A Report on Field Research in Soils

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

Department of Soil Science

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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 Because these are largely one year results they should not be considered as conclusive and the results are not for publication.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

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January, 1966

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								
				1965	1964	1963	1962	1961	1960	1959	1958	Average
Chippewa	Milan	H. Olson	Rothsay	-	5.7	8.1	8.2	-	-	-	-	7.3
Dodge	Dodge Center	G. Sutherland	Kasson	6.1	5.4	6.4	5.0	2.6	4.6	3.7*	4.6*	4.8
Kandiyohi	Pennock	E. Nordstrum	Clarion	-	0.4	2.1	-	-	-	-	-	1.3
Kandiyohi	Kandiyohi	H. Arvidson	Nicollet	-	7.0	7.8	-	-	-	-	-	7.4
Lac Qui Parle	Bellingham	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	Inches of Available Water in a Five Foot Column of Soil								Average
				1965	1964	1963	1962	1961	1960	1959	1958	
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	Inches of Available Water in a Five Foot Column of Soil 1965	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 Precipitation*
	Average Total	Maximum Total	
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.	Air Temperature Ave.Min.	Soil Temperature Ave.2"	Soil Temperature 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	-	-	-	-	-			
6-3-65	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		6/28-7/2		7/6-7/9		7/12-7/16		7/19-7/23		7/26-7/30		8/2-8/6		8/9-8/13	
		A M	P M	A M	P M	A M	P M	A M	P M	A M	P M	A M	P M	A M	P M	A M	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

		8/16-8/20		8/23-8/27		8/30-9/3	
		A M	P M	A M	P M	A M	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

		8/16-8/20		8/23-8/27		8/30-9/3	
		A M	P M	A M	P M	A M	P M
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 1985

% 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				Alfalfa				Significance1/	
	Packed		Not Packed		Packed		Not Packed			
	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Crop	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	130.4	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

Lambarton, 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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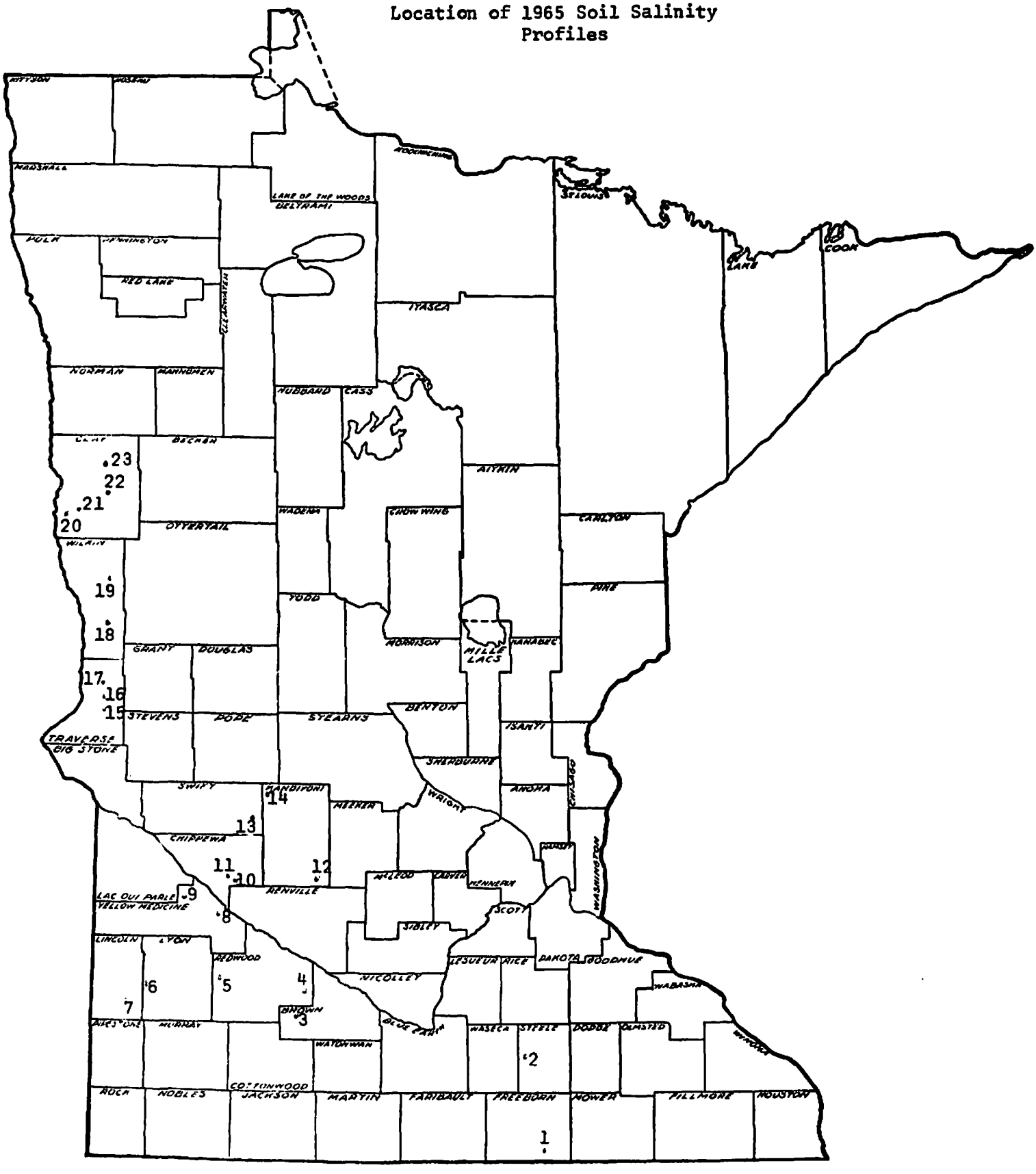
[1]This study was made possible through the excellent cooperation of Orville Gunderson and George Holcomb, area Soil Specialists, Joseph Cummins and Roy Erickson of the Soil Conservation Service, and the county agents or vocational agriculture instructors in those counties where the samplings were made. 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/l	Mg me/l	Na me/l	K me/l	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/l	Mg me/l	Na me/l	K me/l	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/l	Mg me/l	Na me/l	K me/l	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	0.3	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 Sil	24-36	8.0	13.1	0.9	6.6	0.7	1.3	0.2	0
				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/l	Mg me/l	Na me/l	K me/l	SO_4 (ppm)
				Chlorotic					
Tegner silty clay loam	0-6	7.7	12.1	0.8	6.4	0.3	1.7	0.1	50
	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 Traverse Co. Colvin silty clay loam	0-6	7.7	6.3	1.6	11.4	2.5	1.1	0.3	tr
	6-12	7.5	9.7	3.5	35.1	5.4	1.4	0.2	9200
	12-24	7.5	8.8	3.0	27.6	4.9	1.4	0.2	1235
	24-36	7.3	23.5	4.0	26.6	12.0	2.4	0.2	10325
				Beans - Chlorotic					
Colvin silty clay loam	0-6	7.7	7.3	1.1	6.6	1.6	2.6	0.2	369
	6-12	7.6	7.1	3.0	21.8	6.4	4.7	0.2	1325
	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 Wilkin Co. Roxbury loam	0-6	7.5	1.6	0.8	2.9	0.7	1.3	0.2	60
	6-12	7.4	1.6	0.4	1.3	0.1	0.7	0.2	110
	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 Wilkin Co. Colvin Sicl	0-6	7.7	16.3	1.1	5.3	1.0	1.6	0.5	255
	6-12	7.7	15.6	1.0	4.1	1.1	1.7	0.2	135
	12-24	8.1	16.9	1.1	3.4	1.64	1.8	0.3	100
	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/l	Mg me/l	Na me/l	K me/l	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 Reguse 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 just 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				Average Yield
	0	40	120	360	
			(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				Average Yield
	I	II	III	IV	
			(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