Jerome Jensing

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

University of Minnesota

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Some of the results herein reported are from experiments carried on during 1966 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 Because these are largely one year results they should not be considered as conclusive and the results are not for publication.

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Some Climatalogical Notes, 1966

by Donald G. Baker

A. Summary of the Fall, 1966, Soil Moisture Survey

A summary of the fall, 1966, soil moisture survey is shown in table 1. In general the soil moisture reserves are somewhat below average for this time of year as shown in table 2. And at most sites the reserves are lower than last year, which is not surprising since the precipitation was down from last year. This year only at Duluth was the growing season precipitation appreciably above normal by the end of the season, table 3.

Combining the precipitation data with the soil moisture data a summary of the fall 1966 situation is as follows: the reserves in the northern half of the state are average to somewhat below normal, except in the northwest and particularly in the northeast where they are above normal. The southern half the reserves are almost all below average. The lowest reserves are found in the South - central and southeast, where they range from 30-55% of the available water holding capacity.

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

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B. Summary of Southwest Experiment Station (Lamberton) Soil Moisture Data

There are now six years of soil moisture data that have been taken at Lamberton. This years data do not differ appreciably from that of previous years and therefore serve mainly to substantiate earlier conclusions made concerning evapotranspiration.

The moisture apparently consumed by the corn crop has been about equal to that which would be lost if the soil remained at the optimum soil moisture content, i.e., field capacity. This has occurred even though the soil has seldom remained at field capacity. A comparison between the calculated potential evapotranspiration loss and the apparent measured soil moisture loss is

Table 1. Fall, 1966, Soil Moisture Results.

County	Near By Town	Farm Operator	Soil Type	Date Sampled	Crop & Yield	(In) Total Available H_2O Present	% of Possible H_2O	(In) Diff Fall 66-Fall 65	(In) H_2O Used in Season
Big Stone	Ortonville	H. Dimberg	Barnes Clay Loam	11/7/66	Corn	2.1	25.0		26.9 (5/7-11/4)
Big Stone	Beardsley	Wright	Silty Clay Loam	11/7/66	Alfalfa	0.0	3.0		
Chippewa	Milan	H. Olson	Rothsay Silt Loam	11/8/66	Soybeans	5.3	56.4		20.1 (5/4-11/4)
Chippewa	Montevideo	G. Sederstrom	Barnes	11/8/66	Alfalfa	1.0	9.2	+1.6	21.7 (5/2-10/31)
Lodge	Dodge Center	G. Sutherland Kasson	Silt Loam	11/17/66	Corn	3.6	34.0	-2.5	19.6 (5/23-11/17)
Kandiyohi	Pennock	G. Giese	Clarion Silt Loam	11/4/66	Alfalfa	1.8	17.0		23.1 (5/1-10/31)
Kandiyohi	Kandiyohi	H. Arvidson	Nicollet	11/4/66	Fallow	3.9	34.0		
Lac Qui Parle	Bellingham	W. Glasser	Aastad Silty Clay Loam	11/7/66	Small Grain	7.6	60.9		
Lac Qui Parle	Lac Qui Parle	G. Heimdahl	Rothsay	11/7/66	Corn	0.8	8.0	+2.3	16.2 (5/2-10/31)
Lac Qui Parle	Marietta	I. Aebli	Rothsay Silt Loam	11/7/66	Fallow	5.9	56.7		21.7 (7/6-11/7)
Lac Qui Parle	Dawson	M. Nelson	Aastad Silty Clay Loam	11/7/66	Corn	3.4	40.0		21.6 (5/7-11/7)
Lincoln	Arco	C. Madsen	Barnes Clay Loam	11/10/66	Corn 80 u.	2.2	17.2	-1.2	18.1 (5/16-11/10)
Lincoln	Porter	R. Boulton	Barnes Silty Clay Loam	11/10/66	Soybeans 33 bu.	5.0	39.0	-0.3	17.8 (5/2-11/10)
Mille Lacs	Milaca	T. Nichols	Mora Silt Loam	11/14/66	Grass Legume Hay	2.9	21.8	-10.0	24.0 (5/6-11/14)
Polk	Crookston	U of M	Hegne Silty Clay Loam	10/31/66	Pasture	9.2	52.3	+0.8	15.8 (5/31-10/31)

Table 1. Fall 1966 Soil Moisture Results (continued)

County	Near by Town	Farm Operator	Soil Type	Date sampled	Crop & Yeild	(In) Total Available H_2O	% of Possible H_2O	Diff Fall 66 - Fall 65	(In) H_2O Used in Season
Ramsey	St. Paul	U ofM	Waukegan Silt Loam	9/19/66	Sod	7.7	93.4	+0.1	15.0 (5/16-9/19)
Ramsey	St. Paul	U of M	Waukegan Silt Loam	9/19/66	Bare	7.2	87.4	+0.4	12.0 (5/16-9/19)
Ramsey	St. Paul	U of M	Waukegan Silt Loam	9/19/66	Soybeans	3.4	40.8	-3.9	16.6 (5/16-9/19)
Redwood	Belview	V. Anderson	Nicollet Clay Loam	11/10/66		2.4	16.7	-1.0	17.1 (5/16-11/10)
Redwood	Lamberton	U of M	Webster Silty Clay Loam	11/3/66	Corn 45 bu.	4.3	43.8	-0.9	18.2 (5/17-11/3)
Redwood	Morgan	N. Prokosch	Nicollet Clay Loam	11/10/66	Corn 120 bu.	9.4	95.8	+1.6	17.6 (5/7-11/10)
Sibley	Winthrop	D. Woods	Nicollet Clay Loam	11/7/66	Alfalfa	6.6	56.0	-3.5	18.3 (5/25-11/7)
Swift	Danvers	C. Stubbs	Barnes Clay Loam	11/4/66	Corn	7.7	72.0		17.8 (5/2-11/4)
Swift	Murdock	R. Tucker	Vallers Silty Clay	11/4/66	Beans	10.5	94.0		
Wabasha	Kellogg	K. Fickrick	Fayette Silt Loam	11/3/66	Corn	8.6	55.0	-3.8	26.3 (4/19-11/3)
Watonwan	Butterfield	E. Hanson	Nicollet Clay Loam	10/19/66	Corn	7.6	59.9	-2.0	28.7 (5/19-10/19)
Yellow Medicine	Granite Falls	K. Velde	Aastad Silty Clay Loam	11/10/66	Fallow	8.2	54.1	-3.1	20.8 (5/2-10/10)

Table 2. Average Fall Soil Moisture Reserves - Inches of Available Water in a 5-foot column of soil.

County	Nearly Town	Farm Operator	Soil Series	Average	Fall 1966	Years of Data
Big Stone	Ortonville	H. Dimberg	Barnes	2.1	2.1	1966
Big Stone	Beardsley	Wright		0.0	0.0	1966
Chippewa	Milan	H. Olson	Rothsay	6.8	5.3	1962,63,64,66
Chippewa	Montevideo	G. Sederstrom	Barnes	4.3	1.0	1965.66
Dodge	Dodge Center	G. Sutherland	Kasson	4.6	3.6	1960,61,62,63,64,65,66
Kandiyohi	Pennock	G. Giese (Nordstrom)	Clarion	1.1	1.8	1963,64,66
Kandiyohi	Kandiyohi	H. Arvidson	Nicollet	6.2	3.9	1963,64,66
Lac Qui Parle	Bellingham	W. Glasser	Aastad	9.5	7.6	1962,63,64,66
Lac Qui Parle	Lac Qui Parle	G. Heindahl	Rothsay	3.3	0.8	1965,66
Lac Qui Parle	Marietta	I. Aebli	Rothsay	5.9	5.9	1962,63,64,66
Lac Qui Parle	Dawson	M. Nelson	Aastad	6.9	3.4	1963,64,66
Lincoln	Arco	C. Madson	Barnes	3.1	2.2	1963,64,65,66
Lincoln	Porter	R. Boultan	Barnes	4.5	5.0	1963,64,65,66
Lyon	Cottonwood	R. Olson	Aastad	7.0		1963,64,65
Lyon	Marshall	C. Boerloom	Vallers	6.0		1963,64,65
Lyon	Minneota	N. Orsen	Barnes	5.3		1962,63,64,65
Mille Lacs	Milaca	T. Nichols	Mora	6.4	2.9	1961,62,63,64,65,66
Polk	Crookston	U of M	Hegne	5.6	9.2	1961,62,63,64,65,66

Table 2. Average Fall Soil Moisture Reserves - Inches (continued) of Available Water in a 5-foot column of soil.

County	Nearly Town	Farm Operator	Soil Series	Average	Fall 1966	Years of Data
Ramsey	St. Paul	U of M	(sod) Waukegan	7.7	7.7	1965,66
Ramsey	St. Paul	U of M	(bare) Waukegan	7.0	7.2	1965,66
Ramsey	St. Paul	U of M	(soybean) Waukegan	5.1	3.4	1962,63,65,66
Redwood	Belview	V. Anderson	Nicollet	5.6	2.4	1962,63,64,65,66
Redwood	Lamberton	U of M	Webster	5.5	4.3	1961,62,63,64,65,66
Redwood	Morgan	N. Prokosch	Nicollet	8.6	9.4	1965,66
Redwood	Wabasso	D. Kuehn	Nicollet	6.2		1963,64,65
Sibley	Winthrop	D. Woods	Nicollet	8.9	6.6	1961,62,63,64,65,66
Swift	Danvers	C. Stubbs	Barnes	5.8	7.7	1963,64,66
Swift	Murdock	R. Tucker	Vallers	8.8	10.5	1963,64,66
Wabasha	Kellogg	K. Fickrick	Jayette	9.1	8.6	1961,62,63,64,65,66
Watonwan	Butterfield	E. Hanson	Nicollet	7.8	7.6	1961,62,63,64,65,66
Yellow Medicine	Granite Falls	K. Velde	Aastad	10.7	8.2	1963,64,65,66

Table 3. Total departure ofprecipitation from normal since April 4, 1966. (From "Minnesota Weekly Weather. Crop and Livestock Report")

Station	As of Aug. 1	As of Oct. 30
Fargo, N.D.	-0.23 in.	+0.61 in.
International Falls	+2.74	-0.39
Duluth	+2.40	+2.04
St. Cloud	-0.98	-3.28
Sioux Falls, S.D.	-5.22	-2.40
Rochester	-4.34	-4.43
Minneapolis - St. Paul	-3.72	-1.66

Table 4. Comparison of calculated average potential evapotranspiration and the measured soil moisture losses from corn, Lamberton, 1961-66.

	Months							
	A	M	J	J	A	S	O	Total
Potential Loss	1.01	3.05	5.03	6.63	4.68	2.81	1.71	24.92
Measured Loss	0.90	3.10	5.10	6.20	4.65	2.70	0.93	22.23
Difference	+0.11	-0.05	-0.07	+0.43	+0.03	+0.11	+0.78	+2.69

shown in table 4. (The word apparent has had to be used here because neither the downward drainage through the profile nor the surface runoff were measured.) The only real difference between the potential and measured values occurred in July and October, while for the crop season of May-September the difference is less than o.5 inch.

A comparison between the average measured soil moisture losses and the average measured soil moisture losses and the average precipitation, table 5, indicates the very great importance of the soil moisture reserves. For without these reserves to draw upon the crop would indeed run out of water; during the critical months of June, July and August the precipitation on the average is less than the crop use by 2.05, 1.26 and 1.21 inches, respectively. Thus, in three consecutive months a total of 5.52 inches must be withdrawn from the soil. This, of course, is the reason for the value of the fall and spring rains which are in excess of the crop needs. It may be added that over-winter precipitation is an extremely poor source as far as adding to the soil moisture reserves. Minnesota data indicate that only about 25% of the over-winter precipitation enters the soil.

The average daily soil moisture loss, based upon measurements taken at approximately monthly intervals throughout the season, do not differ much from those presented in last year's summary (table 5, page 7, 1965 summary) as shown in table 6.

The fact that the measurements were not taken regularly at the beginning of a month does complicate the problem of obtaining reliable figures. The data in table 6 are only estimates for this season.

C. Summary of Selected Precipitation Data at the Southwest Experiment Station, Lamberton, 1961-66.

The average monthly precipitation at Lamberton is shown in table 7. In the same table is the average number of days on which precipitation was recorded. (This does not include days on which a trace, or less than 0.005 inches, was recorded.) These days then represent, on the average, the number of "rainy" days required to produce the monthly precipitation totals. It is apparent that there is an abrupt increase in precipitation days beginning in April which extends through September.

Table 5. Comparison of the average measured soil moisture losses and the average precipitation, Lamberton, 1961-66.

	Months							
	A	M	J	J	A	S	O	Total
Precipitation	2.63	4.04	3.05	4.94	2.44	3.79	1.34	22.23
Measured Loss	0.90	3.10	5.10	6.20	4.65	2.70	0.93	24.92
Difference	+1.73	+0.94	-2.05	-1.26	-2.21	+1.09	+0.41	-2.69

Carrying the data in table 7 one step further we arrive at the calculated average precipitation that falls per "rainy" day, table 8. In other words the figures in table 8 represent that average amount of rain, or snow, to be expected on a"rainy" day. For example, given that a day in July will be rainy 0.54 inches on the average will fall.

D. Selected Phenological Data of Soybean Growth, St. Paul, 1962-66.

Since 1962 daily measurements have been taken of the height and percent of ground covered by the soybeans grown on the agricultural weather station plot at St. Paul. Averages of these measurements are shown in figure 1. Both curves exhibit the characteristic sigmoid (or drawn-out S) shape.

Based upon these ground cover averages Sherwood Idso (graduate student, Department of Soil Science) has calculated for a hypothetical plant similar to the soybean in geometry the percent of ground that is sunlit for N-S and E-W row orientation during a 24 hour period at the time of 50% ground cover. The calculations are for a station at 45° N. latitude at about July 5. The result is shown in figure 2.

The significance of this figure is that less ground is sunlit under the N-S rows, and therefore more energy is apparently absorbed by the leaves. In contrast the E-W orientation has a higher amount of sunlit soil and presumably less energy is absorbed.

E. Early Planting and Higher Yields

Some time ago I was asked if I could explain why increased yields ordinarily occur with earlier planting of corn. At least this seems to be the result obtained in more southerly parts of the Corn Belt. I could not answer the question at the time, but I have been considering it since then and have several things to suggest and consider.

First, the advantage of early planting in Minnesota is both more limited and more risky than it is in the central and southern Corn Belt regions. This is because the arrival of spring is more abrupt and there is a greater probability of cold temperature damage. For example, the probability of the occurrence of 32°F. or lower at Winnebago increases from 10% on May 19 to 50% on May 5.

Nevertheless, the planting date can in most years probably be advanced anywhere from about 1 week to as much as 2 1/2 weeks. The average corn planting date in the southern 1/4 of Minnesota seems to be about May 12-20. Data from Michigan and Northwestern Iowa indicate May 1-6 as about the optimum. This date may also be provisionally accepted as the optimum in the southern 1/4 of Minnesot

Table 6. Average daily water use at Lamberton, 1961-66.

	A	M	J	J	A	S	O
Average daily water use, inches	0.03	0.10	0.17	0.20	0.15	0.09	0.03

In the average year planting earlier than May 1-6 is of no advantage; temperatures are too cool for germination or cause frost damage to the young plant. Planting later than the above date results in reduced yields in the average year because complete advantage of the environment has not been taken.

Early planting has not been practiced (in my opinion) because most of us are geared to the "temperature season" rather than the "radiation season." And since the "temperature season" lags behind the "radiation season" by some 2-4 weeks (maximum radiation occurs in the third week of June and maximum temperatures in July) agriculture is not taking full advantage of the available energy.

I believe that the advantages of early season planting are due to the following factors:

1. The solar radiation peak is reached on June 22 which, according to figure 1, is when the soybean plant covers only about 25% of the ground as ordinarily grown at St. Paul. If planted two weeks earlier, say on May 5, the cover would be nearly 55%. (We have data indicating that the sigmoid on "S" shaped curve in figure 1 can be shifted about without appreciable change simply due to a change in the planting date.) In other words early planting permits greater efficiency (absorption) of the available energy.

2. As a result of the earlier planting, and presumably greater absorption of energy, the plant will have more foliage. Due to the greater foliage the proportion of exterior leaves to the total number of leaves will be less. Therefore, the fraction of leaves exposed to the frequently occurring above optimum temperatures of July and August will be less than the late planted crop (table 9). One would therefore expect that the earlier planted crop would have a greater number of leaves photosynthesizing at temperatures closer to the optimum. (It should be pointed out here that interior leaves, that is leaves within the plant canopy, are usually several degrees lower than the exterior leaves.)

3. And finally early planting and early development are more advantageous because the plant is less likely to suffer from water stress. Ordinarily soil moisture reserves begin to drop shortly after reaching their peak in early June, figure 3. The implication, of course, is that a more mature plant is better able to withstand moisture stress and with less yield reduction than the more immature plant.

Table 7. Average monthly precipitation, inches, and the average number of days per month with recorded precipitation, Lamberton, 1961-66.*

	Month												
	J	F	M	A	M	J	J	A	S	O	N	D	Total
Inches	0.33	0.69	1.11	2.63	4.04	3.05	4.94	2.44	3.79	1.34	0.75	0.49	25.60
Days	4.8	5.3	6.3	10.1	11.8	10.7	9.1	7.7	10.8	4.2	3.2	4.8	88.8

* Days with trace precipitation not included.

Table 8. Average precipitation, inches, per day of precipitation, Lamberton, 1961-66.

J	F	M	A	M	J	J	A	S	O	N	D	Ave
0.07	0.13	0.18	0.26	0.34	0.28	0.54	0.32	0.35	0.32	0.23	0.10	0.:

* Days of trace precipitation not included.

Table 9. Frequency in days of maximum temperatures greater than 89°F at Lamberton and greater than 84°F at St. Paul.*

Station	May	June	July	Aug.	Sept.
Lamberton (1961-66)	8	29	41	27	4
St. Paul (1961-66)	13	48	68	58	7

* The optimum leaf temperature of corn is approximately 86°F.

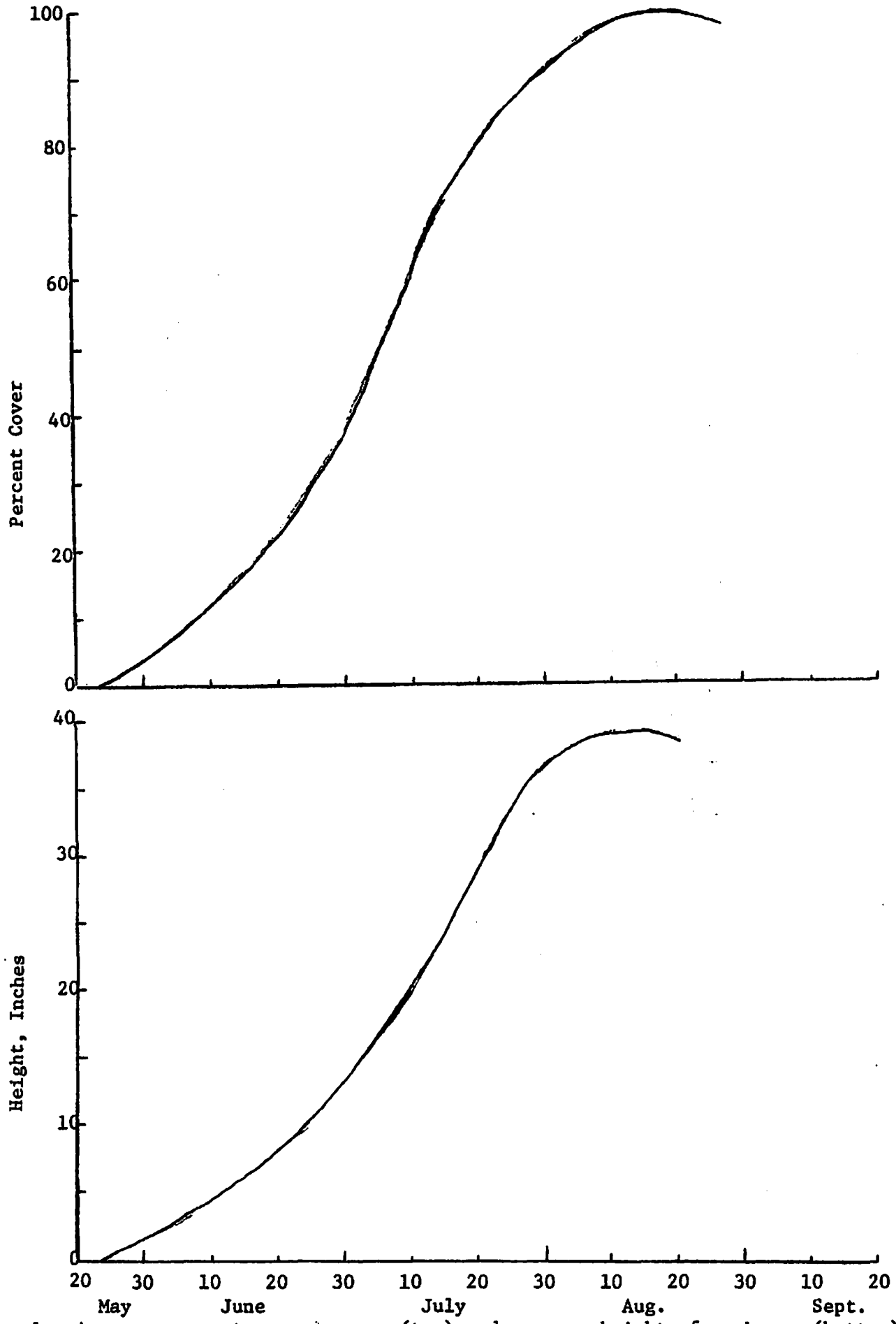

Figure 1. Average percent ground cover (top) and average height of soybeans (bottom) in 30 inch rows, St. Paul, 1962-66.

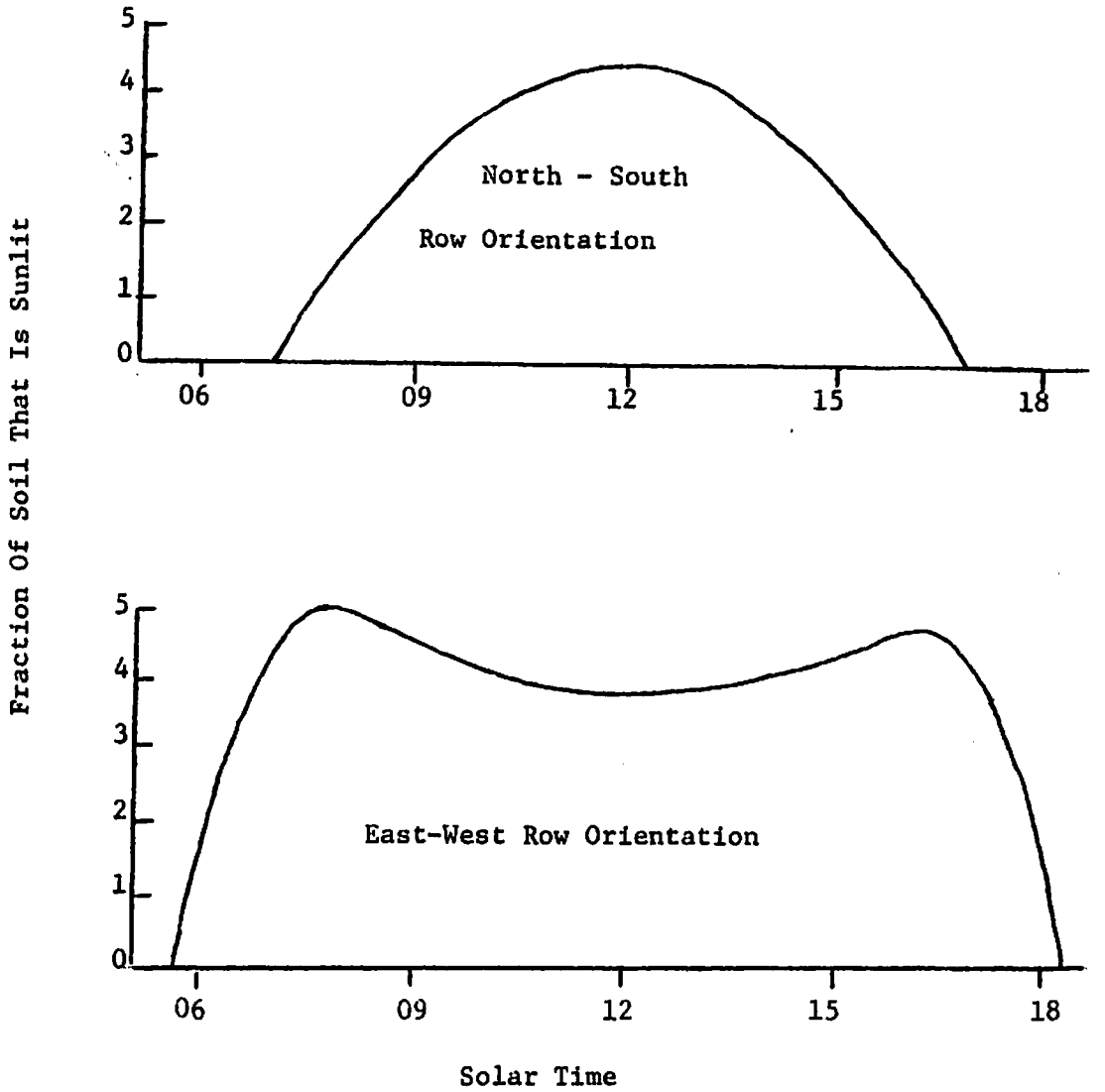

Figure 2. The hourly variations in the fraction of the total soil area that is sunlit for both N-S and E-W row orientation. Calculated for a soybean-like plant at 50% cover and 45° N. latitude, (From S.B.Idso, M.S. Thesis, Dept. Soil Science, U. Minn., 1966.)

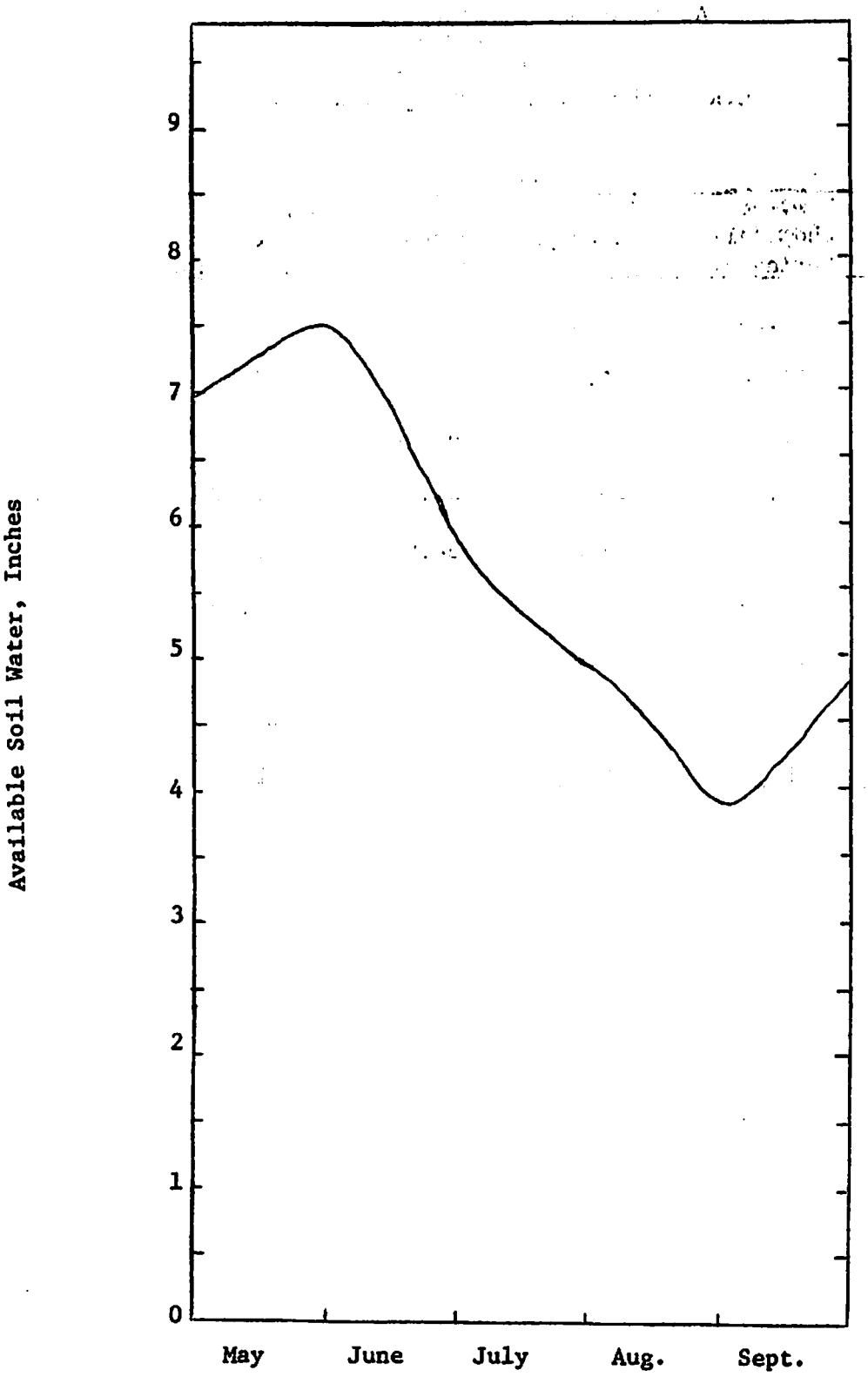

Figure 3. Average soil moisture at Lamberton, 1961-66.

Structure - Nitrogen study
Waseca, 1966
Aggregation, percent stability
Averages of 3 reps
Data Book 27: 267-270
G.R. Blake, J. M. MacGregor, R. Frazier

	Tillage				
Fertilizer	Minimum chop, fall Spring plow	Minimum not chopped Spring plow	Conventional chopped fall plow	Minimum chopped fall plow	Field Cultivate fall & spring chopped
None	49.19	55.25	38.37	40.48	63.80
0-40-40 (fall)	55.36	55.83	35.43	44.04	59.25
40-40-40	50.86	54.40	40.32	46.17	58.78
40-40-40	48.78	50.58	32.20	47.28	65.07
80-40-40	47.85	47.36	38.91	52.77	59.49
240-40-40	54.05	56.79	41.18	43.06	62.33
Significauce	(Tillage)				
95%	ab	ab	c	bc	a
99%	ab	ab	b	ab	a

Structure - Nitrogen Study
Waseca, 1966
Infiltration, inches per hour
Data Book 27: 167-183
G. R. Blake, J. M. MacGregor, R. Frazier

Rep	Minimum Spring plow chop residue	Conventional fall plow chop	Minimum fall plow chop	Field Cultivate fall & spring chop residue
I	3.17	3.49	0.99	2.81
	2.08	3.15	1.93	1.68
II	3.02	2.37	3.02	3.41
	1.79	0.63	4.61	2.08
III	2.19	3.39	1.84	4.03
	1.36	1.32	1.78	3.61
Total	13.61	14.35	14.17	17.62
Average	2.27	2.39	2.36	2.94

There was no significance for tillage.

Structure - Nitrogen Study
Waseca, 1966
Bulk Density
Averages of 6 samples from A&F treatments & 3 Reps
Data Book 32: 94-125
G. R. Blake, J. M. MacGregor, R. Frazier

Depth in inches	Field Cultivate fall & spring chopped	Conventional fall plow chopped	Minimum Spring plow chop (fall)	Minimum fall plow chopped
0-4	1.11	1.14	1.11	1.07
4-8	1.21	1.13	1.11	1.10
8-12	1.27	1.23	1.25	1.22
12-16	1.32	1.31	1.31	1.30
16-20	1.35	1.38	1.38	1.35
20-24	1.40	1.42	1.40	1.41
24-28	1.43	1.42	1.41	1.45
28-32	1.44	1.42	1.41	1.46
32-36	1.43	1.43	1.47	1.45
36-40	1.46	1.46	1.50	1.48

Only significant differences were in the 4-8 inch harizon where Field Cultivate was higher than the other treatments at the 99% level by Duncan's MR Test.

Structure - Nitrogen Study
Waseca
Penetrometer, August 4, 1966
Data Book 27: pp 114-133
G. R. Blake, J. M. MacGregor, R. Frazier

Effect of Fertilizer [1)]

Depth in inches	fall 40-40-40	80-40-40	40-40-40	0-40-40	240-40-40	None	Sig
4	85.8	75.6	76.1	72.6	70.7	74.1	N.S
8	112.4a	103.9ab	99.8ab	92.0b	92.6b	104.3ab	95%
12	133.9a	129.4a	127.3a	126.0a	113.5b	124.6ab	95%

1) Fertilization values are the average of 5 tillages by 3 reps. Significance shown by Duncan's MR test.

Effect of Tillage [2)]

Depth in inches	Minimum spring plow chop residue	Minimum spring plow not chopped	Conventional fall plow chop residue	Minimum fall plow chop	Field Cultivate fall & spring chop residue
4	63.9	62.4	85.1	74.9	92.8
8	93.1	101.3	102.9	94.3	112.6
12	120.8	133.0	126.5	122.3	126.6

2) Tillage values are the average of 6 fertilizers by 3 reps.

Tillage was significant at 90% at 4 in. only. RXF was not significant. FXT was significant at 90% at 4 ins only.

Structure - Nitrogen Study
Waseca, 1966
pH values
Data Book 33: 42-58
G. R. Blake, J. M. MacGregor, R. Frazier

Depth	Treatment 1	3	4	5	Ave.
			Fertilizer A		
0-4"	6.86a	6.96b	6.77c	6.58d	6.79
8-12"	7.03	7.13	6.95	7.02	7.03
20-24"	7.29	7.44	7.32	7.26	7.33
32-36"	7.94	7.79	7.86	7.89	7.87
Total	29.12	29.32	28.90	28.75	
Ave.	7.28	7.33	7.22	7.19	
			Fertilizer F		
0-4"	5.93e	6.26f	5.69g	6.11h	6.00
8-12"	6.87	6.94	6.83	6.94	6.89
20-24"	7.32	7.46	7.29	7.19	7.31
32-36"	7.81	7.67	7.48	7.45	7.60
Total	27.93	28.33	27.29	27.69	
Ave.	6.98	7.08	6.82	6.92	

Subsoil Regeneration Study
Lamberton, 1966
Aggregation, Percent Stability
Data Book 27: 271-275
G. R. Blake and W. W. Nelson

Rep	Corn				Alfalfa			
	Packed		Not Packed		Packed		Not Packed	
	Irrig	Not Irrig	Irrig	Not Irrig	Irrig	Not Irrig	Irrig	Not Irrig
I	37.85	41.51	48.61	34.01	64.01	58.33	55.77	60.48
II	32.13	30.67	41.53	25.91	58.62	50.07	55.62	48.07
III	22.73	26.52	30.67	31.04	38.78	43.52	45.62	38.06
IV	29.67	32.94	34.18	36.89	48.47	45.33	47.55	45.81
V	26.11	28.81	31.97	33.03	54.97	51.66	48.51	48.91
Significance (Packing X Crop)								
99%	a	a	a	a	b	b	b	b

Crop was significant to 99%. Replication was significant to 95%.

Subsoil Regeneration Study
Lamberton, 1966
Infiltration, inches per hour
Data Book 27: 152-164
G. R. Blake and W. W. Nelson

Rep	Packed	Non-Packed
I	4.24	2.86
II	2.27	2.95
III	2.46	2.40
IV	2.06	1.46
V	3.12	3.69
Total	14.15	13.36
Averages	2.83	2.67

Differences not significant for packing

Subsoil Regeneration Study
Lamberton, 1966
Bulk Density
Averages of 5 reps
Data Book 27: 196-225
G. R. Blake and W. W. Nelson

Depth in inches	Corn				Alfalfa			
	Packed		Non Packed		Packed		Non Packed	
	Irrig	Non Irrig	Irrig	Non Irrig	Irrig	Non Irrig	Irrig	Non Irrig
0-4	1.26	1.31	1.23	1.30	1.43	1.40	1.33	1.42
4-8	1.29a	1.34a	1.32a	1.28a	1.47b	1.43b	1.31a	1.40a
8-12	1.49	1.55	1.40	1.35	1.50	1.50	1.40	1.36
12-16	1.49	1.56	1.40	1.32	1.53	1.57	1.34	1.37
16-20	1.42	1.54	1.35	1.37	1.41	1.47	1.36	1.40
20-24	1.38	1.41	1.40	1.36	1.46	1.47	1.34	1.39
24-28	1.36	1.40	1.40	1.42	1.41	1.47	1.41	1.41
28-32	1.36	1.47	1.35	1.43	1.43	1.47	1.41	1.41
32-36	1.39	1.45	1.40	1.47	1.47	1.49	1.42	1.43
36-40	1.41	1.49	1.35	1.46	1.50	1.47	1.48	1.41

Irrigation was significant at 95% at the 16"-20" and the 28"-32" levels. Replication was significant at 99% at 28"-32", and at 95% at 32"-36". Packing was significant at 95% at 4"-8", 8"-12", and 16"-20". Packing was also significant at 99% at 12"-16". Packing X crop was significant at 4-8" at the 95% level, differences shown by letters in a Duncan MR test.

Subsoil Regeneration Study
Lamberton
Penetrometer, August 31, 1966
Data Book 27: pp 135-148
Average of 5 reps
G. R. Blake and W. W. Nelson

Depth in inches	Corn				Alfalfa			
	Packed		Not Packed		Packed		Not Packed	
	Irrig	Non Irrig	Irrig	Non Irrig	Irrig	Non Irrig	Irrig	Non Irrig
10	58.0	58.4	64.0	48.2	100.8	112.4	91.2	83.6
14	126.8a	153.2b	101.6a	110.2b	168.0b	162.0b	115.6b	104.2b
18	145.4	155.0	145.6	141.6	163.0	164.6	160.2	146.4

Packing was significant at 95% at 10 in and at 99% at 14 and 18 ins. Irrigation was not significant at all levels. Packing X Irrigation was significant at 90% at 10 ins but not at the other levels. Irrigation X crop was significant at 14 ins at the 95% level, differences shown by letters in a Duncan MR test.

Subsoil Regeneration Study
Lamberton, 1966
Alfalfa Yield (net dry wt (gms) / plot)
Data Book 27: 185-190
Averages of 5 reps
G. R. Blake and W. W. Nelson

Date	Packed		Not Packed	
Harvested	Irrig	Non Irrig	Irrig	Non Irrig
6/10/66	480	483	501	476
7/15/66	531	649	563	645
8/66	553	586	576	554

Replication was significant at 95% on the August cutting. Packing was not significan
Irrigation significant at 95% on 7/15/66 cutting.

Subsoil Regeneration-Study
Lamberton, 1966
Corn Silage Yields
Pounds per 30 feet of row
Data Book 27: 192-3
G. R. Blake and W. W. Nelson

	Packed		Not Packed	
Rep	Irrig	Non Irrig	Irrig	Non Irrig
I	34.5	40.4	40.3	43.5
II	41.9	37.3	39.3	35.1
III	41.9	36.9	33.3	33.5
IV	42.1	37.0	42.5	40.0
V	45.9	40.9	35.9	34.1

Differences not significant for packing, irrigation or IXP.

Subsoil Regeneration Study
Lamberton
Summary 1960-1966
Alfalfa Yields; lb/A @ 20% moisture

	Cutting 1	2	3	Ave.
		1960 1)		
PI				2660
PNI				
NPI				3760
NPNI				
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	No irrig treatments this year			
		1961		
PI	2378	4120	2385	2961
PNI	2686	4011	2258	2985
NPI	3013	3993	2513	3006
NPNI	3086	4138	2461	3228
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	NS	NS	NS	
		1962		
PI	3760	2930	2240	2977
PNI	3480	3140	2070	2897
NPI	3670	2810	2290	2923
NPNI	3780	3060	1990	2943
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	NS	NS	213 (.05)	

Subsoil Regeneration Study
Lamberton
(continued)

		1963		
PI	1771	2759	2643	2391
PNI	2120	2759	2817	2565
NPI	2149	2701	2410	2420
NPNI	1975	2875	2788	2546
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	NS	NS	268 (.05)	
		1964		
PI	5354	3249	3285	3965
PNI	5499	3104	3086	3898
NPI	5300	2977	3539	3941
NPNI	5590	2940	2904	3813
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	NS	NS	NS	
		1965		
PI	3833	3491	1726	3019
PNI	4728	3493	1836	3354
NPI	3965	2787	1713	2824
NPNI	3980	3365	1741	3031
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	NS	NS	NS	
		1966		
PI	1997	2178	2178	2120
PNI	1997	2541	2360	2301
NPI	1997	2178	2360	2180
NPNI	1815	2541	2178	2180
L.S.D. Packing	NS	NS	NS	
L.S.D. Irrig.	NS	65 (.05)	NS	

1) Oats 1960.

Subsoil Regeneration Study
Lamberton
Summary 1960-1966
Corn Yield; Bu/ac @ 15.5% moisture

	1960	1961	1962	1963	1964	1965	1966[2]
PI	102.0	125.3	117.4	135.3	106.3	100.5	41.3
PNI	104.8	126.7	116.8	134.4	91.8	85.6	38.5
NPI	108.7	114.6	125.2	144.8	90.7	94.7	38.3
NPNI	110.8	118.5	129.6	139.6	103.2	104.7	37.2
	NS	NS	NS	NS	NS	NS	NS
Averages							
Packed	103.4	126.0	117.1	133.9	99.1	94.1	39.9
Not Packed	109.8	116.6	127.4	142.2	97.0	100.7	37.7
Irrigated	1)	120.0	121.3	140.1	98.5	98.6	39.8
Not Irrg	1)	122.6	123.2	137.0	97.5	96.2	37.8

1) No Irrigation in 1960 yields.
2) Corn was harvested as silage. Yield in lbs/90' of row.

Subsoil Regeneration Study
Lamberton, 1966
Soil H_2o %
Averages of 5 reps
Data Book 27: 227-244
G. R. Blake and W. W. Nelson

Depth in inches	Corn				Alfalfa			
	Packed		Not Packed		Packed		Not Packed	
	Irrig	Non Irrig	Irrig	Non Irrig	Irrig	Non Irrig	Irrig	Non Irrig
0-4	20.07	18.20	18.95	17.98	15.28	15.40	16.49	14.91
4-8	22.33a	21.02a	21.69a	20.91a	16.70b	18.00b	18.68b	16.79b
8-12	20.55	18.25	20.34	17.70	16.73	16.87	18.35	16.81
12-16	17.25	14.75	18.29	14.32	13.84	14.49	16.70	14.01
16-20	14.11	12.90	14.21	13.30	11.81	13.12	13.36	12.65
20-24	13.07	12.63	12.80	13.54	11.82	12.16	13.10	13.26
24-28	13.46	12.39	13.37	13.06	12.26	11.83	13.82	13.05
28-32	13.41	12.09	14.32	12.67	11.89	11.76	12.99	13.44
32-36	14.77	13.52	16.01	13.94	12.47	11.60	12.34	15.02
36-40	16.58	15.07	15.67	16.07	12.08	11.39	12.71	15.21

Crop was significant at 99% from 0-12". Irrigation was significant at 99% at the 0-4" level and at 95% at the 8-12" and 12-16" levels. Replication was significant at 99% at the 0-4" and 8-12" levels, but it was significant at 95% at the 4-8", 12-16 and 16-20" levels. Packing X crop was significant 4-8" at the 95% level, differences shown by letters in a Duncan MR test.

Subsoil Regeneration Steady
Summary Db & H_2o content

	Packed				Not Packed			
	Irrig		Not Irrig		Irrig		Not Irrig	
	C	ALF	C	ALF	C	ALF	C	ALF
1960			1.57	1.55			1.34	1.29
1961	1.51	1.45	1.56	1.51	1.32	1.24	1.29	1.31
1962	1.50	1.47	1.56	1.50	1.33	1.33	1.32	1.29
1963	1.53	1.44	1.52	1.48	1.30	1.21	1.25	1.22
1964	1.56	1.50	1.48	1.51	1.36	1.29	1.37	1.36
1965 (12-16")	1.43	1.49	1.52	1.45	1.27	1.25	1.28	1.28
				H_2o Content				
1960								
1961 (6/28)	21.8	17.7	22.0	16.7	21.5	18.7	22.7	15.2
1962 (6/28)	26.9	26.8	25.5	25.8	26.3	26.1	26.8	25.6
1963 (6/25)	20.9	17.0	21.2	17.9	20.1	16.4	20.2	16.0
1964 (6/26)	21.0	20.3	24.0	18.6	23.1	19.4	23.4	18.8
1965 (6/30)	24.5	22.5	24.1	22.3	23.3	22.9	22.5	21.1

See 1960 log p. 37 & data book 20:8 1962.

Structure-Nitrogen Study
Morris, 1966
Average Soil temps and times
Data Book 32: 126-133
G. R. Blake, J. M. MacGregor, Sam Evans

Depth in inches		Tillage, When plowed			
		Till Plant	Minimum Spring	Regular Fall	Minimum Fall
		Average Soil Temperatures °F			
	max	77.4	83.1	77.5	76.9
2	min	58.4	56.8	52.9	59.7
	mean	67.9	70.0	68.2	68.4
	max	71.1	71.6	72.1	70.0
4	min	59.5	60.7	60.7	60.4
	mean	65.3	66.2	66.4	65.2
	max	67.5	67.5	68.3	67.1
6	min	60.3	60.8	61.3	60.7
	mean	63.9	64.1	63.2	63.9
		Mean times of mean temperatures			
	max	15.98	14.91	15.31	15.59
2	min	6.94	7.78	8.03	7.87
	mean	12.02	11.35	11.67	11.73
	max	16.48	15.94	16.39	16.34
4	min	8.96	8.94	9.06	8.85
	mean	12.72	12.44	12.73	12.60
	max	17.36	16.48	16.78	17.01
6	min	10.01	10.23	9.97	10.08
	mean	13.69	13.36	13.38	13.55

Structure-Nitrogen Study
Bulk Density, Water Content
Morris, June 10, 1966

TREATMENT LOCATION	Spring-Plow Till Plant in 66	Min. Spring Plow	Conv. Fall Plow	Min. Fall Plow	L.S.D. (.05)
		Water Content OD Basis			
In Row 0-3"	.2618	.2868	.2726	.2635	N.S.
In Row 3-7"	.3246	.3712	.3951	.3292	N.S.
Between Row	.2886	.2232	.2457	.2469	N.S.
		Bulk Density			
In Row 0-3"	.836	1.014	1.081	1.022	0.143
In Row 3-7"	.935	.976	.936	.975	N.S.
Between Row	.970	.913	.920	.966	N.S.

Note depths are nominal. Actual Depths were 0 to 3 7/8 and 3 1/2 to 6 7/8 inches.

Soil Salinity and Crop Growth in Western Minnesota

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

As a continuation of a study reported on page 10 of the 1965, and on page 28 of the 1966 "Bluebook", soil samples were collected in western Minnesota from Murray county in the south to Kittson county in the north where problems with plant growth were evident. Most of the samples were collected to a depth of 36 inches, with problem soil profiles being usually sampled within a 50 foot distance of profile sampled where normal growth occurred. Although problem soils failed to support growth, the growing indicator crops consisted of soybeans, flax, wheat, oats, alfalfa, potatoes, and corn. An additional study was also conducted at three locations to determine possible variation of salt content in problem soils during the growing season. Samples were analyzed from a total of 20 counties in 1966 to complement those studied in the two previous years. The sampling locations are shown on the accompanying outline map.

Field, greenhouse, or controlled environment chamber experiments have been conducted since 1956 in which soluble or chelated iron compounds were applied either to the soil or solutions sprayed directly to chlorotic plant tissues such as soybeans, flax, caragana or other susceptible species. (These compounds included chelated Fe 138, chelated Fe 330 manufactured by the Geigy Chemical Corporation, some experimental chelated Fe compounds manufactured by Dow Chemical Corporation, Greenz 26 from Crown Zellerback Co, Rayplex Fe and Rayplex Zinc from Rayonier Corporation, ferrous iron sulfate, Nu-Iron solutions, some experimental compounds from Archer-Daniels-Midland, and some coated experimental manganese, iron and zinc compounds prepared by the Minnesota Mining & Manufacturing Company). None were economically satisfactory for eliminating or ameliorating the chlorotic condition of susceptible field crop species.

In 1964, a chlorotic soybean field southwest of Ghent (Lyon county) showed extreme chlorosis, on which the previously expensive, but generally successful chelated iron treatment showed little effect, exhibited essentially normal foliage immediately above tile lines, and in addition supported a number of large and flourishing sand burr plants on a clay soil. This immediately suggested water absorption problems by the growing plants possibly induced by soluble salt content of the soil.

Since plant chlorosis seldom occurs at soil pH of less than 7.0,soil sampling and analyses have been conducted during the past three years (1964, 1965 and 1966). The results of the first two years were reported in the 1965 and 1966 "Bluebooks" and the following analytical data were obtained during 1966. An additional study was made on three fields to determine possible variation in soil conditions during the growing season and these data are shown later with the sampling locations shown on the accompanying map as A, B, and C in Lyon, Yellow Medicine,and Chippewa counties, respectively.

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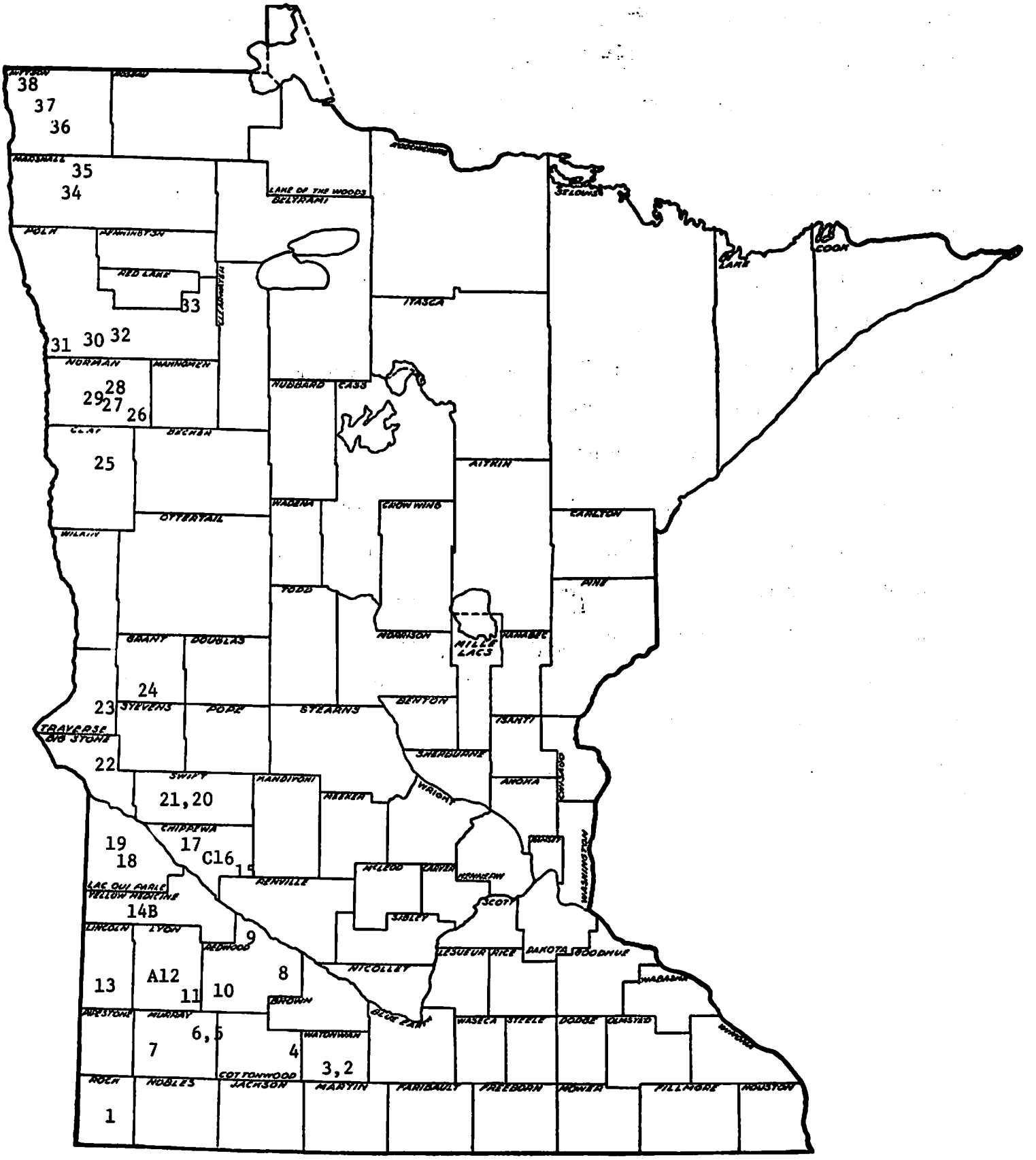
[1]This study was possible only through the active cooperation of George Holcomb and Orville Gunderson, area Soil Specialists, by personnel of the Soil Conservation Service, and by several county agents who were intensely interested in the plant chlorosis problem. Their cooperation and assistance is gratefully acknowledged.

Sampling Locations of 1966 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 a nutritional imbalance in the plant's feeding 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 concentrations 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 various soluble salts present in the soil such as gypsum, sodium chloride, potassium chloride and others. 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.

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 * ppm
					Good Growth of Corn							
	(1)											
382	Steffler	0-6	0.3	6.3	2	6	tr	6	0.5	0.5	5	41
383	Rock Co.	6-12	-	6.3	2	8	tr	8	0.8	0.5	3	45
					Fair Growth of Corn							
386		0-6	0.6	-	4	9	3	6	0.7	0.1	11	41
					Poor Growth of Corn							
384		0-6	0.7	7.9	4	10	4	6	0.8	0.1	3	27
385		6-12	1.2	7.7	5	5	3	2	1.5	0.1	5	64
					Chlorotic Soybeans							
	(2)											
3	Leanus Nelson Watonwan Co.	0-6	1.2	7.8	20	11	2	9	1.9	0.1	51	81
3A		0-6	1.4	7.7	21	11	2	9	0.9	0.2	58	41
3B		6-12	0.9	7.8	20	8	2	6	0.7	0.1	38	23
					Normal Soybeans							
3C		0-6	1.2	7.3	4	10	3	7	1.1	0.1	38	42
3D		6-12	0.7	7.3	3	6	2	4	0.4	tr	31	14
					Chlorotic Soybeans							
	(3)											
4	D. Jacoby Watonwan Co.	0-6	0.6	7.7	16	6	2	4	7.9	tr	24	23
					Chlorotic Soybeans							
	(4)											
408	M. Regnier Cottonwood Co.	0-6	0.7	7.5	20	10	3	7	0.4	0.1	9	41
409	Mountain Lake	6-12	1.0	7.7	26	15	5	10	0.6	tr	12	63

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 ppm *
					Normal Soybeans							
	(4)											
410	M. Regier	0-6	0.6	7.7	7	9	3	6	0.4	0.1	3	35
411	Cottonwood Co.	6-12	0.7	7.4	4	12	5	7	0.5	tr	9	113
					Corn Germinated and died - Foxtail grew							
	(5)											
2	Duane Smith Murray Co. Walnut Grove	-	4.0	7.9	8	50	35	15	11.9	0.3	76	2070
					Poor Corn Growth							
249		0-6	2.8	7.8	16	39	28	11	1.0	0.3	58	486
250		6-12	2.9	7.8	16	42	27	15	1.5	0.2	38	1272
251		12-18	3.5	7.9	6	54	26	28	4.6	0.2	19	1461
					Poor Alfalfa Growth							
252		0-6	2.9	7.7	18	40	28	12	1.3	0.3	58	1215
253		6-12	2.9	7.7	22	36	27	9	2.0	0.2	96	924
254		12-18	3.0	7.8	15	41	27	14	1.8	0.2	31	1149
255		18-24	3.5	7.9	16	53	25	28	2.0	0.3	38	765
		I	Poor to Fair Corn Growth									
	(6)											
312	Harvey Wahl	0-6	1.0	7.7	11	18	6	12	1.1	0.1	11	45
313	Murray Co. Currie	6-12	1.1	7.7	12	26	6	20	1.4	0.1	9	41
		II	Good Corn Growth									
314		0-6	0.7	7.6	2	23	4	19	0.3	0.1	9	32
315		6-12	1.0	7.5	3	41	6	35	0.4	tr	5	18

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ Equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4* ppm
			III	Poor Corn Growth								
	(6)											
316	Harvey Wahl	0-6	3.6	7.4	13	49	23	26	9.0	0.4	11	1410
317	Murray Co.	6-12	3.1	7.5	16	48	23	25	1.8	0.1	19	1470
	Currie											
			IV	Good Corn Growth								
318		0-6	1.4	7.3	7	25	8	17	2.4	0.1	12	75
319		6-12	-	7.7	10	11	5	6	0.7	0.1	58	86
			I	Soil Bank Fallow-Previously Corn Died								
	(7)											
220	Ed Onken	0-6	2.4	6.3	16	36	14	22	3.0	0.1	31	198
221	Murray Co.	6-12	1.2	7.5	7	16	7	9	0.8	0.1	19	81
222	Lake Wilson	12-18	1.1	7.2	5	17	7	10	0.8	0.1	12	90
			II	Chlorotic Soybeans - Poor Growth								
223		0-6	5.0	7.8	25	77	26	51	10.3	0.5	0	675
224		6-12	5.0	8.0	23	79	24	55	12.6	0.1	19	735
225		12-18	4.3	7.8	15	68	25	43	8.7	0.3	11	765
226		18-24	3.4	7.8	13	52	25	27	4.0	0.4	12	780
			III	Chlorotic Soybeans - Poor to Fair Growth								
227		0-6	5.1	7.8	24	72	27	45	16.4	0.3	45	1530
			IV	Soybeans - Fail to Grow								
228		-	9.1	8.3	15	135	24	111	44.8	0.9	24	750

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4* ppm
				Dead Soybeans								
	(8)											
300	Bert Jacoby	0-6	1.7	7.9	17	25	3	22	1.4	tr	45	54
301	Redwood Co.	6-12	1.5	8.0	20	22	2	20	2.5	0.3	76	45
302	Morgan	12-24	1.4	8.1	21	28	1	27	2.8	0.1	45	75
303		24-36	1.4	8.1	18	19	2	17	2.7	0.1	31	60
				Normal Soybeans								
304		0-6	0.8	7.5	9	-	1	-	0.5	0.1	12	45
305		6-12	2.5	7.5	17	57	22	35	2.1	0.3	24	765
306		12-24	1.1	7.9	10	21	2	19	1.3	0.3	96	36
307		24-36	1.4	7.5	4	24	4	20	1.4	0.1	45	90
				Soybeans Damaged Previous Year								
308		0-6	1.0	8.0	16	12	2	10	0.5	0.4	11	63
309		6-12	0.8	8.0	16	13	4	9	0.7	0.2	19	54
310		12-24	1.2	8.2	18	19	4	15	1.7	tr	38	54
311		24-36	1.9	8.1	17	27	4	23	3.4	0.3	120	83
				Short Corn								
	(9)											
292	Cyril Iffert	0-6	3.2	7.8	29	57	25	32	1.0	0.2	3	1350
293	Redwood Co.	6-12	3.1	7.9	24	56	24	32	12.4	0.2	3	1485
294	Belview	12-24	3.9	7.9	20	47	19	28	3.0	0.3	5	1125
295		24-36	4.8	7.9	32	91	17	74	4.5	0.5	150	663
				Normal Corn								
296		0-6	1.2	8.0	13	16	1	15	7.7	0.6	5	72
297		6-12	0.8	8.1	14	16	1	15	7.7	0.8	3	72
298		12-24	2.9	8.0	13	54	9	45	3.8	0.8	3	225
299		24-36	3.9	7.7	7	88	20	68	8.6	0.3	9	660

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4* ppm
				Problem Site								
1	(10) K. Jacobson Redwood Co. Lamberton	-	1.5	7.7	10	25	11	14	1.9	0.4	24	68
				Problem Site								
320	(11) Harold E. Cooper	0-6	4.6	7.3	4	64	26	38	4.9	0.1	58	1200
321	Lyon Co. Tracy	12-18	10.5	7.2	1	151	16	135	-	-	30	1200
				No Problem Site								
322		0-6	0.9	6.1	2	12	4	8	3.5	0.1	3	18
323		12-18	0.8	7.1	2	11	3	9	1.1	0.1	12	9
				Good Corn Growth								
212	(12) J. Van Overbeke	0-6	1.6	7.8	11	25	17	-	1.6	0.9	45	45
213	Lyon Co. Marshall	6-12	1.0	7.8	12	12	7	5	1.1	1.0	38	18
				Poor Corn Growth								
214		0-6	6.5	7.7	12	93	25	68	25.0	6.7	96	1455
215		6-12	6.0	7.8	13	98	20	78	25.7	2.3	58	1350
				Poor Oats Growth								
216		0-6	9.5	8.1	15	123	19	104	49.6	4.5	38	1515
217		6-12	8.0	8.1	12	108	19	89	40.6	3.2	31	1620

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4* ppm
				Idle Land - Previously Problem Area								
	(13)											
218	D. Fruechte	0-6	2.0	5.7	2	32	15	17	0.8	0.2	5	153
219	Lincoln Co.	6-12	2.1	5.9	-	33	17	16	0.8	0.1	5	180
	Verdi											
				Normal Corn Growth								
	(14)											
150	V. Leppke	0-6	1.1	7.7	23	11	3	9	0.7	0.5	31	23
151	Yellow Med. Co.	6-12	0.8	7.8	24	7	2	5	1.1	0.3	12	14
152	14 SW of	12-18	1.8	7.7	24	19	6	13	2.5	0.2	9	38
	Clarkfield											
				Poor Corn Growth								
153		0-6	2.4	7.6	21	28	16	12	1.4	0.8	12	1230
154		6-12	3.3	7.5	21	41	23	18	2.5	0.9	9	-
155		12-18	4.0	7.4	21	58	22	36	5.5	0.5	9	-
			I	Poor Corn Growth								
	(15)											
338	John Zimmer	0-6	3.4	7.6	32	45	22	23	31.8	0.6	-	1410
339	Chippewa Co.	6-12	6.3	7.5	26	78	16	62	27.4	0.4	45	1755
340	Clara City	12-24	6.1	7.7	26	100	23	77	3.7	0.5	31	2610
341		24-36	5.4	7.7	26	88	18	70	5.3	0.5	12	1959
			II	Good Corn Growth								
342		0-6	2.4	7.8	29	29	13	16	4.2	0.5	31	180
343		6-12	3.2	7.9	31	44	14	30	1.6	0.1	24	225
344		12-24	4.2	8.1	30	70	16	54	1.6	0.4	19	630
345		24-36	5.2	8.0	28	84	19	65	4.7	0.5	12	879

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 ppm *
				III Poor Corn Growth								
	(15)											
208	John Zimmer	0-6	3.8	7.6	31	54	32	22	2.9	0.4	76	1305
209	Chippewa Co.	6-12	3.8	-	36	54	26	28	2.9	0.1	45	1125
210	Clara City	12-24	4.7	7.9	28	81	22	59	-	0.1	19	1350
211		24-36	4.9	8.0	19	96	24	72	3.7	0.1	38	1260
				IV Good Corn Growth								
204		0-6	4.5	-	13	62	32	30	1.6	0.5	45	inadeq. sam.
205		6-12	1.7	7.7	5	23	10	13	1.4	0.1	31	90
206		12-24	2.2	7.7	21	30	12	18	0.8	0.1	-	45
207		24-36	1.9	7.8	29	26	11	15	3.9	tr	19	68
				I Dead Soybeans								
	(16)											
268	Morris Gustafson	0-6	6.5	7.8	11	89	53	36	18.1	0.4	50	1239
269	Chippewa Co.	6-12	5.5	7.8	12	78	52	26	14.6	0.3	45	1743
270		12-24	5.0	7.9	9	76	50	26	17.8	0.3	34	1620
271		24-36	3.9	7.9	29	55	43	12	10.6	0.3	28	1248
				II Normal Soybeans								
272		0-6	5.5	7.6	10	133	48	85	10.8	0.4	59	1395
273		6-12	5.1	7.9	12	76	34	42	11.9	0.3	45	1710
274		12-24	4.8	7.9	14	69	42	27	12.6	0.2	19	1509
275		24-36	3.6	8.0	26	48	34	14	8.2	0.2	8	285
				Dead Soybeans								
	(17)											
256	Bernie Bosch	0-6	3.9	7.9	18	55	28	27	4.4	0.5	76	630
257	Chippewa Co.	6-12	4.0	7.9	18	58	24	34	7.3	0.2	76	393
258	Montevideo	12-24	3.6	8.1	12	46	14	32	12.6	0.2	45	101
259		24-36	4.3	8.3	22	50	11	39	17.8	0.2	31	169

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 ppm *
				Partially Recovered Soybeans								
	(17)											
260	Bernie Bosch	0-6	4.5	7.8	10	59	25	34	9.3	0.4	165	1230
261	Chippewa Co.	6-12	4.5	7.9	18	62	53	9	10.8	0.3	72	1089
262	Montevideo	12-24	5.6	8.1	18	78	41	37	20.7	0.3	29	834
263		24-36	4.8	8.3	18	56	28	28	22.3	0.2	34	270
				Completely Recovered Soybeans								
264		0-6	4.0	7.8	15	51	25	26	8.2	0.4	190	248
265		6-12	4.3	7.9	18	53	-	-	15.3	0.4	115	315
266		12-24	5.0	8.1	23	65	42	23	21.1	0.3	29	599
267		24-36	3.6	8.2	20	38	25	13	15.3	0.3	81	90
				Poor Corn								
	(18)											
200	Paul Wager	0-6	5.8	7.7	4	77	23	54	32.6	0.8	76	945
201	LacQuiParle Co.	6-12	7.0	7.8	3	59	23	36	42.4	0.3	98	1395
202	Dawson	12-24	6.5	7.9	4	73	22	51	33.9	0.1	31	1530
203		24-36	6.0	7.8	5	68	23	45	5.2	0.1	31	1440
				Poor Corn								
	(19)											
176	Wayne Glasser	0-6	5.0	7.8	10	55	26	28	19.1	0.9	19	1373
177	LacQuiParle Co.	6-12	5.0	7.8	7	58	26	32	22.1	0.8	19	1485
178	Bellingham	12-24	6.0	-	7	65	23	42	27.3	0.8	19	1530
179		24-36	7.0	7.9	10	68	21	47	34.6	0.9	19	1575
				Better Corn								
172		0-6	3.0	7.8	13	38	27	11	1.2	0.6	9	735
173		6-12	2.8	7.8	21	37	19	18	2.2	0.1	11	330
174		12-24	2.4	8.1	21	32	13	19	3.2	0.1	12	390
175		24-36	1.8	-	48	21	9	12	3.0	0.3	19	263

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 * ppm
				I Poor Corn - 20 inch rows								
	(20)											
188	Dave Hughes	0-6	4.5	7.8	17	50	24	26	10.9	1.4	76	225
189	Swift Co.	6-12	5.3	7.8	16	72	24	48	16.2	0.3	38	1080
190	Danvers	12-24	6.0	8.0	11	80	22	58	14.6	0.1	19	1080
191		24-36	5.0	8.0	16	66	23	43	19.2	0.1	19	428
				II Good Corn - 20 inch rows								
184		0-6	1.7	-	13	14	5	9	3.3	0.1	76	90
185		6-12	0.9	8.0	9	8	3	5	4.0	0.1	31	36
186		12-24	0.7	8.0	5	7	2	5	2.5	tr	19	27
187		24-36	0.7	7.8	3	7	1	6	4.0	tr	12	27
				III Short Corn								
276		0-6	4.6	7.8	17	54	33	21	12.6	0.4	110	1485
277		6-12	6.2	8.0	17	83	42	41	28.5	0.8	190	1710
278		12-24	8.0	8.2	11	103	31	72	49.5	0.5	12	1800
279		24-36	7.5	8.2	15	92	32	60	44.4	0.3	5	540
				IV Normal Corn								
280		0-6	5.0	7.9	18	62	46	16	60.0	0.6	76	1014
281		6-12	4.8	8.0	18	68	34	34	30.4	0.5	31	1764
282		12-24	4.9	8.1	8	72	23	49	41.2	0.3	12	618
283		24-36	4.5	7.9	3	66	22	44	34.6	0.6	5	158
				Dead Soybeans								
	(21)											
284	Jennings Torgelson	0-6	6.0	8.0	15	89	42	47	40.3	0.6	19	1575
285	Swift Co.	6-12	6.5	8.0	18	112	38	74	38.2	0.6	19	1440
286	Danvers	12-24	6.3	8.1	19	122	30	92	41.1	0.4	11	840
287		24-36	6.6	8.1	20	114	30	84	44.6	0.4	1	1260

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 * ppm
					Normal Soybeans							
	(21)											
288	Jennings Torgelson	0-6	4.4	7.9	14	77	21	56	6.6	0.4	9	954
289	Swift Co.	6-12	4.3	7.9	16	76	19	57	7.0	0.3	24	1620
290	Danvers	12-24	4.6	8.0	16	87	16	71	8.3	0.3	4	675
291		24-36	3.9	8.2	22	82	12	70	10.6	0.4	5	225
					Normal Beans							
	(22)											
192	Fred Kohler	0-6	5.0	7.8	4	67	32	35	11.0	0.1	190	675
193	Big Stone Co.	6-12	4.0	7.8	7	58	25	33	9.3	0.1	45	540
194	Ortonville	12-24	3.8	7.5	8	58	24	34	6.9	tr	45	720
195		24-36	3.8	7.9	8	-	24	-	4.4	tr	38	1485
					Chlorotic Beans							
196		0-6	7.0	7.9	9	104	27	77	20.0	0.3	151	1530
197		6-12	7.0	8.0	12	109	26	83	20.3	0.1	111	1710
198		12-24	6.0	7.9	8	88	23	65	12.6	0.1	76	75
199		24-36	4.5	7.9	5	72	23	49	7.3	0.1	45	1530
					Chlorotic Soybeans							
374	Fred Kohler	0-6	6.6	7.8	9	103	21	82	16.8	0.4	45	1911
375	Big Stone Co.	6-12	5.9	7.7	9	90	17	73	13.5	0.1	31	2295
376	Ortonville	12-24	4.9	7.6	6	85	26	59	11.5	0.1	12	2025
377		24-36	4.1	7.5	4	70	19	51	4.8	0.1	12	1935
					Normal Beans							
378		0-6	4.3	7.6	6	73	18	55	6.6	0.1	96	1035
379		6-12	-	7.7	10	79	20	59	8.4	0.4	76	1800
380		12-24	4.3	7.6	6	75	16	59	4.8	0.1	31	2385
381		24-36	4.4	7.5	5	70	20	50	4.6	0.1	19	1530

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 * ppm
				I	Chlorotic Soybeans							
	(23)											
354	Gordon Jacobs	0-6	10.7	7.5	1	115	17	98	66.5	tr	1	1350
355	Traverse Co.	6-12	9.0	7.3	2	90	18	72	52.6	0.4	9	945
356	Dumont	12-24	17.3	7.8	4	194	21	173	113.0	0.5	12	990
357		24-36	10.8	8.1	11	122	16	106	69.2	0.3	9	900
				I	Normal Soybeans							
358		0-6	2.2	7.1	2	28	13	15	4.8	0.1	3	135
359		6-12	3.4	7.0	2	46	16	30	3.5	0.2	12	135
360		12-24	4.0	7.1	2	57	21	36	6.9	0.3	9	315
361		24-36	4.6	7.6	4	61	17	44	11.9	0.1	45	360
				II	Chlorotic Soybeans							
362		0-6	10.1	7.8	14	134	23	111	46.5	0.8	5	2610
363		6-12	11.3	8.2	39	153	17	136	47.8	0.4	1	1935
364		12-24	8.8	8.2	26	116	14	102	36.6	0.4	3	1038
365		24-36	7.9	8.0	23	107	15	92	34.6	0.4	2	945
				II	Normal Soybeans							
366		0-6	2.8	7.7	8	38	13	25	31.1	0.3	5	45
367		6-12	3.7	7.3	7	54	19	35	5.1	0.1	11	360
368		12-24	3.9	7.8	27	57	18	39	5.1	0.1	3	360
369		24-36	3.5	7.9	26	50	17	33	4.8	0.1	3	270
					Chlorotic Soybeans							
	(24)											
346	Verdi Stonburg	0-6	6.4	7.9	5	74	16	58	28.7	0.4	12	1500
347	Grant Co.	6-12	11.3	8.0	3	145	18	127	60.0	0.7	19	810
348	Herman	12-24	11.8	8.3	29	142	15	127	69.0	0.5	12	765
349		24-36	12.1	8.1	27	149	13	136	64.5	0.6	11	1193

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 * ppm
				Normal Soybeans								
	(24)											
350	Verdi Stonburg	0-6	3.7	8.0	31	48	17	31	7.4	0.1	9	270
351	Grant Co.	6-12	2.4	8.0	25	26	10	16	4.4	0.1	11	240
352	Herman	12-24	0.9	8.0	3	12	3	9	1.8	tr	5	36
353		24-36	1.3	7.8	2	17	5	12	1.5	tr	5	45
				Chlorotic Flax - along ditch								
	(25)											
65	Fred Larson	0-6	1.8	8.2	21	16	2	14	2.7	0.3	190	32
66	Clay Co.	6-12	1.3	8.3	23	13	2	11	1.6	0.2	58	14
66A	Glyndon (3N,1E)	12-24	1.0	8.9	33	7	1	6	6.9	tr	31	18
67	Glyndon very fine	24-36	0.8	8.7	31	7	1	6	1.4	tr	17	5
				Chlorotic Flax - away from ditch								
68		0-6	3.4	8.4	28	26	3	23	18.5	0.1	12	135
69		6-12	2.9	8.6	37	18	3	15	16.2	tr	9	117
70		12-24	2.7	8.7	45	20	2	18	11.8	tr	15	89
71		24-36	1.1	8.7	29	13	1	12	3.2	0.1	6	18
				More Normal Flax Growth								
72		0-6	9.0	8.1	23	95	24	71	38.3	0.1	19	1057
73		6-12	7.0	8.3	33	59	9	50	35.6	tr	15	387
74		12-24	3.8	8.7	44	31	3	29	21.0	tr	2	212
75		24-36	3.0	8.6	28	28	2	26	13.5	tr	3	855
				Normal Soybeans								
	(26)											
107	2 mi. W of Syre	0-6	1.0	7.8	8	11	4	7	0.6	0.3	6	23
108	Norman Co.	6-12	0.4	7.9	4	6	1	5	0.6	tr	4	14
109	Bearden	12-24	0.3	8.4	32	10	1	9	0.5	tr	3	9
110	Silt loam	24-36	0.3	8.6	36	1	1	tr	1.0	tr	2	36

Lab No.	Farm operator county & reference no.	Depth inches	Conductivity (mmhos/cm)	pH	% $CaCO_3$ equivalent	Ca + Mg me/l	Ca me/l	Mg me/l	Na me/l	K me/l	Cl ppm	SO_4 ppm *
					Chlorotic Soybeans							
	(26)											
111	2 mi. W of Syre	0-6	1.3	8.4	12	4	1	3	2.5	6.0	3	77
112	Norman Co.	6-12	1.1	8.5	2	2	tr	2	3.7	6.0	12	68
112A	Bearden silt loam	12-24	1.0	9.0	33	4	1	3	6.4	3.0	38	60
113		24-36	1.7	8.8	32	10	1	9	12.6	tr	46	144
					More Normal Soybeans							
	(27)											
76	Fred Krebs	0-6	3.4	8.1	23	36	18	18	9.4	0.3	4	320
77	Norman Co.-Borup	6-12	7.0	8.1	29	79	25	54	19.9	0.1	6	1620
78	Bearden	12-24	10.0	8.4	31	129	20	109	43.2	0.1	9	878
79	Silt loam-sicl	24-36	18.0	8.4	24	225	10	115	61.5	0.4	4	1170
					Chlorotic Soybeans							
80	Bearden	0-6	1.8	7.8	13	12	3	9	5.3	2.0	25	72
81	Silt loam-sicl	6-12	1.7	8.3	17	17	3	14	8.3	0.2	58	81
82		12-24	3.6	8.4	32	42	8	34	10.3	0.1	98	203
83		24-36	5.5	8.1	29	67	20	47	12.4	0.1	58	158
					More Normal Soybeans							
	(28)											
114	Joe Torvestad	0-6	4.5	8.2	20	18	4	14	11.1	10.7	151	198
115	Norman Co.	6-12	3.3	7.9	11	10	3	7	9.1	9.1	230	158
116	Ada (3E,3/4N)	12-24	2.5	7.9	3	12	3	9	8.2	8.1	280	86
117	Bearden silt loam	24-36	2.0	7.8	21	11	3	8	6.9	6.9	230	77
					Chlorotic Soybeans							
118	Bearden silt loam	0-6	3.8	7.5	15	26	5	21	3.7	11.0	19	72
119		6-12	2.4	8.4	23	9	4	5	8.7	10.0	46	72
120		12-24	5.5	8.5	21	25	8	17	18.1	6.0	151	135
121		24-36	6.0	8.6	30	48	11	37	21.7	3.0	330	266