A Report on Field Reserach in Soils

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

Department of Soil Science

University of Minnesota

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Some of the results herein reported are from experiments carried on during 1965 only, and should not be regarded as the results obtained over a number of years. The investigations are those of a more practical nature, and do not include some of the more theoretical problems presently under study in greenhouse and in the laboratory. Because these are largely one year results they should not be considered as conclusive and the results are not for publication.

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Summary of the Fall, 1965, Soil Moisture Survey and 1958-1965 Soil Moisture Results

Donald G. Baker
Department of Soil Science
University of Minnesota
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A summary of the fall, 1965, soil moisture survey is shown in table 1. At almost every site the reserves are higher than they were a year ago. The above normal September rains certainly brought the reserves up, although they alone were not responsible. This was because precipitation for the season as a whole over most of the state was also above normal (see table 2).

In spite of the generally above normal character of the precipitation the soil moisture reserves are not higher than previously recorded as shown in table 3. Exceptions, however, are to be found in the east central and southeast (see Mille Lacs, Ramsey and Wabasha counties) and in the northwest (Polk county) where the soil moisture reserves are at a maximum during the period of record.

Based upon the soil moisture data, tables 1 and 3, and the precipitation data, table 2, it can be stated that soil moistures reserves in Minnesota are: average in the extreme northeast and extreme southwest; probably excessive in the east-central section; and somewhat above average elsewhere. Thus the soil moisture status for the coming season is almost everywhere in a condition to absorb a mild drought next season. Above normal precipitation would create no immediate problems next spring except perhaps in the east-central and in the extreme southeast parts of the state.

The total water consumed by a crop is shown in the last column of table 1. The totals vary around an overall average of about 20 inches. It is apparent from table 1 that the kind of crop has little influence upon the amount of water consumed. This is true as long as equal periods are considered and soil moisture is plentiful. Both of these conditions were fulfilled.

It is to be noted that the water use data in table 1 are approximate because neither downward drainage out of the 5 foot column of soil sampled nor surface runoff was measured. Nevertheless the data are reasonable and a general figure of 20-22 inches (based upon these and previous years' data) may be accepted as the average seasonal (May 1-October 31) water requirement of crops in southern Minnesota. Slightly less may be required in northern Minnesota.

Table 4 shows the average daily water consumption between sampling periods at Lamberton for the 1961-1965 seasons. Corn was the crop each year. As with the data in tables 1-3 the downward drainage of water beyond the 5 foot depth and surface runoff were not measured. An attempt has been made to place the sampling periods with the month, but due to different sampling times the June sample, for example, may overlap into either May or July. The total consumption each yr. has been remarkably consistent varying from 19.15-23.05 inches for the period May 1 to October or November. There is so little water used at the latter part of the season that the ending date is of no great concern.

Table 1. Fall, 1965, soil moisture results

County	Nearby Town	Farm Operator	Soil Type	Date Sampled	Crop and Yield	Total available water Present* (inches)	% of possible Water*	Diff. Fall '65-Fall '64 (inches)	Approx. am't. water used in Season (inches)
Dodge	Dodge Center	G. Sutherland	Kasson silt loam	11/18/65	Soybeans	6.1	58.1	+0.7	21.7 (5/6-11/18)
Lincoln	Arco	C. Madsen	Barnes clay loam	11/3/65	Oats (100 bu.)	3.4	29.6	+2.4	17.2 (5/12-11/3)
Lincoln	Porter	R. Boulton	Barnes silty clay loam	11/2/65	Oats (110 bu.)	5.3	41.1	+3.3	22.1 (5/7-11/2)
Lyon	Cottonwood	R. Olson	Aastad silty clay loam	11/2/65	Soybeans (26 bu.)	7.8	59.1	+2.8	19.8 (5/7-11/2)
Lyon	Marshall	C. Boerboom	Vallers clay loam	11/2/65	Corn (80 bu.)	7.1	57.3	+2.4	16.0 (5/7-11/2)
Lyon	Minnesota	N. Orsen	Barnes clay loam	11/2/65	Soybeans (22 bu.)	4.7	40.5	+0.5	19.3 (5/7-11/2)
Mille Lacs	Milaca	T. Nichols	Mora silt loam	10/22/65	Oats (66 bu.)	13.3	138.5	+9.2	24.7 (4/26-10/22)
Polk	Crookston	U. Minn.	Hegne silty clay loam	11/1/65	Pasture	8.4	49.4	+1.6	18.0 (5/3-11/1)
Polk	Crookston	U. Minn.	Fargo silty clay loam	11/1/65	Wheat	8.4	49.4	+0.8	15.5 (5/17-11/1)
Polk	Crookston	U. Minn.	Fargo silty clay loam	11/1/65	Sugarbeets	5.1	30.0	-	16.9 (5/28-11/1)

(Con't) - Table 1.

County	Nearby Town	Farm Operator	Soil Type	Date Sampled	Crop and Yield	Total available water Present* (inches)	% of possible Water*	Diff. Fall '65-Fall '64 (inches)	Approx. am't. water used in Season (inches)
Ramsey	St. Paul	U. Minn.	Waukegan silt loam	11/7/65	Sod	7.6	93.8	+7.4**	21.0 (6/16-11/7)
Ramsey	St. Paul	U. Minn.	Waukegan silt loam	11/7/65	Bare soil	6.8	83.9	+4.1**	20.8*** (6/16-11/7)
Ramsey	St. Paul	U. Minn.	Waukegan silt loam	11/7/65	Soybeans	7.3	90.1	-	21.8 (6/16-11/7)
Redwood	Belview	V. Anderson	Nicollet clay loam	11/3/65	Alfalfa	3.4	29.6	+3.1	22.0 (5/13-11/3)
Redwood	Lamberton	U. Minn.	Webster silty clay loam	11/3/65	Corn	5.2	52.5	+2.4	20.4 (5/10-11/3)
Redwood	Morgan	N. Prokosch	Nicollet clay loam	11/2/65	Soybeans (32 bu.)	7.8	78.8	-	17.5 (5/13-11/2)
Redwood	Wabasso	D. Kuehn	Nicollet clay loam	11/3/65	Corn	7.8	60.0	+4.2	18.5 (5/11-11/3)
Sibley	Winthrop	D. Woods	Nicollet clay loam	11/9/65	Alfalfa	10.1	86.3	-0.7	25.4 (5/12-11/9)
Wabasha	Kellogg	K. Zickrick	Fayette silt loam	10/26/65	Corn	12.3	79.3	+5.7	23.1 (5/3-10/26)
Watonwan	Butterfield	E. Hansen	Nicollet clay loam	11/10/65	Corn	9.7	69.7	-1.1	17.4 (6/1-11/10)
Yellow Medicine	Granite Falls	K. Velde	Aastad silty clay loam	11/3/65	Corn (90 bu.)	11.3	74.8	-2.9	24.1 (5/7-11/3)

* In a 5 foot column of soil. ** The 1964 sample was taken on Aug. 17. *** The large apparent water use is due to runoff which was not measured.

Table 2. Total departure of precipitation from normal since April 1, 1965*

Station	As of August 1	As of November 1
Fargo, N. D.	+3.09	+4.03
International Falls	-1.00	+3.11
Duluth	-1.06	+1.71
St. Cloud	+7.04	+9.82
Sioux Falls, S. D.	+2.73	+0.64
Rochester	-0.07	+1.21
Minneapolis - St. Paul	+7.50	+9.82

* From "Minnesota Weekly Weather, Crop and Livestock Report."

Table 3. Fall soil moisture reserves, 1958-1965.[1]

County	Nearby Town	Farm Operator	Soil Series	Inches of Available Water in a Five Foot Column of Soil								Average
				1965	1964	1963	1962	1961	1960	1959	1958	
Chippewa	Milan	H. Olson	Rothsay	-	5.7	8.1	8.2	-	-	-	-	7.3
Dodge	Dodge Center	G. Suther-land	Kasson	6.1	5.4	6.4	5.0	2.6	4.6	3.7*	4.6*	4.8
Kandiyohi	Pennock	E. Nord-strum	Clarion	-	0.4	2.1	-	-	-	-	-	1.3
Kandiyohi	Kandiyo-hi	H. Arvid-son	Nicollet	-	7.0	7.8	-	-	-	-	-	7.4
Lac Qui Parle	Belling-ham	W. Glassen	Aastad	-	12.5	8.0	9.8	-	-	-	-	10.1
Lac Qui Parle	Marietta	I. Aebli	Rothsay	-	5.5	2.3	6.4	-	-	-	-	4.7
Lac Qui Parle	Dawson	M. Nelson	Aastad	-	8.3	9.1	-	-	-	-	-	8.7

(Con't) - Table 3.

County	Nearby Town	Farm Operator	Soil Series	1965	Inches of Available Water in a Five Foot Column of Soil 1964	1963	1962	1961	1960	1959	1958	Average
Lincoln	Arco	C. Madsen	Barnes	3.4	1.0	5.7	-	-	-	-	-	3.4
Lincoln	Porter	R. Boulton	Barnes	5.3	2.0	5.6	-	-	-	-	-	4.3
Lyon	Cotton-wood	R. Olson	Aastad	7.8	5.0	8.3	-	-	-	-	-	7.0
Lyon	Cotton-wood	R. Olson	Barnes	-	7.5	6.6	-	-	-	-	-	7.1
Lyon	Marshall	C. Boer-boom	Vallers	7.1	4.7	6.3	-	-	-	-	-	6.0
Lyon	Minnesota	N. Orsen	Barnes	4.7	4.2	5.5	6.9	-	-	-	-	5.3
Mille Lacs	Milaca	T. Nichols	Mora	13.3	4.1	6.3	8.3	2.9	4.9*	5.4*	6.7*	6.5
Polk	Crookston	U. Minn.	Hegne(#1)	8.4	6.8	0.1	5.1	4.1	-	-	-	4.9
Ramsey	St. Paul	U. Minn.	Waukegan (sod)	7.6	0.2**	-	-	-	-	-	-	3.9
Ramsey	St. Paul	U. Minn.	"(bare)	6.8	2.7**	-	-	-	-	-	-	4.7
Ramsey	St. Paul	U. Minn.	"(soy-bean)	7.3	-	1.8	8.1	-	-	-	-	5.7
Redwood	Belview	V. Ander-son	Nicollet	3.4	0.3	7.1	9.7	-	-	-	-	5.1
Redwood	Lamberton	U. Minn.	Webster	5.2	2.8	6.2	7.3	7.5	-	-	-	5.8
Redwood	Morgan	N. Prokosch	Nicollet	7.8	-	-	-	-	-	-	-	7.8

(Con't) - Table 3.

County	Nearby Town	Farm Operator	Soil Series	1965	Inches of Available Water in a Five Foot Column of Soil 1964	1963	1962	1961	1960	1959	1958	Average
Redwood	Wabasso	D. Kuehn	Nicollet	7.8	3.6	7.2	-	-	-	-	-	6.2
Redwood	Wabasso	D. Kuehn	Clarion	-	1.3	5.4	-	-	-	-	-	3.3
Sibley	Winthrop	D. Woods	Nicollet	10.1	10.8	8.6	9.1	8.5	8.1**	8.4*	5.7*	8.7
Swift	Danvers	C. Stubbs	Barnes	-	2.7	7.1	-	-	-	-	-	4.9
Swift	Murdock	R. Tucker	Vallers	-	8.2	7.8	-	-	-	-	-	8.0
Wabasha	Kellogg	K. Zickrick	Fayette	12.3	6.6	8.2	11.5	7.4	10.3*	7.4*	6.3*	8.7
Watonwan	Butter-field	E. Hansen	Nicollet	9.7	10.8	5.2	8.7	4.9	7.0*	1.2*	0.5*	6.0
Yellow Medicine	Granite Falls	K. Velde	Aastad	11.3	14.2	10.2	-	-	-	-	-	11.9

1. Unless otherwise noted samples were taken between mid-October to early November.
* Sampled in mid-September.
** Sampled in August.

Table 4. Average daily water consumption in inches under corn at Lamberton, 1961-1965.

Month (Approximate)	1961 Period	1961 Daily Use	1962 Period	1962 Daily Use	1963 Period	1963 Daily Use	1964 Period	1964 Daily Use	1965 Period	1965 Daily Use
April					4/3-5/1	0.046				
May	5/1-6/28	0.119	5/1-5/28	0.082	5/1-6/13	0.141	5/1-6/10	0.151	5/10-6/3	0.131
June			5/28-6/27	0.242	6/13-6/27	0.153	6/10-7/1	0.159	6/3-7/19	0.184
July	6/28-7/28	0.100	6/27-7/31	0.203	6/27-7/29	0.185	7/1-8/1	0.209	7/19-8/4	0.088
August	7/28-8/30	0.155	7/31-8/31	0.149	7/29-8/29	0.150	8/1-9/1	0.102	8/4-9/1	0.125
September	8/30-10/2	0.121	8/31-9/26	0.078	8/29-10/19	0.047	9/1-10/1	0.081	9/1-10/6	0.091
October	10/2-11/21	0.003	9/26-10/31	0.000			10/1-11/3	0.034	10/6-11/3	0.025
Total Used*	5/1-11/21	19.15	5/1-10/31	23.05	5/1-10/19	21.21	5/1-11/3	22.56	5/10-11/3	20.38

* The average total (1961-1965) = 21.27 in.

Based upon the data in table 4 the average daily consumption may be obtained as well as the observed maximum daily use of water. The minimum daily use would be 0 inches, of course. But for planning purposes both the average and the maximum daily use are important. These values are shown in table 5. The values most likely to be altered with continued measurement are those of July, which appear to be a bit low. (I would estimate both the July average and July maximum to be 0.02-0.03 inches too low).

Table 5. Average daily water use and the maximum daily water use at Lamberton, 1961-1965.

Month	Average/day	Maximum/day
April	0.03 in.	0.05 in.
May	0.12	0.15
June	0.18	0.24
July	0.16	0.21
August	0.14	0.16
September	0.09	0.12
October	0.01	0.03

Carrying the Lamberton data one step further it is possible to calculate the average monthly and maximum monthly water consumption based upon the daily values shown in table 5. Results of these calculations are shown in table 6. As with the July data in table 5 the July totals in table 6 may be too low.

Table 6. Calculated average total and calculated maximum total monthly water consumption.

Month	Calculated Water Consumption: Average Total	Calculated Water Consumption: Maximum Total	Average Precipitation*
April	0.90 in.	1.50 in.	2.66 in.
May	3.72	4.65	4.40
June	5.40	7.20	3.36
July	4.96	6.51	5.33
August	4.34	4.96	2.19
September	2.70	3.60	3.70
October	0.31	0.93	1.08
Total April-October	22.33	29.35	22.72
Total May-October	21.43	27.85	20.06

*Lamberton, 1961-1965.

Based upon other information July might be expected to equal or exceed June in the water requirement of crops. In any case with respect to possible irrigation planning in southern Minnesota the data in tables 5 and 6 should be of practical value.

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WEATHER - 1965

Southwest Experiment Station
Lamberton, Minnesota
W. W. Nelson

Date	Air Temperature Ave.Max.	-Ave.Min.	Soil Temperature Ave.2"	Ave.12"	Prept. /In.	Net * Evap./In.
Apr. 1 - 10	46	33	31	30	2.93	
11 - 20	55	34	40	32	.28	.74
21 - 30	65	37	48	40	1.39	.09
				TOTAL	4.60	.83
May 1 - 10	76	50	62	52	2.02	.24
11 - 20	75	48	62	55	2.95	-.46
21 - 31	68	47	60	59	1.90	-.16
				TOTAL	6.87	-.38
June 1 - 10	81	55	69	61	.87	1.26
11 - 20	83	57	70	65	.11	3.02
21 - 30	83	55	74	67	1.69	1.52
				TOTAL	2.67	5.80
July 1 - 10	82	55	74	68	2.11	.66
11 - 20	85	62	78	70	.14	2.07
21 - 31	85	59	78	71	.52	2.09
				TOTAL	2.77	4.82
Aug. 1 - 10	82	58	76	69	.97	1.23
11 - 20	88	61	71	73	.10	2.36
21 - 31	75	51	71	68	.71	1.23
				TOTAL	1.78	4.82
Sept. 1 - 10	73	48	66	62	.26	1.29
11 - 20	61	45	58	58	1.73	-1.05
21-- 30	55	37	50	51	4.06	-3.02
				TOTAL	6.05	-2.78

SOIL MOISTURE SURVEY

Southwest Experiment Station   Soil Type: Clarion-Nicollet
Lamberton, Minnesota
W. W. Nelson

Sample Date		Inches of Available water within each depth of soil 0-6"	6-12"	12-18"	18-24"	24-36"	36-48"	48-60"	Total Soil Water Present	Maximum Possible Available	Deficit
5-3-65	Avail.	0.78	0.84	0.77	0.64	1.23	1.36	1.31	6.93	9.81	3.22
	Def.	-	-	0.03	0.25	0.74	1.03	1.17			
	Surplus	0.16	0.18	-	-	-	-	-			
6-9-65	Avail.	0.86	0.98	0.94	0.80	1.64	1.81	1.65	8.68	9.81	1.13
	Def.	-	-	-	0.09	0.33	0.58	0.83			
	Surplus	0.24	0.32	0.14	-	-	-	-			
7-19-65	Avail.	0.59	0.49	0.34	0.36	0.97	1.07	1.24	5.06	9.81	4.75
	Def.	0.03	0.17	0.46	0.53	1.00	1.32	1.24			
	Surplus	-	-	-	-	-	-	-			
8-4-65	Avail.	0.32	0.26	0.26	0.33	0.87	1.01	1.24	4.29	9.81	5.52
	Def.	0.30	0.40	0.54	0.56	1.10	1.38	1.24			
	Surplus	-	-	-	-	-	-	-			
9-1-65	Avail.	0.24	0.11	-	-	0.23	0.78	1.08	2.44	9.81	7.37
	Def.	0.38	0.55	0.80	0.89	1.74	1.61	1.40			
	Surplus	-	-	-	-	-	-	-			

TEMPERATURE READINGS WITH THERMOCOUPLE (weekly averages)

Southwest Experiment Station
Lamberton, Minnesota
W. W. Nelson

CROP	DEPTH	6/21-6/25 A M	6/21-6/25 P M	6/28-7/2 A M	6/28-7/2 P M	7/6-7/9 A M	7/6-7/9 P M	7/12-7/16 A M	7/12-7/16 P M	7/19-7/23 A M	7/19-7/23 P M	7/26-7/30 A M	7/26-7/30 P M	8/2-8/6 A M	8/2-8/6 P M	8/9-8/13 A M	8/9-8/13 P M
Corn-Phos. (cult.)	4"	65.3	66.5	67.4	72.0	65.1	67.1	66.9	68.5	70.0	72.1	68.0	70.4	67.2	70.2	66.7	70.7
	12"	65.7	65.1	68.0	67.6	66.5	67.2	66.7	66.6	68.2	69.4	69.0	70.3	67.8	67.7	67.3	67.4
Soybeans Phos.	4"	66.8	70.4	69.4	75.4	66.5	71.2	68.4	72.6	71.7	74.2	70.2	72.8	67.8	71.0	67.6	71.4
	12"	66.7	66.5	69.3	69.3	67.4	67.5	68.7	69.8	70.3	70.6	71.0	71.2	68.0	68.0	67.5	68.1
Cont. Corn (cult.)	4"	62.0	66.2	67.5	72.4	65.8	69.9	68.4	69.6	69.5	71.1	67.2	67.7	65.8	67.3	65.6	67.8
	12"	64.0	62.3	67.6	65.8	66.9	66.0	68.0	67.2	68.4	68.7	67.5	66.7	65.7	65.5	65.5	65.8
Alf. Border	4"	63.8	69.6	66.2	71.4	64.7	69.1	65.3	67.4	70.2	74.8	69.5	73.7	67.5	73.2	66.3	72.2
	12"	63.2	63.1	65.7	64.4	64.3	64.3	64.4	63.0	68.0	68.3	68.5	69.1	67.3	68.5	66.6	66.7
Soybeans-30" (between row)	4"	64.5	72.0	68.7	79.3	66.0	74.5	70.1	79.2	72.2	79.6	70.1	79.1	67.8	78.5	67.6	77.7
	12"	64.7	66.6	67.2	71.8	67.6	67.9	69.8	70.2	71.3	71.7	71.4	72.1	68.7	68.5	68.0	69.5
Soybeans-30"	4"	64.5	69.8	68.9	75.9	66.5	71.1	70.1	73.5	72.2	75.3	70.1	73.1	68.1	72.0	67.2	71.6
	12"	65.8	67.5	69.4	68.9	67.2	66.7	70.2	68.9	71.5	71.4	71.2	72.2	68.3	68.5	67.6	67.5
Soybeans-6"	4"	65.4	71.7	70.0	78.1	66.5	72.6	70.1	75.5	71.0	73.7	68.3	71.6	66.0	72.1	65.9	71.2
	12"	66.6	64.8	70.1	69.4	67.6	67.0	69.7	68.4	70.3	69.5	69.2	68.1	66.5	67.1	66.1	66.6

CROP	DEPTH	8/16-8/20 A M	8/16-8/20 P M	8/23-8/27 A M	8/23-8/27 P M	8/30-9/3 A M	8/30-9/3 P M
Corn-Phos. (cult.)	4"	69.0	71.0	66.0	68.2	58.6	61.4
	12"	68.9	69.1	66.9	66.7	58.6	61.4
Soybeans-Phos.	4."	68.7	70.6	65.6	68.3	58.8	62.2
	12"	69.2	69.4	66.2	66.4	61.5	61.7
Cont. Corn	4"	67.2	67.6	64.3	65.5	58.6	59.7
	12"	67.2	66.1	64.8	64.2	60.2	59.7
Alf. Border	4"	66.9	69.7	64.6	66.9	58.0	61.3
	12"	67.6	67.1	65.0	64.4	60.3	60.0
Soybeans-30" (between rows)	4"	68.4	73.0	65.1	71.0	58.1	64.0
	12"	69.6	70.0	66.3	64.0	61.5	61.0
Soybeans-30"	4"	68.2	70.8	65.1	68.1	58.3	61.4
	12"	68.9	68.6	66.2	65.7	60.9	60.6
Soybeans-6"	4"	67.0	69.8	64.0	67.8	57.7	62.1
	12"	67.6	67.3	65.3	65.4	60.5	60.6

Water Infiltration

R. H. Rust

Infiltration measurements on Port Byron soils at Rosemount; Kenyon soils in Goodhue county; Webster soils at Lamberton; and Central soils at Morris have been made during the past 3 years using a portable sprinkling infiltrometer (developed at Purdue for a regional study).

The average infiltration rate on the Port Byron soils*, using an application rate of about 4 inches per hour, was 0.3 in/1 hour on continuous corn plots (i.e. 4 years in corn). This was determined in August and September.

The infiltration rate on plots in first year corn after bromegrass was 0.5 in/1 hour (2-yr. avg.)

Thus there is some evidence that continuous corn on this soil will reduce infiltration rates--already relatively low--to a point where runoff and erosion would be serious.

The results on the several soils may be summarized as follows:

Port Byron silt loam

Corn (1st yr. after brome)	0.5 in /1 hr.
Corn (4 yrs. continuous)	0.3 "
Soybeans (1st yr. after corn)	0.7 "
Soybeans (2nd yr. after corn)	0.3 "
Bromegrass (3rd yr. sod)	1.9 "

Kenyon silt loam

Corn (1st yr. after brome)	1.0 in /1 hr.
Bromegrass (2nd yr. sod)	0.9 "
(not statistically different)	

Webster clay loam

Corn (1st yr. after brome)	1.0 in /1 hr.
Bromegrass (2nd yr. sod)	0.6 "

Central sandy loam

Fallow (1 yr.)	0.7 in /1 hr.

The equal, or higher, infiltration rates under corn compared to bromegrass sod on Kenyon and Webster soils were contrary to expectations. Aparently the plow layer is the critical horizon on these soils as regards infiltration and 2 or 3 years of brome sod does not produce a more porous surface horizon than the usual cultivation.

The results of the North Central regional study (3 soils in each of 12 states with corn and bromegrass plots) will be published in about one year.

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*For brief descriptions of these soils, refer to Ext. Bul. 278. Port Byron soils are somewhat similar to Tama soils.

Structure - Nitrogen Study

Morris 1964

% moisture in Corn Grain

Data Book 27:6a-6c

J. M. MacGregor, G. R. Blake, Sam Evans

Seedbed preparation Handling of residues Fall or Spring plowed	0-40-40	40-40-40	40-40-40	80-40-40	240-40-40	Ave.
Minimum - chop - spring	30.0	28.4	29.1	26.7	36.2	30.1
Minimum-not chop-spring	35.9	34.4	35.8	42.7	38.4	35.4
Minimum = chop = fall	28.6	31.9	29.4	30.9	28.3	29.8
Conventional-chop-fall	28.1	27.2	26.2	29.0	30.2	28.1
Field cultivate-chop-fall & spring	29.7	27.2	33.4	35.7	31.5	31.5
Averages	30.5	29.8	30.7	33.0	32.9	

Tillage significant at the 90% level.

Structure - Nitrogen Study
Morris, 1965
Corn Yields
27:95-97
J. M. MacGregor, G. R. Blake, Sam Evans

Seedbed preparation Handling of residues Fall or Spring plowed	Fertilizer 0-40-40	40-40-40 fall	40-40-40	80-40-40	240-40-40	Ave.
Minimum - chop - spring	41.3	68.2	77.6	82.6	77.9	69.5
Minimum - not chop - spring	66.2	59.4	70.7	76.8	78.0	70.2
Minimum - chop - fall	47.0	85.9	77.7	82.8	94.0	77.5
Conventional - chop - fall	54.1	63.5	84.9	85.0	82.9	74.1
Chisel plow - chop - fall and spring	43.5	64.7	65.2	77.0	81.1	66.3
Averages	50.4	68.3	75.2	80.8	82.8	

Fertilization was significant at the 1% level. Tillage was not significant. Tillage x Fertilization interaction was significant at the 5% level. Residual effects of manure, rock and superphosphate from an earlier experiment on this land were not significant.

Structure - Nitrogen Study

Morris 1965

% moisture in Corn Grain

Data Book 27:107-109

J. M. MacGregor, G. R. Blake, Sam Evans

Seedbed preparation Handling of Residues Fall or Spring plowed	Fertilizer 0-40-40	40-40-40 (fall)	40-40-40	80-40-40	240-40-40	Ave.
Minimum - chop spring	43.8	43.0	39.8	39.5	41.7	41.6
Minimum not chop spring	39.1	41.5	41.7	40.9	41.7	41.0
Minimum - chop - fall	40.8	38.2	38.6	40.7	37.5	39.2
Conventional-chop-fall	40.8	41.9	41.8	40.7	41.2	41.3
Field cultivate-chop- fall & spring	42.5	41.3	39.5	41.5	43.2	41.6
Averages	41.4	41.2	40.3	40.6	41.1	

Tillage significant at the 95% level.

Structure Nitrogen Study
Waseca 1964
Corn Yields, Bu/A.
Data Book 27:11-13
G. R. Blake, J. M. MacGregor, L. E. Ahlrichs

Seedbed preparation Handling of residues Fall or Spring plowed	Min chop Spring	Min not chop Spring	Conventional chop Fall	Min chop Fall	Field Cultivated chop Fall and Spring	Ave.
0- 0- 0	102.9	92.0	87.9	91.8	97.2	94.4
0-40-40	105.4	108.7	93.9	99.2	78.7	97.2
40-40-40 (fall)	111.8	101.4	94.3	98.1	93.3	99.8
40-40-40	103.3	101.6	93.6	86.5	105.7	98.2
80-40-40	112.3	109.2	89.6	97.2	89.0	99.4
240-40-40	106.9	111.9	104.9	101.5	93.6	103.7
Averages	107.1	104.1	94.0	95.7	92.9	

Differences not significant

Structure Nitrogen Study
Waseca 1964
Moisture % - Corn
Data Book 27:14-16
G. R. Balke, J. M. MacGregor, L. E. Ahlrichs

Seedbed preparation Handling of residues Fall or Spring plowed	Min chop Spring	Min Not chop Spring	Conventional chop Fall	Min chop Fall	Field Cultivated - chop Fall and Spring	Ave.
0- 0- 0	21.0	20.6	21.6	21.5	21.6	21.3
0-40-40	21.2	19.4	19.3	19.6	21.1	20.1
40-40-40(fall)	19.8	21.4	19.6	21.7	16.5	19.8
40-40-40	19.9	26.0	20.3	22.6	19.4	21.6
80-40-40	20.8	18.3	23.1	20.3	15.6	20.0
240-40-40	21.2	20.2	19.0	22.1	19.3	20.4
Averages	20.7	21.0	20.5	21.3	19.3	

Differences not significant

Structure - Nitrogen Study

Waseca 1965

Corn Yields, Bu./A @ 15.5% moisture

Data Book 27:99-101

G. R. Blake, J. M. MacGregor, John Thompson

Seedbed preparation Handling of residues Fall or Spring plowed	Minimum chop Spring	Minimum not chop Spring	Conventional chop Fall	Minimum chop Fall	Field Cultivate chop Fall & Spring	Ave.
0-0-0	54.2	76.3	78.0	93.1	67.2	73.8
0-40-40	71.4	72.4	85.8	90.6	51.1	74.3
40-40-40 (fall)	65.4	60.4	90.0	94.4	58.3	73.3
40-40-40	75.1	74.7	100.8	104.9	79.1	86.5
80-40-40	71.8	86.1	112.8	119.9	82.0	94.1
240-40-40	89.9	83.3	127.8	114.8	66.2	95.6
Averages	71.0	75.2	99.2	103.0	66.3	

Fertilizer was significant at the 99% level, Tillage at 95%, Replication, Fertilizer x Tillage and Fertilizer x Replicate interactions were significant at the 90% level.

Structure - Nitrogen Study

Waseca 1965

% Moisture in Corn Grain

Data Book 27:103-105

G. R. Blake, J. M. MacGregor, John Thompson

Seedbed preparation Handling of residues Fall or Spring plowed	Minimum chop Spring	Minimum not chop Spring	Conventional chop Fall	Minimum chop Fall	Field Cultivate chop Fall & Spring	Ave.
0-0-0	39.5	37.6	35.4	35.9	38.1	37.0
0-40-40	38.4	35.7	35.8	35.5	38.3	36.8
40-40-40 (fall)	37.0	37.0	34.5	35.8	35.2	35.9
40-40-40	36.0	34.4	34.4	34.0	34.6	34.7
80-40-40	37.1	34.5	33.5	33.8	35.6	34.9
240-40-40	36.1	34.9	32.5	33.6	37.4	34.5
Averages	37.0	35.7	34.4	34.8	36.6	

Fertilizer significant at the 99% level; Replication at 95%; and Tillage at 90%.

Structure - Nitrogen Study
Waseca, 1965
Soil Temperatures at 4" depth, °F.
Averages of 12 readings on 3 reps.

G. R. Blake, J. M. MacGregor, and L. E. Ahlrichs

Week Ending		Air Temp.	Minimum Spring	Tillage, when plowed Minimum Fall	Regular Fall	Field Cultivate
June 4	max	75.1	61.7	61.2	61.4	61.3
	min	34.3	55.3	55.0	54.2	55.4
	mean	54.7	58.5	58.1	57.8	58.4
June 11	max	78.9	68.6	68.3	68.1	68.4
	min	54.7	58.0	60.3	59.1	60.7
	mean	66.8	63.3	64.3	63.6	64.6
June 18	max	82.7	73.3	72.7	72.4	72.0
	min	52.3	65.5	64.5	63.6	65.1
	mean	67.5	69.4	68.6	68.0	68.6
June 25	max	79.9	70.2	70.1	69.0	69.8
	min	55.6	64.4	60.3	58.0	64.1
	mean	67.8	67.3	65.2	63.5	67.0
June 29	max	83.3	71.8	74.8	74.4	76.2
(4 days)	min	58.3	64.8	64.1	62.8	64.0
	mean	70.8	68.3	69.5	68.6	70.1

Subsoil Regeneration Study
Lamberton, 1965
Corn Grain Yield (bu./A @ 15.5% moisture
Percent Moisture in Grain
Alfalfa Yield (lbs./A @ 20% moisture)
and Alfalfa Height in INches
G. R. Blake and W. W. Nelson
27:81-93

	Date Harvested	Irrigated	not Irrigated	Irrigated	not Irrigated
Corn Yield	10/16/65	100.5	85.6	94.7	104.7
% Moisture	10/16/65	37.1	39.6	39.3	37.9
Alfalfa Yield	6/14/65	3833	4728	3965	3980
Alfalfa Yield	7/19/65	3491	3493	2787	3365
Alfalfa Yield	9/1/65	1726	1836	1713	1741
Alfalfa Height	6/14/65	27.6	29.0	28.2	27.6

Irrigation x Packing interaction was significant at the 95% level for the corn yield. Nothing else was significant.

Subsoil Regeneration Study
Lamberton
Bulk Density
June 30 - July 1, 1965
27:49-79
G. R. Blake and W. W. Nelson

Depth in Inches	Corn Packed Irrig.	Corn Packed Not Irrig.	Corn Not Packed Irrig.	Corn Not Packed Not Irrig.	Alfalfa Packed Irrig.	Alfalfa Packed Not Irrig.	Alfalfa Not Packed Irrig.	Alfalfa Not Packed Not Irrig.	Significance1/ Crop	Significance1/ Packing
4-8	1.25	1.29	1.15	1.20	1.32	1.35	1.33	1.29	***	**
8-12	1.43	1.45	1.29	1.29	1.44	1.44	1.25	1.28	NS	*
12-16	1.43	1.52	1.28	1.29	1.49	1.45	1.25	1.28	**	***
16-20	1.41	1.49	1.30	1.37	1.36	1.36	1.28	1.35	***	***
20-24	1.37	1.44	1.35	1.42	1.37	1.34	1.33	1.33	***	*
24-28	1.32	1.42	1.36	1.41	1.35	1.35	1.36	1.36	**	NS
28-32	1.33	1.43	1.35	1.42	1.35	1.35	1.37	1.35	**	NS
32-36	1.36	1.52	1.39	1.43	1.40	1.42	1.37	1.36	***	NS

1/ * = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%,
NS = Not Significant

Replication was significant at the 5% level for the 8-12", 12-16", 16-20", 24-28", and 28-32" depths; at the 1% level, for the 32-36" depth. Irrigation was significant at the 10% level for the 4-8" depth and at the 1% level for the 16-20" depth. Irrigation x Crop was significant at the 5% level for the 20-24" depth. Irrigation x Packing x Crop was significant at the 10% level for the 16-20" depth.

Subsoil Regeneration Study
Lamberton
Soil Moisture Percentages
June 30-July 1, 1965
27:17-47
G. R. Blake and W. W. Nelson

Depth in Inches	Corn				Alfalfa				Significance1/	
	Packed		Not Packed		Packed		Not Packed			
	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Crop	Packing
4-8	24.1	23.4	24.9	25.5	21.5	21.4	22.5	21.5	***	**
8-12	24.6	24.4	23.4	24.8	21.7	22.9	23.3	21.9	**	NS
12-16	24.5	24.1	22.6	23.3	21.0	22.2	22.5	21.1	**	NS
16-20	23.6	22.7	21.9	21.7	19.5	20.3	21.8	19.4	**	NS
20-24	23.1	21.7	21.9	22.1	19.3	19.4	20.9	19.9	***	NS
24-28	23.2	21.3	21.7	22.0	18.6	19.6	20.5	19.9	***	NS
28-32	23.9	21.0	22.6	22.0	19.0	20.3	20.7	21.1	***	NS
32-36	23.7	20.8	22.1	22.3	18.7	20.1	22.4	21.0	***	NS

1/ * = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%,
NS = Not Significant

Replication was significant at the 5% level for depths 4-8", 8-12", 12-16", 16-20", and 20-24". At the 1% level, replication was significant at the 24-28", 28-32", and 32-36" depths. Packing x crop was significant at the 10% level for the 4-8" depth. Irrigation x packing x crop was significant at the 5% level for the 8-12" depth and at the 10% level for the 12-16" and 16-20" depths.

Corn After Fallow

Lamberton, 1964

Data Book 23:138-143

G. R. Blake, W. W. Nelson, R. R. Almaras

Corn Yields, Bu/A.

Treatment	Fall Plow Packed	Fall Plow Not Packed	Summer Fallow	Ave.
No fertilizer	132.8	139.2	180.4	134.1
Starter fertilizer	110.7	127.0	101.5	113.1
Starter and Broadcast	131.0	118.2	113.8	121.0
Averages	124.8	128.1	115.2	

Treatment differences were not significant

Corn grain water content, %

Treatment	Fall Plow Packed	Fall Plow Not Packed	Summer Fallow	Ave.
No fertilizer	30.6	21.8	33.7	28.7
Starter fertilizer	27.5	30.6	34.9	31.0
Starter and Broadcast	27.8	30.3	31.0	29.7
Averages	28.6	27.5	33.2	

Replication was significant at the 5% level. Treatment differences were not significant.

Corn After Fallow

Lamberton, 1964

Tissue Analysis

W. W. Nelson, G. R. Blake, R. R. Almaras

Nutrient	No fertilizer	Starter	Starter and Broad-cast
K, %	1.76	1.88	1.69
P, %	.27	.27	.25
Ca, %	.43	.42	.40
Mg, %	.22	.22	.25
Na, %	.01 - 1.00+	.02	.01 - 1.00+
Si, %	.25	.21	.19
Mn,PPM	58	48	51
Fe,PPM	61	59	50
B,PPM	25	20	20
Cu,PPM	12	12	11
Zn,PPM	40	23	22
Al,PPM	14	11	15
Sr,PPM	22	24	20
Mo,PPM	.4	.4	.2
Co,PPM	.1	.1 - 1.0+	1.0+
Ba,PPM	4	6	5

Corn After Fallow

Lamberton, 1964

Tissue Analysis

W. W. Nelson, G. R. Blake, R. R. Allmaras

Nutrient	Fall Plow Packed	Fall Plow Not Packed	Summer Fallow
K, %	1.77	1.77	1.74
P, %	.27	.26	.26
Ca, %	.40	.42	.43
Mg, %	.24	.25	.23
Na, %	.01 - 1.00+	.01 - 1.00+	.02 - 1.00+
Si, %	.22	.19	.24
Mn,PPM	54	49	54
Fe,PPM	61	59	57
B,PPM	21	20	23
Cu,PPM	12	12	11
Zn,PPM	32	23	29
Al,PPM	16	15	15
Sr,PPM	20	23	22
Mo,PPM	.4	.3	.4
Co,PPM	.1 - 1.0+	.1 - 1.0+	.1 - 1.0+
Br,PPM	5.0	5.3	4.7

Minimum Tillage for Potatoes

J. B. Swan, D. A. Daellenbach, F. L. Heck, G. R. Blake

1965

Yield and Specific gravity of tubers	Spring tillage 1/ Deep field Cultivation	No Spring tillage	L.S.D. 95%
Hoffman Farm, Marshall County			
Pounds A size/20 feet of row	27.2	30.3	2.6
Specific gravity	1.095	1.087	0.0006
Thompson Farm, Clay County			
Pounds A size/20 feet or row	28.0	28.5	N.S.
Specific Gravity	1.072	1.072	N.S.

1/ Fall tillage was field cultivating on both farms. Previous Crops: Hoffman farm, barley; Thompson farm, pinto beans.

Soil Salinity and Crop Growth in Southern and Western Minnesota

J. M. MacGregor and R. C. Munter[1]

As a sequel to a similar study reported on page 10 of the 1965 "Bluebook," soil samples were collected in the late fall of 1965 from 23 "problem" sites located from southeastern Freeborn County to northern Clay County. The general practice was to obtain samples from each of two profiles at each location to a depth of 36 to 48 inches, one where chlorotic soybean growth had been observed, and the second from a normal soybean growth area as closely as possible to the problem site sampled. The profiles usually were within 100 feet of each other, and seldom exceeded a 200 foot distance. The sampled locations are shown on the accompanying outline map.

Field experiments were conducted for many years using soluble or chelated iron compounds applied to chlorotic soybeans, either directly to the soil or as foliar sprays and none of these were economically satisfactory. The experiments of 1964 and 1965 were then conducted to determine the salt conditions present in those soils where soybean chlorosis occurred. The 1964 survey consisted of sampling and analyzing only the soils from the severely affected areas, and no attempt was made to sample the adjacent profiles which produced apparently normally green soybean plants. The 1965 sampling sites adjacent "problem" and "non or lesser problem" profiles was to determine some difference which might be present to result in chlorotic or in normal soybean growth and are shown on the accompanying outline map.

Since soybean chlorosis in Minnesota has never been observed where the soil pH is less than 7.0, the following analytical data were obtained at each soil depth:

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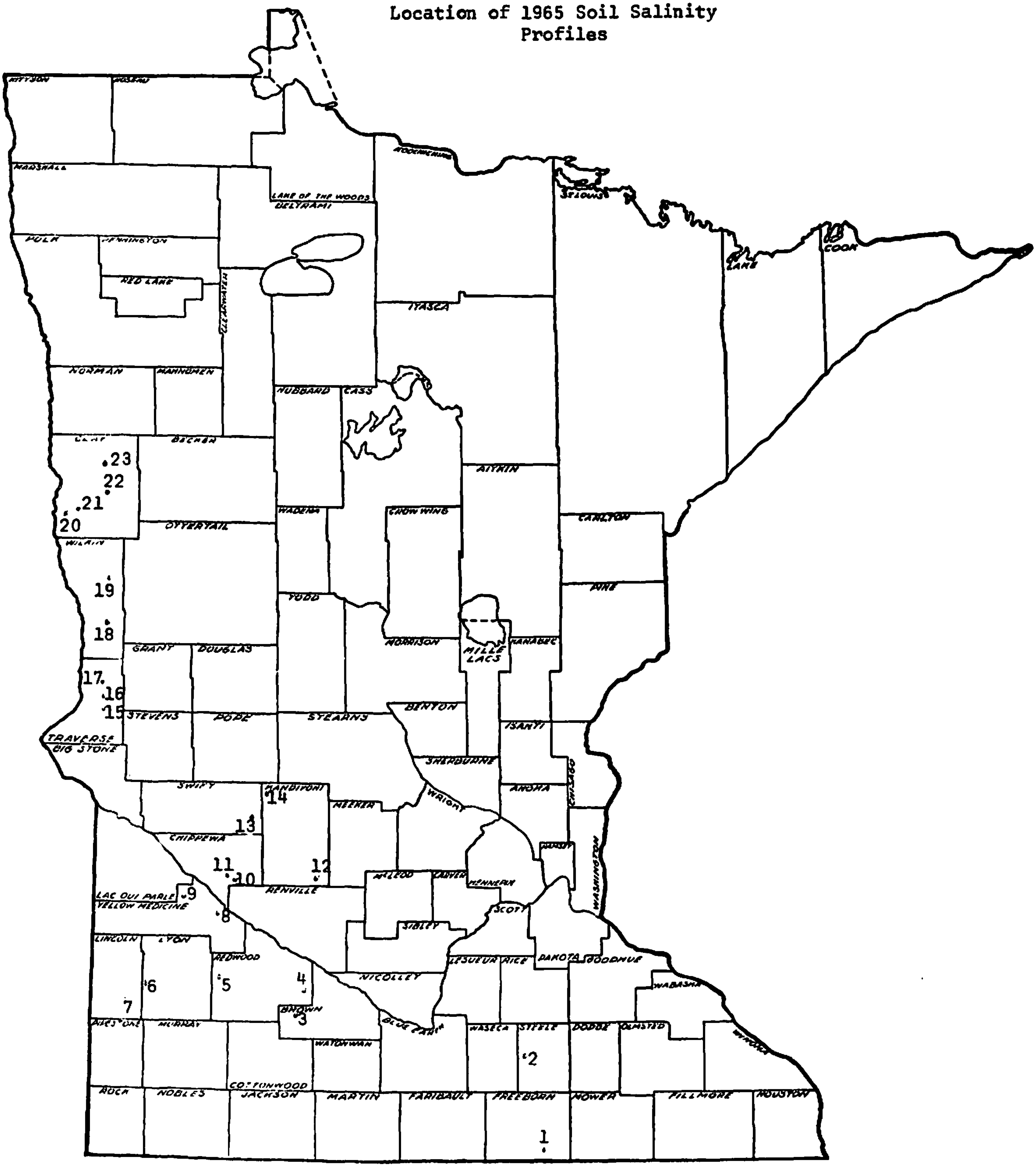
[1]This study was made possible through the excellent cooperation of Orville Gunderson and George Holcomb, area Soil Specialists, Joseph Cummins and Roy Erickson of the Soil Conservation Service, and the county agents or vocational agriculture instructors in those counties where the samplings were made. Their assistance is gratefully acknowledged.

Location of 1965 Soil Salinity Profiles



Soil pH, percent $CaCO_3$ (lime) equivalent, the electrical conductivity and calcium, magnesium, sodium and potassium of the saturated soil extract, as well as the amount of water soluble sulfate (SO_4) present.

Calcium, magnesium, potassium and sulfur are essential to normal plant growth, but the presence of excessive amounts of any or all of these may result in an unbalanced balance in the plants nutritional system and be characterized by growth abnormalities. It is not possible to definitely state the toxic concentrations of each or all of these elements in a given soil, but increasing amounts frequently favor abnormal plant development. Calcium carbonate ($CaCO_3$) is only slightly soluble in most soils, but when the concentration are sufficiently large, the soil moisture contains relatively large quantities which inhibit the uptake of other materials by the plant root. The electrical conductivity of the soil solution extract is an indication of the relative concentration of the very soluble salts present in the soil such as gypsum, sodium chloride, potassium chloride and others and many plants are sensitive with less than 4 mmhos/cm. High concentrations of either the less soluble calcium carbonate or magnesium carbonate, or of the water soluble salts (or both types) all contribute to an unfavorable growing situation.

The analytical results were as follows.

Site number farm operator county soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract conductivity [mmhos/cm]	Ca me/l	Mg me/l	Na me/l	K me/l	SO_4 (ppm)
				Beans - Non Chlorotic					
(1)									
Walter Young	0-6	6.9	0	0.5	3.2	0.3	0.4	0.2	135
Freeborn Co	6-12	6.8	0	0.3	1.5	0.2	0.4	0.1	445
Floyd Sicl	12-24	6.8	0	0.6	2.8	-	0.8	0.2	245
	24-36	6.9	0	0.3	1.3	-	0.5	0.2	110
	36-48	7.1	0	1.2	6.4	0.1	-	-	110
				Chlorotic					
Canisteo	0-6	7.7	14.9	0.5	2.9	0.3	0.5	0.1	100
Sicl	6-12	7.7	12.3	0.4	2.7	0.3	0.5	0.1	50
	12-24	7.7	12.0	0.3	1.8	0.1	0.4	0.1	tr
	24-36	7.8	17.7	0.3	1.7	0.1	0.5	0.1	62
	36-48	7.8	19.4	0.3	1.7	0.1	1.4	0.1	50
				Beans - Non Chlorotic					
(2)									
Willert	0-6	7.5	2.6	0.5	4.0	0.2	0.4	0.2	tr
Steele Co.	6-12	7.1	1.0	0.4	5.0	0.5	0.4	0.1	tr
Glencoe Cl	12-24	7.1	0	0.4	2.6	0.1	0.5	0.01	50
	24-36	7.1	0	0.5	2.6	0.3	0.5	0.3	225
	36-48	7.2	0	0.5	2.1	0.1	1.6	0.4	112
				Chlorotic					
Canisteo Cl	0-6	7.8	33.4	0.8	4.0	0.5	0.5	0.2	100
	6-12	7.7	33.9	0.9	4.6	0.6	0.5	0.1	50
	12-24	7.8	33.5	0.8	4.6	0.5	0.6	0.1	tr
	24-36	7.8	15.8	0.4	2.4	0.1	0.6	0.1	50
	36-48	7.8	17.8	0.7	3.5	0.3	0.6	0.2	100
				Beans - Normal Growth					
(3)									
Matt Holles	0-6	7.5	4.6	2.3	22.8	2.5	1.9	0.3	990
Brown Co.	6-12	7.6	8.5	1.3	10.4	1.3	1.4	0.5	425
Calcareous	12-24	7.5	14.0	1.6	16.2	2.5	0.5	0.5	765
Aastad-Nicollet	-	-	-	-	-	-	-	-	-
				Beans - Chlorotic					
Calcareous	0-6	7.5	11.4	3.3	28.5	5.7	1.8	0.3	4925
Flom-Webster	6-12	7.5	11.4	3.8	31.4	8.5	2.1	0.3	4925
	12-24	7.5	8.1	4.4	29.4	11.9	4.4	0.3	9650
	24-36	7.4	15.5	3.8	24.6	10.7	5.0	0.2	8975
				Beans - Normal Growth					
(4)									
Vilo Dahmes	0-6	7.4	2.4	3.8	34.2	6.2	2.8	1.0	1240
Redwood Co.	6-12	7.6	3.4	4.4	35.1	9.1	2.9	0.8	1240
Calcareous	12-24	7.7	12.6	2.5	18.0	5.3	2.3	0.5	790
Glencoe Sicl	24-36	7.7	14.8	3.5	25.6	9.1	2.3	0.7	3265
				Beans - Poor Growth					
Calcareous	0-6	7.8	2.9	1.6	12.3	2.1	1.3	0.4	565
Glencoe Sicl	6-12	7.7	8.2	2.5	19.9	4.4	2.6	0.3	900
	12-24	7.7	22.2	3.5	27.6	8.5	3.4	0.5	2140
	24-36	7.8	26.0	3.5	27.6	8.4	2.4	0.6	1350

Site number farm operator county Soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract conductivity [mmhos/cm]	Ca me/1	Mg me/1	Na me/1	K me/1	SO_4 (ppm)
				Poor Beans in 1964 Good Corn in 1965					
(4)									
Redwood Co.	0-6	7.9	14.8	1.0	6.0	0.9	1.6	0.3	562
Colvin Sic									
				Beans - Normal Growth					
(5)									
Elmer Rolland	0-6	7.7	22.2	2.0	20.8	1.7	1.1	0.4	625
Redwood Co.	6-12	7.6	21.5	2.8	31.4	2.5	1.1	0.4	5400
Calcareous	12-24	7.7	10.0	3.2	35.1	3.3	2.7	0.4	6415
Glencoe	24-36	7.5	16.7	3.6	30.4	1.1	3.5	0.3	6500
Harpster Sicl									
				Beans - Chlorotic					
Harpster Cl	0-6	7.8	18.5	6.4	27.7	17.3	23.0	1.1	8200
	6-12	7.[illegible]	13.6	6.8	27.5	19.5	21.4	0.8	6750
	12-24	8.1	8.1	6.2	26.6	25.4	18.0	0.7	8440
				Beans - Chlorotic					
(6)									
Regnier	0-6	7.6	14.5	5.5	23.8	7.4	104.3	0.8	9765
Ghent	6-12	7.6	12.8	6.0	23.8	8.0	120.6	0.7	9215
Vallers	12-24	7.6	22.2	7.0	21.8	9.4	159.0	0.8	9215
scl	24-36	7.5	19.0	7.0	24.7	10.1	162.0	0.8	8315
				Beans - Chlorotic					
	0-6	7.5	13.7	6.0	35.2	9.0	29.0	1.4	4815
Vallers	6-12	7.5	15.8	6.5	35.2	10.0	26.1	1.4	8620
scl	12-24	7.3	27.5	5.0	25.6	6.7	27.7	0.8	11225
	24-36	7.3	26.6	4.5	24.7	5.8	8.9	0.8	6950
	.9			**Corn - Normal Growth**					
(7)									
Harold Madsen	0-6	7.8	7.5	0.9	7.6	1.6	1.4	0.1	165
Lincoln Co.	6-12	7.7	7.9	1.0	9.5	0.8	0.7	0.1	225
Calcareous	12-24	7.6	11.5	3.0	32.2	3.5	1.0	0.2	2115
Parnell	24-36	7.8	9.3	2.8	26.6	3.9	0.4	0.2	625
Clay loam									
				Corn - No Growth - Milkweeds grow well					
Calcareous	0-6	7.9	17.1	1.2	10.4	0.9	0.8	0.3	135
Parnell	6-12	7.9	10.7	1.0	8.6	4.1	0.8	0.3	135
Clay loam	12-24	7.6	20.1	3.0	31.4	3.7	0.9	0.2	6300
	24-36	7.7	17.4	3.4	30.4	7.0	0.9	0.2	6300
				Beans - Normal Growth					
(8)									
Kermit Velde	0-6	7.6	12.7	3.8	34.2	5.8	2.1	0.7	3125
Yellow Med. Co.	6-12	7.7	13.3	3.7	33.3	6.6	2.6	0.8	5375
Calcareous	12-24	7.7	14.7	4.8	27.6	13.1	2.8	0.4	6275
Flom	24-36	7.6	13.2	6.4	28.5	20.5	3.3	0.6	6275
Silty clay loam									

Site number Farm operator county Soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract Conductivity [mmhos/cm]	Ca me/1	Mg me/1	Na me/1	K me/1	SO_4 (ppm)
				Beans Died					
Vallers	0-6	7.8	12.4	5.1	25.6	15.6	10.5	0.5	7740
Silty clay	6-12	7.9	11.6	6.6	17.0	21.4	15.7	0.9	9650
loam	12-24	7.8	16.4	10.0	26.6	39.4	22.4	1.0	8975
	24-36	7.8	14.2	10+	26.6	40.2	20.8	0.8	11560
				Chlorotic and Poor Growth of Maple, Willow, Cottonwood Normal Growth with Ash and Siberian Elm					
(9)									
A. Grooters	0-6	7.9	19.9	1.8	8.5	3.1	1.3	1.6	225
yellow med.	6-12	7.9	5.9	1.7	7.6	2.9	1.3	0.3	50
	12-24	7.9	21.1	2.0	9.5	4.6	1.8	0.2	500
	24-36	7.8	18.2	4.2	23.7	13.5	5.0	0.2	2500
				Beans - Normal Growth					
(10)									
D.E.	0-6	7.6	11.5	3.5	20.9	7.9	6.5	0.3	1735
Greenwalt	6-12	7.5	11.4	3.5	20.9	7.7	4.4	0.2	1465
Chippewa Co.	12-24	7.5	2.7	3.5	19.9	7.9	3.9	0.2	1575
Colvin Sic	24-36	7.4	3.8	2.4	13.3	5.5	2.9	0.1	1015
				Beans - Poor Growth					
	0-6	7.7	4.6	6.8	13.3	5.5	21.4	0.3	10915
Colvin Sic	6-12	7.4	3.2	10+	30.2	43.0	24.0+	0.3	11800
	12-24	7.5	3.8	10+	11.4	41.0	24.0+	0.4	12150
	24-36	7.4	2.8	9.0	21.8	35.0	19.0	0.4	8775
				Beans - Better Growth					
(11)									
Maurice	0-6	7.6	7.0	4.5	26.6	12.4	3.4	0.6	5490
Gustafson	6-12	7.7	12.1	5.0	24.7	18.5	6.5	0.6	9540
Chippewa Co.	12-24	7.9	18.9	6.5	31.4	27.8	8.9	0.5	9250
Sletten Sicl	24-36	7.8	70.1	4.5	27.5	-	5.0	0.5	8350
				Beans - Poor Growth					
Sletten Sicl	0-6	7.6	8.7	6.2	-	-	10.2	0.9	11340
	6-12	7.8	8.3	8.5	-	12.4	19.1	0.7	14825
	12-20	8.0	15.2	9.0	23.7	36.5	19.1	0.4	13925
	20-36	7.7	3.6	10+	25.6	40.8	26.6	0.5	12690
				Beans - Normal Growth					
(12)									
Willard	0-6	7.5	15.1	0.8	4.7	1.0	0.6	0.2	450
Anderson	6-12	7.6	4.8	0.8	4.7	0.8	0.9	0.1	112
Kandiyohi Co.	12-24	7.5	12.4	1.0	5.7	1.5	1.2	0.1	112
Colvin Sil	24-36	7.8	6.0	0.7	3.8	0.7	0.9	0.1	112

Site number Farm operator county soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract Conductivity [mmhos/cm]	Ca me/1	Mg me/1	Na me/1	K me/1	SO_4 (ppm)
				Beans Died					
Colvin sil	0-6	7.6	9.4	1.1	6.6	1.0	1.0	0.8	281
	6-12	7.8	18.1	1.4	8.5	1.6	0.8	0.8	135
	12-24	8.0	18.0	0.7	3.8	4.1	0.9	0.3	135
	24-36	8.1	23.7	0.9	4.7	1.0	1.0	0.2	135
				Beans - Better Growth					
(13)									
Tracy Rahto	0-6	8.0	25.0	2.1	11.4	3.9	1.4	0.1	340
Swift Co.	6-12	8.0	26.7	1.2	7.6	1.6	1.0	0.1	112
Calcareous	12-24	8.0	18.6	0.8	4.7	4.9	1.0	0.2	tr
Poorly drained	24-36	8.0	13.1	0.9	6.6	0.7	1.3	0.2	0
Sil									
				Beans - Chlorotic					
Calcareous	0-6	7.8	26.7	4.2	19.0	9.1	2.4	0.3	450
poorly drained	6-12	8.0	27.1	1.5	6.6	2.5	1.0	0.1	100
Sil	12-24	8.0	19.8	1.1	5.7	1.6	1.0	0.1	135
	24-36	7.7	6.6	2.2	16.0	4.3	1.8	0.1	620
				Beans - Normal Growth					
(14)									
Gilbertson	0-6	7.9	31.5	1.2	3.4	1.1	2.9	0.2	425
Colvin silt	6-12	8.0	31.7	1.3	4.5	0.2	2.8	0.2	480
loam	12-24	7.8	36.0	1.3	6.3	1.2	2.7	0.2	370
	24-36	7.7	34.2	0.8	3.9	0.5	1.6	0.2	255
				Chlorotic					
	0-6	7.5	44.4	1.3	5.0	1.2	2.6	0.1	425
	6-12	7.7	46.6	0.9	4.2	0.6	1.3	0.1	315
	12-24	7.8	34.6	0.6	3.1	0.4	0.8	0.1	135
	24-36	7.8	47.9	0.6	3.1	0.2	0.8	0.2	135
				Beans - Less Chlorotic					
(15)									
Harvey Totzke	0-6	7.6	2.8	0.6	3.7	0.7	0.6	0.2	tr
Traverse Co.	6-12	7.1	1.8	0.5	1.9	0.1	0.6	0.7	0
	12-24	7.5	12.7	0.6	2.6	0.4	0.7	0.2	0
	24-36	7.8	26.2	0.7	2.8	0.5	1.0	0.1	135
				Chlorotic					
	0-6	7.7	7.6	0.6	3.9	0.4	0.7	0.5	tr
	6-12	7.7	13.3	0.5	2.9	0.3	0.6	0.2	tr
	12-24	8.1	27.9	0.7	3.4	0.4	0.7	0.1	60
	24-36	7.9	37.9	1.0	4.7	1.0	1.3	0.2	110
				Beans - Non Chlorotic					
(16)									
Marvin Reguse	0-6	7.8	14.8	1.9	-	-	2.4	0.1	425
Colvin silty	6-12	7.6	15.7	1.7	10.7	1.9	1.9	0.1	313
clay loam	12-24	7.5	18.2	5.0	34.2	10.8	4.2	0.3	3800
Traverse Co.	24-36	7.6	14.9	6.0	30.6	13.6	6.3	0.4	3125

Site number Farm operator county soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract Conductivity [mmhos/cm]	Ca me/1	Mg me/1	Na me/1	K me/1	SO_4 (ppm)
				Chlorotic					
Tegner silty	0-6	7.7	12.1	0.8	6.4	0.3	1.7	0.1	50
clay loam	6-12	7.5	18.3	3.4	28.3	4.6	1.8	0.3	2025
	12-24	7.8	18.8	5.0	24.2	16.4	3.1	0.2	8640
	24-36	7.9	21.6	6.5	24.3	23.0	5.2	0.4	8415
				Beans - Non Chlorotic					
(17)									
Joe Duffing	0-6	7.7	6.3	1.6	11.4	2.5	1.1	0.3	tr
Traverse Co.	6-12	7.5	9.7	3.5	35.1	5.4	1.4	0.2	9200
Colvin silty	12-24	7.6	8.8	3.0	27.6	4.9	1.4	0.2	1235
clay loam	24-36	7.3	23.5	4.0	26.6	12.0	2.4	0.2	10325
				Beans - Chlorotic					
Colvin	0-6	7.7	7.3	1.1	6.6	1.6	2.6	0.2	369
silty clay	6-12	7.6	7.1	3.0	21.8	6.4	4.7	0.2	1325
loam	12-24	7.7	7.9	5.5	20.5	14.1	13.0	0.2	6050
	24-36	7.8	23.6	7.5	17.8	20.2	29.2	0.3	3125
				Beans - Normal Growth					
(18)									
Oswald Lyngaas	0-6	7.5	1.6	0.8	2.9	0.7	1.3	0.2	60
Wilkin Co.	6-12	7.4	1.6	0.4	1.3	0.1	0.7	0.2	110
Roxbury loam	12-24	7.7	1.6	0.4	21.4	17.2	0.4	0.2	370
	24-36	8.0	16.2	0.8	1.3	15.7	0.3	0.1	100
				- Less Chlorotic					
Roxbury loam	0-6	6.8	0	4.0	4.2	8.2	6.0	0.3	1325
	6-12	7.0	0	9.0	19.1	14.0	21.7	-	1665
	12-24	7.5	1.7	5.5	8.8	12.9	28.0	0.4	1325
	24-36	7.7	7.0	8.0	16.5	23.3	16.4	1.2	3575
				- Chlorotic					
Roxbury loam	0-6	7.8	3.0	5.5	22.8	14.0	16.7	0.5	3125
	6-12	7.8	2.6	5.0	20.6	14.0	9.4	0.2	4815
	12-24	7.8	3.9	6.0	5.7	-	13.3	0.2	2565
	24-36	8.1	5.3	10+	6.7	-	210.5	0.4	3240
				Beans - Less Chlorotic					
(19)									
Lloyd Ouse	0-6	7.7	16.3	1.1	5.3	1.0	1.6	0.5	255
Wilkin Co.	6-12	7.7	15.6	1.0	4.1	1.1	1.7	0.2	135
Colvin	12-24	8.1	16.9	1.1	3.4	1.64	1.8	0.3	100
Sicl	24-36	8.0	17.7	3.0	10.8	6.6	5.7	0.8	225

Site number Farm operator county soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract Conductivity [mmhos/cm]	Ca me/1	Mg me/1	Na me/1	K me/1	SO_4 (ppm)
				Chlorotic					
Roxbury loam	0-6	7.8	13.4	10+	18.2	27.2	262.0	0.5	9980
	6-12	7.8	13.9	10+	22.5	28.1	273.0	0.3	9540
	12-24	7.9	12.1	10+	19.6	28.4	337.0	0.5	10215
	24-36	7.9	13.6	10+	27.2	37.0	369.0	0.6	3015
				Beans - Less Chlorotic					
(20)									
Emil Olson	0-6	7.5	10.6	0.8	2.9	0.7	2.7	0.2	110
Clay County	6-12	8.2	13.3	0.6	1.8	0.5	2.1	0.2	60
Bearden silty	12-24	8.4	24.1	1.0	1.5	1.1	4.4	0.2	100
clay	24-36	8.4	28.2	4.5	4.8	9.7	22.7	0.4	1215
				Chlorotic					
Bearden	0-6	7.9	11.8	1.5	2.7	0.2	2.8	1.8+	425
silt loam	6-12	8.1	14.6	3.0	6.9	5.8	6.8	0.4	1100
	12-24	8.0	18.4	7.0	10.6	22.1	10.9	1.8+	1890
	24-36	8.0	24.5	8.5	14.2	29.5	8.1	1.8	2340
				Beans - Less Chlorotic					
(21)									
Emil Olson	0-6	7.8	8.1	2.2	7.4	3.9	3.1	0.4	50
(east)	6-12	8.2	18.1	0.8	1.4	1.0	1.5	0.2	50
Bearden silt	12-24	8.3	22.4	1.3	1.3	3.3	1.6	0.3	245
loam	24-36	8.2	22.7	3.6	2.9	11.2	2.6	0.6	255
				Chlorotic					
Emil Olson	0-6	7.6	7.3	1.3	4.5	1.0	3.1	0.6	60
(east)	6-12	7.7	4.8	1.2	3.4	1.0	3.9	0.2	50
Bearden silt	12-24	8.3	26.9	1.3	2.0	1.6	4.4	0.2	60
loam	24-36	8.4	28.3	1.6	2.1	1.6	7.6	0.2	110
				Beans - Less Chlorotic					
(22)									
Paul Hurner	0-6	7.9	8.2	0.6	1.9	0.5	2.4	0.2	135
Clay Co.	6-12	8.0	7.2	0.7	1.6	0.5	3.4	0.2	135
Glyndon very	12-24	8.0	28.2	1.2	1.2	2.0	6.3	0.2	135
fine sandy	24-36	8.0	24.6	1.4	1.0	2.0	3.7	0.3	135
loam									
				Beans - Chlorotic					
Glyndon	0-6	7.9	9.0	1.3	2.8	0.5	1.0	0.8	281
very fine	6-12	8.3	13.3	1.3	19.9	-	1.1	-	500
sandy loam	12-24	8.4	14.7	1.3	-	-	1.4	-	112
	24-36	8.5	25.7	1.7	1.4	0.1	1.8	-	tr

Site number Farm operator county soil type	Depth	pH	% $CaCO_3$ equivalent	Saturation Extract Conductivity [mmhos/cm]	Ca me/l	Mg me/l	Na me/l	K me/l	SO_4 (ppm)
				Beans - Less Chlorotic					
(23)									
Fred Larson	0-6	7.8	24.3	6.2	18.2	15.6	16.5	0.6	2900
Glyndon very	6-12	7.8	23.5	4.1	13.7	9.7	7.9	0.5	1440
fine sandy	12-24	7.9	30.3	7.0	9.2	15.2	131.8	0.4	1665
loam	24-36	8.6	23.1	8.0	7.1	23.0	148.0	0.3	2225
				Chlorotic					
Glyndon very	0-6	8.0	24.0	5.0	11.1	11.0	17.2	0.4	1775
fine sandy	6-12	8.1	29.7	3.8	7.1	9.9	14.6	0.4	1100
loam	12-24	8.3	30.6	8.0	11.1	23.8	22.0	9.5	1550
	24-36	8.5	22.5	5.2	6.6	15.6	19.6	0.5	1550

Site 2 Willert farms Steele Co.	The main difference appears to be in the relatively high $CaCO_3$ equivalent value of the problem soil. Conductivity and other factors are relatively low.
Site 3 Matt Holles Brown Co.	No substantial difference in $CaCO_3$ equivalent, but chlorotic soil area has a markedly greater electrical conductivity indicating presence of high soluble sodium and sulfates. This would be sufficient to induce chlorotic soybeans
Site 4 Vilo Dahmes Redwood Co.	The analyses of these two profiles indicate a greater salt problem where the soybeans were growing normally than the chlorotic location. Lime concentrations are not sufficiently high to be a problem, but electrical conductivity indicates that soluble salts may affect plant growth. This area will be resampled.
Site 5 Elmer Rolland Redwood Co.	Electrical conductivity corroborates a high sodium calcium and magnesium sulfate content which would seriously affect plant growth at the chlorotic profile site.
Site 6 Maurice Regnier Lyon county Vallers SiCL	Here soybeans at both sites showed chlorotic growth Soil pH or calcium carbonate content are not high, but conductivity and high soluble sodium, calcium and magnesium sulfates would be unfavorable for soybean growth.
Site 7 Harold Madson Lincoln Co.	The corn plants were probably affected by the high lime content, and soluble salts were relatively high in the second and third foot depth. The combination of these two subsoil factors would probably produce a limited or elimination of corn growth.
Site 8 Kermit Velde Yellow Med. Co.	Here the high conductivity and high soluble salt content (calcium, magnesium and especially sodium sulfates) would seriously affect soybean growth.
Site 9 A Grooters Yellow Med.	Many species of trees, shrubs and other plants would be seriously damaged by the high salt content present below the 24" depth.

Site 10 D.E. Greenwalt Chippewa Co.	Lime ($CaCO_3$) concentrations are not high, but the very high salt content (calcium, magnesium and especially sodium sulfates) would seriously affect say bean growth.
Site 11 Maurice Gustafson Chippewa County	Conductivity and other analyses show that the high soluble salt content (calcium, magnesium and sodium sulfates) would markedly damage soybean growth.
Site 12 Willard Anderson Kandiyohi Co.	In these profiles, soluble salt content should not be the problem, but the chlorotic profile has considerable lime (calcium and/or magnesium carbonates) commencing at the 6 inch depth.
Site 13 Tracy Rahte Swift Co.	Here, soil pH and lime were high in both profiles, and although the soluble salts were not high, these in combination with the lime may be the cause of the poor soybean growth.
Site 14 Gilbertson farm Kandiyohi Co.	High lime at both of these profiles would limit soybean production, and at the problem site, the presence of only a slightly higher soluble salts accompanied by poorer drainage would be sufficient to produce chlorotic soybeans.
Site 15 Harvey Totzke Traverse Co.	Soluble salts do not seem to be the problem, but lime concentrations below the 12" level appear to be very high.
Site 16 Marvin Raguse Traverse Co.	Although the subsoil (12" and deeper) appear to have a relatively high lime content, the higher soluble salt content (SO_4) may be jus sufficient to produce chlorotic plants.
Site 17 Joe Duffing Traverse Co.	Soluble salt content would probably contribute to poor soybean growth on both of these profiles, and the analytical results fail to show why one profile should have chlorotic soybeans in contrast to the other. This area should be resampled.
Site 18 Oswald Lyngass Wilkin Co.	Soluble salt concentrations (especially sodium sulfate) would cause soybean chlorosis on the two problem areas.
Site 19 Lloyd Ouse Wilkin Co.	Soluble salts (especially sodium sulfate) would produce chlorotic soybean growth at the problem profile.
Site 20 Emil Olson Clay County	Although lime concentrations are slightly high, soluble salts are sufficiently high to produce yellowed soybean plants.
Site 21 Emil Olson(east) Clay County	Here the only marked difference is that the sodium concentration of the chlorotic profile is much higher than the non-chlorotic--especially in the lower depths. This combined with higher calcium carbonate equivalent (lime content) below 12" could be the main cause of soybean yellowing.
Site 22 Paul Herner Clay Co.	Here it appears that the less chlorotic soybean profile has a higher salt content than the less chlorotic site. This would suggest a resampling of this field.
Site 23 Fred Larson Clay Co.	Both profiles are high in pH, calcium carbonate equivalent conductivity and sulfates, and extremely high in sodium. Soybeans growing on these profiles must be affected by the high salt content present.

General comments:

Soybean chlorosis in southern Minnesota appears to be directly related to a high free lime content with essentially no soluble salts present. In western Minnesota it may occur from high concentrations of free lime, a high soluble salt content, or from combinations of both these soil factors. In general, the chlorotic profiles had a lower Ca/Mg ratio.

It would appear that the only real remedy for the chlorotic growth would be to drain the soil, which would gradually remove the excess water soluble salts after some years, but the calcium and magnesium carbonate concentrations would be high for many years. However, a lowering of any one of the salt concentrations might enable normal plant growth. The growing of crop varieties not susceptible to the chlorosis would be one recourse until drainage at least partially corrected the salty soil condition.

Herbicide Residue Studies

Russell Adams, Jr. and Loren Ahlrich

In 1965 three sets of plots were established at Waseca. One set was designed to study the phosphorus triazine herbicide interaction previously observed in greenhouse and growth chamber studies. In this experiment Clintland oats were seeded. Treatments included 0,40,120 and 360 lbs./A of P in combination with 0, 1/8, 1/4 and 3/4 lbs./A of atrazine. Each treatment was replicated 4 times. Average oat yields are shown in Table 1.

Table 1. Oat yields on plots treated with 4 rates of P and 4 rates of atrazine (Waseca, 1965).

Atrazine lbs./A	P lbs./A 0	40	120	360	Average Yield
	(Bu./A)				(Bu./A)
0	60.9	79.1	68.4	66.3	68.7
1/8	68.7	63.1	63.0	67.1	65.5
1/4	63.0	70.5	57.1	75.3	66.5
3/4	51.3	65.3	64.0	60.4	60.2
Average Yield	61.0	69.5	63.1	67.3	

There was no evidence of an effect of increased P fertilization upon oat yields when residue amounts of atrazine was present. However, some general reduction in yield was observed at the 3/4 lb./A rate of atrazine.

In the second experiment atrazine was incorporated into the surface soil to simulate residue conditions. The intention of this study was to determine precisely what yield reduction could be expected when a given amount of residue was present at planting time. Data are shown in Table 2.

Table 2. Yields of Clintland oats grown on plots where 5 rates of atrazine had been incorporated (Waseca, 1965).

Atrazine lbs./A	Replication I	II	III	IV	Average Yield
	(Bu./A)				
0	51.7	76.1	59.2	78.0	66.2
1/8	70.0	--	63.1	58.2	63.8
1/4	70.6	68.1	63.3	57.6	64.9
1/2	66.5	68.2	57.7	66.9	64.7
3/4	79.5	61.6	65.1	69.8	66.5

As can be seen in Table 2 no yield reduction in oats occurred from as much as 3/4 lb./A of atrazine. Unfortunately, stand counts were not made in these experiments; so that exact data on stand reduction is not available. However, stands in the 1/2 and 3/4 lb./A plots in both of the oats experiments were estimated early in the spring to be reduced by 25 to 50%. The unusually favorable season led to stooling and complete recovery of injury to the oats crop as far as yields were concerned.

In the final experiment atrazine was incorporated at 0, 1/8, 1/4, 1/2, 3/4 and 1 lb./A. Following incorporation of atrazine Chippewa-64 soybeans were planted in 36 inch rows. Yield data is given in Table 3.

Table 3. Yields of Chippewa-64 soybeans on plots were 6 rates of atrazine was incorporated (Waseca, 1965).

Atrazine lbs./A	Replication I	II	III	IV	Average Yield
	(Bu./A)				
0	28.1	24.0	28.3	29.0	27.4
1/8	32.8	27.7	26.8	30.6	29.5
1/4	20.7	29.3	25.3	30.0	26.3
1/2	30.1	29.0	24.3	27.1	25.6
3/4	29.8	25.8	26.7	19.3	25.4
	26.4	24.1	25.0	26.0	25.5

As with the oats no significant reduction in soybean yields resulted from any rate of atrazine used. Early in the season considerable necrosis in the soybean leaves, typical of atrazine injury, was noted at the 3/4 and 1 lb./A rate. No apparent reduction in stand occurred and all indications of injury disappeared as the lower leaves dropped and the summer progressed.

It is evident from these data that in a season of abundant rainfall, as was experienced in 1965, considerable atrazine residue must be carried over before serious injury to the crop will occur. Plans are being made to extend these plots to other stations and to continue this research for a few years in order to evaluate just how much atrazine residue must be present at the beginning of the season to produce a significant reduction in yields of oats and soybeans.

Soil Productivity Study

R. H. Rust

The soil productivity study which began in 1956 is an attempt to gain reliable estimates of the productivity of major soil types in Minnesota. This productivity is estimated for the major crops under several generally specified soil management programs. The estimates are incorporated in the soil survey reports published for the individual counties by the Soil Conservation Service, USDA, and the Experiment Station, cooperatively.

Since the project began 547 farm cooperators have furnished crop and soil management data on some 92 extensive soil types in the state. Currently 412 cooperators are enrolled in the project. The following kinds of data are recorded: date and rate of seeding; stand estimate; kind and amount of soil amendments used; moisture and temperature conditions during the growing season; weed and insect control measures; yields and losses of yield from harvesting or abnormal conditions; soil tests of pH, available P and K, organic matter.

In the following table the various soils included in the study are listed together with (1) number of fields, and (2) number of yields. Where 2 or more yields of a crop have been recorded, the crops, number of fields, and the average yields are given. On those soil series where data is available, yields are given according to the mapping phase, i.e., slope plus erosion. The reader may establish the location of the listed soils by reference to Soils of Minnesota, Ext. Bul. 278 (1963), or to the appropriate county soil report.

It should be noted that the average yields, particularly when only a few yields are included, do not necessarily reflect the relative productivity of the soils listed. They serve only to indicate the nature of yield levels attained in the last one to sev years by farmers who are in general using above average management. Many of the yields also reflected very favorable weather patterns as well as very unfavorable seasons. For those personnel concerned the data may serve to indicate where additional effort is needed.

Note: A-1 = 0-2 percent slopes, little or no erosion
B-1 = 2-6 percent slopes, little or no erosion
C-1 = 6-12 percent slopes, little or no erosion
B-2 = 2-6 percent slopes, one-third to two-thirds of surface eroded
D-2 =12-18 percent slopes, one-third to two thirds of surface eroded

Where yields are given according to mapping unit (e.g., B-1), only the years 1960-65 are included.

Table 1. Soil series, number of fields, and number of yields included in soil productivity study to date. Average yields of selected crops given where two or more yields received. Yields of grain crops in bushels; hay silage, and sugar beets, in tons; pasture, in cow-acre days.
* Number of fields on this series
** Number of yields on all crops

Aastad	(11)*	(48)**
Corn	15	51
Flax	6	12
Oats	7	57
Spring wheat	3	32
Barley	4	49
Alfalfa-brome-past.	3	136
Soybeans	3	25
Hay (other)	2	4.6
Pasture (other)	4	171
Anoka	(1)*	(1)**
Arlington	(1)	(7)
Oats	2	64
Alfalfa	3	3.9
Barnes	(16)	(88)
Corn	32	55
A-1	3	52
B-1	21	56
B-2	3	51
C-2	3	51
Oats	13	56
Flax	8	8
Soybeans	7	23
Alfalfa-brome	7	1.9
Barley	5	42
Alfalfa	8	1.8
Spring wheat	6	28
Corn silage	2	6.0
Bearden	(9)	(30)
Corn	7	61
Barley	5	53
Spring wheat	4	38
Sugar beets	4	11.8
Oats	3	55
Soybeans	3	21
Flax	2	1.5
Beltrami	(4)	(17)
Oats	4	75
Alfalfa	8	3.2
Alfalfa-brome-past.	2	76
Corn	3	64
Blue Earth	(3)	(15)
Corn silage	4	8.9
Corn	4	39
Soybeans	3	18
Oats	2	25
Alfalfa-brome	2	3.0
Borup	(1)	(1)
Braham	(4)	(4)
Brainerd	(5)	(17)
Oats	5	38
Corn	4	58
Corn silage	2	13.0
Hay (others)	6	2.8
Brickton	(4)	(6)
Alfalfa-brome	2	3.1
Buse-Barnes	(2)	(14)
Alfalfa-brome	3	1.6
Flax	2	9
Soybeans	3	15
Central	(4)	(5)
Chetek	(1)	(2)
Alfalfa	2	1.9
Chilgren	(5)	(38)
Oats	8	42
Barley	3	47
Flax	3	6.6
Spring wheat	3	18
Alfalfa	4	2.5
Alfalfa-tim.	3	2.4
Hay (other)	4	2.4
Corn silage	3	9.3
Wheat	4	33
Pasture (other)	2	243
Clarion	(37)	(148)
Corn	57	73
B-1	32	72
B-2	6	67
C-1	7	74
Oats	27	71
B-1	23	72
B-2	2	43
C-2	1	71
Soybeans	12	29
Spring wheat	8	31
Alfalfa-brome	13	3.1
Alfalfa	13	3.0
Mix. Leg. grass	3	5.0
Corn silage	3	14.5
Alfalfa-brome-past	3	228
Colvin	(6)	(18)
Alfalfa	4	3.6
Corn	9	70
Comfrey	(1)	(9)
Sorghum	5	8.5
Corn	2	60

Cormant	(4)	(17)
Oats	7	31
Alfalfa-brome	6	3.8
Downs	(3)	(14)
Corn	6	105
Oats	3	65
Alfalfa	3	3.4
Dubuque	(4)	(16)
Alfalfa=brome	3	4.5
Alfalfa	3	2.1
Enstrom	(1)	(2)
Alfalfa-brome past.	2	222
Estelline	(1)	(3)
Esterville	(17)	(62)
Corn	18	60
A-1	13	59
B-2	1	72
Oats	12	45
Alfalfa-brome	10	2.1
Alfalfa	8	
Corn silage	6	7.8
Soybeans	2	10.0
Fairhaven	(9)	(17)
Corn	7	62
Oats	4	63
Alfalfa	2	2.3
Fargo	(23)	(75)
Spring wheat	18	37
Oats	8	41
Soybeans	3	23
Flax	7	13
Barley	7	30
Alfalfa-brome	6	1.5
Alfalfa	2	3.1
Sugar beets	10	13.4
Durham wheat	3	39
Fayette	(7)	(38)
Corn	15	85
B-1	9	87
B-2	3	65
Oats	7	54
Alfalfa-brome	6	6.0
Alfalfa	3	3.0
Flom	(8)	(36)
Corn	12	73
Oats	6	56
Soybeans	3	17
Flax	6	18
Corn silage	3	15.0
Floyd	(5)	(23)
Corn	10	84
Soybeans	6	26
Oats	3	87
Fossum	(2)	(5)
Barley	2	49
Foxhome	(1)	(4)
Freer	(3)	(19)
Oats	5	66
Hay (other)	5	2.4
Corn silage	3	8.1
R.-Cl.-tim.	2	2.0
Freon	(6)	(12)
Oats	6	52
Glencoe	(1)	(1)
Greenbush	(3)	(10)
Corn silage	3	10.4
Hay (other)	2	1.5
Corn	3	61
Grimstad	(7)	(32)
Barley	6	41
Flax	3	10
Soybeans	4	15
Spring wheat	10	32
Oats	3	75
Grygla	(3)	(16)
Oats	4	36
Pasture (others)	2	112
Pasture (mix-leg-grass)	2	81
Alsike-tim.	2	1.3
Hamerly	(1)	(4)
Flax	2	15
Hantho	(2)	(5)
Corn	2	58
Harpster	(1)	(2)
Oats	2	34
Hayden	(24)	(95)
Corn	27	76
B-1	2	101
B-2	3	98
C-1	3	46
D-2	2	86
D-3	4	77

Oats	17	56
Alfalfa	19	3.5
Alfalfa-brome	17	3.7
Alfalfa-brome-past.	9	308
Hegne	(7)	(21)
Spring wheat	7	36
Barley	4	51
Alfalfa	2	1.2
Potaotes	2	251
Hibbing	(4)	(8)
Alfalfa	3	3.2
Holdingford	(1)	(2)
Hubbard	(14)	(71)
Corn	26	62
A-1	13	67
B-2	4	29
Soybeans	12	21
Oats	8	42
Potatoes	5	425
Alfalfa	7	2.4
Alfalfa-brome	6	2.3
Corn silage	5	11.1
Kasson	(2)	(11)
Oats	2	65
Corn	2	83
Kato	(1)	(6)
Corn	2	72
Kenyon	(2)	(11)
Corn	4	86
Hay (other)	3	3.7
Alfalfa	3	2.7
Oats	2	66
Kingston	(3)	(17)
Corn	10	82
Soybeans	5	22
Kingston,variant	(1)	(3)
Oats	2	26
Kittson	(2)	(10)
Corn silage	2	4.9
Alfalfa	3	4.4
Kranzberg	(2)	(7)
Alfalfa-brome	3	2.3
Alfalfa	2	2.3
Lamoure	(2)	(15)
Corn	5	68
Soybeans	3	32
Sweet corn	3	7.0
Alfalfa-brome	2	3.9
Lerdal	(1)	(7)
Corn	4	82
Lester	(12)	(48)
Alfalfa	15	4.0
Corn	12	67
Oats	7	55
Alfalfa-brome	7	3.4
LeSueur	(9)	(40)
Corn	23	79
A-1	5	75
A-2	3	50
B-1	10	87
Soybeans	6	25
Oats	3	53
Barley	2	49
Litchfield	(2)	(18)
Corn	4	84
Soybeans	2	23
Oats	3	72
Potatoes	3	383
Alfalfa	5	3.4
Marcus	(1)	(1)
Marna	(6)	(22)
Corn	13	89
Soybeans	4	38
Alfalfa	2	5.1
Mavie	(2)	(3)
McDonaldsville	(1)	(3)
McIntosh	(3)	(21)
Oats	5	66
Spring wheat	7	33
Barley	4	69
Corn	2	70
Alfalfa	2	3.0
Meeker	(1)	(1)
Menahga	(6)	(21)
Oats	3	38
Alfalfa-brome	8	2.3
Corn silage	5	9.3
Pasture (alfalfa brome)	3	147
Milaca	(8)	(32)
Oats	5	37
Corn	5	61
Hay (other)	6	2.6
Mix leg.-grass	4	2.0
Corn silage	5	11.4
Alfalfa	2	3.4
Alfalfa-brome	2	2.8
Moody	(2)	(6)
Corn	4	70

Mora	(4)	(23)
Corn	7	57
Oats	4	50
Mixed leg.-grass	4	3.2
Corn silage	3	8.3
Nebish	(7)	(39)
Oats	10	47
Alfalfa	7	1.7
Alfalfa-brome	9	4.3
Alfalfa-brome-past.	7	78
Nicollet	(21)	(104)
Corn	43	75
A-1	22	81
B-1	13	75
Oats	15	59
Soybeans	13	30
Spring wheat	4	32
Barley	2	94
Alfalfa	13	3.7
Alfalfa brome	4	4.0
Corn silage	4	7.9
Nokay	(5)	(20)
Corn	7	54
Oats	5	42
Corn silage	6	8.0
Nymore	(3)	(5)
Alfalfa	2	1.8
Onamia	(5)	(23)
Oats	5	63
Corn	6	71
Alfalfa	4	3.5
Alfalfa-brome	2	1.8
Pasture (brome)	2	200
Ostrander	(7)	(22)
Corn	8	77
Soybeans	3	27
Alfalfa	3	4.5
Parent	(1)	(1)
Parnell	(2)	(11)
Corn	6	53
Oats	3	77
Deep Peat	(6)	(26)
Corn	4	71
Soybeans	3	24
Timothy (seed)	3	334
Corn silage	2	6.5
Pasture (other)	5	119
Leg.-grass past.	2	242
Shallow Peat	(5)	(7)
Soybeans	3	24
Barley	2	56
Pierce	(1)	(1)
Racine	(1)	(1)
Redby	(3)	(16)
Leg.-grass hay	3	1.5
Leg.-grass past	5	88
RCl-tim hay	7	2.5
Oats	2	40
Rocksbury	(12)	(41)
Oats	10	60
Flax	5	8
Alfalfa	3	2.9
Hay (other)	6	1.5
Sweet corn-brome	2	
Pasture (other)	3	117
Wheat	5	23
Rockwell	(5)	(17)
Oats	3	52
Barley	4	25
Alfalfa	2	1.7
Corn silage	2	12.9
Wheat	2	29
Rothsay	(1)	(1)
Sioux	(4)	(11)
Oats	5	37
Soybeans	2	12
Alfalfa	2	0.8
Shooks	(2)	(9)
Oats	5	48.
Alfalfa	2	2.0
Skyberg	(3)	(12)
Corn	5	78
Oats	2	83
Leg.-grass past.	2	154
Sletton	(1)	(5)
Soybeans	3	30
Storden-Clarion	(1)	(7)
Oats	2	80
Alfalfa	5	2.9
Tama	(8)	(48)
Oats	15	72
Corn	14	91
A-1	6	87
B-1	4	97
B-2	2	106
C-1	2	43
C-2	1	43
Corn silage	3	14.2
Alfalfa	6	4.2
Alflafa-brome	4	4.3

Leg.-grass hay	4	3.3
Alfalfa-brome past.	3	178
Taylor	(1)	(5)
Oats	3	45
Alfalfa	2	1.7
Terrill	(1)	(2)
Todd	(2)	(8)
Alfalfa-brome	4	2.2
Corn silage	3	7.0
Truman	(3)	(10)
Corn	4	90
Ulen	(4)	(29)
Oats	10	50
Corn	6	52
Corn silage	2	15.5
Alfalfa	3	2.3
Vallers	(3)	(17)
Corn	4	65
Oats	2	63
Soybean	6	21
Varco	(1)	(6)
Corn	4	88
Alfalfa-brome	2	2.8
Vienna	(2)	(6)
Corn	3	63
Oats	2	60
Wabash	(1)	(4)
Corn	3	109
Wadena	(4)	(18)
Corn	7	76
Soybean	4	21
Oats	3	80
Waukegan	(9)	(38)
Corn	15	74
A-1	7	76
B-1	7	71
Alfalfa-brome	3	3.1
Oats	8	81
Alfalfa	4	1.9
Soybeans	2	33
Waukon	(10)	(42)
Corn	10	63
Oats	7	57
Barley	4	36
Spring wheat	3	30
Alfalfa	10	2.2
Mix.leg.-grass	3	4.1
Webster	(39)	(161)
Corn	73	87
Oats	28	63
Soybeans	20	21
Alfalfa	17	4.2
Alfalfa-brome	9	2.8
Corn silage]	5	10.1
Alfalfa-brome past.	2	75
Mix-Leg grass	2	3.2
Webster Calc. Var.	(8)	(37)
Corn	12	89
Oats	3	85
Soybeans	10	34
Alfalfa	4	3.2
Wildwood	(2)	(7)
Oats	2	33
Winger	(4)	(24)
Oats	9	76
Barley	5	40
Spring wheat	4	29
Alfalfa	3	1.6
Zimmerman	(3)	(16)
Corn	3	62
Oats	2	57
Corn silage	4	9.7
Hay (other)	3	9.4

Grand total as of December 1965

	No. Fields	No. Yields
	548	2259

SOILS AND CROP MANAGEMENT SYSTEMS

West Central Experiment Station

Roy L. Thompson, Samuel D. Evans, and Lowell Hanson

All yields were very high in 1965 due to above normal precipitation. Corn yields were 31.5 bu./acre higher on the test than on the base plots. Soybean yields were moderately high with the test plot yielding 3.4 bu./acre more than the base plots. Alfalfa yields were extremely high with a top yield of 6.0 tons/acre on the continuous alfalfa base treatment plots. The 1960-65 yields are given in the following table. For treatments see the February 1965 Blue Book.

	Base Management	Test Management
	Continuous Soybeans	
1960	16.8 bu./A	23.1 bu./A
1961	20.7	28.4
1962	21.2	26.4
1963	23.4	36.7
1964	15.6	22.1
1965	24.7	28.1
Average	20.4	27.5
	Continuous Corn	
1960	61.2 bu./A	70.3 bu./A
1961	62.0	65.5
1962	67.0	87.4
1963	72.7	73.1
1964	36.7	34.2
1965	69.5	101.0
Average	61.6	71.9

	Base Management	Test Management
	Continuous Alfalfa	
1960	1.4 tons/A	1.8 tons/A
1961	2.2	2.0
1962	4.8	5.1
1963	4.9	4.9
1964	3.0	3.1
1965	6.0	5.4
Averages	3.7	3.7
	Rotation Plots	
1960 (oats) Grain:	86.7 bu./A	90.0 bu./A
Silage:	7.9 tons/A (Green wt.)	8.2 tons/A (Green wt.)
1961 (alfalfa) After Grain:	1.87 tons/A	1.79 tons/A
After Silage	2.44 tons/A	2.19 tons/A
1962 (Soybeans)	24.1 Bu./A	25.6 Bu./A
1963 (Corn) =	86.4 Bu./A	113.9 Bu./A
1964 (Oats) Grain:	65.1 Bu./A	94.2 Bu./A
Silage:	1.14 tons/A (Dry wt.)	1.76 tons/A (Dry wt.)
1965 (alfalfa) After Grain:	5.1 tons/A	5.3 tons/A
After Silage:	4.8 tons/A	5.4 tons/A

Continuous Soybean Fertility Study (Rosemount, 1965).

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

Soybeans have been grown continuously on a Port Byron silt loam at Rosemount, Minnesota, since 1957. Fertilizer treatments consisting of varying rates of P and K were applied at the start of the experiment. No additional fertilizer has ever been applied.

In the eighth crop following the fertilizer applications bean yields were generally low due to late planting and a cold spring and early fall which delayed maturity. The yields are reported in Table 1. It is amazing to note that although all the differences may not be significantly different from the control mean, all treatments gave increases over the check. The yields of those plots which received the 0-400-400 fertilizer application in 1957 averaged 4 bushels higher than the unfertilized plots.

Table 1. Residual effect of fertilizer treatments on the yield of soybeans grown continuously (Rosemount, 1965).

	Treatment: (applied in 1957)			1965 Yield	
No.	P	K	Manure	Bu./acre	Diff.
1	0	0		11.6	---
2	20	20		12.7	+1.1
3	40	40		12.7	+1.1
4	60	60		12.3	+0.7
5	80	80		13.4	+1.8
6	400	400		15.9	+4.3
7	400	400	6 ton	13.8	+2.2
8	20	0		12.6	+1.0
9	20	20		12.3	+0.7
10	80	0		14.7	+3.1
11	0	80		12.4	+0.8
12	400	0		15.0	+3.4
13	0	400		14.3	+2.7
14	0	0	6 ton	14.6	+3.0
15	20	0	6 ton	13.1	+1.5

lsd (.95)
hsd (.95)

FERTILIZER ROTATION EXPERIMENT

West Central Experiment Station

Samuel D. Evans and A.C. Caldwell

An NPK factorial expeririment involving the three nutrients alone and in all combinations applied across a five-year rotation and continuous corn has been in existence ten years. Treatments, rates and yields are given in the following tables:

Table 1. Yield of Continuous Corn

Treatment	$N-P_2O_5-K_2O$ Lbs./A	Av. Yield Bu./A	Diff. from Untreated	Treatment Effect	1956-65 Av. Yield Bu./A	1956-65 Treatment Effect
None	0+0+0	61.75	- -	- -	59.3	- -
N	160+0+0	115.35	+53.60	+49.69**	75.8	+24.4
P	0+140+0	67.09	+5.31	+6.13	55.0	-0.1
K	0+0+40	63.36	+1.61	+1.57	54.8	-0.1
NP	144+140+0	116.50	+54.75	-1.12	81.7	+2.8
NK	160+0+40	111.12	+49.37	-1.81	81.7	+2.8
PK	0+140+40	72.26	+10.51	+2.89	53.5	0.8
NPK	144+140+40	120.26	+58.51	+0.99	81.2	+2.4
NPK+	304+320+80	96.36	+34.61	- -	71.6	- -

Table 2. Yield of First-Year Corn

Treatment	$N-P_2O_5-K_2O$ Lbs./A	Av. Yield Bu./A	Diff. from Untreated	Treatment Effect	1956-65 Av. Yield Bu./A	1956-65 Treatment Effect
None	0+0+0	88.81	- -	- -	68.9	- -
N	60+0+0	88.19	-0.62	+12.68**	70.8	+1.3
P	0+20+0	116.04	+27.23	+32.93**	78.3	+8.6
K	0+0+40	72.06	-16.75	-1.48	65.7	-2.6
NP	44+20+0	127.08	+38.27	-2.05	77.6	-0.7
NK	60+0+40	102.23	+13.42	+7.52	67.8	+0.7
PK	0+20+40	114.80	+25.99	-0.12	75.0	+0.5
NPK	44+20+40	125.12	+36.31	-8.38	76.8	+0.6
NPK+	84+100+80	120.46	+31.65	- -	77.6	- -

Table 3. Yield of Second-Year Corn

Treatment	N-P_2O_5-K_2O Lbs./A	Av. Yield Bu./A	Diff. from Untreated	Treatment Effect	1956-65 Av. Yield Bu./A	1956-65 Treatment Effect
None	0+0+0	95.37	- -	- -	73.0	- -
N	80+0+0	98.10	+2.73	+20.02**	76.1	+5.7
P	0+60+0	79.76	-15.61	+6.26	73.6	+4.7
K	0+0+40	73.28	-22.09	+2.06	66.5	-2.4
NP	64+60+0	108.90	+13.53	+1.80	80.1	+1.0
NK	80+0+40	106.99	+11.62	+4.09	72.9	+0.9
PK	0+60+40	97.80	+2.43	+8.66	73.4	+2.4
NPK	64+60+40	112.30	+16.93	-11.40	80.4	-0.7
NPK+	104+100+80	104.76	+9.39	- -	79.7	- -

Table 4. Yield of Soybeans

Treatment	N-P_2O_5-K_2O Lbs./A	Av. Yield Bu./A	Diff. from Untreated	Treatment Effect	1956-65 Av. Yield Bu./A	1956-65 Treatment Effect
None	0+0+0	27.92	- -	- -	23.9	- -
N	20+0+0	29.09	+1.17	-0.78	24.7	+0.5
P	0+40+0	33.78	+5.86	+5.12**	26.5	+1.7
K	0+0+40	29.94	+2.02	+2.01	24.1	+0.2
NP	20+40+0	33.00	+5.08	-1.70	26.5	-0.2
NK	20+0+40	30.64	+2.72	-0.96	24.9	+0.2
PK	0+40+40	37.71	+9.79	+0.22	26.4	+0.7
NPK	20+40+40	33.54	+5.62	-0.73	27.1	+0.2
NPK+	40+80+80	34.38	+6.46	- -	27.9	- -

Table 5. Yield of Flax

Treatment	$N-P_2O_5-K_2O$ Lbs./A	Av. Yield Bu./A	Diff. from Untreated	Treatment Effect	1956-65 Av. Yield Bu./A	1956-65 Treatment Effect
None	0+0+0	28.93	- -	- -	20.5	- -
N	60+0+0	30.40	+1.47	-2.98**	20.2	+0.1
P	0+40+0	28.44	-0.49	+0.57	19.5	-0.3
K	0+0+20	28.38	-0.55	-0.76	20.1	+0.7
NP	60+40+0	32.44	+3.51	+1.51	20.5	-0.5
NK	60+0+20	29.85	+0.92	+0.24	21.8	-0.2
PK	0+40+20	26.99	-1.94	-0.20	21.4	+0.1
NPK	60+40+20	31.96	+3.03	+0.24	19.9	-1.1
NPK+	120+80+40	32.15	+3.22	- -	21.7	- -

Table 6. Yield of Alfalfa

Treatment	$N-P_2O_5-K_2O$ Lbs./A	1956-64 Av. Yield Tons/A	1956-64 Treatment Effect
None	0+0+0	2.50	- -
N	20+0+0	2.34	-0.11
P	0+80+0	3.84	+1.25
K	0+0+40	2.11	-0.01
NP	20+80+0	3.27	-0.22
NK	20+0+40	2.48	+0.25
PK	0+80+40	3.70	+0.11
NPK	20+80+40	3.61	-0.01
NPK+	20+160+80	3.60	- -

Yields were not taken in 1965.

Continuous Corn - High Fertility Experiment
Rosemount Experiment Station
Established - 1953

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

Yield results 1965 (For experimental design and past years results see p. 47 in the in the mimeographed "Bluebook," February 1963, p. 67, Jan. 1964, and p. 33, Feb. 1965.

Fertilizer Treatments*	Yield Bu./Acre 16,500 plants	Yield Bu./Acre 19,500 plants	Yield Inc./#N 16,500 plants	Yield Inc./#N 19,500 plants
1. Check	30.2	40.5	--	--
2. 16 + 32 + 32	52.8	71.8	--	--
3. 49 + 32 + 32	67.5	96.2	.30	.50
4. 82 + 32 + 32	79.0	101.8	.32	.37
5. 32 + 80 + 128	56.5	68.2	--	--
6. 65 + 80 + 128	80.8	99.2	.37	.48
7. 98 + 80 + 128	96.0	109.0	.40	.42
8. 48 + 128 + 224	59.0	94.2	--	--
9. 81 + 128 + 224	95.8	110.8	.45	.21
10. 104 + 128 + 224	104.8	114.5	.44	.20

* #N + #P_2O_5 + #K_2O

The 1965 yield data indicate a tremendous response to nitrogen fertilization. This response can be measured by the yield increase per pound of N applied as indicated by the table above. The late, cold, wet spring along with a cool moist growing season and the 13 year duration of this experiment may be the explanation of this N response.

ALFALFA EXPERIMENT 1965
Pierz (Morrison Co.), Minnesota

C. J. Overdahl, L. D. Hanson
University of Minnesota

Experimental plots were established to determine needed rates of potassium, phosphorus and lime for alfalfa on sandy soils.

Five rates of potassium were applied at seeding time. Each of these plots were split three ways for topdressing. Adequate rates of phosphorus, lime, sulfur and boron were applied.

In a second plot, adequate lime, sulfur and boron were applied to all plots. Three rates of phosphorus and three rates of lime were applied. All plots were replicated four times.

Potassium Experiment:

B = Basic K_2O treatment per acre at seeding time
T = Topdressed K_2O treatment fall of 1964
Yields = Tons per acre at 20% moisture

Cutting	B_0 T_0	B_0 T_{120}	B_0 T_{240}	B_{60} T_0	B_{60} T_{120}	B_{60} T_{240}
1	1.58	2.22	2.12	1.70	2.24	2.38
2	1.72	2.02	2.36	1.74	2.14	2.16
3	.72	.92	1.00	.72	.89	1.10
Total	4.02	5.16	5.48	4.16	5.27	5.64
T Increase	-	1.14	1.46	-	1.11	1.48

Cutting	B_{120} T_0	B_{120} T_{120}	B_{120} T_{240}	B_{180} T_0	B_{180} T_{120}	B_{180} T_{240}
1	1.80	2.49	2.52	2.24	2.32	2.35
2	1.95	2.40	2.52	2.00	2.18	2.34
3	.75	1.00	1.14	.84	.96	1.07
Total	4.50	5.89	6.18	5.08	5.46	5.76
T Increase	-	1.39	1.60	-	.38	.68

Cutting	B_{240} T_0	B_{240} T_{120}	B_{240} T_{240}	Calculated Check Plot Yields*
1	2.28	2.37	2.52	1.06
2	2.12	2.15	2.36	1.26
3	.96	1.05	1.15	.45
Total	5.36	5.57	6.03	2.77
T Increase	-	.21	.67	

*Lime and P response deducted from K check plots.

Summary of Potassium Plots (2 years 1964 and 1965)

Plots with no topdressing (T_0 2 years)

Year	Cutting	B_0	B_{60}	B_{120}	B_{180}	B_{240}
1964	1	1.33	1.46	1.57	1.61	1.72
	2	.98	.94	1.03	1.09	1.28
1964 Total		2.31	2.40	2.60	2.70	3.00
1965	1	1.58	1.70	1.80	2.24	2.28
	2	1.72	1.74	1.95	2.00	2.12
	3	.72	.72	.75	.84	.96
1965 Total		4.02	4.16	4.50	5.08	5.36
2-Year Total		6.33	6.56	7.10	7.78	8.36
2-Year Increases		-	.23	.77	1.45	2.03

Summary of K Experiment:

A top yield of 6.18 tons per acre was obtained. The check yield of 4.02 tons is unusually high for this soil. Rainfall was above normal until the time of the second cutting. If rains had continued, a higher yield would have been obtained from the third cutting (August 31).

The dry weather continued after the last cutting with a regrowth of only 2 or 3 inches at the most. Plots were again topdressed in October, 1965.

There is an unexplained, comparatively high yield on the 120 pound and 240 pound topdressings on the 120 pound seeding time basic treatment. This does not appear in the T_0 of this basic treatment. The response curve of all seeding time treatments is a straight line upward from B_0 to B_{240}. A similar straight line does not occur when averages of all three topdressing treatments within each seeding time basic treatment are averaged. The highest yield occuring with the B_{120} treatment. A similar comparatively high yield was obtained in 1964 when the T treatments were all zero. Topdressing was not started until after the first harvest year.

Actually, the topdressing results are perhaps best indicated by observing B_0 and B_{240}. The 1.49 ton increase from T_{240} where no potassium was applied at seeding time (B_0) compares to a T_{240} increase of .67 tons on the 240 pounds K_2O seeding time treatment (B_{240}). A lower but similar relationship is observed with the 120 pound topdressing of K_2Obetween these two basic treatments.

Summary of Lime - P Plots

Year	Cutting	Lime Rates Tons/Acre L_0	$L_{2\frac{1}{2}}$	L_5
1964	1	1.27	1.41	1.55
	2	0.99	1.08	1.10
1965	1	2.33	2.35	2.48
	2	2.13	2.16	2.25
	3	.91	1.01	1.05
Total		7.63	8.01	8.43
2-Year Increase			.38	.80

Year	Cutting	Rates of P_2O_5/Acre Annually P_0	P_{30}	P_{60}
1964	1	1.29	1.40	1.53
	2	0.99	1.18	1.19
1964 Total		2.28	2.58	2.72
1965	1	2.06	2.48	2.63
	2	1.99	2.23	2.33
	3	.92	1.00	1.05
1965 Total		4.97	5.71	6.01
2-Year Total		7.25	8.29	8.73
Average per year		3.62	4.14	4.36
P_2O_5 Increase/average per year		-	.52	.74

pH	P	K	Soil
6.3	19 Med-High	50 Very low	Brainerd sandy loam

Summary:

There appears to be a lime response with the pH at 6.3. Two and one-half tons of lime changed the pH to 6.7 and five tons increased the pH to 7.0.

There is a definite phosphorus response.

RESULTS AT DULUTH

In fall 1960 a study was undertaken at the Duluth Station to determine the effect of various levels of potassium on alfalfa yield, tissue analysis, and soil test. Treatments of 0, 120, 240, 480 and 960 pounds of K_2O per acre were broadcast and plowed under in fall 1960 and the plots were seeded to an alfalfa-grass mixture with oats as a nurse crop in spring 1961. Phosphorus, lime, and boron were applied in adequate amounts to all plots. In 1963, 200 pounds per acre of K_2O were topdressed on half of each of the plots after the first cutting.

Simple economics show that best profits from potassium use are among the high treatments.

If the potassium treatments continue to produce the above yield trends, it appears that the greatest profit increase will be from the very high levels of potassium.

Alfalfa-brome Yields in Tons per Acre According to Potash Treatment with Related Soil Tests and Tissue Analysis*

K_2O lb/A.	1962	1963	1964**	1965	Average	K Soil Test	Average % K and relative level
0	2.7	2.4	1.1	2.2	2.1	70 Low	1.00 deficient
120	3.1	3.0	1.5	3.2	2.7	80 Low	1.40 deficient
240	3.5	3.7	1.6	3.0	3.0	83 Low	1.44 deficient
480	3.4	3.9	2.0	3.5	3.2	106 Med.	1.78 low
960	3.6	4.3	2.5	3.5	3.5	203 Med-H.	2.33 sufficient

* Data by Grant, Hopen, Caldwell, and Baker
** Sampled at 0- to 6-inch depth in fall 1963 (3 years after application.)

Four-Year Net Returns from Varying Potassium Treatments

K_2O lb./A.	4-Yr. Increase over check, Tons/Acre	4-Yr. Gross Returns*	K Fertilizer Cost**	4-Yr. Net Profit Increase
120	2.19	$43.80	$ 5.50	$38.30
240	3.34	66.80	11.00	55.00
480	4.20	84.00	22.00	62.00
960	5.23	104.60	44.00	60.60

* $20 per ton of alfalfa
** K_2O figured at $55 per ton.

Topdressing Effect on 1964 Yield, Surface Soil Test, and Tissue Analysis

K_2O lb/Acre			Yield		2-Yr.		
Broadcast 1960		Topdressed 1963	1964	1965	increase	K Soil Test	% K Tissue and Relative Level
120		---	1.5	2.5	--	80 low	1.33 deficient
120	+	200	1.8	3.2	1.0	140 medium	2.42 sufficient
240		--	1.6	2.5	--	83 low	1.46 deficient
240	+	200	2.1	3.0	1.0	146 medium	2.55 sufficient
480		--	2.0	2.9	--	106 medium	1.87 deficient
480	+	200	2.3	3.5	0.9	246 high	2.56 sufficient

Rosemount Soils Farm

Rosemount Agricultural Experiment Station
1965

*Paul M. Burson and E. G. Bonnell

The year 1965 was the wettest year in the history of the Rosemount Soils Farm. From April 1 to September 30 there was a total of 29.48 inches. Along with this large amount of rainfall the intensities were very high. For example, on June 1 there was a total of 2.10 inches. Of this total .95 of an inch came in 40 minutes in 3 intensity periods. In one 10 minute period there was .35 of an inch, in another 20 minute period there was .35 of an inch and in another 10 minute period there was .25 of an inch. With such intensities erosion was severe on some fields where grassed waterways were not necessary until this year. On May 27 there was a very damaging frost to the corn on the lower fields. On July 8 there was a severe wind storm that was clocked at 90 miles per hour that caused considerable damage to the corn and small grain plots. With these extreme seasonal and weather conditions coupled with lower than normal temperatures these weather stresses brought out the importance and necessity of good land use, crop rotation systems and response to the different fertilizer treatments. All crops were delayed in planting because of the extremely wet conditions. Almost 8.0 inches of precipitation came during May and June.

Beef Production from Fertilized Renovated and Fertilized Grass Pastures
1965

P. M. Burson, Soils; A. R. Schmid, Agronomy;
A. L. Harvey and J. C. Meiske, Animal Husbandry

Four types of pasture treatments, replicated twice, were compared on the G series. The treatments consisted of grass with no fertilizer, grass with 8 tons of manure per acre applied in the fall, 80 lbs. of actual nitrogen applied in the spring plus 200 lbs. of 0-20-20 applied annually and renovated pastures with the same annual application of 0-20-20. Until 1965 all pastures except the control received the annual treatment of 200 lbs. of 0-20-20 as based on soil test. In 1965 no 0-20-20 was applied on the manured pastures because of the very high soil test for phosphate and potash. The 80 lbs. of actual nitrogen was applied in single and split applications. In one combination the nitrogen was apllied about May 1 as compared to all being applied about June 10. Two other combinations were compared with one-half the rate applied about May 1 and the remaining one-half about July 1. This was compared to still another combination of nitrogen treatments with one-half applied about June 10 and the remaining one-half about July 1. Split application has not been as effective but the early June application has been the best. At this period the early normal and rapid spring growth has been grazed off. Then the June application may extend the effectiveness of the nitrogen treatments.

All pastures were limed in the fall of 1956 with 3 tons per acre of ground limestone. The two renovated pastures were cultivated three times in the fall, and one time in the spring with a deep tiller. All tillage operations were on the contour of the slope. Then it was disked and seeded to a mixture of vernal alfalfa at 5 lbs. per acre, alsike clover at 1 lb. per acre, Lincoln bromegrass at 6 lbs. per acre and Orchard grass at 2 lbs. per acre.

Results and Discussion

Grazing started May 11 using "common to medium" Holstein steers. Grazing was terminated September 8. The three improved pastures (manure, commercial fertilizer and renovation) were superior to the control pastures in beef produced per acre, value of beef produced per acre and the number of steer days per acre, as shown in Table 1 . The value of beef produced per acre over lime, fertilizer, tillage and seed costs was highest for the nitrogen at $49.64 per acre, followed by renovation at $45.01 per acre, manure at $35.05 per acre and the control at $33.60 per acre. For an average of 4 years the renovated and the nitrogen pastures produced about the same return followed by the manure and the control last. In 1965 the greatest return per acre in terms of beef produced was $16.00 from the use of 80 lbs. of N on grass after lime and fertilizer changes had been deducted. The response of the manure treatment and the nitrogen treatments are usually about the same from year to year but in 1965 the manure treatment was not much better than the control. This was caused be some sick steer that did not gain and for some time had to be kept off the pasture for medical treatment.

Table 1. Beef produced from brome-timothy on renovated pasture rotational grazing). May 11 to September 8, 1965 (120 days).

Treatment Pasture No.		Control (G4,G6)	Manure[a] (G1,G7)	Nitrogen[b] (G2, G5)	Renovated[c] (G3, G8)
No. acres		3.2	3.2	3.0	3.4
No. steers at start		4	6	6	6
Av. initial wt., lb.		529	524	525	523
No. steers at finish		4	5	5	5
Av. final wt., lb.		681	652	684	675
Total gain, lb.		600	741	999	910
Av. daily gain, lb.		1.35	1.18	1.68	1.52
Total no. steer days		444	627	594	598
Steer days/acre		138	195	198	176
Beef produced/acre		187	231	333	297
Value of beef produced/acre @$18.50 cwt. (est.)		$34.60	$42.74	$61.61	$56.90
Fertilizer, lime, and manure cost/acre		0.97	7.69	11.97	5.25
Tillage and seed cost					6.64
Value of beef produced/acre	1965	$33.63	$35.05	$49.64	$45.01
less lime, fertilizer,	1964	37.04	59.01	54.81	49.22
tillage and seed costs	1963	42.95	57.69	67.95	70.19
	1962	49.90	66.05	63.00	68.01
	Ave.	40.67	54.45	58.85	58.10

All steers were implanted with stilbestrol May 11. Lime--all pastures @ 3 tons per acre, cost $0.97 per year over 10 year period.

[a]Manure, 8 tons per acre annually (fall), value $9.60 (charge per acre $6.72 assuming 30% carry-over).

[b]Nitrogen, 80 lbs. N/acre annually, cost $9.60 (charge per acre $6.72 assuming 30% carry-over). Also, 200 lbs./acre 0-20-20 (charge per acre $2.12 assuming 9¢ lb. for P, 7¢ lb. for K and 20 and 50% carry-over, respectively.

[c]Renovated 1960-61, four workings with a deep tiller and once with disk, cost at $3 per operation per acre $15 or $5 per year over 3 years. Also, same amount of 0-20 as on N pasture. Seed was Vernal alfalfa 5 lbs./acre,alsike 1, Lincoln brome-grass orchardgrass 2; cost $4.92 or $1.64 per year over a 3 year period.

BEEF PRODUCTION FROM LENIENTLY GRAZED ALFALFA-GRASS PASTURE GRAZED THROUGHOUT THE SEASON versus MODERATELY GRAZED ALFALFA-GRASS SUPPLEMENTED WITH PIPER SUDAN PASTURE

A. R. Schmid, Agronomy; P. M. Burson, Soils, A. L. Harvey and J. C. Meiske, Animal Husbandry

This experiment was started this year to answer the question should one graze alfalfa-grass pasture leniently and throughout the season or would it be bette to graze it moderately heavy, and then when its production is down in July and August to supplement it with sudangrass pasture.

Two alfalfa-grass pastures, one seeded in 1963 (D pasture) and one in 1961 (E pasture), were divided to form 8 pastures of 1.875 acres each. Each pair of treatments (lenient versus moderate with sudan) was arranged on a part of the pasture having the same fertilization and cropping history (4 pairs or replications). Sudan was provided in two 3 acre pastures (field 47). These two pastures had previously been in alfalfa and were plowed in June of 1965 prior to seeding. Because of the late wet spring the Piper sudan (30 lb. per acre) was not seeded until June 8 on the north part and June 11 on the south part of field 47. Then the cool weather slowed the growth so that the first grazing was not started until July 19.

Holstein steers with an average weight of 513.7 lbs. were placed on the treatments starting with the alfalfa-grass on May 21 (see Table 1). The 7.5 acres for lenient grazing (4 pastures 1.875 acres each) were allotted 16 animals (4 per pasture) and the 7.5 acres for moderate grazing 28 animals (7 per 1.875 acre pasture). Assuming that each steer represented 2/3 of an animal unit this amounted to 0.69 animal unit per acre on the lenient and 1.24 on the moderate for the period they were grazed. The sudan stocking rate was 3.11 for the period it was grazed. The combined alfalfa-grass plus sudan figured out to .89 animal units per acre for the entire season.

Results and Discussion

As shown in Table 1, the average daily gain per animal ranged from 1.89 to 2.09 lbs. Because of the lower stocking rate and favorable weather, at no time were the steers on lenient grazing short of pasture. On the moderately grazed treatment plus sudan no grazing was available from July 29 to August 17. During this time these animals were kept on an alfalfa-grass holding pasture. Sudan provided pasture only from July 19 to 29 and September 1 to 8. Better performance of the sudan (with earlier seeding and warmer weather) might have filled the gap. As a result more steer days per acre and more beef per acre were obtained from the leniently grazed alfalfa-grass than from the alfalfa-grass and sudan combined. This difference was statistically significant at the 1 percent point.

It would appear that in order to have sudan pasture pay as a supplement to alfalfa-grass it would have to be productive and provide pasture shortly after the 4th of July. The annual cost of seed, nitrogen fertilizer, plowing, discing and seeding increases the cost per acre over alfalfa-grass. This is reflected in the larger returns per acre of $77.38 for the leniently grazed as compared to the $51.43 for the moderately grazed alfalfa-grass and sudan combined. More years of work on this comparison are needed to come to firm conclusions.

Table 1. Beef produced from alfalfa-grass pasture leniently grazed throughout the season versus alfalfa-grass moderately grazed and supplemented with Piper sudan pasture (4 replications of alfalfa-grass).

	Alfalfa-grass[a]	Alfalfa-grass plus sudan		
	only	Alfalfa-grass	sudan[b]	combined[c]
No. acres	7.5	7.5	6	13.5
No. steers at start	16	28		
No. days on pasture	110	74	17	91
Stocking rate/acre in A.U.	.69 (season)	1.24 (period)	3.11 (period)	.89 (season)
Av. initial wt. lb.	514.1			513.4
Av. final wt.,lb.	743.8			720.4
Total gain, lb.	3631	3818	939	4757
Av. daily gain lb.	$2.09^{n.s.}$	1.86	2.00	1.88
Total no. steer days	1738	2057	469	2526
Steer days/acre lb.	231.7	274.2	78.2	187.1
Beef produced/acre lb.	484.2**	509.1	156.5	352.4
Value of beef produced/acre@ $18.50 cwt. (est.)	$89.58	$94.18	$28.95	$65.19
Fertilizer, lime, tillage, seed and salt cost/acre[e]	$12.20	$12.32	$18.34	$13.76
Value of beef produced/acre less lime, fertilizer, tillage, seed and salt costs	$77.38	$81.86	$10.61	$51.43

[a]Mixture - V. alf. 5, alsike 1, L. brome 6 orch. G.2 (2 reps. on "D" 1963 seeding and 2 on "E" 1961 seeding)

[b]Sudan drilled at 30#/acre on 6/8-11 and grazed 7/19-29 and 9/1-8

[c]Cattle off alf.-grass-sudan experiment from 7/29 to 8/17

[d]Each steer figured as 2/3 of animal unit (A.U.)

[e]Alfalfa-grass pasture costs - 200 lbs/acre 0-20-20 (charge 4.28/acre assuming 9¢ lb. for P, 7¢ lb. for K and 20 and 50% carryover respectively). Tillage and seeding $6.64 per year ($19.92 spread over 3 years). Lime 3 tons per acre $.97/acre ($9.70 spread over 10 years).

Sudan costs - seed $5.10, lime $.97, plow and disc $4.00, 60# N $7.20 (alfalfa plowed under assumed to contribute 60#N).

n.s.Not significantly different from the 1.88 for the combined.

**Significantly different (1% level) from the 352.4 for the combined

Nitrogen Fertilization of Oats Seeded to Alfalfa 1965

Paul M. Burson and E. G. Bonnell

Five rates of dry nitrogen fertilizer was applied to the Dodge Variety of oats at planting time. The rates were 20, 30, 40, 60 and 80 lbs. of actual nitrogen per acre. This was conducted on two fields with one in soybeans and the other in corn in 1965. These two fields had been in a fertilized corn and soybean cropping system since 1959. The results are as follows:

	Bu. yield per acre	
Lbs. of N per acre	Following corn	Following soybeans
check	65.9	48.7
20	72.5	68.7
30	65.6	58.7
40	55.0	60.0
60	43.7	56.2
80	37.5	52.5

The early season growth including emergence was best on the higher rates of nitrogen of 30 lbs. or more. Later in the season lodging began to occur especially following the heavy wind and rain storm on July 8. Lodging was progressively worse on all rates from 30 lbs. of nitrogen per acre and higher. At the same time yields per acre went down as lodging became worse. Very little lodging occurred on the 20 lb. rate of nitrogen per acre. However, the oat yield for all nitrogen treatments was 4.3 bu. more per acre following soybeans as compared to following corn.

On five other fields in rotation with corn, soybeans and alfalfa, 30 lbs. of nitrogen per acre was applied at seeding time. Oats were seeded at 1 1/2 bu. per acre and Vernal alfalfa at 20 lbs. per acre. There were three treatments which included check, residual carry-over of starter and sidedressed nitrogen on starter and sidedressed nitrogen on the corn and the residual starter fertilization for corn plus the 30 lbs. of nitrogen applied in 1965 on the oats seeded to alfalfa. The check has never received fertilizer. The average results for the five fields are as follows:

Bu. Yield per acre

check	Residual Fertilizer	Residual fertilizer and 30 lbs. N per acre
57.6	67.9	84.3

The residual fertilizer gave an increase of 10.3 bu. over the check while the additional 30 lbs. of nitrogen and residual gave 16.4 bu. increase over the residual. There was lodging on all fields when the nitrogen was applied. No lodging occurred on the check and residual. It was interesting to note that there was about double the growth of the newly seeded alfalfa with the 30 lbs. of nitrogen over the residual and check treatments. This difference continued until after June 15. Probably the reason for this early spring alfalfa growth difference on the nitrogen treatment was the cool wet season, especially during the early part. However, the increase in yield was 16.4 bu. for 30 lbs. of nitrogen or it took slightly less than 2 lbs. of nitrogen for each bu. increase in yield.

Corn in Rotation vs Continuous Corn with Fertilizer 1965

Paul M. Burson and E. G. Bonnell

On twelve different fields trials were run to compare the difference between corn yields following alfalfa in a rotation with continuous corn yields on fields having been in continuous corn since 1957. Some fields had been in continuous corn since 1952. All fields had starter fertilizer according to the soil test. On the areas using nitrogen fertilizer as a sidedressing, at the first cultivation, the continuous corn received 100 lbs. of actual N while the corn in rotation received 66 lbs. of actual N per acre.

The check areas on each field have never been fertilized during the history of the soils farm. The average yield results are as follows:

Fertilizer Treatments	Continuous Corn	Rotation Corn	Increase for Rotation
check	53.6	95.5	41.9
Starter	84.8	112.7	27.9
Starter + N	120.7	125.0	4.3

These yields show the difference in landuse and fertilizer response in a year of great seasonal stress as was true of the cool wet season which prevailed throughout 1965. In such a season as 1965 nitrogen was most important in corn production. This is shown by nitrogen fertilizer response on continuous corn as compared to the nitrogen contributed by the alfalfa in the rotation system. There was an increase of 35.9 bu. for starter and nitrogen over starter with continuous corn as compared to 12.3 bu. increase for starter and nitrogen as compared to starter alone with corn in rotation. The starter fertilizer was 250 lbs. per acre of 4-12-24.

Soybean Fertilization and Row Spacing 1965

Paul M. Burson and E. G. Bonnell

The 1965 soybean feilds were very erratic. Growth was very poor until about July 25, regardless of soil treatments. During this 1965 early period, growth was very slow, leaves were spotted and generally light green and yellow in color. By August 1 they had made complete recovery but were so delayed that yields were below the normal production and maturity was very late. Even though the overall yields were much lower, the fertilization did improve the speed of maturity so the front damage was at a minimum. The beans were small in size but were of generally good quality.

On 5 fields the checks averaged 20.6 bu. per acre, residual corn starter from the previous year was 23.3 bu. per acre while 250 lbs. of 4-12-24 as band starter averaged 26.0 bu. per acre. On one of the fields, 33 lbs. of nitrogen was sidedressed at the first cultivation and the yield was 28.3 bu. per acre. When 66 lbs. of nitrogen was applied the yield was down to 26.6 bu. per acre.

On another field strip a fertilized row spacing trial was conducted using 250 lbs. of 4-12-24 in 38, 30 and 7 inch rows. No difference was noted in fertilizer response as compared with the check. This was probably the result of a previous fertilizer history. The yields were progressively lower as the rows became narrower. The 38 inch rows produced 28.3 bu. per acre, 30 inch rows 25.0 bu. and the 7 inch drilled rows 16.6 bu. per acre. As the rows became narrower the lodging became more serious with no lodging on the 38 inch rows. with severe lodging on the 7 inch rows.

Lime and Fertilizer on Continuous Corn
1965

Paul M. Burson and E. G. Bonnell

Manure, lime and starter fertilizer on 13 years of continuous corn was the best combination of soil treatments for the wet cool weather conditions in 1965. Lime was applied in December, 1961 at the rate of 3 tons per acre according to soil test. Manure is applied annually at the rate of 10 tons per acre and plowed under. The starter fertilizer 6-24-12 was placed in a band at 175 lbs. per acre according to soil test. The soil types are Judson and Clyde silty clay loams. The 1955 yield results are as follows:

Soil treatments	Bu. yield per acre
1. Check	111.0
2. Manure	128.0
3. Manure + lime	137.0
4. Manure + starter	135.5
5. Manure + lime + starter	140.0

On another field which was mainly a Port Byron silt loam, upland soil, which had been in continuous corn for 8 years but no manure had been applied. Nitrogen was sidedressed at the first cultivation at the rate of 100 lbs. per acre.

This field was limed in November 1964 at 3 tons per acre according to soil test. The results are as follows:

Soil treatments	Bu. Yield per acre
1. No lime	28.0
2. Lime	44.0
3. No lime + starter(1)	33.0
4. Lime + starter	62.0
5. No lime + starter + N(2)	99.0
6. Lime + starter + N	106.0

(1) Starter banded 275 lbs. per acre 4-12-24.
(2) N 100 lbs. per acre sidedressed at 1st cultivation.

Pop-up Fertilization of Corn
1965

Paul M. Burson, R. D. Curley and E. G. Bonnell

Pop-up fertilization is a term used to designate the placement of a small and known amount of fertilizer with the corn seed at planting time in addition to the regular banded starter application. It is thought in northern areas of the cornbelt, with a shorter growing season that a small amount of fertilizer with the seed will hasten emergence and early growth to the benefit of earlier maturity before frost danger. It is well known that to much fertilizer in contact with the seed will injury germination and reduce the stand. The same kind of planter equipment was used in 1965 as in the previous years. A herbicide applicator was used to apply the pop-up fertilizer with the seed. It was necessary to cut a larger opening in the applicator to get on a sufficient amount because of the different granulation of the fertilizer as compared to a herbicide. The 1965 trials include different combinations of fertilizer treatments in 4 replications. The starter band fertilization included 200 lbs. per acre of 8-24-12 and 300 lbs. per acre of 5-15-10. The pop-up fertilizer included the same material with the 8-24-12 at 75 lbs. per acre and the 5-15-10 at 100 lbs. per acre alone and in combination with the band starter. The amount of pop-up fertilizer would not exceed a total of 20 lbs. of nitrogen and potash. The above rates would equal a total of 15 lbs. per acre because of a possible salt injury. No injury of stand was found. All fertilizer treatments had a range of 1500 to 2000 more plants per acre than the check. As shown in the following table starter fertilizer gave yield of 129.7 bu. per acre while starter and pop-up produced 135.3 bu. per acre or an increase of 5.6 bu. for the pop-up.

Bushel Yield per acre

Starter	Pop-up	Starter + Pop-up
129.7	120.7	135.3

There was a difference in maturity as shown by the earlier tosseling and earlier denting. As compared to the check, pop-up fertilizer averaged 3 to 4 days in advance of the check when there was 80% or more of tosseling, 5 days advance with starter band and 7 to 8 days with the combination of pop-up and starter.

On another field of continuous corn for 13 years pop-up gave no increase in yield but did improve maturity as indicated above. On this field the starter produced 118.0 bu. per acre while the starter + N and the starter + N + pop-up each produced 127.0 bu. per acre.

The year 1965 was an important nitrogen and potash year but mainly for the use of nitrogen. On the phosphate pop-up treatment of 100 lbs. per acre of 0-45-0.

The yield was only 101.0 bu. per acre as compared to 120.7 bu. per acre where nitrogen, phosphate and potash were used. Lodging occurred on the phosphate treatment but no lodging on the plots receiving all three nutrients. In previous years the phosphate has shown the better early response.

Effect of Irrigation, Fertility Level and Plant Population on Corn and Alfalfa at Park Rapids, Minnesota - 1965.

E. C. Seim, A. C. Caldwell, J. Grava, E. R. Allred, W. E. Dorsey, and J. B. Swan

In 1965 a potential yield study of corn and alfalfa with supplemental irrigation was initiated on a sandy loam soil at the Park Rapids Sulfur Experimental Field. For each crop high fertility practices and high populations were compared with average management practices prevalent in the area. One-half of the plot area was irrigated on a schedule (Table 4). The other half was unirrigated. The one exception was a light irrigation of the alfalfa seeding which was necessary for the survival of the stand.

In the alfalfa experiment, the full treatment plots received 50 lbs./A of P as 0- 46- 0, 300 lbs./A of K as 0- 0- 60, 5 lbs./A B as borax and 50 lbs./A of S as gypsum. The control (average management) plots received gypsum only (50 lbs./A of S). All fertilizer treatments were broadcast and worked in before planting. Ranger alfalfa was inoculated and seeded at the rate of 20 lbs./A. In late July the plots were sprayed with dalapon (2 lbs./A) to control quackgrass. On August 19, the plots were clipped about 8 inches above the ground. No yields were taken from the plots in 1965.

In the corn experiment, the full treatment plots received 150 lbs./A of N as ammonium nitrate, 25 lbs./A of P as 0- 46- 0, 200 lbs./A of K as 0- 0- 60 and 50 lbs./A of S as gypsum. Starter fertilizer, 300 lbs./A of 4- 12- 24 was applied in a band on each side of the hill. Row width was 36 inches with a hill spacing of 18 inches. Final plant population was 18,300 plants per acre. The control (average management) plots received starter fertilizer only (150 lbs./A of 4- 12- 24). Row spacing was 36 inches, hill spacing 36 inches. Final plant population was 9150 plants per acre. An 85 day corn variety, Minhybrid 805, was used in these trials.

One half of the plots was irrigated on a regular schedule. The other half received no supplemental irrigation. Rainfall measured at the experimental site is shown in table 1.

Month	Rainfall, inches
May	3.50
June	5.59
July	1.60
August	2.61
September	6.78
Total	20.08

During the period from July 13 to August 23 the only precipitation received was 1.08 in. on August 5th and 6th.

During July and August, Park Rapids received about 2.5 inches of rainfall below the average amount for the area (see table 3). The unirrigated corn was severely affected by the summer drought. The high fertility, high population corn was more seriously affected by drought than the low population, low fertility corn.

The irrigated corn grew well through the summer but its development and maturity was delayed by cool weather during August and September (Table 3). Silage yields were taken on October 2. Two weeks later (October 16) ear corn yields were obtained. Killing frost on September 26 (minimum temperature 19°F.), had stopped all growth of corn by this time. Ears were slightly dented but moisture content of the corn was very high (about 50 percent).

The yields of silage and of ear corn are shown in table 2. Irrigation and full fertility treatment nearly doubled the silage yields. Irrigated low fertility, low population plots produced 3.3 tons of silage per acre. Irrigated high fertility, high population plots averaged 6.1 tons of silage per acre. Unirrigated plots produced 2.3 tons of silage per acre with the low fertility, low population treatment and 2.5 tons per acre of silage with the high fertility and high population treatment.

Forty one bushels of ear corn per acre were harvested from the irrigated low fertility, low population plots. High fertility plus high population increased the yield to 72 bushels per acre, an increase of 31 bushels. The yield would have been much higher if the corn had sufficient time to completely mature.

The unirrigated corn was severely damaged by a prolonged period of midsummer drought. Under those conditions the heavily fertilized, high population plots were the first to suffer from lack of moisture. Growth, pollination and maturity were so delayed that only a token yield of 12.5 Bu./A. was obtained.

Corn of the low population, low fertility plots withstood the effects of drought much better because of the reduced competition for available water and produced an average yield of 26.5 bushels of ear corn per acre.

It is evident that in a year such as 1965 irrigation meant the difference between having a crop and not having one. Climatic conditions, however, were a limiting factor for top corn production. Field corn (according to D. G. Baker and J. H. Strub, Jr. Climate of Minnesota, Technical Bul. 248. Univ. of Minn. 1965) requires a total of about 2400 growing degree days (GDD). The total GDD for the growing season of 1965 for the Park Rapids area was 1529 (table 3). The average GDD accumulated during the warm season crop period at Park Rapids is about 1766 (Baker and Strub, Jr.).

Past experience and the results obtained in 1965 would seem to indicate that crops which are more adapted to the prevalent climatic conditions in the Park Rapids area (for example potatoes) would utilize high fertility levels and supplemental irrigation better than field corn.

Table 2. Effect of Irrigation, Fertility level and population on corn at Park Rapids, Minnesota.

Plot No.	Treatments Moisture Irrigated	Fertility	Population	Silage tons/acre	% Moisture ear corn %	Ear Corn yield Bu./acre
1	"	LF	LP	3.36	51.2	39
2	"	LF	LP	3.23	47.9	43
		Averages		3.30	49.5	41
2	Irrigated	HF	HP	6.27	53.1	75
4	"	HF	HP	5.93	51.5	69
		Averages		6.10	52.3	72
1	Non-irrigated	LF	LP	2.37	43.8	32
3	"	LF	LP	2.26	43.4	21
		Averages		2.31	43.6	26.5
2	Non-irrigated	HF	HP	2.47	66.6	9
4	"	HF	HP	2.52	58.5	16
		Averages		2.50	62.5	12.5

Low fertility plots received 150#/acre of 4-12-24 starter
High fertility plots received 150#/acre N
25#/acre P Broadcast
200 #/acre K
300 #/acre of 4-12-24 starter
Low population level - 9,150 plants/acre

Table 3. Rainfall and Temperature Data for the

Growing Season of 1965, Park Rapids Weather Station*

Month	Rainfall (inches) Total	Rainfall (inches) Departure from normal	Temperature (°F) Average	Temperature (°F) Departure from normal	Growing degree Days (GDD) Base Temperature = 50°F.
May	4.35	0.80	54.8	1.6	50
June	6.57	2.62	63.1	0.2	393
July	2.00	-1.50	66.8	- 2.4	521
August	2.93	-1.10	66.0	- 0.7	496
September	6.20	4.16	48.8	- 7.3	69
Total	22.05	4.98			1529
Average			59.9	- 8.6	

*From Climatological Data, Minnesota, Wol. 71, 1965. U. S. Weather Bureau.

Table 4. Date, Duration and Rate of Supplemental

Irrigation on the Corn and Alfalfa High Potential Plots, Park Rapids - 1965.

Date	Hours	Amount Applied (inches)
June 16	2.0	1.00
" 24	4.0	2.00
July 7	3.0	1.50
" 19	3.0	1.50
" 26	4.5	2.25
August 4	4.5	2.25
" 14	4.5	2.25
" 22	4.5	2.25
TOTAL	30.0	15.0

Table 5. Effect of Fertilization and Supplemental Irrigation on the Chemical Composition of Sixth Corn Leaf at Silking Time, Park Rapids. 1965.

Treatment	K %	P %	Ca %	Mg %	Mn ppm	Fe ppm	B ppm	Cu ppm	Zn ppm	Mo ppm	Co ppm
Low fertility, irrigated	1.34	.32	.91	.34	64	1192	5	10	24	1.14	.54
Low fertility, non-irrigated	1.42	.32	.88	.28	70	174	6	15	28	1.35	.29
High fertility, irrigated	1.77	.29	.71	.20	71	993	5	10	20	.58	.34
High fertility, non-irrigated	2.10	.29	.84	.27	80	153	5	12	24	.91	.40

The Effect of Urea or Ammonium Nitrate Nitrogen on the Nitrate Nitrogen Content of Webster clay loam surface soil and Different Portions of Growing Corn Plants at Lamberton in 1964 & 1965

J. M. MacGregor and W. W. Nelson

Many farmers have become concerned with the effect of nitrogen fertilization on the nitrate content of corn plants during the growing season, especially where growth is retarded by dry soil conditions at some period of growth. Research in several mid-western states has shown that drowth conditions result in marked increases in the nitrate content of corn. Olson (1) stated that forages and silages containing less than 0.15% of nitrate nitrogen appear safe to feed, feeds containing 0.15% to 0.40% nitrate nitrogen should be supplemented to supply a ration averaging less than 0.15% nitrate nitrogen, whereas those forages containing over 0.45% nitrate nitrogen are potentially dangerous to feed, even at restricted levels. He concluded that nitrate poisoning of livestock is relatively rare, and that fertilizer practices should be based on Experiment Station recommendations without concern for the possibility of nitrate poisoning.

A long term nitrogen fertilizer experiment has been in progress at the Southwest Experiment Station at Lamberton on a Webster soil planted to continuous corn beginning with the 1960 growing season. Nitrogen has been annually applied at rates of 40, 80 or 160 pounds per acre either as ammonium nitrate or as urea for six years.

In 1964 corn plants were randomly sampled from two replications on each of five different nitrogen treatments in mid-June mid-July, mid-August, and finally in mid-September. Soil samples were also taken at the same times at the six-inch depth immediately adjacent to the corn roots. The corn plants were immediately chilled following sampling, and dried in a circulating air oven at 55°C. After drying, the tissues were separated into leaves, upper stalks and lower stalks (with the exception of the mid-June sampling which consisted entirely of leaves). The soil samples were also chilled and all samples were then analysed for nitrate content.

The entire sampling and analytical procedure was repeated in 1965, but since the corn was not planted until early June, the sampling of soil and leaf tissue for that month was omitted.

The nitrate values obtained on all samples are shown in the following table. The tissue samples considered to be at toxic levels for uncontrolled animal feeding by Olson's nitrate values are identified with the symbol 't'.

The nitrate content of the soil was directly related to the amounts of fertilizer nitrogen applied over the five and six year period, with the relatively large amounts present in mid-June of 1964 or mid-July, 1965 rapidly decreasing as the growing season progressed.

Nitrate levels of the corn leaves sampled in mid-June were relatively high, and as the rates of nitrogen applied increased, toxic nitrate levels were consistently present. By mid-July 1964, however, nitrate levels of the leaves were and remained at relatively low levels for the remainder of the growing season. Because of the later 1965 planting, the July tissues contained toxic levels in July 1965.

Upper stalks, which were not available for the June 1964 sampling, could be considered relatively safe for feeding during the three months in which these were analyze In 1965, all fertilized upper stalks contained toxic amounts of nitrate nitrogen.

However, in the lower stalks, tissues growing on the plots (1964) receiving no nitrogen, had relatively low concentrations, but as rate of nitrogen fertilization increased (especially in July with relatively high soil nitrate levels) these tissues consistently contained toxic nitrate concentrations which decreased as the growing season progressed. The nitrate content of lower corn stalks sampled in August and September were relatively safe for feeding where nitrogen was applied annually at the 80 pound per acre rate. However, when this N fertilization rate was doubled to an annual application rate of 160 pounds per acre, the lower corn stalks contained toxic nitrate levels through the entire growing season.

Nitrate Nitrogen Concentrations in 1964 and 1965 Corn Plants on Webster Clay Loam at Lamberton Fertilized Annually with Ammonium Nitrate or Urea
(Average of 2 replicates)

Lbs N/A annually	Avg. Soil Nitrate-N in ppm				Percentage nitrate nitrogen in corn tissues									
					Leaves				Upper stalks			Lower stalks		
	June	July	August	Sept.	June	July	August	Sept.	July	August	Sept.	July	August	Sept.
check														
1964	5	2	1	1	0.28	0.03	0.03	0.02	0.06	0.04	0.02	0.03	0.03	0.01
1965	=	6	5	6	--	0.25	0.03	0.02	0.63	0.02	0.03	0.92	0.03	0.02
80/A NH_4NO_3-N (spring)														
1964	19	5	3	2	0.47	0.06	0.04	0.02s	0.24	0.07	0.02	0.72	0.16	0.05
1965	-	29	18	8	--	0.29	0.04	0.02	0.72	0.04	0.02	1.20	0.11	0.03
80/A Urea-N (spring)														
1964	23	4	4	2	0.44	0.05	0.04	0.03	0.25	0.06	0.03	0.42	0.30	0.17
1965	-	12	20	7	--	0.33	0.01	0.03	0.92	0.02	0.02	0.81	0.07	0.02
160/A NH_4NO_3-N (fall)														
1964	46	33	6	4	0.60	0.11	0.04	0.02	0.39	0.16	0.08	0.80	0.82	0.53
1965	-	9	5	8	--	0.76	0.03	0.03	0.77	0.07	0.02	1.12	0.25	0.21
160/A Urea-N (fall)														
1964	36	6	6	2	0.58	0.14	0.07	0.01	0.43	0.12	0.03	0.67	0.76	0.38
1965	-	12	7	16	--	0.26	0.04	0.04	0.75	0.09	0.05	1.02	0.60	0.69

t = values exceeding 0.44% NO_3-N are considered to contain toxic concentrations for animal feeding, even in limited quantities.

In the July 1965 sampling, the lower stalks of even the unfertilized corn contained toxic concentrations.

This illustrates that heavy nitrogen fertilization and stage of corn growth results in abundant soil nitrate and toxic nitrate levels in some corn tissues grown under the conditions in 1964 and 1965. It is probable that either legume ground or soils receiving heavy applications of barnyard manure would result in similar trends, but of lower magnitude. Nitrate nitrogen concentrations present in June, 1964 corn, and in mid July, 1965 corn show that growth stage probably has a more important effect on nitrate nitrogen concentrations in corn tissue than N application rates.

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(1)Olson, Oscar: Nitrate Problems in Livestock Feeds. Report of the Fourteenth Annual Soils and Fertilizer Short Course. Leamington Hotel, Mpls, Minn., November 23-24

The effect of nitrogen source, placement and time of application on the yield of continuous and corn soil nitrate content of Webster clay loam at Lamberton in 1965

J. M. MacGregor and W. W. Nelson

The effect of fertilizer nitrogen, either as ammonium nitrate or as urea, on corn yield has been studied for the past six years. Previous reports have also included the nitrogen present in the corn plants, but this was not done in 1965.

From 1960 through 1965, uniform but ample amounts of P and K fertilizer have been applied to all plots. Varying amounts and kinds of nitrogen have been applied either before or after plowing in the fall, at time of seeding, or as a late June sidedressing. April and May of 1965 were excessively wet with rainfall of 4.60" and 6.87", with a relatively normally drier four months following. Planting was delayed until June since soil sampling to a 96" depth were desired, but these were not obtainable until August. A relatively cool summer further delayed corn growth and an earlier than normal frost in September resulted in a lower than normal yield. The 1965 ear corn yields are shown in the following table in order of decreasing yields. All of the plots are fall plowed.

Table 1. The effect of nitrogen source, rate of application and time of application to Webster clay loam at Lamberton on the sixth year yield of ear corn in 1965.

(Average of four replicates)

Treatment #	Time & method of N application (N in lbs./A)	Avg. yield of ear corn (Bu./A)	Significance[a]
13	80 urea-N at planting	84.4	a
18	160 NH_4NO_3-N as sidedressing	77.6	ab
12	80 NH_4NO_3-N at planting	74.2	abe
9	160 urea-N plowed down in fall	73.5	abcd
7	80 urea-N " " " "	73.0	abcd
8	160 NH_4NO_3-N " " " "	70.8	bcde
16	80 NH_4NO_3-N as sidedressing	68.1	bcde
17	80 urea-N " "	64.7	bcde
6	80 NH_4NO_3-N plowed down in fall	63.4	bcdef
10	40 NH_4NO_3-N at planting	63.4	bcdef
11	40 urea-N " "	59.8	cdefg
5	40 urea-N on top of plowing in fall	57.4	defg
14	40 NH_4NO_3-N as sidedressing	54.8	efg
15	40 urea-N " "	48.4	fgh
4	40 NH_4NO_3-N on top of plowing in fall	45.6	ghi
3	40 urea-N - plowed down in fall	38.8	hi
2	40 NH_4NO_3-N - " " " "	34.9	hi
1	check - no N	33.1	i

[a]According to Duncan's Multiple Range Test, those yields with similar letters are not mathematically different at the 5% level.

The heavy rains of early spring lowered the efficiency of fall applied fertilizer and in general, nitrogen applied at planting in the spring was most efficient, followed by late sidedressed N treatments, then N fertilizer left over winter on the plowed surface, with the fall plowed under nitrogen being the least effective of the four treatments for increasing corn yields. With the heavy April-May rains, the later and more shallow N applications were more effective.

A second approach would be a study of the total 6 year (1960-65) ear corn yield with the different N application over this period as shown in the following table:

Table 2. Total six year ear corn yield, increas e and pounds of N applied to a Webster silty clay loam at Lamberton.

Rank	Treatment (lbs. N/A)	Total Bu/A	6 yr. average	N applied in 6 yr.
1	160 urea plowed down in fall	574.1	95.7	960
2	80 NH_4NO_3 - late sidedressing	567.3	94.6	480
3	160 NH_4NO_3 - " "	554.6	92.4	960
4	80 urea - at planting	546.7	91.1	480
5	80 urea - late sidedressing	541.4	90.2	480
6	160 NH_4NO_3 - plowed down in fall	533.8	89.0	960
7	80 NH_4NO_3 - " " " "	522.7	87.1	480
8	40 NH_4NO_3 - at planting	519.0	86.5	240
9	80 NH_4NO_3 - " "	507.9	84.7	480
10	80 ureas - plowed down in fall	507.7	84.6	480
11	40 NH_4NO_3 - late sidedressing	489.5	81.6	240
12	40 urea - top of plowing in fall	482.8	80.5	240
13	40 urea - at planting	475.9	79.3	240
14	40 urea - late sidedressing	463.0	77.2	240
15	40 NH_4NO_3 - top of plowing in fall	462.5	77.1	240
16	40 urea - plowed under in fall	450.3	75.1	240
17	40 NH_4NO_3 - " " " "	432.5	72.1	240
18	check - no nitrogen	402.4	67.1	-

In general, the 40 pound rate is not increasing corn yields well as the later applied N, with a maximum spread of some 14 bushels per year over the 6 years. With the 80 pounds of N per acre, there is a maximum average increase variation of 10 bushels, with the fall applied N being in general less effective. Where 160 pounds of N were applied there is an approximate 7 bushel spread between the two forms of N which is probably not significant until carried on for approximately a 10 year period.

Soil Nitrates

Since it was obvious that much of the fertilizer N applied over the 6 year period was not being utilized by the corn crop, it was decided to determine the nitrate-N content of the soil to a depth of 96", to determine if there was an accumulation at any depth. Four replications of the (1) no nitrogen, (2) 40 NH_4NO_3, (6) 80-NH_4NO_3 and (8) 160 NH_4NO_3 (all plowed down each fall) were sampled by a tractor-powered hydraulic probe, frozen and analyzed late in 1965. The results are shown in Table 3.

Table 3. The effect of increasing rates of ammonium nitrate nitrogen for six years to a Webster clay loam at Lamberton on soil nitrate-nitrogen concentration under continuous corn in 1965.

(Average of four replications)

Soil depth in inches	Check - #N (Total corn yield 402 bu.)	40# N/A plowed down in fall 6 yr. total 240#N (Total corn yield 433 bu.)	90# N/A plowed down in fall 6 yr. total 480#N (Total corn yield 523 bu.)	160#N/A plowed down in fall 6 yr. total 960#N (Total corn yield 534 bu.)
	Pounds of nitrate nitrogen per acre			
0-6	3.1	2.4	2.9	2.5
6-12	2.2	2.2	2.1	3.0
12-24	3.7	3.0	6.0	12.3
24-36	2.6	5.6	11.8	20.3
36-48	4.3	5.6	13.8	14.8
Total in 4 feet	15.9	18.8	36.6	52.9
48-60	5.2	6.6	11.3	16.9
60-72	6.6	6.8	10.3	9.0
72-84	6.6	5.7	7.9	7.1
84-96	6.2	5.2	6.4	6.3
Total in 5-8 feet	24.6	24.3	35.9	39.3
Total NO_3 -N in 96"	40.5	43.1	72.5	92.2

-82-

It is apparent that nitrate nitrogen content under continuous corn was increased but little where 40 pounds of nitrogen was applied each fall for six years. Total corn yield over the six years increased by only 31 bushels.

Where 80 pounds of nitrogen was annually applied, total six year corn yield was increased and nitrate -N increased by 101 bushels per acre below the 12" depth. The upper 48 inches of the soil profile (generally considered the root feeding zone) contained approximately twice the nitrate nitrogen occurring under either the untreated or the 40 pound N plots. The fifth through eighth foot soil depth contained only about 50% more nitrogen than the check or the 40# N plots.

As might be expected, the application of 160 pounds of fertilizer nitrogen increased total six year yield by 132 bushels per acre and substantially increased nitrate nitrogen concentrations in the second to fifth foot of soil. However, when the entire 96 inch depth is considered, the 40 pounds of N applied annually increased total nitrate nitrogen by only 2.6 pounds per acre, the 80 pound rate by only 32 pounds, and the 160 pound rate by only 51.7 pounds per acre. All of these amounts are small in comparison to the total amounts of N applied over the six years.

Some of the nitrogen has been utilized in higher corn production, especially on the 80 and 160 pound areas. Since nitrate nitrogen content is greatest in the 12 to 60 inch depth suggests that considerable nitrate-N losses are occurring in the drainage water being removed by a tile system traversing one end of each set of plots, with consequently no marked nitrate accumulation in the subsoil which occurred on the untiled Barnes loam at Morris.

Nitrate Nitrogen Content of a Barnes Loam at Morris in 1965 and Corn Yields after Nine Years of Continuous Corn with Varying Rates of Nitrogen Fertilization (1957-1965)

J. M. MacGregor, G. R. Blake, R. Thompson & S. Evans

In 1957 a continuous corn experiment was initiated at the West Central School and Experiment Station at Morris to study the effect of annual fertilization with different rates of fertilizer nitrogen with adequate and uniform phosphorus and potassium supplied. Plant population has varied from 16,000 to 18,000 plants per acre during the nine year period. Vegetative residues were not removed from the field with additional PK being applied at the commencement of the experiment and again in 1962.

Ear corn yields for the nine year period are shown in Table 1.

Table 1. The Effect of Annual Fall or Spring Nitrogen Topdressings on a Barnes Loam with Uniform PK on the Yield of Ear Corn From 1957 through 1965 at Morris.

Nutrients Applied (lbs/A)	Time of Application	1957	1958	1959	1960	1961	1962	1963	1964	1965	9-year Avg.
N PO_2O_5 K_2O		Bushels of ear corn at 15.5% moisture									
0-40-40	spring	65.2	73.2	36.1	53.3	32.3	38.1	62.7	33.2	50.4	49.4
40-40-40	fall	71.0	81.5	40.9	48.2	48.3	59.0	80.9	34.1	68.3	59.1
40-40-40	spring	69.4	81.0	41.5	56.0	47.6	62.0	83.5	29.6	75.3	60.5
80-40-40	spring	72.1	82.4	39.7	53.7	45.0	65.3	77.4	29.1	80.8	60.6
240-40-40	spring	71.3	80.3	36.8	52.5	46.1	67.1	79.5	24.7	82.8	60.1

The average yields over the nine year period indicate that the plots receiving no commercial nitrogen produced approximately 50 bushels of ear corn per acre, whereas the three rates of nitrogen increased yields an additional 10 bushels to approximately 60 bushels per acre irrespective of quantities of fertilizer nitrogen applied.

The comparatively low responses to relatively high rates of nitrogen application raised the question as to the fate of at least a portion of the heavier application of nitrogen.

Late in October of 1965, each of the triplicated spring applied fertilizer plots was sampled by means of a tractor operated hydraulic soil sampling tube to a depth of 8 feet (96 inches). The samples were frozen until analyzed for their nitrate nitrogen content in December. The results expressed in pounds of nitrate nitrogen per acre at the different depths are shown in Table 2. Corn roots did not penetrate below the 48 inch depth.

Table 2. Pounds of nitrate nitrogen per acre in Barnes loam after nine years of fertilizing continuous corn at Morris.

Soil depth(inches)	Nutrient treatment in pounds per acre: Annually / 9 yr.total	0-40-40 / 0-360-360	40-40-40 / 360-360-360	80-40-40 / 720-360-360	240-40-40 / 2160-360-360
		Pounds of nitrate nitrogen per acre			
0-6		10.0	10.4	11.3	12.0
6-12		6.1	9.8	10.4	13.5
12-24		10.8	13.3	18.6	49.7
24-36		8.0	8.1	32.2	309.2
36-48		9.8	14.8	23.2	269.2
Total in upper 48"		44.7	56.4	95.7	653.6
Increase where N applied		—	11.7	51.0	608.9
48-60		9.8	17.7	32.4	183.1
60-72		16.6	15.5	46.7	208.9
72-84		16.1	17.4	48.7	224.8
84-96		18.4	18.4	38.9	184.7
Total in 5'-8' depth		60.9	69.0	166.7	801.5
Increase where N applied		—	8.1	105.8	740.6
Lbs/A NO_3-N in 96"		105.6	125.4	262.4	1455.1
Increase where N applied		—	19.8	156.8	1349.5
Percentage of applied N in 0"-48"		—	3.3%	7.1%	28.2%
Percentage of applied N in 48-96"		—	2.3%	14.7%	34.3%
Percentage of applied N in 0-96"		—	5.6%	21.8%	62.5%

The data in table 1 show that increasing rates of fertilizer N above 40 pounds per acre did not increase corn yields. Table 2 data show that in this soil which is not tiled, there is little accumulation of NO_3-N on the 40 pound N plots (total 360 N) above the profiles where no N was applied. In the entire 96 inch depth, there was an increase of only 19.8 lbs. of nitrate nitrogen per acre. It is probable that most of the 360 pounds of N applied over the 9 year period was utilized by the corn crop with the 10 bushel per acre increase, with only 5.6% of the applied N remaining in the soil.

Where 80 pounds of N was applied annually, the NO_3-N content increased markedly below the 12 inch depth. Apparently 51 pounds (7.1% of the 720 pounds applied) remained in the upper 4 feet of soil where it would be available to plants, but 105.8 pounds (14.7% of the applied 720 pounds) had been carried down to the 4 to 8 foot depth and would not be available to even the deepest corn roots. A total of 156.8 pounds of applied N remained in the 8 foot depth of soil (21.8%) of the 720 pounds applied) but about two thirds would be not available to future corn crops.

The 240 pound annual N rate resulted in a much larger NO_3-N concentration below the 12 inch depth, with 608.9 pounds (28.2% of that applied) in the upper 4 feet and available, and 801.5 pounds N (34.3% of that applied) in the 4 to 8 foot depth. This means that the heavy N fertilization resulted in less than a third of the N remaining available, while more than a third was essentially unavailable at the end of the nine year period, with nearly two-thirds (62.5%) of the applied nitrogen remaining in the 96 inch soil depth.

Since the 80 and 240 pound nitrogen application rates did not increase average corn yield beyond the 40 pound per acre rate, increasing rates of N application to this loam soil result in the downward movement of larger proportions, where they are unavailable to plant roots, even under the relatively low (22.6") average annual precipitation at Morris.

FALL vs SPRING TOP DRESSING OF NITROGEN ON GRASSLANDS

Richard H. Anderson, Station Agronomist, Grand Rapids

Three replications of various levels and time of application were established on an existing bromegrass stand. Previous yields had been low although a fair plant population existed. Thus, a situation was present somewhat similar to infertile pastures. Soil test indicated following conditions:

Soil Testure:	Sandy Loam
pH	5.1
Organic Matter:	2.8%
Extractable Phosphorus:	170 lb per acre
Exchangeable Potassium:	200 lb per acre

Treatments and plot yields as follows. (200# 0-0-60 were top dressed over entire experiment to bring K into optimum level.)

Treatment (lbs of N)	Reps			
	I	II	III	X
check	1.415	2.027	1.540	1.66
33.5# Fall	2.091	2.287	1.680	2.02
67# Fall	2.847	3.078	2.858	2.93
100# Fall	3.286	3.593	3.701	3.53
33.5# Spring	2.556	2.524	2.559	2.55
67# Spring	3.430	3.662	4.106	3.73
100# Spring	3.892	3.708	3.905	3.84

L.S.D. (.05) .414

ANOKA

SOURCE	D.F.	S.S.	M.S.	F
Total	20	13.98	.699	
Treatment	6	13.19	2.198	40.7 **
Reps	2	.14	.07	1.296 N.S.
Error	12	.65	.054	

Assuming $15.00 per ton value of bromegrass and $5.00 cost per 100# of Ammonium Nitrate:

Treatment		Yield Ton/Acre	Value of Add'l Yield	Fertilizer Cost	Value Over Cost
Check		1.66	-----	-----	-----
33.5#	Fall	2.02	$ 5.40	$ 5.00	$ .40
33.5#	Spring	2.55	13.35	5.00	8.35
67#	Fall	2.93	19.05	10.00	9.05
67#	Spring	3.73	31.05	10.00	21.05
100#	Fall	3.53	28.05	15.00	13.05
100#	Spring	3.84	32.70	15.00	17.70

THE EFFECT OF NITROGEN ON THE YIELD AND PROTEIN CONTENT OF BARLEY

Olaf C. Soine, Soil Scientist

Northwest Experiment Station 1965

In Cooperation with Dr. J. MacGregor and Dr. D. Rasmusson

Institute of Agriculture, St. Paul

The field study this year followed the same procedure as last year with the exception that fewer treatments were used. Both plots were located on the Station and in 1964 field 17 was in potatoes and field 40 was in sugarbeets. Trophy, Larker, and Parkland were the test varieties of barley used.

Methods

Ammonium nitrate was applied at 0, 10, and 20 lbs. of actual nitrogen per acre as a broadcast treatment and harrowed in before the plots were sown. Four other fertilizer treatments were applied in a band 2 inches away from the seed when the barley was sown. These plots were sown across the broadcast treatments and included the following:

Check

0-40-0 @ 100 lbs./acre

10-40-0 @ 100 lbs./acre

20-40-20@ 100 lbs./acre

The treatments and varieties of barley were replicated and randomized.

Protein analysis will be run under the direction of Dr. MacGregor and Dr. Rasmusson.

THE EFFECT OF NITROGEN ON THE YIELD AND PROTEIN CONTENT OF BARLEY

Discussion: The average yield in bushels per acre and the bushel weights are given in Tables 1 and 2, respectively, for 1965.

The average yields were good for all three varieties; however, Larker gave the best response. The broadcast treatments of 10 and 20 lbs. of ammonium nitrate produced increases of 1.60 to 10.76 bushels per acre of barley when compared to the check plots.

The addition of potash did not produce any consistent increase in yield when compared to the other treatments.

There was only slight lodging on some of the plots with higher rates of nitrogen.

The soil analysis is given in Table 3.

Table 1. Average Yield of Trophy, Larker, and Parkland Barley for Both Locations - 1965

	Rate Per Acre of Ammonium Nitrate Broadcast Before Seeding								
	0	10	20	0	10	20	0	10	20
Treatment		Trophy			Larker			Parkland	
Check	60.90	64.34	62.50	57.52	67.89	68.28	64.07	69.47	69.85
0-40-0	62.37	62.56	68.98	66.57	68.68	75.50	63.82	68.28	70.12
10-40-0	69.59	71.03	67.63	69.59	78.78	72.35	62.37	67.50	71.97
20-40-20	63.42	71.95	71.30	66.57	71.15	71.69	62.63	70.12	68.27

Table 2. Average Bushel Weights for Trophy, Larker and Parkland Barley for Both Locations - 1965

	Pounds Per Bushel								
	Rate Per Acre - Ammonium Nitrate Broadcast Before Seeding								
	0	10	20	0	10	20	0	10	20
Treatment	Trophy			Larker			Parkland		
Check	43.6	42.3	42.6	44.7	45.9	44.8	46.0	47.3	45.9
0-40-0	43.2	43.6	42.5	45.2	45.4	45.8	45.6	45.0	45.7
10-40-0	43.1	44.3	42.4	45.8	44.9	45.7	45.6	45.4	46.0
20-40-20	43.8	44.0	43.2	45.6	45.9	45.5	45.1	45.8	45.6

Table 3. The following soil test is given for both locations.

Location	Texture	PH	Organic Matter		Ex. Phosphorus		Ex. Potassium	
			Per Cent	R. Level	Lbs./A.	R. Level	Lbs./A.	R. Level
Field 17 0-6"	Si Clay	7.5	5.2	M	55	VH	260	H
" 17 6-12"	Clay	7.9	4.2	L	13	M	160	M
Field 40 0-6"	Loam	7.9	4.4	M	20	M	150	M
" 40 6-12"	Loam	8.1	3.5	M	4	VL	100	M

PHOSPHORUS FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station

Samuel D. Evans

In 1965 a phosphorus experiment was set up to determine (1) the effect of broadcast phosphorus on corn yields and soil test levels, (2) the effect of row phosphorus at two soil test levels, and (3) the effect of high phosphorus applications on the zinc content of corn leaves and on corn yields.

Yield - Bushels/Acre @ 15.5% Moisture

Row Treatment lbs./A Broadcast Treatment lbs./A	0 P	15 P	30 P	45 P	45 P + 10 Zinc	Average
0 P	94.91	94.91	95.45	97.02	95.78	95.55
45 P	95.42	94.08	94.18	91.31	98.40	94.71
Average	94.68	94.50	94.82	94.16	97.09	

LSD (5%) Average of 2 broadcast fertilizer treatments - - - - - 5.32 Bu./A

LSD (5%) Average of 2 row fertilizer treatments - - - - - - - - - 6.27 Bu./A

LSD (5%) Between 2 row means at one broadcast level - - - - - 7.45 Bu./A

LSD (5%) Between 2 broadcast means at one row level - - - - - - 9.19 Bu./A

Coefficient of variation (a) 8.42%

Coefficient of variation (b) 7.37%.

Initial soil tests (Barnes silty clay loam)

PH - 6.6 Organic Matter - 6.7%

Extractable phosphorus - 19 Exchangeable potassium - 353

Comparison of Phosphorus Sources

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

A phosphorus source experiment was established at Rosemount in 1951. Twelve treatments of various phosphate materials were replicated four times across a regular rotation of corn, soybeans, wheat, and alfalfa. Potassium has been applied as required according to soil test. Lime applications were made on two replicates in the fall of 1961.

A prolonged drought in the summer of 1964 eradicated the alfalfa stands so no hay yields were obtained in 1965. To compensate for the poor alfalfa growth in 1964, the 1965 corn was given a sidedressed application of 60 lbs. of N/acre. The 1965 corn yields are reported in the following table.

The effect of various phosphate fertilizers on yield of corn, wheat, and soybeans.

(Port Byron silt loam - Rosemount-1965)

Treatments	Rate	Corn	Wheat	Soybeans
	lbs. P_2O_5/A/Yr.	Bu./A.	Bu./A.	Bu./A.
None	0	111.1	12.3	16.8
Ord. Superphosphate	40	125.4	19.8	15.7
Conc. Superphosphate	40	125.2	23.3	16.3
Calcium metaphosphate	40	129.4	18.0	18.6
Phosphoric Acid	40	124.7	19.4	20.1
Fuzed Tricalcium phosphate	40	127.5	17.6	18.4
Florida Rock and ord. Super.	20 + 20	128.8	20.1	21.1
Florida Rock	100	118.9	16.5	18.1
	lbs. P_2O_5/A./4 yrs.			
Fl. Rock Phosphate	1000	130.4	18.3	18.9
Western Rock Phos.	1000	123.9	17.4	20.3
Colloidal clay rock phos.	1000	121.0	12.4	18.3
Tunisian rock phos.	1000	121.8	18.0	16.7

Corn yields were increased by all phosphate treatments. Increases ranged from 7.8 bushels per acre for Florida rock phosphate applied at the rate of 100 lbs. of P_2O_5/acre annually to 19.4 bushels when the Florida rock was applied every 4 years at the 1000 lbs. P_2O_5 per acre rate. The last heavy rock phosphate applications were made in 1963. The last heavy applications at Tunisian rock phosphate occurred in 1962.

Wheat yields, although adversely affected by climatic conditions and rust infections, were increased from 0.1 to 10.9 bushels per acre by phosphate treatments. Poorest response was obtained from colloidal clay rock phosphates. Best response was obtained from concentrated superphosphate. Generally the more readily available phosphates gave the best response.

Soybean yields were generally low due to the poor growing conditions early and late in the season. Many pods did not mature completely before frost. No pattern of phosphate response is evident in the 1965 yields.

In past years all phosphate treatments have produced yield increases in alfalfa. Wheat yields have been increased in some years. Corn yields have also shown increase in past years but no particular treatment has been consistently superior to the others. In 1963 and 1964 soybean yields showed small but consistent increases due to the phosphate treatments.

The effect of lime and molybdenum on the yield of alfalfa, oats, corn, and soybeans.

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

The purpose of this experiment, started in the fall of 1951, is to study the long time effects of lime on (1) the yields of some common crops, and (2) on the physical and chemical properties of the soil. Treatments of 0, 3, 6, 12, and 24 tons of dolomitic lime per acre were applied on 4 replications in 1951. A rotation of corn, oats, and 2 years of alfalfa was established. Each year corn and oats have received 200 lbs. of 5-20-20 per acre. The alfalfa has received P and K as needed according to soil test. Since 1959 soybeans have replaced one year of alfalfa in the rotation. The beans receive 100 lbs. of 5-20-20 starter fertilizer per acre.

In 1960, molybdenum as $(NH_4)_2 MoO_4$ was applied at the rate of 8.7 ounces per acre on one of the check plots in each replicate.

In 1965 yields were obtained for corn, oats and soybeans. Alfalfa yields were not taken as most of the stand was lost during the 1964 drought. The 1965 yields are reported in the accompanying table.

Effect of lime and molybdenum on yields of corn, oats, and soybeans.

(Port Byron silt loam - Rosemount, 1965).

Lime Treatment	Corn		Oats		Soybeans	
Tons/A.	Bu./A.	Diff.	Bu./A.	Diff.	Bu/A.	Diff.
0	125.0	-	92.5	-	18.8	-
3	134.5	+9.5	82.5	-10.0	17.5	-1.3
6	126.7	+1.7	89.9	- 2.6	17.3	-1.5
12	133.8	+8.8	92.9	+ 0.4	17.2	-1.6
24	130.7	+5.7	95.8	+ 3.3	19.4	+0.6
0 + 8.7 oz. Mo/acre	127.8	+2.8	93.2	+0.7	16.8	-2.0
		N.S.		N.S.		N.S.

All treatments gave increases in corn yield but these were not significant at the 5% probability level. Oat yields were good but there was an excessive amount of plot variation due to lodging on some reps. No significant differences in soybean yield were recorded.

In past years the major effect of liming has been on the yield of alfalfa which has been doubled by the lime treatments. The molybdenum treatment has also produced yield increases in the alfalfa.

Sulfur Investigations on Soils and Crops

Report No. 7.

A. C. Caldwell, J. Grava, E. C. Seim, G. W. Rehm, Chih-ning Sun, R. S. Adams, and W. P. Martin

Department of Soil Science

University of Minnesota

The current research on sulfur had its beginning in 1962. Since that time major investigations have included studies on the oxidation of elemental sulfur in soil, effects of rates and kinds of sulfur-bearing materials on field crops, the movement of sulfur in soil, the measurement of sulfur in the atmosphere and rainfall, development of a satisfactory method for the determination of sulfur in plant tissue, an examination of the S-bearing compounds present during oxidation of elemental sulfur in soil, studies on the effects of soil type characteristics on sulfur oxidation, and an evaluation of the S-supplying power of some of the major soil types of Minnesota.

This report includes primarily the results of the field trials at the Park Rapids experimental site, for 1965, and other information gathered since June 1965.

Appreciation is expressed to the Sulphur Institute and the Tennessee Valley Authority for help in the financing of these studies.

Field Research

E. C. Seim

In 1965 studies on sulfur were carried on at the Park Rapids, Minnesota sulfur experimental field. Experiments begun in previous years on alfalfa, corn, soybeans, and sunflowers were continued in 1965. In addition new experiments on potatoes, corn and small grains were initiated. Supplemental irrigation facilities became available in 1965. The potatoes were irrigated on a regular schedule and other crops on a supplemental basis only.

Alfalfa

Two studies with several rates and types of sulfur on alfalfa were established in 1962. One study measures the effect of the various materials applied annually. The other study measures the residual effect of the 1962 sulfur treatments. The experiments compare the effects of three rates of elemental sulfur (25, 50, 100 lbs. S/acre) and a 50 lb. S/acre application of gypsum with a control (0 lbs. S/acre). An additional heavy gypsum application (1000 lbs. S/acre) was included in the residual study. All plots received complete applications of phosphorus and potassium according to soil tests at the beginning of the experiment. Borax (20 lbs/acre) was applied after the 1st cutting in 1962. Additional potassium has been topdressed as needed. The results of previous years have been presented in reports 1-6.

In 1965 three cuttings of alfalfa were taken. The 1965 yield results for the annually applied S treatments are reported in Table 1. Table 2 contains the 1965 yield results for the residual treatments.

The difference between the controls and the treated plots increased with each successive cutting. For the first cutting the yields of the treated plots

Table 1. Effect of annual applications of sulfur-bearing materials on the yield of alfalfa (1965).

Material	Rate lbs.S/acre	Yield: 1st cut tons/acre	2nd cut tons/acre	3rd cut tons/acre	Total tons/acre
None	0	1.31	0.56	0.25	2.11
Sulfur	25	2.35	1.55	0.91	4.81
Sulfur	50	2.40	1.72	0.83	4.94
Sulfur	100	2.49	1.46	0.74	4.68
Gypsum	50	2.59	1.63	0.87	5.09
lsd (.05)		.35	.32	.19	.62
(.01)		.48	.43	.26	.84
hsd (.05)		.51	.46	.27	.88
(.01)		.64	.57	.34	1.11

Table 2. Residual effect of sulfur-bearing materials on the yield of alfalfa. (1965)

Material	Rate lbs. S/acre*	Yield: 1st cut tons/acre	2nd cut tons/acre	3rd cut tons/acre	Total tons/acre
None	0	1.33	0.54	0.33	2.19
Sulfur	25	2.16	0.96	0.65	3.78
Sulfur	50	2.24	1.35	0.71	4.30
Sulfur	100	2.51	1.57	0.84	4.92
Gypsum	50	2.18	1.20	0.70	4.08
Gypsum	1000	2.46	1.36	0.86	4.67

* applied in 1962.

lsd (.05)		.41	.34	.22	.64
(.01)		.55	.45	.30	.87
hsd (.05)		.58	.48	.32	.91
(.01)		.72	.59	.40	1.13

were at least 1.8 times larger than the checks. For the second cutting they were 2.6 times larger and for the third cutting they were more than 2.9 times larger than the checks. The comparable figures for the residual study are 1.6, 1.7, 1.9. The figures therefore indicate that sulfur from natural sources (atmospheric and soil) are rapidly exhausted by the first cutting. As a consequence of the exhaustion of sulfur supply and possibly also because of enzyme and protein deficiencies present in the untreated plants, recovery of the alfalfa on the check plots following the first cutting was much slower than recovery of the treated alfalfa.

The highest yielding annual treatment was 50 lbs. of sulfur per acre as gypsum but there was no significant difference between the yields of the treated plots. The highest yielding residual treatment was 100 lbs. of sulfur per acre from elemental sulfur.

The residual data in 1965 indicate that although the 25 lbs. per acre elemental sulfur treatment is still producing 1.7 times more hay than the checks they are not producing the maximum yield possible when sulfur is non-limiting. The yields from plots treated with 50 lbs. of sulfur as gypsum also show some evidence that they are beginning to tail off.

The total sulfur content of the alfalfa tissue was determined for each cutting by the nitric perchloric acid digestion method developed by Rehm and Blanchar. The results are shown in table 3 for the annually treated plots and in Table 4 for the residual study. As in previous years all sulfur treatments significantly increased the sulfur content of the alfalfa. The sulfur level of the untreated alfalfa is in the critical range for the 1st and 2nd cuttings. All of the percentages for the third cutting are somewhat higher.

Table 3. Effect of annual applications of sulfur-bearing materials on the sulfur content of alfalfa (1965).

Material	Rate lbs. S/acre	Sulfur content of tissue (%) 1st cut	2nd cut	3rd cut
None	0	0.175	0.145	0.221
Sulfur	25	0.291	0.267	0.392
Sulfur	50	0.304	0.312	0.422
Sulfur	100	0.363	0.366	0.520
Gypsum	50	0.271	0.307	0.421
lsd (.05)		.054	.032	.055
(.01)		.073	.043	.072
hsd (.05)		.077	.045	.079
(.01)		.096	.056	.098

Table 4. Residual effect of sulfur-bearing materials on the sulfur content of alfalfa (1965).

Material	Rate lbs. S/acre	Sulfur content of tissue (%) 1st cut	2nd cut	3rd cut
None	0	0.151	0.136	0.222
Sulfur	25	0.176	0.146	0.213
Sulfur	50	0.216	0.173	0.288
Sulfur	100	0.260	0.212	0.316
Gypsum	50	0.179	0.147	0.223
Gypsum	1000	0.326	0.268	0.413
lsd (.05)		.026	.042	.052
(.01)		.035	.057	.071
hsd (.05)		.037	.060	.074
(.01)		.045	.074	.092

This is probably due to the third cutting being taken at a less mature stage than the 1st and 2nd cuttings in order to allow time for recovery before frost.

In the annually treated plots 100 lbs. S/acre as elemental sulfur produced the hay with the highest sulfur content. On the residual study, the heavy gypsum application (1000 lbs. S/acre in 1962) has produced hay with the highest percent of sulfur. The sulfur contents of the 25 lb. per acre elemental sulfur treatments and the 50 lbs. S per acre gypsum treatments also give indications that effects of these two treatments are beginning to diminish.

Alfalfa following corn

Alfalfa was seeded in 1963 to an area which had been in corn in 1962. Treatments were modified to include a check; the residual effect of elemental sulfur applied in 1962 at the rate of 25, 50 and 100 lbs. of S per acre; gypsum at 60 lbs. S per acre; the residual effect of 10 lbs. of S per acre as K_2SO_4 and 16-20-0-S applied to the corn; and a sulfur plus trace element treatment that supplied a total of 25 lbs. of sulfur per acre. No additional sulfur was applied in 1964 or 1965. In 1964 only the second cutting was taken for yield as the 1st cutting was severely hit by drought. In 1965 supplemental irrigations made it possible to obtain three cuttings. The yield data are reported in Table 5. Yields up to 4.8 tons per acre were obtained on the gypsum treated plots. The total yield for the check plots averaged 2.0 tons/acre.

In 1964 the plots which had received trace elements plus sulfur produced the top yields (but differences between treatments were slight). In 1965 the yields of the trace element plus sulfur plots were clearly below the yields of

Table 5. Effect of sulfur-bearing materials on theyield of alfalfa following corn. (1965)

Material	Rate lbs. S/acre	Date of Application	Yield (tons/acre) 1st cut	2nd cut	3rd cut	Total
None	0		1.03	0.51	0.45	2.00
Sulfur	25	1962	1.88	1.24	0.84	3.62
Sulfur	50	1962	2.14	1.34	1.03	4.51
Sulfur	100	1962	2.21	1.39	0.93	4.53
Gypsum	60	{10 lb. S. in 1962; 50 lb. S. in 1963}	2.36	1.44	1.04	4.83
K_2SO_4	10	1962	1.57	0.90	0.65	3.12
16-20-0-S	10	1962	1.35	0.62	0.50	2.48
Trace + S	25	{10 lb. S/acre as Zn-Mn-N-S 1962; 15 lbs. S/acre as trace element mixture in 1963}	2.11	1.29	0.81	4.22
lsd (.05)			.28	.43	.17	.66
(.01)			.37	.58	.23	.88
hsd (.05)			.44	.69	.28	1.05
(.01)			.54	.83	.33	1.27

the gypsum or heavier elemental sulfur treatments. Although the different levels and times of sulfur application make comparisins between treatments difficult, it appears that there has been no beneficial effect of the trace-elements in raising the yield above what might have been expected from an equal application of readily soluble sulfate sulfur.

The sulfur content of the alfalfa tissue is reported in Table 6. The data indicated that sulfur has reached a limiting level on the NPS and K_2SO_4 treated plots, and near-limiting on those which received 25 lbs. per acre as elemental sulfur. Despite the low levels of sulfur in the tissue on these plots yield increases were still obtained.

Small Grain

In 1965 the effects of sulfur-treatments on the yield of small grain were conducted using Traill Barley, Lodi Oats, and Chris Wheat. All plots received a broadcast application of 30 lbs. of N per acre, 35 lbs. of P per acre, and 249 lbs. of K per acre and100 lbs. per acre of sulfur free 12-32-16 starter applied in the row at planting time. Treatments consisted of 10 lbs. of sulfur per acre as elemental sulfur, gypsum or sodium sulfate applied in the row at planting. Treatments were replicated five times for each small grain.

The results of the sulfur treatments on the yield on the sulfur content of the whole plant at the time of heading out and on the sulfur content of the grain are shown in Table 7 for barley, Table 8 for oats, and Table 9 for wheat.

Barley yields ranged from 38.1 to 46.5 bushels per acre. There were no significant differences in yield between treatments. Gypsum and sodium

Table 6. Effect of sulfur-bearing materials on the sulfur content of alfalfa following corn. (1965)

Material	Rate lbs. S/acre	Date of Application	Sulfur Content of Tissue (%) 1st cut	2nd cut	3rd cut
None	0		0.144	0.134	0.232
Sulfur	25	1962	0.171	0.147	0.255
Sulfur	50	1962	0.211	0.163	0.315
Sulfur	100	1962	0.249	0.233	0.318
Gypsum	60	10 lbs. S in 1962; 50 lbs. S in 1963	0.244	0.207	0.300
K_2SO_4	10	1962	0.153	0.133	0.194
16-20-0-S	10	1962	0.187	0.133	0.219
Trace + S	25	10 lbs. S/acre as Zn-Ma-N-S in 1962; 15 lbs. S/acre as Trace Elem mix in 1963	0.189	0.166	0.240
lsd (.05)			.042	.029	.055
(.01)			.057	.040	.074
hsd (.05)			.068	.48	.089
(.01)			.081	.057	.106

Table 7. Effect of sulfur-bearing materials on the yield and sulfur content of Barley. (1965)

Material	Rate lbs. S/acre	Yield bu/A	Sulfur Content whole plant %	grain %
None	0	39.9	0.124	0.116
Gypsum	10	43.1	0.164	0.124
Elem. Sulfur	10	38.1	0.180	0.133
Na_2SO_4	10	46.5	0.171	0.132
lsd (.05)		N.S.	N.S.	.009
(.01)				.013
hsd (.05)				.012
(.01)				.016

Table 8. Effect of sulfur-bearing materials on the yield and sulfur content of oats. (1965)

Material	Rate lbs. S/acre	Yield bu/A	Sulfur Content whole plant %	grain %
None	0	55.9	0.160	0.139
Gypsum	10	55.8	0.159	0.142
Elem. Sulfur	10	49.4	0.181	0.155
Na_2SO_4	10	56.0	0.185	0.156
lsd (.05)		N.S.	N.S.	.109
(.01)				.153
hsd (.05)				.149
(.01)				.195

sulfate had a tendency to increase the yield from 3 to 6 bushels. Elemental sulfur had a negligible or slightly negative effect on the yield.

Sulfur content of the whole plants was increased by treatment but due to a wide variation these differences were not significant. The sulfur content of the grain did show a significant increase although the magnitude of the increase was not large.

Table 9. Effect of sulfur-bearing materials on the yield and sulfur content of wheat. (1965)

Materials	Rate lbs/A	Yield bu/A	Sulfur Content whole plant %	Sulfur Content grain %
None	0	19.6	0.166	0.159
Gypsum	10	21.8	0.174	0.163
Elem. Sulfur	10	20.8	0.219	0.187
Na_2SO_4	10	21.9	0.208	0.178
lsd (.05)		N.S.	.011	.015
(.01)			.015	.021
hsd (.05)			.015	.020
(.01)			.020	.026

Oat yields ranged from 49.4 to 56.0 bushels per acre. The interpretation of the data is similar to that for barley. There were no significant differences in yield but elemental sulfur had a slight tendency to decrease yield. The sulfur content of the grain was significantly increased by all of the sulfur treatments.

Wheat yields ranged from 19.6 to 21.9 bushels per acre. No significant differences in the yields were observed. There were significant increases, however, in the sulfur content of the whole plant and in the sulfur content of the grain.

Corn

In 1965 the effect of sulfur on corn was studied in two experiments. The first was a continuation of the continuous corn study established in 1963. As the corn was still immature when the first fall frosts threatened silage yields were taken. Two weeks later the corn had matured sufficiently to make ear corn yields meaningful. The corn still showed considerable variation in maturity and moisture content. The 1965 yields are reported in Table 10. The sulfur contents of the 6th leaf samples taken at the time of silking are included in Table 10 and seem to indicate that all of the sulfur applied in 1963 has been removed by the three corn crops or has otherwise become unavailable to the plant roots due to position or form. There were no significant differences in yield.

The second study involving sulfur fertilization of corn was placed on a new area which was plowed out of sod in the fall of 1964. The data of previous years indicated that a sulfur deficiency on corn would be most likely to occur on corn following sod in a cold wet year. Under these conditions the oxidation of the sulfur from the organic matter would be retarded and no buildup of available sulfur due to cultivation would have had a chance to occur. Only one sulfur treatment was used, 10 lbs. of sulfur per acre as Na_2SO_4. The corn received a basic fertilizer application of 150# N/acre as ammonium nitrate; 25# P/acre as 0-54-0; and 200# K/acre as 0-0-62. A sulfur-free starter (5-10-30) was used at the rate of 300 lbs. /acre. The corn was thinned to a final population of 18, 300 plants per acre. Supplemental irrigation was applied as needed.

Within two weeks from the time of planting the corn on the untreated plots was showing chlorosis and veination. Within another week the deficiency symptoms were general on the untreated plots giving the experimental area a checkerboard effect. In addition to the deficiency symptoms which generally follow the pattern for sulfur deficiency described by Fox et al. (1961),* the untreated corn averaged from 6 to 12 inches shorter than the treated corn. At this time the corn was side dressed with 60# N. From this point on the deficient corn began to outgrow the deficiency.

Samples of the deficient and normal corn plants were taken for sulfur analysis on a weekly basis from the onset of the deficiency until the corn was knee high, and again at silking time. The early samples consisted of whole plants. At silking time the 6th corn leaf was sampled. In addition samples were taken of the corn grain at harvest. The results are reported in Table 12.

The silage yields, percent moisture in ears at harvest and the ear corn yields are reported in Table 11. The untreated corn had outgrown the deficiency by late July and consequently no differences were observed in the silage yield. The treated corn was more mature, 4% drier, and produced 9.1 bushels more ear corn than the untreated corn.

Sulfur deficiency symptoms were observed in several other fields in Hubbard County and in a TVA cooperator's field in Todd County. Samples from the Voghtman field in Hubbard County were the most striking in the development of the symptoms. The corn never outgrew the stunting because of a severe summer drought. The sulfur content of a sample of the deficient plants was 0.165%.

Near Batavia, Minnesota, in Todd County, deficiency symptoms similar to those observed at Park Rapids were observed in a TVA-cooperators field. Corn which had received the 8-16-32 starter fertilizer was deficient and stunted. The sulfur content of the tissue was 0.228%. In the same field corn which had received 5-20-20 starter fertilizer was healthy and the sulfur content of the tissue was 0.270%.

Table 10. Effect of sulfur on the yield and sulfur content of 3rd year corn.

Material	Rate lbs. S/acre (applied in 1963)	Silage yield Tons/acre	Ear corn yield Bu/acre	Sulfur content 6th leaf %
None	0	5.31	75.7	.197
Na_2SO_4	5	5.59	71.0	.195
"	15	5.29	75.8	.199
"	25	5.41	75.9	.207
		N.S.	N.S.	N.S.

Table 11. Effect of sulfur on the silage and ear corn yield of corn after sod. (1965)

Treatment	Rate lbs. S/acre	Silage yield	Ear Corn Moisture %	Ear Corn Yield Bu/acre
None	0	6.04	50.6	73.8
Sulfur (Na_2SO_4)	10	6.20	46.0	82.9

Table 12. Effect of sulfur on the sulfur content of corn after sod. (1965)

Treatment	Rate lbs. S/acre	Sulfur Content of Tissue, Sampling 6-23-65	6-30-65	7-8-65	6th Leaf
None	0	.225	.235	.242	.200
Sulfur (Na_2SO_4)	10	.356	.280	.260	.238

Sunflowers

The study on the effect of sulfur on the yield of sunflower seed was continued in 1965. No additional applications of sulfur were made in 1965. All plots received 80 lbs. of P_2O_5/acre as 20-52-0 and 300 lbs. of K_2O/acre as 0-0-62. The 1965 yields are reported in Table 13. No effects of sulfur on the yield of sunflower seed were observed in 1964 or 1965. In 1965 yields ranged from 440 lbs. to 1090 lbs. /acre. Plots in the interior of the field produced less seed than the exterior plots regardless of treatment.

Table 13. Effect of sulfur on the yield of sunflower seed.

Treatment	Rate lbs. S/acre	Yield lbs. /acre
None	0	777.4
Gypsum	50	678.7 N. S.

Soybeans

The soybean study initiated in 1963 was continued in 1965. No additional applications of sulfur were applied. All plots received applications of P (100# P/acre as 0-54-0) and K (150# K/acre as 0-0-62) before planting in 1965.

The 1965 soybean yields are reported in Table 14. The maturity of the beans was delayed by the cool season but advanced sufficiently to make a harvest possible. Increases in yield up to 2.9 bu/acre due to the residual sulfur treatments were recorded. The statistical analysis of the data is not yet complete, however, and it is not known how significant these increases will be. In previous years there have been no significant differences in yields due to sulfur.

Table 14. Effect of sulfur-bearing materials on the yield of soybeans (1965).

Treatment	Rate lb. S/acre	Yield bu/acre
	(applied in 1963)	
None	0	14.9
Sulfur	25	16.2
Sulfur	50	17.6
Gypsum	50	17.8

Red-Clover-Brome

In 1965 no yields were taken from the newly seeded red clover-brome plots. The plots were clipped to a height of 6 to 8 inches in late August to control weeds. Visible color differences were noticed between the checks and treated plots before frosts in the fall.

Potatoes

In 1965 the availability of irrigation made it possible to conduct a study on potatoes at yield levels for which sulfur might become limiting. Two sulfur-bearing materials (elemental sulfur and gypsum) at the rate of 50 lbs. of S/acre were compared with a control. Basic applications of 500# K/acre, as 0-0-62, 200# N/acre as 33-0-0, and 50# P/acre as 0-54-0 were applied before planting. Plots were replicated six times. The variety Bounty was chosen because of its ability to outyield other varieties under irrigation. Irrigation was begun when the plants were about 12" tall and continued on a regular schedule until late August. Plant petioles and leaves were analyzed for sulfur. Yields were recorded and the quality of potatoes was checked by running specific gravity on representative samples from each plot.

Yields, percent total solids, and percent total sulfur in the petioles are reported in Table 15. The differences in yield are not significant. Potato quality as measured by specific gravity test and converted to total solids was also unaffected by the sulfur treatments. There were large differences in the sulfur content of the potato petioles taken at midseason.

Table 15. Effect of Elemental Sulfur and Gypsum on the Yield, Total Solids, and Sulfur Content of Irrigated "Bounty" potaotes.

Treatment	Rates lbs. S/acre	Yield bu/acre	Total Solids %	Total Sulfur in petioles %
None	0	645	20.8	.199
Sulfur	50	647	21.1	.318
Gypsum	50	668	21.2	.344

Sulfur in the Atmosphere

The collection and analysis of rainwater for sulfur and the measurement of the SO_2 content of the atmosphere by the lead peroxide "candle" method has continued. The data recorded for the months of May 1965 to August 1965 are reported in Table 16. Previous monthly data has been reported in reports 1-6.

Work in Progress

The collection and analysis of rain and snowfall and the analysis of SO_2 in the atmosphere by means of lead peroxide coated "candles" is continuing.

Additional tissue analyses are being completed on potatoes, corn and soybeans. Where applicable samples are being checked for interactions with N, P and K.

Table 16. Sulfur in the atmosphere and sulfur in precipitation at four locations in Minnesota from May 1965 to August 1965.

Period	Rainfall (inches)	S in Rainfall (lbs/A)	SO_2 in atmosphere (lbs S/A)
	St. Paul		
May	3.29	1.97	2.47
June	5.36	1.01	1.44
July	3.75	.81	2.09
August	3.59	1.17	1.44
	Park Rapids		
May	3.50	.79	1.31
June	5.59	.66	.64
July	1.60	.43	.85
August	2.61	.28	.69
	Duluth		
May	2.93	1.16	1.85
June	3.53	1.45	.89
July	3.57	1.09	.98
August	3.90	--	.65
	Lamberton		
May	7.33	1.50	1.91
June	2.60	.64	.59
July	2.55	.82	.69
August	1.69	.37	.98

Leaching of Sulfate Sulfur

A leaching study was established in the spring of 1964. Sulfur treated plots received 200 lbs. of sulfur per acre as gypsum. Sweet corn was grown on both treated and untreated plots. In 1965 one half of the plots were irrigated on a schedule to provide 1 inch of water every ten days. Soil samples were taken at 6 inch intervals to a depth of 36 inches at the close of the 1964 growing season (Sept. 26) and in the spring and fall of 1965. (May 8th and Sept. 24, 1965)

Sulfate sulfur in the core samples was extracted with .15% of $CaCl_2$ and measured turbidimetrically as $BaSO_4$.

The detailed results of the fall 1964 sampling were given in the previous report (Report No. 6).

The results of the 1965 spring sampling are shown in Table 18. Table 17 presents the results of the fall 1965 sampling.

The results are presented graphically in Figures 1 and 2.

There was no difference in sulfate in the profile of the untreated plots between the spring and fall samples. On the treated plots there was a significant decrease in the sulfur content of the profile between the spring of 1965 and fall 1965. The peak S content was still found in the 12-18 samples but had decreased from about 20 ppm to 9.6 ppm.

A comparison of the treated plot data for the spring of 1965 with the results of the previous fall (1964) indicates that there was little change in the sulfate content of the upper profile during the winter. Below 18 inches the average sulfate content did decrease by about 5 ppm during the winter months.

Table 17. Sulfate sulfur in the profile of a Dorset sandy loam on September 24, 1965.

Treatment	Core	Plot	Depth of Sample (inches) 0-6	6-12	12-18	18-24	24-30	30-36	Total Sulfate Sulfur 0-36"
			ppm S.						lbs S/acre
Unirrigated	1	1	6.8	5.0	5.8	5.0	5.0	5.0	
			7.5	4.8	5.8	5.0	5.0	5.0	
No. S.	2	"	2.5	2.3	3.3	1.5	1.5	1.5	
			2.5	7.0	3.0	1.5	1.5	2.0	
	3	"	2.0	2.0	2.3	2.3	2.3	2.5	
			2.0	2.0	2.3	2.3	2.5	2.5	
	Average		3.9	3.2	3.8	2.9	3.0	3.1	39.8
Irrigated	7	3	4.8	4.0	4.8	2.5	2.8	2.5	
			4.8	4.8	4.8	2.8	2.8	2.8	
No. S.	8	"	4.0	3.3	2.8	3.3	2.8	2.5	
			4.0	2.8	3.3	3.3	3.3	2.5	
	9	"	2.8	2.3	2.8	1.8	1.5	1.5	
			2.5	2.3	2.8	2.8	1.5	1.5	
	Average		3.8	3.3	3.6	2.8	2.5	2.2	36.4
Unirrigated	4	2	4.0	9.8	14.3	8.8	9.5	5.8	
			4.0	9.5	15.0	8.8	9.6	6.3	
Gypsum @ 200 lb. S/acre in 1964	5	"	4.8	3.0	6.0	3.5	3.5	3.5	
			5.0	3.0	6.0	3.5	3.5	3.5	
	6	"	9.8	7.8	8.0	9.5	7.8	7.5	
			9.8	7.8	8.3	9.5	7.5	8.0	
	Average		6.2	6.8	9.6	7.3	6.9	5.7	85.0

Table 18. Sulfate sulfur in the profile of a Dorset sandy loam on May 8, 1965.

Treatment	Core	Plot	0-6	6-12	12-18	18-24	24-30	30-36	Total Sulfate Sulfur 0-36" lbs S/acre
			Depth of sample (inches) ppm S.						
No. S.	1	1	3.5	2.5	3.0	1.5	2.5	2.0	
			3.5	3.8	2.5	2.5	2.5	1.5	
	2	"	5.3	4.5	5.3	7.0	3.8	4.3	
			6.0	4.3	6.3	5.3	4.3	5.0	
	3	"	4.0	2.8	3.0	2.0	2.0	1.5	
			4.0	2.8	3.0	2.5	2.0	3.0	
	7	3	4.5	2.5	2.8	2.8	2.3	3.0	
			4.0	4.0	2.0	2.8	2.8	3.0	
	8	"	4.8	1.8	3.3	3.0	2.5	2.8	
			5.0	2.5	3.0	2.8	2.5	2.8	
	9	"	6.3	3.5	3.0	2.5	2.5	2.5	
			6.3	3.5	3.3	2.5	2.5	2.5	
	Average		4.7	3.2	3.4	3.1	2.7	2.8	39.8
Gypsum @ 200 lbs S/acre	4	2	9.5	16.5	23.8	7.5	2.5	2.5	
			9.0	15.0	23.8	7.5	2.5	2.5	
in Spring 1964	5	"	7.3	19.5	18.8	4.5	3.5	3.0	
			7.3	19.5	19.0	4.5	3.5	2.5	
	6	"	9.0	37.5	23.8	5.0	1.5	1.5	
			9.0	37.5	23.8	5.0	1.5	1.5	
	10	4	11.3	23.0	19.8	8.3	2.8	3.8	
			11.3	23.0	17.8	8.3	2.8	3.8	
	11	"	9.8	20.0	21.5	9.8	8.8	11.5	
			10.0	20.3	22.0	9.8	7.5	9.8	
	12	"	16.3	13.3	16.5	11.3	9.0	6.5	
			15.5	15.8	17.5	11.3	9.0	6.5	
	Average		11.4	21.7	20.8	7.7	4.6	4.6	141.6

Figure 1
Sulfate sulfur in the profile of a Dorset sandy loam.

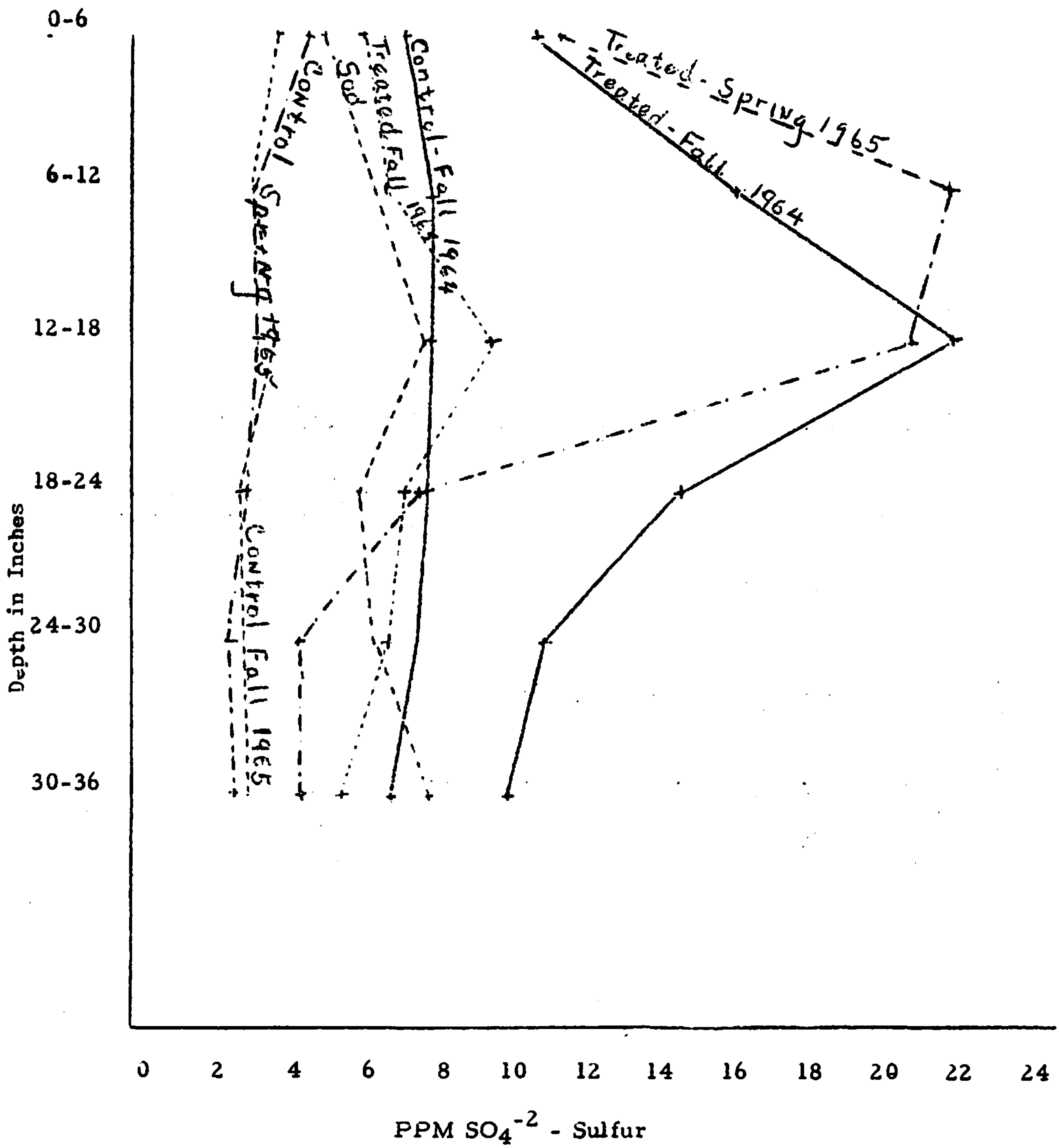
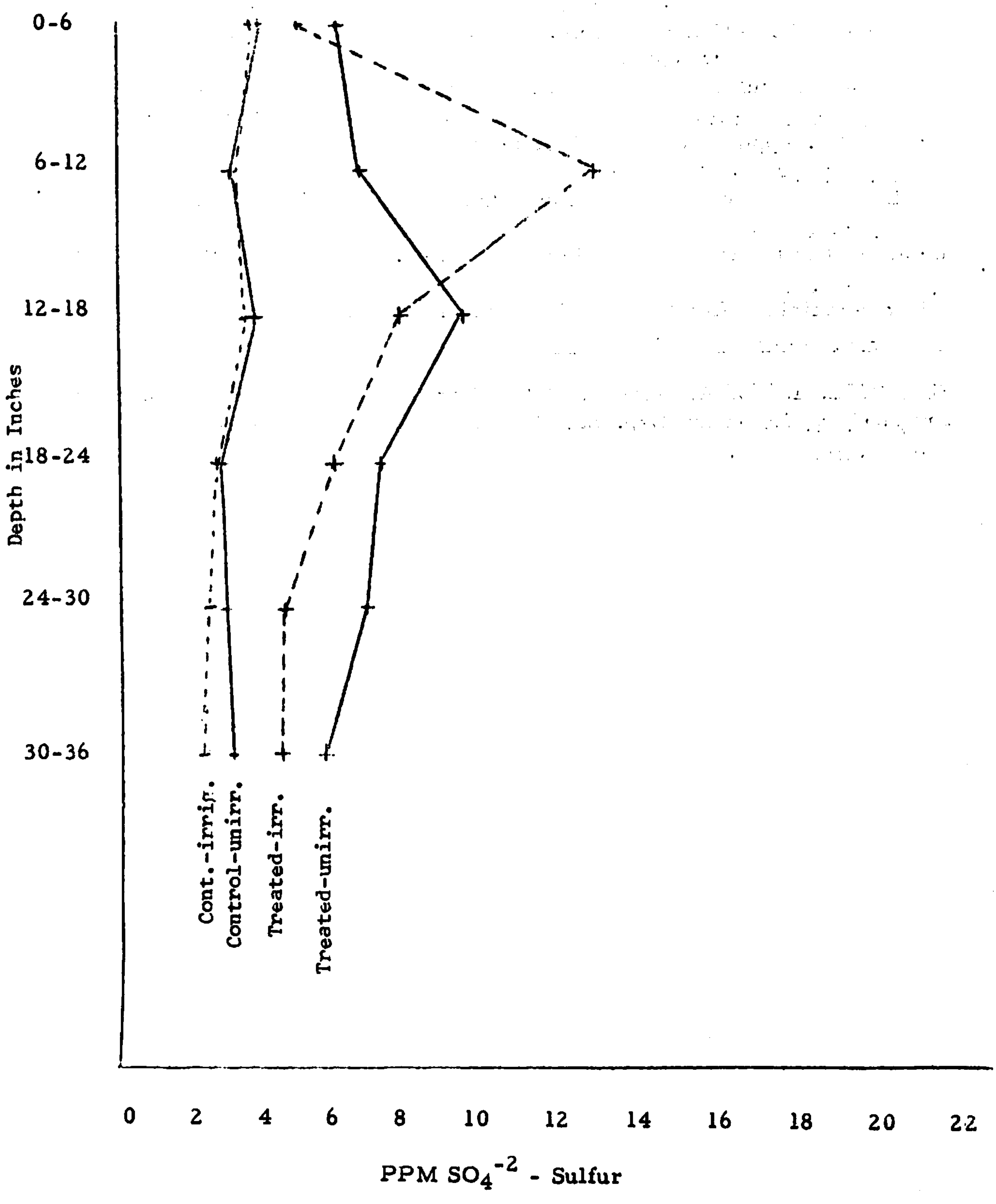


Figure 2
The effect of irrigation on the Sulfate sulfur in the profile of a Dorset sandy loam.



Irrigation caused no change in the sulfur content of the profile samples of the untreated plots. The sulfur content of the irrigated plot samples which had received the sulfur applications in 1964 averaged about 1 ppm less than the unirrigated treated plot samples. The one exception to this was observed in the 6-12 inch sample. If the one core sample which was very high in sulfate sulfur at this level is not used in calculating the averages, a value of 7.4 ppm is obtained instead of 13.3 ppm.

If the amount of sulfate sulfur in the control profile is subtracted from the amount in the treated profile we obtain 45.2 lbs. or 22.6% the applied sulfur remaining after two growing seasons and one winter.

Fox, R. L. and C. A. Hoover; Sulfur Fertilizers aid Corn and Soybean Production. Nebraska Exp. Sta. Quart. Winter 1961.

Sulfur Investigations on Soils and Crops
(Summary)

A. C. Caldwell, E. C. Seim, G. W. Rehm, Chi-ning-Sun,
J. Grava, R. S. Adams, W. E. Dorsey, W. P. Martin and E. Allred
Department of Soil Science, University of Minnesota.

A program of sulfur research on soils and crops in Minnesota was begun in 1962. Financial assistance was provided by the Sulphur Institute and the Tennessee Valley Authority. Studies have been conducted in the field, greenhouse and laboratory. Major investigations have included effects of rates and kinds of sulfur-bearing materials on the yield and sulfur content of field crops, (2) the movement of sulfur through the soil, (3) sulfur in the atmosphere and precipitation, (4) oxidation of elemental sulfur in the soil, (5) evaluation of sulfur supplying power of various soils. Field work is conducted in northcentral Minnesota at the sulfur experimental field, Park Rapids.

Most striking and consistent yield responses to sulfur treatments have been obtained with alfalfa. Sulfur, applied either as gypsum or as elemental-S has been an important factor in the establishment and maintenance of alfalfa. Sulfur treatments have more than doubled forage yields, and increased the S content of alfalfa.

Discoloration was observed in corn (after sod) on plots without S treatments in the early stages of growth. Corn receiving 10 lbs. /acre of S had normal appearance. The discoloration in corn gradually disappeared after the application of sidedressed nitrogen and as the season progressed. Sulfur content in the tissues from normal and abnormal plants seem to indicate that this discoloration in corn was indicative of S deficiency.

Sulfur treatments have increased S content in the tissue of small grains, soybeans, sunflowers and potatoes. However, additions of S have not resulted in significant yield increases in these crops.

Results of the sulfur status study with 79 soils indicated that the soils of northcentral and northeastern Minnesota are relatively low in S supplying power. Soils of southern and western Minnesota have a relatively high S supplying power.

Leaching studies have shown that sulfate-S movement from top-dressed gypsum is greater in cultivated soil than in soil under a sod crop. Irrigation also increased the downward movement of sulfate-S.

The greatest amounts of S in precipitation and in the atmosphere were recorded at St. Paul, close to the industrial Twin City area, and the lowest amounts were found at Park Rapids. Intermediate amounts of S were recorded at Duluth in northeastern Minnesota and at Lamberton in southwest Minnesota

Publications, Reports.

Sulfur investigations on Soils and Crops. Department of Soil Science, University of Minnesota.

Report No. 1. February 1963
Report No. 2. June 1963
Report No. 3. January 1964
Report No. 4. June 1964
Report No. 5. December 1964
Report No. 6. June 1965
Report No. 7. January 1966

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The Effect of Boron, Phosphorus and Potassium on the Yield of Five Legume - Grass Hay Fields and the Boron Composition of the Aflalfa in Carlton County in 1965

J. M. MacGregor, P. Borich & G. Randall*

In July, 1964, following the removal of first cutting of hay, experimental plots were established on four Carlton County farms to determine the effect of boron alone and in addition to phosphorus - potassium on the yield and composition the mixed legume-grass hays grown in the area. A 6 x 6 Latin square design was used. Symptoms of boron deficiency of legumes were evident on the second cutting of two of the four fields in August, 1964. While the boron applications at rates of 1 or 2 pounds per acre reduced teh severity of the B deficiency symptoms, these treatments did not significantly increase 1964 second cutting hay yields. Boron with phosphorus - potassium improved growth, but there again was no significant increase in hay yield of the second cutting on any of the four fields in a relatively dry midsummer growing period.

In the spring of 1965, an additional 1 and 2 pounds of boron per acre were applied to the four 1964 fields, and a fifth field was added. First and second cuttings were harvested and the alfalfa plants of each field were analyzed for boron content. The first cutting of 1965 was very heavy and lodging on the PK plots was a problem, with no visible growth difference on any treatment. The second cutting growth was reasonably good and the yield was much heavier than in 1964, with untreated and PK treated plots on three of the five fields exhibiting boron deficiency. As in 1964, the boron treatments appeared to relieve the deficiency symptoms of the alfalfa to some extent, but even the plots receiving 4 pounds of boron (nearly 40 pounds of borax) per acre still showed some of the characteristic symptoms of boron deficiency.

Hay yields (at 15% moisture) and boron content of alfalfa for the two 1965 cuttings were as follows:

The Boron Content of Alfalfa and Grass Legume Hay Yields on Five Carlton County Farms in 1965

Field 1. George Oraskovich Farm - Carlton Vilas sandy loam
Soil test pH 7.2, Organic matter 5.4%(H) P 180(VH) Ex.K 420(VH)

Fert.Treatment (lbs/A)	Hay Yield in tons/acre at 15% moisture: 1st cutting	2nd cutting	Total(1965)	Boron content of aflalfa ppm: 1st cutting	2nd cutting
none	1.80	0.65	2.45	80 a	60 a
0-60-180	1.69	0.93	2.62	69 a	42 a
0-60-180 + 1B	1.73	1.05	2.78	92 a	97 b
0-60-180 + 2B	1.82	0.85	2.67	95 a	106 b
0-60-180 + 2B[1]	2.02	0.86	2.88	100 a	122 b
0-60-180 + 4B[2]	1.57	1.12	2.69	113 a	167 c

According to Duncan's multiple Range test, those with different letters are significantly different from each other.

None of the yield increases of either the first or second cutting or total yield were mathematically significant. Boron content of oven-dried first cutting alfalfa was not significantly affected by mineral treatment, but the lower yielding second cutting under drier soil conditions was affected by increasing amounts of boron applie

*The cooperation of SCS personnel in classifying these soils is gratefully acknowledge

[1]One pound of boron applied annually in spring of 1964 and in 1965

[2]Two pounds " " " " " " " " " " "

Field 2. Marvin Benson Farm-Mahtowa-Vilas sandy loam (near woods)
Soil test --pH 6.9, organic matter 2.8 (L), Avail P 70(VH),Ex.K-100(M)

Fert.Treatment (lbs/A)	Hay Yield in tons/acre at 15% moisture 1st cutting	2nd cutting	Total(1965)	Boron content of alfalfa ppm 1st cutting	2nd cutting
none	2.86 a	1.15 a	4.01 a	65 a	34 a
0-60-180	3.51 b	1.61 b	5.12 b	72 ab	36 a
0-60-180 + 1B	3.49 b	1.72 b	5.21 b	92 bc	70 b
0-60-180 + 2B	3.56 b	1.52 b	5.08 b	112 cd	85 bc
0-60-180 + 2B[1]	3.36 b	1.48 ab	4.83 b	112 cd	85 bc
0-60-180 + 4B[2]	3.46 b	1.43 ab	4.89 b	126 e	104 c

The fertilizer treatments increased the second cutting yield significantly (5% level), whereas the first and total cuttings produced highly significant increases (1% level). There were no increase for PK&B over the PK alone treatment. There were marked B deficiency symptoms in the second cutting alfalfa of this field especially on the 0-60-180 treatment with no B. The addition of boron decreased the symptoms, but failed to completely remove the rosetting as well as the red and yellow leaf coloration.

Boron concentrations in the alfalfa of both cuttings were significantly increased by the boron treatments to the soil the larger increases occurring at the higher application rates.

[1]one pound of boron applied annually in spring of 1964 and in 1965
[2]two pounds " " " " " " " " " " "

Field 3. Marvin Benson Farm (near building) Mahtowa, Vilas sandy loam
Soil test --pH 7.3, organic matter 4.1 (M),Avail P 190(VH),Ex.K-320(VH)

Fert.Treatment (lbs/A)	Hay Yield in tons/acre at 15% moisture 1st cutting	2nd cutting	Total 1965	Boron content of alfalfa ppm 1st cutting	2nd cutting
none	1.74	1.19	2.93	70 a	60 a
0-60-180	1.80	1.05	2.85	64 a	53 a
0-60-180 + 1B	1.81	1.20	3.01	84 b	97 b
0-60-180 + 2B	1.77	1.12	2.89	86 b	102 b
0-60-180 + 2B[1]	1.78	1.23	3.01	82 b	112 b
0-60-180 + 4B[2]	1.73	1.19	2.92	96 c	127 c

None of the fertilizer treatments significantly increased first or second cutting or total yields on this field. Second cutting alfalfa growing on two of the six 0-60-180 plots showed a marked boron deficiency, and it is probably that since this experiment was located near a former poultry house, there may have been substantial applications of poultry manure made some years ago and this would supply some boron to the soil. Boron applications again significantly increased the boron content of the alfalfa hay, whereas the PK alone treatment tended to produce larger hay yields, the alfalfa having no more or possibly lower boron concentrations than the unfertilized hay.

[1]one pound of boron applied annually in spring of 1964 and in 1965
[2]two pounds " " " " " " " " " " "

Field 4. Lauri Waisanen farm, -Kettle River - Unnamed sandy loam
Soil test --pH 6.3, organic matter 4.5%(M) Avail p.18(M),Ex.K. 120(M)

Fert.Treatment (lbs/A)	Hay yield in tons/acre at 15% moisture 1st cutting	2nd cutting	Total 1965	Boron content of alfalfa ppm 1st cutting	2nd cutting
none	2.32 a	1.40 a	3.72 a	83 a	38 a
0-60-180	2.64 ab	1.94 b	4.58 b	55 a	36 a
0-60-180 + 1B	2.71 ab	1.97 b	4.68 b	125 b	76 b
0-60-180 + 2B	2.89 b	2.01 b	4.90 b	129 b	92 c
0-60-180 + 2B[1]	2.75 b	2.05 b	4.80 b	126 b	88 c
0-60-180 + 4B[2]	2.73 b	1.94 b	4.67 b	128 b	112 d

The first cutting hay yield was significantly (5% level) increased by all fertilizer treatments, with the second cutting and total hay yield increases being highly significant (1% level), although none of the latter fertilizer yields were significantly different from each other. The PK treatment appears to produce the significant effect rather than the boron. Plant growth on the untreated plots was shorter than on the five treated plots, with boron deficiency symptoms being most evident on the PK plots. Boron treatments did not entirely remove these symptoms, although the B treated alfalfa plants contained significantly more boron than those plants grown where no boron was applied.

[1]one pound of boron applied annually in spring of 1964 and in 1965
[2]two pounds " " " " " " " " " " "

Field 5. Gerald Mower Farm-Cromwell-Vilas loamy sand
Soil test--pH 7.1-organic matter 3.6% (M) avail p.200+(VH)Ex.K 510 (VH)

Fert.Treatment (lbs/A)	Hay yield in tons/acre at 15% moisture 1st cutting	2nd cutting	Total 1965	Boron content of alfalfa ppm 1st cutting	2nd cutting
none	2.08	0.82	2.90	75 a	42 a
0-60-180	2.45	0.96	3.41	72 a	40 a
0-60-180 + 1B	2.32	1.00	3.32	100 bc	77 b
0-60-180 + 2B	2.44	0.98	3.42	111 bc	103 c
0-60-180 + 2B[1]	2.48	1.02	3.50	90 ab	77 b
0-60-180 + 4B[2]	2.28	0.92	3.20	116 c	93 c

The fertilizer treatments were applied to this field in May of 1965, with double application of boron on the two heavier treatments. None of the treatments significantly increased hay yields and no boron deficiency symptoms were noted on the legumes of either the first or the second cutting although such symptoms were common a short distance away in the same field.

Boron applications significantly increased boron uptake by the alfalfa plants, however.

[1]two pounds of boron applied in spring of 1965
[2]four " " " " " " " "

Present Conclusions of this Study

1. Whereas the phosphate-potash (0-60-180) treatment has significantly increased some hay yields on two of the experimental fields, the boron treatment has failed to increase crop yield on any cutting of the five fields. (All fields were originally limed and well PK fertilized by the farm operator.)

2. Boron deficiency symptoms were observed on the second cutting alfalfa plants of three of the fields. Symptoms were most severe on PK treated plots, with the untreated plots exhibiting the symptoms to a lesser degree.

3. The boron treatments decreased the severity of the alfalfa boron deficiency symptoms to a certain extent, but failed to completely remove the stunting, rosetting, reddening, and yellowing of the plants.

4. All boron treatments materially increased the boron uptake by plants on both cuttings of all five experimental fields. However, the boron content of alfalfa from even the PK plots apparently was not at critically low levels essential for normal plant growth.

5. The results of this study during 1964 and 1965 have shown little encouragement for the economic application of boron for the purpose of controlling alfalfa yellowing on the soils of this region. The symptoms attributed to boron deficiency are more probably induced by other soil factors, of which limited soil water may be one important eontributor.

Direct and Residual Effect of Zinc Fertilization of Corn on a Zinc Deficient Silty Clay Loam in Southern Kandiyohi County

J. M. MacGregor and O. M. Gunderson

During the 1961 growing season, zinc deficiency was observed on some corn plants on the C. H. Litch farm at Lake Lillian. With the cooperation of the farm owner and Dr. R. R. Allmaras of the A.R.S. Soil and Water Research Station at Morris, a field experiment of zinc application for corn was initiated in May of 1962. Soybeans were seeded in 1963 but died out because of residue remaining from a 1962 application of atrazine. Corn was grown in 1964 and in 1965. Leaves were sampled (6th leaf from the ground) in each of the three years and were analyzed by the X-ray fluorescence procedure. The average zinc content of the leaves and yield of ear corn per acre for the three years are shown in the following table.

The Effect of 1962 Zinc Fertilization of a Zinc Deficient Silty Clay Loam in Southern Kandiyohi County on Zinc Concentrations in Corn Leaves and Corn Yields in 1962, 1964 and 1965.

1962 Treatment (lbs./A)	Leaf zinc in ppm			Yield of ear corn in bu./A		
	1962	1964	1965	1962	1964	1965
No zinc	9	19	8	43	40	38
		Zinc broadcast and plowed under in spring				
15 zinc sulfate	13	19	12	69	58	59
30 " "	19	20	20	66	56	58
60 " "	27	27	25	76	56	69
120 " "	29	28	31	67	50	69
	Zinc sulfate and/or nitrogen applied as a band starter					
20 nitrogen (N) alone	9	-	11	61	41	47
30 zinc sulfate	10	-	13	59	53	55
15 zinc sulfate + 20 N	10	-	14	63	58	56
30 " " " " "	11	-	13	64	65	65
60 " " " " "	12	-	20	63	62	59
	Zinc chelate coated on seed corn ($7\frac{1}{2}$ oz. $Na_2ZnEDTA$ per bu.)					
Seed treatment alone	9	-	8	55	51	48
" " + 30 zinc sulfate plowed down	22	-	17	74	67	67

Comparatively good agreement was evident between the amounts of zinc applied in 1962 and subsequent concentrations in the corn leaves. Earlier investigators in other sections of the United States have shown that the critical level of leaf zinc for normal corn growth to be approximately 15 to 20 parts per million. In general, the band applied zinc appears to be much less available to the corn plants than equal amounts broadcast and plowed under in 1962, even four cropping seasons later.

The zinc treatments produced substantial increases in corn yield with banding being only slightly less productive than plowing down, even though the corn leaves growing on the banded zinc plots contained considerably less zinc in each of the three growing seasons.

Although zinc chelate coatings on the seed increased corn yield in each of the three years, the zinc content of these leaves was extremely low, which might be expected from the amount of zinc initially applied (less than 1 oz. of the chelate per acre) and the corn yields were considerably less than any of the zinc sulfate treatments.

Nitrogen applications, either alone or in combination with zinc, had little appreciable effect on corn yields.

It is apparent that where zinc deficient soils do occur in Minnesota, the application of zinc sulfate, either plowed down or as a band application, will be an economic practice for corn production.

ZINC FERTILIZATION OF CONTINUOUS CORN

West Central Experiment Station

Samuel D. Evans

Two zinc experiments were set up at the West Central Experiment Station in 1965. The first was an experiment comparing rates and sources of zinc on a soil which had not shown any zinc deficiency symptoms. The second was a demonstration on a field which exhibited zinc deficiency in 1964.

1. Zinc Experiment

Treatment	Yield - Bu./A @ 15.5%
Check	97.80
5 lbs. zinc as zinc sulfate	98.93
10 lbs. zinc as zinc sulfate	96.63
20 lbs. zinc as zinc sulfate	98.93
45 lbs. phosphorus	99.54
45 lbs. phosphorus + 10 lbs. zinc as zinc sulfate	96.45
8 lbs. zinc 45 chelate	97.47
LSD (5%)	5.14

Coefficient of Variation - 4.48%

Initial soil test (Barnes silty clay loam)

PH - 6.6 Organic Matter - 6.7%

Extractable phosphorus - 19 Exchangeable potassium - 353

2. Zinc Demonstration

Treatment	Yield - Bu./A @ 15.5%
125 lbs. of 8-32-16	74.1
100 lbs. of 8-32-16 + 10 lbs. zinc as zinc sulfate	82.0

Initial soil test (Barnes loam) - This field is extremely variable

PH - 7.2 to 8.2 Organic Matter - 2.8 to 5.0%

Extractable phosphours - 40 to 75 Exchangeable potassium 130 to 400

EXTENSION DEMONSTRATION ON CORN FERTILIZATION 1965

C. J. Overdahl

County agents in several counties established fertilizer trials to observe the effect of starter, nitrogen sidedressing, and zinc treatments. They also included any fertilizer material or method in question where more information was desired. The latter involved ground soybeans, certain low-analysis material sold as specialty goods or soil conditioners, and pop-up fertilizers. Plots were replicated twice.

Corn yields in bushels per acre at 15.5 percent moisture are shown in the following tables.

Table 1. Watonwan County, John Ankeny, County Agent; Lemuel Swanson, Cooperator

Fertilizer Treatment in the Row	Sidedressed Nitrogen None	Sidedressed Nitrogen 70 Pounds
	Yield, bu./acre	
None	83	89
16+64+32	92	99
+ 5 lb. zinc	91	98
Ground Soybeans	84	91

Soil Test:	pH	OM%	P	K	Soil Texture
	7.7	5.0 M	30 H	290 VH	Clay Loam

- Final stand averaged about 18,000 plants per acre.
- Ground soybeans were applied at 125 pounds per acre.
- Preceding crop was corn
- Corn moisture percentage at time of harvest varied from 22.8 where 8-32-16 at 200 pounds per acre was used to 25.7 where ground soybeans were used as starter.

Ground soybeans appear to have no effect on yield or in reducing moisture content. There is no evidence of zinc response even though it might have been expected where the soil pH is high and row phosphorus applications and phosphorus soil test is high. There is an average increase of about seven bushels from the nitrogen treatments and about ten bushels from the 8-32-16 starter fertilizer.

Table 2. Big Stone County, Curtis Churness, County Agent; Dale Blum, Cooperator

Fertilizer Treatment in the Row	Sidedressed Nitrogen None	Sidedressed Nitrogen 70 Pounds
	Yield Bu./Acre	
None	24	35
9+28+9	41	45
+ 5 lb. zinc	44	50
0+0+75	20	37

Moisture content at harvest time (Oct. 25) was extremely high, varying from 42 percent on the plots receiving starter to 48 percent on untreated plots. Nitrogen response averaged about 10 bushels, starter increased yield by 13 bushels, and zinc appeared to increase yield about 4 bushels, although such small increases are questionable since greater variation within identical treatments occurred.

Table 3. Nobles County, Francis Januschka, County Agent; Earl Newburn, Cooperator

Fertilizer Treatment in the Row	Sidedressed Nitrogen None	Sidedressed Nitrogen 70 Pounds
	Yield, Bu./Acre	
None	104	116
9+36+18	111	120
+ 5 lb. zinc	113	120
+ pop-up	114	121

Soil Test:	pH	OM%	P	K	Soil Texture
	6.0	6.0 VH	20 M	310 VH	Loam

There was a 9-bushel increase from nitrogen, but little increase, if any, from zinc or "pop-up" fertilizer. Pop-up fertilizer is a small amount of mixed fertilizer applied in direct contact with the seed, for quick starter effect, in addition to the regular starter placed 2 inches to the side of and below the seed. Starter effect was also small. Medium-textured soils, such as a loam, usually do not show as large a starter effect as do finer textured soils unless the P and K tests are lower than in this demonstration.

Moisture at harvest time varied from 33 percent on untreated plots to 28 percent where starter and nitrogen were applied.

Corn was planted in 30-inch rows. The stand at harvest time was 23,500 plants per acre. Atrazine was used to control weeds and parathion was applied to control rootworms.

Table 4. Nobles County, Francis Januschka, County Agent; Lenz Bros., Cooperators

Fertilizer Treatment in the Row	Sidedressed Nitrogen None	Sidedressed Nitrogen 70 Pounds
	Yield Bu./Acre	
None	80	95
10+40+20	87	100
+ 5 lb. zinc	80	99
+ 50 lb. pop-up	84	93

Soil Test:	pH	OM%	P	K	Soil Texture
	7.0	5.5 M	62 VH	450 VH	Silty Clay Loam

Apparently with P and K tests as high as shown here, there are small needs for these nutrients under any weather conditions. The wet soils and cold temperatures, such as experienced this year, generally are expected to create a need for starter.

Corn was planted with a till planter on unplowed soil. Atrazine was used to control weeds, and diazinon was applied to control corn rootworms.

Table 5. Sibley County, John Peterson, County Agent; Russell Carlson, Cooperator

Fertilizer Treatment in the Row	Sidedressed Nitrogen None	Sidedressed Nitrogen 70 Pounds
	Yield, bu./Acre	
None	66	71
175# 5-20-20	68	84
+ 5 lb. zinc	63	74
175# soil conditioner	70	70

There is about an 8-bushel increase from nitrogen. The preceding crop was alfalfa. There appears to be a good yield increase from starter where nitrogen was used, but little if any response from 175 pounds per acre of soil conditioner and either no response or possibly a slight decrease from zinc. Ear moisture content was lowest (35 percent) at harvest time (October 16), with starter or starter plus nitrogen, and highest, (38 percent), on the plot with soil conditioner plus nitrogen and on the untreated plots. Corn was planted June 9.

Table 6. Sibley County, John Peterson, County Agent; David Battcher, Cooperator

Fertilizer Treatment in the Row	Sidedressed Nitrogen None	Sidedressed Nitrogen 70 Pounds
	Yield bu./Acre	
None	87	92
175# 5-20-20	110	112
175# inert sand	82	85
175# soil conditioner	91	100

This was a somewhat poorly drained Webster clay loam. The nearly inert sand was added with the prospect of maintaining better air and moisture relationships near the seed, but it appears to have had an adverse effect, if any. There is response of about 22 bushels from starter and very little nitrogen response. The soil conditioner used was a mineral material with very little nutrient value as demonstrated by its small yield increase compared to equal amounts of 5-20-20.

Ear moisture on the harvest date, October 30, was 26 percent where starter or starter plus nitrogen was used and from 32 to 34 percent on the other treatments. Corn was planted May 19.

A Survey of Grass Seed Production Fields in Northwestern Minnesota - 1965

John Grava, D. M. Larsen, G. W. Randall, R. S. Farnham,
W. P. Martin, and J. M. MacGregor

Previous investigations on the grass seed production project have dealt mainly with the effects of fertilization with primary nutrients, N, P and K on the yield of grass seed. Rates and time of application have been studied on mineral and organic soils in northwestern Minnesota (see "The Blue Books" of 1961, 1962, 1963 and 1964). The findings of these studies have been helpful in advising growers on the use of commercial fertilizers.

An exploratory survey of 12 grass seed production fields was conducted in 1964. Soils were classified and chemical analyses made on soil and plant tissue samples (see "The Blue Book" of Feb. 1965, pp. 113-126).

A similar survey was conducted during the summer of 1965. A total of 25 Timothy and 21 Park Kentucky Blue grass seed production fields were investigated in Clearwater, Roseau and Lake of the Woods Counties. Fifteen Timothy fields were on peat and ten on mineral soils. Six bluegrass fields were on peat and 15 on mineral soils. Five of the Timothy stands were one year old, 16 were two or three years old and four were six to seven years old. Three of the bluegrass fields had one year old stands, 13 stands were two to three years old and five had four to five years old stands.

Plant tissue samples were collected from representative areas about the time when grasses headed out. The samples have been submitted for spectrographic analysis. Soil samples were collected from the same areas from which the plant samples had been obtained. Soils were classified as to the soil type. Chemical analyses of the samples are nearly completed.

Grass seed yields were determined by harvesting mature plants from three - one square yard areas from the same spots where tissue and soil samples had been collected.

Based on information provided by growers and on actual determinations of seed yields, the average production field in the three county area received following amounts of plant nutrients, and produced seed yield as indicated in table 1.

Table 1. Average Amounts of Plant Nutrients Used, Fertilizer Costs and Seed Yields of Timothy and Park Kentucky Blue Grass in Northwestern Minnesota - 1965

Species, Soils	Plant Nutrients Used N + P_2O_5 + K_2O	Fertilizer Cost*	Average Seed Yield
	lbs./acre	\$/acre	lbs./acre
(1) Timothy			
On mineral soils	58 + 21 + 18	10.74	201
On peat	25 + 32 + 32	8.02	310
All Timothy fields	36 + 28 + 27	8.90	272
(2) Park Kentucky Blue grass			
On mineral soils	51 + 29 + 9	10.20	469
On peat	21 + 43 + 43	9.08	289
All Blue grass Fields	43 + 33 + 18	9.92	418

*Fertilizer costs per pound of nutrient:
N, 13.5 cents; P_2O_5, 10 cents; K_2O, 4.5 cents.

Generally, grass fields on mineral soils receive twice as much nitrogen as those on peat soils. Most commonly used commercial fertilizers on peat soils have ratios of 1:2:2 or 1:4:4 on mineral soils the fertilizers may have ratios of 1:1:0, 2:1:0 or 2:1:1.

Seed producers in the three county area considered the season of 1965 as one of the best in recent years and consequently obtained relatively high seed yields, especially of certified Park Kentucky Bluegrass. This may have been due to favorable weather conditions during the growing season. Cool season grasses such as Timothy and Kentucky Bluegrass prefer somewhat cool and moist weather. Following are climatological data as measured at the weather station, Roseau power plant from April 1 to July 31, 1965 (from climatological data, Minnesota, Vol. 71, 1965, U. S. Weather Bureau).

Precipitation (inches)		Temperature (°F)		Growing Degree Days $T_b = 40°F$
Total	Departure from normal	Average	Departure from normal	
21.8	+2.1	33.1	-4.4	1817

Slow-release nitrogen studies on Turf Grass-1965

R. S. Farnham

Studies of slow-release turf fertilizers were continued in 1965 on plots located on the St. Paul Campus. The comparisons did not include periodic clippings as in previous years but instead nitrogen analyses of dry grass clippings was determined near the end of the growing season (October 1, 1965) and visual ratings for color and thickness were made. These data were obtained to determine the long-lasting effectiveness of various slow-release turf fertilizers.

Materials and Methods

The slow-release fertilizers included in this study were resin-coated 16-8-8, 20-10-5, and ammonium nitrate furnished by Archer-Daniels Midland; Uramite (urea formaldehyde), American Humates organic fertilizer produced from weathered lignite mined in Wyoming; and two new organic materials (treatment no's 7 and 8) using peat as the organic filler. The resin-coated fertilizers have proven very effective as to their slow-release characteristic over the past few years of experimentation and thus were good materials to use to compare the effectiveness of the other fertilizers used.

Plots were located between Agronomy and Plant Pathology buildings and the size of each was 5' by 20'. Color and thickness ratings were made on Oct. 1, 1965 and nitrogen analyses were determined on clippings collected at this time. Plots were watered as needed.

Results

Data in table 1 show the results of visual observation and nitrogen analyses at end of growing season for bluegrass. The treatments can be compared to two checks which received no fertilizer.

Observations periodically during the growing season showed little difference in the fertilizer materials as to thickness and color of the grass. The data on nitrogen analyses at the end of the season does not differ significantly with different fertilizer treatments but does show great differences when compared to the check receiving no fertilizer.

The extremely slow release organic material from sewage sludge (milorganite) was superior to all others in nitrogen content color and thickness at the end of the season but were no better than the others during the growing season.

The low rating on color and thickness of grass and very low nitrogen level of the two check plots is noteworthy.

It can be concluded from this experiment that several slow-release nitrogen fertilizers prepared especially for turf grass are suitable for application in the spring as a single application. Further evaluations need to be made on basis of cost per pound of nitrogen as many of these slow-release forms vary considerably in price.

Table 1. 1965 TURF PLOTS - ANALYSES AT END OF SEASON*

Treatment	N Rate lbs/1000 sq ft	Color and Thickness Ave. Rating**	Nitrogen as % Dry Matter
1. 16-8-8 (coated)	8	6.0	3.17
2. 20-10-5 (coated)	8	6.1	3.47
3. NH_4NO_3 (coated)	8	7.5	3.11
4. Uramite (U-F)	8	7.2	3.06
5. American Humates(ORG.)	8	6.5	2.99
6. Milorganite (Sewage Sludge)	8	8.0	3.33
7. Batch "I" (Organic)	8	5.0	2.98
8. 53026 (Organic)	8	6.2	3.26
9. Check I (No fertilizer)	0	2.0	2.70
10. Check II (No fertilizer)	0	1.0	1.90

*Sampled Oct. 1, 1965.

**Color and thickness rating made on Oct. 1, 1965 ranges from 8 as best appearance to 1 as poorest. All analyses are averages of two replicates.

SOIL TESTING DURING 1965

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes more than thirty thousand samples annually. The following data show the number of various types of samples analyzed in 1965:

Regular farm, garden and lawn samples	27,313
Florist (greenhouse)	1,268
Limestone and marl	62
Departmental research samples	2,000
Total	30,643

The number of regular soil samples processed by the laboratory was considerably below that of previous years. In 1964, for example, over 33,000 samples were received for routine tests. It seems that sample collection was hindered by unfavorable weather conditions during 1965. Sample collection in some areas was almost impossible due to heavy snow cover, floods and excessive soil moisture during spring and an extremely wet fall. On the other hand, the influx of samples during November and December was very heavy. About 12,500 samples, or 45 percent of the total number of samples were received during the last two months of the year. 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 1965

Month	Number of Samples
January	1947
February	987
March	840
April	1506
May	1132
June	524
July	675
August	1621
September	2648
October	2905
November	6315
December	6111

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