-0.8	-0.9
August 30-Sept. 5	27	56.9	60.4	58.6	56.9	59.9	58.4	57.3	60.1	58.7	-0.1	-0.3
Sept. 6-Sept. 12	28	51.4	57.7	55.3	51.4	56.7	54.1	52.1	57.3	54.7	+0.6	-0.6
Sept. 13-Sept. 15	29	60.0	67.7	63.8	59.7	65.3	62.5	61.0	65.0	63.0	+0.8	-0.5

Measurements made by Palmer max-min thermometers placed in the row.

24 inch row width

Varieties and population: 50,000 Trojan TX68; 40,000 Pioneer 3985; 20,000 Trojan TX80

Table 3A. Mean Weekly Sod Cover Soil Temperatures (°F) at two-, four-, and twelve-inch depths at Park Rapids, 1968

Period	Climatological Week Number	Weekly Mean Soil Temperature (°F) 2-Inch Depth AM °F	PM °F	AVG. °F	4-Inch Depth AM °F	PM °F	AVG. °F	12-Inch Depth AM °F	PM °F	AVG. °F	Number of Readings per Period AM	PM	AVG.
May 12-May 16	11	50.9	58.0	57.1	52.2	56.5	55.0	53.1	51.0	52.3	4	5	4
May 17-May 23	12	45.6	57.0	51.3	47.0	53.4	50.2	49.3	48.7	49.1	7	6	6
May 24-May 30	13	49.9	56.8	53.8	50.6	53.7	52.5	51.3	50.4	50.9	6	5	4
May 31-June 6	14	55.1	65.1	60.1	54.9	62.3	58.5	55.1	52.7	55.1	6	5	4
June 7-June 13	15	62.7	71.8	67.3	64.1	69.6	66.0	64.7	64.7	64.7	6	6	6
June 14-June 20	16	57.8	70.8	64.3	59.7	68.4	64.1	62.0	61.9	61.9	6	6	6
June 21-June 27	17	61.6	72.1	66.4	62.1	68.4	65.1	62.6	63.8	63.1	7	6	6
June 28-July 4	18	58.2	68.0	63.8	59.3	65.9	63.0	61.4	61.6	61.5	5	6	4
July 5-July 11	19	64.3	77.1	70.6	65.4	73.0	69.3	65.7	66.2	65.9	7	6	6
July 12-July 18	20	69.7	81.4	75.8	70.0	77.3	73.8	70.2	70.2	70.3	5	7	5
July 19-July 25	21	66.1	77.2	71.7	67.5	74.4	71.0	69.5	69.0	69.2	7	7	7
July 26-August 1	22	61.2	74.6	67.7	63.1	70.3	66.7	66.0	65.6	65.9	7	6	6
August 2-August 8	23	66.1	83.1	74.5	67.3	76.6	71.9	68.6	68.8	68.2	5	6	4
August 9-August 15	24	63.2	77.3	70.2	64.5	72.8	68.6	67.9	67.4	67.6	7	7	7
August 16-August 22	25	62.8	74.3	68.6	63.9	70.7	67.4	65.4	66.2	65.7	7	6	6
August 23-August 29	26	61.3	71.8	66.9	61.8	69.8	66.0	66.0	66.1	65.7	6	5	4
August 30-August 31	27	62.9	72.5	67.6	63.2	69.3	66.0	64.8	64.9	65.2	2	1	1

AM readings taken about 8:15 AM DST (± 90 minutes)
PM readings taken about 4:50 PM DST (± 40 minutes)

Temperatures measured by three thermocouples in parallel

Table 3B. Mean Weekly Bare Soil Soil Temperatures (°F) at two-, four-, and twelve-inch depth at Park Rapids, 1968

Period	Climatological Week Number	Weekly Mean Soil Temperature (°F) 2-Inch Depth AM °F	2-Inch Depth PM °F	2-Inch Depth AVG. °F	4-Inch Depth AM °F	4-Inch Depth PM °F	4-Inch Depth AVG. °F	12-Inch Depth AM °F	12-Inch Depth PM °F	12-Inch Depth AVG. °F	Number of Readings per Period AM	PM	AVG.
May 12-May 16	11	49.4	64.9	56.8	50.5	62.1	56.4	51.1	49.1	48.5	4	5	4
May 17-May 23	12	41.4	65.2	53.1	44.0	59.6	51.8	49.3	48.8	49.2	7	6	6
May 24-May 30	13	49.7	65.7	58.9	50.6	61.0	56.8	53.1	52.8	53.0	6	5	4
May 31-June 6	14	56.3	77.3	67.2	56.0	70.3	63.6	57.8	56.4	57.5	6	5	4
June 7-June 13	15	60.8	74.8	67.8	60.9	71.2	66.1	63.6	63.9	63.8	6	6	6
June 14-June 20	16	55.4	76.3	65.9	55.4	71.9	63.7	60.7	61.4	61.1	6	6	6
June 21-June 27	17	59.3	76.6	67.0	59.3	72.4	65.8	62.8	62.3	62.5	7	6	6
June 28-July 4	18	56.0	74.2	66.2	57.2	69.3	63.8	61.8	62.2	61.8	5	6	4
July 5-July 11	19	65.0	85.2	74.1	65.1	79.5	72.2	68.3	67.8	68.0	7	6	6
July 12-July 18	20												
July 19-July 25	21												
July 26-August 1	22												
August 2-August 8	23												
August9-August 15	24												
August 16-August 22	25												
August 26-August 29	26	57.4	80.9	69.0	60.4	76.7	68.1	66.6	65.8	66.0	4	2	2
August 30-August 31	27	61.7	81.9	70.3	62.6	76.6	69.0	65.4	63.6	63.8	2	1	1

Table 4. Mean Weekly Soil Temperature of Irrigated Potatoes at 4 and 12-inch Depth and Mean Weekly Air Temperature, Park Rapids, 1968.

Period	POTATOES						AIR TEMPERATURE		
	4-Inch Depth			12-Inch Depth					
	Min. °F	Max. °F	Avg. °F	Min. °F	Max. °F	Avg. °F	Min. °F	Max °F	Avg. °F
May 12-May 16	49.2	53.0	51.1	51.8	53.0	52.4			
May 17-May 23	44.8	53.5	49.2	47.2	50.5	48.8			
May 24-May 30	51.0	57.6	54.3	53.6	55.6	54.6	60.5	44.5	52.5
May 31-June 6	58.4	69.9	64.1	57.4	62.7	60.1	54.5	72.8	63.7
June 7-June 13	62.0	76.9	69.4	63.6	67.9	65.7	54.6	74.3	64.4
June 14-June 20	56.9	72.4	64.6	60.3	65.0	62.6	44.4	70.3	57.4
June 21-June 27	59.9	70.0	64.9	62.1	64.4	63.3	51.3	70.4	60.9
June 28-July 4	58.7	65.9	62.3	60.7	63.7	62.2	47.7	69.6	58.6
July 5-July 11	62.1	72.7	67.4	63.6	66.0	64.8	53.3	80.0	66.6
July 12-July 18	69.0	72.7	70.9	67.7	68.1	67.9	63.6	82.7	73.1
July 19-July 25	64.1	66.6	65.4	65.0	65.9	65.4	53.4	77.6	65.5
July 26-August 1	59.3	61.9	60.6	61.3	62.4	61.9	47.1	72.3	59.7
August 2-August 8	64.1	67.4	65.8	64.1	64.4	64.3	56.6	79.9	68.2
August 9-August 15	59.0	62.7	60.9	59.6	62.7	61.1	47.0	68.6	57.7
August 16-August 22	61.7	64.1	62.9	61.1	62.0	61.6	53.1	74.1	63.6
August 23-August 29	62.1	65.4	63.8	62.0	63.9	62.9	51.3	74.1	62.7
August 30-September 5	58.4	61.7	60.1	59.7	61.4	60.6	47.6	66.6	57.1

Table 4 (continued)

Period	POTATOES 4-Inch Depth Min. °F	Max. °F	Avg. °F	12-Inch Depth Min. °F	Max. °F	Avg. °F	AIR TEMPERATURE Min. °F	Max. °F	Avg. °F
September 6-September 12	54.1	60.4	57.3	56.7	57.4	57.1	42.6	67.3	54.9
September 13-September 15	63.3	66.7	65.0	59.3	60.7	60.0	56.3	77.0	66.7

Soil temperature measured by Palmer Max-Min thermometer placed on the row.

Table 5. Pan evaporation measurements at Park Rapids, 1968*

Month	Number of Days	Inches Pan Evaporation Per Day	Estimated Potential Evapotranspiration Penman	Estimated Potential Evapotranspiration Thornthwaite	Ratio of Penman PE Estimate / Meas'd. Pan Evaporation	Ratio of Thornthwaite PE Estimate / Meas'd. Pan Evaporation
May	16	0.145	0.12	0.10	0.83	0.69
June	29	0.184	0.15	0.16	0.82	0.87
July	31	0.201	0.16	0.18	0.80	0.90
August	31	0.193	0.13	0.15	0.67	0.78
September	13	0.115	0.09	0.09	0.78	0.78

* Class A Type pan used

Penman Calc from G. R. Blake, E. R. Allred, C. H. M. van Bavel, and F. D. Whistler, Agricultural Drouth and Moisture excess in Minnesota, Technical Bulletin 235, May 1960.

EFFECT OF BORON RATES ON STAND, APPEARANCE AND NUTRIENT COMPOSITION OF CORN AND ALFALFA

Department of Soil Science, University of Minnesota

A. C. Caldwell, E. C. Seim, and Dean Fairchild

In conducting some field experiments on a sulfur deficient soil in west north central Minnesota it was found that the area was low in available boron. Since it was suspected that many acres of similarly coarse textured soils were also deficient in boron, it was thought desirable to study boron response further. An additional factor favorable to conducting studies on this experimental field was the availability of irrigation water to ensure an adequate supply of this important plant growth factor, particularly in a moisture deficient area and also in an area where there appeared to be considerable promise of future irrigation development.

It was decided therefore to study boron further on these soils and an experiment was set up with the objectives of determining the effects of boron rates on stand, appearance and nutrient composition of corn and alfalfa.

PROCEDURES

The soil on which the experiments were conducted is a Dorset sandy loam, low in sulfur, but also low in boron, containing less than 1 ppm of available B. The soil had been limed to pH 6.5.

Boron rates on corn

Boron rates of 0, 1, 2, 4, and 8 lbs/A of actual B (applied broadcast as Borax), were used in a series of plots randomized and replicated

4 times. Other nutrients (S, P, K, and N) were applied according to soil test. The corn variety was Minhybrid 806, with an 85 day maturity rating. Usual insect and weed control practices were followed. The corn was irrigated every 7 to 10 days depending partly on need. Periodically observations were made on growth and plant appearance. Corn tissue samples were obtained first at thinning time, and about every 2 weeks thereafter until tasseling. In early sampling large mature leaves were taken, but later on when the ear became apparent, the ear leaf was sampled. All told, 6 samples were secured. When corn ears became mature, yields were taken.

Boron on alfalfa

Boron rates of 0, 2, 4, 8, and 16 lbs/A of actual B (applied broadcast as Borax), were applied on randomized and replicated plots for alfalfa. Other nutrients (P, K, and S) were applied as needed. The variety Glacier was planted at the rate of 12 lbs/A. As a measure of possible damage from heavier rates of B, stand counts were made. Alfalfa tissue was taken for analysis when plants were about 10 inches high and when sampled for yield.

Plant analysis

Corn and alfalfa tissues were analyzed for content of chemical elements by spectrographic analysis. Nitrogen and S (which are not determined by spectrographic means) were estimated by accepted procedures.

Soil sampling and analysis

Soils were sampled in the fall at 0-6, 6-12, and 12-18 inch depths by a hydraulic tube method. Soils were analyzed for available B by the hot water soluble method, B being determined colorimetrically as a boron-curcumin complex by the method of Grinstead and Snider.

RESULTS AND DISCUSSION

Boron on corn

It became evident early in the growth of the corn that the 8 pound rate of B was toxic. Plants were shorter than on other plots and were somewhat chlorotic. Later on in the season the damaged plants outgrew these ill effects to some degree, but the yield data (table 1) show that the best treatment was 4 pounds of B per acre, and the lowest yields were obtained when 8 pounds of B were applied.

Table 3 shows the effect of B rates on the B content of corn tissue. The figures all through the season reflect the impact of rates. The heaviest rate induced very high levels of B, especially in the young plants. If the figure for the critical level of B in corn of 10 ppm (Agron. Jour. 61:18), is assumed to be approximately correct, the data show that corn from plots without B were below the critical level and even when 1 and 2 pounds of B were applied the B content of the mature corn was close to a deficiency situation.

The effects of B rates on the S content of corn are shown in table 3. Data for later samplings seem to indicate an enhancement of S uptake with increase in B applications, however these differences though consistent are not great and are of doubtful significance.

Data for the analysis of other chemical constituents in corn tissue are given in tables 4 through 13. An examination of these figures fails to show any consistent pattern of influence of B rates on these essential plant nutrients.

Boron rates on alfalfa

The effects of B rates on the stand and yield of alfalfa are shown in table 14. It was apparent in the field and the stand counts show that the heaviest B application (16 lbs/A) was toxic to alfalfa. The stand was just about cut in half when this amount of B was used. The yield data reflect the effects of B also, but not to the degree that they should. Growth was not as vigorous as was hoped for and perhaps 1970 yields will be better when plants become better established. However the yields do show that the 2 pound B rate was the best.

Thirty ppm of B is given as the critical level in alfalfa (see citation given above), and without B application (table 15) the amount of B in alfalfa tissue is too low. It can be ssen also that an application of 2 lbs/A is enough to meet the needs of the plant.

The N and S contents of alfalfa seemed to be influenced favorably by B applications, (table 16). As was the case with corn, the S content of mature alfalfa increased progressively with B rates. Since the same phenomenon occurred in both crops this effect could well be real, but it is a little difficult at this point to evaluate the significance of this to plant growth.

The effects of B rates on 10 inch and mature alfalfa are given in tables 17 and 18, respectively. An examination of these data reveals no consistent influence of B on these essential nutrients.

Effect of B rates on available B in the soil

Soils were sampled at 6 inch intervals down to the 18 inch depth on the corn plots. The available B in the samples are shown in table 19. After one season of cropping and irrigation, B is still concentrated in the top 6 inches of soil, but measurable amounts have also moved down to 18 inches when 2 or more lbs/A of B were applied.

SUMMARY

Boron broadcast at 8 pounds of actual B per acre (as Borax) was harmful to corn. The best treatment was 4 pounds of B per acre, this rate giving the highest yield and moving the B level in corn tissue well above the critical point. An increase in B rates brought about progressive increases in S content in corn tissue, but had little effect on other essential macro- and micronutrients. Boron broadcast at 16 pounds actual B per acre (as Borax) damaged the stand of alfalfa, reducing it to about half that of highter treatments or none at all. Two pounds of B was the best treatment, this rate giving the best yield and a sufficiently high B level in the plant. The N and S contents of mature alfalfa increased progressively with increases in rates of B application, but other essential macro- and micronutrients were not affected. All B rates for corn increased the B level in the soil. Applications of 2, 4, and 8 pounds of B per acre affected the available B down to a depth of 18 inches, though the major concentration was in the top 6 inches of soil.

Table 1. Effect of boron rates on yield of corn.

Treatments B, lbs/A	Corn yield bu/A
0	120.1
1	113.6
2	120.5
4	129.9
8	100.2

Table 2. Effect of boron rates on B content of corn tissue.

Treatments	Samplings*					
B, lbs/A	1	2	3	4	5	6
	B in tissue, ppm					
0	8.1	6.8	6.3	5.0	7.8	8.9
1	15.6	13.5	8.7	6.8	10.4	12.0
2	22.7	21.0	13.2	7.5	11.6	14.5
4	43.9	38.7	24.1	13.5	21.3	22.4
8	108.2	80.1	46.6	34.8	50.6	43.3

*Sampling started when corn was a few inches high and continued at about 2 week intervals thereafter.

Table 3. Effect of boron rates on the sulfur content of corn tissue.

Treatments	Samplings					
B, lbs/A	1	2	3	4	5	6
	S in tissue, %					
0	.308	.357	.285	.276	.253	.253
1	.310	.349	.294	.268	.263	.289
2	.256	.358	.292	.290	.266	.284
4	.290	.351	.314	.296	.282	.260
8	.327	.359	.308	.301	.280	.274

Table 4. Effect of boron rates on the nitrogen content of corn tissue.

Treatments	Samplings					
B, lbs/A	1	2	3	4	5	6
	N in tissue, %					
0	3.46	4.28	3.73	3.05	3.06	2.69
1	3.62	4.24	3.54	2.98	3.01	2.71
2	3.36	4.31	3.56	3.08	3.10	2.71
4	3.58	4.26	3.77	3.22	3.02	2.53
8	3.74	4.27	3.80	3.16	3.20	2.55

Table 5. Effect of boron rates on P content of corn.

Treatment	Samplings					
B, lbs/A	1	2	3	4	5	6
	P in tissue, %					
0	.41	.39	.24	.22	.37	.37
1	.42	.40	.25	.23	.39	.35
2	.40	.39	.25	.23	.38	.38
4	.43	.41	.25	.21	.37	.33
8	.45	.41	.25	.24	.37	.33

Table 6. Effect of boron rates on the K content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	K in tissue, %					
0	2.35	2.40	2.45	2.07	2.06	1.71
1	2.52	2.39	2.35	1.96	2.01	1.63
2	2.18	2.46	2.41	2.07	2.04	1.74
4	2.47	2.54	2.43	2.04	2.08	1.64
8	2.44	2.48	2.44	2.12	2.09	1.71

Table 7. Effect of boron rates on the Ca content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	Ca in tissue, %					
0	.63	.66	.67	.64	.69	.81
1	.64	.68	.69	.68	.77	.78
2	.54	.65	.62	.67	.72	.80
4	.59	.67	.65	.62	.81	.82
8	.65	.66	.69	.69	.74	.76

Table 8. Effect of boron rates on the Mg content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	Mg in tissue, %					
0	.24	.23	.24	.26	.28	.35
1	.25	.25	.26	.30	.34	.38
2	.21	.24	.24	.30	.32	.37
4	.24	.26	.25	.27	.35	.39
8	.26	.27	.25	.28	.29	.34

Table 9. Effect of boron rates on the Fe content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	Fe in tissue, ppm					
0	1214	746	502	440	473	1164
1	1862	852	490	317	477	1052
2	2459	722	492	406	526	1071
4	1894	693	522	400	437	1029
8	2270	824	469	552	567	1046

Table 10. Effect of boron rates on Mn content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	Mn in tissue, ppm					
0	105	92	97	81	78	81
1	98	99	98	85	87	77
2	117	89	92	89	79	75
4	95	89	96	81	91	85
8	112	83	92	85	86	74

Table 11. Effect of boron rates on Cu content of corn.

Treatment B, lbs/A	Sampling 1	2	3	4	5	6
	Cu in tissue, ppm					
0	14	13	8	9	5	5
1	13	10	7	9	6	5
2	12	9	9	8	6	5
4	15	10	8	9	6	5
8	13	9	8	8	6	4

Table 12. Effect of boron rates on the Zn content of corn.

Treatment B, lbs/A	Sampling 1	2	3	4	5	6
	Zn in tissue, ppm					
0	37	25	20	14	19	15
1	36	29	20	15	22	16
2	43	23	19	13	20	15
4	45	24	19	14	22	15
8	41	28	19	14	20	14

Table 13. Effect of boron rates on Mo content of corn.

Treatment	Sampling					
B, lbs/A	1	2	3	4	5	6
	Mo in tissue, ppm					
0	1.8	.9	.9	.6	.6	.7
1	1.9	.9	.9	.8	.6	.7
2	2.2	.8	.9	.7	.6	.8
4	1.9	.9	.8	.7	.6	.6
8	2.2	.9	.9	.6	.4	.7

Table 14. Effect of boron rates on stand and yield of alfalfa.

Treatments B, lbs/A	Stand plants/f^2	Yield* tons/A
0	39	1.3
2	44	1.5
4	33	1.3
8	33	1.3
16	17	1.2

*Newly seeded alfalfa - 1 cutting only.

Table 15. Effect of boron rates on boron content of alfalfa.

Treatments B, lbs/A	Stage of growth: 10" tall	Stage of growth: Mature
	B in tissue, ppm	
0	22.6	16.5
2	34.9	43.5
4	44.3	46.7
8	59.8	56.1
16	82.7	74.6

Table 16. Effect of boron rates on nitrogen and sulfur content of alfalfa.

Treatments B, lbs/A	Stage of growth: 10" tall	Stage of growth: Mature	Stage of growth: 10" tall	Stage of growth: Mature
	N in tissue, %		S in tissue, %	
0	3.61	2.23	.353	.296
2	3.44	2.41	.373	.299
4	3.83	2.49	.341	.324
8	3.44	2.64	.373	.347
16	3.59	2.64	.385	.339

Table 17. Effect of boron rates on certain chemical elements in alfalfa 10" high.

Treatments B, lbs/A	P	K	Mg	Fe	Mn	Cu	Zn	Mo
	in %			in ppm				
0	.271	2.06	.300	92	43	3	17	4
2	.273	2.07	.313	92	41	3	18	4
4	.285	2.09	.311	98	40	3	16	4
8	.295	2.26	.318	98	41	3	18	5
16	.287	2.17	.329	101	43	3	19	4

Table 18. Effect of boron rates on certain chemical elements in mature alfalfa.

Treatments B, lbs/A	P	K	Mg	Fe	Mn	Cu	Zn	Mo
	in %			in ppm				
0	.212	1.68	.305	320	40	3	15	4
2	.245	1.71	.332	424	42	4	15	5
4	.227	1.58	.313	425	39	4	15	4
8	.236	1.62	.299	437	42	4	15	5
16	.247	1.82	.328	428	43	4	16	5

Table 19. Effect of boron rates on available boron in the soil after one cropping season.

Treatments B, lbs/A	Depth 0 - 6"	6 - 12"	12 - 18"
	available B, ppm		
0	.36	.28	.22
1	.61	.30	.23
2	.72	.45	.47
4	1.11	.80	.40
8	1.98	1.45	.71

CONTINUOUS CORN - HIGH FERTILITY EXPERIMENT

Rosemount Experiment Station
W. P. Martin, P. M. Burson, D. S. Fairchild, B. D. McCaslin

This experiment was established in 1953. Yields have been harvested annually for 17 years. During this time, soil and plant samples have been periodically taken and analyzed. Yield results from past years may be found in the 1963, 1964, 1965, 1966, 1967, 1968 and 1969 mimeographed "Bluebook".

The 1969 growing season was unfavorable for optimum corn production at Rosemount. The spring was characterized by excessive amounts of soil moisture from spring rains and the past fall's accumulation. From August to harvest, a moisture shortage was critical.

The corn was planted in 30-inch rows on May 14. Four pounds of active atrazine plus one cultivation resulted in poor weed control. Yields obtained in 1969 were generally quite poor (Table 1). A slight response was shown to the first 100 pound increment of N at all levels of P and K. A further N addition of 100 pounds resulted in no significant increase in yields in treatments 4 and 7. Within treatment 10, the addition of 244 pounds of N resulted in a 23 bushel increase over the 144 pounds of N with the same rates of P and K. But this yield increase was not consistent with the other treatments of 200 or more pounds of N. After 17 years, yields from the check treatment were still high. A possible reason for this may be due to the 4 foot depth of colluvium material on which this experiment is located. The soil type within the experimental area is a Port Byron silt loam.

Table 1. The fertility treatments and corresponding 1969 corn yields.

Treatment Number	Fertilizer Treatments*	1969 Yield ** bu/A
1	0 + 0 + 0	84.8 abc***
2	12 + 36 + 108	75.1 a
3	112 + 36 + 108	86.3 abc
4	212 + 36 + 108	87.6 abc
5	28 + 84 +252	80.8 abc
6	128 + 84 + 252	97.9 cd
7	228 + 84 + 252	104.6 de
8	44 + 132 + 396	90.5 abc
9	144 + 132 + 396	93.9 bc
10	244 + 132 + 396	117.1 e

* Pounds per acre of N + P_2O_5 + K_2O. Applied in 1969.

** Combined yield average of the high and low populations at each fertility treatment.

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

All fertility treatments were tested at two plant populations. Results given in Table 2 show higher yields at the high populations in 1969.

Table 2. The plant population and corresponding 1969 corn yields.

Population Plants/Acre	1969 Yield * bu/A
Low - 23,000	84.3 a
High - 32,000	99.4 b

* Combined yield average of all ten fertility treatments at each population.

Sixth leaf samples were taken at advanced silking stage from all high population plots for tissue analysis. Results are presented in Table 3.

Between the ten fertilizer treatments, highly significant differences were observed in the leaf tissue concentrations of P, K, Fe, Mg, Zn, Cu, and Mn. Concentration of P and K increased as the amount of each respective nutrient in the fertilizer treatments was increased. Manganese (Mn) content also increased with the higher fertilizer rates.

Leaf contents of Zn and Mg decreased with the higher rates of phosphate and potash. Leaf contents of Zn and Cu are low and approach the deficient range of reported levels for optimum corn production.

Soil samples were taken from 0-36" after crop removal. As of this date, the samples have not been analyzed. Samples were taken to 36" to determine if there has been a movement of N, P, and K at these different levels of fertility for a period of 17 years.

Table 3. Spectrographic analyses of sixth leaf in 1969 of continuous corn under variable fertilizer treatments.

Treatment Number	Fertilizer Treatments	%				ppm					
		P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn	B
1	0 + 0 + 0	0.22 a	1.24 a	0.61 a	0.39 d	45.4 a	130.0 a	19.0 bc	3.9 ab	38.4 a	9.4 a
2	12 + 36 + 108	0.25 ab	1.60 bc	0.51 a	0.28 abc	46.4 a	122.0 a	14.6 ab	3.3 a	38.0 a	8.8 a
3	112 + 36 + 108	0.30 bc	1.36 ab	0.63 a	0.34 c	52.8 a	171.9 b	26.3 d	6.7 d	69.8 bcd	10.6 a
4	212 + 36 + 108	0.32 cd	1.38 ab	0.56 a	0.30 bc	48.7 a	162.2 b	21.2 c	5.5 c	71.1 bcd	9.4 a
5	28 + 84 + 252	0.31 bcd	1.98 d	0.56 a	0.27 ab	54.5 a	171.1 b	13.5 a	5.2 c	51.2 ab	9.4 a
6	128 + 84 + 252	0.37 de	1.78 cd	0.57 a	0.24 ab	55.7 a	191.9 bcd	19.3 bc	5.0 bc	73.4 bcd	9.6 a
7	228 + 84 + 252	0.37 d	1.80 cd	0.56 a	0.21 a	51.5 a	188.9 bc	19.3 bc	5.4 c	79.6 bcd	10.8 a
8	44 + 132 + 396	0.33 cde	1.92 d	0.55 a	0.23 ab	55.4 a	183.1 bc	11.9 a	4.1 abc	60.6 abc	7.6 a
9	144 + 132 + 396	0.37 de	1.91 d	0.55 a	0.22 a	53.7 a	214.4 cd	15.5 ab	4.0 abc	95.1 d	10.2 a
10	244 + 132 + 396	0.39 e	1.90 d	0.55 a	0.22 a	53.1 a	220.9 d	15.6 ab	4.4 abc	90.3 cd	9.7 a
Significance		**	**	N.S.	**	N.S.	**	**	**	**	N.S.
F Value		8.28	13.35	2.12	7.91	1.20	10.25	7.03	6.34	4.43	1.19
CV		11.7	8.8	8.3	15.2	12.9	11.4	18.1	16.6	28.1	17.4

WASECA EXPERIMENTS

Russell D. Frazier

Soil Scientist, Southern School & Experiment Station

Zinc Sources on Corn

In a continuation of work started in 1968 at Waseca, liquid and granular applications were made on a site different from that used in 1968. Materials were applied to the soil before planting. Treatments and yield results are given below. Soil type of the experimental area is Webster Clay loam. Corn was planted May 3; Northrup-King PX 50 was used at a population of 28,000 plants per acre. Anhydrous Ammonia was used on the area, supplying N at a rate of 170 pounds per acre.

Results

Liquid	Zn Rate/acre	Yield, bu./ac.
1. Zn SO_4	10 lb.	158 c
2. Zn NO_3	10 lb.	172 d
3. Na_2Zn	2.5 lb.	154 b
Granular		
4. Zn SO_4	10 lb.	156 bc
5. Check	--	149 a

Soil test vaules: pH, 6.6; p, 72; K, 430.

These same treatments in 1968 on a nearby but poorly drained area gave a decidedly negative response to all forms of zinc fertilization.

Alfalfa Fertilization

Cooperating with Dr. Bill Lueschen, we established a fertility trial on the station in May, 1969. Soil type of the area is Webster Clay loam. Soil test values before treatment were: pH, 5.7; P, 40; K, 240. Limestone was applied at a uniform rate of 7 tons per acre.

Seeding was made with no companion crop, using chemical establishment of EPTC + 2, 4 DB. Two cuttings were removed on July 14 and August 25. Total yield and treatments are shown below. Split plots were used of three varieties: Vernal, Saranac and Minnesota Synthetic N. Six replications were used. Rates of P_2O_5 used were 30 and 150 pounds per acre; K_2O rates were 0, 60 and 300 pounds per acre. There were no significant differences found for varieties nor for fertilizer treatment.

Average Total yield in tons per acre for two cuttings, including all three varieties are shown below:

		K_2O lb./ac.			
		0	60	300	Mean
P_2O_5	30	1.74	1.81	1.79	1.78
lb./ac.	150	1.87	1.91	1.89	1.89
	mean	1.81	1.86	1.84	

Residual Effects of N-P-K- Treatments on Soybeans

Soybeans have been bulk-planted on the N-P-K plots since 1967, when broadcast fertilization treatments were stopped. Merit beans were planted in 1969. Averages of two reps are shown:

	Bu/acre
Check	29.9
N	27.7
P	28.4
K	32.2
NP	29.3
NK	32.5
PK	34.5
NPK	32.7
NPK+	35.2

Corn Population Research

The corn management information indicates higher and higher yields as we increase population. Some date which Dr. Lueschen and I have gathered at Waseca indicates that with present full-season single-crosses we should not assume that the sky is the limit on population. We selected ten of the best full-season varieties we could find by discussion with University and seed company agronomists. Populations studied were 24-, 32-, 40-, and 48,000 plants per acre. The tables below indicate the 1969 yield results following fertilizer application totalling 800 pounds per acre N, 375 pounds per acre P_2O_5 and 750 pounds per acre K_2O applied in the past two seasons.

	1969 Bu/Ac average of 4 reps			
Single Cross	24,000	32,000	40,000	48,000
A	150	154	151	149
B	160	161	162	144
C	152	153	144	112
D	162	166	147	134
E	140	143	135	120
F	146	142	143	120
G	132	139	131	126
H	166	159	155	146
I	124	129	127	103
J(Prolific)	117	130	105	117

Fertilizer:
  1968 400+250+500
  1969 400+125+250
Insecticide: Bux Ten
Herbicide:
  Atrazine - Ramrod Pre
  Atrazine + Oil Post

1969 Foliar-Applied Micronutrients (Tilney Farms, Lewisville)

Again in 1969, micronutrients were foliar-applied in replicated plots in a production field at The Tilney Farms. Materials were taken up in water with urea at the rate of 1 lb. urea in 20 gallons of water. Treatments were made on July 25. Crop history on the field was corn-corn-sugarbeets-soybean (Hark).

Soil test information for 1969:

Depth	pH	P	K
0-12"	7.3	28	410
12-18"	7.2	18	310
18-24"	7.2	16	390
24-30"	7.0	11	400
30-36"	7.0	10	390

Results	Material, lb/acre	Bu/ac
1. Fe 138 chelate	10	34.3 ab
2. Mn chelate	5	38.8 b
3. Cu chelate	5	30.6 a
4. Zn chelate	5	38.0 b
5. All 4 chelates	ditto	35.1 b
6. Check	--	37.4 b

Foliar contents for the treatments were:

Treatment		P	K	Ca	Mg	Al	Fe	Zn	Cu	Mn
		%				P P M				
Fe	1.	.48	2.04	.989	.37	30	150	37	11	49
Mn	2.	.48	2.12	.980	.34	29	144	37	11	51
Cu	3.	.48	2.23	1.00	.38	27	142	33	13	68
Zn	4.	.48	2.17	.980	.37	28	148	42	12	67
mix	5.	.51	2.15	1.03	.39	32	171	45	13	52
check	6.	.49	2.05	1.05	.41	33	154	37	13	67

Sugar Corn Experiments

Data for the 1967 sugar corn experiments were included in the 1968 Blue Book. Analysis of the 1967-1969 data is awaiting return of the 1969 lab data from the cooperating company laboratory.

Statistical analysis of the 1967 sugar production data indicated significant response to K treatment, but not to N, nor to band versus seed placement of row fertilizer.

Treatments have included N levels of 70 and 140 and 210 pounds per acre, K_2O treatments of 0, 200 and 400 pounds per acre and band versus seed placement of row fertilizer in nominal amounts.

In 1968, sugar production yields were calculated in a different fashion than previously, giving a more accurate picture of sugar production. Again, potassium treatment gave significant response. Row placement also had a significant effect on production.

Pounds per acre sugar production from sugar corn
Waseca, 1968

Treatment	Pounds sugar/acre	Significance
Band	1878	*
Seed Placement	1754	
N 70	1829	ns
N 140	1787	
N 210	1832	
K 0	1749	*
K 200	1779	
K 400	1920	

Examination of 1969 data submitted to the analytical laboratory tends to indicate that production of plant material was increased due to K fertilization, but not from N fertilization nor from method of row fertilization. When sugar analysis and other data are available, statistical analysis of 3-year's data will be completed.

Fertilizer and Lime Trials at Pierz, Morrison Co., Minnesota 1969

C. J. Overdahl, B. C. McCaslin, D. S. Fairchild

This experiment was initiated in the fall of 1962. These plots were established to determine needed rates of potassium, lime, and phosphorus. Lime applications of 5 tons per acre were made in 1962, bringing the average soil pH to 6.7. Seeding treatments of K in the spring of 1963 consisted of 0, 60, 120, 180 and 240 pounds per acre of K_2O.

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 in 1968 when the topdressing treatments were omitted on half of them.

Results definitely show that high rates of potassium, both at seeding time and topdressed later, are necessary for most economical production.

This experiment has terminated as of 1969. A complete discussion of yields, soil and plant tissue levels and fertilizer recommendations will be summarized in a miscellaneous report to be published in 1970.

METHOD OF CORN PLANTING STUDY

Lancaster, Wisconsin
University of Wisconsin
Lancaster Experiment Farm

William Paulson, Supt., Arthur Peterson, and James Swan

The following field experiment was conducted near Lancaster, Wisconsin during the 1969 growing season on the same site as the 1968 study.

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

Previous crop: Corn

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

100 lbs. of N as anhydrous ammonia

Planting Date: May 12 - tillage on same day

Experimental Design: Two - 3 x 3 latin squares

Plot size of 24 x 50 feet with alleys from 15-50 feet

Soil temperature measurements (3-inch depth in row) were made on only two of the 6 columns. Four couples were used in parallel on each treatment.

Corn: Wisconsin 110 days.

Population: June 16 - avg. of 2 rows - 26 feet long/plot

Plow wheeltrack	18,400	
None-Coulter plant	29,727	thinned to about 19,000
Chisel Coulter plant	28,700	

At Harvest: October 27

Plow wheeltrack	17,300
Non-Coulter plant	17,800
Chisle Coulter plant	19,800

Treatments:

	Tillage	Planting
C	Chisel	Coulter plant
WT	Spring plow	Wheeltrack plant
N	None	Coulter plant

CORN YIELDS (Bu/Acre)

Replicates	I	II	III	IV	V	VI	Total
Row 1	C 107.0	N 103.9	WT 87.2	N 84.8	WT 105.0	C 117.1	
Row 2	WT 113.9	C 117.8	N 74.9	C 99.1	N 87.3	WT 127.5	
Row 3	N 88.4	WT 124.8	C 100.0	WT 117.3	C 129.9	N 133.2	
	309.3	346.5	263.0	301.2	322.2	377.8	1920.0

ANOVA RANDOMIZED BLOCKS

	SS	dF	MS	F
Total	5080.86	17	--	--
Blocks	2588.29	5	517.65	4.17*
Treatment	1252.33	2	626.17	5.04*
Error	1240.24	10	124.0	--

Level of significance	5%	1%
$F_{(2,10)}$ =	4.10	7.56
$F_{(5,10)}$ =	3.33	5.64

Duncan's Multiple Range Test - Corn Yields 1969

	Plow-wheeltrack	Chisel Coulter plant	NONE Coulter plant
÷ 6	675.7	672.3	572.5
Avg =	112.6	112.0	95.4

1% & 5% level of significance

	5%	5%	1%
P =	2	3	2
dF =	3.15	3.30	4.48
x 4.545	14.3	15.0	20.4

$S_{\bar{x}} = \sqrt{\frac{ms}{6}} \quad \sqrt{\frac{124}{6}} = \sqrt{20.66}$

$S_{\bar{x}} = 4.545$

Plow WT and NONE CP are significantly different at the 5% level

Chisel CP and NONE CP are also significantly different at the 5% level

Early Corn Growth gms/plant

Replicate

	I	II	III	IV	V	VI	
Row 1	C 0.20	N 0.37	WT 0.54	N 0.242	WT 0.39	C 0.125	1.867
	WT 0.27	C 0.103	N 0.345	C 0.121	N 0.193	WT 0.584	1.616
	N 0.15	WT 0.36	C 0.38	WT 0.33	C 0.185	N 0.25	1.655
	0.62	0.833	1.265	0.693	0.768	0.959	5.138

RANDOMIZED BLOCK ANOVA - EARLY GROWTH

	SS	df	MS	F
Total	0.28618045	17	--	--
Block	.08947578	5	.02038	5.6*
Treatment	0.16074845	2	.08037	22.3**
Error	.0359562	10	.00359	--

$F_{(2, 10)} = 1\% \ (7.56); \quad 5\% \ (4.10)$

$$S_{\bar{x}} = \sqrt{\frac{ms}{6}} = \sqrt{\frac{.00359}{6}} = \sqrt{.000598} = .0243$$

Duncan's Multiple Range Test

	5% level	P= 2	P= 3	1% level	P= 2	P= 3
df error		3.15	3.30		4.48	4.73
df, 10	x .0243	0.0765	0.0243	x .0243	0.109	0.113

Plow wheeltrack	NONE Coulter plant	Chisel Coulter plant
0.415 gms/plant	0.258 gms/plant	0.186 gms/plant

Early growth of plow wheeltrack is significantly different from both None and Chisel at 1% level.

WEATHER SUMMARY - 1969

University of Wisconsin Experimental Farm - Lancaster

Month	Temperature				Precipitation		Growing Degree Day Base 50°	
	Mean Max.	Mean Min.	Mean	Departure from Normal	Total	Departure from Normal	1969	Departure from Normal
Apr.	59.2	39.2	49.2	1.9	3.25	-.12	--	--
May	68.8	48.3	58.6	1.4	3.44	.72	284	30
June	71.4	52.2	61.8	-5.2	8.24	3.32	352	-161
July	81.4	62.2	71.8	.7	3.75	.10	665	--
Aug.	83.8	59.7	70.5	2.1	.52	-2.92	672	94
Sept.	72.5	50.2	61.4	.9	1.71	-1.94	344	18
Oct.	56.4	37.5	47.0	-4.0	3.50	1.67	--	--
							2317	2336

Last day in spring with minimum temperature 32° or below 5/12
28° or below 4/29

First day in fall with minimum temperature 32° or below 10/14
28° or below 10/14

TRACE ELEMENT STUDY WITH KENTUCKY BLUEGRASS AND TIMOTHY - 1969 [1)]

John Grava, D. S. Fairchild, B. D. McCaslin,
G. W. Randall and R. S. Farnham

Three field experiments with Kentucky blugrass and timothy were conducted to study the effects of trace element applications on seed yields and chemical composition of tissue. 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.	Ed Baumgartner Roseau County	Bluegrass Park	1968 seeding	Peat
2.	E. Helmstetter Lake of the Woods Co.	Bluegrass Park	1967 seeding	Spooner very fine sandy loam
3.	C. Viken Roseau County	Timothy Climax	1967 seeding	Glyndon silt 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 lbs./acre boron
3. Copper (Cu)	50 lbs/acre $CuSO_4 \cdot 5H_2O$
4. Manganese (Mn)	50 lbs/acre $MnSO_4$
5. Zinc (Zn)	50 lbs/acre $ZnSO_4 \cdot H_2O$
6. B, Cu, Mn, Zn	Same as above

1) See Soil Series 84, "A Report on Field Research in Soils", March 1969, pp. 172 for results obtained from similar investigations conducted in 1968.

All treatments received a uniform application of N, P and K. All materials were applied on October 15, 1969.

The individual plots were 10 feet wide and 20 feet long. Plant tissue samples were collected at the beginning of the emergence of heads or panicles. Contents of the four chemical elements were determined in a multi-element 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 three 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 243 to 356 pounds per acre, resulted from application of the three major nutrient elements (table 2).

Table 2. Effect of Fertilization on the Seed Yield of Park Kentucky Bluegrass and Climax Timothy, 1969.

Plant Nutrients Applied N P_2O_5 K_2O	Field 1 Bluegrass Peat (E.B.)	Field 2 Bluegrass Vfsl (E.H.)	Field 3 Timothy Sil (C.V.)
Lbs/Acre		Yield of seed, lbs/acre	
None	201	115	126
12 + 48 + 48*	444	---	---
24 + 96 + 96*	411	---	---
60 + 30 + 30*	---	299	---
90 + 45 + 45*	---	380	391
120 + 60 + 60*	---	---	482

*Following trace elements applied: B, Cu, Mn, Zn.
Fertilizer treatments were made on October 15, 1968

Seed yields of grasses were not affected by trace element treatments on mineral soils (table 3). On peat (field 1), the yield of bluegrass seed was increased by 124 pounds per acre with the combined treatment of B, Cu, Mn, Zn. Copper alone increased the seed yield on peat by 60 pounds per acre, a difference that was significant at the 18% level.

Effects of trace element treatments on the chemical composition of grass tissue are shown in tables 4, 5 and 6. The B, Cu, Mn, Zn contents of tissue were increased with the rates of trace elements used on organic as well as on mineral soils. Most significant, however, may be the effect of copper treatment on the Cu content of bluegrass tissue on peat. The Cu content was increased to 8 ppm with an application of 50 pounds per acre of copper sulfate. Only 2 or 3 ppm of Cu were found in tissue without the copper treatment. According to studies conducted elsewhere, when the tissue of grasses contains less than 6 ppm Cu, responsive crops are likely to show deficiencies.

Table 3. Effect of Trace Element Applications on the Seed Yields of Kentucky Bluegrass and Timothy, 1969.

Treatments of Trace Elements	Field 1 Bluegrass Peat (E.B.)	Field 2 Bluegrass Vfsl (E.H.)	Field 3 Timothy sil (C.V.)
		Yield of seed, lbs/acre	
None	320 a#	295	402
Boron (B)	296 a	316	432
Copper (Cu)	381 ab	301	417
Manganese (Mn)	325 a	329	434
Zinc (Zn)	360 ab	303	433
B, Cu, Mn, Zn	444 b	299	391
Significance	*	N.S.	N.S.
CV(%)	21	14	10

All plots received the following amounts of plant nutrients: Field No. 1, 12 + 48 + 48; Field No. 2, 60 + 30 + 30; Field No. 3, 90 + 45 + 45. All fertilizer materials were applied on October 15, 1968.

#Means in vertical columns followed by different letters are significantly different at 5% level.

Table 4. Effect of Trace Element Applications on the Chemical Composition of Kentucky bluegrass tissue, 1969. Field 1. E. B. Roseau County, Peat.

Treatment	B	Cu	Mn	Zn
		Parts per million in dry matter		
None	7 a	3 a	43 b	19 a
B	15 b	3 a	46 b	18 a
Cu	7 a	8 b	33 a	18 a
Mn	8 a	2 a	66 c	20 a
Zn	8 a	2 a	42 b	30 c
B, Cu, Mn, Zn	15 b	8 b	40 ab	25 b
Significance	**	**	**	**
CV(%)	24	42	13	10

Table 5. Effect of Trace Element Applications on the Chemical Composition of Kentucky blugrass tissue, 1969. Field 2. E. H. Lake of the Woods County, Vfsl.

Treatment	B	Cu	Mn	Zn
		Parts per million in dry matter		
None	6 a	5 a	28 a	14 a
B	10 b	5 a	27 a	13 a
Cu	6 a	9 b	26 a	14 a
Mn	6 a	4 a	45 c	15 a
Zn	6 a	4 a	27 a	18 b
B, Cu, Mn, Zn	11 b	9 b	36 b	19 b
Significance	**	**	**	**
CV(%)	16	34	19	7

Table 6. Effect of Trace Element Applications on the Chemical Composition of Timothy Tissue, 1969. Field 3. C. V. Roseau County, Sil.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	6 a	4 a	16 a	16 a
B	9 b	4 a	16 a	16 a
Cu	6 a	6 ab	15 a	15 a
Mn	6 a	4 a	19 b	17 a
Zn	6 a	4 a	16 a	23 b
B, Cu, Mn, Zn	8 b	7 b	16 a	22 b
Significance	**	**	**	**
CV (%)	7	25	5	5

SOYBEAN NITROGEN FERTILIZER STUDIES

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

Ammonium nitrate, urea, urea plus sulfur and sulfur-coated urea sources of nitrogen were compared at Lamberton, Morris and Waseca. At Waseca, urea-formaldehyde was compared also. Nonnodulating and nodulating isolines of Chippewa maturity and Chippewa 64 soybeans were grown on the plots. The seed yields for 1969 are shown in Tables 1, 2 and 3. Nitrogen fertilizer significantly increased seed yields at all locations. Rainfall was less than normal at Morris and the yields reflect this. At Lamberton and Waseca, rainfall was nearer to normal, although a dry period occurred in late August at both locations. The nodulating plants were well-nodulated at all locations. In nitrogen fertilizer placement studies at Rosemount, seed placement and banded ammonium nitrate was compared at the rates indicated in Table 4. Seed yields were increased by as much as 13 bushels per acre. These results indicate that nitrogen fertilizer for soybeans needs further consideration.

Table 1. Effect of nitrogen fertilizer on 1969 soybean seed yield at Morris, Minnesota when different sources of nitrogen fertilizer at the rate of 200 pounds N per acre were disced into the soil in the spring of 1969.

Nitrogen Source	Soybean Variety		
	Nonnods	Nods	Chippewa 64
	bu/acre	bu/acre	bu/acre
Check	14.0 a	16.5 a	15.5 a
Ammonium nitrate	19.1 b	20.0 b	18.2 b
Urea	21.6 c	21.3 b	22.6 c
Urea + sulfur	18.9 b	20.1 b	18.5 b
Sulfur-coated urea	20.4 bc	19.1 b	19.4 b

Yields followed by the same letter under a variety are not significantly different from each other.

Table 2. Effect of nitrogen fertilizer on 1969 soybean seed yield at Lamberton, Minnesota when different sources of nitrogen fertilizer at the rate of 200 pounds N per acre were disced into the soil in the spring of 1969.

Nitrogen Source	Soybean Variety		
	Nonnods	Nods	Chippewa 64
	bu/acre	bu/acre	bu/acre
Check	20.3 a	27.7 bc	27.8 a
Ammonium nitrate	27.4 c	29.7 c	30.3 b
Urea	24.7 b	24.6 a	28.9 ab
Urea + sulfur	27.4 c	29.2 bc	30.2 b
Sulfur-coated urea	28.2 c	27.1 b	31.1 b

Yields followed by the same letter under a variety are not significantly different from each other.

Table 3. Effect of nitrogen fertilizer on 1969 soybean seed yield at Waseca, Minnesota when different sources of nitrogen fertilizer at the rate of 200 pounds N per acre were disced into the soil in the spring of 1969.

Nitrogen Source	Soybean Variety		
	Nonnods	Nods	Chippewa 64
	bu/acre	bu/acre	bu/acre
Check	32.1 a	40.0 a	34.1 a
Ammonium nitrate	43.8 b	45.0 bc	40.2 bcd
Urea	44.9 c	44.3 bc	40.9 cd
Urea + sulfur	43.4 bc	41.7 abc	42.0 d
Sulfur-coated urea	40.9 b	41.2 ab	36.9 ab
Urea-formaldehyde	40.5 b	42.5 abc	37.9 bc

Yields followed by the same letter under a variety are not significantly different from each other.

Table 4. Effect on soybean seed yield when different nitrogen fertilizer rates and placements were applied to Merit soybeans grown at Rosemount, Minnesota in 1969.

Treatment		Seed Yield bu/acre
Check		28.1 a
Seed placement:	5#N	27.8 a
	10#N	39.1 b
	15#N	40.9 b
Band:	50#N	41.3 b
	100#N	36.3 b
	200#N	31.6 a
10#N Seed placement: and 100#N Band		37.5 b
10#N Seed placement: and 50#N Band		39.0 b

Yields followed by the same letter under a variety are not significantly different from each other.

SOYBEAN FERTILIZER PLACEMENT STUDY

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

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 and Waseca. Treatments, fertilizer rates and seed yields are shown in Tables 1, 2 and 3. The yields at Morris were low due to lack of rainfall. The largest response was obtained from broadcast fertilizer applications. Starter fertilizer had less effect on seed yields either with or without broadcast fertilizer even though starter and broadcast effects were significant. At Lamberton the yields and the responses were largely due to greater rainfall. The largest response was to combinations of starter and broadcast fertilizer. Band fertilizer increased the yield of the broadcast check by 2.1, 2.6 and 3.9 bushels per acre even though the soil test level of the broadcast check was 25 pounds per acre at the beginning of the 1969 season. Foliar analyses indicated that the yield increases were from P additions. These data indicate the influence of variety on fertilizer response in this case. The yield increase with Corsoy was 17 bushels per acre, compared to about 10 bushels for Chippewa even though the checks of both varieties yielded about 25 bushels per acre. Similarly, adequate fertility is essential in order for a variety to perform at its maximum. At Waseca seed yields were not increased in most cases by broadcast or starter fertilizer. Seed yields were decreased significantly in many cases.

Table 1. Effect on soybean seed yield when different fertilizer placements were applied to soybeans grown at Morris, Minnesota in 1969.

Starter fertilizer	Chippewa 64 No broadcast	Chippewa 64 Broadcast	Merit No broadcast	Merit Broadcast	Traverse No broadcast	Traverse Broadcast
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	17.7 a	22.2 bc	18.4 a	23.1 bc	19.8 a	23.2 bc
Band (2x2)	20.1 ab	22.0 bc	18.2 a	23.1 bc	21.6 ab	24.1 bc
Seed placement	21.2 bc	23.2 bc	20.5 ab	24.5 c	19.6 a	23.7 bc
Band & seed placement	21.3 bc	20.8 bc	17.8 a	21.8 bc	21.4 ab	24.9 c

Fertilizer rates:

Band	10 + 20 + 10
Seed placement	4 + 8 + 4
Broadcast	0 + 60 + 30

Soil test values:

pH	7.7
P	7 lbs/acre (low)
K	300 lbs/acre (high)

Means under a variety followed by the same letter are not different at 5% level of significance (lsd test).

Table 2. Effect on soybean seed yield when different fertilizer placements were applied to soybeans grown at Lamberton, Minnesota in 1969.

Starter fertilizer	Chippewa 64		Corsoy		Hark	
	No broadcast	Broadcast	No broadcast	Broadcast	No broadcast	Broadcast
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	25.5 a	33.7 bcd	25.8 a	39.8 c	24.5 a	36.1 c
Band (2x2)	33.5 bc	35.8 cd	36.9 b	42.4 de	33.3 b	40.0 d
Seed placement	32.6 b	35.4 cd	34.7 b	40.3 cd	33.0 b	37.3 c
Band & seed placement	34.2 bcd	36.1 d	41.0 cd	43.5 e	36.6 c	38.3 cd

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Fertilizer rates: Band 15 + 20 + 18; Seed placement 5 + 7 + 6; Broadcast 0 + 60 + 30

Soil test values: pH 5.7; P 10 lbs/acre (low); K 290 lbs/acre (high)

Means under a variety followed by the same letter are not different at 5% level of significance (lsd test).

Table 3. Effect on soybean seed yield when different fertilizer placements were applied to soybeans grown at Waseca, Minnesota in 1969.

Starter fertilizer	Chippewa 64		Corsoy		Hark	
	No broadcast	Broadcast	No broadcast	Broadcast	No broadcast	Broadcast
	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre	bu/acre
Check	38.1 bc	37.2 ab	43.9 c	40.2 ab	41.4 a	40.8 a
Band (2x2)	40.5 c	34.6 a	43.6 c	39.1 a	41.3 a	39.7 a
Seed placement	37.2 ab	34.8 a	42.4 bc	41.9 abc	39.2 a	38.6 a
Band & seed placement	37.9 bc	37.0 ab	40.7 abc	41.7 abc	41.6 a	39.7 a

Fertilizer rates:
- Band: 16 + 40 + 53
- Seed placement: 4 + 8 + 12
- Broadcast: 0 +100 +150

Soil test values:
- pH 7.1
- P 71 lbs/acre (very high)
- K 333 lbs/acre (very high)

Means under a variety followed by the same letter are not different at 5% level of significance (lsd test).

Table 4. Effect on soybean seed yield when different fertilizers were applied to Chippewa 64 soybeans grown at Waseca, Minnesota in 1969.

Treatment	Fertilizer Depth	
	6 inches	14 inches
	bu/acre	bu/acre
Check	37.4 a	
Check (plus knife)	38.1 a	38.2 a
500 + 0 + 0	38.5 a	38.3 a
0 + 200 + 300	36.1 a	37.3 a
500 + 200 + 300	38.6 a	37.0 a

Means under a variety followed by the same letter are not different at 5% level of significance (lsd test).

EFFECT OF MICRONUTRIENTS ON SOYBEAN SEED YIELDS

G. E. Ham and R. D. Frazier

Micronutrients were applied to soybeans grown at Waseca and Clear Lake. At Waseca, the soil treatments consisted of 10 pounds per acre sulfate source (elemental basis) and 3 pounds per acre chelate and silviplex sources (elemental basis). Foliar treatments were 3.0 pounds per acre sulfate source and 0.6 pounds per acre chelate and silviplex sources. At Clear Lake all treatments were foliar. Sulfate sources were applied at the rate of 3.0 and 6.0 pounds per acre (elemental basis) as low and high treatments in Table 1. Silviplex and chelate sources were applied at the rates of 0.6 and 1.2 pounds per acre. No significant yield increases were obtained from the treatments at either location. The coefficient of variation was 18.6% and 7.6% at Clear Lake and Waseca, respectively. The large variation at Clear Lake was due to lack of water during one day spell irregular irrigation patterns. Foliar analyses are being conducted to determine if the nutrients were taken up by the plants and to compare uptake from the various sources of micronutrients.

Table 1. Effect on soybean seed yield when different micronutrients were applied as foliar treatments to soybeans grown at Clear Lake, Minnesota in 1969.

Treatment	Soybean Variety			
	Chippewa 64		Merit	
	Low[a]	High[a]	Low[a]	High[a]
	bu/acre	bu/acre	bu/acre	bu/acre
Check	27.8		19.3	
Fe-chelate	28.4	28.4	23.7	-
Fe-silviplex	28.3	23.8	-	-
Fe-sulfate	29.6	23.6	20.2	17.8
Mn-chelate	30.7	25.6	23.8	-
Mn-silviplex	27.6	22.0	-	-
Mn-sulfate	25.9	20.0	21.0	21.9
Cu-chelate	27.8	27.3	23.2	-
Cu-silviplex	30.3	25.7	-	-
Cu-sulfate	29.4	24.4	20.0	20.6
Zn-chelate	29.2	24.7	25.3	-
Zn-silviplex	24.8	25.1	-	-
Zn-sulfate	26.3	24.9	24.4	18.6
Multiplex	28.4	28.1	24.9	27.1

Table 2. Effect on soybean seed yield when different micronutrients were applied to Chippewa 64 soybeans grown at Waseca, Minnesota in 1969.

Treatment	Foliar bu/acre	Soil bu/acre
Check	39.4	-
Fe-chelate	38.4	40.0
Fe-silviplex	37.9	-
Fe-sulfate	38.0	39.0
Mn-chelate	39.7	40.4
Mn-silviplex	39.1	-
Mn-sulfate	35.9	39.2
Cu-chelate	40.8	40.0
Cu-silviplex	38.8	-
Cu-sulfate	38.4	40.0
Zn-chelate	37.8	38.9
Zn-silviplex	39.7	-
Zn-sulfate	38.4	38.5

FOUR YEARS (1966-69) OF EXPERIMENTS WITH DIFFERENT ZINC FERTILIZER SOURCES AND PHOSPHATE FOR CONTINUOUS CORN ON A ZINC DEFICIENT HAMERLY LOAM NEAR BENSON, MINNESOTA IN SWIFT COUNTY

O.M. Gunderson, J.M. MacGregor, S.D. Evans and R.G. Munter

An investigation of commercial sources of zinc and the effect of heavy phosphate fertilization was commenced with field corn in the spring of 1966 with two main objectives:

(1) To determine the relative effectiveness of several commercially available zinc compounds on corn growth, yield and composition.

(2) The comparative effect of heavy phosphate fertilization on zinc availability to growing field corn and yield.

A zinc deficient calcareous loam had been previously observed on the Richard Mikkelson farm at the junction of Highways 22 and 29 and 5 year lease arrangements were completed with the owner on a 7 acre tract. Two randomized block experiments were established about the middle of May, 1966, each consisting of 7 treatments in quadruplicate. Three rates of granular zinc sulfate to supply 10, 20, and 40 pounds of zinc per acre, ZnMNS to supply 10 pounds of zinc per acre, and the solid granular chelated zinc (Zn 45) to supply 2.5 lbs of zinc per acre were broadcast and plowed down both in 1966 and in 1967. The seventh treatment consisted of 0.5 lbs of chelated zinc per acre as Zn 45 applied in the granular form along the corn row in each of the first 3 years, and as a liquid row application in 1969.

The phosphate interaction experiment was located a few hundred feet distant, being of the same size and design with annual phosphate treatments being plowed down and zinc as the sulfate applied during the first 2 years. The farm operator also applied a total of 100+40+40 per acre in 1966 over the entire area.

Zinc deficient soils are usually low lying calcareous areas subject to poor drainage and excessive moisture in the spring. Late corn planting generally is the rule. These low-lying areas are also subject to relatively poor air drainage, and are generally subject to early fall frost which necessitates the planting of early maturing corn (and even this often fails to mature). The extreme variability in zinc supplying power of such soils, even in limited areas, is well known, making adequate treatment replication extremely difficult and often unsatisfactory.

The soil of each plot was sampled in 1968 and analyzed for available zinc as reported on page 123, Soil Series 84. Severity of visual zinc deficiencies of the growing plants, zinc and phosphorus analyses of the sixth corn leaf determined, and ear corn yield have been obtained in each of the four years. These are reported in the following three tables.

Table 1 shows a direct relationship between zinc deficiency symptoms and the ear corn yields obtained. Zinc treatments which resulted in more normal plant growth produced significantly higher yields. The 40 pound per acre rate of zinc as the sulfate (a total of 80 pounds Zn/A) resulted in essentially normal plant growth, but application rates of half or even a quarter of this resulted in equivalent increases in corn yields. The ZnMNS treatment was only slightly less effective with the chelated form of zinc being ineffective on both visual deficiency symptom removal and on corn yield.

The effect of heavy annual phosphate applications at rates of 320 or 640 pounds of P_2O_5 per acre resulted in severe Zn deficiency symptoms and decreases in ear corn yield. Granular zinc sulfate plowed down in both 1966 and 1967 (supplying a total of 20 pounds of zinc per acre) resulted in normal plant growth and grain yield.

Table 1. Visual Zinc Deficiency Symptoms of Plants and Ear Corn Yields With Zinc Fertilization of a Zinc Deficient Loam Near Benson (Swift County) - 1966-69.

(Ear corn at 15.5% moisture)

1966 & 1967 Zinc treatments (lbs/A)	1966		1967		1968		1969		4 year average	
	Visual (a) rating	Bu/A	Visual (a) rating	Bu/A	Visual(a) rating	Bu/A	Visual(a) rating	Bu/A	Visual (a) rating	Bu/A
No Zinc	5.1	92.0 bc	3.2	56.1 a	3.0	71.3 a	6.8	90.8 NS	4.5	77.5 a
10 as $ZnSO_4$ (P.D.)	7.9	115.4 a	7.1	77.5 a	6.5	92.4 a	8.2	96.1 NS	7.4	95.4 c
20 " " "	8.1	111.8 a	8.6	75.6 a	8.7	94.8 a	9.2	97.3 NS	8.7	94.3 c
40 " " "	9.0	109.3 a	8.5	81.7 a	9.0	88.8 a	10.0	90.1 NS	9.1	92.5 c
10 as ZnMNS (PD)	8.7	103.8 ab	8.0	79.2 a	7.5	86.9 a	8.5	94.7 NS	8.2	91.2 bc
0.5 Zn as Zn 45 (annually row)	2.6	85.5 c	6.4	69.7 a	6.0	93.4 a	8.0	83.3 NS	5.8	83.0 ab
2.5 Zn as Zn 45 (bdct. & P.D. in '66 & '67)	6.0	93.3 bc	3.9	58.4 a	3.0	79.0 a	4.5	81.0 NS	4.4	77.9 a
Phosphate-Zinc Interaction Experiment										
40 P_2O_5-annual PD	7.0	98.4 ab	7.5	68.5 a	7.0	86.9 abc	6.8	96.8 abc	7.1	87.7 c
80 " " "	7.0	96.9 ab	7.0	65.8 a	5.7	94.5 bc	7.3	104.2 abc	6.8	90.4 cd
160 " " "	5.7	96.3 ab	8.0	60.8 a	6.2	100.0 c	6.8	94.4 ab	6.7	87.9 c
320 " " "	3.9	96.8 ab	5.0	50.2 a	3.2	81.4 ab	4.8	89.7 ab	4.2	79.5 b
640 " " "	2.7	83.4 b	3.5	34.3 a	2.5	72.0 a	2.5	82.2 a	2.8	68.0 a
320 " " " + 10 Zn as $ZnSO_4$ ('66 & '67)	8.5	113.6 a	8.4	74.8 a	8.7	92.6 bc	9.8	110.6 bc	8.9	97.9 de
640 P_2O_5 annual PD + 10 Zn as $ZnSO_4$ in '66 & '67)	7.9	107.6 a	8.5	74.7 a	8.2	100.6 c	8.3	117.2 c	8.2	100.0 e

(a) ranged from 0 representing severe zinc deficiency symptoms to 10 representing apparently normal plant growth.
Zn 45 applied as granules in 1966, 1967, 1968 and as a liquid in 1969.

Table 2 illustrates the zinc-phosphorus relationship occurring in the sixth corn leaf during the four years of the study. It is evident that the $ZnSO_4$ treatments increased leaf zinc concentrations, whereas the ZnMNS and the two Zn 45 treatments failed to supply available Zn. Increasing Zn concentrations in the corn leaves resulted in lower P content.

Heavy P fertilization with no zinc treatments increased P leaf content and this was materially lowered by the addition of the two 10 lb Zn/A treatments applied in 1966 and in 1967.

Table 3 shows the four year average relationship between the P:Zn concentrations in the sixth corn leaf and the yields of ear corn. Corn yields were apparently depressed where the P:Zn ratio exceeded 400, with the maximum yields occurring when the ratio was about half of that value.

Table 2. Zinc and Phosphorus Concentrations and P:Zn Ratios in Sixth Corn Leaves Grown After Zinc or Phosphate Fertilization on a Zinc Deficient Calcareous Loam Near Benson. (1966-69)

1966 & 1967 zinc treatments (lbs/A)	1966			1967			1968			1969		
	ppm Zn	%P	P/Zn	ppm Zn	%P	P/Zn	ppm Zn	%P	P/Zn	ppm Zn	%P	P/Zn
No Zinc	7.2 c	0.400 a	556	9.2 d	0.367 a	399	14.8 a	0.410 cd	277	13.8 a	0.339 NS	246
10 as $ZnSO_4$ (PD)	11.7 bc	0.297 bc	254	13.8 c	0.304 bc	220	16.4 ab	0.338 d	206	17.6 a	0.272 NS	155
20 " " "	14.0 b	0.259 c	185	18.2 b	0.273 c	150	23.4 bc	0.462 bc	197	28.0 b	0.265 NS	95
40 " " "	18.0 a	0.259 c	143	26.5 a	0.281 bc	106	29.4 c	0.511 b	174	42.6 c	0.302 NS	71
10 " ZnMNS (PD)	9.3 bc	0.326 abc	351	12.8 cd	0.285 bc	223	15.3 a	0.630 a	412	18.2 a	0.284 NS	156
0.5 Zn as Zn 45 (annually row)	8.6 c	0.394 a	458	11.8 cd	0.331 ab	281	12.1 a	0.351 d	290	15.6 a	0.382 NS	245
2.5 Zn as Zn 45 (bdct. & PD in '66 & '67)	8.3 c	0.372 ab	448	11.5 cd	0.323 abc	281	12.7 a	0.458 bc	361	14.9 a	0.325 NS	218
Phosphate-Zinc Interaction Experiment												
40 P_2O_5-annual PD	10.0 ab	0.351 bc	351	10.2 abc	0.317 c	311	13.3 a	0.410	308	17.1 a	0.362	212
80 " " "	10.2 ab	0.313 bc	307	12.5 ab	0.312 c	250	16.1 a	0.338	210	18.4 a	0.350	190
160 " " "	8.4 bc	0.359 bc	427	10.5 abc	0.323 c	308	13.1 a	0.462	353	15.1 a	0.385	255
320 " " "	7.5 c	0.400 b	533	9.0 bc	0.436 b	484	12.7 a	0.510	402	14.2 a	0.410	289
640 " " "	7.3 c	0.486 a	666	8.2 c	0.570 a	695	9.3 a	0.630	677	13.4 a	0.600	448
320 " " " + 10 Zn as $ZnSO_4$ ('66 &'67)	12.4 a	0.325 bc	262	13.2 a	0.308 c	233	15.4 a	0.351	228	28.4 b	0.321	113
640 P_2O_5 annual PD + 10 Zn as $ZnSO_4$ in ('66-'67)	11.0 a	0.304 c	276	12.0 ab	0.310 c	258	17.3 a	0.458	265	27.1 b	0.289	107

Table 3. Average Phosphorus:Zinc Ratio of the Sixth Corn Leaf and Average Ear Corn Yield When Grown on a Zinc Deficient Calcareous Loam Over a 4-Year Period (1966-69) Near Benson, Minnesota.

1966 & 1967 Zinc treatments(lbs/A)	Average P/Zn ratio in 6th corn leaf	Average 4 year corn yield(bu/A)
No Zinc	370 c	77.5 a
10 as $ZnSO_4$ (PD)	209 ab	95.4 c
20 " " "	157 a	94.3 c
40 " " "	124 a	92.5 c
10 " ZnMNS "	286 bc	91.2 bc
0.5 Zn as Zn 45 (annually row)	319 c	83.0 ab
2.5 Zn as Zn 45 (bdct. & PD in '66 & '67)	327 c	77.9 a
Phosphate-Zinc Interaction Experiment		
40 P_2O_5 annual PD	296 b	87.7 c
80 " " "	239 a	90.4 cd
160 " " "	336 b	87.9 c
320 " " "	427 c	79.5 b
640 " " "	622 d	68.0 a
320 " " " + 10 Zn as $ZnSO_4$ ('66 & '67)	209 a	97.9 de
640 P_2O_5 annual PD + 10 Zn as $ZnSO_4$ in ('66 & '67)	227 a	100.0 e

SOIL PESTICIDE RESIDUES

Russell S. Adams, Jr.

This was the last year for the herbicide interaction plots. Field data for 1969 and four year averages are given in Tables 1 and 2. In these plots atrazine was incorporated in a split plot design across plots receiving no chemical, linuron (2 1/2 lb/A), CDAA (5 lb/A), amiben (3 lb/A) and trifluralin (1 lb/A). Atrazine was applied at four rates, 0, 1/4, 1/2 and 1 lb/A. All plots were cultivated for weed control.

Results were in great contrast between stations in 1969. At Waseca no significant rain occurred within the first 30 days after planting of the soybeans. As a result atrazine, even a 1 lb/A, had little affect on stands or yields. By contrast, water stood in the plots much of the time the first 30 days after planting of the soybeans at Lamberton. The affect of atrazine was severe. Interaction effects were clearly visible. Linuron treated plots were most affected by atrazine residues. Injury occurred even with 1/4 lb/A of atrazine. The water logged conditions appeared to contribute to pathogenic activity and damping off at Lamberton. Stands in the trifluralin plots were severely reduced. Atrazine residue seemed to counteract this effect. Growth chamber studies had indicated several years earlier that this possibility existed. However, at three locations and over four years of study this particular effect was observed only this one time. As a result it cannot be judged of economic significance and should not be considered in management decisions. Especially since yields were not appreciably affected.

Injury from atrazine to soybeans at Lamberton in 1969 was least in the CDAA treated plots.

Data in Table 1 and Table 2 indicate that at Waseca neither yield nor stand were significantly affected by any interaction between atrazine residue at 1 lb/A and the herbicides in the experiment. This rate of atrazine may not have been high enough to produce the effects observed at the other two stations.

At Lamberton and Morris atrazine injury was significantly greater in the linuron treatments. At Lamberton and Morris CDAA and trifluralin treatments showed the least injury from atrazine residue. When compared to the no atrazine treatments, a "residue" of 1 lb/A of atrazine in the linuron treatments reduced yields by 5 to 7 bushels more than 1 lb/A atrazine in the cultivated checks. Atrazine at 1 lb/A in the CDAA and trifluralin treatments reduced yields to about the same extent as in the cultivated checks.

"Residual" atrazine gave some benefit from weed control. At Lamberton and Morris weeds were a problem. As a result a 5 to 9 bushel loss in yield was experienced in the cultivated control due to weed competition. As a result of weed infestation stand reduction was not well correlated to yield reductions.

Loss in yield of soybeans was well correlated at Lamberton and Morris to soil moisture content and total precipitation occurring between April 1 and June 15. The more moisture available in the soil during this critical period the more likely injury from atrazine residues was to occur.

One must be careful in interpreting the effects of trifluralin. Other research has indicated that trifluralin may prune the roots of soybeans in the zone of application. This might prevent the absorption of atrazine. If the atrazine "residue" had been plowed down, so that the atrazine and trifluralin occurred at different levels in the soil, more injury from the atrazine might have resulted.

Table 1. Yield of Chippewa 64 soybeans as affected by herbicide treatments and residue amounts of atrazine. Four replications.

"Residual" atrazine	Cultivated check		Linuron		CDAA		Amiben		Trifluralin	
	1969	4 year average	1969	4 year average	1969	4 year average	1969	4 year average	1969	4 year average
lb/A					bu/A					
					Lamberton					
0 (weed free check)	31.6	24.5								
0	27.5	19.1	29.7	21.5	32.8	23.1	32.3	22.6	28.8	22.1
1/4	28.3	18.5	18.7	20.0	31.0	22.1	31.2	21.4	26.4	21.0
1/2	18.6	16.4	8.1	15.5	26.0	21.4	29.2	20.0	27.1	21.0
1	5.2	13.0	0.2	11.1	15.0	16.2	7.2	14.5	6.7	16.2
					Morris					
0 (weed free check)	26.7	25.6								
0	22.1	16.6	25.0	23.4	23.4	20.4	23.0	23.3	24.2	23.9
1/4	23.2	19.4	22.7	24.1	23.0	22.3	22.3	23.9	22.6	25.4
1/2	21.9	17.9	23.9	20.5	22.0	19.2	22.8	21.2	21.9	23.4
1	21.4	16.2	22.5	15.9	25.9	19.4	25.1	19.6	25.1	23.0
					Waseca					
0 (weed free check)	32.1	37.1								
0	34.8	34.0	35.9	34.5	33.2	34.6	32.3	34.4	35.0	33.8
1/4	35.2	34.1	37.4	35.6	34.2	34.3	30.5	33.1	34.0	33.4
1/2	30.0	30.6	32.0	31.0	31.9	33.2	32.6	33.0	32.2	32.3
1	31.4	28.2	29.3	28.5	31.6	30.5	32.8	29.8	32.6	30.0

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

"Residual" atrazine	Cultivated check 1969	Cultivated check 4 year average	Linuron 1969	Linuron 4 year average	CDAA 1969	CDAA 4 year average	Amiben 1969	Amiben 4 year average	Trifluralin 1969	Trifluralin 4 year average
					% of control					
					Lamberton					
0	100	100	61	86	101	102	93	96	54	86
1/4	83	85	22	79	102	93	88	96	64	80
1/2	72	84	11	66	78	89	68	81	55	85
1	29	68	0	54	70	79	31	74	31	73
					Morris					
0	100	100	98	99	101	104	97	107	95	110
1/4	96	102	100	107	94	100	97	97	93	115
1/2	93	96	101	89	108	88	102	92	98	108
1	88	88	69	63	80	81	71	75	85	90
					Waseca					
0	100	100	100	102	100	105	104	105	98	99
1/4	100	104	104	107	105	104	100	104	100	98
1/2	100	107	105	98	102	103	100	100	100	102
1	100	89	102	92	95	96	100	94	103	94

NUTRIENT CONCENTRATION OF DRAINAGE TILE WATER IN CENTRAL MINNESOTA

J. E. Ellis, Lowell Hanson, J. M. MacGregor and Robert Munter

During the summer of 1968, plans were made for collection and analysis of tile line drainage water samples from farms in south central Minnesota. J. E. Ellis agreed to take responsibility for selecting and making arrangements with farmer cooperators and collecting the samples. A total of 19 farms were selected in the counties of Kandiyohi, McLeod, Meeker, Renville, Sibley and Wright.

Considerations involved in selection of sample sites included:

1) Tile outlets which drained one specific field under one crop and one rate of fertilization.
2) Tile lines without surface inlets.
3) Tile lines in mineral soils.
4) A range of rates of fertilization from low to high.
5) A cooperator who would be willing to supply field information and rainfall records.

Collection of samples were planned for roughly two week intervals with the understanding that the schedule would have to be somewhat flexible due to weather conditions and other programs of the area soils agent.

The types of data considered important were:

Field data:

Farm location and soil types

Crop record (1967, 68, 69 and current year)

Fertilizer application record (same years)

Soil samples for routine soil test

(Field data - continued)

Estimate of flow rate

Water temperature

Analytical data:

Concentration of NO_3-N

Concentration of NO_2-N

Concentration of PO_4-P

Concentration of K

Electrical conductivity

The initial samples were collected during October of 1968. During the winter of 1969, information developed by Dr. Robert Holt indicated that surface water runoff was an important source of soluble phosphorus. As a result of this, plans were made to also collect open ditch water samples in the immediate vicinity of the tile outlet sample sites wherever feasible during the spring and summer of 1969.

Following are the analytical data for samples collected during 1968 and 1969. Missing data indicate lack of flow or high water conditions preventing sampling. Some of the sampling sites do not have open ditch sites available for sampling.

Table 1. NO_3-N in ppm in water samples. County, Farm and Code Number.

Sampling Period		Kandiyohi: Damhof K-1	Kandiyohi: Johnson K-2	Kandiyohi: Pioneer Seed Corn K-3	McLeod: Huebert Mc-1	McLeod: Katzenmeyer Farms Mc-2	McLeod: Rickert Mc-3
1st round Oct. 1968	Tile	35.4	10.8	20.3	11.7	9.2	19.1
2nd round April-May 1969	Tile	14.5		18.3	17.1	14.9	35.0
	Ditch		9.8				
3rd round April-May-June 1969	Tile	19.5		27.4		13.2	41.0
	Ditch	9.5		8.8	10.5		
4th round April-May-June 1969	Tile	17.6	11.5	29.1	31.0	13.7	38.0
	Ditch	16.4	4.1	3.5	13.8		10.7
5th round April-May-June 1969	Tile	16.9		34.4		22.5	42.5
	Ditch	0.6		5.0			
6th round April-May-June 1969	Tile	[1]46.4		38.3		22.9	
	Ditch	0.4		7.0			
7th round April-May-June-July 1969	Tile	43.0		36.0		22.3	
	Ditch	0.7		6.1			
Crop&Fertilizer History	1967	Corn 120+60+30	Corn 75+54+54	Corn 200+100+100	Corn 115+60+60	Corn 110+90+110	Corn 125+54+54
	1968	Corn 185+80+90	Idle None	Corn 200+100+150	Corn 115+60+60	Corn 110+90+110	Corn 125+54+54
	1969	Corn 130+40+40	Idle & Alf None	Corn 215+100+100	Soybeans 9+21+63	Corn 110+90+110	Oats-Alf. 80+54+54

[1]The sixth and seventh round represent a different tile than the previous samples. This line has a surface inlet and a manure pile may have affected the drainage water.

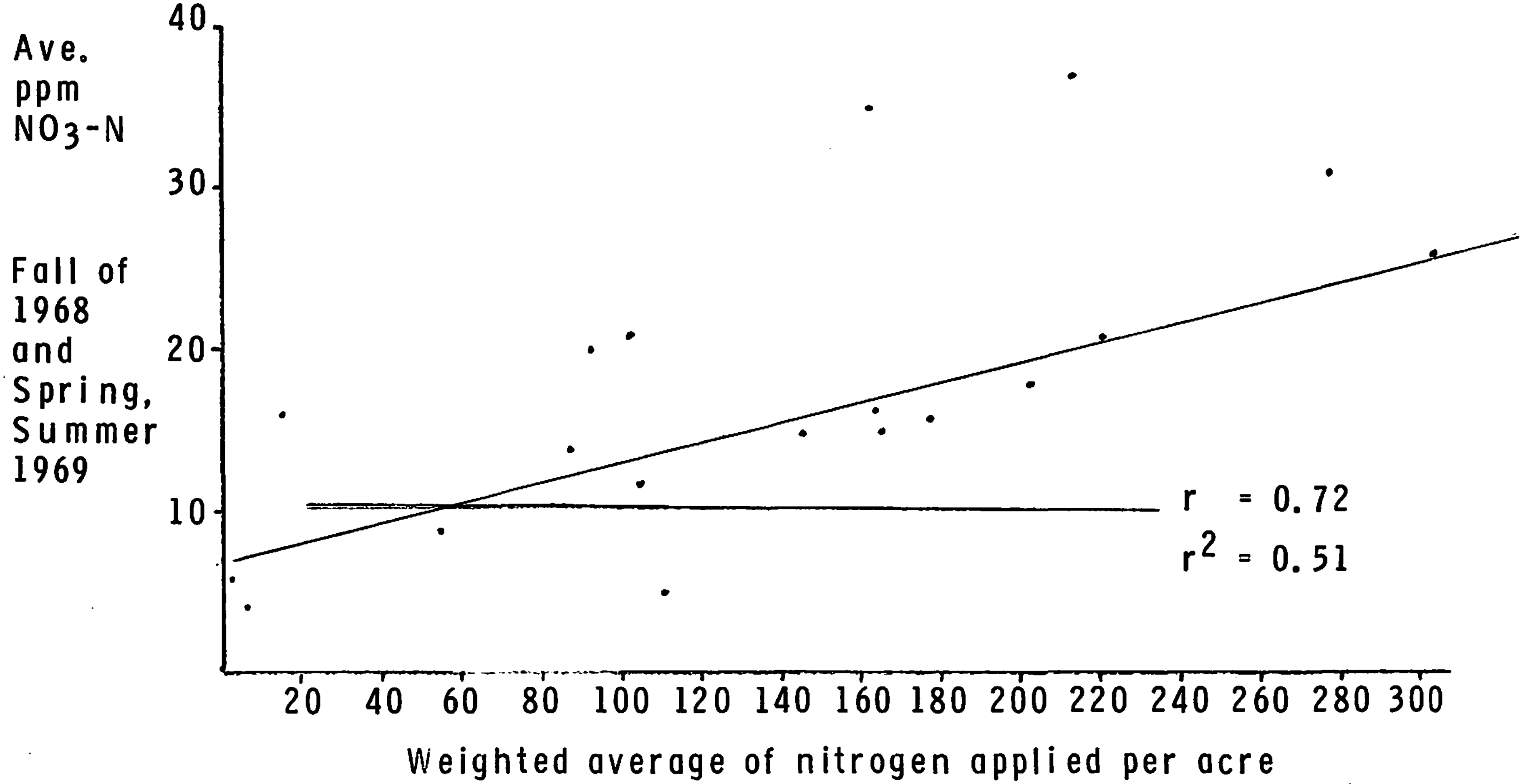
(Table 1. continued)

Sampling Period		Sample Site					
		Meeker			Renville		
		Burgstahler M-1	Peterson M-2	Pravecher M-3	Muetzel R-1	Scheibel R-2	Wertish R-3
1st round Oct. 1968	Tile	36.8	22.3	16.4	13.1	25.2	10.7
2nd round April-May 1969	Tile	18.0	13.9	21.4	12.9	23.8	11.0
	Ditch	12.8	1.5				6.1
3rd round April-May-June 1969	Tile	17.5	14.0	19.4	14.1	37.2	13.6
	Ditch	11.1	1.3			16.5	5.0
4th round April-May-June 1969	Tile	12.1	14.8		22.6	27.0	11.7
	Ditch	6.2	1.6			13.8	1.5
5th round April-May-June 1969	Tile	19.9	18.2	14.9		45.2	22.5
	Ditch	3.1	4.9			15.4	0.5
6th round April-May-June 1969	Tile	10.0	23.5	30.0			
	Ditch	12.8	4.4				
7th round April-May-June-July 1969	Tile						
	Ditch						
Crop&Fertilizer History	1967	Soybeans None	Corn	Corn 100+100+100	Soybeans None	Corn 150+100+100	Idle & Oats None
	1968	Corn 130+90+90	Corn 147+25+25	Corn 215+84+108	Corn 115+108+54	Corn 180+100+100	Oats None
	1969	Corn 140+68+68	Corn 147+25+25	Corn 90+100+100	Corn 140+102+98	Corn 200+75+75	Corn 115+50+50

(Table 1. continued)

Sampling Period		Sibley: Forsberg S-1	Sibley: Kuhlman S-2	Sibley: Lagerstedt S-3	Sibley: Lundgren S-4	Wright: Booth W-1B	Wright: Streich W-2D	Wright: Varner W-3G
1st round Oct. 1968	Tile	10.8	3.0	3.2		11.0	24.5	8.3
2nd round April-May 1969	Tile	15.4	6.4	6.6		10.0	27.8	15.0
	Ditch	14.7	6.1	8.7	0.08			11.7
3rd round April-May-June 1969	Tile	14.8	5.2	5.2	2.1	5.5	28.8	17.4
	Ditch	8.7	6.7	8.8	10.8			8.4
4th round April-May-June 1969	Tile	15.1	3.7	4.3	7.1	6.6	35.6	16.1
	Ditch	6.6	4.8	16.4	22.8			
5th round April-May-June 1969	Tile	16.9	2.2	8.9	10.0		53.5	12.4
	Ditch	9.6	5.1	9.0	20.9			
6th round April-May-June 1969	Tile	20.0	6.9	7.0	11.2			
	Ditch	13.6	7.9	12.0	17.1			
7th round April-May-June-July 1969	Tile	19.2						
	Ditch	7.4						
Crop&Fertilizer History	1967	SwCorn & Corn 100+36+36	Soybeans 6+24+24	Soy & Corn None	Alfalfa	None	Corn 14+37+48	Corn 120+85+85
	1968	Corn 137+124+142	Oats None	Soybeans 6+24+24	Sugarbeets 100+85+250	Plowed Fall None	Corn 165+37+48	Corn 120+85+85
	1969	Corn 194+90+97	Soybeans 12+48+48	Soybeans None	Corn & Oats 75+60+30	Fallow None	Corn 165+37+48	Oats & Alf. 15+60+60

Relationship of Average NO_3-N Concentrations in Tile Line Drainage Water to a Weighted Average of Applied Nitrogen Webster and Glencoe Soils, South Central Minnesota



Factors used 1967 0.25 x total N
68 0.50 x " "
69 0.75 x " "

Equation for line:
$y = 6.6 + 0.08x$

Table 2. NO_2-N in ppm in water samples. County, Farm and Code Number.

Sampling Period		Kandiyohi: Damhof K-1	Kandiyohi: Johnson K-2	Kandiyohi: Pioneer Seed Corn K-3	McLeod: Huebert Mc-1	McLeod: Katzenmeyer Farms Mc-2	McLeod: Rickert Mc-3
1st round Oct. 1968	Tile						
2nd round April-May 1969	Tile				0.01	0.1	0.1
	Ditch		0.01		0.5-1.0		
3rd round April-May-June 1969	Tile	0.5		0.1		0.1	.1
	Ditch	0.1	0.1	0.1	0.1		
4th round April-May-June 1969	Tile	0.3	0.1	0.1	0.1	0.1	0.1
	Ditch	0.2	0.8	0.3	0.2		0.2
5th round April-May-June 1969	Tile	0.3		0.1		0.1	0.1
	Ditch	0.1	0.4				
6th round April-May-June 1969	Tile 1)	0.2		0.2		0.1	
	Ditch	0.2		0.5			
7th round April-May-June-July 1969	Tile	0.1		0.1		0.1	
	Ditch	0.1		1.0			
Crop&Fertilizer History	1967	Corn 120+60+30	Corn 75+54+54	Corn 200+100+100	Corn 115+60+60	Corn 110+90+110	Corn 125+54+54
	1968	Corn 185+80+90	Idle None	Corn 200+100+150	Corn 115+60+60	Corn 110+90+110	Corn 125+54+54
	1969	Corn 130+40+40	Idle & Alf None	Corn 215+100+100	Soybeans 9+21+63	Corn 110+90+110	Oats-Alf 80+54+54

[1] The sixth and seventh round represent a different tile than the previous samples. This line has a surface inlet and a manure pile may have affected the drainage water.

(Table 2. continued)

		Sample Site					
		Meeker			Renville		
Sampling Period		Burgstahler M-1	Peterson M-2	Pravecher M-3	Muetzel R-1	Scheibel R-2	Wertish R-3
1st round Oct. 1968	Tile						
2nd round April-May 1969	Tile	0.1	0.1	0.1	0.1		
	Ditch	0.1	0.1				
3rd round April-May-June 1969	Tile	0.1	0.1	0.1	0.1	0.1	0.1
	Ditch	0.1	0.1			0.1	0.1
4th round April-May-June 1969	Tile	0.1	0.1		.1	0.1	0.1
	Ditch	1.0	0.1			1.0	0.3
5th round April-May-June 1969	Tile	.1	.1	.1		.1	.1
	Ditch	.2	.2			.5	.1
6th round April-May-June 1969	Tile	0.1	0.2	0.2			
	Ditch	0.1	0.2				
7th round April-May-June-July 1969	Tile						
	Ditch						
	1967	Soybeans None	Corn	Corn 100+100+100	Soybeans None	Corn 150+100+100	Idle & Oats None
Crop&Fertilizer History	1968	Corn 130+90+90	Corn 147+25+25	Corn 215+84+108	Corn 115+108+54	Corn 180+100+100	Oats None
	1969	Corn 140+68+68	Corn 147+25+25	Corn 90+100+100	Corn 140+102+98	Corn 200+75+75	Corn 115+50+50

(Table 2. continued)

Sampling Period		Sibley: Forsberg S-1	Sibley: Kuhlman S-2	Sibley: Lagerstedt S-3	Sibley: Lundgren S-4	Wright: Booth W-1B	Wright: Streich W-2	Wright: Varner W-3
1st round Oct. 1968	Tile					0.1	2.0	
2nd round April-May 1969	Tile	0.1	0.1	0.1	0.1	0.1	2.0	0.1
	Ditch	0.1	0.1	0.1	1.0			0.1
3rd round April-May-June 1969	Tile	0.1	0.1		0.1	0.1	0.3	0.1
	Ditch	0.1	0.1	0.1	0.3			0.1
4th round April-May-June 1969	Tile	0.1	0.1	0.1	.1	0.1	0.3	0.1
	Ditch	0.5	1.0	0.2	.2			
5th round April-May-June 1969	Tile	.1	.1	.1	0.1		0.8	0.1
	Ditch	.5	.2	.2	1.0			
6th round April-May-June 1969	Tile	0.1	0.1	0.1	0.1			
	Ditch	0.3	0.1	0.2	0.9			
7th round April-May-June-July 1969	Tile	0.1						
	Ditch	0.5						
Crop&Fertilizer History	1967	SwCorn & Corn 100+36+36	Soybeans 6+24+24	Soy & Corn None	Alfalfa	None	Corn 14+37+48	Corn 120+85+85
	1968	Corn 137+124+142	Oats None	Soybeans 6+24+24	Sugarbeets 100+85+250	Plowed Fall None	Corn 165+37+48	Corn 120+85+85
	1969	Corn 194+90+97	Soybeans 12+48+48	Soybeans None	Corn & Oats 75+60+30	Fallow None	Corn 165+37+48	Oats & Alf. 15+60+60

Table 3. PO_4-P in ppm in water samples. County, Farm and Code Number.

Sampling Period		Sample Site					
		Kandiyohi			McLeod		
		Damhof K-1	Johnson K-2	Pioneer Seed Corn K-3	Huebert Mc-1	Katzenmeyer Farms Mc-2	Rickert Mc-3
1st round Oct. 1968	Tile	0.019	0.730	0.012	0.014	0.005	0.092
2nd round	Tile	0.073		0.06	0.08	0.08	0.01
April-May 1969	Ditch		0.06		0.14		
3rd round April-May-June	Tile	0.34		0.01		0.02	0.04
1969	Ditch	0.13	0.12		0.25		
4th round April-May-June	Tile	0.15	0.01	0.02	0.01	0.02	0.03
1969	Ditch	0.02	0.02	0.02	0.03		0.05
5th round April-May-June	Tile	0.18		0.12		0.01	0.04
1969	Ditch	0.02	0.04				
6th round April-May-June	Tile	1) 0.05		0.01	0.01	0.04	
1969	Ditch	0.03		0.01	0.01		
7th round April-May-June-	Tile	1) 0.02		0.01		0.01	
July 1969	Ditch	0.18		0.05			
	1967	Corn 120+60+30	Corn 75+54+54	Corn 200+100+100	Corn 115+60+60	Corn 110+90+110	Corn 125+54+54
Crop&Fertilizer History	1968	Corn 185+80+90	Idle None	Corn 200+100+150	Corn 115+60+60	Corn 110+90+110	Corn 125+54+54
	1969	Corn 130+40+40	Idle & Alf None	Corn 215+100+100	Soybeans 9+21+63	Corn 110+90+110	Oats-Alf 80+54+54

1) The sixth and seventh round represent a different tile than the previous samples. This line has a surface inlet and a manure pile may have affected the drainage water.

(Table 3. continued)

Sampling Period		Sample Site: Meeker			Renville		
		Burgstahler M-1	Peterson M-2	Pravecher M-3	Muetzel R-1	Scheibel R-2	Wertish R-3
1st round Oct. 1968	Tile	0.021	0.016	0.013	0.008	0.006	0.058
2nd round April-May 1969	Tile	0.01	0.01	0.03	0.03	0.06	0.05
	Ditch	0.01	0.15				0.15
3rd round April-May-June 1969	Tile	0.04	0.01	0.02	0.03	0.07	0.01
	Ditch	0.01	0.24			0.02	0.01
4th round April-May-June 1969	Tile	0.02	0.04		0.01	0.02	0.01
	Ditch	0.01	0.47			0.01	0.01
5th round April-May-June 1969	Tile	0.01	0.01	0.01		0.02	0.02
	Ditch	0.03	0.61			0.01	0.01
6th round April-May-June 1969	Tile		0.02	0.01			
	Ditch		0.40				
7th round April-May-June-July 1969	Tile						
	Ditch						
	1967	Soybeans None	Corn	Corn 100+100+100	Soybeans None	Corn 150+100+100	Idle & Oats None
Crop&Fertilizer History	1968	Corn 130+90+90	Corn 147+25+25	Corn 215+84+108	Corn 115+108+54	Corn 180+100+100	Oats None
	1969	Corn 140+68+68	Corn 147+25+25	Corn 90+100+100	Corn 140+102+98	Corn 200+75+75	Corn 115+50+50

(Table 3. continued)

Sampling Period		Sibley: Forsberg S-1	Sibley: Kuhlman S-2	Sibley: Lagerstedt S-3	Sibley: Lundgren S-4	Wright: Booth W-1B	Wright: Streich W-2	Wright: Varner W-3
1st round Oct. 1968	Tile	0.005	0.030	0.007		0.01	0.01	0.032
2nd round April-May 1969	Tile	0.02	0.04	0		0.01	0.05	0.03
	Ditch	0.14	0.21	0.18	0.04			0.17
3rd round April-May-June 1969	Tile	0.02	0.01		0.04	0.01	0.04	0.09
	Ditch	0.01	0.04	0.07	0.01			0.16
4th round April-May-June 1969	Tile	0.01	0.01	0.01	0.01	0.02	0.08	0.03
	Ditch	0.01	0.01	0.04	0.01			
5th round April-May-June 1969	Tile	0.01	0.02	0.01	0.04		0.04	0.03
	Ditch	0.01	0.01	0.78	0.03			
6th round April-May-June 1969	Tile	0.01	0.01	0.01	0.01			
	Ditch	0.03	0.01	0.05	0.04			
7th round April-May-June-July 1969	Tile	0.04						
	Ditch	0.03						
Crop&Fertilizer History	1967	SwCorn & Corn 100+36+36	Soybeans 6+24+24	Soy & Corn None	Alfalfa	None	Corn 14+37+48	Corn 120+85+85
	1968	Corn 137+124+142	Oats None	Soybeans 6+24+24	Sugarbeets 100+85+250	Plowed Fall None	Corn 165+37+48	Corn 120+85+85
	1969	Corn 194+90+97	Soybeans 12+48+48	Soybeans None	Corn & Oats 75+60+30	Fallow None	Corn 165+37+48	Oats & Alf 15+60+60

Table 4. Potassium concentration and conductivity of selected samples.

County	Farm	Code #	Sample Round	Site	[K] ppm	Conductivity mmhos/cm
Kandiyohi	Damhof	K-1-3	3	Tile	3.8	1.1
	"	K-1-3	3	Ditch	8.5	1.0
	"	K-1-4	4	Tile	3.0	0.7
	"	K-1-4	4	Ditch	2.2	0.7
	"	K-1-5	5	Tile	2.2	0.7
	"	K-1-5	5	Ditch	0.6	1.1
	Johnson	K-2-2	2	Ditch	5.6	1.1
	"	K-2-4	4	Tile	28.4	1.4
	"	K-2-4	4	Ditch	6.7	1.0
	Pioneer Seed Corn	K-3-3	3	Tile	0.8	1.0
	"	K-3-3	3	Ditch	7.1	1.0
	"	K-3-4	4	Tile	1.0	0.8
	"	K-3-4	4	Ditch	3.0	0.7
	"	K-3-5	5	Tile	0.8	0.8
	"	K-3-5	5	Ditch	3.1	0.8
McLeod	Huebert	Mc-1-3	3	Ditch	5.9	1.3
	Katzenmeyer Farms	Mc-2-3	3	Tile	0.6	0.6
	"	Mc-2-4	4	Tile	0.4	0.6
	Rickert	Mc-3-2	2	Tile	0.4	0.4
Meeker	Burgstahler	M-1-2	2	Tile	2.1	1.2
	"	M-1-2	2	Ditch	3.0	0.9
	"	M-1-3	3	Tile	1.4	0.9
	"	M-1-3	3	Ditch	3.6	1.0
	"	M-1-4	4	Tile	0.9	0.8
	"	M-1-4	4	Ditch	3.9	1.0
	Peterson	M-2-2	2	Tile	1.2	0.6
	"	M-2-2	2	Ditch	4.6	0.3
	"	M-2-3	3	Tile	1.0	0.5
	"	M-2-3	3	Ditch	6.9	0.3
	"	M-2-4	4	Tile	1.4	0.7
	"	M-2-4	4	Ditch	10.6	0.5
	Pravecher	M-3-2	2	Tile	0.7	0.7
	"	M-3-3	3	Tile	0.7	0.7

(Table 4. continued)

County	Farm	Code #	Sample Round	Site	[K] ppm	Conductivity mmhos/cm
Renville	Muetzel	R-1-2	2	Tile	1.5	0.9
	"	R-1-3	3	Tile	1.8	0.9
	Scheibel	R-2-3	3	Tile	1.6	0.7
	"	R-2-3	3	Ditch	1.6	0.7
	"	R-2-4	4	Tile	0.9	0.6
	"	R-2-4	4	Ditch	2.6	0.6
	Wertish	R-3-3	3	Tile	2.0	1.4
	"	R-3-3	3	Ditch	5.8	0.9
	"	R-3-4	4	Tile	3.0	1.5
	"	R-3-4	4	Ditch	4.4	1.0
Sibley	Forsberg	S-1-3	3	Tile	1.1	0.6
	"	S-1-3	3	Ditch	2.6	0.7
	"	S-1-4	4	Ditch	2.0	0.5
	"	S-1-4	4	Tile	0.8	0.3
	Kuhlman	S-2-3	3	Tile	2.0	0.6
	"	S-2-3	3	Ditch	2.9	0.7
	"	S-2-4	4	Tile	1.9	0.4
	"	S-2-4	4	Ditch	2.3	0.5
	Lagerstedt	S-3-3	3	Tile	0.7	0.8
	"	S-3-3	3	Ditch	5.4	0.8
	"	S-3-4	4	Tile	0.4	0.4
	"	S-3-4	4	Ditch	2.5	0.5
	Lundgren	S-4-2	2	Tile	0.9	0.6
	"	S-4-2	2	Ditch	2.3	0.7
	"	S-4-3	3	Tile	0.6	0.5
Wright	Booth	W-1A-1	1	Tile	0.4	0.4
	"	W-1A-2	2	Tile	0.8	0.7
	"	W-1B-1	1	Tile	0.3	0.5
	"	W-1B-2	2	Tile	0.4	0.7
	"	W-1B-3	3	Tile	0.1	0.4
	"	W-1B-4	4	Tile	0.4	0.5
	Streich	W-2-1	1	Tile	1.0	0.7
	"	W-2-2	2	Tile	1.0	0.8
	"	W-2-3	3	Tile	0.5	0.5
	"	W-2-4	4	Tile	0.7	0.7
	Varner	W-3-2	2	Creek	4.3	0.6
	"	W-3-2	2	Tile	0.8	0.5
	"	W-3-3	3	Creek	3.3	0.6
	"	W-3-3	3	Tile	1.3	0.6
	"	W-3-4	4	Tile	1.0	0.4

Table 5. Crop and fertilizer history of sample fields

County & Farm	Code #	Crop & Fertilizer (lbs. per acre)			
		1966	1967	1968	1969
Kandiyohi					
Damhof	K-1		Corn 120+60+30	Corn 185+80+90	Corn 130+40+40
Johnson	K-2		Corn 75+54+54	Idle None	Idle & Alf None
Pioneer Seed Corn	K-3		Corn 200+100+100	Corn 200+100+150	Corn 215+100+100
McLeod					
Huebert	Mc-1		Corn 115+60+60	Corn 115+60+60	Soybeans 9+21+63
Katzenmeyer Farms	Mc-2		Corn 110+90+110	Corn 110+90+110	Corn 110+90+110
Rickert	Mc-3	Corn 125+54+54	Corn 125+54+54	Corn 125+54+54	Oats & Alf 80+54+54
Meeker					
Burgstahler	M-1		Soybeans None	Corn 130+90+90	Corn 140+68+68
	M-1B	No Fertilizer Ever Applied			
Peterson	M-2		Corn	Corn 147+25+25 Heavy Manure	Corn 147+25+25 Heavy Manure
Pravecher	M-3	Corn	Corn 110+100+100	Corn 215+84+108	Corn 90+100+100

(Table 5. continued)

County & Farm	Code #	Crop & Fertilizer (lbs. per acre) 1966	1967	1968	1969
Renville					
Muetzel	R-1		Soybeans None	Corn 115+108+54	Corn 140+102+98
Scheibel	R-2	Corn 130+100+80	Corn 150+100+100	Corn 180+100+100	Corn 200+75+75
Wertish	R-3	Corn	Idle & Oats None	Oats None	Corn 115+50+50
Sibley					
Forsberg	S-1		SwCorn & Corn 100+36+36	Corn 137+124+142	Corn 194+90+97
Kuhlman	S-2	Soybeans 6+24+24	Soybeans 6+24+24	Oats None	Soybeans 12+48+48
Lagerstedt	S-3	Soybeans	Soybeans & Corn None	Soybeans 6+24+24	Soybeans None
Lundgren	S-4		Alfalfa	Sugarbeets 100+85+250	Corn & Oats 75+60+30
Wright					
Booth	W-1A	Alfalfa None	Wheat None	Corn 110+40+40	Diverted None
Booth	W-1B	Alfalfa None	None	Plowed Fall None	Fallow None
Streich	W-2	Alfalfa	Corn 14+37+48	Corn 165+37+48	Corn 165+37+48
Varner	W-3	Corn 120+85+85	Corn 120+85+85	Corn 120+85+85 Heavy Manure	Oats & Alf 15+60+60 Heavy Manure

SOIL TESTING

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes more than twenty three thousand samples annually. The following data show the number of various types of samples analyzed in 1969.

Regular farm, garden and lawn samples		17,955
Florist (Greenhouse) samples		1,647
Specials:	Sulfur	1,267
	Zinc	834
	Soluble Salts	265
	pH	424
Limestone		44
Departmental research samples		1,101
	Total	23,537

The monthly distribution of regular soil samples received by the laboratory is shown in Table 1.

Table 1. Monthly distribution of soil samples received by the University of Minnesota Soil Testing Laboratory during 1969.

Month	Number of Samples
January	610
February	687
March	987
April	3,310
May	1,334
June	559
July	842
August	1,388
September	2,882
October	2,704
November	1,585
December	1,067

SUBJECT INDEX