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

February 1967

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 Because these are largely one year results they should not be considered as conclusive and the results are not for publication.

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| | **Climatological Notes** | |
| 1. | Some Climatological Notes, 1966 | 1 |
| | **Soil Physics** | |
| 2. | Structure - Nitrogen Study, Waseca, 1966 | 14 |
| 3. | Subsoil Regeneration Study - Lamberton, 1966 | 19 |
| 4. | Structure - Nitrogen Study, Morris, 1966 | 30 |
| | **Soil Salinity** | |
| 5. | Soil Salinity and Crop Growth in Western Minnesota | 32 |
| | **Herbicide Residues** | |
| 6. | Soil Residue Studies | 66 |
| | **Lime Experiments** | |
| 7. | Lime Plots, Lamberton 1966 | 69 |
| | **Soil Productivity** | |
| 8. | Soil Productivity Study | 71 |
| | **Soil & Crop Management** | |
| 9. | Soil and Crop Management Systems, West Central Experiment Station | 78 |
| 10. | Continuous Corn Silage Experiment, West Central Experiment Station | 80 |
| 11. | Continuous Corn - High Fertility Experiment, Rosemount Exp. Sta. | 81 |
| 12. | Fertilizer Rotation Study, Southern Minnesota School & Exp. Sta. | 82 |
| | **Rosemount Experiments** | |
| 13. | Rosemount Soils Farm | 86 |
| 14. | Soybean Fertilization | 95 |
| 15. | Alfalfa Hay Yields With Plow-Down Fertilizer | 96 |
| | **Irrigation & Fertility Levels for Corn & Alfalfa** | |
| 16. | Effect of Irrigation, Fertility Level and Plant Population on Corn and Alfalfa at Park Rapids, Minnesota - 1965. | 98 |

Page

Nitrogen

17. The Effect of Nitrogen Source, PLacement and Time of Application on the Yield and Composition of Continuous Corn on Webster Clay Loam at Lamberton in 1966 105
18. The Effect of Urea or Ammonium Nitrate Nitrogen on the Nitrate Nitrogen Content of Webster clay loam surface soil and Different Portions of Growing Corn Plants at Lamberton in 1964, 1965 & 1966 110
19. Barley - Nitrogen Protein Study, Crookston, 1966 113
20. Fall vs Spring Nitrogen Fertilization of Small Grains in West Polk County in 1965-66. 115
21. The Effect of Rate and Split Versus Single Applications of Nitrogen on Yields of Bromegrass 118

Phosphorus

22. Comparison of Phosphorus Sources 121
23. Comparison of Urea Ammonium Phosphates with Standard Phosphorus Sources 124
24. 1966 Phosphorus Placement Study - Seed Incorporation (Pop-up) 127
25. Phosphorus Fertilization of Continuous Corn 130
26. Uptake of phosphate by roots and tops of sugarbeets 131

Secondary and Micro (Trace or Minor) Nutrient Elements

27. Sulfur Investigations on Soils and Crops-Summary 136
28. Sulfur Investigations on Soils and Crops 140
29. 1966 Zinc-Phosphate for Corn Study in Swift County 158
30. Direct and Residual Effect of Zinc Fertilization of Corn on a Zinc Deficient Silty Clay Loam in Southern Kandiyohi County 160
31. Zinc Fertilization of Continuous Corn 162
32. The Effect of Boron, Phosphorus and Potassium on the Yield of Four Legume-Grass Hay Fields in Carlton County in 1965-1966 163

Soybean Fertilization

33. 1966 Soybean Fertilization 166

Sugarbeet Fertilization

34. Sugarbeet Fertilization 167

Potato Fertilization

35. Potato Fertilization Plot Results, 1966 170

Oil Crop Fertilization

36. Fertilizer Trials on Oil Crops 175

Fertilization for Grass Seed

37. Effects of Fertilization on Seed Yield and Chemical Composition of Tissue of Park Kentucky Bluegrass 180

Improvement of Forested Soils

38. Improvement of Forested Soils 189

Land Forming

39. Land Forming at Northwest Experiment Station - 1966 190

Soil Testing

40. Soil Testing in Minnesota During 1966 192

# 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:

Mr. E.C. Drogemuller, Work Unit Conservationist, Soil Conservation Service, U.S.D.S, Gaylord

Mr. A.N. Fischer, Work Unit Conservationist, Soil Conservation Service, U.S.D.S, Dodge Center

Mr. O. Gunderson, Area Soils Agent, Morris

Mr. G. Holcumb, Area Soils Agent, Marshall

Mr. W.M. Kalton, Work Unit Conservationist, Soil Conservation Service, U.S.D.A., Milaca

Mr. P.N. Kennedy, Work Unit Conservationist, Soil Conservation Service, U.S.D.A., St. James

Dr. W.W. Nelson, Southwest Experiment Station, Lamberton

Mr. G.J. Sickeler, Work Unit Conservationist, Soil Conservation Service, U.S.D.S., Kellogg

Dr. O.C. Soine, Northwest Experiment Station, Crookston

## 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.

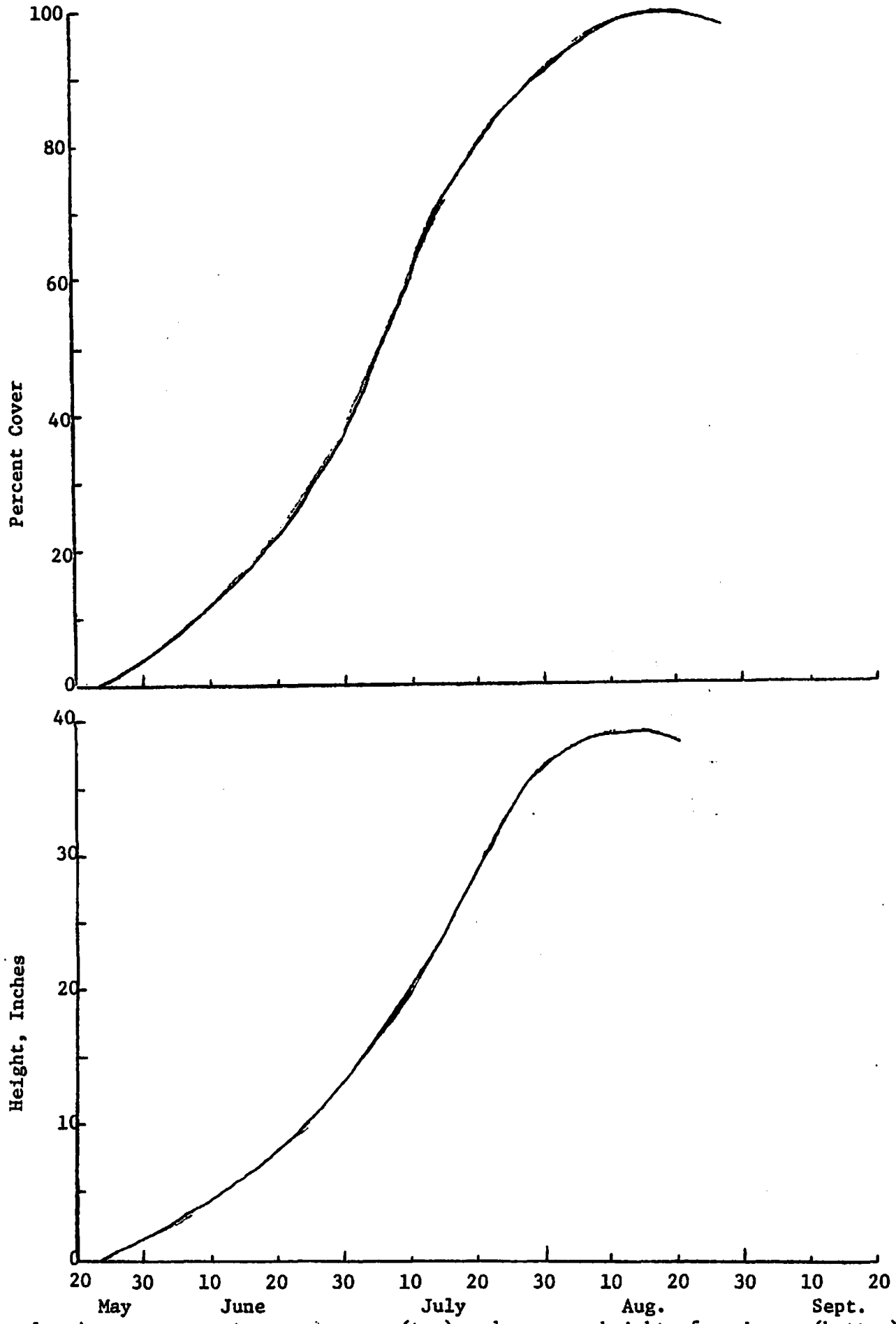



Figure 1. Average percent ground cover (top) and average height of soybeans (bottom) in 30 inch rows, St. Paul, 1962-66.

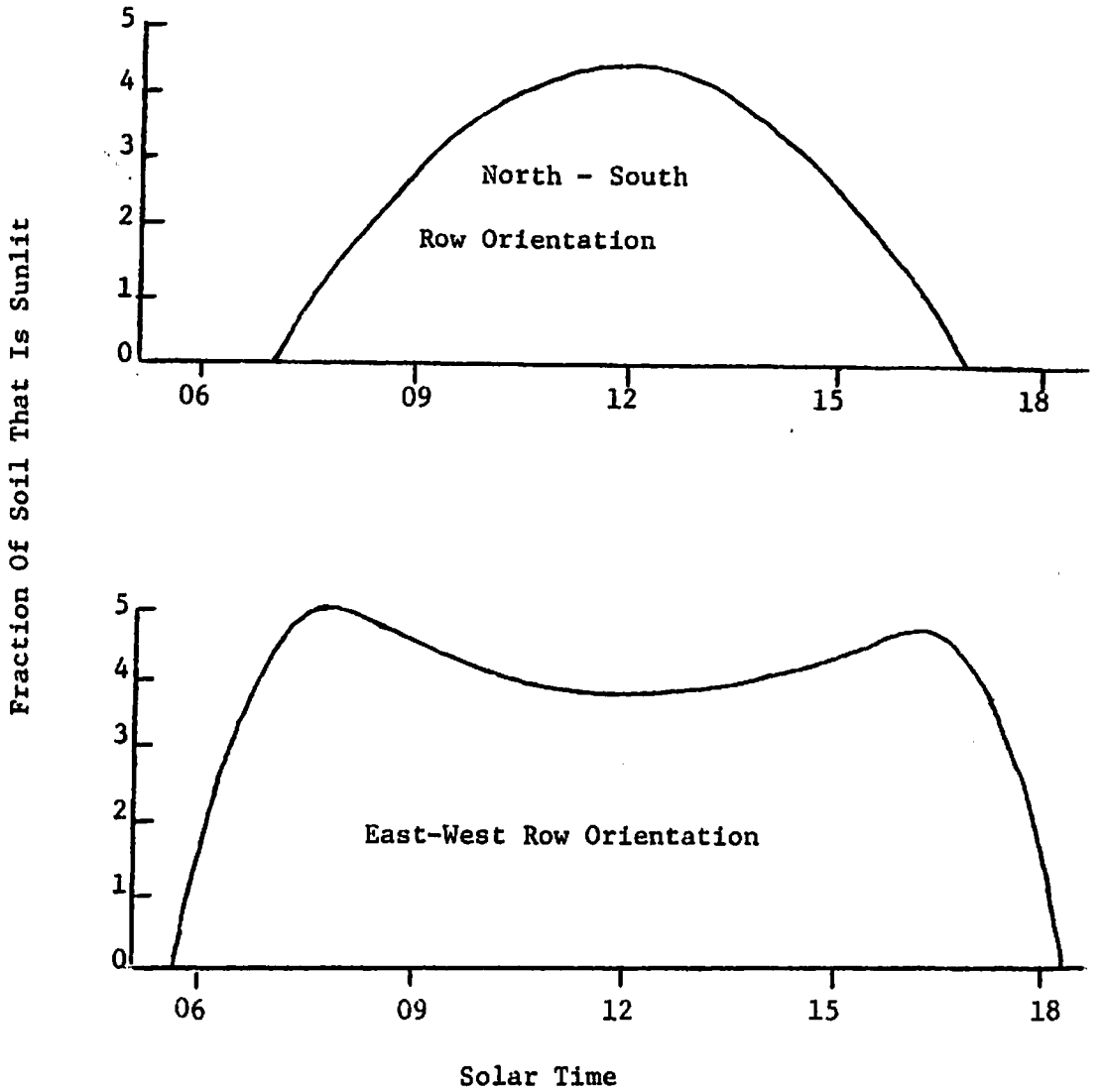



Figure 2. The hourly variations in the fraction of the total soil area that is sunlit for both N-S and E-W row orientation. Calculated for a soybean-like plant at 50% cover and 45° N. latitude, (From S.B.Idso, M.S. Thesis, Dept. Soil Science, U. Minn., 1966.)

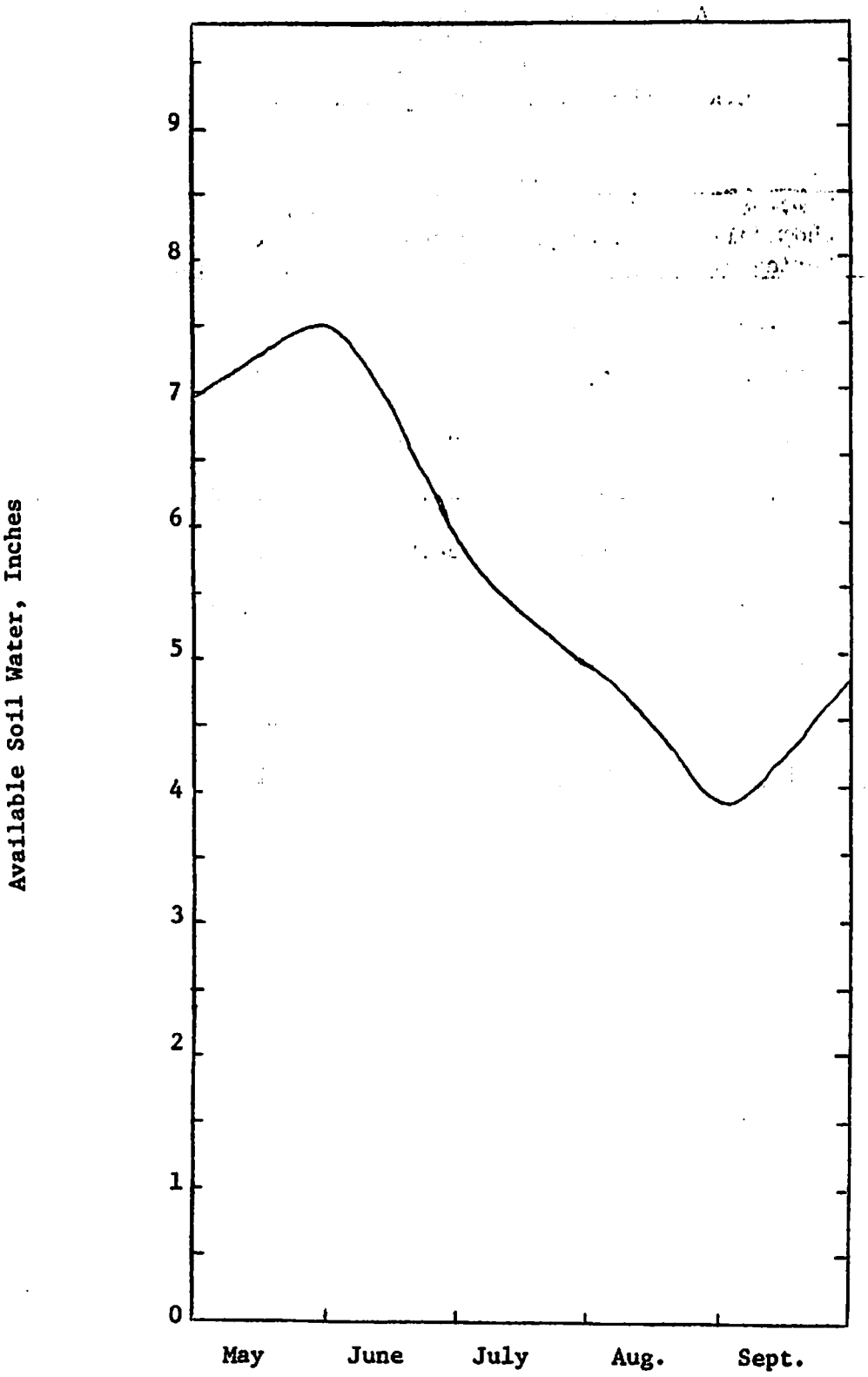



Figure 3. Average soil moisture at Lamberton, 1961-66.

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<br>LOCATION | Spring-Plow<br>Till Plant<br>in 66 | Min.<br>Spring Plow | Conv.<br>Fall Plow | Min.<br>Fall Plow | L.S.D.<br>(.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.

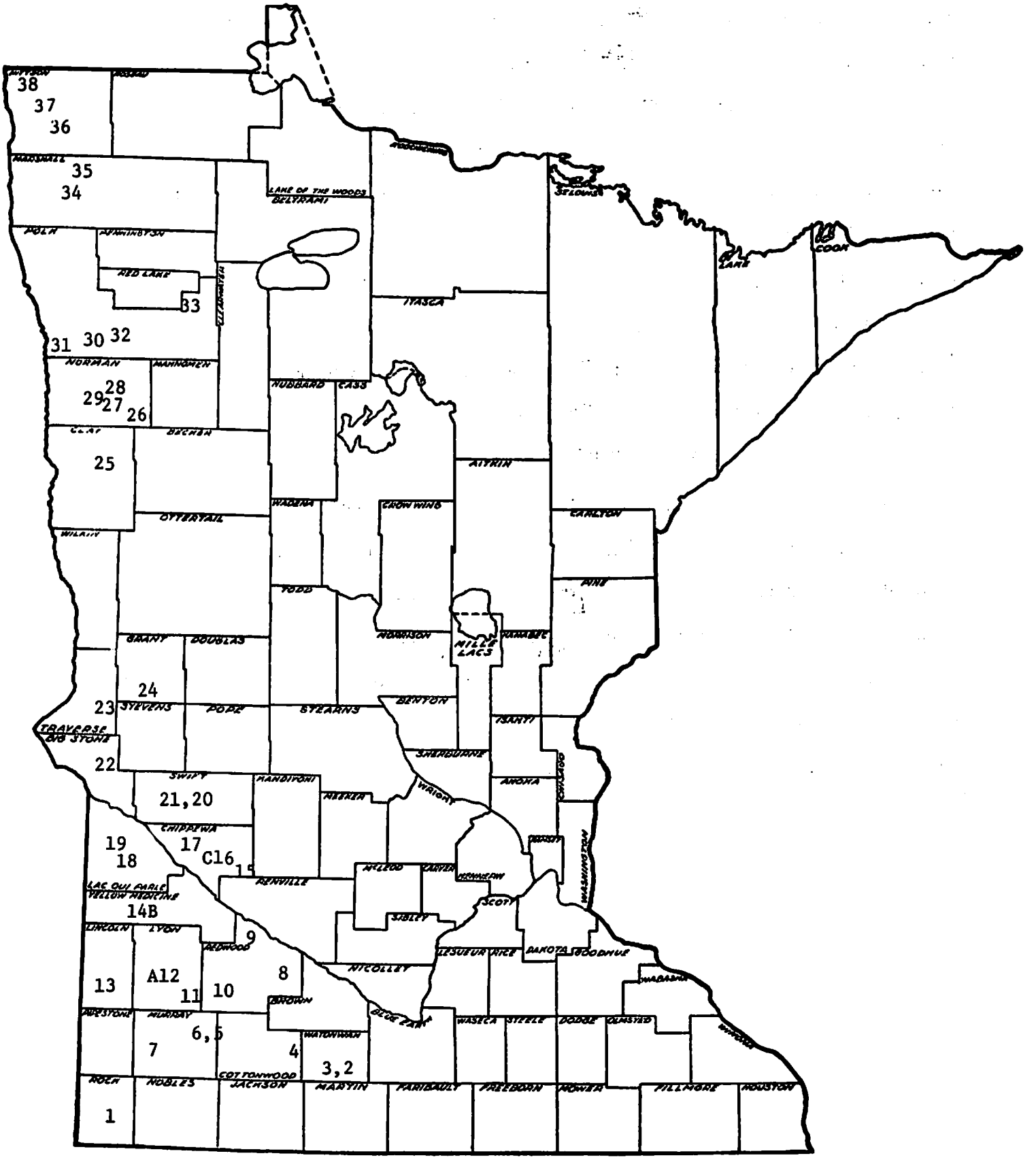
In 1964, a chlorotic soybean field southwest of Ghent (Lyon county) showed extreme chlorosis, on which the previously expensive, but generally successful chelated iron treatment showed little effect, exhibited essentially normal foliage immediately above tile lines, and in addition supported a number 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.

---

[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<br>Murray Co.<br>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.<br>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 |

| 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 * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | More Normal Flax | | | | | | | | |
| | (29) | | | | | | | | | | | |
| 122 | Carl Gunkle | 0-6 | 0.9 | 8.3 | 22 | 3 | 3 | - | 3.0 | 0.2 | 3 | 36 |
| 123 | Norman Co. | 6-12 | 0.8 | 8.5 | 32 | 7 | 2 | 5 | 1.6 | tr | 3 | 32 |
| 124 | Ada (8S, 2W) | 12-24 | 2.6 | 8.7 | 35 | 20 | 3 | 17 | 14.8 | 0.1 | 4 | 41 |
| 125 | Bearden silt loam | 24-36 | 6.0 | 8.6 | 28 | 31 | 4 | 27 | 38.7 | 0.1 | 3 | 108 |
| | | | | Chlorotic Flax | | | | | | | | |
| 126 | Glyndon silt loam | 0-6 | 1.2 | 8.4 | 20 | 10 | 3 | 7 | 3.7 | 0.1 | 9 | 239 |
| 127 | | 6-12 | 1.1 | 8.7 | 21 | 9 | 3 | 6 | 2.7 | 0.1 | 6 | 23 |
| 128 | | 12-24 | 3.5 | 8.8 | 33 | 34 | 6 | 28 | 14.8 | 0.1 | 2 | 158 |
| 129 | | 24-36 | 8.0 | 8.6 | 35 | 82 | 12 | 70 | 50.1 | 0.1 | 4 | 383 |
| | | | | More Normal Flax | | | | | | | | |
| | (30) | | | | | | | | | | | |
| 100 | M. Skang | 0-6 | 1.4 | 7.9 | 20 | 23 | 5 | 18 | 3.4 | 0.1 | 24 | 50 |
| 100A | W. Polk Co. | 6-12 | 1.6 | 8.1 | 20 | 11 | 3 | 8 | 5.9 | tr | 12 | 480 |
| 101 | Beltrami (2E, 1N) | 12-24 | 2.2 | 8.4 | 26 | 23 | 4 | 19 | 11.7 | tr | 1 | 68 |
| 102 | Glyndon silt loam | 24-36 | 3.8 | 8.3 | 27 | 44 | 13 | 31 | 16.4 | tr | 3 | 113 |
| | | | | Chlorotic Flax | | | | | | | | |
| 103 | Glyndon silt loam | 0-6 | 1.1 | 8.1 | 16 | 12 | 3 | 9 | 2.5 | 0.2 | 2 | 32 |
| 104 | | 6-12 | 0.9 | 8.2 | 18 | 8 | 3 | 5 | 4.1 | tr | 2 | 23 |
| 105 | | 12-24 | 1.7 | 8.4 | 25 | 14 | 3 | 11 | 9.6 | tr | 3 | 32 |
| 106 | | 24-36 | 1.7 | 8.4 | 17 | 11 | 2 | 9 | 12.6 | tr | 1 | 104 |
| | | | | Normal Flax | | | | | | | | |
| | (31) | | | | | | | | | | | |
| 92 | Ole Ronningen | 0-6 | 0.5 | 7.8 | 23 | 6 | 2 | 4 | 0.9 | 0.1 | 1 | 383 |
| 93 | W. Polk Co. | 6-12 | 0.4 | 8.1 | 34 | 6 | 1 | 5 | 1.2 | tr | 1 | 14 |
| 94 | Beltrami (1S, 10W) | 12-24 | 1.6 | 8.1 | 34 | 27 | 4 | 23 | 6.6 | 0.1 | 1 | 45 |
| 95 | Bearden silty clay loam | 24-36 | 3.6 | 8.2 | 25 | 53 | 16 | 37 | 10.3 | 0.1 | 1 | 567 |

| 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 Flax | | | | | | | |
| 96 | Hegne Silty | 0-6 | 0.8 | 8.0 | 12 | 12 | 5 | 7 | 0.8 | 0.1 | 1 | 27 |
| 97 | Clay | 6-12 | 0.7 | 7.8 | 11 | 11 | 4 | 7 | 0.8 | 0.1 | 1 | 14 |
| 98 | | 12-24 | 0.3 | 8.0 | 7 | 11 | 4 | 7 | 1.4 | 0.1 | 1 | 9 |
| 99 | | 24-36 | 3.0 | 8.0 | 6 | 42 | 20 | 22 | 5.7 | 4.5 | 6 | 72 |
| 84 | Penningroth Farm | 0-6 | 1.0 | 7.7 | 3 | 13 | 3 | 10 | 2.3 | 0.2 | 15 | 312 |
| 85 | W. Polk County | 6-12 | 1.3 | 8.7 | 3 | 12 | 3 | 9 | 3.0 | 0.1 | 125 | 14 |
| 86 | 15 S.E. Crookston | 12-24 | 1.8 | 7.9 | 24 | 18 | 8 | 10 | 4.8 | tr | 9 | 54 |
| 87 | Kittson Loam | 24-36 | 1.8 | 8.2 | 38 | 18 | 8 | 10 | 5.0 | tr | 4 | 113 |
| | | | | | Chlorotic Flax | | | | | | | |
| 88 | | 0-6 | 1.4 | 8.0 | 12 | 15 | 6 | 10 | 6.2 | 0.2 | 6 | 32 |
| 89 | | 6-12 | 2.5 | 8.3 | 23 | 25 | 6 | 19 | 11.9 | tr | 4 | 162 |
| 90 | | 12-24 | 5.5 | 8.2 | 18 | 65 | 21 | 44 | 19.7 | 0.2 | 15 | 284 |
| 91 | | 24-36 | 5.5 | 7.8 | 25 | 58 | 18 | 41 | 41.0 | 0.1 | 4 | 32 |
| | | | | | Normal Soil | | | | | | | |
| 164 | Arnold Stonberg | 0-6 | 3.2 | 7.7 | 13 | 34 | 26 | 8 | 2.7 | 0.6 | 46 | 525 |
| 165 | Polk County | 6-12 | 2.8 | 7.5 | 10 | 33 | 24 | 10 | 2.1 | 0.1 | 31 | 1695 |
| 166 | Oklee (3E) | 12-24 | 2.9 | 7.2 | 14 | 34 | 23 | 11 | 2.5 | 0.3 | 46 | 1125 |
| 167 | Rocksbury | 24-36 | 3.0 | 7.4 | 15 | 36 | 23 | 13 | 2.5 | 0.3 | 31 | 825 |
| | | | | | Soluble Salt Condition | | | | | | | |
| 168 | Rocksbury | 0-6 | 8.0 | 7.9 | 20 | 83 | 18 | 63 | 28.4 | 1.8 | 46 | 1080 |
| 169 | | 6-12 | 6.0 | 8.0 | 24 | 75 | 19 | 56 | 20.9 | 0.3 | 31 | 675 |
| 170 | | 12-24 | 6.3 | 7.8 | 24 | 74 | 16 | 58 | 23.6 | 0.3 | 31 | 428 |
| 171 | | 24-36 | 6.0 | 7.8 | 21 | 62 | 15 | 47 | 24.5 | 0.5 | 31 | 248 |

| 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 Flax** | | | | | | | |
| 32 | Richard Field | 0-6 | 1.3 | 8.0 | 18 | 25 | 5 | 20 | 3.0 | 0.1 | 31 | 338 |
| 33 | Marshall County | 6-12 | 2.9 | 8.2 | 28 | 13 | 3 | 10 | 3.0 | 0.1 | 31 | 72 |
| 34 | 9NE of Stephan | 12-24 | 4.0 | 7.9 | 24 | 38 | 4 | 34 | 7.1 | 0.1 | 60 | 167 |
| 35 | Bearden Silt loam | 24-36 | 3.8 | 8.0 | 33 | 60 | 10 | 50 | 8.7 | 0.3 | 96 | 324 |
| | | | | | **More Normal Flax** | | | | | | | |
| 36 | Fargo | 0-6 | 0.5 | 7.3 | 4 | 3 | tr | 3 | 2.5 | 0.2 | 12 | 27 |
| 37 | Clay | 6-12 | 0.3 | 7.5 | 6 | 2 | tr | 2 | 2.0 | tr | 15 | 36 |
| 38 | | 12-24 | 0.7 | 7.8 | 7 | 5 | 1 | 4 | 7.3 | tr | 60 | 32 |
| 39 | | 24-36 | 3.4 | 7.8 | 4 | 22 | 7 | 15 | 18.5 | 0.2 | 280 | 234 |
| | | | | | **Poor Potatoes** | | | | | | | |
| 24 | Ole Johnson | 0-6 | 6.0 | 8.1 | 6 | 74 | 29 | 45 | 27.2 | 0.2 | 330 | 743 |
| 25 | Marshall County | 6-12 | 8.5 | 8.3 | 8 | 94 | 29 | 64 | 38.5 | 0.2 | 500 | 900 |
| 26 | 11NE of Stephen | 12-24 | 10.0 | 8.6 | 53 | 118 | 16 | 102 | 44.2 | 0.1 | 820 | 518 |
| 27 | Bearden Silt Loam | 24-36 | 15.0 | 8.6 | 41 | 144 | 17 | 127 | 56.3 | 0.1 | 920 | 675 |
| | | | | | **Good Potatoes** | | | | | | | |
| 28 | Bearden | 0-6 | 0.6 | 8.4 | 6 | 6 | 1 | 4 | 1.9 | 0.1 | 38 | 99 |
| 29 | Silt Loam | 6-12 | 0.7 | 8.4 | 8 | 7 | 1 | 5 | 2.5 | 0.1 | 45 | 45 |
| 30 | | 12-24 | 1.4 | 8.6 | 27 | 11 | 1 | 11 | 11.7 | tr | 230 | 45 |
| 31 | | 24-36 | 2.3 | 8.7 | 32 | 26 | 1 | 25 | 13.5 | 0.1 | 230 | 104 |
| | | | | | **Good Wheat Growth (Durum)** | | | | | | | |
| 40 | Erlandson Bros | 0-6 | 4.0 | 7.1 | 4 | 24 | 16 | 8 | 18.9 | 0.8 | 570 | 54 |
| 40A | Kittson County | 6-12 | 5.8 | 7.6 | 4 | 30 | 8 | 22 | 33.9 | 1.3 | 820 | 113 |
| 41 | 4.5 SE of Kennedy | 12-24 | 13.4 | 7.5 | 14 | 81 | 32 | 49 | 54.5 | 0.1 | 1320 | 540 |
| 42 | Fargo Clay | 24-36 | 14.0 | 7.7 | 10 | 89 | 36 | 53 | 56.3 | 0.1 | 2220 | 698 |

| 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 | SO4 ppm * |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Bare Spot in Wheat | | | | | | | |
| 43 | Fargo | 0-6 | 21.0 | 7.1 | 5 | 182 | 100 | 82 | 66.3 | 1.0 | 3960 | 383 |
| 44 | Clay | 6-12 | 27.0 | 7.2 | 6 | 180 | 100 | 80 | 65.0 | 0.1 | 3960 | 270 |
| 45 | | 12-24 | 21.0 | 7.6 | 11 | 144 | 76 | 68 | 65.1 | 0.1 | 3000 | 675 |
| 46 | | 24-36 | 18.0 | 7.4 | 13 | 132 | 71 | 61 | 62.3 | 0.2 | 2760 | 216 |
| | | | | | Bare Spot in Oat Field | | | | | | | |
| 47 | Kittson County Fargo-Clay | 12-24 | 16.0 | 7.6 | 14 | 139 | 79 | 50 | 38.5 | 0.1 | 2000 | 234 |
| | | | | | Normal Flax | | | | | | | |
| 48 | A. V. Hunt | 0-6 | 0.5 | 7.3 | 3 | 4 | 1 | 3 | 0.9 | 0.1 | 19 | 18 |
| 49 | Kittson County | 6-12 | 0.2 | 7.4 | 2 | 3 | 1 | 2 | 0.9 | 0.1 | 15 | 14 |
| 50 | 3/4 NE of Hallock | 12-24 | 0.3 | 7.7 | 2 | 2 | 1 | 1 | 2.5 | tr | 38 | 9 |
| 51 | Fargo Clay | 24-36 | 0.8 | 7.9 | 13 | 6 | 2 | 4 | 4.6 | 0.1 | 19 | 37 |
| | | | | | Chlorotic Flax | | | | | | | |
| 52 | Hegne Clay | 0-6 | 0.4 | 8.3 | 9 | 4 | 1 | 3 | 1.4 | 0.1 | 4 | 14 |
| 53 | | 6-12 | 0.3 | 8.2 | 9 | 4 | 1 | 3 | 1.1 | tr | 12 | 14 |
| 54 | | 12-24 | 0.4 | 8.5 | 21 | 3 | 1 | 2 | 3.9 | tr | 12 | 18 |
| 55 | | 24-36 | 0.8 | 8.3 | 20 | 4 | 1 | 3 | 7.8 | tr | 31 | 36 |
| | | | | | Good Wheat | | | | | | | |
| 56 | Bill Moore | Not Compacted | 9.5 | 7.7 | 13 | 76 | 38 | 38 | 22.4 | 0.1 | 1000 | 119 |
| 57 | Kittson County | 6-12 | 2.5 | 7.7 | 9 | 17 | 4 | 13 | 11.6 | tr | 500 | 18 |
| 58 | 8 NW of Hallock Fargo-Clay | 12-24 | 5.5 | 7.8 | 16 | 43 | 17 | 26 | 18.9 | 0.2 | 820 | 99 |

| Lab. No. | Farm operator county & refrerence 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 Oats | | | | | | | |
| 59 | Fargo Clay | 0-6 | 1.9 | 7.5 | 5 | 14 | 3 | 11 | 8.2 | 0.1 | 378 | 4 |
| | | | | | Large Bare Spot | | | | | | | |
| 60 | | 0-6 | 8.0 | 7.6 | 5 | 70 | 41 | 29 | 16.9 | 0.3 | 1000 | 89 |
| 61 | | 6-12 | 16.0 | 7.4 | 6 | 133 | 68 | 65 | 31.6 | 0.1 | 2460 | 225 |
| 62 | Compacted | 0-6 | 17.0 | 6.9 | 5 | 146 | 95 | 51 | 30.8 | 0.6 | 2760 | 135 |
| 63 | Fargo Clay | 6-12 | 17.0 | 7.4 | 5 | 145 | 92 | 53 | 34.4 | 1.3 | 2760 | 113 |
| 64 | | 24-36 | 16.0 | 7.6 | 14 | 142 | 85 | 57 | 34.8 | 0.2 | 2760 | 90 |

*Sulphates determined on a 1:5 Soil Solution ratio all other elements were determined on saturation extracts

| | |
|---|---|
| Site 1<br>Steffler<br>Rock County | Salinity is not a problem on these sites. The soil where good growth occurs is actually acid. |
| Site 2<br>Leanus Nelson<br>Watonwan Co. | Soluble salts are not a problem here, but where chlorosis occured the less soluble carbonates (20%) are high enough to be a problem. |
| Site 3<br>D. Jacoby<br>Watonwan Co. | Soluble salts are not a problem on these sites. The level of carbonates (16%) found is apparently sufficient to induce chlorosis. |
| Site 4<br>M. Regnier<br>Cottonwood Co.<br>Mountain Lake | The soluble salts are low and not a problem here. The primary difference between the normal growth and the chlorotic sites, is in the level of carbonates. The normal site has a 4 to 7% $CaCO_3$ equivalent, whereas the chlorotic site has 20 to 26% $CaCO_3$ equivalent. |
| Site 5<br>Duane Smith<br>Murray Co.<br>Walnut Grove | The soluble salts on the site were the corn germinated but failed to grow are not high enough to kill established plants. Under certain moisture stress and at certain soil temperatures, conditions may have existed where such levels of salts were able to kill young seedlings. The salts may also have been at a higher concentration at the time of germination as compared to the time the soils were sampled.<br><br>The soluble salts in the poor growth site for corn and alfalfa are only moderate (3%), but coupled with the carbonates present (16-22%) a situation exists where fertility problems may occur. |
| Site 6<br>Harvey Wahl<br>Murray Co.<br>Currie | The carbonate level on the poor growth site is 11 to 16% $CaCO_3$ equivalent and 2 to 10% on the good growth site. The conductivities for the poor growth site III are approaching a critical level, 3.6 mmhos, for sensitive crops. The problem here is most likely one of fertility caused by the higher carbonates. |
| Site 7<br>Ed Onken<br>Murray Co.<br>Lake Wilson | A reason for the corn not surviving in the fallow site cannot be found in the analysis. The possibility of disease or nematode infestation may exist. |
| Site 8<br>Bert Jacoby<br>Redwood Co.<br>Morgan | The dead and damaged soybean sites are both low in soluble salts, but the $CaCO_3$ equivalent is 16 to 21%. The normal soybean site has a somewhat lower carbonate level, but it seems doubtful if this small difference would cause the beans to die in one area and not the other. Soil moisture at time of sampling from the site of the dead soybeans was 90% wetter than where the normal beans were growing. The site that had damaged beans the previous year was 30% wetter than where normal growth occurred. It therefore appears that soil wetness was the contributing factor. |

| | |
|---|---|
| Site 9<br>Cyril Iffert<br>Redwood Co.<br>Belview | The concentration of soluble salts and the less soluble carbonates were twice as high on the short corn site. Soil moisture may also have had an influence. The soil from the short corn site was 35 to 63% wetter than the soil where growth was normal. |
| Site 10<br>K. Jacobson<br>Redwood Co.<br>Lamberton | The problem on this site is not due to soluble salts. Carbonates ordinarily do not cause much of a problem at the level found here (10%), but along with some other adverse physical or chemical factor its influence may be significant. |
| Site 11<br>Harold E. Cooper<br>Lyon County<br>Tracy | High soluble salts as reflected by the conductivities is likely the problem here. The conductivity is 4.6 to 10.5 mmhos on the problem site and less than 1 mmho where no problem exists. Carbonates are very low. |
| Site 12<br>J. Van Overbeke<br>Lyon Co.<br>Marshall | The poor growth of corn and oats can be attributed to the high level of soluble salts. The carbonate levels (11 to 15%) were about the same for the problem and non-problem sites. |
| Site 13<br>D. Fruechte<br>Lincoln Co.<br>Verdi | The problem is other than salinity. This soil is actually acid. |
| Site 14<br>Yel. Med. Co.<br>Verdi | The carbonates are very high (20%+) on both the normal and poor corn sites. Although the conductivity is somewhat higher where poor growth occurred, it is unlikely that this difference alone would be the cause. There may be a fertility problem caused by the carbonates, and having a more pronounced effect on the one site. |
| Site 15<br>John Zimmer<br>Chippewa Co.<br>Clara City | The poor corn growth in site I compared to II appears to be a reflection of higher soluble salts. Sodium sulphates are very high in the 0-12" depth with magnesium sulphates the highest in the 12 to 24" depth. On site II the corn did well even in the presence of 30% $CaCO_3$ equivalent,but the high soluble salt concentration was at a lower depth which may account for the difference. In comparing site III against IV, site III showing poor growth was very high in carbonates, 36% $CaCO_3$ equivalent in the 6 to 12" depth. This level of carbonates along with the higher soluble salts is sufficient to be detrimental. |
| Site 16<br>M. Gustafson<br>Chippewa Co. | It is suprising that soybeans were not affected at site II under the high soluble salt condition found (about 5 mmhos). The data for the site where the beans died and where they were normal is very similar. Soil moisture at 6 to 12" was 33% greater where poor growth occurred. The possibility of toxicity from an element such as boron cannot be ruled out. |

| | |
|---|---|
| Site 17<br>Bernie Bosch<br>Chippewa Co.<br>Montevideo | Why the soybeans died on one site and recovered completely on another having a similar salt level is puzzling. Again toxicity by an element like boron could be the cause of the dead beans. The soil moisture where the beans died was 26% greater than where they fully recovered. This may be in part due to the fact that transpirational losses of moisture are not occuring where the beans had died. |
| Site 18<br>Paul Wager<br>Lac Qui Parle Co.<br>Dawson | The poor growth of corn on this site is likely the result of the high level of soluble salts as reflected by the conductivities. Because the carbonates are low and sodium is high there may exist an undesirable level of exchangeable sodium. The result would be a dispersed and puddled soil with poor aeration and impeded drainage. |
| Site 19<br>Wayne Glasser<br>Lac Qui Parle Co.<br>Bellingham | Although the better growth site for corn is higher in carbonates than the poor site, the latter is very high in soluble salts. Where normal growth occurred, there is a very high amount of carbonates, 48% $CaCO_3$ equivalent, in the 24 to 36" depth. Why this high level of carbonates didn't affect growth may be because it occurs below the rooting depth, since this is a poorly drained soil with a high water table. The high level of sodium present in the poor growth site may also have resulted in deterioration of soil structure resulting in poor aeration and drainage. |
| Site 20<br>Dave Hughes<br>Swift County<br>Danvers | Similar high conductivities were found for site I and III having poor corn growth, and site IV having normal growth. If high soluble salts was the cause of poor growth on sites I and III, then why didn't similar concentrations affect site IV. It may be that a plant growing under these high levels of osmotic tension and high sodium is easily affected beneficially or detrimentally, by small changes in other chemical or environmental factors. |
| Site 21<br>J. Torgelson<br>Swift Co.<br>Danvers | The normal growth of soybeans occurred on a site that is at a critical level of soluble salts (4 to 5 mmhos) and carbonates (16%) for the development of chlorosis. The site where the soybeans died was higher in soluble salts as shown by the conductivities (6 to 6.5 mmhos). The large amount of sodium present where the beans died may also have an effect on soil aeration and drainage. All these factors together could be sufficient to kill the beans especially in the early growth stage. |
| Site 22<br>F. Kohler<br>Big Stone Co.<br>Ortonville | The situation here is similar to that on the J. Torgelson farm in Swift Co. Conductivities of 3 to 5 mmhos show an effect on the beans but when they went above 6 mmhos its influence was realized. The level of carbonates (10% or less) was about the same for all sites. |

| | |
|---|---|
| Site 23<br>G. Jacobs<br>Traverse Co.<br>Dumont | Total soluble salts as reflected by the conductivities are very high in the chlorotic sites, 9 - 17 mmhos compared to 2 - 4 mmhos in the non-chlorotic sites. Carbonates were very low in chlorotic site I and very high in the normal site II, but because this high level occurs below 12 inches the majority of the root may have remained above and therefore not affected by the carbonates. |
| Site 24<br>Verdi Stonburg Farm<br>Grant Co.<br>Herman | The relatively high conductivity of the soil on which the chlorotic soybeans were growing along with high sodium (Na) and sulfate ($SO_4$) content indicates that soluble salt concentrations are the probable cause of the unhealthy soybean growth. Even the more normally growing soybean growth is probably affected to some degree by soluble salts present. |
| Site 25<br>Fred Larson Farm<br>Clay Co,3N,1E<br>Glyndon | This farm soil was sampled in 1965 (Site 23, pp. 37,38 1966 Bluebook) and the results obtained were the reverse of the expected pattern. The soils of the 1966 sampling show the same results with the more normal flax growth showing a much higher conductivity (soluble salt content and higher sulfate ($SO_4$) content than the chlorotic flax of the other two profiles.) The analyses of all three profiles would indicate soluble salt problems precluding normal flax growth. |
| Site 26<br>Norman Co.<br>2 mi. W of Syre | The soluble salt content (indicated by electrical conductivity) is not especially high in either soil, but apparently soluble sodium (Na) is relatively high in the problem soil (especially in the subsoil) which would seriously affect soybean growth. |
| Site 27<br>Fred Krebs Farm<br>Norman Co<br>Borup | Here the more normally growing soybeans are growing in a soil higher in soluble salt content than the chlorotic soybeans. The analyses shown do not explain (as in Site 24) why soybeans were more chlorotic with lower soluble salts. |
| Site 28<br>Joe Torvestad Farm<br>Norman Co. | The indicated soluble salt content (electrical conductivity) would suggest that both sets of soybeans would have difficulty in growing normally, since salts at this level would be limiting and soil water and aeration could cause differences in growth. |
| Site 29<br>Carl Gunkle Farm<br>Norman Co. | The soluble salt content of both of these soils is moderate, but the Na content of both could contribute to poor growth - along with the higher sulfate content where the chlorotic flax is growing. |
| Site 30<br>M. Skang Farm<br>W. Polk Co. | Here the more normal growing flax actually has a higher salt content in the soil than where the chlorotic flax was growing. It is evident that the soil analyses conducted do not show why chlorotic flax growth developed. |

| | |
|---|---|
| Site 31<br>Ole Romningen Farm<br>W. Polk Co. | Here again the soluble salt content is not high, and the cause of chlorotic growth is not evident from the soil analyses. |
| Site 32<br>Penningroth Farm<br>W. Polk Co. | On this farm the flax was extremely chlorotic, which could be attributed to the high soluble salt content as shown by conductivity, Na and $SO_4$ content, as well as by the high $CaCO_3$ equivalent. |
| Site 33<br>Arnold Stonberg<br>Polk Co. | The soluble salt content of this soil is very high (especially Na salts) and could be expected to seriously affect plant growth. |
| Site 34<br>Richard Field Farm<br>Marshall Co. | The soluble salts in the soil indicated by electrical conductivity and also the $CaCO_3$ content (equivalent) of the chlorotic growth area would normally cause growth problems of susceptible crops such as flax. |
| Site 35<br>Ole Johnson Farm<br>Marshall Co. | The soluble salt content (indicated by the electrical conductivity) containing a high proportion of sodium (Na) and sulfate ($SO_4$) would be expected to seriously affect potato plant development. |
| Site 36<br>Erlandson Bros.<br>Kittson Co. | These analyses indicate the high resistance of durum wheat to soluble salt effect in the soil. However, the extremely high conductivity of the bare soils in the wheat and oat fields would be expected with the high sodium (Na) chlorides (Cl) and sulfates ($SO_4$), with a relatively low lime ($CaCO_3$ equivalent) content. |
| Site 37<br>A.V. Hunt Farm<br>Kittson Co. | There was little difference in the soluble salt content of these two soils and the chlorosis may have developed from the higher lime content ($CaCO_3$ equivalent) or aeration differences of the Hegne clay. |
| Site 38<br>Bill Moore Farm<br>Kittson Co. | Small grains are relatively resistant to soluble salts in the soil as shown by the high conductivities (soluble salt indicator) of the wheat and oat fields. The bare and compacted areas apparently contain salts in sufficient concentrations to preclude even small grain production. |

## Seasonal Variations in Soil Salt Concentrations

A study was made of possible changes in soil salt concentrations during the 1966 growing seasons. Three known problem soils were selected (one near Ghent in Lyon county, one near Porter in Yellow Medicine county, and one east of Montevideo in Chippewa county--marked A, B, and C respectively on the accompanying map--and sampled about the 20th of each month, commencing in May. The analytical results including schematics (figure (A), (B) and (C)) of the electrical conductivities are shown on the following pages.

The two sites on the Maurice Regnier farm show contrasting patterns of salt movement (figure A). The salts in the surface of site I were at their highest concentration in the May sampling and continued to decrease through June and July followed by an increase in the subsurface in August. The salts in the surface of site II were at their lowest in May with a large increase in June and followed by a drop in July. The pattern of movement in the 24 to 36" depth was just the opposite of the surface. It therefore appears that during the time interval from May 20 to June 20, soluble salts moved from the lower depths to the surface. Between the June and July samplings the salts moved downward out of the surface to the lower depths. Another visit to these sites to determine their proximity to tile lines and position in the micro-relief may suggest reasons for the differing patterns.

The surface six inches in site I on the Wollum farm (Figure B) had a conductivity of 8 mmhos on May 20 and dropped to 7 mmhos by June 20 where it remained through the July and August samplings. The greatest changes at this site was a buildup of salts in July at the 6 to 18 inch depth with a maximum (9.5 mmhos) at 6 to 12 inches. This buildup in salts continued into August with the maximum (11.6 mmhos) now occurring at 18 to 24 inches. The Wollum II site (figure B) behaved differently in that there was no buildup at the lower depths. The conductivities in the surface initially increased through June and then dropped off considerably by July 18. The levels of soluble salts on May and June 20 were dangerously high. Between June 20 and July 18 there was a considerable movement of salts out of the surface site sampled. Since there was no July buildup at the lower depths the salts must have moved out laterally. Another visit to these sites for further observations with these data in hand is recommended.

On the Gustafson farm only one site was sampled. At the May sampling the conductivities were highest at 12 to 24 inches followed by an increase at all depths by June. The June and July samplings were similar with soluble salts at the same level for every depth sampled. From July to August there was a tremendous increase in soluble salts at all depths below the surface six inches. At the September sampling the salts had returned to the earlier levels.

## Seasonal Variation Study

| 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 | | | | | | | |
| 140 | Maurice Regnier | 0-6 | 9.0 | 7.6 | 16 | 60 | 36 | 24 | 61.6 | 2.3 | 280 | 1410 |
| 141 | Farm-Lyon County | 6-12 | 6.5 | 7.6 | 14 | 49 | 21 | 28 | 36.6 | 1.2 | 125 | 1515 |
| 142 | 3 SW of Ghent | 12-18 | 5.0 | 7.5 | 19 | 46 | 20 | 26 | 30.8 | 0.7 | 76 | 1455 |
| 143 | May 20 sampling | 18-24 | 4.0 | 7.4 | 24 | 40 | 21 | 19 | 17.3 | 0.8 | 46 | 900 |
| 144 | Vallets silty clay loam | 24-36 | 3.6 | 7.4 | 26 | 37 | 21 | 16 | 13.7 | 0.8 | 46 | 338 |
| | | | | | II | | | | | | | |
| 145 | | 0-6 | 6.0 | 7.5 | 18 | 57 | 35 | 22 | 16.2 | 1.3 | 280 | 728 |
| 146 | | 6-12 | 5.0 | 7.6 | 17 | 52 | 27 | 25 | 18.2 | 1.9 | 230 | 1440 |
| 147 | | 12-18 | 4.5 | 7.4 | 15 | 47 | 24 | 23 | 17.8 | 1.3 | 125 | 1410 |
| 148 | | 18-24 | 3.8 | 7.2 | 24 | 39 | 25 | 14 | 16.2 | 1.3 | 76 | 570 |
| 149 | | 24-36 | 3.7 | 7.4 | 24 | 35 | 22 | 13 | 14.2 | 1.0 | 76 | 263 |
| | | | | | I | | | | | | | |
| 5 | June sampling | 0-6 | 7.0 | 7.4 | 19 | 67 | 53 | 14 | 24.5 | 2.0 | 350 | 2013 |
| 6 | | 6-12 | 4.5 | 7.5 | 18 | 45 | 35 | 10 | 18.7 | 1.4 | 76 | 1980 |
| 7 | | 12-18 | 3.8 | 7.3 | 10 | 41 | 36 | 5 | 16.2 | 1.1 | 31 | 1642 |
| 8 | | 18-24 | 3.8 | 7.3 | 29 | 33 | -- | -- | 15.0 | 1.0 | 19 | 652 |
| 9 | | 24-36 | 3.0 | 7.4 | 29 | 31 | 25 | 6 | 13.5 | 0.8 | 12 | 157 |
| | | | | | II | | | | | | | |
| 10 | | 0-6 | 8.5 | 7.6 | 17 | 68 | 40 | 28 | 42.0 | 1.7 | 125 | 2070 |
| 11 | | 6-12 | 6.0 | 7.6 | 15 | 45 | 32 | 13 | 37.9 | 1.8 | 58 | 1800 |
| 12 | | 12-18 | 5.0 | 7.5 | 21 | 40 | 27 | 13 | 31.6 | 0.4 | 19 | 1035 |
| 13 | | 18-24 | 3.8 | 7.4 | 21 | 38 | 28 | 10 | 20.6 | 0.4 | 19 | 405 |
| 14 | | 24-36 | 1.7 | 7.4 | 18 | 10 | 7 | 3 | 12.5 | 0.1 | 15 | 157 |

| 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 | | | | | | | |
| 229 | Maurice Regnier | 0-6 | 4.0 | 7.8 | 20 | 51 | 27 | 24 | 12.6 | 3.3 | 190 | 1695 |
| 230 | July sampling | 6-12 | 3.8 | 7.8 | 19 | 47 | 27 | 20 | 13.7 | 4.0 | 120 | 1980 |
| 231 | | 12-18 | 3.8 | 7.9 | 13 | 44 | 24 | 20 | 12.8 | 2.4 | 3 | 1905 |
| 232 | | 18-24 | 3.5 | 7.7 | 35 | 38 | 21 | 17 | 11.9 | 2.2 | 76 | 1965 |
| 233 | | 24-36 | 3.2 | 8.0 | 30 | 32 | 17 | 15 | 10.6 | 1.1 | 190 | 247 |
| | | | | | II | | | | | | | |
| 234 | | 0-6 | 6.5 | 7.9 | 18 | 53 | 23 | 30 | 44.6 | 3.5 | 280 | 2055 |
| 235 | | 6-12 | 6.0 | 8.0 | 18 | 46 | 19 | 27 | 44.6 | 2.8 | 120 | 2139 |
| 236 | | 12-18 | 5.0 | 7.9 | 24 | 39 | 16 | 23 | 33.3 | 1.0 | 76 | 1767 |
| 237 | | 18-24 | 3.8 | 7.8 | 28 | 37 | 18 | 19 | 18.0 | 1.1 | 110 | 393 |
| 238 | | 24-36 | 2.5 | 8.0 | 20 | 21 | 11 | 10 | 12.6 | 1.9 | 76 | 180 |
| | | | | | I | | | | | | | |
| 324 | August sampling | 0-6 | 4.2 | 7.6 | 18 | 60 | 18 | 42 | 6.2 | 0.3 | 5 | 1230 |
| 325 | | 6-12 | 4.7 | 7.6 | 18 | 54 | 27 | 27 | 20.2 | 1.9 | 24 | 1575 |
| 326 | | 12-18 | 5.2 | 7.6 | 19 | 62 | 24 | 38 | 15.9 | 2.2 | 58 | 1530 |
| 327 | | 18-24 | 3.8 | 7.6 | 34 | 44 | 21 | 23 | 10.1 | 1.4 | 19 | 923 |
| 328 | | 24-36 | 3.4 | 7.8 | 23 | 38 | 19 | 19 | 9.1 | 1.5 | -- | 315 |

| 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 | | | | | | | |
| 135 | Nels Wollum Farm | 0-6 | 8.0 | 7.9 | 15.6 | 64 | 25 | 39 | 61.6 | 2.0 | 190 | 1510 |
| 136 | Yel. Med. County | 6-12 | 5.5 | 7.7 | 12.7 | 54 | 29 | 25 | 32.6 | 1.0 | 46 | 1577 |
| 137 | Porter | 12-18 | 4.8 | 7.7 | 9.7 | 49 | 25 | 24 | 20.3 | 0.8 | 31 | 1042 |
| 138 | May 20 sampling | 18-24 | 4.0 | 7.7 | 9.8 | 55 | 27 | 48 | 19.1 | 0.8 | 31 | 840 |
| 139 | Vallers silty clay loam | 24-36 | 3.5 | 7.6 | 4.8 | 38 | 23 | 15 | 1.4 | 1.1 | 24 | 735 |
| | | | | | II | | | | | | | |
| 130 | | 0-6 | 12.0 | 7.9 | 15.2 | 75 | 24 | 21 | 68.5 | 1.8 | 125 | 1530 |
| 131 | | 6-12 | 6.0 | 7.6 | 10.4 | 62 | 28 | 35 | 34.4 | 1.2 | 24 | 1560 |
| 132 | | 12-18 | 4.3 | 7.5 | 8.6 | 48 | 29 | 19 | 18.3 | 0.9 | 24 | 1650 |
| 133 | | 18-24 | 3.6 | 7.5 | 12.4 | 41 | 27 | 14 | 13.6 | 0.9 | 19 | 713 |
| 134 | | 24-36 | 3.7 | 7.4 | 7.2 | 44 | 29 | 15 | 13.6 | 8.4 | 24 | 255 |
| | | | | | I | | | | | | | |
| 15 | June 20 sampling | 0-6 | 7.0 | 7.8 | 14.9 | 57 | 29 | 28 | 40.5 | 1.0 | 76 | 2633 |
| 16 | | 6-12 | 5.0 | 7.7 | 12.5 | 50 | 29 | 21 | 28.9 | 0.7 | 31 | 2318 |
| 17 | | 12-18 | 4.5 | 7.6 | 9.5 | 48 | 33 | 15 | 18.7 | 0.5 | 12 | 1913 |
| 18 | | 18-24 | 3.7 | 7.4 | 6.2 | 41 | 30 | 11 | 16.7 | 0.4 | 9 | 2228 |
| 19 | | 24-36 | 3.5 | 7.4 | 1.9 | 37 | 28 | 9 | 15.1 | 0.5 | 19 | 180 |
| | | | | | II | | | | | | | |
| 20 | | 0-6 | 14.0 | 8.1 | 13.9 | 90 | 35 | 45 | 88.5 | 0.8 | 378 | 3240 |
| 21 | | 6-12 | 5.5 | 7.6 | 9.8 | 56 | 28 | 28 | 29.4 | 0.7 | 38 | 2250 |
| 22 | | 12-18 | 4.3 | 7.5 | 8.9 | 47 | 28 | 19 | 19.7 | 0.5 | 15 | 1935 |
| 23 | | 18-24 | 3.9 | 7.5 | 6.8 | 47 | 27 | 20 | 18.5 | 0.5 | 15 | 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) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | I | | | | | | | |
| 244 | Nels Wollum | 0-6 | 7.0 | 8.1 | 16.2 | 62 | 24 | 38 | 60.0 | 1.6 | 280 | 2001 |
| 245 | July 18 sampling | 6-12 | 9.5 | 8.1 | 14.2 | 63 | 26 | 37 | 83.7 | 1.8 | 380 | 2475 |
| 246 | | 12-18 | 7.0 | 8.0 | 13.8 | 57 | 28 | 29 | 55.7 | 1.2 | 500 | 1461 |
| 247 | | 18-24 | 4.8 | 7.9 | 8.7 | 46 | 26 | 20 | 32.8 | 1.1 | 31 | 801 |
| 248 | | 24-36 | 3.6 | 7.8 | 3.0 | 38 | -- | -- | -- | -- | -- | 369 |
| | | | | | II | | | | | | | |
| 239 | | 0-6 | 8.0 | 8.1 | 16.8 | 68 | 23 | 45 | 71.0 | 3.8 | 280 | 2100 |
| 240 | | 6-12 | 5.0 | 8.0 | 13.7 | 59 | 26 | 33 | 22.8 | 2.5 | 96 | 2361 |
| 241 | | 12-18 | 4.0 | 7.9 | 12.9 | 81 | 26 | 55 | 15.3 | 1.1 | 45 | 1965 |
| 242 | | 18-24 | 3.6 | 8.0 | 3.5 | 39 | 22 | 17 | 13.4 | 0.8 | 45 | 345 |
| 243 | | 24-36 | 2.9 | 8.1 | 1.8 | 28 | 14 | 14 | 12.0 | 0.8 | 45 | 2325 |
| 329 | August sampling | 0-6 | 7.1 | 7.9 | 16.4 | 65 | 22 | 43 | 47.8 | 2.0 | 24 | 1620 |
| 330 | | 6-12 | 9.2 | 7.9 | 11.7 | 73 | 22 | 51 | 63.5 | 1.5 | 45 | 2160 |
| 331 | | 12-18 | 9.3 | 7.8 | 13.6 | 74 | 25 | 49 | 61.5 | 1.4 | 58 | 1650 |
| 332 | | 18-24 | 11.3 | 7.8 | 9.1 | 121 | 22 | 99 | 22.2 | 2.1 | 38 | 870 |
| 333 | | 24-36 | 5.7 | 7.8 | 7.4 | 54 | 19 | 35 | 29.2 | 1.7 | 31 | 1230 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 156 | Gustafson Farm | 0-6 | 2.5 | 7.9 | 11 | 31 | 11 | 20 | 2.3 | 0.2 | 4 | 218 |
| 157 | Chippewa Co. | 6-12 | 3.5 | - | 15 | 46 | 20 | 26 | 2.3 | 0.1 | 6 | 1253 |
| 158 | May 20 sampling | 12-24 | 4.3 | 7.9 | 20 | 52 | 20 | 32 | 3.4 | 0.1 | 9 | 1005 |
| 159 | Sletten silty clay loam | 24-36 | 3.5 | 7.8 | 7 | 45 | 13 | 32 | 6.4 | 0.1 | 4 | 1155 |
| 160 | June 20 sampling | 0-6 | 5.0 | 7.4 | 11 | 59 | 23 | 36 | 5.8 | 0.1 | 9 | 735 |
| 161 | | 6-12 | 5.0 | 7.8 | 11 | 62 | 19 | 43 | 7.3 | 0.1 | 4 | 1905 |
| 162 | | 12-24 | 5.0 | 7.9 | 18 | 64 | 17 | 47 | 10.7 | 0.1 | 6 | 1800 |
| 163 | | 24-36 | 5.1 | 7.9 | 19 | 38 | 18 | 20 | 13.5 | 0.2 | 6 | 1620 |
| 180 | July 20 sampling | 0-6 | 5.0 | 8.0 | 11 | 76 | 24 | 52 | 10.6 | 0.2 | 12 | 533 |
| 181 | | 6-12 | 5.0 | 8.0 | 15 | 80 | 23 | 57 | 13.4 | 0.1 | 12 | 1388 |
| 182 | | 12-24 | 5.5 | 7.9 | 20 | 86 | 23 | 63 | 17.0 | 0.1 | 12 | 1583 |
| 183 | | 24-36 | 4.8 | 8.1 | 19 | 67 | 17 | 50 | 16.0 | 0.1 | 5 | 780 |
| 334 | August sampling | 0-6 | 4.3 | 7.9 | 12 | 67 | 22 | 45 | 4.9 | 0.2 | 5 | 270 |
| 335 | | 6-12 | 8.7 | 7.7 | 17 | 157 | 24 | 133 | 63.7 | 1.0 | 12 | 578 |
| 336 | | 12-24 | 9.4 | 7.9 | 39 | 156 | 27 | 129 | 22.0 | 1.3 | -- | 458 |
| 337 | | 24-36 | 10.1 | 7.8 | 23 | 154 | 25 | 129 | 31.8 | 1.6 | 9 | 630 |
| 370 | Sept. sampling | 0-6 | -- | 7.6 | 12 | 69 | 20 | 49 | 5.3 | 0.5 | -- | 675 |
| 371 | | 6-12 | 4.1 | 7.6 | 12 | 60 | 16 | 44 | 5.1 | 0.3 | 9 | 2160 |
| 372 | | 12-24 | -- | 7.6 | 19 | -- | 18 | -- | 9.9 | 0.8 | 5 | 1710 |
| 373 | | 24-36 | 5.2 | 7.8 | 20 | 72 | 15 | 57 | 12.5 | 0.5 | 3 | 1080 |

Seasonal Study of Electrical
Conductivities on Saturation Extracts

Figure A.

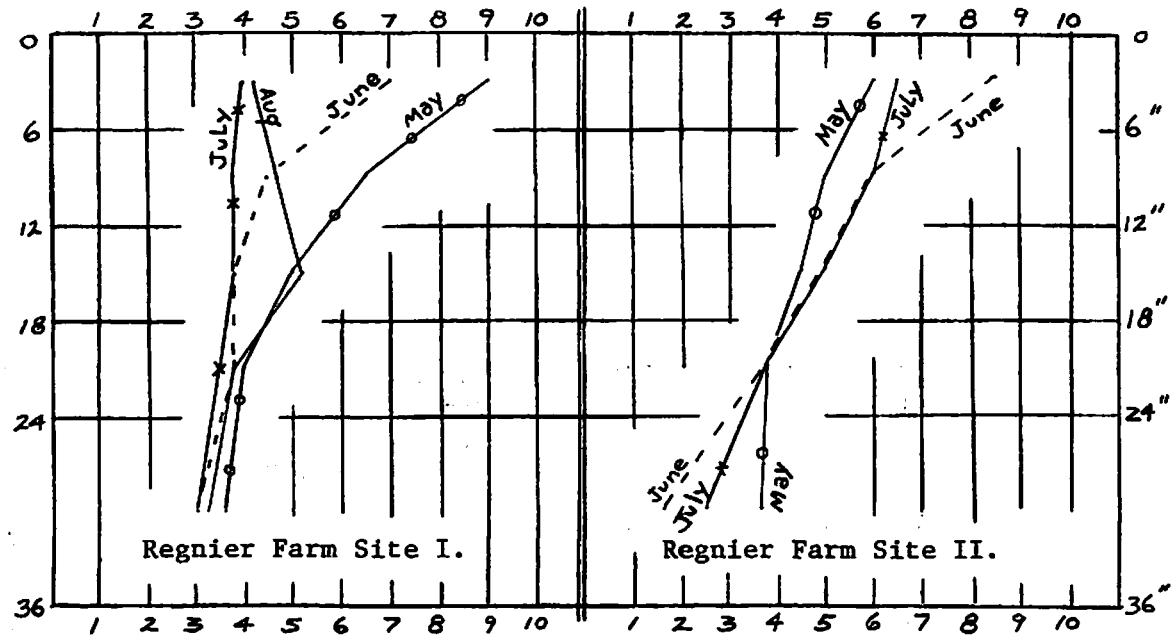
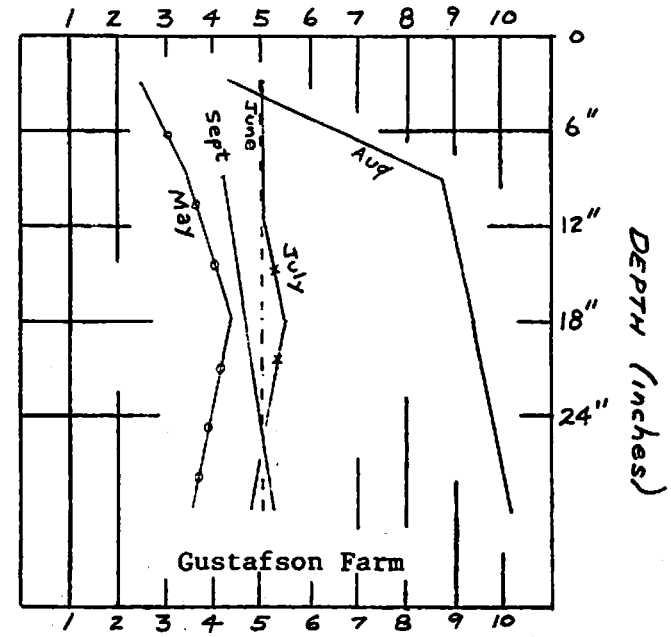



Figure C.




Electrical Conductivities mmhos/cm 25° C.(EC.)

(EC.)

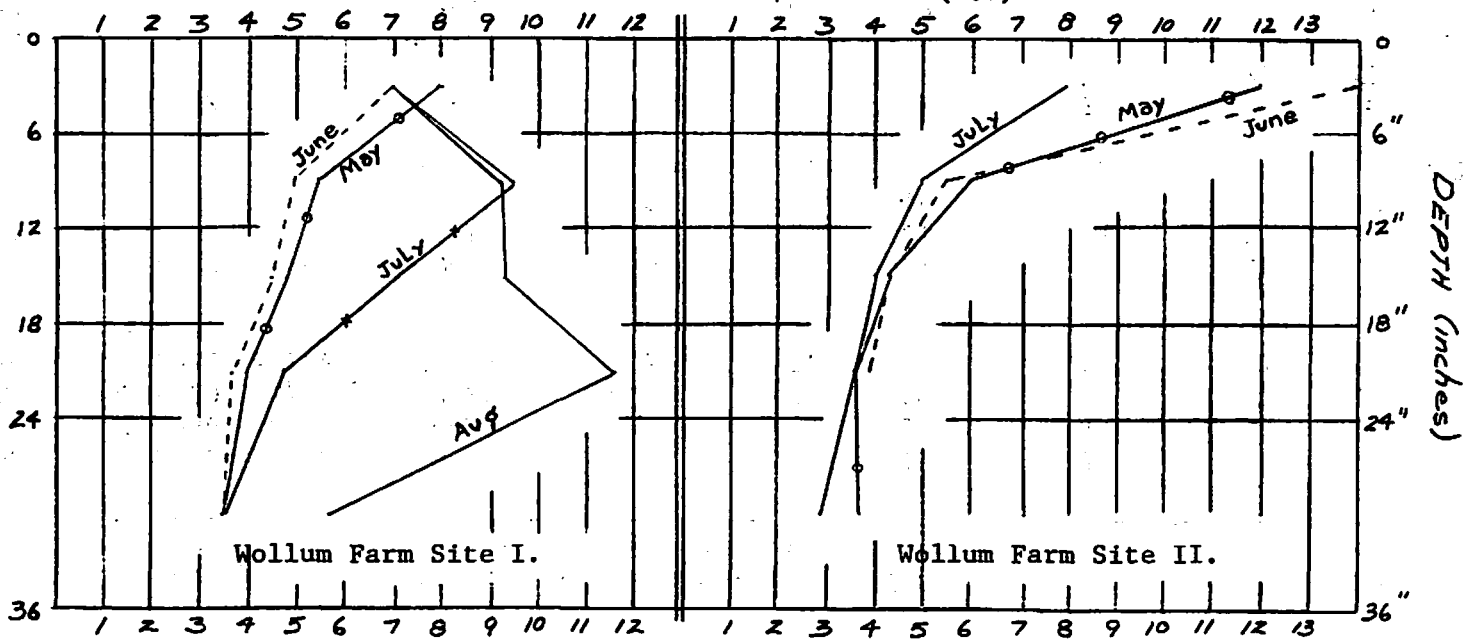



Figure B.

## General Summary

As was reported last year, 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 a combination of both. This years data showed that in general high soluble salts was the main factor in western Minnesota.

Corn, oats and potato growth appear to be affected more by high soluble salts than high carbonates. If growth was affected by carbonates, it was probably a fertility problem induced by carbonates through a lowering of solubilities and therefore availability.

Considering all of the data from the flax sites, there appears to be very little difference in the level of soluble salts or carbonates between the lesser chlorotic and the chlorotic sites. Apparently the plants, chlorotic or not, are under a critical level of stress from high levels of soluble salts. Under such conditions a small change in some environmental factor (temperature or moisture) or some chemical factor could result in the development of, or recovery from, chlorosis. It is recognized that temperature, through its effect on the physiology of the plant, and soil moisture may determine whether or not a plant develops chlorosis at a given soluble salt or carbonate level.

It is to be remembered that the conductivities, a reflection of soluble salt concentration, reported here are what they were at sampling time. Higher or lower levels may have existed prior to sampling and the physical appearance of the crop at the time of sampling may or may not be a reflection of an earlier circumstance.

The majority of the soils sampled are classified as poorly drained solonchalk soils developed on calcareous glacial till, or fine textured lacustrine sediments.

## Soil Residue Studies

S. E. Nelson & R. S. Adams, Jr.

The soil residue plots initiated at Waseca in 1965 were continued in 1966 and expanded to Lamberton and Morris. In these plots atrazine was incorporated prior to planting to simulate residue conditions. The data is summarized in Table 1.

Oat stands at Lamberton and Morris were reduced by approximately 50% by 1/2 lb/A of "residual" atrazine. At Waseca 1 lb/A of "residual" atrazine was required to bring about similar stand reductions. The average stand reduction by 1/2 lb/A atrazine at the three locations was 42%; but produced no significant yield reduction. At Lamberton and Morris the 1 lb/A rate of atrazine reduced stand by approximately 70% but yields by only 10% at Morris and somewhat greater at Lamberton. At all locations 1 1/2 lb/A "residual" atrazine reduced stands by about 75% with a resulting reduction of greater than 50% in oat yield. These results were similar to those obtained at Waseca in 1965, indicating that considerable injury to the oat seedlings by residual atrazine may be overcome. The oats in the treated plots generally stooled better and bore a stiffer straw and plumper berry, with well filled heads.

Up to 1 lb/A of "residual" atrazine did not affect soybean yields adversely. At the 1 lb/A rate stand counts were reduced, on the average, by 10%, but yields were increased by 9%. The increase in yield was attributed to some weed control by the "residual" atrazine. This was particularly apparent at Morris where heavy weed infestation occurred. With the 1 lb/A application of atrazine severe necrosis and leaf drop occurred early in the season. By the end of the season no effects of the atrazine on the soybeans could be visually observed.

A new field study was started in 1966, as a result of some growth chamber work indicating a favorable interaction between "residual" atrazine and amiben or trifluralin. In these plots atrazine was incorporated at rates of 0, 1/4, 1/2 and 1 lb/A across other plots treated with no chemical, linuron, CDAA, amiben or trifluralin. The latter chemicals were applied at customary field rates (linuron, 2 1/2 lb/A; CDAA, 5 lb/A; amiben 3 lb/A; and trifluralin, 1 lb/A). The experiment was replicated four times giving a 4 x 4 x 5 experiment. The soybeans were cultivated as needed. Data is summarized in Table 2.

During the summer and at harvest the soybeans in the plots treated with 1 lb/A of atrazine and linuron or amiben appeared to be retarded in growth at all three locations. Early in the season necrosis and leaf drop was most severe in these plots. A slightly greater reduction in stand occurred in these plots than with 1 lb/A atrazine alone. However, effects of yield were not as pronounced. Only at Morris was the yield significantly reduced by the combination of 1 lb/A atrazine and linuron as compared to the linuron treatment alone.

Weed infestations were severe at Morris, even though the soybeans were cultivated, considerable increase in yield was realized by the addition of weed control chemicals to the plots. The reduction in yield by the combination of 1 lb/A atrazine and linuron (compared to linuron alone) was not due to weed infestation as weed control was good in all linuron treated plots.

Table 1. Stand and yield of oats and soybeans when atrazine was incorporated at three locations. Averages of 4 replications.

| Atrazine Treatment lbs/A | Lamberton Stand Count % Control | Lamberton Yield Bu/A | Morris Stand Count % Control | Morris Yield Bu/A | Waseca Stand Count % Control | Waseca Yield Bu/A |
|---|---|---|---|---|---|---|
| | | | Oats | | | |
| 0 | 100 | 42.4 | 100 | 86.9 | 100 | 81.9 |
| 1/4 | 82 | 37.7 | 77 | 98.6 | 93 | 85.0 |
| 1/2 | 56 | 42.0 | 55 | 85.8 | 63 | 77.8 |
| 1 | 33 | 19.8 | 29 | 79.9 | 50 | 70.8 |
| 1 1/2 | 24 | 21.3 | 20 | 54.7 | 29 | 50.6 |
| | | | Soybeans | | | |
| 0 | 100 | 19.9 | 100 | 22.5 | 100 | 29.0 |
| 1/4 | 93 | 20.6 | 99 | 27.3 | 109 | 31.3 |
| 1/2 | 85 | 19.1 | 98 | 27.9 | 103 | 26.8 |
| 1 | 87 | 21.5 | 87 | 23.5 | 97 | 31.6 |

Table 2. Yield of soybeans as affected by herbicide chemical treatments at three locations. Averages of four replications.

| "Residual" atrazine | No Chemical | Linuron | CDAA | Amiben | Trifluralin |
|---|---|---|---|---|---|
| lb/A | Bu/A | | | | |
| | | Lamberton | | | |
| 0 | 19.9 | 19.0 | 22.8 | 23.0 | 21.4 |
| 1/4 | 20.6 | 21.4 | 21.5 | 22.1 | 19.8 |
| 1/2 | 19.1 | 20.5 | 24.6 | 23.3 | 22.0 |
| 1 | 21.5 | 19.4 | 22.5 | 23.8 | 22.1 |
| | | Morris | | | |
| 0 | 22.5 | 35.6 | 29.9 | 32.4 | 34.6 |
| 1/4 | 27.3 | 35.4 | 33.8 | 35.0 | 36.5 |
| 1/2 | 27.9 | 34.8 | 30.5 | 32.3 | 35.5 |
| 1 | 23.5 | 25.1 | 33.3 | 32.6 | 33.1 |
| | | Waseca | | | |
| 0 | 29.0 | 32.6 | 29.2 | 32.3 | 28.9 |
| 1/4 | 27.5 | 31.9 | 26.8 | 27.7 | 27.7 |
| 1/2 | 26.8 | 28.3 | 29.8 | 29.0 | 31.2 |
| 1 | 27.9 | 29.8 | 27.8 | 28.2 | 27.5 |

# LIME PLOTS, LAMBERTON 1966

J. GRAVA, W.W. NELSON AND G.W. RANDALL

A field experiment was established in the fall of 1965 to study the effects of liming on crop yields, chemical composition of plants and chemical properties of soil. The crops grown are a) alfalfa, and b) corn and soybeans in a sequence. Dolomitic lime (89.1% C.C.E., 96.4% passing 8-Mesh Sieve, 42.3% passing 60-Mesh Sieve) was applied in the fall of 1965. The rates used were as follows: 0,3 and 6 tons per acre. The treatments were replicated five times. The plots are 20 feet wide and 40 feet long. A row width 30 inches is used on the corn-soybean plots.

Soil samples were collected from the plot area during August, 1965. The surface ph values ranged from 5.3 to 6.0 on alfalfa area (Series 4) and 6.0 to 6.3 on corn-soybean area (Series 5).

Table 1 shows ph values of two sampling areas.

Table 1. ph values of surface and subsoil, Lamberton lime plots, August 1965.

| Depth of sampling, inches | Hole 4 Series 4 | Hole 21 Series 5 |
|---|---|---|
| | pH | pH |
| 0-6 | 5.3 | 6.0 |
| 6-12 | 5.6 | 6.4 |
| 12-18 | 6.0 | 7.6 |
| 18-24 | 6.7 | 7.6 |
| 24-30 | 7.4 | 8.2 |

Alfalfa was seeded with oats as a companion crop. Table 2 shows yields of oats obtained in 1966.

Table 2. Yield of oats, Lamberton lime plots, 1966.

| Rate of Lime to /acre | Yield of Oats, Bu./acre |
|---|---|
| 0 | 100 |
| 3 | 103 |
| 6 | 101 |

Statistical evaluation of yield data showed that these differences were nonsignificant.

The yields and moisture content of corn obtained in 1966 are presented in table 3.

Table 3. Yield and moisture content of corn, Lamberton lime plots, 1966.

| Rate of Lime to. /acre | Corn Yield bu./acre | Moisture % |
|---|---|---|
| 0 | 63 | 35.2 |
| 3 | 80 | 35.2 |
| 6 | 68 | 34.9 |
| C.V. (coefficient of variability) | 23 | 5.0 |

Statistical evaluation of corn yield data indicated that these differences were nonsignificant because of extreme variability in plots.

Planting Date: May 2, Herbicide: Ramrod at recommended rate; all corn plots received 83+48+24 LB./A of plant nutrients, expressed as N, $P_2O_5$ and $K_2O$.

Chemical composition of sixth corn leaf is shown in table 4.

Table 4. Chemical composition of sixth corn leaf at silking. Lamberton lime plots-1966.

| Lime treatment tons/acre | P | K | Ca | Mg | B | Cu | Zn | Mn | Mo | Al | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | -----Percent------- | | | | ----------Parts per million---------- | | | | | | |
| 0 | .28 | 1.31 | .78 | .43 | 8 | 5 | 25 | 38 | 1.72 | 90 | 81 |
| 3 | .26 | 1.22 | .76 | .48 | 8 | 5 | 23 | 34 | 2.04 | 82 | 80 |
| 6 | .30 | 1.37 | .76 | .47 | 7 | 5 | 24 | 33 | 1.82 | 87 | 90 |

# Soil Productivity Study

R. H. Rust, E. R. Gross

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 593 farm cooperators have furnished crop and soil management data on some 99 extensive soil types in the state. Currently 245 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 sufficient 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 by farmers who are in general using above average management. The standard deviations of the yield figures have been included in most instances to give some idea of the range in yields obtained. Many of the yields reflect 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
C-2 = 6-12 percent slopes, one-third to two thirds of surface eroded
D-2 = 12-18 percent slopes, one-third to two thirds of surface eroded

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
( ) Standard deviation of yields in parenthesis

| | | |
|---|---|---|
| Aastad | (11)* | (57)** |
| Corn | 18 | 51 (21) |
| Flax | 6 | 12 (6) |
| Oats | 8 | 62 (23) |
| Spring wheat | 4 | 23 (18) |
| Barley | 4 | 48 (5) |
| Alfalfa-brome-past. | 4 | 139 (21) |
| Soybeans | 3 | 24 (5) |
| Hay (other) | 4 | 4.3 |
| Pasture (other) | 4 | 196 (5) |
| Anoka | (1)* | (1)** |
| Antigo | (3) | (11) |
| Corn silage | 4 | 12.5 (7.1) |
| Hay (other) | 2 | 1.4 |
| Corn | 3 | 61 (9) |
| Barnes | (16) | (104) |
| Corn | (31) | 55 (20) |
| A-1 | 5 | 68 (15) |
| B-1 | 16 | 53 (18) |
| B-2 | 7 | 54 (26) |
| C-2 | 3 | 50 (17) |
| Oats | 19 | 54 (29) |
| B-1 | 9 | 56 (33) |
| C-2 | 7 | 47 (25) |
| Flax | 9 | 9 (3) |
| Soybeans | 11 | 20 (4) |
| Alfalfa-brome | 12 | 2.2 |
| B-1 | 9 | 56 (33) |
| C-2 | 7 | 47 (25) |
| Barley | 4 | 35 (11) |
| Alfalfa | 5 | 1.9 |
| Spring wheat | 6 | 28 (13) |
| Corn silage | 4 | 5.8 (5.6) |
| Bearden | (9) | (32) |
| Corn | 4 | 52 (20) |
| Barley | 4 | 52 (10) |
| Spring wheat | 4 | 39 (1) |
| Sugar beets | 4 | 9.5 (5.7) |
| Oats | 2 | 58 (11) |
| Soybeans | 3 | 20 (0) |
| Beltrami | (4) | (20) |
| Oats | 4 | 74 (29) |
| Alfalfa | 8 | 2.2 |
| Corn | 2 | 66 (11) |
| Blue Earth | (3) | (15) |
| Corn silage | 3 | 8.1 (2.5) |
| Corn | 6 | 54 (31) |
| Alfalfa-brome | 2 | 3.0 |
| Borup | (1) | (2) |
| Braham | (4) | (4) |
| Brainerd | (5) | (20) |
| Oats | 4 | 43 (25) |
| Corn | 4 | 57 (20) |
| Corn silage | 2 | 6.5 (9.1) |
| Alfalfa | 3 | 3.6 |
| Brickton | (4) | (4) |
| Alfalfa-brome | 2 | 3.1 |
| Buse-Barnes | (2) | (11) |
| Alfalfa-brome | 3 | 1.2 |
| Flax | 4 | 11 (3) |
| Soybeans | 3 | 15 (4) |
| Canisteo | (8) | (43) |
| Corn | 16 | 87 (33) |
| Oats | 4 | 81 (17) |
| Soybeans | 8 | 31 (3) |
| Alfalfa | 6 | 3.1 |
| Chetek | (1) | (3) |
| Alfalfa-brome | 2 | 1.9 |
| Chilgren | (5) | (43) |
| Oats | 9 | 35 (27) |
| Barley | 3 | 46 (17) |
| Flax | 2 | 3 (4) |
| Apring wheat | 4 | 27 (23) |
| Alfalfa | 4 | 2.5 |
| Alfalfa-tim. | 3 | 2.7 |
| Hay (other) | 3 | 2.4 |
| Corn silage | 3 | 9.3 (6.6) |
| Pasture (other) | 2 | 243 |
| Clarion | (37) | (159) |
| Corn | 55 | 73 (21) |
| B-1 | 41 | 75 (23) |
| B-2 | 8 | 75 (10) |
| C-2 | 5 | 65 (11) |
| Oats | 28 | 69 (22) |
| B-1 | 22 | 69 (24) |
| B-2 | 4 | 72 (8) |
| C-2 | 2 | 55 (21) |

| | | |
|---|---|---|
| Soybeans | 14 | 27 (10) |
| Spring wheat | 9 | 35 (15) |
| Alfalfa-brome | 12 | 2.9 |
| Alfalfa | 14 | 3.0 |
| Mix. Leg. grass | 5 | 4.8 |
| Corn silage | 3 | 11.5 (1.3) |
| Alfalfa-brome-past | 6 | 246 (3) |
| **Colvin** | (6) | (16) |
| Alfalfa | 4 | 3.4 |
| Corn | 6 | 71 (23) |
| **Comfrey** | (1) | (12) |
| Sorghum | 5 | 8.6 (5.6) |
| Corn | 2 | 60 (5.9) |
| **Cordova** | | |
| Corn | 3 | 79 (31) |
| Oats | 2 | 64 (7) |
| Alfalfa | 3 | 3 (38) |
| **Cormant** | (4) | (19) |
| Oats | 5 | 30 (12) |
| Alfalfa-brome | 4 | 4.0 |
| **Downs** | (3) | (18) |
| Corn (B-1) | 6 | 105 (22) |
| Oats | 2 | 71 (21) |
| Alfalfa | 3 | 3.4 |
| **Dubuque** | (4) | (6) |
| **Enstrom** | (1) | (4) |
| Alfalfa-brome | 2 | 1.5 |
| **Estelline** | (1) | (8) |
| **Esterville** | (17) | (76) |
| Corn | 22 | 61 (25) |
| A-1 | 18 | 63 (25) |
| B-2 | 6 | 51 (20) |
| Oats | 15 | 41 (23) |
| A-1 | 11 | 35 (23) |
| B-2 | 3 | 50 (19) |
| Alfalfa-brome | 11 | 2.2 |
| Alfalfa | 8 | 2.9 |
| Corn silage | 6 | 7.1 (2.9) |
| Soybeans | 3 | 10 |
| **Fairhaven** | (9) | (22) |
| Corn | 8 | 60 (17) |
| Oats | 4 | 63 (12) |
| Alfalfa | 2 | 3.7 |
| **Fargo** | (23) | (93) |
| Spring wheat | 18 | 34 (11) |
| Oats | 11 | 45 (27) |
| Soybeans | 3 | 22 (9) |
| Flax | 7 | 13 (4) |
| Barley | 8 | 30 (13) |
| Alfalfa-brome | 5 | 1.5 |
| Alfalfa | 2 | 3.0 |
| Sugar beets | 10 | 8.2 (6.5) |
| Durum wheat | 4 | 42 (11) |
| **Fayette** | (7) | (38) |
| Corn | 16 | 92 (25) |
| B-1 | 2 | 83 (4) |
| B-2 | 8 | 95 (26) |
| C-2 | 6 | 90 (29) |
| Oats | 7 | 71 (28) |
| Alfalfa-brome | 5 | 4.4 |
| Alfalfa | 3 | 3.7 |
| **Flom** | (8) | (40) |
| Corn | 13 | 71 (27) |
| Oats | 6 | 55 (22) |
| Soybeans | 3 | 17 (15) |
| Flax | 6 | 17 (8) |
| Corn silage | 2 | 14.5 (3.5) |
| **Floyd** | (5) | (28) |
| Corn | 12 | 82 (18) |
| Soybeans | 8 | 24 (7) |
| Oats | 3 | 86 (23) |
| **Fossum** | (2) | (4) |
| Barley | 2 | 49 (2) |
| **Foxhome** | (1) | (5) |
| **Freer** | (3) | (14) |
| Oats | 3 | 54 (14) |
| R.-Cl.-tim. | 2 | 2.0 |
| **Freon** | (6) | (11) |
| Oats | 5 | 53 (25) |
| **Grimstad** | (7) | (36) |
| Barley | 8 | 35 (16) |
| Flax | 3 | 10 (5) |
| Soybeans | 4 | 15 (0) |
| Spring wheat | 9 | 31 (7) |
| Oats | 3 | 74 (12) |
| **Grygla** | (3) | (20) |
| Oats | 4 | 38 (10) |
| Pasture (mix) | 5 | 72 |
| Alsike-tim. | 2 | 1.1 |

| | | |
|---|---|---|
| Hamerly | (1) | (4) |
| Flax | 2 | 15 (3) |
| Harpster | (1) | (2) |
| Oats | 2 | 34 (12) |
| Hayden | (24) | (104) |
| Corn | 29 | 84 (27) |
| B-1 | 11 | 84 (34) |
| B-2 | 4 | 104 (16) |
| C-2 | 10 | 82 (26) |
| D-2 | 2 | 86 (20) |
| D-3 | 2 | 73 (22) |
| Oats | 14 | 53 (11) |
| Alfalfa | 27 | 3.0 |
| B-1 | 8 | 2.8 |
| C-1 | 3 | 2.8 |
| C-2 | 8 | 3.6 |
| Alfalfa-brome | 15 | 3.3 |
| B-1 | 5 | 3.5 |
| B-2 | 3 | 3.1 |
| C-2 | 5 | 3.6 |
| Alfalfa-brome-past | 10 | 306 (29) |
| Hegne | (7) | (22) |
| Spring wheat | 6 | 35 (5) |
| Barley | 4 | 51 (15) |
| Alfalfa | 2 | 1.2 |
| Potatoes | 2 | 313 (96) |
| Hibbing | (4) | (6) |
| Alfalfa | 2 | 3.0 |
| Holdingford | (1) | (2) |
| Hubbard | (14) | (85) |
| Corn | 34 | 58 (29) |
| A-1 | 29 | 64 (30) |
| B-2 | 2 | 41 (15) |
| Soybeans | 12 | 19 (6) |
| Oats | 9 | 44 (15) |
| Potatoes (irrig) | 5 | 373 (78) |
| Alfalfa | 6 | 2.4 |
| Alfalfa-brome | 6 | 2 |
| Corn silage | 6 | 10.4 (5.8 |
| Kasson | (2) | (12) |
| Oats | 2 | 65 (21) |
| Corn | 3 | 71 (19) |
| Kato | (1) | (6) |
| Corn | 2 | 71 (21) |

| | | |
|---|---|---|
| Kenyon | (2) | (11) |
| Corn | 4 | 81 (7) |
| Hay (other) | 2 | 3.5 |
| Alfalfa | 2 | 2.7 |
| Oats | 2 | 66 (22) |
| Kingston | (3) | (18) |
| Corn | 10 | 80 (32) |
| Soybeans | 5 | 23 (11) |
| Kingston, variant | (11) | (3) |
| Oats | 2 | 26 |
| Kittson | (2) | (10) |
| Corn silage | 2 | 4.9 (1.9) |
| Alfalfa | 3 | 4.4 |
| Kranzberg | (2) | (15) |
| Alfalfa-brome | 3 | 2.2 |
| Alfalfa | 2 | 2.2 |
| Corn | 4 | 57 (13) |
| Flax | 5 | 12 (5) |
| Lamoure | (2) | (9) |
| Corn | 4 | 55 (7) |
| Soybeans | 3 | 32 |
| Sweet corn | 3 | 7.0 |
| Alfalfa-brome | 2 | 3.9 |
| Lerdal | (1) | (7) |
| Corn | 4 | 81 (4) |
| Lester | (12) | (54) |
| Alfalfa | 14 | 3.6 |
| B-1 | 4 | 3.3 |
| B-2 | 5 | 4.2 |
| C-2 | 5 | 3.2 |
| Corn | 14 | 70 (16) |
| A-1 | 2 | 87 (9) |
| B-1 | 3 | 56 (16) |
| B-2 | 3 | 64 (7) |
| C-2 | 8 | 67 (19) |
| Oats | 9 | 50 (23) |
| B-2 | 4 | 40 (28) |
| C-2 | 3 | 56 (6) |
| Alfalfa-brome | 8 | 3.3 |
| LeSueur | (9) | (45) |
| Corn | 23 | 71 (32) |
| A-1 | 12 | 67 (13) |
| A-2 | 4 | 37 (26) |
| B-1 | 7 | 97 (14) |
| Soybeans | 10 | 20 (10) |
| Oats | 1 | 25 |
| Barley | 2 | 49 (10) |

| | | |
|---|---|---|
| Litchfield | (2) | (20) |
| Corn | 4 | 84 (13) |
| Soybeans | 1 | 26 (0) |
| Oats | 3 | 72 (24) |
| Potatoes (irrig) | 1 | 240 (0) cwt |
| Alfalfa | 6 | 3.3 |
| Maddock | (4) | (6) |
| Marcus | (1) | (1) |
| Marna | (6) | (23) |
| Corn | 14 | 89 (24) |
| Soybeans | 3 | 34 (6) |
| Alfalfa | 2 | 5.1 |
| Mavie | (2) | (3) |
| McDonaldsville | (1) | (3) |
| McIntosh | (3) | (20) |
| Corn | 2 | 69 (0) |
| Oats | 5 | 62 (10) |
| Spring wheat | 7 | 33 (8) |
| Barley | 4 | 71 (26) |
| Alfalfa | 1 | 3.5 |
| Alfalfa-brome | | |
| A-1 | 5 | 1.3 |
| B-1 | 3 | 1.6 |
| C-1 | 3 | 3.6 |
| Menahga | (6) | (30) |
| Oats | 5 | 29 (20) |
| Alfalfa-brome | 10 | 2.1 |
| Corn silage | 4 | 7.6 (2.5) |
| Pasture (alfalfa brome) | 5 | 107 (1) |
| Milaca | (8) | (32) |
| Oats | 4 | 31 (19) |
| Corn | 5 | 60 (16) |
| Hay (other) | 5 | 2.2 |
| Mix. leg.-grass | 3 | 1.8 |
| Corn silage | 4 | 10.2 (3.8) |
| Alfalfa | 2 | 3.4 |
| Alfalfa-brome | 3 | 2.8 |
| Moody | (2) | (6) |
| Corn | 4 | 70 (19) |
| Mora | (4) | (21) |
| Corn | 6 | 57 (34) |
| Oats | 4 | 49 (37) |
| Mix. leg.-grass | 1 | 3.2 |
| Corn silage | 3 | 8.3 (3.6) |

| | | |
|---|---|---|
| Nebish | (7) | (47) |
| Oats | 10 | 47 (21) |
| Alfalfa | 8 | 1.9 |
| A-1 | 3 | 2.3 |
| B-1 | 5 | 1.7 |
| Alfalfa-brome | 12 | 3.5 |
| B-1 | 5 | 3.0 |
| C-1 | 6 | 3.5 |
| Alfalfa-brome-past) | 8 | 78 (36) |
| A-1 | 5 | 71 (41) |
| B-1 | 3 | 90 (30) |
| Nicollet | (21) | (118) |
| Corn | 52 | 74 (30) |
| A-1 | 43 | 77 (32) |
| B-1 | 9 | 72 (25) |
| Oats | 14 | 58 (19) |
| A-1 | 11 | 61 (20) |
| B-1 | 3 | 47 (13) |
| Soybeans | 16 | 28 (8) |
| Spring wheat | 4 | 40 (11) |
| Alfalfa | 13 | 3.8 |
| Alfalfa brome | 5 | 3.9 |
| Corn silage | 5 | 11.9 (6.9) |
| Nokay | (5) | (18) |
| Corn | 6 | 53 (19) |
| Oats | 5 | 42 (24) |
| Corn silage | 6 | 5.5 (2.8) |
| Nymore | (3) | (4) |
| Alfalfa | 2 | 1.8 |
| Onamia | (5) | (21) |
| Corn | 6 | 70 (11) |
| Oats | 4 | 64 (5) |
| Alfalfa | 3 | 4.1 |
| Alfalfa-brome | 2 | 1.8 |
| Pasture (brome) | 2 | 200 (70) |
| Ostrander | (7) | (25) |
| Corn | 9 | 85 (32) |
| Soybeans | 4 | 25 (2) |
| Alfalfa | 4 | 3.8 |
| Parent | (1) | (1) |
| Parnell | (2) | (11) |
| Corn | 6 | 52 (25) |
| Oats | 3 | 76 (9) |

| | | |
|---|---|---|
| Deep Peat | (6) | (34) |
| Corn | 5 | 57 (34) |
| Soybeans | 4 | 25 (2) |
| Timothy (seed) | 3 | 333 (24) |
| Corn silage | 3 | 9.6 (4.7) |
| Pasture (other) | 7 | 118 (41) |
| Leg.-grass past. | 2 | 242 (43) |
| Shallow Peat | (5) | (9) |
| Soybeans | 3 | 24 (7) |
| Barley | 3 | 56 (7) |
| Corn | 2 | 93 (2) |
| Racine | (1) | (1) |
| Redby | (3) | (18) |
| Oats | 3 | 58 (6) |
| Leg.-grass hay | 3 | 4 |
| Leg.-grass past | 4 | 82 (52) |
| RCl-tim hay | 3 | 2.3 |
| Rocksbury | (12) | (45) |
| Oats | 12 | 41 (28) |
| Flax | 7 | 5 (5) |
| Alfalfa | 1 | 4.1 |
| Hay (other) | 3 | 1.8 |
| Pasture (other) | 2 | 109 (1) |
| wheat | 5 | 23 (11) |
| Rockwell | (5) | (17) |
| Oats | 3 | 52 (22) |
| Barley | 3 | 27 (11) |
| Wheat | 2 | 28 (2) |
| Alfalfa | 2 | 1.6 |
| Corn silage | 2 | 12.9 (12) |
| Sioux | (4) | (16) |
| Oats | 7 | 32 (21) |
| Soybeans | 2 | 11 (4) |
| Alfalfa | 2 | 0.8 |
| Shooks | (2) | (12) |
| Oats | 4 | 47 (15) |
| Alfalfa | 2 | 2.0 |
| Skyberg | (3) | (14) |
| Corn | 5 | 85 (20) |
| Oats | 3 | 87 (10) |
| Leg.-grass past. | 2 | 153 (37) |
| Sletton | (1) | (5) |
| Soybeans | 2 | 30 (0) |
| Storden-Clarion | (1) | (7) |
| Oats | 2 | 80 (11) |
| Alfalfa | 5 | 2.9 |
| Tama | (8) | (50) |
| Oats | 14 | 70 (20) |
| A-1 | 3 | 83 (32) |
| B-1 | 4 | 63 (6) |
| B-2 | 3 | 60 (8) |
| C-2 | 4 | 76 (26) |
| Corn | 14 | 86 (24) |
| A-1 | 4 | 80 (14) |
| B-1 | 6 | 98 (17) |
| B-2 | 2 | 106 (4) |
| C-2 | 2 | 43 (0) |
| Corn silage | 2 | 14.2 (3.1) |
| Alfalfa | 5 | 4.3 |
| Alfalfa-brome | 4 | 4.2 |
| Leg.-grass hay | 4 | 3.3 |
| Alfalfa-brome past | 3 | 177 (40) |
| Taylor | (1) | (5) |
| Oats | 3 | 46 (12) |
| Alfalfa | 1 | 1.5 |
| Terrill | (1) | (3) |
| Todd | (2) | (12) |
| Alfalfa-brome | 4 | 2.1 |
| Corn silage | 3 | 7.0 (1.7) |
| Oats | 4 | 32 (11) |
| Truman | (3) | (10) |
| Corn | 5 | 86 (19) |
| Soybean | 2 | 27 (13) |
| Ulen | (4) | (35) |
| Corn | 6 | 51 (19) |
| Oats | 10 | 53 (17) |
| Corn silage | 2 | 15.5 (3.5) |
| Alfalfa | 2 | 2.6 |
| Vallers | (3) | (20) |
| Corn | 5 | 55 (17) |
| Soybeans | 6 | 21 |
| Varco | (1) | (8) |
| Corn | 6 | 80 (17) |
| Alfalfa-brome | 2 | 2.7 |
| Vienna | (2) | (7) |
| Corn | 3 | 63 (28) |
| Oats | 2 | 60 (13) |
| Wabash | (1) | (6) |
| Corn | 3 | 109 (14) |
| Wadena | (4) | (21) |
| Corn | 8 | 73 (30) |
| Oats | 3 | 79 (9) |
| Soybean | 3 | 23 (7) |

| | | |
|---|---|---|
| Waukegan | | |
| Corn A-1 | 17 | 75 (17) |
| Oats | 9 | 81 (14) |
| Soybeans | 3 | 30 (5) |
| Alfalfa | 3 | 1.8 |
| Alfalfa-brome | 3 | 3.5 |
| Waukon | (10) | (47) |
| Corn | 10 | 68 (19) |
| Oats | 7 | 60 (21) |
| Barley | 4 | 40 (21) |
| Spring wheat | 4 | 26 (11) |
| Alfalfa | 9 | 2.1 |
| Mix. leg.-grass | 3 | 4.1 |
| Webster | (39) | (167) |
| Corn | 71 | 76 (25) |
| Oats | 27 | 61 (17) |
| Soybeans | 24 | 22 (7) |
| Alfalfa | 14 | 4.0 |
| Alfalfa-brome | 8 | 2.8 |
| Corn silage | 7 | 11.6 (4.8) |
| Mix.-Leg-grass | 2 | 2.2 |
| Wildwood | (2) | (11) |
| Oats | 2 | 32 (14) |
| Barley | 2 | 32 (14) |
| S. wheat | 2 | 16 (5) |
| Winger | (4) | (31) |
| Oats | 8 | 77 (18) |
| Barley | 5 | 47 (14) |
| Spring wheat | 3 | 34 (20) |
| Alfalfa | 3 | 1.6 |
| Zimmerman | (3) | (19) |
| Corn | 3 | 62 (15) |
| Oats | 2 | 56 (20) |
| Corn silage | 4 | 9.7 (3.8) |

Grand total as of December 1966-

| No. Fields | No. Yields |
|---|---|
| 545 | 2473 |

Soil and Crop Management Systems
West Central Experiment Station
Roy L. Thompson and Samuel D. Evans

This experiment was reviewed and a revised plan was prepared for the 1966 cropping season. For the 1960-65 treatments and yields see the February, 1965 and 1966 Blue Books. The 1966 treatments and yields are as follows:

| Continuous Soybeans | Base | Test |
|---|---|---|
| Seeding rate | 60-70 lbs/acre | 70-120 lbs/acre |
| Row width | 38 inches | 6 inches |
| Weed control | 3 cultivations | Treflan @ 1 lb/A |
| Fertilizer | None | 0+45+45 + 10 Zinc |
| Variety | Chippewa | Chippewa |
| Planting date | May 20 | May 16 |
| YIELD | 29.44 Bu/A | 32.11 Bu/A |
| **Continuous Corn** | | |
| Population, plants/acre | 14,000 - 16,000 | 25,000 - 28,000 |
| Row width | 38 inches | 19 inches |
| Insecticide | None | Diazinon |
| Fertilizer | 46+26+13 Broadcast | 200+100+100 + 15 Zinc Broadcast and 3+12+12 with seed |
| Weed control | 3 cultivations | Atrazine @ 4 lbs/acre |
| Variety | UH127 | UH127 |
| Planting date | May 19 | May 3 |
| YIELD | 61.52 Bu/A | 46.43 Bu/A |
| **Continuous Alfalfa** | | |
| Variety | Vernal | Vernal |
| Seeding rate | 12 lbs/A | 12 lbs/A |
| Fertilizer | 0+46+0 | 0+90+90 |
| YIELD | No yields in 1966 - new stand | |

Soil and Crop Management Systems
(continued)

| Rotation (oats, seeded down) | Base | Test |
|---|---|---|
| Variety | Lodi & Vernal | Lodi & Vernal |
| Seeding rates | 3 Bu + 12 lbs. | 3 Bu + 12 lbs. |
| Fertilizer | None | 60+90+90 |
| Oat Yields | 55.42 Bu/A | 73.56 Bu/A |

This experiment was hurt severly by the dry weather in July, 1966. This was particularly true in the test plots of continuous corn. These plots started tasseling about July 13 when the soil was very dry and the plants were wilting and no substantial rain fell until July 26. No changes are planned for the 1967 season.

# Continuous Corn Silage Experiment
West Central Experiment Station
Samuel D. Evans

In 1965 an experiment was initiated on McIntosh silt loam to determine the effect of removal of continuous corn silage and fertilizer application on corn grain and corn silage yields. Rates of fertilizer used were 74+48+48 and 148+96+96. All plots received a broadcast application of 10 lbs of zinc as zinc sulfate in the fall of 1965.

Silage Yields
Dry Matter, tons/acre

On plots harvested as grain in 1965 & 1966:

Low fertility (74+48+48) - 6.26

High fertility (148+96+96) - 6.50

On plots harvested as silage in 1965 & 1966:

Low fertility (74+48+48) - 6.24

High fertility (148+96+96) - 6.33

Grain Yields
Bushels/acre @ 15.5% Moisture

On plots harvested as grain in 1965 & 1966:

Low fertility (74+48+48) - 115.12

High fertility (148+96+96) - 115.03

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

Grain (0+0+0) - 79.01 Bu/acre

Silage (0+0+0) - 5.26 tons/acre

Summary -

Two years of continuous corn silage caused no reduction in silage yields. Additional fertilizer above the 74+48+48 did not increase grain or silage yields.

Continuous Corn - High Fertility Experiment
Rosemount Experiment Station
Established - 1953
W. P. Martin, P. M. Burson, and G. W. Randall

Yield results 1966 (For experimental design and past years results see p. 47 in the mimeographed "Bluebook", Feb. 1963; p. 67, Jan. 1964; p. 33, Feb. 1965 and p. 54, Feb. 1966.)

| | Fertilizer Treatments* | 1966 Yield Bu/acre | | 14 yr. Ave. Yield Bu/acre | |
|---|---|---|---|---|---|
| | | 16,500 plants | 19,500 plants | 16,500 plants | 19,500 plants |
| 1 | Check | 114.5 | 106.5 | 79.8 | 87.6 |
| 2 | 20+40+40 | 109.5 | 106.5 | 86.4 | 97.7 |
| 3 | 100+40+40 | 129.0 | 118.5 | 89.8 | 101.0 |
| 4 | 180+40+40 | 114.5 | 123.2 | 93.0 | 104.7 |
| 5 | 36+88+136 | 106.0 | 108.8 | 87.0 | 98.3 |
| 6 | 116+88+136 | 120.8 | 118.8 | 94.0 | 104.9 |
| 7 | 196+88+136 | 117.8 | 120.2 | 94.0 | 104.8 |
| 8 | 52+136+232 | 108.2 | 112.5 | 89.8 | 102.4 |
| 9 | 132+136+232 | 115.8 | 118.8 | 96.6 | 106.2 |
| 10 | 212+136+232 | 116.0 | 121.8 | 96.8 | 106.8 |

* Pounds of $N+P_2O_5+K_2O$ applied this year. These rates have been upgraded throughout the years, although the ratios have remained approximately the same.

The 1966 corn yields were generally quite good. Yields from the check treatment were very high and far above average for both populations. Small yield responses can be seen due to nitrogen fertilizer. The 14 year averages are also presented. These averages show the higher population to produce greater yields than the lighter population. Again, a small response to nitrogen fertilizer is shown.

# Fertilizer Rotation Study at Waseca in 1966

Southern Minnesota School & Experiment Station
A. C. Caldwell, John Thompson and G. W. Randall

An NPK factorial experiment involving the three major fertilizer nutrient elements alone and in all combinations applied across a five-year rotation and continuous corn has been conducted at Waseca eleven years. The cropping sequence in the rotation is corn, corn, soybeans, oats, alfalfa, and continuous corn not in rotation.

## Corn

First year corn yields at Waseca ranged from 104.7 to 128.7 bushels per acre. The fertilizer treatments did not produce any significant yield effects although potassium showed an 8 bushel increase.

Second year corn yields varied from 96.5 to 119.2 bushels per acre and were somewhat lower than the first year yields. Again no significant treatment effects were evident.

The continuous corn yields ranged from 62.2 to 115.1 bushels per acre. Nitrogen treatments caused significant yield increases amounting to 41 bushels per acre. The phosphate and potash treatments did not show any effect on the continuous corn yield.

## Alfalfa

Total yields taken from three cuttings of alfalfa ranged from 3.23 to 4.36 tons per acre. Significant increases in yield occurred with phosphate and potash, with a significant decrease following nitrogen fertilization.

## Oats

The oats yields, which were quite high, did not show any significant response to the fertilizer treatments. Most treatments decreased yield in comparison to the check treatment. A positive PK interaction of 10.1 bushels was found.

## Soybeans

Excellent soybean yields were obtained during 1966. These ranged from 35.6 to 43.0 bushels per acre. Individual N, P, and K treatments resulted in decreased yields while the NPK treatment produced the largest increase over the check treatment yield. Again, a significant PK interaction of 3.0 bushels was found.

The following tables contain only the 1966 yields.

Table 1. Yield of first year corn

| Treatment | $N-P_2O_5-K_2O$ | Ave. Yield bu/a | Difference from untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 108.6a | -- | -- |
| N | 40+0+0 | 104.7a | -3.9 | +0.2 |
| P | 0+80+0 | 107.4a | -1.2 | +0.1 |
| K | 0+0+80 | 118.6a | +10.0 | +8.4 |
| NP | 40+80+0 | 110.4a | +1.8 | +3.6 |
| NK | 40+0+80 | 115.8a | +7.2 | +0.7 |
| PK | 0+80+80 | 112.8a | +4.2 | -2.1 |
| NPK | 40+80+80 | 117.5a | +8.9 | +0.2 |
| NPK+ | 80+160+160 | 128.7a | +20.1 | --- |

Table 2. Yield of second year corn

| Treatment | lbs/A $N-P_2O_5-K_2O$ | Ave. Yield bu/A | Difference from untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 103.9a | --- | --- |
| N | 80+0+0 | 107.4a | +3.5 | +3.7 |
| P | 0+80+0 | 110.7a | +6.8 | +1.5 |
| K | 0+0+80 | 96.5a | -7.4 | -6.3 |
| NP | 80+80+0 | 107.7a | +3.8 | -2.9 |
| NK | 80+0+80 | 106.3a | +2.4 | +3.5 |
| PK | 0+80+80 | 98.5a | -5.4 | -2.0 |
| NPK | 80+80+80 | 103.2a | -0.7 | +0.3 |
| NPK+ | 160+160+160 | 119.2a | +15.3 | --- |

Table 3. Yield of continuous corn

| Treatment | $N-P_2O_5-K_2O$ | Ave. Yield bu/A | Difference from untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 75.8bc | --- | --- |
| N | 160+0+0 | 104.3ab | +18.5 | +40.6** |
| P | 0+160+0 | 73.8bc | -2.0 | +5.1 |
| K | 0+0+160 | 62.2c | -13.6 | -3.0 |
| NP | 160+160+0 | 115.1a | +39.3 | +2.3 |
| NK | 160+0+160 | 110.5a | +34.7 | +5.8 |
| PK | 0+160+160 | 69.9c | -5.9 | +0.7 |
| NPK | 160+160+160 | 114.4a | +38.6 | -4.2 |
| NPK+ | 320+320+320 | 103.4ab | +27.6 | --- |

Table 4. Yield of first cutting alfalfa.

| Treatment | $N-P_2O_5-K_2O$ | Ave. Yield T/A | Difference from Untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 1.57b | --- | --- |
| N | 20+0+0 | 1.30b | -0.27 | -0.17* |
| P | 0+80+0 | 1.90a | +0.33 | +0.44** |
| K | 0+0+80 | 1.59b | +0.02 | +0.23* |
| NP | 20+80+0 | 1.51b | -0.06 | +0.06 |
| NK | 20+0+80 | 1.40b | -0.17 | +0.16* |
| PK | 0+80+80 | 2.01a | +0.44 | +0.17 |
| NPK | 20+80+80 | 2.19a | +0.62 | +0.13 |
| NPK+ | 20+160+160 | 1.43b | -0.14 | --- |

Table 5. Yield of second cutting alfalfa.

| Treatment | $N-P_2O_5-K_2O$ | Ave. Yield T/A | Difference from Untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 1.02a | --- | --- |
| N | 20+0+0 | 0.98a | -0.04 | -0.11* |
| P | 0+80+0 | 1.16a | +0.14 | +0.07 |
| K | 0+0+80 | 1.18a | +0.16 | +0.10 |
| NP | 20+80+0 | 0.98a | -0.04 | --- |
| NK | 20+0+80 | 1.01a | -0.01 | --- |
| PK | 0+80+80 | 1.19a | +0.17 | --- |
| NPK | 20+80+80 | 1.14a | +0.12 | +0.06 |
| NPK+ | 20+160+160 | 1.19a | +0.17 | --- |

Table 6. Yield of third cutting alfalfa.

| Treatment | $N-P_2O_5-K_2O$ | Ave. Yield T/A | Difference from Untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 0.90c | --- | --- |
| N | 20+0+0 | 0.96bc | +0.06 | -0.01 |
| P | 0+80+0 | 1.16a | +0.26 | +0.14** |
| K | 0+0+80 | 0.92c | +0.02 | -0.01 |
| NP | 20+80+0 | 1.06abc | +0.16 | -0.08 |
| NK | 20+0+80 | 0.99abc | +0.99 | +0.01 |
| PK | 0+80+80 | 1.11ab | +0.21 | -0.03 |
| NPK | 20+80+80 | 1.03abc | +0.13 | --- |
| NPK+ | 20+160+160 | 1.05abc | +0.15 | --- |

Table 7. Total 1966 alfalfa yield.

| Treatment | lbs/A $N-P_2O_5-K_2O$ | Ave. Yield T/A | Difference from Untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 3.49b | --- | --- |
| N | 20+0+0 | 3.23b | -0.26 | -0.29* |
| P | 0+80+0 | 4.22a | +0.73 | +0.66** |
| K | 0+0+80 | 3.69b | +0.20 | +0.31* |
| NP | 20+80+0 | 3.55b | +0.05 | -0.02 |
| NK | 20+0+80 | 3.40b | -0.09 | +0.18 |
| PK | 0+80+80 | 4.30a | +0.81 | +0.13 |
| NPK | 20+80+80 | 4.36a | +0.87 | +0.19 |
| NPK+ | 20+160+160 | 3.66b | +0.17 | --- |

Table 8. Yield of oats.

| Treatment | lbs/A $N-P_2O_5-K_2O$ | Ave. Yield bu/A | Difference from Untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 98.7a | --- | --- |
| N | 80+0+0 | 87.1a | -11.6 | -0.7 |
| P | 0+80+0 | 88.3a | -10.4 | +3.3 |
| K | 0+0+80 | 87.0a | -11.7 | +1.4 |
| NP | 80+80+0 | 83.9a | -14.8 | +7.9 |
| NK | 80+0+80 | 81.4a | -17.3 | +7.3 |
| PK | 0+80+80 | 88.2a | -10.5 | +10.1* |
| NPK | 80+80+80 | 106.9a | +8.2 | --- |
| NPK+ | 120+160+160 | 82.2a | -16.5 | --- |

Table 9. Yields of soybeans.

| Treatment | lbs/A $N-P_2O_5-K_2O$ | Ave. Yield bu/A | Difference from Untreated | Treatment Effect |
|---|---|---|---|---|
| Check | 0+0+0 | 39.1a | --- | --- |
| N | 20+0+0 | 38.2a | -0.9 | --- |
| P | 0+40+0 | 37.6a | -1.5 | +0.9 |
| K | 0+0+40 | 37.7a | -1.4 | +1.7 |
| NP | 20+40+0 | 35.6a | -3.5 | +0.8 |
| NK | 20+0+40 | 36.9a | -2.2 | +1.4 |
| PK | 0+40+40 | 39.5a | +0.4 | +3.0* |
| NPK | 20+40+40 | 43.0a | +3.9 | +1.4 |
| NPK+ | 40+80+80 | 42.4a | +3.3 | --- |

Rosemount Soils Farm

Rosemount Agricultural Experiment Station
1966

Paul M. Burson

The year 1966 was a very satisfactory year with about normal weather and growing conditions. The rainfall distribution throughout the growing season was good with a total of 19.46 inches from May 1 through October 31. The continued use of good landuse, soil fertility and management is showing excellent yield results. Top yield of corn in 1966 was 178.0 bu. per acre. Top yields are the result of a good rotation, banded fertilizer at planting time, broadcast plow-down fertilizer and 80 to 100 lbs. of actual N sidedressed at the 1st cultivation. The check yields range from 60.0 to 109.0 bu. per acre, depending on the soil type conditions of fertility, management and topsoil remaining.

## Corn in Rotation

The 1st year of corn following alfalfa, had a top yield of 176.0 bu. per acre with banded fertilizer at 300 lbs. per acre of 4-12-24, 80 lbs. of N sidedressed at 1st cultivation and 300 lbs. of 0-20-20 broadcast plow-down applied in 1960, 1963 and 1966. The check yield was 107.0 bu. per acre.

On the 2nd year corn following alfalfa with the same treatment of 80 lbs. of N was applied as sidedressing, the top yield was 158.0 bu. per acre with the check producing 93.0 bu. per acre.

With a green manure crop of alfalfa and with the same combination of treatments except 80 lbs. of N was applied as sidedressing, the top yield again was 178.0 bu. per acre with the check producing 103.0 bu. per acre.

These comparisons show the value of a legume crop followed by corn regardless if the legume is a green manure crop or was a hay crop.

## Continuous Corn

There are 4 fields on the Soils Farm at Rosemount that have been in continuous corn from 6 to 14 years. These fields for 1966 have not produced as well as the fields that have been in a regular crop rotation system. The check yields have ranged from 59.0 to 103.0 bu. per acre. Banded fertilizer at 300 lbs. per acre of 4-12-24 produced from 93.0 to 134.0 bu. per acre while the band plus 140 lbs. of sidedressed N produced from 137.0 to 144.0 bu. per acre.

Throughout the years the corn in rotation with no fertilizer has out yielded the continuous corn with no fertilizer by about 20.0 bu. per acre. This indicates the difference in favor of a rotation on upland, rolling soils that have been previously eroded.

## Lime and Fertilizer on Continuous Corn
1966

On one field of mainly Port Byron silt loam, upland soil, which has been in corn for 9 years and which was limed at 3 tons per acre in November 1964 produced the following bu. yields per acre.

| Soil treatments | No lime | Lime |
|---|---|---|
| Check | 97.0 bu. | 97.0 bu. |
| Band(1) | 91.0 " | 104.0 " |
| Band + N(2) | 142.0 " | 148.0 " |

(1) 4-12-24 at 300 lbs. per acre
(2) 140 lbs. N sidedressed at 1st cultivation

On another field having been in continuous corn for 14 years, limed at the same time and fertilized with manure and banded fertilizer, was the best combination of fertilizer treatments for 1966. Manure was applied annually at the rate of 10 tons per acre plow-down.

The banded fertilizer was 6-24-12 at the rate of 200 lbs. per acre. The soil types are Judson and Clyde silty clay loams, slow in drainage as was the case in 1966. The 1966 yield bu. yields per acre are as follows:

| Soil treatments | No lime | Lime |
|---|---|---|
| Check | 114.0 | 108.0 (wet) |
| Manure | 109.0 | 138.0 |
| Band + Manure | 129.0 | 140.0 |
| Band + Manure + N(1) | --- | 136.0 |

(1) 80 lbs. N sidedressed at 1st cultivation.

The lime response was the greatest when used with other soil treatments. Sidedressed N with this rate of manure annually has never given any response to sidedressed N and was again shown in the 1966 corn yields.

## POP-UP (STARTER) FERTILIZER

Pop-up (starter) fertilizer for corn is not new. It is an old practice. If has been referred to as a step beckward. However, it is nothing more than starter fertilizer brought up to date with the modern methods of accuracy of application. Furthermore, this method of fertilizer application seems to have a place with the new custom spreading fall plow-down service now available to farmers by the fertilizer industry. Pop-up (starter) fertilizer has been used since fertilizer first came into being. Truck gardeners around the Twin City area have used starter solutions for certain crops for 35 to 40 years. The

splitboot attachment on the corn planter which came on the market many years ago was a partial pop-up (starter) fertilizer method of application. The splitboot placed the then low analysis fertilizer in no specific place in relation to the seed. Some was placed with the seed, some on the surface, some to the side and more in some places than in others. But no one knew how much actually went in with the seed. Everyone knew some went in with the seed and there was a starter benefit. With the use of this practice the remaining nutrients for the growing of the final corn crop had to come from the natural fertility of the soil. As new higher analysis material came into use and applied at higher rates per acre, too much was placed with the seed with the splitboot attachment and severe germination injury occurred. Here the band application was developed with the idea that all of the fertilizer needs could be applied at one time. This is not a truly starter fertilizer as compared to having a known amount of fertilizer placed with the seed as a specific starter. As the natural soil fertility went down these basic needs had to be supplied. This is where broadcasting came into existence and the availability of the custom fall plow-down. Present day fertilizer application practices are giving a new look at old practices. The principles of fertilization will not change to any degree but the application methods will.

The problem facing the corn farmer today is the rapidly increasing labor cost and time. This is brought about by a number of things such as - all fertilizer needs applied at planting time, higher rates per acre meaning more fertilizer to transport over the field, narrow row planting with flexi-unit planter instead of the now conventional planter, more rows per planter unit for narrow rows meaning more fertilizer material to transport and handle as compared to the conventional corn planter and the increasing need and use of herbicides and insecticides. Here is where the custom fall plow-down fertilizer service, now available by the industry, can relieve a big share of this spring labor problem for the farmer at planting time. Latest figures by the Minn. Dept. of Agri. indicate there are about 350 licensed fertilizer blenders, mixers and manufacturers at the present time. It is estimated that about 90% are able to provide some custom spreading service but in another year will further expand their present service as the demand occurs. It is further estimated that broadcast fall plow-down in 1966 is running about 150% greater than in the fall of 1965. Broadcasting fertilizer is not new but has been updated through custom service, with materials provided on a prescription basis, as determined by soil test, and applied on the corn crop as well as the other crops in the cropping system as it was years ago.

This is where pop-up (starter) at planting time could team-up with the fall plow-down and give a new look in fertilizer use and relieve the farmer of the increasing labor cost and time now occurring at corn planting time. At present most farmers trying pop-up (starter) are using it with the band application. At Rosemount we have used pop-up (starter) with both band and broadcast plow-down. The following tables indicate some of the results:

Table 1. Pop-up (starter) fertilizer with and without band and with and without broadcast plow-down for corn.

FIELD 30A

1966 - 6 years continuous corn

| Fertilizer treatments | Yield bu. per acre no plow-down | Yield bu. per acre with plow-down[1] |
|---|---|---|
| 1. Check | 127.0 | 140.0 |
| 2. Check + N | 128.0 | 140.0 |
| 3. P(st) L-7-21-7 (14#NK) + N | 130.0 | 138.0 |
| 4. P(st) D-10-30-12 (14#NK) + N | 135.0 | 148.0 |
| 5. P(st) D-12-24-12 (16#NK) + N | 139.0 | 149.9 |
| 6. B 4-12-24 300# per acre + N | 136.0 | 145.0 |
| 7. B 6-24-12 200# per acre + N | 120.0 | 139.0 |
| 8. B 4-12-24 300# per acre + P(st) D-12-24-12 (16#NK) + N | 129.0 | 144.0 |
| 9. B 4-12-24 300# per acre + P(st) L-7-21-7 (14# NK) + N | 130.0 | 153.0 |
| 10. B 6-24-12 200# per acre + P(st) D-12-24-12 (16#NK) + N | 134.0 | 149.0 |
| 11. B 6-24-12 200# per acre + P(st) L-7-21-7 (14#NK) + N | 138.0 | 145.0 |
| 12. B 4-12-24 300# per acre + P(st) 10-30-12 (14#NK) + N | 142.0 | 148.0 |
| 13. B 6-24-12 200# per acre + P(st) 10-30-12 (14#NK) + N | 143.0 | 153.0 |

Planted May 25, 1966
Av. 4 replications split plot plow-down

B - Band 4-12-24 300# per acre
6-24-12 200# per acre
L - Liquid fertilizer
D - Dry fertilizer
P(st) - Pop-up starter fertilizer
N - Nitrogen plow-down 130# per acre

[1]Plow-down 4-12-24 800# per acre spring, 1966.

| Soil test (Fall, 1966): | P | K |
|---|---|---|
| Plow-down | Very high | medium + |
| No plow-down | medium | medium |

Atrazine broadcast after planting
Planting rate - 24,000 kernels - drilled
Final stand - check 19,000 plants per acre
all fertilizer 22,000 plants per acre

Maturity: Moisture content Oct. 25, 1966, was 2% +, less moisture on plow-down than on no plow-down.

Tasselling and denting pop-up (starter) + plow-down was 4 to 6 days in advance of check.

Table 2. Pop-up (starter) fertilizer with and without plow-down for corn.

FIELD 10
1966 - 11 years continuous corn

| Fertilizer Treatments | Yield bu. per acre no plow-down | Yield bu. per acre with(1) plow-down |
|---|---|---|
| 1. Check | 60.0 | 80.5 |
| 2. B-4-12-24 300# per acre | 85.0 | 122.5 |
| 3. B-4-12-24 300# per acre + N | 116.0 | 145.6 |
| 4. P)st) L-7-21-7 (14#NK) + N | 125.0 | 150.1 |
| 5. P(st) D-10-30-12 (14#NK) + N | 126.0 | 151.3 |
| 6. B-4-12-24 300# per acre + P(st) L-7-21-7 (14#NK) + N | 128.0 | 153.5 |
| 7. B-4-12-24 300# per acre + P(st) D-10-30-12 (14#NK) + N | 137.0 | 151.8 |
| 8. B-4-12-24 300# per acre + P(st) D-12-24-12 (14#NK) + N | 134.0 | 152.0 |

Planted May 26, 1966

B - Band placement
P(st) - Pop-up (starter) placement
L - Liquid fertilizer
D - Dry fertilizer
N - Nitrogen sidedressed 140# per acre at 1st cultivation.

(1) Plot 1-1959-62-65
" 2-1960-63-66
" 3-1961-64-

Every three years 0-20-20 was applied and plowed down at 300 and 600 lbs. per acre.

| Soil test (Spring 1966): | P | K |
|---|---|---|
| plow-down | High | medium + |
| no plow-down | medium | medium |

Atrazine banded at planting time
Planting rate - 24,000 kernels-drilled

| Final stand: | |
|---|---|
| check | 19,000 plants |
| Band | 20,000 plants |
| B + P | 22,000 plants |

No rootworm injury on any treatment.

The plow-down 0-20-20 was applied on the basis of a soil test at the rates of 300 and 600 lbs. per acre. Plots were laid out across the 100 ft. field strip cropped field. In 1959 the first series was started with one additional series in 1960 and one again in 1961. Then the plow-down treatments were again repeated on the same plots so the repeated treatments were made every three years. With this arrangement it would be possible to determine the response the current year and the two following years as to any residual response and if there was any accumulative response.

Table 3. Pop-up (starter) fertilizer vs. Band vs. Band + pop-up (starter)

FIELD 30A
1965 - 5 years continuous corn

| Fertilizer treatments | Yield bu. per acre |
|---|---|
| 1. Check | 99.5 |
| 2. P)st) D-0-45-0 (50#) + N | 97.3 |
| 3. P(st) L-5-15-10 (14#NK) + N | 124.0 |
| 4. B-5-15-10 (L) 300# per acre + P(st) L-5-15-10 (14#NK) + N | 134.0 |
| 5. P(st) D-8-24-12 (15#NK) + N | 131.5 |
| 6. B-8-24-12 (D) 200# per acre + P(st) D-8-24-12 (15#NK) + N | 128.0 |
| 7. B-5-15-10 (L) 300# per acre + N | 129.0 |
| 8. B-8-24-12 (D) 200# per acre + N | 129.7 |

Planted May 19, 1965

B - Band placement
P - Pop-up (starter) placement
L - Liquid fertilizer - Furnished by T.V.A.
D - Dry fertilizer
N - Nitrogen 100# sidedressed 1st cultivation

4 replications

Atrazine broadcast at pre-emergence.

Maturity: 80% tasselling and denting
Pop-up 3 to 4 days over check
Pop-up (starter + band 7 to 8 days over check

Planting rate - 24,000 kernels per acre
Final stand - check 19,000 plants per acre
All fertilizer 21,000 plants per acre.
Root worm injury was serious on pop-up (starter) phosphate and check.

Table 4. Pop-up (starter) fertilizer with and without band and with and without plow-down on variable planting rates of soybeans.

FIELD 37
1966 - 4 years continuous row crops

| Fertilizer treatments | Yield bu. per acre no plow-down | Yield bu. per acre with plow-down |
|---|---|---|
| **Planting rate 60# per acre** | | |
| 1. Check | 28.0 | 28.3 |
| 2. P(st) L-7-21-7 (20#NK) | 31.6 | 30.0 |
| 3. P(st) D-10-30-12 (20NK) | 33.3 | 31.6 |
| 4. P(st) D-10-30-12 (14NK) | 33.3 | 35.0 |
| 5. P(st) L-7-21-7 (14NK) | 28.3 | 30.0 |
| 6. P(st) L-7-21-7 (7NK) | 33.3 | 30.0 |
| 7. P(st) D-10-30-12 (7NK) | 28.3 | 30.0 |
| 8. Band (D) 4-12-24 300# per acre | 26.6 | 35.0 |
| **Planting rate 45# per acre** | | |
| 1. Check | 26.6 | 31.6 |
| 2. P(st) L-7-21-7 (20#NK) | 26.6 | 33.3 |
| 3. P(st) D-10-30-12 (20#NK) | 25.0 | 35.0 |
| 4. P(st) D-10-30-12 (14#NK) | 28.3 | 36.6 |
| 5. P(st) L-7-21-7 (14#NK) | 26.6 | 35.0 |
| 6. P(st) L-7-21-7 (7#NK) | 26.6 | 33.3 |
| 7. P(st) D-10-30-12 (7#NK) | 28.3 | 33.3 |
| 8. Band (D) 4-12-24 300# per acre | 35.0 | 33.1 |

(1) Plow-down 4-12-24 800# per acre spring 1966
P(st)-Pop-up (starter) placement
L - Liquid fertilizer
D - Dry fertilizer
Planting date - June 9, 1966
Treflan broadcast for weed control

| Soil test: | P | K |
|---|---|---|
| | High | very high |

Maturity: Leaf drop on plow-down was 5 to 7 days in advance of no plow-down. Check was latest of all treatments.

Table 5. Pop-up (starter) fertilizer vs. pop-up (starter) plus band on stands of corn.

4 year average
1963-1966

| Plants per acre (Final Stand) | | |
|---|---|---|
| Check | (1) Pop-up (starter) | (1) Pop-up (starter + Band) |
| 18,600 | 20,500 | 20,400 |

(1) 20 lbs. total or less of nitrogen and Potash

Planting rate 23,000 to 24,000 kernels

## SUMMARY AND OBSERVATIONS

1. General fertility levels of fields 10, 30A and 37 are considered high because of regular annual fertilizer treatments. They are comparable to the soil fertility levels found with the good farmers of Minnesota.

2. The check areas of field 10 have never been fertilized while the check areas on fields 30A and 37 have had the normal band fertilization in previous years.

3. Broadcast plow-down fertilizer plus pop-up (starter) fertilizer on both corn and soybeans seems to about offset the results from band plus pop-up (starter).

4. Pop-up (starter) fertilizer apparently is an efficient means of getting nutrients into the plant, especially during the early stages of plant growth.

5. It did not seem to matter whether the fertilizer was liquid or dry.

6. No results were obtained in 1964 because of the very dry weather. All corn yields, regardless of treatments, were reduced over 50 percent.

7. Pop-up (starter) fertilizer alone is not sufficient. Additional fertilizer must be supplied especially with higher plant populations and narrower row spacing.

8. A fertilizer ratio of 1:2:1 or 1:3:1 or similar ratio high in phosphate and low in nitrogen and potash appears at present to be the better for pop-up (starter) fertilizer.

9. Different pop-up (starter) rates have been used but it appears now until different evidence is available that a total of 20 lbs. per acre of nitrogen and potash is the maximum amount. (Table 5. Plant Population)

10. If trace nutrients are needed it might be possible to add them in pop-up (starter) fertilizer. No work has been done in Minnesota on this practice.

11. The phosphate in the pop-up (starter) stimulates root growth and causes a rapid root proliferation. Previous root work has shown similar results.

12. Too much nitrogen and potash in contact with the seed will injure germination, delay emergence and reduce stand.

13. Potash appears to be more harmful than nitrogen regardless of moisture conditions. Seasonal differences in moisture and temperature shows up in a different response of each of the three major nutrients used in the pop-up (starter).
In 1963, a more normal season, all three nutrients were equally responsive. In 1964, which was very dry, the early phosphate response was most noticeable. However, in 1965 which was very wet and continued cold from early spring, the phosphate response was very poor but the nitrogen and potash gave the best response in growth with the nitrogen being the most responsive of all.

14. Pop-up (starter) fertilizer has increased emergence 3 to 5 days but the later the corn is planted and as the soil apparently becomes warmer this difference in emergences seems to diminish.

15. All basic fertilizer needs of nitrogen, phosphate and potash can be fall plow-down. Nitrogen may be expected on sandy soils.

16. Soil tests should be used to determine the basic fall plow-down fertilizer needs.

17. Broadcasting fertilizer is an old practice but has been brought up to date by custom fall plow-down offered by industry for the row crops.
It is now more universally used on all types of crops.

18. From 1959 through 1966 the broadcast plow-down of 300 and 600 lbs. of phosphate and potash as used in field 10 the 600 lbs. per acre was no better in response than the 300 lbs. per acre even though both rates were applied every 3rd year.

19. Only one years work (1966) with soybeans using pop-up (starter) with and without plow-down has been conducted. The maximum rate of a <u>total</u> of 20 lbs. of nitrogen and potash was not harmful to seed germination and growth. Lower rates of 14 and 7 lbs. per acre appeared about equal.

20. Soybeans were planted at two rates per acre, 60 and 45 lbs. per acre in 40 inch rows. The 45 lb. rate was generally higher in yield than the 60 lb. rate.

21. Nodulation and root proliferation on soybeans were both stimulated by the use of pop-up (starter) fertilizer.

22. Band fertilizer cost is cheaper than for custom plow-down because of the difference in amounts used per acre but in the case of the farmer the extra labor and time cost required in the spring for banding can offset the extra fertilizer cost for the custom fall plow-down. However, when considering costs and charges the most valuable period of a farmers time over the crop season probably is the period from April 15 to June 1 when he must figure his labor and time costs at a premium.

## SOYBEAN FERTILIZATION

Questions have been raised about sidedressing soybeans with N the same as for corn. This practice was conducted on one field in 1966 with the following results. The rate of application was 80 lbs. of N applied on July 5 (1st cultivation) and another area sidedressed on July 29 (2nd cultivation). More work needs to be conducted. The later application of N gave 3.4 bushels increase over the earlier N sidedressed but no increase over the check. The residual fertilizer yield from the 1965 fertilized corn was the best with 26.6 bushels per acre. This is consistent with other years.

| Fertilizer Treatment | Yield Bushel per acre |
|---|---|
| Check | 25.0 |
| Residual | 26.6 |
| Band (1) | 21.6 |
| Band + 80# N - July 5 | 21.6 |
| Band + 80# N - July 29 | 25.0 |

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

## POTASH PLACEMENT FOR ALFALFA HAY

Trials were continued in 1966 comparing plow-down potash and surface cultivation with field cultivator after plowing. This project was started in 1963. Yields were harvested in 1964, 1965 and 1966. In April 1966 all the treatments were repeated but were applied as topdressing with no cultivation. The total accumulative yields for the 3 years are as follows:

Total Tons per Acre Yield

2 cuttings per year

| Check | 0-60-0 | 0-120-0 | 0-0-120 | 0-0-240 | 0-60-0<br>0-0-120 | 0-60-0<br>0-0-240 | 0-120-0<br>0-0-120 | 0-120-0<br>0-0-240 |
|---|---|---|---|---|---|---|---|---|
| **Surface Cultivation** | | | | | | | | |
| 9.06 | 9.55 | 11.33 | 6.62 | 9.20 | 11.79 | 13.88 | 12.26 | 15.08 |
| **Plow-down** | | | | | | | | |
| 8.89 | 6.70* | 7.10* | 9.87 | 12.02 | 13.49 | 13.98 | 13.14 | 14.11 |

* 2 year yield. 1966 samples lost
Seeded April 25, 1963.
Variety - Vernal
Rate - 12 lbs. per acre with 1 bu. of oats per acre
Soil test: pH-7.0, P-low medium, K-medium
Limed - 3 tons per acre 1951.
Soil types - Port Byron S. L.-variable
Bold very fine sand loam - variable

These data indicate, in general, that the surface application is somewhat better than the plow-down. Potash alone was not effective. Phosphate appeared to be the main limiting nutrient. The higher rates of a combination of phosphate and potash produced the higher yields.

## ALFALFA HAY YIELDS WITH PLOW-DOWN FERTILIZER 1966

Field trials of broadcast plow-down 0-20-20 fertilizer at two rates of 300 and 600 lbs. per acre were continued in 1966. The grade of fertilizer and the rates per acre were based on soil test. These treatments were repeated every three years on the same plots. The plots were established in 1959, 1960 and 1961. The yields of alfalfa in tons of hay per acre are as follows:

| | Alfalfa Hay Yield in Tons per acre | | | | | | |
|---|---|---|---|---|---|---|---|
| | Check | Plow-down (1) 1959-62-65 | | Plow-down (1) 1960-63-66 | | Plow-down (1) 1961-64-? | |
| Fertilizer rate (1) | | 300 | 600 | 300 | 600 | 300 | 600 |
| Tons per acre | 3.71 | 4.47 | 5.20 | 5.02 | 5.16 | 4.89 | 5.04 |

(1) 0-20-20 was plowed down on each plot every 3rd year at the rate of 300 and 600 lbs. per acre.

These data generally indicate there is little difference between the 300 and 600 lb. rate per acre of 0-20-20. The yield increase for the broadcast plow-down over the check ranged from .76 tons per acre of 300 lbs. per acre where the last treatment was made in 1965 to 1.49 tons per acre where the 600 lb. rate was made for the same year 1965.

## BEEF PRODUCTION AND TIME OF FERTILIZER APPLICATION

P. M. Burson, Soils; A. R. Schmid, Agronomy;
J. C. Meiske and R. D. Goodrich, Animal Science

In 1951 a soil survey or a soil inventory was made on the Rosemount soils farm. This soil inventory gives the soil type, name, the percent slope and the seriousness of erosion or the amount of topsoil remaining. From this soil inventory information, landuse intensity was determined and established on the land as you see it today. Continuous row cropping is the most intensive use that can be applied on the level to undulating land while on the very rolling to steeper land permanent legume hay and pasture mixtures were established. Generally all land having an eight percent or more slope was established to permanent hay and pasture. On these rolling to steep slopes is where the Beef Cattle Grassland project is now located. Some of the slopes will run as high as 17 to 20 percent with little or no topsoil remaining. In some places gullies had to be filled before the permanent pasture and forage crops could be established.

To establish these permanent stands of pasture and hay forages lime and fertilizer must be applied. These needs should be determined by soil tests as the soil tests are the best guides we have to determine lime and fertilizer use. Besides the kind and amount of fertilizer to use the time and frequency are very important. This is not beginning to show in the production of beef per acre.

On field 11 adjacent to the pasture area Dr. J. M. MacGregor started an experiment on how to fertilize to permanently maintain alfalfa stands on these rolling to steep pasture soils. In his study, running for eleven years (1951-1961), the check plots produced a total of 30.1 tons per acre. This was compared to a basic treatment of 300 lbs. per acre of 0-20-20 (based on soil test) at seeding time where the total increase in yield ranged from zero to 5.4 tons per acre over the check plots. However, when this same basic treatment was used plus an annual topdressed application (applied either fall or spring), the total production per acre for the 11 years was 45.5 tons per acre or 15.4 tons more than the check yields. These same fertilizer treatments (as based on soil test) and time of application have been used on pastures A, B, C, D and E. The basic treatment was 500 lbs. per acre of 0-20-20 applied at time of renovation and seeding as compared to the same basic fertilizer treatment plus an annual topdressed treatment of 200 lbs. per acre of 0-20-20. In 1965 these differences were compared on pastures D and E where the present grazing trials are now being conducted. The basic treatment of 500 lbs. per acre of 0-20-20 was made on pasture D in 1963 and on pasture E in 1961. Each was seeded in their respective years. In 1965 the basic treatments, with no annually topdressed treatment, produced on the alfalfa grass mixture 448.3 lbs. of beef per acre as compared to 544.7 lbs. per acre where the basic plus the annual topdressed treatment was made. This is an increase of 96.3 lbs. per acre for the basic plus annual treatments.

The annual use of fertilizer can and does contribute to the maintaining of a better stand of the legume in the pasture mixture. The alfalfa goes into the winter each year with a better developed root system and more top growth so there is less chance of winter and early spring injury.

In 1966 these same pastures (D and E) were grazed in the same rotation system. However, on the basic fertilizer treatment which had not received a previous annual application treatment of 200 lbs. per acre of 0-20-20 was topdressed. There was an average per acre of 240.0 lbs. of beef produced for both treatments indicating a distinct benefit from the 200 lb. fertilizer rate when applied two to four years after the basic treatment. Some of these variations may be contributed to the amount of topsoil remaining along with the benefit from the fertilizer treatment. Under some soil conditions the 200 lb. rate may not be effective. An additional comparison of the basic and annual fertilizer treatments were made in 1966 where fertilized supplemental sudan pastures were used in the rotational grazing program. The sudan pasture soils are quite uniform in topography and previous management and are typical soils that would be used for cropland on the average farm. The sudan grass was fertilized with 200 lbs. of 0-20-20 and 100 lbs. of N per acre at the time of seeding. With this alfalfa grass mixture plus the fertilized sudan on the basic treatment there was 258.6 lbs. of beef produced per acre as compared to 247.7 lbs. of beef per acre on the basic plus the annual treatment. Here the well fertilized sudan grass pasture with 100 lbs. of N per acre could have offset the differences in fertility levels on the soils in the alfalfa grass mixture. This characteristic difference has occurred other years on pastures B, C and E where the pastures of higher fertility levels tended to make the pastures of lower fertility caused by erosion or a lack of proper nutrient balance to look better than they really were.

These results indicate that all pastures, regardless of kind, should be properly limed and fertilized as to kind, rate and time of fertilizer application if effective beef production is to be obtained the same as any other crop on the land.

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

E. C. Seim, A. C. Caldwell, J. Grava, E. R. Allred, J. Eix, J. B. Swan, and G. Rehm.

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

In the alfalfa experiment, the full treatment plots received 50 lbs./A of P as 0-460, 300 lbs./A of K as 0-0-60, 5 lbs./A B as borax and 50 lbs./A of S as gypsum. The control (average management) plots received gypsum only (50 lbs./A of S). All fertilizer treatments were broadcast and worked in before planting. Ranger alfalfa was inoculated and seeded at the rate of 20 lbs./A. In late July the plots were sprayed with dalapon (2 lbs./A) to control quackgrass. On August 19, the plots were clipped about 8 inches above the ground. No yields were taken from the plots in 1965. Three cuttings were obtained in 1966. Full treatment plots were topdressed after each cutting with 100# K (0-0-60). The control plots were topdressed early in the spring with 200#/acre of 0-20-20.

In the corn experiment, the full treatment plots received 150 lbs./A of N as ammonium nitrate, 25 lbs./A of P as 0-46-0, 200 lbs./A of K as 0-0-60 and 50 lbs./A of S as gypsum. Starter fertilizer, 300 lbs./A of 4-12-24 was applied in a band on each side of the hill. The full treatment plots were sidedressed with 90# of nitrogen per acre as ammonium nitrate. Row width was 36 inches with a hill spacing of 18 inches. Final plant population was 18,300 plants per acre. The control (average management plots received starter fertilizer only (150 lbs./A of 4-12-24). Row spacing was 36 inches, hill spacing 36 inches. Final plant population was 9150 plants per acre. An 85 day corn variety, Minhybrid 805, was used in these trials.

One half of the plots was irrigated on a regular schedule. The other half received no supplemental irrigation. The natural precipitation and supplemental irrigation records for the 1966 season are shown in table 1 for alfalfa and table 2 for corn.

Table 3 presents additional climatic data for the 1966 growing season. In 1966 there were a total of 1934 growth degree days (GDD), about 200 more than the average GDD (1766) accumulated during the average warm season crop period according to Baker and Straub Jr. During the 1965 season when we had very bad luck with corn, the total there was only 1529 GDD.

Table 1. Precipitation and supplemental irrigation during 1966 growing season for alfalfa at Park Rapids, Minnesota.

| Date | Hours | Irrigation (inches) | Precipitation |
|---|---|---|---|
| 5/1/66 - start of spring growth | | | |
| 5/11/66 | | | .16 |
| 5/13/66 | | | .20 |
| 5/15/66 | | | .41 |
| 5/19/66 | | | .09 |
| 6/5/66 | | | .40 |
| 6/13/66 | | | .35 |
| 6/19/66 | | | .07 |
| 6/21/66 | | | .24 |
| 6/22/66 | 4.0 | 2.13 | |
| 6/24/66 | | | 2.18 |
| 6/27/66 | | | .13 |
| 7/2/66 | 4.0 | 2.00 | |
| 7/4/66 | | | 1.28 |
| 7/9/66 | | | .71 |
| 7/12/66 | 4.0 | 2.00 | |
| 7/17/66 | | | .25 |
| 7/22/66 | | | .48 |
| 7/23/66 | | | .08 |
| 7/24/66 | | | .37 |
| 7/25/66 | | | 2.21 |
| 7/31/66 | | | .11 |
| 8/1/66 | | | 2.37 |
| 8/15/66 | | | 1.75 |
| 8/22/66 | | | 1.37 |
| 9/13/66 | | | .55 |
| Total | | 6.13 | 15.76 |

Total $H_2O$ (Irr. + Precip) 21.89

Table 2. Precipitation and supplemental irrigation during 1966 growing season for corn at Park Rapids, Minnesota.

| Date | Irrigation Hours | Irrigation Amt. applied | Precipitation (inches) |
|---|---|---|---|
| 5/21/66-corn planted | | | |
| 6/5/66 | | | .40 |
| 6/6/66 | .5 | .25 | |
| 6/8/66 | .5 | .37 | |
| 6/13/66 | | | .35 |
| 6/19/66 | | | .07 |
| 6/21/66 | | | .24 |
| 6/22/66 | 4.0 | 2.13 | |
| 6/24/66 | | | 2.18 |
| 6/27/66 | | | .13 |
| 7/2/66 | 4.0 | 2.00 | |
| 7/4/66 | | | 1.28 |
| 7/9/66 | | | .71 |
| 7/12/66 | 4.0 | 2.00 | |
| 7/17/66 | | | .25 |
| 7/22/66 | | | .48 |
| 7/23/66 | | | .08 |
| 7/24/66 | | | .37 |
| 7/25/66 | | | 2.21 |
| 7/31/66 | | | .11 |
| 8/1/66 | | | 2.37 |
| 8/15/66 | | | 1.75 |
| 8/22/66 | | | 1.37 |
| 9/13/66 | | | .55 |
| Total | | 6.75 | 14.90 |

Total $H_2O$ (Irr. + Precip.) 21.65

Table 3. Rainfall and temperature data for the growing season of 1966, Park Rapids weather station.

| Month | Rainfall (inches) | | Temperature (of) | | Growing Degree Days (G.D.D.) |
|---|---|---|---|---|---|
| | Total | Departure from Normal | Average | Departure from Normal | Base Temp. RE= 50°F. |
| May | 1.28 | -2.27 | 50.2 | -3.0 | 116 |
| June | 3.57 | -0.38 | 65.1 | 2.2 | 453 |
| July | 6.31 | 2.81 | 72.3 | 3.1 | 691 |
| August | 6.55 | 2.52 | 64.4 | -2.3 | 446 |
| September | 0.56 | -1.48 | 57.6 | 1.5 | 228 |
| Total | 18.27 | 1.20 | | | 1934 |
| Average | | | 61.9 | 1.5 | |

* From climatological data, Minnesota, Vol. 72, 1966, U.S. Weather Bureau

The 1966 corn yields are shown in table 4. High fertility plots out-yielded the low fertility low population plots by 43 to 55 bushels. Irrigation was not necessary after July 12th and the earlier irrigation appeared to have no effect on the yield. In this respect however, it must be remembered that drought was so severe in 1965 that unirrigated plot yields were so poor that starter fertilizer and natural fertility may not have been utilized and consequently were made available to the 1966 crop.

Despite, the satisfactory yields recorded; midseason and early fall estimates of the crop were considerably more optimistic than the outcome. Corn in this area always seems to progress slowly from the milk stage through denting to maturity. This may be partially attributed to cool nights and low fall temperature but experimentation with different hybrids may provide a variety more closely adapted to the climatic and management requirements of the area. With irrigation still higher plant populations will be necessary to increase yields. This will require a hybrid which can stand crowding and which will respond well to the heavy fertilization practices required.

Table 4. Effect of irrigation, fertility level and population on corn at Park Rapids, Minnesota

| Treatments | | | % Moisture Ear Corn | Ear Corn Yield | Shelling Percentage |
|---|---|---|---|---|---|
| Moisture | Fertility | Population | | Bu/Acre | |
| Irrigated | Low Fert. | Low Pop. | 41.9 | 48.1 | 77.8 |
| | LF | LP | 39.5 | 53.7 | 80.1 |
| Average | | | 40.7 | 50.9 | 78.95 |
| Irrigated | High Fert. | High Pop. | 37.3 | 100.1 | 80.1 |
| | HF | HP | 39.3 | 110.6 | 78.9 |
| Average | | | 38.0 | 105.4 | 79.5 |
| Non-irrigated | LF | LP | 40.2 | 68.5 | 80.0 |
| " " | LF | LP | 39.9 | 76.0 | 79.8 |
| Average | | | 40.1 | 72.3 | 79.9 |
| Non-irrigated | HF | HP | 40.2 | 109.9 | 81.4 |
| " " | HF | HP | 38.4 | 120.9 | 79.7 |
| Average | | | 39.1 | 115.4 | 80.1 |

The effect of fertility and irrigation treatments on the yield of alfalfa are shown in Table 5. Despite an extremely late start which decreased the 1st cutting yield (normally the heaviest), 4.5 ton yields were obtained from plots which received the complete management treatment (fertilizer plus water). This is an increase of 2.0 tons over fertility alone or 1.8 tons over water alone.

In the case of alfalfa then water and fertility go hand in hand in increasing yields. Ordinary management practices (50# S as gypsum) without irrigation produced 2.2 tons of alfalfa for the three cuttings. The increases due to irrigation were obtained with only three irrigations supplying 6.13 inches of water.

Soil samples were taken in late August 1966 to determine what effect the fertilizer and water management practices have had on the available P and K, pH and organic matter. The results are shown in Tables 6 and 7.

Table 5. Effect of irrigation and fertility on yield of alfalfa at Park Rapids, Minn.

| Treatment | | Yield (Tons/A | | | |
|---|---|---|---|---|---|
| Moisture | Fertility | 1st cutting | 2nd cutting | 3rd cutting | Total |
| Irrigated | Low Fert. | .55 | .95 | .91 | 2.41 |
| " | " " | .81 | 1.30 | .78 | 2.89 |
| | Average | .68 | 1.13 | .85 | 2.65 |
| Irrigated | High Fert. | 1.03 | 2.33 | 1.10 | 4.46 |
| " | " " | .89 | 2.41 | 1.15 | 4.45 |
| | Average | .96 | 2.37 | 1.13 | 4.46 |
| Non-Irrig. | Low Fert. | .45 | .54 | .97 | 1.96 |
| " " | " " | .61 | .85 | .98 | 2.44 |
| | Average | .53 | .70 | .97 | 2.20 |
| Non-Irrig. | High Fert. | .50 | .64 | 1.20 | 2.34 |
| " " | " " | .53 | .90 | 1.28 | 2.71 |
| | Average | .52 | .77 | 1.24 | 2.53 |

Table 6. Effect of fertilizer and water management practices on pH, organic matter, P & K of a Dorset sandy loam in corn production, (Park Rapids, 1966).

| Irrigation Trt. | Fertility Trt. | Population | pH | O.M. % | P lbs/A | K lbs/A |
|---|---|---|---|---|---|---|
| Non-irrig. | High Fert. | High Pop. | 5.8 | 3.0 | 61 | 250 |
| | | | 5.8 | 3.2 | 50 | 200 |
| Irrig. | H.F. | H.P. | 6.4 | 3.3 | 40 | 200 |
| | | | 6.3 | 3.7 | 32 | 140 |
| Non-irrig. | Low Fert. | Low Pop. | 6.4 | 3.0 | 36 | 100 |
| | | | 6.5 | 3.9 | 24 | 70 |
| Irrig. | L.F. | L.P. | 6.7 | 3.9 | 20 | 60 |
| | | | 6.7 | 4.3 | 18 | 60 |

Table 7. Effect of fertilizer and water management practices on pH, organic matter, P, and K of a Dorset sandy loam in alfalfa production. (Park Rapids, 1966)

| Non-Irrig. | Alf. | Pot. | Plot | Fert. Trt. | Depth-in. | pH | O.M. % | P lb/A | K lb/a |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | Heavy | | | | | |
| | | | | | 0-1 | 6.1 | 2.0 | 55 | 600 |
| | | | | | 1-2 | 6.0 | 2.0 | 51 | 330 |
| | | | | | 2-3 | 6.0 | 2.0 | 29 | 220 |
| | | | | | 3-6 | 6.0 | 2.2 | 23 | 80 |
| | | | | | 6-12 | 6.2 | 1.5 | 37 | 50 |
| " | " | " | 3 | H | | | | | |
| | | | | | 0-1 | 6.3 | 3.0 | 61 | 590 |
| | | | | | 1-2 | 6.3 | 3.0 | 40 | 230 |
| | | | | | 2-3 | 6.3 | 1.7 | 35 | 200 |
| | | | | | 3-6 | 6.2 | 3.0 | 30 | 110 |
| | | | | | 6-12 | 6.4 | 2.3 | 37 | 130 |
| Irrig. | " | " | 5 | | | | | | |
| | | | | | 0-1 | 6.7 | 4.6 | 110 | 600 |
| | | | | | 1-2 | 6.2 | 4.4 | 70 | 260 |
| | | | | | 2-3 | 6.0 | 3.6 | 33 | 250 |
| | | | | | 3-6 | 6.2 | 4.4 | 21 | 140 |
| | | | | | 6-12 | 6.4 | 2.5 | 29 | 80 |
| " | " | " | 7 | | | | | | |
| | | | | | 0-1 | 6.7 | 3.3 | 36 | 550 |
| | | | | | 1-2 | 6.1 | 3.6 | 20 | 100 |
| | | | | | 2-3 | 6.1 | 3.5 | 11 | 60 |
| | | | | | 3-6 | 6.3 | 4.0 | 15 | 60 |
| | | | | | 6-12 | 6.3 | 3.2 | 19 | 50 |
| Non-Irrig. | " | " | 2 | Low Fert. | | | | | |
| | | | | | 0-1 | 6.0 | 2.4 | 34 | 130 |
| | | | | | 1-2 | 6.2 | 2.6 | 21 | 70 |
| | | | | | 2-3 | 6.1 | 2.2 | 25 | 70 |
| | | | | | 3-6 | 6.1 | 2.5 | 29 | 60 |
| | | | | | 6-12 | 6.1 | 1.7 | 36 | 50 |
| " | " | " | 4 | L | | | | | |
| | | | | | 0-1 | 6.3 | 3.6 | 19 | 70 |
| | | | | | 1-2 | 6.1 | 4.1 | 16 | 60 |
| | | | | | 2-3 | 6.2 | 5.0 | 14 | 50 |
| | | | | | 3-6 | 5.9 | 4.4 | 13 | 60 |
| | | | | | 6-12 | 6.2 | 2.7 | 19 | 50 |
| Irrig. | " | " | 6 | Low | | | | | |
| | | | | | 0-1 | 6.8 | 4.3 | 37 | 110 |
| | | | | | 1-2 | 6.5 | 3.6 | 18 | 80 |
| | | | | | 2-3 | 6.4 | 4.2 | 18 | 60 |
| | | | | | 3-6 | 6.4 | 4.5 | 18 | 50 |
| | | | | | 6-12 | 6.4 | 2.7 | 20 | 40 |
| " | " | " | 8 | L | | | | | |
| | | | | | 0-1 | 6.7 | 4.1 | 27 | 70 |
| | | | | | 1-2 | 6.3 | 4.1 | 12 | 60 |
| | | | | | 2-3 | 6.2 | 3.9 | 11 | 50 |
| | | | | | 3-6 | 6.2 | 3.5 | 14 | 40 |
| | | | | | 6-12 | 6.3 | 2.6 | 13 | 40 |

# The Effect of Nitrogen Source, Placement and Time of Application in the Yield and Composition of Continuous Corn on Webster Clay Loam at Lamberton in 1966

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

The effect of fertilizer nitrogen, applied either as ammonium nitrate or as urea on continuous corn yield at Lamberton has been studied during the past seven years. The nitrogen content of corn grain and vegetative tissue was determined in the first five years, no analyses were made in 1965, but in 1966, corn sixth leaf samples were analysed by the Ohio State University Spectographic Laboratory for 16 different elements.

From 1960 through 1966, uniformly ample amounts of phosphate and potash fertilizers have been applied to the entire plot area. Three rates of nitrogen, either as ammonium nitrate or as urea were applied, either before, or after plowing in the fall, at the time of seeding, or as a late June sidedressing. All plots were fall plowed. In 1966, for some reason such as hot dry weather during silking, there was an extremely poor kernel set, and many of the ears failed to have a single kernel. This materially reduced 1966 corn yields which were as follows:

Table 1. The Effect of Nitrogen Source, Rate and Time of Application to Webster Clay Loam at Lamberton on Corn Yield in 19 in the Seventh Year of Continuous Corn.

| Treatment No. | Time and Method of Application (N in lbs/A) | Avg. ear corn yield @ 15.5% moisture bu/A | Significance[a] |
|---|---|---|---|
| 18 | 160 $NH_4NO_3$-sidedressed | 51.4 | a |
| 15 | 40 urea- " | 50.4 | ab |
| 12 | 80 $NH_4NO_3$-at planting | 49.0 | abc |
| 17 | 80 urea-sidedressed | 47.3 | abe |
| 6 | 80 $NH_4NO_3$-plowed down in fall | 47.2 | abe |
| 16 | 80 $NH_4NO_3$-sidedressed | 43.8 | bed |
| 13 | 80 Urea-at planting | 41.8 | ed |
| 14 | 40 $NH_4NO_3$-sidedressed | 38.6 | de |
| 8 | 160 $NH_4NO_3$-plowed down in fall | 38.5 | de |
| 7 | 80 urea- " " " " | 37.8 | def |
| 9 | 160 Urea- " " " " | 37.3 | def |
| 11 | 40 Urea-at planting | 33.8 | efg |
| 5 | 40 urea-on top of plowing in fall | 30.9 | fgh |
| 2 | 40 $NH_4NO_3$-plowed down in fall | 26.8 | ghi |
| 4 | 40 $NH_4NO_3$-on top of plowing in fall | 24.3 | hi |
| 10 | 40 $NH_4NO_3$-at planting | 23.7 | i |
| 3 | 40 Urea-plowed down in fall | 19.8 | i |
| 1 | None | 11.0 | j |

ev = 27.0

The 1966 yields are the lowest of the years of the experiment, and with very late killing frosts, the corn was mature when harvested. The yields during the seven years is shown in the following table.

Table 2. The Effect of Nitrogen Source, Rate, and Time of Application to Webster Clay Loam at Lamberton on Corn Yield from 1960 through 1966 (Average of four replications).

| Treatment No. | Time and Application Method N in lbs/A | Yield of ear corn in bu/A @ 15.5% moisture | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | Average | Sig. |
| 9 | 160 Urea-fall P.U. | 79.4 | 112.5 | 43.5 | 152.8 | 112.4 | 73.5 | 37.7 | 87.4 | a |
| 18 | 160 $NH_4NO_3$-S.D. | 40.7 | 97.4 | 77.7 | 151.7 | 109.5 | 77.6 | 51.4 | 86.6 | a |
| 13 | 80-Urea at planting | 57.7 | 99.1 | 40.5 | 149.3 | 115.7 | 84.4 | 41.8 | 84.1 | ab |
| 17 | 80-Urea-S.D. | 76.9 | 86.4 | 48.2 | 143.8 | 121.4 | 64.7 | 47.3 | 83.6 | abc |
| 8 | 160 $NH_4NO_3$-fall P.U. | 69.8 | 97.9 | 46.7 | 147.7 | 100.9 | 70.8 | 38.5 | 81.8 | abc |
| 6 | 80 $NH_4NO_3$-fall P.U. | 67.4 | 97.9 | 43.6 | 149.6 | 100.8 | 63.4 | 47.3 | 81.4 | abc |
| 12 | 80 $NH_4NO_3$-at planting | 59.3 | 90.0 | 32.7 | 149.2 | 112.5 | 74.2 | 49.0 | 81.0 | abcd |
| 16 | 80 $NH_4NO_3$-S.D. | 50.4 | 98.4 | 46.7 | 140.7 | 113.0 | 68.1 | 43.8 | 80.2 | abcd |
| 7 | 80-Urea-fall P.U. | 61.7 | 76.9 | 36.7 | 154.5 | 104.9 | 73.0 | 37.8 | 77.9 | abcd |
| 10 | 40 $NH_4NO_3$-at planting | 66.2 | 92.0 | 45.4 | 152.2 | 99.8 | 63.4 | 23.7 | 77.5 | abcde |
| 14 | 40 $NH_4NO_3$-S.D. | 63.6 | 92.6 | 39.5 | 148.6 | 90.4 | 54.8 | 38.6 | 75.4 | bcdef |
| 5 | 40-Urea-fall-top | 62.3 | 101.3 | 37.0 | 140.7 | 84.1 | 57.4 | 30.9 | 73.4 | bcdef |
| 15 | 40-Urea-S.D. | 57.7 | 95.6 | 24.9 | 142.3 | 94.1 | 48.4 | 50.4 | 73.3 | bcdef |
| 11 | 40-Urea-at planting | 45.4 | 91.1 | 31.4 | 147.6 | 100.6 | 59.8 | 33.8 | 72.8 | cdef |
| 4 | 40-$NH_4NO_3$-fall-top | 49.0 | 96.7 | 29.6 | 140.1 | 101.5 | 45.6 | 24.3 | 69.5 | def |
| 3 | 40-Urea-fall P.U. | 55.1 | 78.2 | 29.1 | 148.8 | 100.3 | 38.8 | 19.8 | 67.2 | ef |
| 2 | 40-$NH_4NO_3$-fall P.U. | 42.3 | 87.5 | 30.9 | 148.6 | 88.3 | 34.9 | 26.8 | 65.6 | f |
| 1 | None | 49.5 | 88.2 | 26.1 | 132.6 | 72.9 | 33.1 | 11.1 | 59.1 | g |

C.V. = 11.4

It is evident that the yields over the seven years are grouped according to the nitrogen rate applied, with less consistent differences as to the source and time at which the nitrogen was applied.

The spectrographic analyses of the sixth corn leaf sampled during 1966 are shown in table no. 3.

Table 3. Spectographic Analyses of Sixth Leaf in 1966 of Continuous Corn Grown under Variable Nitrogen Fertilizer Treatment.

| Replicates | Treatment | % | | | | ppm | | | | | | | | | | % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P | K | Ca | Mg | Mn | Fe | B | Cu | Zn | Al | Sr | Mo | Co | BA | NA | Si |
| I and II | No N | .26 | 1.66 | .60 | .36 | 31 | 114 | 8 | 6 | 25 | 87 | 25 | 1.60 | .45 | 6 | .01 | .45 |
| III and IV | (1)" | .23 | 1.81 | .59 | .28 | 23 | 108 | 6 | 4 | 19 | 75 | 24 | 1.18 | .25 | 4 | .01 | .34 |
| | Avg. | .245 | 1.74 | .60 | .32 | 27 | 111 | 7 | 5 | 22 | 81 | 24 | 1.39 | .35 | 5 | .01 | .40 |
| I and II | 40 $NH_4NO_3$PV | .26 | 1.87 | .63 | .40 | 31 | 102 | 7 | 7 | 22 | 75 | 31 | 1.54 | .31 | 5 | .01 | .37 |
| III and IV | (2) " | .24 | 1.77 | .60 | .35 | 29 | 111 | 7 | 4 | 21 | 65 | 25 | 1.37 | .22 | 4 | .01 | .32 |
| | Avg. | .250 | 1.82 | .62 | .38 | 30 | 106 | 7 | 6 | 22 | 70 | 28 | 1.45 | .26 | 4 | .01 | .35 |
| I and II | 40 Urea PV | .19 | 1.28 | .45 | .29 | 24 | 75 | 5 | 7 | 17 | 53 | 17 | 1.17 | .24 | 4 | .01 | .29 |
| III and IV | (3) " | .22 | 1.45 | .51 | .36 | 28 | 114 | 8 | 4 | 21 | 63 | 24 | 1.28 | .16 | 4 | .01 | .26 |
| | Avg. | .205 | 1.37 | .48 | .32 | 26 | 90 | 6 | 6 | 19 | 58 | 20 | 1.22 | .20 | 4 | .01 | .28 |
| I and II | 40 $NH_4NO_3$ Top | .19 | 1.46 | .39 | .21 | 17 | 63 | 3 | 3 | 17 | 51 | 19 | 0.85 | .11 | 4 | .01 | .29 |
| III and IV | (4) " | .30 | 1.62 | .59 | .39 | 29 | 116 | 7 | 3 | 21 | 64 | 23 | 1.39 | .21 | 5 | .01 | .36 |
| | Avg. | .245 | 1.54 | .49 | .30 | 23 | 90 | 5 | 3 | 19 | 68 | 21 | 1.12 | .16 | 4 | .01 | .32 |
| I and II | 40 Urea Top | .22 | 1.68 | .47 | .27 | 21 | 77 | 3 | 4 | 18 | 61 | 23 | 1.18 | .20 | 4 | .01 | .34 |
| III and IV | (5) " | .20 | 1.24 | .50 | .31 | 27 | 115 | 7 | 3 | 20 | 40 | 21 | 1.15 | .22 | 4 | .01 | .25 |
| | Avg. | .210 | 1.46 | .48 | .29 | 24 | 96 | 5 | 4 | 19 | 50 | 22 | 1.16 | .21 | 4 | .01 | .30 |
| I and II | 80 $NH_4NO_3$ PV | .26 | 1.67 | .55 | .36 | 36 | 89 | 7 | 4 | 22 | 56 | 31 | 1.46 | .21 | 5 | .01 | .30 |
| III and IV | (6) " | .26 | 1.82 | .52 | .33 | 44 | 105 | 8 | 7 | 24 | 58 | 27 | 1.20 | .17 | 5 | .01 | .30 |
| | Avg. | .260 | 1.75 | .54 | .34 | 40 | 97 | 8 | 6 | 23 | 57 | 29 | 1.33 | .19 | 5 | .01 | .30 |
| I and II | 80 Urea PV | .28 | 1.91 | .61 | .45 | 45 | 102 | 6 | 6 | 30 | 82 | 26 | 1.60 | .30 | 6 | .01 | .38 |
| III and IV | (7) " | .25 | 1.53 | .64 | .49 | 37 | 102 | 8 | 18 | 25 | 121 | 30 | 1.71 | .27 | 5 | .02 | .32 |
| | Avg. | .265 | 1.72 | .62 | .47 | 41 | 102 | 7 | 12 | 28 | 102 | 28 | 1.66 | .28 | 6 | .02 | .35 |

Table 3. Analyses of Sixth Leaf(Continued).

| Replicates | Treatments | % | | | | ppm | | | | | | | | | | % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P | K | CA | Mg | Mn | Fe | B | Cu | Zn | Al | Sr | Mo | Co | Ba | Na | Si |
| I and II | 160$NH_4NO_3$ PV | .30 | 1.33 | .67 | .48 | 56 | 102 | 8 | 5 | 26 | 60 | 25 | 1.66 | .15 | 5 | .01 | .39 |
| III and IV | (8) " | .20 | 1.24 | .43 | .35 | 37 | 69 | 4 | 4 | 21 | 36 | 22 | 1.16 | .16 | 4 | .01 | .19 |
| | Avg. | .250 | 1.28 | .55 | .41 | 46 | 85 | 6 | 4 | 24 | 48 | 24 | 1.41 | .16 | 4 | .01 | .29 |
| I and II | 160 Urea PV | .33 | 2.38 | .70 | .44 | 65 | 118 | 9 | 9 | 26 | 92 | 32 | 1.62 | .30 | 5 | .01 | .41 |
| III and IV | (9) " | .19 | 1.42 | .36 | .28 | 27 | 73 | 5 | 3 | 16 | 42 | 22 | 1.05 | .18 | 3 | .01 | .17 |
| | Avg. | .260 | 1.90 | .53 | .36 | 46 | 96 | 7 | 6 | 21 | 67 | 27 | 1.34 | .24 | 4 | .01 | .29 |
| I and II | 40 $NH_4NO_3$ PL | .31 | 2.11 | .74 | .47 | 35 | 126 | 8 | 8 | 28 | 93 | 38 | 1.70 | .37 | 5 | .01 | .36 |
| III and IV | (10) " | .25 | 1.61 | .64 | .33 | 30 | 97 | 8 | 4 | 20 | 63 | 34 | 1.34 | .28 | 4 | .02 | .26 |
| | Avg. | .280 | 1.86 | .69 | .40 | 32 | 112 | 8 | 6 | 24 | 78 | 36 | 1.52 | .32 | 4 | .02 | .31 |
| I and II | 40 Urea PL. | .30 | 1.87 | .67 | .37 | 30 | 103 | 7 | 5 | 18 | 60 | 30 | 1.42 | .17 | 5 | .02 | .35 |
| III and IV | (11) " | .23 | 1.59 | .46 | .27 | 22 | 76 | 5 | 3 | 18 | 45 | 19 | 1.07 | .16 | 4 | .01 | .26 |
| | Avg. | .265 | 1.73 | .57 | .32 | 26 | 90 | 6 | 4 | 18 | 52 | 25 | 1.25 | .16 | 4 | .02 | .30 |
| I and II | 80$NH_4NO_3$ PL. | .25 | 1.97 | .56 | .37 | 34 | 106 | 7 | 4 | 21 | 74 | 35 | 1.43 | .24 | 4 | .02 | .25 |
| | | .31 | 1.41 | .72 | .47 | 32 | 109 | 8 | 5 | 21 | 81 | 29 | 1.80 | .27 | 5 | .01 | .37 |
| | Avg. | .280 | 1.69 | .64 | .42 | 33 | 108 | 8 | 4 | 21 | 78 | 32 | 1.62 | .26 | 4 | .02 | .31 |
| I and II | 80 Urea PL. | .28 | 1.59 | .64 | .39 | 30 | 126 | 7 | 4 | 23 | 81 | 22 | 1.62 | .38 | 5 | .01 | .25 |
| III and IV | (13) " | .28 | 1.59 | .57 | .38 | 35 | 96 | 6 | 7 | 23 | 57 | 23 | 1.41 | .37 | 5 | .01 | .28 |
| | Avg. | .280 | 1.59 | .60 | .38 | 32 | 111 | 6 | 6 | 23 | 69 | 22 | 1.52 | .38 | 5 | .01 | .26 |
| I and II | 40 $NH_4NO_3$ SD | .22 | 1.64 | .50 | .33 | 23 | 92 | 5 | 5 | 16 | 73 | 24 | 1.42 | .20 | 4 | .01 | .22 |
| III and IV | (14 " | .28 | 1.58 | .76 | .45 | 39 | 108 | 8 | 9 | 21 | 81 | 32 | 1.82 | .32 | 5 | .01 | .33 |
| | Avg. | .250 | 1.61 | .63 | .39 | 31 | 100 | 6 | 7 | 18 | 77 | 28 | 1.62 | .26 | 4 | .01 | .28 |

Table 3. Analyses of Sixth Leaf(Continued).

| Replicates | Treatment | % | | | | ppm | | | | | | | | | | % | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P | K | Ca | Mg | Mn | Fe | B | Cu | Zn | Al | Sr | Mo | Co | Ba | Na | Si |
| I and II | 40 Urea SD | .26 | 2.15 | .52 | .20 | 25 | 133 | 4 | 4 | 21 | 69 | 26 | 1.06 | .24 | 5 | .02 | .26 |
| III and IV | (15) " | .25 | 1.57 | .55 | .37 | 23 | 91 | 6 | 3 | 18 | 61 | 26 | 1.39 | .14 | 4 | .01 | .31 |
| | Avg. | .255 | 1.86 | .54 | .29 | 24 | 112 | 5 | 4 | 20 | 65 | 26 | 1.22 | .19 | 4 | .02 | .28 |
| I and II | 80$NH_4NO_3$ SD | .26 | 1.81 | .54 | .28 | 28 | 114 | 6 | 4 | 19 | 56 | 26 | 1.36 | .23 | 4 | .01 | .23 |
| III and Iv | (16) " | .29 | 1.90 | .59 | .38 | 35 | 95 | 9 | 6 | 22 | 76 | 24 | 1.50 | .22 | 5 | .01 | .30 |
| | Avg. | .275 | 1.85 | .56 | .33 | 32 | 105 | 8 | 5 | 20 | 66 | 25 | 1.42 | .22 | 4 | .01 | .26 |
| I and II | 80 Urea SD | .30 | 1.70 | .81 | .48 | 36 | 141 | 8 | 7 | 24 | 99 | 28 | 1.85 | .29 | 6 | .01 | .33 |
| III and IV | (17) " | .30 | 1.48 | .67 | .43 | 42 | 87 | 8 | 4 | 18 | 68 | 22 | 1.59 | .21 | 4 | .01 | .31 |
| | Avg. | .300 | 1.59 | .74 | .45 | 39 | 114 | 8 | 6 | 21 | 83 | 25 | 1.72 | .25 | 5 | .01 | .32 |
| I and II | 160$NH_4NO_3$ SD | .30 | 1.67 | .70 | .52 | 48 | 99 | 8 | 7 | 20 | 62 | 28 | 1.94 | .28 | 5 | .01 | .34 |
| | | .26 | 1.48 | .63 | .47 | 50 | 93 | 9 | 4 | 26 | 76 | 29 | 1.58 | .14 | 4 | .01 | .31 |
| | Avg. | .280 | 1.58 | .66 | .50 | 49 | 96 | 8 | 6 | 23 | 69 | 28 | 1.76 | .21 | 4 | .01 | .32 |
| I and II | Extra | .26 | 1.70 | .57 | .38 | 32 | 97 | 8 | 4 | 24 | 53 | 25 | 1.38 | .25 | 4 | .01 | .34 |
| III and IV | (19) | .25 | 1.84 | .55 | .39 | 32 | 89 | 7 | 4 | 23 | 74 | 29 | 1.39 | .18 | 4 | .02 | .27 |
| | Avg. | .255 | 1.77 | .56 | .38 | 32 | 93 | 8 | 4 | 24 | 64 | 27 | 1.38 | .22 | 4 | .02 | .31 |
| I and II | Extra | .28 | 2.06 | .47 | .24 | 24 | 93 | 7 | 3 | 22 | 69 | 22 | 1.07 | .19 | 4 | .01 | .32 |
| III and IV | (20) | .30 | 2.37 | .51 | .31 | 33 | 110 | 8 | 6 | 22 | 116 | 29 | 1.29 | .25 | 5 | .03 | .25 |
| | Avg. | .290 | 2.22 | .49 | .28 | 29 | 101 | 8 | 5 | 22 | 92 | 25 | 1.18 | .22 | 4 | .02 | .28 |

The results shown in Table 3 made available for the reader to examine and make his or her own conclusions as to the effect of nitrogen fertilizer in the concentrations of the 16 elements present in the corn leaves.

# The Effect of Urea or Ammonium Nitrate Nitrogen on the Nitrate Nitrogen Content of Webster clay loam surface soil and Different Portions of Growing Corn Plants at Lamberton in 1964, 1965, & 1966

J. M. MacGregor and W. W. Nelson

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

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

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

The entire sampling and analytical procedure was repeated in 1965, but since the corn was not planted until early June, the sampling of soil and leaf tissue for that month was omitted. The 1966 sampling commenced in mid-June as in 1964.

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

The nitrate content of the soil was directly related to the amounts of fertilizer nitrogen applied over the five to seven year period, with the relatively large amounts present in mid-June of 1964 or mid-July, 1965 & 1966, rapidly decreasing as the growing season progressed.

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

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

In the lower stalks, tissues growing on the plots (1964) receiving no

Nitrate Nitrogen Concentrations in 1964, 1965, & 1966 Corn Plants on Webster Clay Loam at Lamberton Fertilized Annually with Ammonium Nitrate or Urea
(Average of 2 replicates)

| Lbs N/A annually | Avg. Soil Nitrate-N in ppm | | | | Percentage nitrate nitrogen in corn tissues | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Leaves | | | | Upper stalks | | | Lower stalks | | |
| | June | July | August | Sept. | June | July | August | Sept. | July | August | Sept. | July | August | Sept. |
| check | | | | | | | | | | | | | | |
| 1964 | 5 | 2 | 1 | 1 | 0.28 | 0.23 | 0.03 | 0.02 | 0.06 | 0.04 | 0.02 | 0.03 | 0.03 | 0.01 |
| 1965 | - | 6 | 5 | 6 | -- | 0.25 | 0.03 | 0.02 | 0.63 | 0.02 | 0.03 | 0.92 | 0.03 | 0.02 |
| 1966 | 6 | 1 | 2 | 1 | 0.18 | 0.04 | 0.02 | 0.02 | 0.07 | 0.02 | 0.02 | 0.05 | 0.02 | 0.02 |
| 80/A $NH_4NO_3$-N (Spring) | | | | | | | | | | | | | | |
| 1964 | 19 | 5 | 3 | 2 | 0.47t | 0.06 | 0.04 | 0.02s | 0.24 | 0.07 | 0.02 | 0.72t | 0.16 | 0.05 |
| 1965 | - | 29 | 18 | 8 | -- | 0.29 | 0.04 | 0.02 | 0.72t | 0.04 | 0.02 | 1.20t | 0.11 | 0.03 |
| 1966 | 38? | 4 | 1 | 1 | 0.24 | 0.13 | 0.03 | 0.02 | 0.37 | 0.04 | 0.02 | 0.97t | 0.12 | 0.16 |
| 80/A Urea-N (spring) | | | | | | | | | | | | | | |
| 1964 | 23 | 4 | 4 | 2 | 0.44 | 0.05 | 0.04 | 0.03 | 0.25 | 0.06 | 0.03 | 0.42 | 0.30 | 0.17 |
| 1965 | - | 12 | 20 | 7 | -- | 0.33 | 0.01 | 0.03 | 0.92t | 0.02 | 0.02 | 0.81t | 0.07 | 0.02 |
| 1966 | 25 | 2 | 2 | 1 | 0.24 | 0.10 | 0.03 | 0.02 | 0.28 | 0.06 | 0.02 | 0.74 | 0.31 | 0.05 |
| 160/A $NH_4NO_3$-N (fall) | | | | | | | | | | | | | | |
| 1964 | 46 | 33 | 6 | 4 | 0.60t | 0.11 | 0.04 | 0.02 | 0.39 | 0.16 | 0.08 | 0.80t | 0.82t | 0.53t |
| 1965 | - | 9 | 5 | 8 | -- | 0.76t | 0.03 | 0.03 | 0.77t | 0.07 | 0.02 | 1.12t | 0.25 | 0.21 |
| 1966 | 16 | 4 | 2 | 5 | 0.30 | 0.16 | 0.04 | 0.03 | 0.43 | 0.11 | 0.06 | 0.95t | 0.44 | 0.70t |
| 160/A Urea-N (fall) | | | | | | | | | | | | | | |
| 1964 | 36 | 6 | 5 | 2 | 0.58t | 0.14 | 0.07 | 0.01 | 0.43 | 0.12 | 0.03 | 0.67t | 0.76t | 0.38 |
| 1965 | - | 12 | 7 | 16 | -- | 0.26 | 0.04 | 0.04 | 0.75t | 0.09 | 0.05 | 1.02t | 0.60t | 0.69t |
| 1966 | 45 | 26 | 2 | 5 | 0.31 | 0.16 | 0.08 | 0.03 | 0.51 | 0.11 | 0.01 | 1.23t | 0.60t | 0.55t |
| Manure | | | | | | | | | | | | | | |
| 1966 | 12 | 4 | 1 | 1 | 0.18 | 0.05 | 0.03 | 0.02 | 0.10 | 0.02 | 0.02 | 0.11 | 0.02 | 0.02 |
| Alfalfa[a] | | | | | | | | | | | | | | |
| 1966 | 13 | 6 | 11 | 5 | 0.23 | 0.18 | 0.06 | 0.03 | 0.47t | 0.12 | 0.03 | 1.04t | 0.28 | 0.66t |

[a]By error - 60#/A of $NH_4NO_3$-N was sidedressed on alfalfa plots in mid-July

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

nitrogen, had relatively low concentrations, but as rate of nitrogen fertilization increased (especially in July with relatively high soil nitrate levels) these tissues consistently contained toxic nitrate concentrations which decreased as the growing season progressed. The nitrate content of lower corn stalks sampled in August and September were relatively safe for feeding where nitrogen was applied annually at the 80 pound per acre rate. However, when this N fertilization rate was doubled to an annual application rate of 160 pounds per acre, the lower corn stalks contained toxic nitrate levels through the entire growing season. In the July 1965 sampling, the lower stalks of even the unfertilized corn contained toxic concentrations.

The application of farm manure at the rate of 10 tons per acre in the spring of 1966, resulted in little increase in nitrate-N of the corn tissues above that from plots receiving no nitrogen. Apparently this rate of manure application did not materially increase the nitrate content of the corn plants in 1966.

Unfortunately, the 1966 corn planted on alfalfa ground was fertilized with 60 pounds of N per acre in mid-July of 1966. The nitrate-N content of the plants increased and the information obtained was of little value.

This illustrates that heavy nitrogen fertilization and stage of corn growth results in abundant soil nitrate and toxic nitrate levels in some corn tissues grown under the conditions in 1964, 1965 and 1966. It is possible that either legume ground or soils receiving very heavy applications of barnyard manure would result in similar trends, but of lower magnitude. Nitrate nitrogen concentrations present in June, 1964 corn, and in mid July, 1965 and 1966 corn show that growth stage probably has a more important effect on nitrate nitrogen concentrations in corn tissue than N application rates.

---

(1) Olson, Oscar: Nitrate Problems in Livestock Feeds. Report of the Fourteenth Annual Soils and Fertilizer Short Course. Leamington Hotel, Mpls, Minn., November 23-24, 1964.

# Barley - Nitrogen - Protein Study

Northwest Experiment Station, Crookston, 1966
Olaf C. Soine, J. M. MacGregor

This experiment was started in 1964 to study the effect of nitrogen alone and in combinations with phosphate and potash on the yield, bushel weight and protein content of barley. The field work was done by this Station and the protein analysis by the Department of Soil Science.

The 2 nitrogen treatments were broadcast before seeding and the treatments 0-40-0, 10-40-0, 20-40-20, and 20-40-0 were applied in a band at seeding time, alone and in combination with the nitrogen - broadcast. For example, the treatment *10-40-0 means that 10-0-0 was broadcast and *0-40-0 was applied in a band at seeding time on the same plot.

The barley varieties and fertilizer treatments were randomized and replicated 4 times.

Sugarbeets were grown on this land in 1965.

The yield in bushels per acre for Larker, Parkland and Trophy is given in Table 1, with an average for the 3 varieties and Duncan's Range of significance.

The **40-40-20 treatment gave the highest yield for all varieties, and averaged 16 bushels more per acre than the check plot. The first 5 treatments in Table 1, with the broadcast rate of **20-0-0 produced the highest yields and were higher than the next group of treatments with the *10-0-0 broadcast. The treatments without any broadcast were the lowest.

Table 2 gives the bushel weights for the 15 different treatments and shows that Larker has the highest bushel weights followed by Parkland and Trophy respectively.

Table 1. Barley - Nitrogen - Protein Study
Northwest Experiment Station - 1966

| Treatment lbs./acre $N-P_2O_5-K_2O$ | | | Yields in bushels per acre Larker | Parkland | Trophy | Ave. | Duncan's Range |
|---|---|---|---|---|---|---|---|
| **40 | 40 | 20 | 48.7 | 48.5 | 48.5 | 48.58 | |
| **40 | 40 | 0 | 49.8 | 44.8 | 43.4 | 46.01 | |
| **20 | 0 | 0 | 44.9 | 44.8 | 46.8 | 45.48 | |
| **30 | 40 | 0 | 45.0 | 43.7 | 46.9 | 45.20 | |
| **20 | 40 | 0 | 45.6 | 41.7 | 45.5 | 44.26 | |
| *30 | 40 | 0 | 46.4 | 42.4 | 42.9 | 43.90 | |
| *30 | 40 | 20 | 47.0 | 38.6 | 44.0 | 43.20 | |
| *20 | 40 | 0 | 47.3 | 37.6 | 39.9 | 41.59 | |
| *10 | 40 | 0 | 40.7 | 35.6 | 41.0 | 39.11 | |
| *10 | 0 | 0 | 40.4 | 34.6 | 39.8 | 38.29 | |
| 20 | 40 | 20 | 38.7 | 34.9 | 39.3 | 37.64 | |
| 20 | 40 | 0 | 37.6 | 35.0 | 36.8 | 36.47 | |
| 10 | 40 | 0 | 38.4 | 33.8 | 37.1 | 36.41 | |
| 0 | 40 | 0 | 34.2 | 30.0 | 35.3 | 33.15 | |
| 0 | 0 | 0 | 34.0 | 29.1 | 34.6 | 32.54 | |

Barley sown: May 5; harvested July 25, 1966.
Treatments *10-0-0 and **20-0-0 broadcast before seeding; remaining treatments applied in a band at seeding with and without the nitrogen broadcast treatments.

Table 2. Barley - Nitrogen - Protein Study
Northwest Experiment Station - 1966

| Treatment lbs./acre N-$P_2O_5$-$K_2O$ | | | bushel weight Larker | Parkland | Trophy | Average |
|---|---|---|---|---|---|---|
| **40 | 40 | 20 | 47.8 | 46.0 | 44.0 | 45.9 |
| **40 | 40 | 0 | 47.0 | 46.0 | 42.8 | 45.3 |
| **20 | 0 | 0 | 48.3 | 45.5 | 43.0 | 45.6 |
| **30 | 40 | 0 | 47.5 | 46.8 | 42.8 | 45.7 |
| **20 | 40 | 0 | 46.3 | 45.8 | 43.5 | 45.2 |
| *30 | 40 | 0 | 47.5 | 45.3 | 43.5 | 45.4 |
| *30 | 40 | 20 | 47.8 | 46.3 | 44.0 | 46.0 |
| *20 | 40 | 0 | 47.5 | 46.5 | 43.8 | 45.9 |
| *10 | 40 | 0 | 47.8 | 45.3 | 43.8 | 45.6 |
| *10 | 0 | 0 | 48.0 | 45.3 | 42.8 | 45.4 |
| 20 | 40 | 20 | 47.5 | 45.5 | 44.3 | 45.9 |
| 20 | 40 | 0 | 47.5 | 46.0 | 43.3 | 45.6 |
| 10 | 40 | 0 | 47.8 | 45.8 | 43.5 | 45.7 |
| 0 | 40 | 0 | 47.8 | 45.3 | 43.8 | 45.6 |
| 0 | 0 | 0 | 47.5 | 45.5 | 43.0 | 45.3 |

The protein data is given in Table 3 for Larker, Parkland and Trophy with an average for the three varieties. The protein content is low for all three varieties and is considerably lower than the 1965 trials. Parkland had the highest protein content of the three varieties.

The higher rates of nitrogen did not influence the protein content when compared to the check. The treatments 0-40-0 and 0-0-0 were equal to, or slightly higher than, the other treatments.

Sugarbeets were grown on this field in 1965 and may in part account for the low protein. The high temperatures during midsummer and the presence of Septoria were also contributing factors.

Table 3. Percent protein in Larker, Parkland and Trophy - 1966

| Treatment lbs./acre N-$P_2O_5$-$K_2O$ | | | Percent Protein Larker | Parkland | Trophy | Ave. |
|---|---|---|---|---|---|---|
| **40 | 40 | 20 | 10.5 | 11.2 | 10.8 | 10.8 |
| **40 | 40 | 0 | 10.8 | 11.3 | 10.6 | 10.9 |
| **20 | 0 | 0 | 10.7 | 11.3 | 10.8 | 10.9 |
| **30 | 40 | 0 | 10.6 | 10.7 | 10.5 | 10.6 |
| **20 | 40 | 0 | 10.6 | 10.8 | 9.9 | 10.4 |
| *30 | 40 | 0 | 10.4 | 10.8 | 10.7 | 10.6 |
| *30 | 40 | 20 | 10.2 | 10.9 | 10.4 | 10.5 |
| *20 | 40 | 0 | 10.6 | 11.0 | 10.2 | 10.6 |
| *10 | 40 | 0 | 10.6 | 11.2 | 10.6 | 10.8 |
| *10 | 0 | 0 | 10.5 | 11.3 | 11.0 | 10.9 |
| 20 | 40 | 20 | 10.6 | 11.2 | 10.3 | 10.7 |
| 20 | 40 | 0 | 11.3 | 11.1 | 10.2 | 10.9 |
| 10 | 40 | 0 | 10.7 | 11.1 | 10.3 | 10.7 |
| 0 | 40 | 0 | 10.8 | 11.6 | 10.7 | 11.0 |
| 0 | 0 | 0 | 10.6 | 10.9 | 10.8 | 10.8 |

# Fall vs Spring Nitrogen Fertilization of Small Grains in West Polk County in 1965-66

G.W. Randall, S.L. Bigger and J.M. MacGregor

On October 27, 1965, following the removal of the sugar beet crop, experimental plots were established on two fields in the Crookston area to determine the effect of the time of application of nitrogen fertilizer on the yield of spring wheat. Soils of both fields consisted of a Fargo-Bearden complex, therefore, high clay contents. At this time a randomized block design consisting of five treatments replicated six times was established, and the application of nitrogen on the fall treatments was completed. On May 9, 1966, just prior to seeding, the nitrogen was applied to the spring treatments, all nitrogen being applied as ammonium nitrate. A blanket treatment of 40 lbs. $P_2O_5$ was also applied by the farmer cooperators. Due to the ensuing weather conditions, one of the fields was seeded to oats rather than to spring wheat.

Climatic conditions for the duration of this experiment are shown in table 1. Temperature data show that January and February were much colder with June and July being warmer than average. The small grain yields, being somewhat lower than expected, may be attributed to the adverse affect of these high temperatures during July. Rainfall during this nine month period was below normal with substantial rainfall only in June.

Table 1. Temperature and precipitation data in the Crookston area during the nine month period November 1, 1965 to August 1, 1966.*

| | Temperature | | Precipitation | |
|---|---|---|---|---|
| Month | Average | Departure | Average | Departure |
| November | 25.4 | -1.4 | .56 | -.38 |
| December | 18.6 | 6.1 | .71 | .13 |
| January | -9.0 | -14.2 | .16 | -.41 |
| February | 3.2 | -6.0 | .23 | -.32 |
| March | 27.2 | 4.1 | .95 | .06 |
| April | 36.9 | -4.2 | 1.25 | -.11 |
| May | 51.0 | -3.9 | 1.31 | -1.19 |
| June | 65.7 | 1.9 | 4.49 | .90 |
| July | 72.4 | 2.2 | 3.17 | .22 |
| Total | | | 12.83" | |
| Average | | -1.7° | | -1.10" |

* Source - Climatological Data, Minnesota, U.S. Dept. of Commerce. Vol. 71. No. 11 - Vol. 72. No. 7.

Visual observations of the spring wheat plot on August 4, (the harvesting date), showed that all plots receiving the 80 pound rate of N to be somewhat lodged. Also,

wheat receiving the spring application of N seemed to have better growth. The treatments and average yields are given in table 2.

Table 2. Nitrogen treatments, average 1966 yields and significance of rate and time of application of N fertilizer to Chris spring wheat on the Gerhard Ross farm (Polk County, Minnesota).

| Treatment | Yield (6 rep. Avg.) | Significance[a] |
|---|---|---|
| 1. None | 23.3 bu/A | a |
| 2. 40# N Fall | 28.6 " | b |
| 3. 40# N Spring | 33.4 " | c |
| 4. 80# N Fall | 31.1 " | bc |
| 5. 80# N Spring | 33.0 " | c |

[a] According to Duncan's Multiple Range Test, those yields with similar letters are not significantly different at the .05 level.

Wheat yields from all four nitrogen treatments were significantly higher than the yields from the check. The 40 and 80 pound spring treatments and the 80 pound fall treatment, (with no significant differences) produced the highest yields. Averaging the 40 and 80 pound N rates, the wheat yield from the spring applications was 33.2 bu/a in comparison to the 29.8 bushel yield from the fall applications. Also, the averages of the combined application times of the 40 and 80 pound N rates were 31.0 and 32.0 bu/acre, respectively.

The oats plot was harvested on August 10. At this time, because of the high rat of N, the oats on almost all 40 pound and on all 80 pound treatments were lodged. A green color of the oats was noticed on the 80 pound treatments, evidence that it may have lodged even before reaching maturity. The check treatment, showing a thinner stand of oats, was still standing. Table 3 shows the treatments and oat yields from this experiment.

Table 3. Nitrogen treatments, average 1966 yields and significance of rate and time of N application for oats on the Ray Eggert farm. (Polk County, Minnesota)

| Treatment | Yield (6 rep. avg.) | Significance |
|---|---|---|
| 1. None | 65.8 bu/a | b |
| 2. 40# N Fall | 61.1 " | ab |
| 3. 40# N Spring | 68.1 " | b |
| 4. 80# N Fall | 54.1 " | a |
| 5. 80# N Spring | 64.4 " | b |

[a] According to Duncan's Multiple Range Test, those yields with similar letters are not significantly different at the .05 level.

Yields from this experiment on oats were obviously affected by the lodging. Combining the 40 and 80 pound treatments, the oat yields of the fall and spring treatments were 57.6 and 66.2 bushels/acre, respectively. Also, with the fall and spring treatments combined, the yields for the 40 and 80 pound treatments were 64.6

and 59.2 bushels/acre, respectively.

It is apparent that spring N application was more effective for increasing wheat yield than the fall treatment, but oat lodging precluded such evidence with oats in 1966.

North Central Experiment Station
Grand Rapids, Minnesota
1966

# The Effect of Rate and Split Versus Single Applications of Nitrogen on Yields of Bromegrass

Richard H. Anderson

Results of an experiment conducted in 1964 - 1965 on bromegrass grown on sandy loam soil showed that nitrogen topdressed in the spring was more effective than when applied the previous fall. One hundred pounds (the highest rate) gave the highest yield but not significantly higher than with the 67 pound nitrogen rate. The effect of rate of nitrogen fertilizer was not observable in regrowth following removal of the first crop.

Table 1. Bromegrass yields in response to fall or spring nitrogen application.

| Rate of N (lbs) | Fall Application (Tons) | Spring Application (Tons) |
|---|---|---|
| 0 | 1.66 | 1.66 |
| 33.5 | 2.02 | 2.55 |
| 67.0 | 2.93 | 3.73 |
| 100.0 | 3.53 | 3.84 |

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

The 1966 experiment was designed to study:

1. The effect of rate of nitrogen topdressing.
2. The effect of split applications.

Procedure:

1. Four replications were provided with six plots in each measuring 30 inches by 54 feet.
2. The bromegrass to which the nitrogen was applied had been seeded in 1964 as a varietal trial. Fertilizer plots were oriented perpendicular to and crossing all varietal plots.
3. Fertilizer rates selected were, in addition to a check, 50, 100, and 150 lbs of N applied once, and 100 and 150 lbs split in equal parts of 50 + 50 and 75 + 75, respectively, and applied at two dates. The first applications were made on May 6, 1966. The second application of the split treatment was made on June 15.

4. Harvests were taken on June 14 and August 24, 1966. Swaths 15 inches wide were taken over the full length of each plot. Samples were dried to determine moisture content and yields computed in tons per acre. (15% moisture content basis).

Table 2. Bromegrass yields at several levels of nitrogen fertilization.

| Nitrogen Rates Lbs N Per/Acre | Yield in Tons Per Acre | | | | | |
|---|---|---|---|---|---|---|
| | 1st Cutting | Test of Signifi.* | 2nd Cutting | Test of Signifi.* | Season Total | Test of Signifi.* |
| Check | 1.15 | c | .64 | d | 1.79 | d |
| 50 | 1.77 | b | .68 | d | 2.45 | c |
| 50 + 50 | 1.78 | b | 1.53 | b | 3.31 | b |
| 100 | 2.10 | a | .84 | cd | 2.94 | b |
| 75 + 75 | 1.96 | ab | 1.93 | a | 3.89 | a |
| 150 | 2.04 | ab | 1.01 | c | 3.05 | b |

* Duncan's Multiple Range Test. Treatment means with a common letter are not statistically different at the one percent level.

In this test, early season yields (first cutting) are increased by all rates of nitrogen fertilization.

Yields at the lowest rate, 50 lbs N per acre, are not significantly lower than yields at the highest rate, 150 lbs N per acre, in the first cutting.

The split applications, providing a readily available supply of N after the first harvest, result in significantly higher yields in second cutting. Yields of plots receiving 50 lbs and 100 lbs of N at one time were not significantly greater than check plot yields in the second cutting. The rate of 150 lbs N applied at one time apparently contributed something to yield in the second cutting but less than the effect of the second application of N at either the 50 lb. or 75 lb. level.

Split applications of 75 lbs. N before the growing season and 75 lbs. during the growing season produced the highest total season yields. No significant difference existed between yields where100 lbs., 150 lbs., or two 50 lb. applications were made.

Conclusions:

1. On sandy soil, nitrogen applications should be made as near as possible to the time of demand by the crop.

2. An efficient rate of nitrogen topdressing of grasslands appears to fall in a range of 50 lbs. to 100 lbs. of elemental nitrogen applied at any one time.

3. Where amounts of elemental nitrogen in excess of 100 lbs. are to be applied to a crop, significant yield advantages are to be gained by split applications timed to meet the demand of the crop.

# Comparison of Phosphorus Sources

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

A phosphorus source experiment was established at Rosemount in 1951. Twelve treatments of various phosphate materials were replicated four times across a regular rotation of corn, soybeans, wheat, and alfalfa. Potassium has been applied as required according to soil test. Lime applications were made on two replicates in the fall of 1961. In 1965 and 1966 the corn was sidedressed with 60 and 80 lbs of N/acre respectively.

Table 1
The effect of various phosphate fertilizers on yield of corn, wheat, soybeans and alfalfa. (Port Byron silt loam - Rosemount, 1966).

| Treatments | Rate lbs.$P_2O_5$ A/yr. | Alfalfa 1st cut. Tons/ acre | Alfalfa 2nd cut. Tons/ acre | Alfalfa Total Tons/ acre | Corn 1 bu/ acre | Wheat bu/ acre | Soybean bu/ acre |
|---|---|---|---|---|---|---|---|
| None | 0 | 1.9 | 1.4 | 3.3 | 90.5 | 15.5 | 11.2 |
| Ord. Superphosphate | 40 | 2.6 | 2.0 | 4.7 | 86.3 | 21.6 | 7.8 |
| Conc. Superphosphate | 40 | 2.9 | 2.1 | 5.0 | 82.5 | 24.4 | 10.0 |
| Calcium Metaphosphate | 40 | 2.4 | 1.8 | 4.2 | 93.9 | 19.8 | 9.3 |
| Phosphoric acid | 40 | 2.7 | 2.0 | 4.7 | 88.8 | 23.2 | 11.0 |
| Fuzed Tricalcium Phosphate | 40 | 2.5 | 1.7 | 4.2 | 88.8 | 23.8 | 12.1 |
| Florida Rock and ord. Super | 20+20 | 2.5 | 1.8 | 4.2 | 91.9 | 23.1 | 9.7 |
| Florida Rock Phos. | 100 | 2.8 | 1.9 | 4.7 | 96.2 | 23.3 | 12.4 |
| lbs. $P_2O_5$/A/4yrs. | | | | | | | |
| Fl. Rock Phosphate | 1000 | 2.8 | 1.8 | 4.6 | 87.5 | 22.5 | 10.4 |
| Western Rock Phosphate | 1000 | 2.7 | 2.1 | 4.8 | 92.9 | 23.1 | 11.9 |
| Colloidal Clay Rock Phos. | 1000 | 2.2 | 1.8 | 4.0 | 95.3 | 18.4 | 11.3 |
| Tunisian Rock Phos. | 1000 | 2.6 | 1.9 | 4.6 | 88.6 | 18.8 | 11.1 |

The 1966 crop yields are shown in table 1 . The most consistent effect of the phosphate treatments has been to increase alfalfa yields. All sources were effective regardless of P solubility. The sidedressed application of Nitrogen to the corn has apparently eliminated effects of the phosphate on corn. Evidently at least part of the effects noted in past years may have been due to benefits derived from the increased vigor and nitrogen fixation by the preceding alfalfa crop. Whea yields have been increased by phosphate treatments in 1966 and in most past years. Generally the more available forms of P have been most effective for this crop. Soybeans have given erratic response in past years as in 1966. There are some indi tions that the level at which potassium is being applied may not be sufficient to supply the needs of all the crops in the rotation. It is also noteworthy to mentio that it has been difficult to maintain good weed control and the content is notably more difficult on the heavily fertilized plots.

Future plans call for reliming and increased applications of N and K to supply the needs of higher corn and bean populations possible with narrow row management practices.

The effect of li e and molybdenum on the yield of alfalfa, oats, corn, and soybean.

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

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

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

In 1966 yields were obtained for alfalfa, oats, corn and soybeans. The 1966 yields are shown in table 1.

Lime significantly increased alfalfa yields in the rotation, but had no significant effect on the yield of corn, oats or soybeans in 1966. In 1965 and 1966 the corn was sidedressed with additional nitrogen (60# Nitrogen 1965, 80# Nitrogen 1966) . This has tended to eliminate any beneficial effect of the lime due to increased nitrogen fixation by the alfalfa on the treated plots.

There is evidence that present fertilization practices may not be supplying adequate levels of K, Mg or some trace elements. Tentative plans are to modify the experiment by maintaining a rotation but establishing continuous corn and alfalfa.

Table 1

Effect of lime and molybdenum on the yield of alfalfa, oats, corn and soybeans. (Port Byron silt loam, Rosemount, 1966).

| Lime Treatment Tons/A | Alfalfa 1st cutting | Alfalfa 2nd cutting | Alfalfa Total Tons/acre | Corn Bu/acre | Oats Bu/acre | Soybeans Bu/acre |
|---|---|---|---|---|---|---|
| 0 | 1.09 | .75 | 1.84 | 79.9 | 60.9 | 15.5 |
| 3 | 2.07 | 1.46 | 3.53 | 83.3 | 60.1 | 14.8 |
| 6 | 2.45 | 1.55 | 4.00 | 77.7 | 58.3 | 14.4 |
| 12 | 2.46 | 1.67 | 4.13 | 86.2 | 60.2 | 11.7 |
| 24 | 2.29 | 1.55 | 3.84 | 84.3 | 61.9 | 8.87 |
| 0 +8.70z. Mo/acre | 2.09 | 1.21 | 3.30 | 77.0 | 62.2 | 12.8 |

# Comparison of Urea Ammonium Phosphates with Standard Phosphorus Sources
West Central Experiment Station
Samuel D. Evans

Plots were established at the West Central Experiment Station in 1966 to determine the effectiveness of 4 TVA urea ammonium phosphate grades as phosphorus sources for corn. These materials were compared to the standard commercial phosphorus sources.

Table 1. Chemical composition of TVA materials used.

| Nominal grade | N % Total | N % $NH_3$ | N % Urea | N % Biuret | $P_2O_5$ % Citrate avail. | $P_2O_5$ % Water soluble |
|---|---|---|---|---|---|---|
| 29-29-0 | 29.9 | 10.4 | 19.4 | 0.1 | 28.5 | 26.6 |
| 25-35-0 | 24.8 | 12.1 | 12.4 | 0.3 | 36.5 | 34.3 |
| 34-17-0 | 37.0 | 6.3 | 30.4 | 0.8 | 17.7 | 17.0 |
| 33-20-0 | 33.8 | 7.2 | 26.1 | 0.5 | 20.4 | 18.5 |

Table 2. Soil test values of the experimental area (Doland silt loam)

| | Replicate 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| PH | 7.9 | 7.8 | 7.8 | 7.8 | 7.9 | 7.9 |
| O.M. % | 5.3 | 5.3 | 5.0 | 5.7 | 6.1 | 5.9 |
| Ext. P | 8 | 8 | 9 | 9 | 11 | 7 |
| Exch. K | 220 | 200 | 170 | 180 | 140 | 200 |

Table 3. Plant height, grain yield, and ear weight.

| Treatments | Plant height July 8, 1966 inches | Yield Bu/A @ 15.5% | Average ear weight @ 15.5% |
|---|---|---|---|
| Check | 42.00 | 107.95 | 0.434 |
| 0-46-0 | 42.33 | 108.03 | 0.435 |
| 21-53-0 | 41.42 | 107.92 | 0.437 |
| 29-29-0 | 41.42 | 108.90 | 0.435 |
| 25-35-0 | 41.92 | 109.74 | 0.443 |
| 34-17-0 | 42.37 | 105.97 | 0.426 |
| 33-20-0 | 42.00 | 105.46 | 0.428 |

All plots except the check plot received a broadcast application of the various test materials to give 21.8 lbs. of P per acre. Additional nitrogen

Comparison of Urea Ammonium Phosphates with Standard Phosphorus Sources (continued)

(33 1/2-0-0) was broadcast on all plots to give a total application of 100 lbs. of N per acre. A uniform application of 50 lbs. of 6-24-24 per acre was applied in the row to all plots at planting time.

Table 4. Chemical composition of plant samples taken 6/29/66.

| | Check | 0-46-0 | 21-53-0 | 29-29-0 | 25-35-0 | 33-20-0 | 34-17-0 |
|---|---|---|---|---|---|---|---|
| K % | 4.26 | 4.00 | 4.04 | 4.04 | 4.12 | 3.96 | 3.62 |
| P % | .42 | .42 | .42 | .43 | .40 | .40 | .42 |
| Ca % | .58 | .60 | .59 | .59 | .59 | .61 | .58 |
| Mg % | .44 | .44 | .43 | .46 | .46 | .46 | .48 |
| Na % | .04 | .04 | .03 | .04 | .04 | .03 | .02 |
| Si % | .67 | .66 | .70 | .46 | .63 | .61 | .65 |
| Mn ppm | 68 | 58 | 67 | 67 | 62 | 66 | 63 |
| Fe ppm | 302 | 304 | 288 | 290 | 239 | 292 | 392 |
| Bo ppm | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Cu ppm | 8 | 8 | 9 | 6 | 7 | 8 | 8 |
| Zn ppm | 18 | 18 | 17 | 20 | 16 | 19 | 22 |
| Al ppm | 282 | 292 | 251 | 202 | 232 | 240 | 260 |
| Sr ppm | 21 | 20 | 16 | 18 | 21 | 18 | 12 |
| Mo ppm | 1.86 | 1.95 | 1.86 | 1.86 | 1.90 | 2.02 | 2.16 |
| Co ppm | 1.89 | 2.12 | 1.63 | 1.69 | 1.91 | 1.78 | 1.68 |
| Ba ppm | 7 | 6 | 6 | 8 | 6 | 7 | 8 |

Table 5. Chemical composition of leaf samples taken 8/1/66.

| | Check | 0-46-0 | 21-53-0 | 29-29-0 | 25-35-0 | 33-20-0 | 34-17-0 |
|---|---|---|---|---|---|---|---|
| K % | 2.12 | 2.23 | 2.00 | 1.85 | 2.22 | 2.27 | 2.39 |
| P % | .30 | .34 | .23 | .22 | .34 | .28 | .37 |
| Ca % | .62 | .67 | .51 | .47 | .73 | .64 | .75 |
| Mg % | .51 | .50 | .41 | .39 | .54 | .49 | .55 |
| Na % | .01 | .01 | .01 | .01 | .01 | .02 | .01 |
| Si % | .27 | .27 | .27 | .20 | .29 | .24 | .23 |
| Mn ppm | 85 | 99 | 71 | 71 | 98 | 89 | 106 |
| Fe ppm | 258 | 149 | 144 | 103 | 166 | 231 | 136 |
| Bo ppm | 4 | 4 | 3 | 3 | 5 | 3 | 5 |
| Cu ppm | 7 | 7 | 7 | 4 | 8 | 6 | 9 |
| Zn ppm | 13 | 15 | 12 | 11 | 14 | 15 | 15 |
| Al ppm | 30 | 35 | 32 | 23 | 48 | 30 | 32 |

Comparison of Urea Ammonium Phosphates with Standard Phosphorus Sources (continued)

Table 5 continued

| | Check | 0-46-0 | 21-53-0 | 29-29-0 | 25-35-0 | 33-20-0 | 34-17-0 |
|---|---|---|---|---|---|---|---|
| Sr ppm | 16 | 16 | 10 | 12 | 18 | 21 | 18 |
| Mo ppm | 2.06 | 1.76 | 1.31 | 1.47 | 2.38 | 1.81 | 2.09 |
| Co ppm | 2.00 | 1.37 | 1.20 | 1.60 | 3.19 | 1.58 | 2.05 |
| Ba ppm | 5 | 5 | 4 | 4 | 5 | 4 | 5 |

Yields and chemical analyses show no apparent difference between the test materials and standard commercial phosphorus sources. In addition, even the small amount of phosphorus applied in the starter (5.2 lbs P/acre) was sufficient for a yield of 107.95 Bu/acre on the check plot.

# 1966 Phosphorus Placement Study
## - Seed Incorporation (Pop Up) -
## Southwest Experiment Station

W. W. Nelson and G. W. Randall

An experiment was initiated in the spring of 1966 at Lamberton to determine the effect of small amounts of seed incorporated fertilizer on the 1) early growth of corn, 2) chemical composition of the plant at both an early stage and again at the silking stage and, 3) the yield of corn. The design used was a split plot with four starter treatments and two broadcast treatments all replicated five times. The corn variety planted was DeKalb 3 x 3. Small plants were harvested on June 23. Corn yields were somewhat low, probably due to the hot, dry conditions during pollination.

Plant weights and corn yields as affected by this seed incorporation of fertilizer are shown in the following tables.

Table 1. A description of the starter and broadcast treatments applied to the phosphorus placement experiment.

| | | Broadcast Treatment* | | | |
|---|---|---|---|---|---|
| | | No Broadcast | | Broadcast | |
| Starter Treatment | | 67+0+0 | | 67+60+30 | |
| Description | Nutrients | Trt. No | Application | Trt. No. | Application |
| Check | 0+0+0 | 1 | 67+0+0 | 5 | 67+60+30 |
| 2 x 2 Band | 12+48+24 | 2 | 79+48+24 | 6 | 79+108+54 |
| Seed Inc. | 3+12+6 | 3 | 70+12+6 | 7 | 70+72+36 |
| 2 x 2 Band + Seed Inc. | 15+60+30 | 4 | 82+60+30 | 8 | 82+120+60 |

*refers to broadcast $P_2O_5$ and $K_2O$ of 0+60+30.

Table 2. Average weight of 15 small plants and the average corn yield of these eight treatments.

| Treatment No. | Plant weight* | Corn Yield** |
|---|---|---|
| 1 | 491.8 gms | 51.9 bu/A |
| 2 | 772.6 | 66.8 |
| 3 | 712.0 | 58.0 |
| 4 | 973.4 | 73.2 |
| 5 | 619.8 | 62.9 |
| 6 | 897.0 | 67.3 |
| 7 | 853.0 | 74.2 |
| 8 | 1,075.2 | 72.6 |

* weight in grams of 15 small plants harvested June 23
** bushels per acre at 15.5% moisture

For appropriate statistical analysis of this split plot design, the two broadcast treatments have to be combined.

Table 3. The average plant weight and corn yield of the starter treatments with broadcast treatments combined.

| Trt. No. | Description | Plant weight | Corn yield |
|---|---|---|---|
| 1 (1+5) | Check | 555.8 gms | 57.4 bu/A |
| 2 (2+6) | 2 x 2 Band | 834.8 | 67.0 |
| 3 (3+7) | Seed Inc. | 782.5 | 66.1 |
| 4 (4+8) | 2 x 2 Band + Seed Inc. | 1,024.3 | 72.9 |

Table 4. The average plant weight and corn yield of the broadcast treatments with the starter treatments combined.

| Treatment | Plant weight | Corn yield |
|---|---|---|
| No Broadcast | 737.4 gms | 62.4 bu/A |
| Broadcast | 861.2 | 69.2 |

Table 5. Duncan's Multiple Range Test showing which means due to starter fertilizer treatment are significantly different from each other.

| Trt. No. | Description | Plant weight | Corn yield |
|---|---|---|---|
| 4 | 2x2 Band + Seed Inc | 1,024.3 a* | 72.9 a |
| 2 | 2x2 Band | 834.8 b | 67.0 ab |
| 3 | Seed Inc. | 782.5 b | 66.1 b |
| 1 | Check | 555.8 c | 57.4 c |

* weight and yield figures followed by the same letter belong to the same .05 level population.

## Interpretation of Data

### Plant weight

The green weights of the 15 small plants were found to vary significantly at the .05 level with the broadcast treatments (F - 9.08) and at the .01 level with the starter treatments (F - 46.87). The broadcasting of 0+60+30 ($P_2O_5$ amd $K_2O$) significantly increased the early plant weights from 737 gms to 861 gms. The application of starter fertilizer (Trt. 2) and seed incorporated fertilizer (Trt. 3) also significantly increased the plant weights over the check with no significant difference in weight between Trt. 2 and Trt. 3. The combination of the 2x2 Band and seed incorporated (Trt. 4) significantly increased the plant weights (1,024.3 gms) over the individual application of 2x2 Band (834.9 gms) or seed incorporated (782.5 gms).

Significant differences at the .05 level were not found among the five replications. Also, no interaction was found between the broadcast treatments and the starter treatments.

Corn Yield

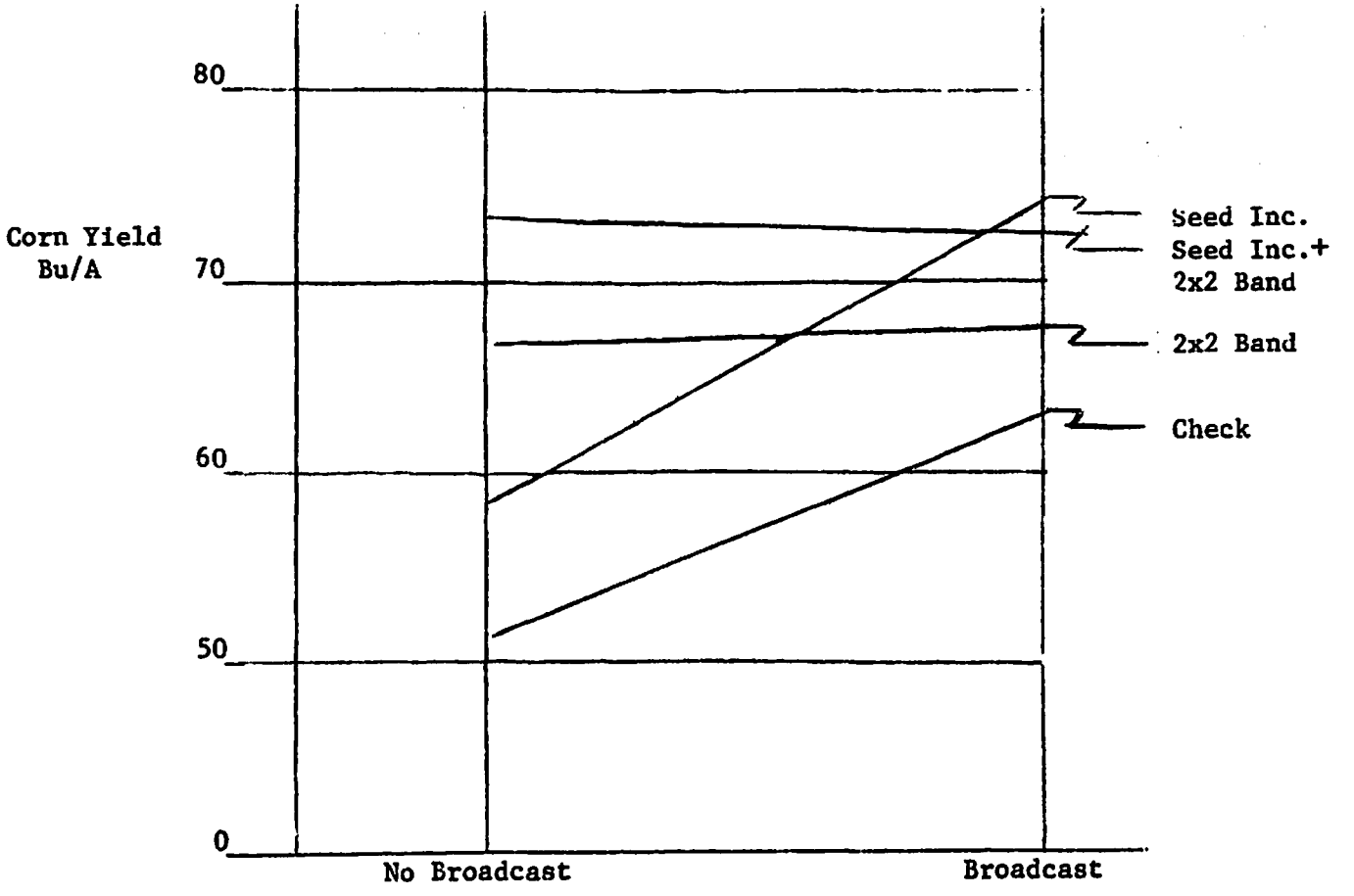
The corn yields were also found to vary significantly at the .05 level with the broadcast treatments (F - 9.52) and at the .01 level with the starter treatments (F - 17.99). The broadcasting of 0+60+30 significantly increased the yields from 62.4 to 69.2 bushels per acre. The application of 2x2 Band fertilizer (Trt. 2) and seed incorporated fertilizer (Trt. 3) also significantly increased the yields over the check with no significant difference between these two treatments. The combination of 2x2 Band and seed incorporated (Trt. 4), producing the highest yield of 72.9 bushels, gave a significant yield increase over the check (57.4 bu.) and over the seed incorporated (66.1 bu.).

The highly significant broadcast x starter interaction indicates that the yields from the check treatment (Trt. 1) and the seed incorporated treatment (Trt. 3) were significantly higher on the broadcast area than on the area where no broadcast treatment was applied. The 2x2 Band treatment (Trt. 2) and the 2x2 Band + seed incorporated treatment (Trt. 4) did not show a significant increase with broadcast fertilization. For illustration see Figure 1.

The coefficients of variability, a measure of the unexplained variation within the experiment, were quite low for both green weights and the corn yields. These values were 11.1 and 7.2, respectively, indicating that this was a very homogeneous experiment.

The linear correlation coefficient between the green plants weights and the corn yields was .645 which was significant at the .01 level.

Figure 1. The effect of the starter treatments with two broadcast treatments (Bdcst x Starter IA) on the yield of corn.



# Phosphorus Fertilization of Continuous Corn
West Central Experiment Station
Samuel D. Evans

In 1965 a phosphorus experiment was set up on Forman clay loam to determine; (1) the interaction of row and broadcast levels of phosphorus on corn yields and, (2) the effect of high phosphorus applications on the zinc content of corn leaves and corn yield.

## 1966 Yield - Bushels/acre @ 15.5% Moisture

| Broadcast Treatment lbs/A \ Row Treatment lbs/A | OP | 15P | 30P | 45P | 45P+10Zn | Average |
|---|---|---|---|---|---|---|
| OP | 98.69 | 95.55 | 93.02 | 98.96 | 102.66 | 97.77 |
| 45P | 99.38 | 92.91 | 95.36 | 91.77 | 95.04 | 94.89 |
| Average | 99.04 | 94.23 | 94.19 | 95.36 | 98.85 | |

## 1966 Leaf Sample Analysis
Phosphorus and Zinc*

| Broadcast Treatment lbs/A \ Row Treatment lbs/A | OP | 15P | 30P | 45P | 45P+10Zn |
|---|---|---|---|---|---|
| OP | .19 / 16 | .23 / 17 | .24 / 16 | .28 / 13 | .23 / 19 |
| 45P | .22 / 13 | .23 / 12 | .25 / 10 | .33 / 14 | .25 / 17 |

* Leaf taken opposite and below ear leaf. Upper value is % phosphorus and lower value is ppm zinc.

# Uptake of phosphate by roots and tops of sugarbeets

Northwest Experiment Station
Olaf C. Soine, Soil Scientist

This study was started in 1963 to attempt to measure the uptake of phosphorus by sugarbeet tops and roots by using phosphate alone and in combination with the ammonium form of nitrogen. The literature reports that several workers have noted the increased uptake of phosphorus when it is mixed with the ammonium form of nitrogen.

Three different rates of phosphate alone and in combination with 2 different rates of nitrogen were applied in a band approximately 2 inches to the side and below the seed. The plots were replicated and randomized and were seeded on land which was in black fallow the previous year.

The statistical analysis, sugar, purity, percent total nitrogen, and phosphorus determination were made by the American Crystal Sugar Company, Denver, Colorado.

Samples of the roots and tops were taken four times during the growing season for phosphorus determinations and the analysis was made by the Department of Soil Science, University of Minnesota. On August 17, 1965, samples of tops from five treatments were taken for micronutrient analysis and sent to the Department of Soils at Ohio State University.

Discussion: The data in Table 1 gives the treatment, rate, and yield per acre and percent sucrose, yield of sugar, purity, percent total nitrogen and phosphorus in p.p.m. for 1964-66.

There has been no significant differences in the yield of sugarbeets, sugar per acre, or the percent sucrose over the past 3 years. The percent purity varied slightly but the differences have not been significant. The total nitrogen content increased when phosphate and nitrogen fertilizers were added but the differences were not significant.

There was significant difference in the phosphorus - p.p.m. - between the check plot and the other treatments, but there were no significant differences between these other treatments.

The uptake of phosphorus by the tops and roots in percent for the four different sampling dates is given in tables 2 and 3. The data do not show any large uptake of phosphorus by the tops or roots of beets when nitrogen is added to the phosphate fertilizer. The largest uptake occurred during the early spring but the amount gradually decreased as the growing season progressed. The tops absorbed more phosphorus than the roots.

The micro-nutrient data for the tops are given in table 4 for the five different fertilizer treatments for 1964-65. The results for the two years were very similar. The amount of iron in the 1965 data was lower than in 1964 but the average amount appears to be above the deficiency levels. The cobalt and molybdenum content were higher in 1965 than they were in 1964.

Uptake of phosphate by roots and tops of sugarbeets
(continued)

Table 1. Uptake of phosphorus by sugarbeets - Average 1964-1966.

| Treatment | Rate per/acre | Yield tons/acre | Percent sucrose | Yield sugar lbs./acre | Purity percent | %Total nitrogen | Phos p.p.m. |
|---|---|---|---|---|---|---|---|
| check | ---- | 12.12 | 14.3 | 3470 | 84.7 | 1.04 | 543 |
| 1 P | 40 | 11.83 | 14.5 | 3436 | 84.9 | 1.13 | 625 |
| 2 P | 80 | 12.54 | 14.1 | 3549 | 85.0 | 1.05 | 623 |
| 3 P | 120 | 12.34 | 14.3 | 3620 | 85.7 | 1.01 | 625 |
| 1 N + 1 P | 10 + 40 | 12.61 | 14.3 | 3620 | 84.5 | 1.18 | 590 |
| 1 N + 2 P | 10 + 80 | 11.75 | 14.1 | 3325 | 84.7 | 1.17 | 603 |
| 1 N + 3 P | 10 + 120 | 12.37 | 14.6 | 3614 | 86.2 | 1.14 | 608 |
| 2 N + 1 P | 20 + 40 | 12.00 | 14.2 | 3417 | 84.5 | 1.08 | 585 |
| 2 N + 2 P | 20 + 80 | 12.45 | 14.5 | 3608 | 84.8 | 1.05 | 675 |
| 2 N + 3 P | 20 + 120 | 11.81 | 14.5 | 3416 | 85.2 | 1.06 | 662 |
| av. all P- treatments | | 12.24 | 14.3 | 35.35 | 85.2 | 1.06 | 624 |
| av. all 10N + P-treat. | | 12.24 | 14.3 | 35.20 | 85.1 | 1.16 | 600 |
| av. all 20N + P-treat. | | 12.09 | 14.4 | 34.80 | 84.8 | 1.06 | 641 |

L.S.D.

Page 3
Uptake of phpsphate by roots and tops of sugarbeets
(continued)

Table 2. Uptake of Phosphorus by Sugarbeet Tops 1965

| Treatment | Rate | Time of Sampling | | | |
|---|---|---|---|---|---|
| | | June 28 | July 28 | August 31 | September |
| | Lbs./Acre | Per Cent Phosphorus | | | |
| Check | - | .530 | .370 | .298 | .260 |
| 1P | 40 | .589 | .408 | .297 | .286 |
| 2P | 80 | .615 | .402 | .299 | .284 |
| 3P | 120 | .603 | .384 | .288 | .292 |
| N + 1P | 10 + 40 | .589 | .352 | .285 | .288 |
| N + 2P | 10 + 80 | .593 | .399 | .290 | .291 |
| N + 3P | 10 + 120 | .605 | .401 | .296 | .296 |
| 2N + 1P | 20 + 40 | .591 | .385 | .312 | .286 |
| 2N + 2P | 20 + 80 | .608 | .380 | .299 | .297 |
| 2N + 3P | 20 + 120 | .614 | .418 | .289 | .297 |
| Av. All P Treatments | | .602 | .398 | .295 | .287 |
| Av. All N + P Treatments | | .596 | .384 | .290 | .292 |
| Av. All N + P Treatments | | .603 | .394 | .300 | .293 |

Uptake of phosphate by roots and tops of sugarbeets.
(continued)

Table 3. Uptake of Phosphorus by Sugarbeet Roots 1965

| Treatment | Rate | Time of Sampling | | | |
|---|---|---|---|---|---|
| | | June 28 | July 28 | August 31 | September |
| | Lbs./Acre | Per Cent Phosphorus | | | |
| Check | - | .447 | .215 | .142 | .102 |
| 1P | 40 | .611 | .273 | .171 | .113 |
| 2P | 80 | .600 | .280 | .163 | .122 |
| 3P | 120 | .551 | .249 | .151 | .122 |
| 1N + 1P | 10 + 40 | .508 | .227 | .147 | .105 |
| 1N + 2P | 10 + 80 | .528 | .249 | .157 | .113 |
| 1N + 3P | 10 + 120 | .593 | .253 | .169 | .125 |
| 2N + 1P | 20 + 40 | .562 | .247 | .169 | .130 |
| 2N + 2P | 20 + 80 | .565 | .274 | .167 | .129 |
| 2N + 3P | 20 + 120 | .590 | .260 | .182 | .132 |
| Av. All P Treatments | | .587 | .267 | .162 | .119 |
| Av. All $N_1$ + P Treatments | | .543 | .243 | .158 | .114 |
| Av. All $N_2$ + P Treatments | | .572 | .260 | .173 | .130 |

Uptake of phosphate by roots and tops of sugarbeets.
(continued)

Table 4. Uptake of phosphorus by sugarbeet tops, micro-nutrient analysis. 1964-65.

| Treatment | Parts per million | | | | | | | | | | Percent | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mn | Fe | B | Cu | Zn | Al | Sr | Mo | Co | Ba | K | P | Ca | Mg. | Na | Si |
| Check | 80 | 108 | 50 | 18 | 84 | 99 | 19 | 11.8 | 1.29 | 6 | 3.2 | .30 | .78 | 1.03 | .83 | .09 |
| 40# P | 59 | 103 | 46 | 13 | 86 | 93 | 19 | 8.9 | .78 | 6 | 3.0 | .26 | .55 | .82 | .90 | .08 |
| 120# P | 61 | 93 | 49 | 15 | 89 | 79 | 17 | 33.0 | 1.04 | 5 | 2.6 | .33 | .62 | .94 | .90 | .08 |
| 20# N + 40# P | 72 | 127 | 50 | 18 | 92 | 105 | 21 | 34.9 | 1.07 | 9 | 2.9 | .33 | .76 | 1.00 | 1.09 | .10 |
| 20# N + 120# P | 79 | 96 | 50 | 15 | 79 | 84 | 20 | 30.8 | .98 | 8 | 3.0 | .32 | .72 | .99 | .81 | .08 |

Sugarbeet roots - 1964

| Treatment | Parts per million | | | | | | | | | Percent | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mn | Fe | B | Cu | Zn | Al | Sr | Mo | Co | K | P | Ca | Mg | Na | Si |
| Check | 24 | 19 | 13 | 8 | 29 | -1 | 8 | .4 | .6 | .98 | .09 | .10 | .23 | 1.38 | .05 |
| 40# P | 20 | 21 | 14 | 7 | 37 | -1 | 8 | .6 | .8 | .77 | .15 | .10 | .26 | 1.20 | .05 |
| 120# P | 22 | 21 | 13 | 5 | 30 | -1 | 3 | .4 | .5 | .74 | .18 | .10 | .24 | 1.36 | .05 |
| 20 # N +40# P* | 20 | 17 | 12 | 4 | 18 | -1 | 9 | .2 | .3 | .72 | .13 | .09 | .23 | 1.30 | .05 |
| 20# N + 120# P | 22 | 19 | 13 | 6 | 31 | -1 | 8 | .5 | .6 | .96 | .15 | .10 | .23 | 1.38 | .05 |

*One replicate

# SULFUR INVESTIGATIONS ON SOILS AND CROPS

Summary - December 1966

A. C. Caldwell, J. Grava, E. C. Seim, G. W. Rehm
and W. P. Martin

Department of Soil Science

University of Minnesota

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

This report summarizes yield data and analytical studies completed or in progress since July 1966. A brief review of the work in progress and future plans is included.

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

## Results and work in progress

In 1966 field studies were again conducted at the Park Rapids, Minnesota sulfur experimental field. Experiments begun in previous years on alfalfa, corn, small grain, and potatoes were continued in 1966. Yields and composition of red clover-brome hay were obtained from trials established in 1965. Supplemental irrigation was practiced on all crops.

In 1966 annual applications of sulfur and gypsum approximately doub-

led the yield of alfalfa. Yields ranged from 2.0 tons to 4.2 tons despite an extremely late start in the spring which delayed and decreased the 1st cutting yield. Elemental sulfur and gypsum were equally effective in increasing yield. All sulfur treatments significantly increased the sulfur content of the tissue.

Sulfur treatment applied in 1962 continued to increase alfalfa yields in 1966. One hundred pounds of elemental sulfur and 1000 lbs of sulfur as gypsum continued to maintain alfalfa yields at near maximum levels. Intermediate rates of sulfur continued to produce yield increases but tissue analysis indicates that sulfur levels in the tissue have fallen to limiting levels. ($<$ 2%).

Similar results were obtained from the yield data and tissue analysis of another study of alfalfa following corn. Adequate sulfur treatments have increased alfalfa yields from 2.1 to 4.7 tons per acre for three cuttings in 1966. Tissue analysis indicates that all residual treatments except 100 lbs. of elemental sulfur per acre are running out. Plots which received sulfur plus trace elements showed no additional benefit beyond what could be attributed to the sulfur supplied.

Yields of small grain were disappointing in 1966 despite an adequate supply of moisture, increased seeding rate, and higher nitrogen application. This is attributed largely to an adverse season. Despite the low yields, 10 lbs. of sulfur increased barley yields by 4 to 11 bushels and significantly increased the sulfur content of the tissue. Sodium sulfate was most effective in increasing yield and sulfur content, followed by elemental sulfur and gypsum.

Oat yields were increased by 4 to 8 bushels per acre by the sulfur treatment with corresponding increases in the sulfur content of the whole

plant tissue.

Increases in wheat yields were smaller (1.7 to 6.0 bushels per acre) and did not show a consistent advantage for any particular sulfur material. The highest mean yield was produced by the gypsum treatment (10 #S/acre). All sulfur treatments increased the sulfur content of the whole plant tissue but it is interesting to note that the sulfur content of the control plants was greater than .2% (.251) which is much higher than the sulfur content of untreated oat and barley plants (.172 and .195% respectively).

In 1966 corn yields of 110-114 bushels were produced with an 85 day hybrid but the 4 bushel increase due to sulfur treatment was not significant at the 5% probability level. Sulfur deficiency symptoms were evident early in the season but were outgrown as the season advanced. Treated corn was consistently drier than the untreated corn.

Red Clover-brome showed significant increases in yield and sulfur content of the hay due to sulfur treatment applied at the time of seeding or to the preceding small grain crop. On untreated plots the red clover was a pale yellowish-green color, was shorter and slower maturing. Treated clover was vigorous and dark-green in color. Sulfur contents of brome and red clover were essentially the same for similar sulfur treatments indicating that both species competed equally for the available sulfur supply.

Yield of Russet Burbank potatoes averaged 543 bushels/acre but there was no significant increase in yield or specific gravity due to sulfur treatment at the 5% probability level. Sulfur content of the petioles at midseason was significantly increased by the sulfur treatment.

The analyses of corn, oat, barley, and wheat grain and potatoe tubers for total sulfur contents are in progress. Plans also provide for a num-

ber of samples to be analyzed for N, P, K, and trace elements.

A survey of pH, organic matter, extractable phosphorus and exchangeable potassium levels on the soils of the experimental plots indicated that annual applications of 100# of sulfur in the elemental form have reduced the pH of the 0-1 and 1-2 inch depths to 4.7 and 5.2 respectively. The pH of the surface two inches of unsulfured plots is 6.8 and 6.2 respectively. As a result of this survey a more extensive sampling of the soil is planned.

The study of the movement of sulfate sulfur in the profile is continuing. Samples were taken at the beginning and end of the 1966 growing season and analyses are nearing completion.

The measurement of sulfur in the rainwater and in the atmosphere is continuing.

New Studies

New studies on the effect of $NH_4^+$ and $NO_3^-$ on the uptake of the sulfate ion are just getting underway. These studies will involve the use of $N^{15}$ and $S^{35}$ to follow the uptake of N and S into the plants. Studies are also beginning on the absorption of sulfur dioxide and hydrogen sulfide by soil and soil components.

Plans are also being readied to test the effect of several new sulfur-bearing fertilizers at the sulfur experimental field in 1967.

# SULFUR INVESTIGATIONS ON SOILS AND CROPS

Report No. 9

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

Department of Soil Science
University of Minnesota

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

This report includes 1966 yield data and analytical studies completed or summarized since July 1966. A brief review of the work in progress and future plans is included.

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

## Field Research

In 1966 field studies were again conducted at the Park Rapids, Minnesota sulfur experimental field. Experiments begun in previous years on alfalfa corn, small grain and potatoes were continued in 1966. Yield and composition data were obtained for the red clover-brome trials established in 1965. (The potatoes were irrigated on a regular schedule. Other crops received supplemental irrigation when necessary.)

### Alfalfa

Two studies with several rates and types of sulfur on alfalfa were established in 1962. One study measures the effect of the various materials applied annually. The other study measures the residual effect of the 1962 sulfur treatments. The experiments compare the effects of three rates of elemental sulfur (25, 50, 100 lbs. S/acre) and a 50 lb. S/acre application of gypsum with a control (0 lbs. S/acre). An additional heavy gypsum application (1000 lbs. S/acre) was included in the residual study. All plots received complete applications of phosphorus and potassium according to soil tests at the beginning of the experiment. Borax (20 lbs/acre) was applied after the 1st cutting in 1962 and after the 2nd cutting in 1965. Additional potassium has been topdressed as needed. The results of previous years have been presented in reports 1-8.

In 1966 three cuttings of alfalfa were taken. The 1966 yield results for the annually applied S treatments are reported in Table 1. Table 2 contains the 1966 yield results for the residual treatments. Total sulfur content of the alfalfa tissue is reported in tables 3 and 4.

Table 1. Effect of annual applications of sulfur-bearing materials on the yield of alfalfa (1966).

| Material | Rate lbs S/acre | 1st cut tons/acre | 2nd cut tons/acre | 3rd cut tons/acre | total tons/acre |
|---|---|---|---|---|---|
| None | 0 | .74 | .72 | .60 | 2.06 |
| Sulfur | 25 | 1.17 | 1.55 | 1.39 | 4.11 |
| Sulfur | 50 | 1.20 | 1.42 | 1.26 | 3.88 |
| Sulfur | 100 | 1.26 | 1.43 | 1.21 | 3.90 |
| Gypsum | 50 | 1.20 | 1.65 | 1.38 | 4.23 |
| lsd (.05) | | .21 | .39 | .23 | .69 |
| (.01) | | .29 | .54 | .32 | .94 |
| hsd (.05) | | .31 | .48 | .33 | .94 |
| (.01) | | .38 | .60 | .42 | 1.23 |

Table 2. Residual effect of sulfur-bearing materials on the yield of alfalfa (1966).

| Material | Rate lbs S/acre* | Yield 1st cut tons/acre | 2nd cut tons/acre | 3rd cut tons/acre | total tons/acre |
|---|---|---|---|---|---|
| None | 0 | .70 | .45 | .36 | 1.51 |
| Sulfur | 25 | 1.19 | 1.03 | .78 | 3.00 |
| Sulfur | 50 | 1.28 | 1.28 | .93 | 3.49 |
| Sulfur | 100 | 1.40 | 1.57 | 1.17 | 4.14 |
| Gypsum | 50 | 1.13 | .99 | .68 | 2.80 |
| Gypsum | 1000 | 1.26 | 1.47 | 1.09 | 3.82 |
| lsd (.05) | | .19 | .23 | .12 | .46 |
| (.01) | | .25 | .30 | .16 | .62 |
| hsd (.05) | | .28 | .34 | .18 | .69 |
| (.01) | | .34 | .42 | .22 | .85 |

*applied in 1962.

Table 3. Effect of annual applications of sulfur-bearing materials on the sulfur content of alfalfa (1966).

| Material | Rate lbs. S/acre | Sulfur content of tissue (%) 1st cut | 2nd cut | 3rd cut |
|---|---|---|---|---|
| None | 0 | .158 | .189 | .208 |
| Sulfur | 25 | .303 | .375 | .330 |
| Sulfur | 50 | .344 | .411 | .365 |
| Sulfur | 100 | .381 | .440 | .389 |
| Gypsum | 50 | .351 | .379 | .289 |
| lsd (.05) | | .025 | .031 | .032 |
| (.01) | | .035 | .042 | .043 |
| hsd (.05) | | .036 | .044 | .046 |
| (.01) | | .046 | .055 | .057 |

Table 4. Residual effect of sulfur-bearing materials on the sulfur content of alfalfa (1966).

| Material | Rate lbs. S/acre | Sulfur content of tissue (%) 1st cut | 2nd cut | 3rd cut |
|---|---|---|---|---|
| None | 0 | .146 | .171 | .206 |
| Sulfur | 25 | .175 | .165 | .200 |
| Sulfur | 50 | .189 | .213 | .220 |
| Sulfur | 100 | .242 | .250 | .261 |
| Gypsum | 50 | .169 | .166 | .198 |
| Gypsum P | 1000 | .343 | .327 | .329 |
| lsd (.05) | | .043 | .030 | .035 |
| (.01) | | .058 | .041 | .048 |
| hsd (.05) | | .064 | .045 | .053 |
| (.01) | | .078 | .055 | .065 |

In 1966 annual applications of sulfur and gypsum approximately doubled the yield of alfalfa. Yields ranged from 2.0 tons to 4.2 tons despite an extremely late start in the spring which delayed and decreased the 1st cutting yield. Elemental sulfur and gypsum were equally effective in increasing yield. All sulfur treatments significantly increased the sulfur content of the tissue. (Table 3).

Sulfur treatment applied in 1962 continued to increase alfalfa yields in 1966. One hundred pounds of elemental sulfur and 1000 lbs. of sulfur as gypsum continued to maintain alfalfa yields at near maximum levels (Table 2). Intermediate rates of sulfur continued to produce yield increases but tissue analysis indicates that sulfur levels in the tissue have fallen to levels which are not significantly different from the level in the untreated alfalfa (Table 4) and have fallen below the .3% level necessary for maximum yields. Only the 1000#S application as gypsum continues to supply sulfur at levels sufficient to maintain tissue sulfur at .3% or greater.

The third cutting was taken at a somewhat less mature stage than the first and second cuttings to allow sufficient time for recovery before frost. This probably accounts for the generally higher sulfur content of the tissue from the third cutting plants.

Alfalfa following corn

Alfalfa was seeded in 1963 to an area which had been in corn in 1962. Treatments were modified to include a check; the residual effect of elemental sulfur applied in 1962 at the rate of 25, 50 and 100 lbs. of S per acre; gypsum at 60 lbs. S per acre; the residual effect of 10 lbs. of S per acre as $K_2SO_4$ and 16-20-0-S applied to the corn; and a sulfur plus trace element treatment that supplied a total of 25 lbs. of sulfur per acre. No additional sulfur was applied in 1964 or 1965. In 1964 only the second cutting was taken

for yield as the 1st cutting was severely hit by drought. In 1965 and 1966 supplemental irrigations made it possible to obtain three cuttings. The 1966 yield data are reported in Table 5. Sulfur treatments increased alfalfa yields from 2.1 to 4.7 tons per acre for three cuttings in 1966. Plots which received sulfur plus trace elements showed no additional benefit beyond what could be attributed to the sulfur supplied.

The sulfur content of the alfalfa tissue is reported in Table 6. The data indicate that sulfur has reached a limiting level on all plots. Only the 100 lbs. per acre of elemental sulfur treatment has produced alfalfa with adequate levels of sulfur in the tissue for normal growth, (.254 to .287%). Even this is below the .3% level established by Alway and reconfirmed by our past experiments as being necessary for maximum yields. Despite the low levels of sulfur in the tissue yield increases were still obtained by some treatments. For example, the trace element + S treatment and the 25 lbs. of elemental sulfur per acre treatments have sulfur contents which do not differ significantly from the sulfur content of the checks, but the yields are significantly better than the check yields. We may assume therefore on the basis of the past history of the $K_2SO_4$, N-P-S treatments that next year there will be no significant effect of these two residual sulfur applications on the yield of the alfalfa.

Alfalfa-general

The alfalfa received a total of 15.76 inches of precipitation during the growing season and 10.25 inches of supplemental irrigation. Two inches of water were applied after each cutting to speed recovery and three other irrigations were made during periods of moisture stress. The total water received by the crop was therefore 26.01 inches.

Table 5. Effect of sulfur-bearing materials on the yield of alfalfa following corn. (1966)

| Material | Rate lbs. S/acre | Date of Application | Yield (tons/acre) 1st cut | 2nd cut | 3rd cut | Total |
|---|---|---|---|---|---|---|
| None | 0 | | .84 | .66 | .63 | 2.13 |
| Sulfur | 25 | 1962 | 1.08 | 1.12 | 1.08 | 3.28 |
| Sulfur | 50 | 1962 | 1.59 | 1.40 | 1.26 | 4.25 |
| Sulfur | 100 | 1962 | 1.46 | 1.71 | 1.48 | 4.65 |
| Gypsum | 60 | 10 lb. S. in 1962<br>50 lb. S. in 1963 | 1.54 | 1.58 | 1.23 | 4.35 |
| $K_2SO_4$ | 10 | 1962 | .89 | .73 | .71 | 2.33 |
| 16-20-0-S | 10 | 1962 | .84 | .76 | .81 | 2.41 |
| Trace + S | 25 | 10 lb. S/acre as Zn-Mn-N-S 1962<br>15 lbs. S/acre as trace element mixture in 1963 | 1.30 | 1.23 | .96 | 3.49 |
| lsd (.05) | | | .23 | .25 | .20 | .56 |
| (.01) | | | .31 | .34 | .27 | .75 |
| hsd (.05) | | | .37 | .41 | .32 | .89 |
| (.01) | | | .45 | .49 | .38 | 1.08 |

Table 6. Effect of sulfur-bearing materials on the sulfur content of alfalfa following corn (1966).

| Material | Rate lbs. S/acre | Date of Application | Sulfur Content of Tissue (%) 1st cut | 2nd cut | 3rd cut |
|---|---|---|---|---|---|
| None | 0 | | .176 | .180 | .212 |
| Sulfur | 25 | 1962 | .172 | .165 | .209 |
| Sulfur | 50 | 1962 | .174 | .192 | .236 |
| Sulfur | 100 | 1962 | .287 | .278 | .254 |
| Gypsum | 60 | 10 lbs. S in 1962<br>50 lbs. S in 1963 | .227 | .198 | .228 |
| $K_2SO_4$ | 10 | 1962 | .164 | .160 | .183 |
| 16-20-0-S | 10 | 1962 | .159 | .170 | .222 |
| Trace + S | 25 | 10 lbs. S/acre as Zn-Ma-N-S in 1962<br>15 lbs. S/acre as Trace Elem mix in 1963 | .169 | .162 | .193 |
| lsd (.05) | | | NS | .026 | .051 |
| (.01) | | | NS | .035 | .069 |
| hsd (.05) | | | NS | .041 | .081 |
| (.01) | | | NS | .050 | .098 |

The alfalfa following corn was irrigated on a similar schedule. Precipitation equalled 15.76 inches and supplemental irrigation equalled 10.50 inches for a total amount of water supplied of 26.26 inches.

Small Grain

The study of the effect of sulfur treatments on the yield of small grain (barley, wheat and oats) was repeated in 1966. The nitrogen application was increased to 55# Nitrogen per acre in 1966 from 30# per acre in 1965. The additional N was supplied as ammonium nitrate and disked in before planting. Other basic treatments were as follows: 20# P per acre (as 20-52-0), and 249# of K ( as 0-0-62) were broadcast and disked in before planting. The equivalent of a 12-32-16 starter was formulated from sulfur free materials and applied in the row at planting time at 100# per acre. Sulfur treatments consisting of 10# S per acre as gypsum, elemental sulfur or sodium sulfate were applied in the row at planting time. Planting date was May 7. Varieties used were Traill barley, Lodi oats and Chris wheat. The treatments were replicated five times for each crop.

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

During the growing season (from May 7 to August 9) the small grain received 12.09 inches of precipitation. This was supplemented by four irrigations which provided an additional 6.00 inches of moisture, for a total of 18.09 inches.

Table 7. Effect of sulfur-bearing materials on the yield and sulfur content of Barley (1966).

| Material | Rate lbs. S/acre | Yield bu/A | Sulfur Content whole plant % |
|---|---|---|---|
| None | 0 | 22.3 | .195 |
| El. Sulfur | 10 | 29.2 | .206 |
| Gypsum | 10 | 26.9 | .233 |
| $Na_2SO_4$ | 10 | 33.8 | .253 |
| lsd (.05) | | 6.9 | .037 |
| (.01) | | NS | NS |
| hsd (.05) | | | |
| (.01) | | | |

Table 8. Effect of sulfur-bearing materials on the yield and sulfur content of oats (1966).

| Material | Rate lbs. S/acre | Yield bu/A | Sulfur Content whole plant % |
|---|---|---|---|
| None | 0 | 54.2 | .172 |
| El. Sulfur | 10 | 57.7 | .191 |
| Gypsum | 10 | 58.0 | .239 |
| $Na_2SO_4$ | 10 | 62.7 | .233 |
| lsd (.05) | | NS | .027 |
| (.01) | | | .038 |
| hsd (.05) | | | .037 |
| (.01) | | | .049 |

Table 9. Effect of sulfur-bearing materials on the yield and sulfur content of wheat (1966).

| Materials | Rate lbs/A | Yield bu/A | Sulfur Content whole plant % |
|---|---|---|---|
| None | 0 | 16.2 | .252 |
| El. Sulfur | 10 | 22.2 | .281 |
| Gypsum | 10 | 18.6 | .312 |
| $Na_2SO_4$ | 10 | 17.9 | .291 |
| lsd (.05) | | .3 | .032 |
| (.01) | | .5 | .045 |
| hsd (.05) | | .5 | .043 |
| (.01) | | .6 | .057 |

Yields of small grain were disappointing in 1966 despite an adequate supply of moisture, increased seeding rate, and higher nitrogen application. This is attributed largely to an adverse season. Despite the low yields, 10 lbs. of sulfur increased barley yields by 4 to 11 bushels and measurably increased the sulfur content of the tissue. Sodium sulfate was most effective in increasing yield and sulfur content, followed by elemental sulfur and gypsum.

Oat yields were increased by 4 to 8 bushels per acre by the sulfur treatment with corresponding increases in the sulfur content of the whole plant tissue.

Increases in wheat yields were smaller (1.7 to 6.0 bushels per acre) and did not show a consistent advantage for any particular sulfur material. The highest mean yield was produced by elemental sulfur (10 #S/acre). All sulfur treatments increased the sulfur content of the wheat tissue but it is interesting to note that the sulfur content of the control plants was greater than .2% (.251) which is much higher than the sulfur content of untreated oat and barley plants (.172 and .195% respectively).

Corn

The 1965 study of the effect of sulfur on the yield and sulfur content of corn was continued in 1966. Only one sulfur treatment was used (10 lbs. S per acre as $Na_2SO_4$) in addition to the control. Treatments were replicated six times. Minn hybrid 805 (85 day) was planted May 21 and thinned to a final population of 18,300 plants per acre. Supplemental irrigation was applied at four times during the growing season for a total of 6.25 inches of water applied. Natural precipitation during the growing period totaled 14.90 inches.

Basic fertilizer applications of 150#N/acre; 25# P/acre, and 200# K per acre were reapplied in 1966 and disked in before planting. Three hundred pounds per acre of 5-10-30 starter were applied at planting time and the corn was sidedressed with 90# of N/acre. All basic fertilizer materials were sulfur-free. Shortly after germination sulfur deficiency symptoms could be detected among the control plants. They were not as evident however as in 1965 possibly because this was 2nd year corn and possibly because, despite a late spring, the ground conditions after planting in 1966 were more favorable than in 1965. Deficiency symptoms disappeared by the time the corn was knee high, but a difference in height persisted until tasselling. The treated corn was in full tassell 4-5 days earlier than the controls.

The 1966 yield data are reported in table 10. Despite the early season advantage of the treated corn, the untreated corn had apparently caught up by harvest time. The treated corn averaged 4.3 bushels more corn per acre and was slightly drier but these differences were not significant at the 5% probability level.

Table 10. Effect of sulfur on the yield of 2nd year corn (1966).

| Treatment | Rate lbs. S/acre | Ear Corn Moisture % | Shelling percentage % | Ear Corn yield Bu/acre |
|---|---|---|---|---|
| None | 0 | 40.1 | 81.3 | 110.1 |
| Sulfur ($Na_2SO_4$) | 10 | 38.9 | 80.5 | 114.4 |
| lsd (.10) (.05) | | 1.05 | NS | NS |

Potatoes

A study on the effect of sulfur on the yield of potatoes under irrigation was begun in 1965 and continued in 1966. Two sulfur-bearing materials (elemental sulfur and gypsum) at the rate of 50 lbs. of S/acre were compared with a control. Basic applications of 500# K/acre as 0-0-62, 200 #N/acre as 33-0-0 and 50# P/acre as 0-54-0 were applied before planting and disked in. Plots were replicated six times. In 1966 the variety planted was Russet Burbank. The plants were irrigated on a regular schedule and a vigorous program of disease and insect control was practiced. Plant petioles were sampled at midseason and analyzed for sulfur. Yields were recorded and the quality of the potatoes was checked by running specific gravity on representative samples from each plot. Yields, specific gravity and the per cent sulfur in the petioles are reported in Table 11.

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

Table 11. Effect of Elemental Sulfur and Gypsum on the Yield, Total Solids, and Sulfur Content of Irrigated potatoes. ("Russet Burbank")

| Treatment | Rates lbs. S/acre | Yield bu/acre | Specific Gravity | Total Sulfur in petioles |
|---|---|---|---|---|
| None | 0 | 539 | 1.143 | .158 |
| Sulfur | 50 | 563 | 1.141 | .219 |
| Gypsum | 50 | 529 | 1.144 | .243 |
| lsd (.05) | | NS | NS | .007 |

Red Clover

An area which had been in small grain in 1964 was adapted to a Red Clover-Brome study in 1965. Basic applications of N, P, and K were broadcast before planting in 1964 and disked in. These basic applications supplied 35# N per acre as 20-52-0 and 249# K (300# $K_2O$) per acre as 0-0-62. An additional 100# of 12-32-16 was applied as starter on the small grain in 1964. The area had received 4 ton of dolomitic lime per acre in 1962.

The sulfur treatments were designed to study (1) the effects of reapplication of the same materials used on the 1964 grain crop at heavier rates (40# S/acre); (2) residual effects of sulfur treatments applied to small grain (oats and barley) in 1964; and (3) the effect of additional gypsum (40 # S per acre) plus trace elements. The exact treatments are listed in Table 12.

Table 12. Treatments on Red-Clover Brome Study.

| Treatment No. | Sulfur-bearing Material | 1964 lbs. S/acre | S applied 1965 lbs. S/acre | Total lbs. S/acre | Previous Crop 1964 |
|---|---|---|---|---|---|
| 1 | None | 0 | 0 | 0 | Barley |
| 2 | Gypsum | 10 | 40 | 50 | " |
| 3 | El. Sulfur | 10 | 40 | 50 | " |
| 4 | $Na_2SO_4$ | 10 | 0 | 10 | " |
| 5 | Gypsum | 10 | 0 | 10 | " |
| 6 | El. Sulfur | 10 | 0 | 10 | " |
| 7 | None | 0 | 0 | 0 | Oats |
| 8 | Gypsum + Trace | 10 | 57* | 67 | " |
| 9 | El. Sulfur | 10 | 0 | 10 | " |
| 10 | $Na_2SO_4$ | 10 | 10 | 20 | " |

*Trace elements consisted of the sulfate salts of Zn, Cu, Mn and Fe and ammonium molybdate. Sulfur supplied by these salts was 17.4 lbs/acre.

Wegner Red Clover at 10#/acre and Lincoln Brome at 4# per acre were sown May 29, 1965. No yields were taken in 1965 but the field was clipped to 6.8 inches in late August to control weeds. Visible color differences were noted between checks and treated plots by the fall of 1965. In 1966 two cuttings were obtained and had the very favorable fall season been anticipated a third cutting would have been possible without damaging the stand. The plots were topdressed with 100# K/acre as 0-0-62 after the first cutting. Throughout the season on the untreated plots the red clover was a pale yellowish green color, was shorter and slower maturing. Treated clover was vigorous and dark-green in color.

The 1966 yield data are shown in Table 13. Sulfur treatments increased 1st cutting yields from 6 to 40%. Second cutting yields were even more strikingly effected by the sulfur treatments. As check plot yields began to decline with the depletion of natural soil sulfur, yield increases up to 109% were recorded.

Table 13. Effect of sulfur-bearing materials and residual sulfur treatments on the yield of red clover-brome. (1966)

| Treatment No. | Yield | | |
|---|---|---|---|
| | 1st cutting tons/acre | 2nd cutting tons/acre | Total tons/acre |
| 1 | 1.24 | .94 | 2.18 |
| 2 | 1.59 | 1.82 | 3.41 |
| 3 | 1.45 | 1.54 | 2.99 |
| 4 | 1.53 | 1.38 | 2.91 |
| 5 | 1.39 | 1.30 | 2.69 |
| 6 | 1.53 | 1.35 | 2.88 |
| 7 | 1.14 | .87 | 2.01 |
| 8 | 1.34 | 1.53 | 2.87 |
| 9 | 1.27 | 1.15 | 2.42 |
| 10 | 1.36 | 1.45 | 2.81 |

Sulfur contents of the red clover and brome are reported in Table 14. The sulfur contents of the brome and the red-clover were essentially the same for similar sulfur treatments indicating that both species competed equally for the available sulfur supply. The sulfur contents are generally lower than might be expected for alfalfa grown under similar conditions. In no instance was the .3% sulfur level reached in the red clover. The question therefore remains as to whether additional sulfur applications will bring about further yield increases.

Table 14. Effect of sulfur-bearing materials and residual sulfur treatments on the sulfur content of red clover and brome (1966).

| Treatment No. | 1st cutting Red Clover % S | 1st cutting Brome % S | 2nd cutting Red Clover % S |
|---|---|---|---|
| 1 | .128 | .120 | .115 |
| 2 | .208 | .179 | .135 |
| 3 | .202 | .162 | .147 |
| 5 | .173 | .168 | .129 |
| 5 | .155 | .158 | .120 |
| 6 | .163 | .169 | .131 |
| 7 | .139 | .157 | .119 |
| 8 | .208 | .198 | .147 |
| 9 | .163 | .175 | .119 |
| 10 | .186 | .188 | .138 |

The composition of the stand was unaffected by the treatment (Table 15). Apparently the red clover can compete and even choke out the brome when it is adequately supplied with nutrients.

Table 15. Effect of sulfur-bearing materials and residual sulfur treatments on the composition of red clover-brome hay. (1st cutting 1966)

| Treatment No. | % Red Clover | % Brome |
|---|---|---|
| 1 | 94.5 | 5.5 |
| 2 | 93.2 | 6.8 |
| 3 | 94.1 | 5.9 |
| 4 | 93.8 | 6.2 |
| 5 | 94.8 | 5.2 |
| 6 | 92.6 | 7.4 |
| 7 | 95.4 | 4.6 |
| 8 | 95.8 | 4.2 |
| 9 | 96.3 | 3.7 |
| 10 | 95.3 | 4.8 |

Soil Test Data for S-plot established in 1962.

In August a number of soil samples were taken to survey the pH, organic matter, extractable phosphorus and exchangeable potassium levels on the alfalfa plots established in 1962. Samples were taken by one inch increments to three inches and another increment from 3 to 6 inches. Each sample was a composite of two cores from each of six replicated plots. The survey of the effect of the sulfur treatments on pH is reported in Table 16. The data indicate that annual applications of 100# of sulfur in the elemental form have reduced the pH of the 0-1 and 1-2 inch depths to 4.7 and 5.2 respectively. The pH of the surface two inches of unsulfured plots is 6.8 and 6.2 respectively. As a result of this survey a more extensive sampling of the soil is planned.

Table 16. Survey of the effect of sulfur treatments on pH of soil under alfalfa.

| Treatment | pH Depth (inches) | | | |
|---|---|---|---|---|
| | 0-1 | 1-2 | 2-3 | 3-6 |
| Check | 6.8 | 6.2 | 6.1 | 6.3 |
| 100# S(1962) | 6.0 | 5.5 | 5.8 | 6.0 |
| 100# S(annually) | 4.7 | 5.2 | 5.7 | 6.0 |
| 1000# S(gypsum) 1962 | 6.4 | 5.8 | 6.0 | 6.1 |
| 50# S (gypsum) 1962 | 6.3 | 5.8 | 6.0 | 6.1 |
| Check (Alf after corn) | 6.8 | 6.7 | 6.7 | 6.7 |

Results of the other tests showed adequate levels of P and K in all soil increments. There apparently has not been any effect of sulfur on these nutrient elements.

# 1966 Zinc-Phosphate for Corn Study in Swift County

O. M. Gunderson, J. M. MacGregor,
G. W. Randall, S. D. Evans, R. I. Pietz

During the spring of 1966, a project was initiated to study 1) the effect of various zinc materials and rates on corn yield as well as the zinc and phosphorus content of the corn leaf tissue and 2) the effect of increasing amounts of phosphorus fertilizer on the uptake of zinc and phosphorus by the plant on the corn yield.

On May 16, two randomized block design experiments were established on the Richard Mickelson farm 2 miles north of Benson in Swift County. Each experiment consisted of seven treatments replicated four times. All zinc treatments except the chelate (Zn 45), which was row applied, and all phosphorus treatments were broadcast applications and then plowed down. The farmer also applied a total of 100+40+40 ($N+P_2O_5+K_2O$) per acre as a blanket broadcast application before plowing. Because of the late, wet spring, and the relatively low lying, poorly drained heavy soil, a 90 day maturity corn hybrid was planted on May 30. Atrazine was applied on June 1. Sixth leaf samples were taken at late silking stage in early September for zinc and phosphorus analyses. The results obtained are shown in the following tables.

Table 1. Zinc and Phosphorus Content of the Sixth Corn Leaf & Corn Yields following Zinc and Phosphate Fertilization in 1966.

| Trt. No. | Treatment (lbs Zn) | Plant P (%) | Plant Zn (ppm) | Yield (bu/A) |
|---|---|---|---|---|
| 1 | NONE | 0.400a[1] | 7.2c | 92.0bc |
| 2 | 10# as $ZnSO_4$ | 0.297bc | 11.7bc | 115.4a |
| 3 | 20# " | 0.259c | 14.0b | 111.8a |
| 4 | 40# " | 0.259c | 18.0a | 109.3a |
| 5 | 10# as ZnMnS | 0.326abc | 9.3bc | 103.8ab |
| 6 | 0.5# as Zn chelate | 0.394a | 8.6c | 85.5c |
| 7 | 2.5# as Zn chelate | 0.372ab | 8.3c | 93.3bc |

1.According to Duncan's Multiple Range Test, numerical values followed by the same letter are not significantly different at the .05 level.

Table 1 shows that significant differences occurred in the zinc and phosphorus content of the sixth corn leaves, as well as in corn yield from the different zinc treatments. Plant P content was highest in the check treatment and was much lower in leaves from the 10 pound Zn (as $ZnSO_4$) treatment. Increasing the rate to 20 and 40 pounds decreased the plant Zn only slightly. The ZnMnS and Zn chelate treatments did not reduce the plant P significantly.

Leaf Zn was lowest from the check treatment. The application of Zn as $ZnSO_4$ significantly increased the plant Zn content, with the 40 pound rate resulting in a significantly higher plant Zn content than any other treatment. Again, the ZnMnS and Zn chelate treatments failed to increase the uptake of zinc significantly.

Corn yields were highest on those treatments where Zn was applied as $ZnSO_4$. However, no significant differences in yield occurred among the 10, 20 and 40 pound rates. A small yield increase over the check was found with the ZnMnS treatment, but no increases in yield resulted from the Zn chelate treatments.

Table 2. The Effect of Seven Phosphate Treatments on the Uptake of P and Zn and on Corn Yield in Swift County in 1966.

| Trt. No. | Treatment (lbs $P_2O_5$)* | Plant P (%) | Plant Zn (ppm) | Yield (bu/A) |
|---|---|---|---|---|
| 1 | 40 | .351bc[1] | 10.0ab | 98.4ab |
| 2 | 80 | .313bc | 10.2ab | 96.9ab |
| 3 | 160 | .359bc | 8.4bc | 96.3ab |
| 4 | 320 | .400b | 7.5c | 96.8ab |
| 5 | 640 | .486a | 7.3c | 83.4b |
| 6 | 320+10#Zn as $ZnSO_4$ | .325bc | 12.4a | 113.6a |
| 7 | 640+ " | .304c | 11.0a | 107.6a |

* includes the 40 lbs. applied by the farmer.

1. According to Duncan's Multiple Range Test, numerical values followed by the same letter are not significantly different at the 0.05 level.

Significant differences were resulted among the seven phosphate treatments for plant P, plant Zn and corn yield as shown in Table 2. Increasing phosphate fertilization rates resulted in raising the plant P from 0.351 to 0.486% and reducing the plant Zn content from 10.0 to 7.3 ppm. The plant P content of the 640 pound phosphate treatment was significantly higher than those from any other treatment. The addition of 10 pounds of Zn to the 320 and 640 pound phosphate treatments decreased the plant P content substantially. However, these zinc treatments resulted in significantly higher plant Zn contents.

Highest yields were produced on the 320 and 640 pound phosphate treatments <u>with</u> 10 pounds of zinc per acre as $ZnSO_4$. The 640 pound rate of phosphate <u>without</u> zinc produced the lowest yield.

<u>Initial conclusions of this study</u>

1. On some of these cold, wet, calcareous and heavy soils of western Minnesota, it is apparent that corn yield does respond to the application of zinc. This is apparently more evident at high rates of phosphate fertilization.

2. Significant responses in plant P, plant Zn and corn yield are clearly shown from the application of zinc as $ZnSO_4$, whereas, the application of ZnMnS did not clearly show these responses. Corn showed no yield response to zinc chelate ($Na_2Zn$) applications.

3. High rates of fertilizer phosphate increased the plant P, but apparently decreased the uptake of zinc. Zinc uptake at these high phosphate fertilization rates can apparently be increased with the addition of zinc sulfate at the rate of 10 pounds of zinc per acre (approximately 30 pounds of $ZnSO_4$ per acre).

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

J. M. MacGregor, O. M. Gunderson and R. Pietz

During the 1961 growing season, zinc deficiency was observed on some corn plants on the C. H. Litch farm at Lake Lillian. With the cooperation of the farm owner and Dr. R. R. Allmaras of the A.R.S. Soil and Water Research Station at Morris, a field experiment of zinc application for corn was initiated in May of 1962. Soybeans were seeded in 1963 but died out because of residue remaining from a 1962 application of atrazine. Corn was grown in 1964, 1965 and in 1966, usually being planted from late May until mid June, due to wet soil conditions. Late planting has usually resulted in comparatively low yields. Leaves were sampled (6th leaf from the ground) in each of the four years and were analyzed by the X-ray fluorescence procedure or by atomic adsorption procedures. The average zinc content of the leaves and yield of ear corn per acre for the four years are shown in the following table.

The Effect of 1962 Zinc Fertilization of a Zinc Deficient Silty Clay Loam in Southern Kandiyohi County on Zinc Concentrations in Corn Leaves and Corn Yields in 1962, 1964, 1965 and 1966

| 1962 Treatment (lbs./A | Leaf zinc in ppm | | | | Yield of ear corn in bu./A | | | |
|---|---|---|---|---|---|---|---|---|
| | 1962 | 1964 | 1965 | 1966 | 1962 | 1964 | 1965 | 1966 |
| No zinc | 9 | 19 | 8 | 10 | 43 | 40 | 38 | 41 |
| Zinc broadcast and plowed under in spring | | | | | | | | |
| 15 zinc sulfate | 13 | 19 | 12 | 10 | 69 | 58 | 59 | 54 |
| 30 " " | 19 | 20 | 20 | 14 | 66 | 56 | 58 | 51 |
| 60 " " | 27 | 27 | 25 | 15 | 76 | 56 | 69 | 56 |
| 120 " " | 29 | 28 | 31 | 25 | 67 | 50 | 69 | 52 |
| Zinc sulfate and/or nitrogen applied as a band starter | | | | | | | | |
| 20 nitrogen (N) alone | 9 | - | 11 | 11 | 61 | 41 | 47 | 45 |
| 30 zinc sulfate | 10 | - | 13 | 12 | 59 | 53 | 55 | 51 |
| 15 zinc sulfate + 20 N | 10 | - | 14 | 11 | 63 | 58 | 56 | 61 |
| 30 " " " " " | 11 | - | 13 | 16 | 64 | 65 | 65 | 60 |
| 60 " " " " " | 12 | - | 20 | 12 | 63 | 62 | 59 | 51 |
| Zinc chelate coated on seed corn (7 1/2 oz.Na ZnEDTA per bu.) | | | | | | | | |
| Seed treatment alone | 9 | - | 8 | 9 | 55 | 51 | 48 | 48 |
| " " + 30 zinc sulfate plowed down | 22 | - | 17 | 13 | 74 | 67 | 67 | 64 |

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

The zinc treatments produced substantial increases in corn yield with banding being only slightly less productive than plowing down, even though the corn leaves growing on the banded zinc plots contained considerably less zinc in each of the three growing seasons. With an extreme yield variation in 1966, corn yields were not significantly different with the different 1962 treatments.

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

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

It is apparent that where zinc deficient soils do occur in Minnesota, the application of zinc sulfate, either plowed down or as a band application, will be an economic practice for corn production, especially with the apparent residual effect lasting over several crop years.

# Zinc Fertilization of Continuous Corn
West Central Experiment Station
Samuel D. Evans

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

| Treatment* | | Yield Bu/A @ 15.5% | | Leaf Analysis Zn, ppm | | Leaf Analysis P, % | |
|---|---|---|---|---|---|---|---|
| 1965 | 1966 | 1965 | 1966 | 1965 | 1966 | 1965 | 1966 |
| Check | Check | 97.80 | 101.85 | 15 | 16 | .21 | .24 |
| 5 lbs zinc as ZnS | None | 98.93 | 104.01 | 17 | 18 | .25 | .26 |
| 10 lbs zinc as ZnS | None | 96.63 | 102.14 | 17 | 24 | .22 | .29 |
| 10 lbs zinc as ZnS | 10 lbs zinc as ZnS | 96.67 | 100.62 | 17 | 23 | .22 | .27 |
| 20 lbs zinc as ZnS | None | 98.93 | 104.70 | 22 | 23 | .30 | .26 |
| 0.5 lbs zinc as ZnCh | 0.5 lbs zinc as ZnCh | 97.47 | 98.30 | 19 | 20 | .27 | .24 |
| 45 lbs P Broadcast | 45 lbs P Broadcast | 99.54 | 96.39 | 16 | 13 | .29 | .26 |
| 45 lbs P Broadcast+ 10 lbs zinc as ZnS | 45 lbs P Broadcast + No addt'l zinc | 96.45 | 94.82 | 18 | 19 | .22 | .32 |

* ZnS - Zinc Sulfate, ZnCh - Zinc 45 Chelate, all zinc applied in the row at planting time, all plots received a uniform row application of 125 lbs of 8-32-16, 80 lbs of actual N was sidedressed each year.

# The Effect of Boron, Phosphorus and Potassium on the Yield of Four Legume - Grass Hay Fields in Carlton County in 1965 and 1966

J. M. MacGregor, P. Borich and G. Randall

In July, 1964, following the removal of first cutting of hay, experimental plots were established on four Carlton County farms to determine the effect of boron alone and in addition to phosphorus - potassium on the yield and composition of the mixed legume-grass hays grown in the area. A 6x6 Latin square design was used. Symptoms of boron deficiency of legumes were evident on the second cutting of two of the four fields in August, 1964. While the boron applications at rates of 1 or 2 pounds per acre reduced the severity of the B deficiency symptoms, these treatments did not significantly increase 1964 second cutting hay yields. Boron with phosphorus - potassium improved growth, but there again was no significant increase in hay yield of the second cutting on any of the four fields in a relatively dry midsummer growing period.

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

In the fall of 1965, there was an excellent legume-grass stand on Field 4 (the Lauri Waisanen farm just west of Kettle River). In the spring of 1966, there was not a single legume plant surviving on any of the plots of the experiment - due to severe winterkilling. Since boron is primarily needed for alfalfa growth, and not for grasses, it was reluctantly decided to terminate the studies on this field. Extreme frost heaving appeared to be the cause of the severe alfalfa winterkill.

The remaining four fields were refertilized with 1 or 2 pounds of boron per acre early in 1966 and two cuttings of hay were removed, as in previous years. Soil samples were collected on three replicates of each of the five fields and available soil boron is now being determined. Two of the four fields (Field No. 2 on the Marvin Benson farm north of Mahtowa - and Field No. 5 of the Gerald Mowers farm at Cromwell) showed visible boron deficiency symptoms of the untreated alfalfa plants and also those receiving PK alone, whereas the remaining two fields showed no visible growth abnormalities.

1965 & 1966 Hay Yields on Boron - Phosphate & Potash Experiments
in Carlton County in Tons per acre

| Cooperator | Treat. | 1st Cut | 2nd Cut | 1966 Tot. | 1965-66 Total |
|---|---|---|---|---|---|
| (1) | | | | | |
| Oraskovich (check) | 1 | 2.26 a | 0.80 a | 3.06 a | 5.64 a |
| 0-60-180 + No B | 2 | 2.50 a | 0.83 a | 3.33 a | 5.78 a |
| 0-60-180 + 1 lb.B/A | 3 | 2.30 a | 0.92 a | 3.22 a | 5.99 a |
| 0-60-180 + 2 lb.B/A | 4 | 2.35 a | 0.75 a | 3.10 a | 5.77 a |
| 0-60-180 + 1 lb.B/A (annually) | 5 | 2.42 a | 0.88 a | 3.30 a | 6.18 a |
| 0-60-180 + 2 lb.B/A (annually) | 6 | 2.43 a | 0.90 a | 3.33 a | 6.00 a |
| (2) | | | | | |
| Benson #1 (check) | 1 | 1.76 a | 1.16 a | 2.92 a | 6.94 a |
| 0-60-180 + No B | 2 | 2.18 a | 1.36 b | 3.54 b | 8.66 b |
| 0-60-180 + 1 lb.B/A | 3 | 2.18 a | 1.50 b | 3.68 b | 8.90 b |
| 0-60-180 + 2 lb.B/A | 4 | 2.08 a | 1.42 b | 3.50 b | 8.58 b |
| 0-60-180 + 1 lb.B/A (annually) | 5 | 2.17 a | 1.38 b | 3.55 b | 8.38 b |
| 0-60-180 + 2 lb.B/A (annually) | 6 | 2.18 a | 1.39 b | 3.57 b | 8.46 b |
| (3) | | | | | |
| Benson #2 (check) | 1 | 3.01 a | 1.56 a | 4.57 a | 8.34 a |
| 0-60-180 + No B | 2 | 3.01 a | 1.68 a | 4.69 a | 8.46 a |
| 0-60-180 + 1 lb.B/A | 3 | 3.24 a | 1.68 a | 4.92 a | 8.97 a |
| 0-60-180 + 2 lb.B/A | 4 | 3.14 a | 1.63 a | 4.77 a | 8.57 a |
| 0-60-180 + 1 lb.B/A (annually) | 5 | 3.10 a | 1.58 a | 4.68 a | 8.59 a |
| 0-60-180 + 2 lb.B/A (annually) | 6 | 3.04 a | 1.66 a | 4.70 a | 8.43 a |
| (5) | | | | | |
| Mowers (check) | 1 | 2.17 a | 1.64 a | 3.81 a | 7.23 a |
| 0-60-180 + No B | 2 | 2.11 a | 1.68 a | 3.79 a | 7.80 ab |
| 0-60-180 + 1 lb.B/A | 3 | 2.37 ab | 1.66 a | 4.03 ab | 7.86 ab |
| 0-60-180 + 2 lb.B/A | 4 | 2.52 b | 1.71 a | 4.23 b | 8.27 b |
| 0-60-180 + 1 lb.B/A (annually) | 5 | 2.48 b | 1.79 a | 4.27 b | 8.40 b |
| 0-60-180 + 2 lb.B/A (annually) | 6 | 2.38 ab | 1.64 a | 4.02 ab | 7.73 ab |

a,b - Those yields with either a or b are significantly different whereas ab are not significant from a or b.

Significance of 1965-66 Legume Grass Hay Yields
following Boron-PK Treatments in Carlton County

| | | Treatment Totals | |
|---|---|---|---|
| 1. | Oraskovich | First Cut | Not Significant |
| | | Second Cut | " " |
| | | 1966 Total | " " |
| | | 1965 & 1966 Total | " " |
| 2. | Benson #1 | First Cut | Not Significant |
| | | Second Cut | * |
| | | 1966 Total | * |
| | | 1965 & 1966 Total | ** |
| 3. | Benson #2 | First Cut | Not Significant |
| | | Second Cut | " " |
| | | 1966 Total | " " |
| | | 1965 & 1966 Total | " " |
| 5. | Mowers | First Cut | * |
| | | Second Cut | Not Significant |
| | | 1966 Total | * |
| | | 1965 & 1966 Total | ** |

* Significant at .05 level
** " " .01 level

It is apparent that the fertilizer produced yield increases on only two of the four fields (Fields 2 & 5). On Field 2, the significant yield increases evidently resulted from the phosphate-potash treatment, rather than from the applied boron. It is apparent that, even with visible boron deficiency symptoms developing on the alfalfa of the untreated plots, the application of boron improved the appearance of the plants but failed to significantly increase resulting hay yields.

On field No. 5, the heavier boron applications had a marked effect on the growing alfalfa, and this evidently resulted in a significant yield increase in 1966.

This experiment has demonstrated that the application of boron for alfalfa to the soils of this area may or may not result in significantly increased hay yields, even though alfalfa plants may show typical boron deficiency symptoms. The symptoms usually do not develop during the first year the hay crop is grown, being more likely to become evident with increasing age of the stand. It is also more likely to develop on the soils of coarser texture, which suffer more from a lack of moisture, and on these soils it may possibly become evident during the first cropping year.

While indiscriminate application of boron at the rate of 1 or 2 pounds per acre per year is not recommended, this is probably good insurance, especially on the sandier soils, since the cost of this treatment is relatively low. Liming of acid soils and fertilizing with ample amounts of phosphate-potash fertilizer is an essential practice on all soils of this region in north eastern Minnesota.

# 1966 Soybean Fertilization
## Southwest Experiment Station

W. W. Nelson and G. W. Randall

In 1964 an experiment was designed to study the effect of N, P and K fertilizer treatments on the soybean yield and chemical composition of the soybean leaf. A randomized block design with seven treatments replicated five times was used. This experimental plot is moved each year to an area that has not been previously fertilized. The variety Chippewa was planted in 30" rows. Results of the 1966 experiment are as follows:

Table 1. The fertilizer treatments, yields and chemical composition of soybeans at the Southwest Experiment Station.

| Trt. No. | Treatment (lbs $N-P_2O_5-K_2O$) | Yield (bu/A) | P | K | Ca | Mg | Mn | Fe |
|---|---|---|---|---|---|---|---|---|
| | | | % | | | | ppm | ppm |
| 1 | 0+0+0 | 25.5bc[1] | .325 | 1.84 | 1.10 | .44 | 36 | 106 |
| 2 | 0+40+0 | 26.6ab | .325 | 1.88 | 1.20 | .48 | 36 | 109 |
| 3 | 0+0+40 | 25.0c | .335 | 2.31 | 1.12 | .43 | 38 | 109 |
| 4 | 0+40+40 | 26.5ab | .350 | 2.28 | 1.31 | .49 | 50 | 115 |
| 5 | 20+0+0 | 26.2abc | .365 | 2.02 | 1.15 | .48 | 45 | 114 |
| 6 | 20+40+0 | 27.3a | .370 | 2.00 | 1.16 | .48 | 47 | 115 |
| 7 | 20+40+40 | 27.4a | .400 | 2.43 | 1.31 | .52 | 68 | 128 |

1. According to Duncan's Multiple Range Test, the yields followed by the same letter are not significantly different at the .05 level.

There was a significant soybean yield response to fertilizer; although, it was quite small. The complete NPK treatment (No. 7) produced the highest yield. Individual N, P and K responses were +0.8, +1.3 and -0.2 bushels per acre, respectively. This would seem to indicate phosphate fertilizer to be the most beneficial fertilizer element in contributing to higher soybean yields at Lamberton.

Soybean leaf analyses show the P content to increase with nitrogen and phosphate fertilizer. The addition of potash fertilizer greatly increased the plant K content. Plant Ca and Mg contents were also higher when treatments contained phosphate fertilizer. The combined fertilizer treatment (NPK) resulted in greater plant Mn and plant Fe concentrations in the soybean leaf.

# Sugar Beet Fertilization
## West Central Experiment Station
Samuel D. Evans

A replicated 3 x 3 x 3 factorial NPK experiment was set out at the West Central Experiment Station in 1966. The work was set up on Hammerly clay loam with the following soil tests:

| | |
|---|---|
| pH | 7.7 |
| Organic Matter | 5.8 - 6.2% |
| Extractable phosphorus | 3 - 5 lbs/acre |
| Exchangeable potassium | 400 - 420 lbs/acre |

Nitrogen, phosphorus, and potassium were used at 3 rates of each in all combinations. The rates were as follows:

| Nitrogen | Phosphorus | Potassium |
|---|---|---|
| None | None | None |
| 70 lbs N/acre | 25 lbs P/acre | 25 lbs K/acre |
| 140 lbs N/acre | 50 lbs P/acre | 50 lbs K/acre |

The fertilizer was applied on May 5, beets were planted on May 6, and harvest was carried out on October 25-26.

Statistical analyses were made for all variables and there were no interactions of the various nutrients. Therefore, only the averages for the various nutrients alone are presented in table 1. Averages for 6 nutrients are listed in table 2.

Table 1. Sugarbeet yield data, 1966.

| | Yield tons/acre | Sucrose % | Sugar lbs/acre |
|---|---|---|---|
| No nitrogen | 15.72 a | 17.51 a | 4492 a |
| 70 lbs nitrogen | 17.40 b | 17.13 b | 5967 b |
| 140 lbs nitrogen | 18.23 b | 16.81 b | 6127 b |
| No phosphorus | 17.36 | 17.20 | 5973 |
| 25 lbs phosphorus | 16.84 | 17.12 | 5758 |
| 50 lbs phosphorus | 17.16 | 17.12 | 5872 |
| No potassium | 16.86 | 17.27 | 5825 |
| 25 lbs potassium | 17.28 | 17.14 | 5913 |
| 50 lbs potassium | 17.21 | 17.04 | 5865 |

* Values in the same column followed by different letters are significantly (P=0.05) different.

The yield data show that in 1966 at Morris only nitrogen had an effect on yield and % sucrose. With nitrogen only the first 70 lb. increment affected the variables significantly. Even though the second 70 lb. increment increased yield and sugar production per acre and decreased sucrose content, the changes were not significant.

Petiole samples were taken twice during the season and were analyzed at Ohio State. The analysis indicated that some plots were in the low range with respect to some nutrients according to the Ohio State standards (table 3).

Summary of Petiole Analyses of 6 Elements

Table 2. Fertility Treatments

| Element | Sampling Date | 0P | 25P | 50P | 0K | 25K | 50K |
|---|---|---|---|---|---|---|---|
| Phosphorus, % | Early | .23 | .17 | .21 | .20 | .21 | .22 |
| Phosphorus, % | Late | .41 | .37 | .35 | .34 | .42 | .36 |
| Potassium, % | Early | 5.33 | 4.27 | 5.31 | 5.19 | 4.66 | 5.06 |
| Potassium, % | Late | 5.41 | 5.12 | 5.18 | 5.33 | 5.44 | 4.95 |
| Manganese, ppm | Early | 28 | 20 | 23 | 25 | 20 | 27 |
| Manganese, ppm | Late | 23 | 23 | 20 | 21 | 21 | 23 |
| Boron, ppm | Early | 18 | 15 | 16 | 17 | 15 | 17 |
| Boron, ppm | Late | 23 | 22 | 19 | 22 | 21 | 21 |
| Copper, ppm | Early | 6 | 4 | 5 | 5 | 5 | 5 |
| Copper, ppm | Late | 8 | 8 | 6 | 7 | 7 | 8 |
| Zinc, ppm | Early | 14 | 12 | 13 | 13 | 12 | 13 |
| Zinc, ppm | Late | 15 | 12 | 14 | 13 | 14 | 15 |

* Early date - 7-22-66. Late date - 8-24-66; values underlined are in the low range by Ohio State standards.

Table 3. Deficient, low, and sufficient ranges for 6 elements.

| | Deficient | Low | Sufficient |
|---|---|---|---|
| Phosphorus, % | 0 - 0.13 | 0.14 - 0.25 | 0.26 - 1.30 |
| Potassium, % | 0 - 0.60 | 0.61 - 1.00 | 1.01 - 11.00 |
| Manganese, ppm | 0 - 10 | 11 - 25 | 26 - 200 |
| Boron, ppm | 0 - 8 | 9 - 15 | 16 - 200 |
| Copper, ppm | 0 - 2 | 3 - 5 | 6 - 100 |
| Zinc, ppm | 0 - 8 | 9 - 15 | 16 - 200 |

Evaluation of petiole analyses:

Phosphorus - The standard values appear to be too high at the early sampling date. At the later sampling date sufficient phosphorus was present in all treatments.

Potassium - Sufficient potassium was present in all treatments at both sampling dates.

Manganese - Two possibilities exist; (1) the standard values are too high or (2) most treatments were manganese deficient.

Boron - Levels of boron appear to be adequate in most treatments. The addition of phosphorus might possibly reduce the boron content.

Copper - At the early sampling date the plants are slightly low in copper or the range is too low. At the later date levels are adequate.

Zinc - Values in all treatments are at the high end of the low range. The addition of 10 lbs of zinc did not raise the zinc level in the petioles much so zinc is apparently not limiting.

# Potato Fertilization Plot Results, 1966

Fertilizer plots on potatoes were established at the Eldon Tessman farm near Osseo and at the Howard Gray farm near Clear Lake in 1966.

The objective was to determine the need for fertilizer on soils that have been under an intensive phosphorus and potash buildup for nearly ten years and to observe fertilizer response through a similar experiment on a farm which had not had the benefit of this nutrient buildup. Included, was a lime rate study to observe magnesium differences in both plant tissue and in potato yield. Magnesium deficiency had previously been observed to be a problem where high potassium levels had been used. Four varieties were grown in order to observe lime effects on the buildup of scab organism on the tuber surfaces. All plots had two replications. Yields and related factors from nitrogen, phosphate and potash were as follows:

Eldon Tessman farm, Osseo. P test 200+, K test 600+, pH 5.4 sandy loam.

**Nitrogen Response**

| | Norland | | | Russet Burbank | | |
|---|---|---|---|---|---|---|
| | total yield cwt/A | over 2" size cwt/A | Specific Gravity | total yield cwt/A | Over 2" size cwt/A | Specific Gravity |
| 50+100+500 | 228 | 187 | 1.050 | 240 | 209 | 1.056 |
| 100+100+500 | 307 | 261 | 1.052 | 174 | 139 | 1.059 |
| 200+100+500 | 346 | 311 | 1.054 | 192 | 165 | 1.065 |

**Phosphate Response**

| | | % P petiole | | | % P petiole | |
|---|---|---|---|---|---|---|
| 100+ 0+500 | 319 | .39 | 1.055 | 226 | .34 | 1.052 |
| 100+100+500 | 304 | .56 | 1.056 | 238 | .52 | 1.063 |

**Potash response**

| | Norland | | | Petiole Analysis | |
|---|---|---|---|---|---|
| | total yield cwt/A | over 2" size cwt/A | Specific Gravity | % K | % Mg |
| 100+100+ 0 | 332 | 259 | 1.051 | 11.6 | .14 |
| 100+100+ 50 | 315 | 268 | 1.053 | 12.0 | .17 |
| 100+100+100 | 293 | 267 | 1.054 | 12.3 | .09 |
| 100+100+250 | 356 | 319 | 1.050 | 13.0+ | .15 |
| 100+100+500 | 277 | 241 | 1.050 | 12.8 | .14 |

Potash response Continued. -Tessman Farm.

| | | Russet Burbank | | | |
|---|---|---|---|---|---|
| 100+100+ 0 | 268 | 228 | 1.064 | 11.2 | .22 |
| 100+100+ 50 | 199 | 177 | 1.060 | 11.2 | .16 |
| 100+100+100 | 182 | 149 | 1.057 | 10.6 | .19 |
| 100+100+250 | 245 | 213 | 1.056 | 9.5 | .17 |
| 100+100+500 | 236 | 208 | 1.067 | 11.7 | .16 |

Howard Gray farm, Clear Lake, P test 17 lbs., K test, 130 lbs., pH 5.4 sandy loam.

Nitrogen Response

| | Norland | | | Russet Burbank | | |
|---|---|---|---|---|---|---|
| | total yield cwt/A | over 2" size cwt/A | Specific gravity | total yield cwt/A | over 2" size cwt/A | Specific gravity |
| 50+100+500 | 309 | 275 | 1.049 | 260 | 221 | 1.075 |
| 100+100+500 | 353 | 321 | 1.049 | 352 | 327 | 1.077 |
| 200+100+500 | 323 | 281 | 1.058 | 320 | 275 | 1.080 |

Phosphate response

| | | % P petiole | | | % P petiole | |
|---|---|---|---|---|---|---|
| 100+ 0+500 | 255 | .29 | 1.057 | 246 | - | 1.078 |
| 100+100+500 | 325 | .26 | 1.053 | 308 | .35 | 1.079 |

Potash Response

| | Norland total yield cwt/A | over 2" size cwt/A | Specific gravity | Petiole Analysis % K | % Mg |
|---|---|---|---|---|---|
| 100+100+ 0 | 207* | 108 | 1.058 | - | - |
| 100+100+100 | 232 | 218 | 1.058 | 8.3 | .55 |
| 100+100+250 | 313 | 269 | 1.052 | 10.0 | .38 |
| 100+100+500 | 338 | 297 | 1.061 | 11.8 | .31 |
| 100+100+1000 | 341 | 290 | 1.060 | 11.3 | .37 |
| | Russet Burbank | | | | |
| 100+100+ 0 | 172* | 127 | 1.069 | - | - |
| 100+100+100 | 273 | 232 | 1.077 | 8.2 | .42 |
| 100+100+250 | 304 | 274 | 1.077 | 11.4 | .28 |
| 100+100+500 | 333 | 300 | 1.075 | 10.5 | .27 |
| 100+100+1000 | 294 | 268 | 1.071 | 8.6 | .34 |

* 1 rep only

Lime plot Tessman farm

| lime treatment* lbs./acre | total yield cwt/A | % Mg | Al ppm |
|---|---|---|---|
| 0 | 344 | .21 | 180 |
| 1000 | 360 | .18 | 167 |
| 2000 | 377 | .21 | 153 |
| 4000 | 354 | .21 | 140 |

Soil pH 5.4

## SUMMARY

There appears to be no phosphorus or potassium response at the Tessman plot. The 200 pound nitrogen treatment appears to yield the best.

There is a response to N, P and K on the Gray plot. The Russet Burbank variety gave extremely variable results. The potatoes were very knobby and were generally a poor indicator as to which fertilizer treatments were most effective.

Perhaps the most striking difference between the two plot locations was the magnesium content. The very high potassium treatments have induced a low magnesium content in the petioles on the Tessman farm. Considerably higher magnesium content is shown on the petioles from Gray's farm.

There are little, if any, conclusions that can be drawn from the lime plot. Lime was broadcast and plowed 12 inches deep. Perhaps much of the lime is at too low a depth to have much effect.

Plot work conducted by-

C. J. Overdahl, C. P. Klint, O. C. Turnquist, G. W. Randall, R. D. Munson, George Roadfelt, and Enoch Bjuge.

## Maximum Yield Study-Alfalfa
## Rosemount Experiment Station

Dr. L. J. Elling of the Agronomy department established a maximum yield study with alfalfa at Rosemount in the spring of 1965. Members of the Soils Science Department assisted in the lime and fertilizer phase.

Since soils tested high in both P and K and quite acid, three rates of lime (0,3,10 tons) were used, but only two rates of fertilizer (800 pounds per acre of 4-12-24 vs. none). Half the fertilized area is top dressed annually with 800 pounds per acre of 4-12-24. Two varieties were used plus four replications.

Yields* tons/acre

| fertilizer treatments | 1965 seeding year | 1966 | 2 years increase |
|---|---|---|---|
| none | 2.77 | 5.02 | - |
| 800# 4-12-24 B. S.** | 3.17 | 5.46 | .84 |
| 800# 4-12-24 B. S. + 800 4-12-24 T.D.** | 3.13 | 5.51 | .85 |

*Average of 2 varieties, 2 cuttings 1965, 3 cuttings 1966. 15% moisture.
**B. S.=Before seeding, broadcast worked twice and plowed 10 inches deep.
T.D = top dressed fall 1965.
There was a significant difference between fertilized and unfertilized plots at the 5% level.

Yields* tons/acre

| lime treatments tons/acre | 1965 seeding year | 1966 | 2 years increase |
|---|---|---|---|
| 0 | 2.95 | 5.22 | - |
| 3 | 2.99 | 5.45 | .27 |
| 10 | 3.13 | 5.32 | .28 |

*Average of 2 varieties, 2 cuttings 1965, 3 cuttings 1966.
15% moisture. No significant yield differences due to lime treatments.

Lime and basic application of fertilizer were applied in the fall of 1964, worked twice with a field cultivator and plowed 10 inches deep.

Soil tests to a 6" depth in the fall of 1965 were as follows:

| lime rate | pH Rep I | pH Rep II | O. M.% Rep I | O. M.% Rep II |
|---|---|---|---|---|
| none | 5.8 | 5.4 | 4.8 | 4.3 |
| 3 ton | 6.0 | 6.0 | 4.7 | 4.6 |
| 10 ton | 6.1 | 6.3 | 4.7 | 4.3 |

| fertilizer rate | P test Rep I | P test Rep II | K test Rep I | K test Rep II |
|---|---|---|---|---|
| none | 40 | 45 | 180 | 200 |
| 800# 4-12-24 | 55 | 80 | 240 | 350 |
| +top dressed | - | 110 | 250 | - |

The lack of lime response and small change in pH due to liming suggested further sampling, this time in 2 inch increments, in the fall of 1965 to observe distribution to a 12 inch depth.

| | pH according to lime treatments | | | P test by treatment | | K test by treatment | |
|---|---|---|---|---|---|---|---|
| | tons per acre | | | | | | |
| depth | 0 | 3 | 10 | none | 192#$P_2O_5$ | none | 384#$K_2O$ |
| 0-2" | 6.1 | 5.7 | 6.2 | 50 | 90 | 240 | 330 |
| 2-4" | 5.9 | 5.9 | 6.6 | 55 | 55 | 220 | 230 |
| 4-6" | 5.9 | 6.1 | 6.6 | 52 | 80 | 210 | 300 |
| 6-8" | 5.8 | - | 6.4 | 40 | 75 | 200 | 330 |
| 8-10" | 5.8 | - | 6.2 | 24 | 60 | 190 | 290 |
| 10-12" | 5.8 | - | 5.8 | 13 | 11 | 160 | 190 |

Tissue analysis average from first cutting of alfalfa in 1965, according to treatment showed that $K_0$ = 1.84%, $K_{384}$ = 2.21%, $P_0$ = .25%, $P_{192}$ = .25%. Calcium and magnesium levels reflected no effect of lime treatments. Boron levels were slightly below the threshhold levels of "sufficient". Tissue analysis is being made of all three cuttings in 1966.

L. J. Elling, Jim Justin, R. D. Munson, prepared by C. J. Overdahl.

# Fertilizer Trials on Oil Crops
Northwest Experiment Station
Crookston, Minnesota - 1966
Olaf C. Soine, Soil Scientist

---

Sunflowers: There is considerable interest in sunflower production in the Red River Valley, and in 1966 an estimated 27,000 acres were planted. The yield per acre was 920 lbs. as given by the Minnesota Crop and Livestock Reporting Service. The price per pound is approximately 4 1/2 cents.

Three fertilizer trials were conducted this year, two on the Station, and one at Gonvick. Plots were laid out consisting of four replicates and 13 treatments at the Experiment Station and 10 treatments at Gonvick.

The yield and bushel weights for the 2 fields on the Station are given in table 1. Field 16, which was in flax in 1965, gave the best yields. Every treatment except the 20 lbs. of potash gave an increase yield when compared to the check plot.

Field 42 was in sugarbeets in 1965 and the soil on this field was Bearden silt loam. The yields of sunflowers were much lower when compared to field 16. The treatments, 40-80-0 and 40-80-40 gave the largest yield increase.

There was no significant difference in the bushel weights for fields 16 and 42.

The oil content for fields 16 and 42 is given in table 2 with an average for both fields. All the plots on field 42 were higher in oil content when compared to field 16. The differences between treatments on either field were not large. No single treatment produced a very large increase in percentage of oil when compared to the check.

Table 3 gives the yield, bushel weight, and oil content for the trial at Gonvick. Nitrogen - 40-0-0 - gave the best yield increase. The bushel weights were similar for all treatments.

(continued)

Fertilizer Trials on Oil Crops -
(continued)

Table 1.

THE EFFECT OF FERTILIZER ON THE YIELD
AND
BUSHEL WEIGHT OF SUNFLOWERS
NORTHWEST EXPERIMENT STATION - 1966

| Treatment lbs./acre | Yield lbs./acre | | | Bus. wt. |
|---|---|---|---|---|
| $N-P_2O_5-K_2O$ | Field 16* | Field 42** | av. 2 fields | av. 2 fields |
| 0-0-0 | 1840 | 953 | 1397 | 29 |
| 20-0-0 | 1873 | 1057 | 1465 | 28 |
| 0-40-0 | 1980 | 1050 | 1515 | 29 |
| 0-0-20 | 2037 | 1062 | 1550 | 29 |
| 20-40-0 | 1999 | 1165 | 1582 | 28 |
| 0-40-20 | 2094 | 916 | 1505 | 29 |
| 20-40-20 | 1896 | 1158 | 1527 | 29 |
| 40-0-0 | 2015 | 1227 | 1621 | 29 |
| 0-80-0 | 1960 | 939 | 1450 | 29 |
| 0-0-40 | 1644 | 932 | 1288 | 29 |
| 40-80-0 | 2031 | 1348 | 1670 | 30 |
| 0-80-40 | 1857 | 966 | 1412 | 29 |
| 40-80-40 | 1945 | 1383 | 1664 | 29 |

* Field 16: Bearden silty clay loam, 1965 crop - flax
** Field 42: Bearden silt loam, 1965 crop - sugarbeets

Sunflowers planted in 22 inch rows at 20,000 plants per acre.
Fertilizer applied as a band treatment.
Amiben at 3 lbs/acre gave 99% weed control.

Variety: Peredovik
Date of planting: May 25, 1966

(continued)

Fertilizer Trials on Oil Crops
(continued)

Table 2.

THE EFFECT OF FERTILIZER
ON THE
OIL CONTENT OF SUNFLOWERS
NORTHWEST EXPERIMENT STATION - 1966

| Treatment lbs./acre $N-P_2O_5-K_2O$ | Percent Oil Field 16 | Field 42 | Average |
|---|---|---|---|
| 0-0-0 | 46.3% | 47.1% | 46.7% |
| 20-0-0 | 46.8 | 48.2 | 47.5 |
| 0-40-0 | 45.3 | 48.0 | 46.6 |
| 0-0-20 | 44.8 | 48.2 | 46.5 |
| 20-40-0 | 44.5 | 47.7 | 46.1 |
| 0-40-20 | 45.7 | 47.8 | 46.7 |
| 20-40-20 | 44.9 | 48.1 | 46.5 |
| 40-0-0 | 45.1 | 47.3 | 46.2 |
| 0-80-0 | 44.6 | 48.6 | 46.6 |
| 0-0-40 | 44.4 | 48.6 | 46.5 |
| 40-80-0 | 43.5 | 47.6 | 45.5 |
| 0-80-40 | 44.7 | 48.3 | 46.5 |
| 40-80-40 | 45.0 | 47.7 | 46.3 |

Variety: Peredovik

Table 3.

THE EFFECT OF FERTILIZER ON THE YIELD, BUSHEL WEIGHT
AND
OIL CONTENT OF SUNFLOWERS
GONVICK - 1966

| Treatment* lbs./acre $N-P_2O_5-K_2O$ | Yield lbs/acre | Bu. Weight lbs/bus. | Oil Content percent |
|---|---|---|---|
| 0-0-0 | 1285 | 28 | 50.2 |
| 40-0-0 | 1447 | 28 | 50.1 |
| 0-40-0 | 1195 | 29 | 50.8 |
| 0-0-40 | 1122 | 28 | 49.5 |
| 40-40-0 | 1418 | 28 | 49.5 |
| 0-40-40 | 1178 | 28 | 50.6 |
| 40-40-40 | 1259 | 27 | 48.7 |
| 40-80-40 | 1193 | 28 | 50.1 |
| 40-80-80 | 1301 | 28 | 49.0 |
| 80-80-80 | 1413 | 28 | 48.1 |

*Fertilizer broadcast prior to planting
Date of planting: May 23, 1966
Row width: 40 inches

Variety: Peredovik

(continued)

Fertilizer Trials on Oil Crops
(continued)

The oil content for the sunflowers on the field at Gonvick was higher than the two fields on the Experiment Station. No single fertilizer treatment produced an increased percentage of oil when compared to the check plot on the Gonvick field.

Tame Mustard: Considerable acreage of tame mustard is grown each year in the Red River Valley, and questions about the fertilization of this crop have been asked. An experiment consisting of 12 different treatments with 3 replicates was laid out on a Bearden silt loam soil. A combination of broadcast and band treatments were used; for example, **20-0-0 broadcast and 0-40-0 applied in a band at seeding time.

The field data is given in table 4. There was no significant difference in yield. The treatment, **20-40-0, (**20-0-0 broadcast + 0-40-0 band applied) gave the best yield increase - 335 lbs. The treatment *20-40-0, (*10-0-0 broadcast + 10-40-0 band applied) was the only treatment that was below the check plot in yield.

Mustard tends to shatter when the crop nears maturity and the plants are dry. This may account for the high L.S.D. figure in this trial.

Crambe: This crop produces an oil that is used in industry where high temperatures are attained. There is no acreage of this crop being grown at the present time.

An experiment with 12 treatments and 3 replications was laid out on a Bearden silt loam soil in 1966. A combination of broadcast and band treatments was used, similar to the tame mustard trial.

Table 5 gives the yield of Crambe in lbs. per acre. Treatments **20-0-0 (broadcast) and x 30-40-20 (*10-0-0 broadcast plus 20-40-20 band application) gave significant increases when compared to the check plot.

(continued)

Table 4. YIELD RESPONSE OF TAME MUSTARD TO COMMERCIAL FERTILIZER NORTHWEST EXPERIMENT STATION - 1966

| Treatment lbs./acre $N-P_2O_5-K_2O$ | Yield lbs./acre | Duncan's Range |
|---|---|---|
| **20-40-0 | 1363 | |
| **60-80-40 | 1266 | |
| *10-40-0 | 1228 | |
| *30-40-20 | 1200 | |
| **20-0-0 | 1171 | |
| **30-40-0 | 1128 | |
| 20-40-20 | 1119 | |
| 0-40-0 | 1095 | |
| 10-40-0 | 1057 | |
| *10-0-0 | 1030 | |
| 0-0-0 | 1028 | |
| *20-40-0 | 988 | |
| L.S.D. 5% | 393 | |
| L.S.D. 1% | 534 | |

Mustard sown @ 10#/acre in 7 inch rows.
Treatments *10-0-0 and **20-0-0 broadcast before seeding.
Remaining treatments applied alone and in combination with broadcast treatments in a band at seeding time.
Sown May 7, 1966 - harvested August 11, 1966.

Table 5. YIELD RESPONSE OF CRAMBE TO COMMERCIAL FERTILIZER NORTHWEST EXPERIMENT STATION - 1966

| Treatment lbs./acre $N-P_2O_5-K_2O$ | Yield lbs./acre | Duncan's Range |
|---|---|---|
| **20-0-0 | 1374 | |
| *30-40-20 | 1318 | |
| 40-80-40 | 1200 | |
| **20-40-0 | 1191 | |
| *10-40-0 | 1172 | |
| 20-40-20 | 1091 | |
| *20-40-0 | 1081 | |
| 10-40-0 | 1045 | |
| 0-0-0 | 1040 | |
| *10-0-0 | 1027 | |
| 0-40-0 | 988 | |
| **30-40-0 | 981 | |
| L.S.D. 5% | 209 | |
| L.S.D. 1% | 284 | |

Crambe sown @ 15#/acre in 7 inch rows.
Treatments *10-0-0 and **20-0-0 broadcast before seeding.
Remaining treatments applied alone and in combinations with broadcast treatments in a band at seeding time.
Plots sown May 9 - harvested August 18, 1966

# Effects of Fertilization on Seed Yield and Chemical Composition of Tissue of Park Kentucky Bluegrass

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

Ten field experiments were conducted on growers' fields in northwestern Minnesota to study effects of fertilization on seed production of Park Kentucky Bluegrass and Timothy. The investigations consisted of: (a) Date of fertilization, 5 trials (3 trials with K. Bluegrass and 2 trials with Timothy); (b) Fertilization of 5 to 8 year old Timothy stands, three 5x2x2 factorial experiments; (c) Two potassium rate trials with K. Bluegrass. The determinations involved the measurement of seed yield, determination of 16 chemical elements in grass tissue, and climatological measurements at the experimental sites.

Since the investigations on Timothy will be used by D.M. Larsen for his M.S. thesis problem, data from K. Bluegrass plots only is given in this report.

Cool season grasses, such as K. Bluegrass and Timothy prefer somewhat cool and moist weather. The 1965-66 season, as shown in table 1, was characterized by wet and cool fall, rather heavy snowfall and extremely cold January and February. Normal rainfall was received at Roseau in the spring but the temperature was rather low during April and May. The rainfall in June and July was slightly above normal. The average temperatures in June and July were about 1°F. Above normal. However, there were 15 days in July when the maximum air temperature exceeded 79°F. (4 days in July of 1965). K. Bluegrass was harvested on July 7-9, and Timothy on August 2-4. Thus, due to a later harvest, Timothy was more exposed to high temperatures than K. Bluegrass.

Table 1. Climatological Data As Measured at Roseau U.S. Weather Station.

| Period | Precipitation (inches) | | Temperature (°F.) | | GDD $T_b$ = 40°F. |
|---|---|---|---|---|---|
| | Total | Departure From Normal | Ave. | Departure From Normal | |
| 1965/66 | | | | | |
| Aug-Oct. | 7.24 | 0.32 | 51.4 | -3.5 | 1052 |
| Nov.-Mar. | 5.33 | 2.01 | 10.5 | -2.0 | |
| Apr.-July | 11.19 | 1.72 | 54.0 | -1.6 | 1858 |
| Total | 23.76 | +4.05 | | | 2910 |
| Average | | | 35.2 | -2.3 | |

## A. Date of Fertilization Trials

Of the three experiments with K. Bluegrass only one could be used for seed harvest. Two other experiments had to be discontinued because the cooperators inadvertently had applied additional fertilizer in the spring.

Table 2 shows soil test results of an alkaline Colvin sicl in Roseau County

Table 2. Soil Test Results, Colvin Silty Clay Loam, G. Kveen, Roseau County.

| Sampling Depth, Inches | ph. | Extractable P pp 2 m | Exchangeable K pp 2 m |
|---|---|---|---|
| 0-1 | 7.7 | 55 | 150 |
| 1-2 | 7.9 | 16 | 90 |
| 2-3 | 7.9 | 12 | 80 |
| 3-6 | 8.1 | 55 | 90 |
| 6-12 | 8.5 | 8 | 80 |
| 12-18 | 8.4 | 8 | 50 |
| 18-24 | 8.8 | 10 | 30 |

The seed yields obtained in this experiment are shown in table 3.

The chemical composition of K. Bluegrass is given in table 4. Nitrogen content was determined at the Department of Soil Science by the Micro-Kjeldahl Method. The other elements were determined with a emission spectrograph by the Ohio State University Plant Analysis laboratory.

Plant tissue samples were collected from another "Date of Fertilization" trial on a peat soil. The results are given in table 5. Seed yields could not be obtained on this experiment because of excessive lodging.

Table 3. Effect of date of fertilizer application on the seed yield of Park Kentucky Bluegrass-1966. Colvin Silty Clay Loam, G. Kveen, Roseau County.

| Date of Fertilization | Seed Yield LB./Acre |
|---|---|
| Aug. 25, 1965 | 421 |
| Sept. 15, 1965 | 495 |
| Oct. 15, 1965 | 590 |
| May 26, 1966 | 329 |
| June 15, 1966 | 189 |
| Split (1/2 Sept. 15 & 1/2 May 26) | 435 |

All plots received: 60+46+46

Seeded: May 1959; Renovated: 1962

Fertilization in 1965: None.

Flooded for 6 weeks during spring 1966.

Table 4. Effect of date of fertilization on chemical composition of Kentucky Bluegrass tissue, Colvin sicl, G. Kveen, Roseau County - 1966

| Date of Fertilization* | N | P | K | Ca | Mg | B | Cu | Zn | Mn | Mo | Al | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per Cent | | | | | Parts Per Million | | | | | | |
| Check (June 15, 66) | 1.64 | .32 | 1.89 | .39 | .24 | 5 | 10 | 27 | 77 | .73 | 199 | 254 |
| August 25, 65 | 1.62 | .30 | 2.13 | .36 | .22 | 4 | 9 | 21 | 52 | .68 | 151 | 169 |
| September 15, 65 | 1.93 | .32 | 2.26 | .42 | .24 | 4 | 11 | 23 | 63 | .93 | 166 | 236 |
| October 15, 65 | 2.03 | .31 | 2.21 | .36 | .23 | 4 | 9 | 21 | 57 | .59 | 68 | 91 |
| May 26, 66 | 3.39 | .37 | 2.75 | .39 | .25 | 4 | 10 | 26 | 63 | .77 | 68 | 131 |
| Split (1/2 Sep. 15 & 1/2 May 26) | 2.56 | .33 | 2.32 | .39 | .24 | 4 | 9 | 22 | 56 | .79 | 109 | 151 |

* All plots received: 60+46+46 ($N, P_2O_5, K_2O$) treatment; fertilizer was applied on "June 15" plots after the collection of plant tissue samples.

Table 5. Effect of date of fertilization on chemical composition of Kentucky Bluegrass tissue, deep peat, L. Miller, Roseau County - 1966

| Date of Fertilization* | N | P | K | Ca | Mg | B | Cu | Zn | Mn | Mo | Al | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per Cent | | | | | Parts Per Million | | | | | | |
| August 25, 65 | 2.99 | .33 | 1.81 | .48 | .36 | 6 | 5 | 35 | 50 | 1.23 | 13 | 55 |
| September 15, 65 | 3.02 | .33 | 2.05 | .44 | .34 | 5 | 6 | 37 | 49 | 1.05 | 12 | 53 |
| October 15, 65 | 3.20 | .34 | 1.99 | .46 | .35 | 5 | 7 | 39 | 45 | .96 | 13 | 61 |
| May 1, 66 | 3.29 | .35 | 2.38 | .45 | .34 | 5 | 5 | 37 | 48 | .83 | 13 | 61 |
| May 20, 66 | 3.23 | .36 | 2.29 | .40 | .33 | 5 | 5 | 37 | 51 | 1.02 | 12 | 60 |
| Split (1/2 Sept. 15 & 1/2 May 1) | 3.18 | .34 | 1.96 | .44 | .34 | 5 | 5 | 36 | 47 | .97 | 11 | 53 |

* All plots received: 30+46+46 ($N, P_2O_5, K_2O$) treatment.

B. Potassium Rate Study

Burson et al. (1959-1963) found that K topdress applications had little or no effect on seed yields of K. Bluegrass in Roseau County, even on soils (peat, sandy loam, silt loam) with low exchangeable K content. The potassium rate most often used was 80 lbs. $K_2O$ per acre. However, some growers had observed less lodging and obtained increased seed yields with the use of relatively high K application.

To investigate effects of K application on K. Bluegrass seed production two field experiments were established in northwestern Minnesota. Fertilizer topdress applications were made on established stands on a Rocksbury loam and a deep peat on September 15, 1965. A randomized block design was used with the treatments replicated four times. Plant tissue samples were collected prior to the heading-out time. Seed yields were obtained from only one experiment on the loam soil. The grass had severely lodged on the peat.

Soil test results of samples obtained prior to fertilizer application from the experiment on loam soil are given in table 6.

Table 6 Soil test results·Rocksbury loam, E. Helmstetter, Lake of the Woods County.

| Sampling Depth, Inches | ph | Extractable P pp2m | Exchangeable K pp2m |
|---|---|---|---|
| 0-1 | 8.4 | 40 | 100 |
| 1-2 | 8.3 | 18 | 70 |
| 2-3 | 8.3 | 22 | 60 |
| 3-6 | 8.0 | 12 | 50 |
| 6-12 | 8.4 | 4 | 40 |
| 12-18 | 8.3 | 3 | 50 |
| 18-24 | 8.5 | 3 | 60 |

As shown in table 7 K. Bluegrass seed yields were increased by the application of nitrogen and phosphorus. However, no yield increases were obtained with the addition of potassium, even at the higher rates.

The chemical composition of K. Bluegrass tissue from the two experimental sites are given in tables 8 and 10.

As shown in Fig. 1 the K content in grass tissue was affected quite differently by potassium topdress application to the two soils. On the peat there appears to be a curvilinear relationship with the greatest increases in K content taking place up to the 140 lbs. K per acre rate. On the loam soil, the first increment of 35 lb. K/acre increased the K content in grass tissue by 0.19%, but no increases are shown beyond that point. One gets the impression that, for some unknown reason, the potassium applied to this mineral soil was not absorbed by the plants.

Table 7. Effect of potassium application on the seed yield of Park Kentucky Bluegrass - 1966.Rocksbury loam, E. Helmstetter, Lake of the Woods County.

| Treatment | Seed Yield lb./acre |
|---|---|
| None | 93 |
| 60+46+0 | 305 |
| 60+46+42 | 232 |
| 60+46+84 | 308 |
| 60+46+126 | 283 |
| 60+46+168 | 317 |
| 60+46+336 | 298 |

Fertilizer applied: Sept. 15, 1965

Seeded: 1962

Fertilizer used in 1965: 75+75+0

Table 9. Soil test results.Deep peat, L. Miller, Roseau County.

| Sampling Depth, Inches | ph | Extractable P pp2m | Exchangeable K pp2m |
|---|---|---|---|
| 0-1 | 6.6 | 23 | 160 |
| 1-2 | 6.6 | 13 | 90 |
| 2-3 | 6.6 | 8 | 50 |

Table 8. Effect of Potassium treatments on chemical composition of Kentucky Bluegrass tissue, Rocksbury loam, E. Helmstetter, Lake of the Woods County - 1966

| Treat No. | Treatment* N | $P_2O_5$ | $K_2O$ | N | P | K | Ca | Mg | B | Cu | Zn | Mn | Mo | Al | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lb./acre | | | Per Cent | | | | | Parts Per Million | | | | | | |
| 7 | None | | | 1.75 | .29 | 1.92 | .33 | .19 | 6 | 9 | 20 | 38 | .24 | 6 | 22 |
| 1 | 60 | 46 | 0 | 1.98 | .29 | 1.99 | .39 | .21 | 6 | 12 | 20 | 38 | .35 | 7 | 29 |
| 2 | 60 | 46 | 42 | 2.01 | .29 | 2.18 | .38 | .20 | 5 | 10 | 20 | 34 | .25 | 8 | 29 |
| 3 | 60 | 46 | 84 | 2.06 | .30 | 2.13 | .36 | .20 | 5 | 9 | 20 | 37 | .30 | 7 | 27 |
| 4 | 60 | 46 | 126 | 2.03 | .29 | 2.13 | .38 | .20 | 5 | 15 | 21 | 37 | .35 | 8 | 31 |
| 5 | 60 | 46 | 168 | 2.06 | .30 | 2.21 | .38 | .19 | 5 | 11 | 20 | 34 | .27 | 7 | 29 |
| 6 | 60 | 46 | 336 | 2.07 | .30 | 2.24 | .37 | .20 | 6 | 10 | 21 | 35 | .30 | 7 | 38 |

* Fertilizer applied on Sep. 15, 1965.

Table 10. Effect of potassium treatments on chemical composition of Kentucky Bluegrass tissue, deep peat, L. Miller, Roseau County - 1966

| Treat No. | Treatment* N | $P_2O_5$ | $K_2O$ | N | P | K | Ca | Mg | B | Cu | Zn | Mn | Mo | Al | Fe |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | lb./acre | | | Per Cent | | | | | Parts Per Million | | | | | | |
| 7 | None | | | 3.04 | .31 | 1.67 | .45 | .36 | 7 | 4 | 36 | 43 | .97 | 12 | 49 |
| 1 | 30 | 46 | 0 | 3.21 | .34 | 1.77 | .47 | .38 | 7 | 5 | 36 | 47 | 1.13 | 12 | 54 |
| 2 | 30 | 46 | 42 | 3.18 | .35 | 1.97 | .47 | .36 | 7 | 4 | 37 | 46 | 1.04 | 12 | 60 |
| 3 | 30 | 46 | 84 | 3.15 | .34 | 2.16 | .46 | .34 | 6 | 4 | 36 | 49 | .81 | 13 | 54 |
| 4 | 30 | 46 | 126 | 3.09 | .34 | 2.36 | .43 | .32 | 6 | 4 | 35 | 43 | .72 | 12 | 49 |
| 5 | 30 | 46 | 168 | 3.27 | .35 | 2.61 | .36 | .31 | 5 | 4 | 34 | 42 | .66 | 11 | 51 |
| 6 | 30 | 46 | 336 | 3.19 | .35 | 3.00 | .33 | .25 | 5 | 4 | 33 | 45 | .50 | 12 | 51 |

* Fertilizer applied on Sep. 15, 1965.

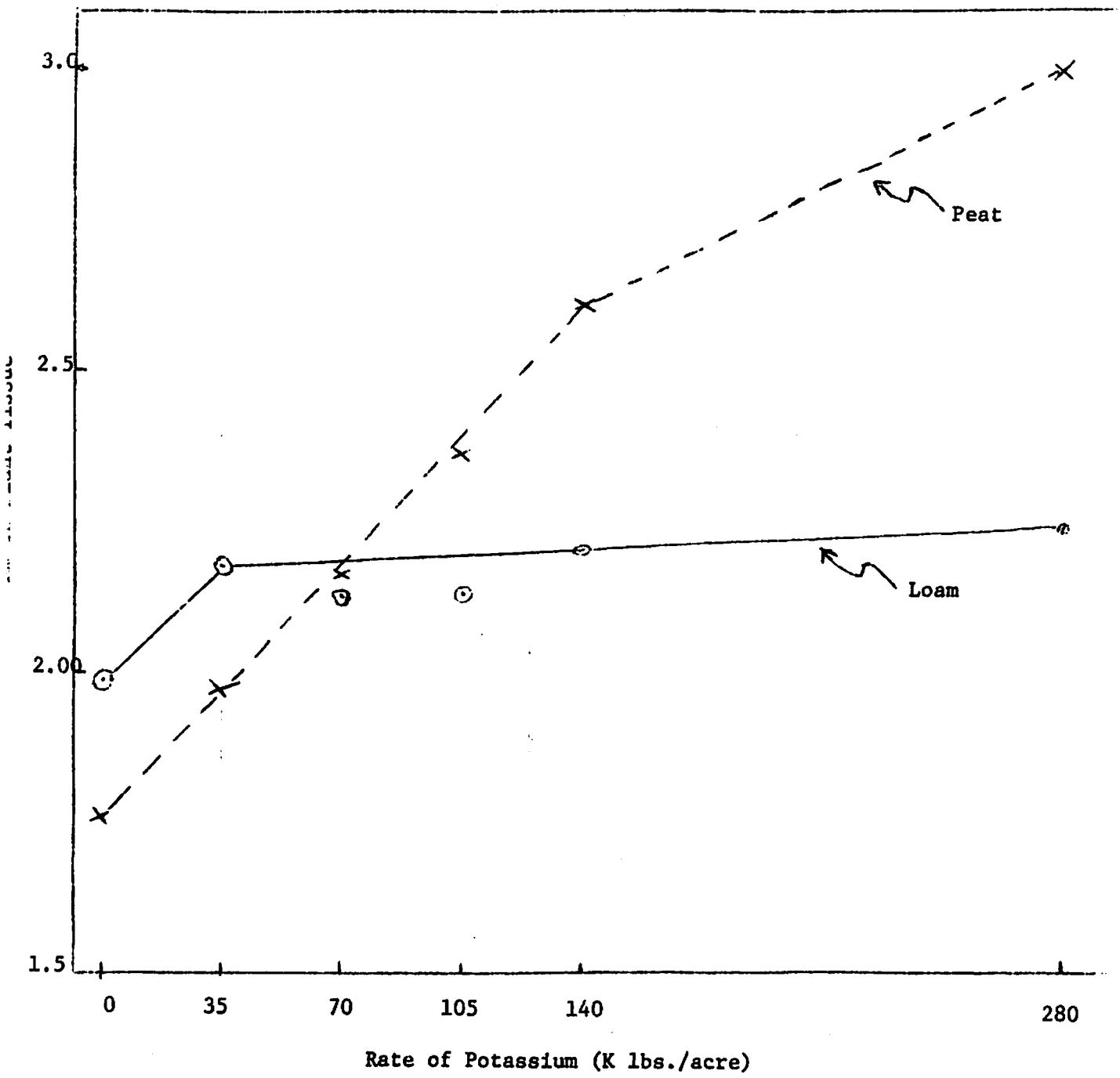



Figure 1 Effect of Potassium topdress applications to mineral and peat soils on the K content of K. Bluegrass tissue.

# Improvement of Forested Soils

R. H. Rust

In 1965 a 25 acre field was selected in Wadena County for investigation of soil properties which affect productivity. The site is located on drumlin topography (about 2 - 4 percent slopes) which covers some 500,000 acres in parts of Wadena, East Ottertail and Todd counties. At this site the associated soils with a range in natural drainage conditions are the Rockwood, Blowers, and Paddock series - all of which have a fragipan, to a greater or lesser extent, at 2 to 3 feet below the surface.

In 1966 the field was limed (2 T/A) and fertilized with phosphate (100 lbs/A 0-45-0), potash (500 lbs/A 0-0-60), and gypsum (300 lbs/A), then seeded to a mixture of Vernal alfalfa and Lincoln bromegrass.

Fifteen legume and legume-grass mixtures were seeded in replicate plots on 3 different soil conditions to assess adaptability.

Five plots (200 x 150 feet) were marked out on a uniform 4 percent slope for future hydrologic studies. Water stage recorders (4) and observation wells (12) were installed at upper and lower ends of the plots about July 1 and observation of the water table made for the remainder of the season.

Approximately 18 inches of rainfall were recorded during the period May 15 through October 15. No appreciable perched water tables were observed after July 1 (when the observation wells were installed).

A good to excellent stand of alfalfa was established.

- - - - - - - -

This project is being conducted in cooperation with the Agricultural Research Service.

# Land Forming
# at
# Northwest Experiment Station - 1966

Olaf C. Soine, Scientist

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

The plots and treatments were randomized and the crops and fertilizer treatments were replicated 4 times. The soil type is Bearden silt loam. Wheat and barley were seeded on May 24, and this late date of seeding may account for the low yields of these 2 crops. The corn was planted on May 25.

The 5 methods of land forming are:

1. Check, no treatment
2. .02% grade in one direction
3. .01% grade in one direction
4. Level grade
5. Land smoothing - pulling soil from high spots to low with no attempt to grade.

The yields of barley were low on all plots and there was no significant effect on the yields by either land forming or fertilizer treatments.

The yields of wheat on the "no treatment" plots were slightly lower than on the other 4 land forming plots. The results of the fertilizer treatments were variable and no single rate gave a consistent increase in yield.

All the corn yields were good. The yields of corn on the "no treatment" plots were lower than the yields on the other 4 treatments. The 0-40-0 and the 40-40-20 rates produced the most consistent yield increases of corn.

Effect of 5 Different Methods of Land Forming
on
The Yield of Corn, Wheat and Barley

| Land forming treatments | Fertilizer lbs./acre N | $P_2O_5$ | $K_2O$ | Corn* bushels | Wheat per | Barley acre |
|---|---|---|---|---|---|---|
| No treatment | 0 | 0 | 0 | 80.0 | 17.2 | 35.0 |
| | 0 | 40 | 0 | 81.4 | 20.3 | 39.9 |
| | 0 | 40 | 20 | 71.5 | 14.6 | 31.5 |
| | 40 | 40 | 20 | 85.2 | 18.6 | 38.5 |
| .02% grade | 0 | 0 | 0 | 80.4 | 26.6 | 27.8 |
| | 0 | 40 | 0 | 84.2 | 25.1 | 34.0 |
| | 0 | 40 | 20 | 69.9 | 28.7 | 33.8 |
| | 40 | 40 | 20 | 91.5 | 25.0 | 39.4 |
| .01% grade | 0 | 0 | 0 | 78.6 | 20.2 | 23.4 |
| | 0 | 40 | 0 | 86.8 | 18.4 | 21.7 |
| | 0 | 40 | 20 | 86.3 | 20.2 | 26.9 |
| | 40 | 40 | 20 | 91.2 | 26.7 | 38.8 |
| Level grade | 0 | 0 | 0 | 85.4 | 22.6 | 36.4 |
| | 0 | 40 | 0 | 88.8 | 23.3 | 35.6 |
| | 0 | 40 | 20 | 72.5 | 24.9 | 36.2 |
| | 40 | 40 | 20 | 92.3 | 24.7 | 40.0 |
| Land smoothing | 0 | 0 | 0 | 93.1 | 22.5 | 33.8 |
| | 0 | 40 | 0 | 88.5 | 22.1 | 32.0 |
| | 0 | 40 | 20 | 89.7 | 20.3 | 36.6 |
| | 40 | 40 | 20 | 86.5 | 22.6 | 36.3 |

*Corn planted in 22 inch rows, 20,000 population.
Bushels per acre at 15.5% moisture.

# Soil Testing in Minnesota During 1966

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes nearly forty thousand samples annually. The following data show the number of various types of samples analyzed in 1966:

| | |
|---|---|
| Regular farm, garden and lawn samples | 35,721 |
| Florist (Greenhouse) samples | 1,867 |
| Limestone | 37 |
| Departmental research samples | 913 |
| Total | 38,538 |

The monthly distribution of regular soil samples received by the laboratory is s in table 1.

Table 1. Monthly distribution of soil samples received by the University of Minnesot Soil Testing Laboratory during 1966.

| Month | Number of Samples |
|---|---|
| January | 3016 |
| February | 2388 |
| March | 3747 |
| April | 4549 |
| May | 1300 |
| June | 885 |
| July | 881 |
| August | 2035 |
| September | 3464 |
| October | 4900 |
| November | 5469 |
| December | 3087 |