SOIL SERIES 109

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1981 edition of the "Bluebook" is a compilation of data collected and analyzed throughout Minnesota. Information was contributed by personnel of the Department of Soil Science including Extension Soil Specialists, Scientists at the branch stations of Crookston, Lamberton, Morris, and Waseca; Becker and Staples experimental site; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, and the Soil and Water Research group of the SEA-USDA, the Tennessee Valley Authority, The Departments of Agriculture and Natural Resources also contributed information.

Sincere appreciation is expressed for materials, financial assistance or program support from several organizations including: Potash and Phosphorus Institute of North America, CENEX, Farmland, Midland Cooperative, Howe Incorporated, Minnesota Crop Improvement Association, American Soybean Association, Golf Course Superintendents Association, Minnesota Limestone Producers Association, Minnesota Plant Food and Chemicals Association, Minnesota Soil and Water Conservation Committee, 3M Company, Dow Chemical, Olin Corporation, Nachurs, Minnesota Wheat Council, Minnesota Soybean Council, Sugarbeet Research and Education Board, Malting Barley Improvement Association, The Red River Valley Potato Growers Association, The Iron Range Resources Commission, The Minnesota State Planning Agency, Minnesota Water Planning Board, The Water Resources Research Center of the Graduate School, The Staples Vo-Tech Institute, The Tennessee Valley Authority and the North Central Forest Experiment Station.

The investigators also greatly appreciate the cooperation of many county agents, farmers, technical assistants, secretaries and the representatives of the various firms and businesses who contributed time, land, machinery and materials and without whose support many of the results reported here would not have been possible.

Some of the results are from 1980 experiments only and should be regarded on this basis. Since most data are from only 1980 studies, conclusions are not conclusive and are thus not for further publication without the written consent of the individual researchers involved.

The University of Minnesota, including the Agricultural Experiment Station, is committed to the policy that all persons shall have equal access to its program, facilities, and employment without regard to race, creed, color, sex, national origin, or handicap.

TABLE OF CONTENTS

Page

1. Minnesota Spring Soil Moisture Situation.....1
2. Additional Remarks on Current Soil Moisture and Soil Temperature Conditions.....3
3. Soil Moisture Profiles at Lamberton, Morris and Waseca.....5
4. Hydrologic Year Precipitation, October 1979 - September 1980.....5

Becker Experiments

5. Influence of Nitrogen Rate, Timing of Nitrogen Applications and Use of Nitrification Inhibitors for Irrigated Corn Production.....9
6. Influence of Nitrogen Form Nitrogen Rate, Timing of Nitrogen Application and Nitrification Inhibitors for Irrigated Corn.....14
7. High Corn and Soybean Yield Trials on the Coarse Textured, Irrigated Soils of Minnesota.....18
8. Corn Yields from Varying Levels of Potash.....27
9. Micronutrients Fertilization of Potatoes Under Irrigation.....29
10. Controlling Soil pH for Potatoes Under Irrigation.....33
11. Fertilizer Trial on Strawberries on an Irrigated Sand.....35
12. Micronutrient Tests on Alfalfa.....37
13. Soil Test Lab Comparison on Irrigated Corn.....43

Crookston Experiments

14. Crookston Weather Summary 46
15. Use of N-Serve in a Spring Nitrogen Application Program on Corn.....48
16. Residual Effects of Copper on Organic Soils.....49
17. Phosphorus Fertilization of Sugarbeets.....51
18. High Phosphorus and Potassium Rates on Spring Wheat.....52
19. Effect of Potassium Fertilization on Spring Wheat.....53
20. Effect of Nitrogen and Phosphorus Application Methods on Spring Wheat.....54
21. Effects of Nitrogen Carrier, Rate and Application Date on Spring Wheat 55
22. Effect of Anhydrous Ammonia on Germination of Spring Wheat and Barley.....56
23. Effects of Different Fertilizer Programs on Soil Test Levels in a Continuous Wheat Cropping System.....57
24. Nitrogen Fertilization and Nitrogen Utilization by Fourteen Small Grain Varieties.....59

Page

25. Nitrogen Incorporation Study on Wheat.....62

Lamberton Experiments

26. Soil Moisture Probabilities.....66

27. Twenty-one Years of Field Experimentation With Nitrogen Source, Placement, and Time of Application to a Webster Loam near Lamberton.....67

28. Nitrate Correlation Study with Corn Following Corn, Soybeans and Wheat.....70

Morris Experiments

29. Morris Weather Summary.....72

30. Continuous Corn Silage.....73

31. Manure Rate Study.....74

32. Residual Effect of Heavy Applications of Animal Manures on Corn Growth and Yield and on Soil Properties.....76

33. Nitrogen Fertilization and Nitrogen Utilization by Eight Small Grain Varieties.....78

34. Influence of Nitrogen Fertilization on Forage Production and Nitrogen Utilization by Three Small Grain Varieties.....81

35. Use of N-Serve as a Nitrification Inhibitor in Fall vs. Spring Nitrogen Application Programs for Corn Production in West Central Minnesota.....83

36. Soil Test Lab Comparisons.....85

Staples Experiment

37. Alfalfa and Red Clover Potassium Trials.....90

38. Barley Fertilization Trials under Irrigation.....96

39. Fertilizer Nitrogen Uptake by Irrigated Potatoes.....101

40. Influence of Nitrogen Rate, Timing of Application and Use of Nitrification Inhibitors on Irrigated Corn.....103

Waseca Experiments

41. Waseca Weather Summary.....105

42. High Phosphorus and Potassium Rates for Continuous Corn.....106

43. Liquid and Dry Starter Fertilizers for Corn in South-Central Minnesota.....112

44. Rotation Nitrogen Study.....115

45. N Rate, Source-Incorporation Study.....117

46. Use of Dwell (terrazole) and N-Serve as Nitrification Inhibitors with Spring Application for Corn Production in Southern Minnesota.....120

Page

47. Maximum Yield Demonstration....122

48. Conservation Tillage Study....126

49. Soybean Tillage-Herbicide Study....134

50. Correcting Chlorosis of Soybeans by Foliar Application of Iron....139

51. Soil Innoculant....141

52. Soil Test Comparison Study....144

Corn

53. Nitrate-Nitrogen in the Soil Profile and the Response of Corn to Nitrogen Fertilization in Southeastern Minnesota....152

54. Deep Sampling of Soils for Residual Nitrates and Its Potential as a Diagnostic Technique for Corn Production in Southwestern Minnesota....155

55. Sulfur and Magnesium Trial on Corn in Central Minnesota....157

56. Tillage Study Summary....161

Experimental Nitrogen Materials

57. The Effect of Three Nitrogen Products on Soil pH in the Greenhouse....165

58. The Effect of Three Nitrogen Products on Lawn Grass Growth and Nutrient Content....167

Grass Seed

59. Fertilization of Grasses Grown for seed Production....168

Pasture

60. Pasture Fertilization Trials....176

Sugarbeets

61. The Effect of Three Nitrogen Levels on Sugarbeet Variety Performance....185

62. Nitrogen Fertilization of Sugarbeets in West-Central Minnesota....198

Sunflowers

63. Starter and Broadcast Fertilizer Trials on Sunflowers....204

64. Sunflower Fertilization....206

65. Phosphorus and Potassium Fertility Studies on Sunflowers....208

66. Fertilizer Trials on Sunflowers....214

Wheat

67. Fertilizer Trials on Wheat on High Fertility Soils in Northwestern Minnesota....217

Page

68. Potassium on Wheat - Pennington County.....219

69. Copper and Manganese Fertilization of Wheat on an Organic Soil.....221

70. N-Rate, Source and Incorporation Study.....223

Wild Rice

71. Wild Rice Fertilization Research.....230

MINNESOTA SPRING SOIL MOISTURE SITUATION 1981

Donald G. Baker, Soil Scientist, Soil Science Dept., Univ. of Minn.
Earl L. Kuehnast, D.N.R., Div. of Waters, State Climatologist
David L. Ruschy, Field Monitor, Soil Science Dept., Univ. of Minn.

The Soil Moisture Monitoring Program is funded under U.S. Water Resources Council Title III Grant Funds, secured by Minnesota Water Planning Board. The Department of Natural Resources Water Division, and University of Minnesota, Soil Science Department. The field soil moisture monitoring was performed by D.L. Ruschy under the supervision of D.G. Baker, and E.L. Kuehnast.

Soil moisture measurements were obtained at 51 sites in late autumn by the Soil Monitoring program under the direction of the Soil Science Department of the University of Minnesota and sponsored by the Division of Waters of Minnesota, Department of Natural Resources.

Medium to fine textured soils were sampled to a depth of 5-feet to determine the amount of plant available water. Samples under corn were most common, but wheat and soybean fields were sampled as well as forested areas. In areas with limited data, estimates were made from late summer and autumn precipitation measurements. The maximum amount of plant available water that these soils could hold averages a little more than 10-inches. The Spring, 1981, projected soil moisture amounts across the state are divided into four areas of soil moisture content which range from 3 inches to about 9 inches and are labeled dry, normal, wet and very wet as shown in Fig. 1.

The dry area with less than 4 inches of soil moisture is located in the western part of the state. It includes all or parts of the western two tiers of counties except Kittson, Red Lake and Nobles counties and includes parts of the counties of Clearwater, Kandiyohi, Renville, Redwood, Cottonwood, Nicollet, Brown and Watonwan. The top soils are the driest in the state in this area.

The area of normal soil moisture amounts, generally 4 to 6 inches, includes all areas of the above described dry area, except the northeast, southeast, and strips in the northwest, and central parts of the state. Again, top soils are dry in this area.

The area of wet soil moisture conditions, 6 to 8 inches of soil water, is in the northeast and in three narrow strips 10 to 20 miles wide. The northeast includes all of Lake and Cook counties and parts of eastern St. Louis county, a strip from Red Lake Falls to Baudette, a strip from central Stearns county southeast through Sherburne, Anoka and northern Washington counties and narrow irregular S-shaped strip from the Dakota-Goodhue county border southwest into Blue Earth county, east into Olmsted county and southwest through Faribault county.

The very wet area, generally containing 8 to 9 inches of plant available soil moisture in the top 5-feet of soil is in the southeast and includes all of Wabasha, Winona, Fillmore and Houston counties and parts of Goodhue, Waseca, Steele, Dodge, Olmsted, Mower and Freeborn counties.

With normal precipitation, 4 to 6 inches across the state, from January through April, the soil moisture situation should be on the whole quite good. This is because dry top soil can absorb moisture from snow melt and spring rains. The amount will vary depending on how far down the top soils are dry. For example, if soils are dry down to 5 to 6 inches, much of the normal snow melt or rains can be expected to be absorbed, but dry top soils of 1-inch will not absorb much.

A combination of factors has led to deeper than usual freezing of the soil this winter. Those factors are primarily the lack of snow cover, which serves as an insulator, and secondarily the dry soil which varies in degree across the state as noted. With each cold spell the freezing level moves deeper. Under normal conditions the deepest penetration of the soil freezing line occurs in early March and at St. Paul averages about 44 inches under a soil bare of vegtation.

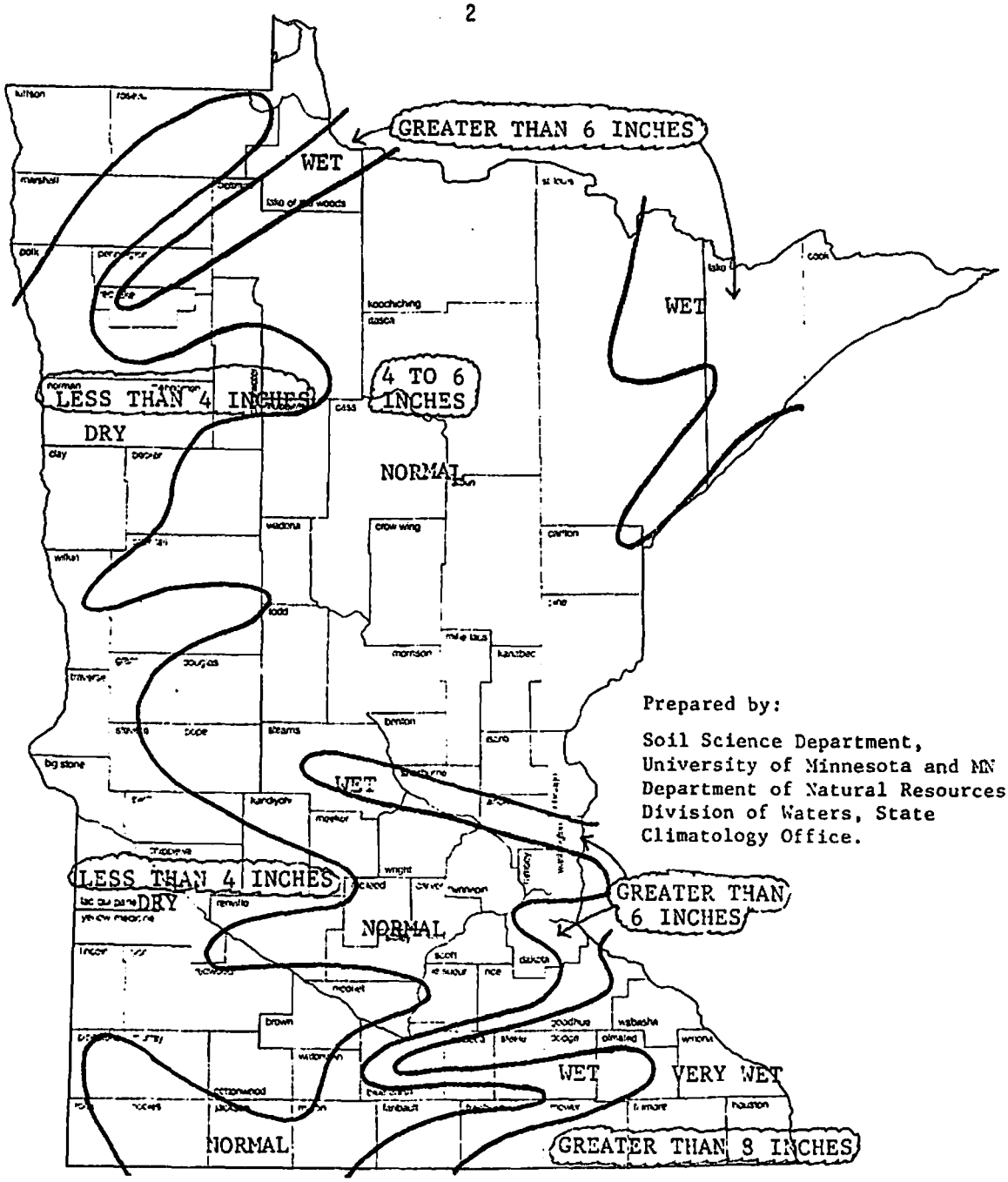

Fig. 1 Plant available soil moisture on December 1, 1980 expressed in inches for the top five feet of medium to fine textured soils. Information is based on actual soil moisture observations; however, precipitation amounts used in conjunction resulted in a more detailed analysis of the soil moisture.

Additional Remarks On Current Soil Moisture and Soil Temperature Conditions

D.G. Baker and E.L. Kuehnast
(Soil Science Dept., U. of Minn. and Dept. of Natural Resources, respectively)

The previously mentioned dry top soil condition that exists over much of the state plus the below normal snow cover that lasted until early February have brought about special and interesting conditions worthy of a special study (which is being made). Except for the possible damage caused to water pipes by the deeper than usual freezing, I believe we can study these events without at the same time feeling guilty that what we are studying is someone's disaster. (Some ornamental plants may be damaged due to low soil temperatures but the dry top soil will probably mean less mechanical damage to roots.)

The first condition is the dry top soil found almost everywhere except in southeastern and northeastern Minnesota. It is believed that this condition will result an unusual condition of interest to hydrologists and soil conservationist alike. The dry top soils even though well below freezing and very porous and are open to water in their present condition. Under the usual state of affairs soils enter the winter in a fairly moist condition with most pores containing water. Upon freezing the soil presents a concrete like structure which water cannot penetrate. For water to enter the soil the snow cover has to be melted and the top soil thawed. As a result the meltwater from the snow runs off with little entering the soil. It appears that on the average 90% or more of the over-winter precipitation is lost as runoff. Such conditions raise the potential for soil erosion losses.

This spring, however, due to the unusual condition of the soils, little runoff is expected in southeastern and northeastern Minnesota. Thus, until the soil water reservoir has been replenished we do not look for water to be added to lakes and streams and the spring soil erosion potential will be reduced.

A special study is being made to see if what has been described will take place and to measure the soil water reservoir that is available. Anyone interested in this situation can make their own study as follows: Find how deep the dry soil layer is before encountering the concrete-like frozen layer. A shovel or spade will be sufficient. The pore space available for snowmelt runoff and spring rains is about one-half of the depth of the loose (dry) topsoil. At St. Paul under corn and alfalfa the loose soil layer equalled 3 and 5 inches, respectively. Therefore, about 1.5 and 2.5 inches of water could be held. Since about 10 inches of snow contain (very approximately) 1 inch of water, these soils could hold not only all of the water currently on the surface in the form of snow but some later rains as well.

The second item of interest this winter, and a reflection of the dry topsoils but more particularly the lack of an effective snow cover, is the deeper freezing of the soil. The main value of snow to agricultural soils, since on the average most of the snow is lost as runoff rather than entering the soil, is its insulating value. A minimum of about 5 inches of snow is required for it to be an effective insulator. Water in the soil also plays a part in temperature because the heat capacity of water on a weight basis is 5 times greater than soil and on a volume basis is about 2 times greater. Thus, in the absence of water soils have less heat to give up and cool more readily.

Fig. 2 shows the progress of the 1981 freezing isotherm ($32^{o}F$) with depth in 3 plots of different vegetative cover at St. Paul compared to a long-term average. The soil is a Waukegan silt loam.

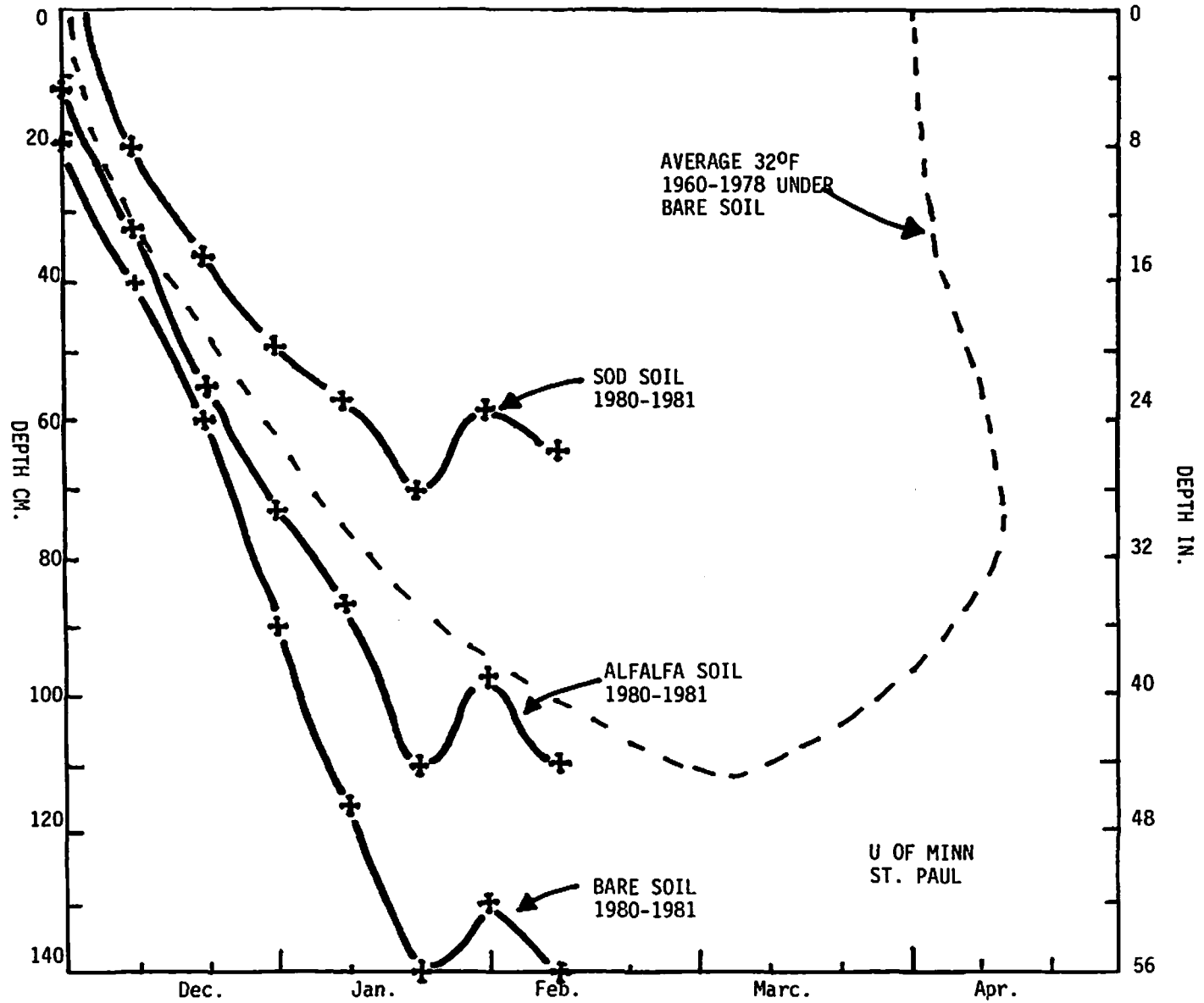

Fig. 2 Soil freezing depths at St. Paul, 1980-81 under 3 different covers compared to the long term mean at St. Paul under a soil bare of vegetation.

Soil Moisture Profiles at Lamberton, Morris and Waseca

by S. Evans, W.W. Nelson, G. Randall, and D.G. Baker

The change in total plant available soil moisture under corn for the 1980 season is shown in Fig. 3 at the three experiment stations. For comparison the long-term 1960-1976 average soil moisture profile at Lamberton is also shown.

All profiles show the characteristic mid-season decrease in soil moisture that ordinarily occurs beginning about mid-June until late August or early September. This draw-down period is that time when precipitation is unequal to the vegetation demands for water and the soil moisture reservoir supplies the deficit. The Waseca profile shows that from about early August the rains were more than sufficient with the reservoir being recharged much earlier than usual.

The Lamberton profile indicates that the usual late summer and early autumn rains did not occur resulting in much drier than normal soils at the end of October. Thus, Lamberton will be much more dependent than usual upon the spring rains of 1981 for adequate soil water reserves.

Hydrologic Year Precipitation, October 1979 - September 1980

E.L. Kuehnast and D.G. Baker

The annual cycle of soil water runs approximately from September to the following August with the soil reaching its lowest water content in late August or early September. From then until the following June, when the maximum content is reached, is a period of additions to the soil reserves. In the case of agricultural soils a major recharge occurs in the late summer and fall and a secondary one in the spring. The drainage, systems, streams and rivers, and surface waters, marshes and lakes, show a somewhat similar cycle. Perhaps the major difference is that the minimum lags the soil minimum by about one month. Since the soil has what might be termed the "first call" upon the precipitation, that is, is ordinarily little or no runoff until the soil has been recharged to some degree, this lag is to be expected.

Hydrologists, who are most concerned with surface waters, have established a "hydrologic year" that runs from October to the following September. It explains the water cycle and annual variations in water supplies much better than the calendar year of January through December. For the 1980 growing season the hydrologic year precipitation is shown in Fig. 4, as well as the departure from normal in Fig. 5.

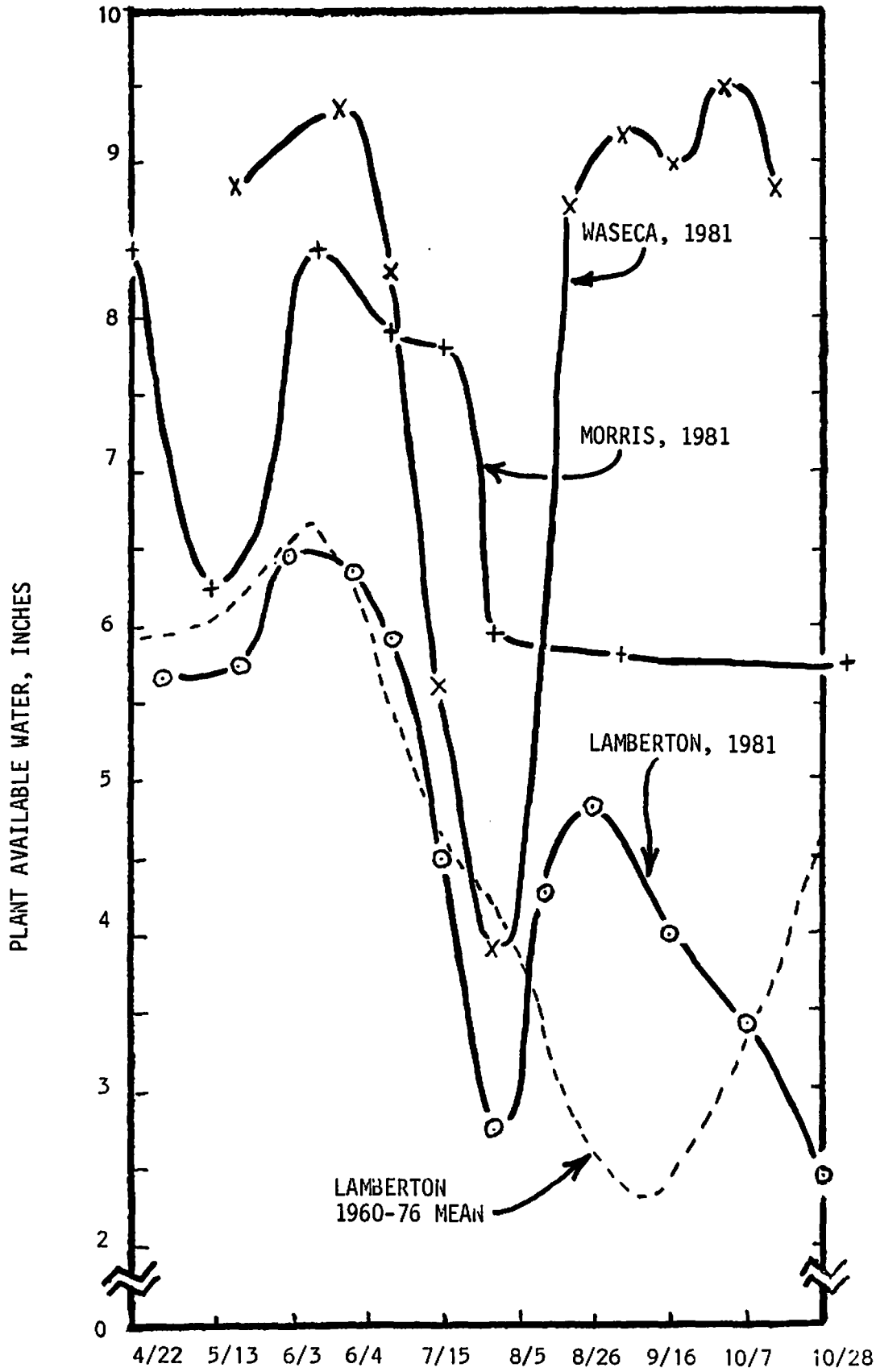

Fig. 3 Soil moisture at Lamberton, Morris, and Waseca in 1980 compared to long term mean at Lamberton.

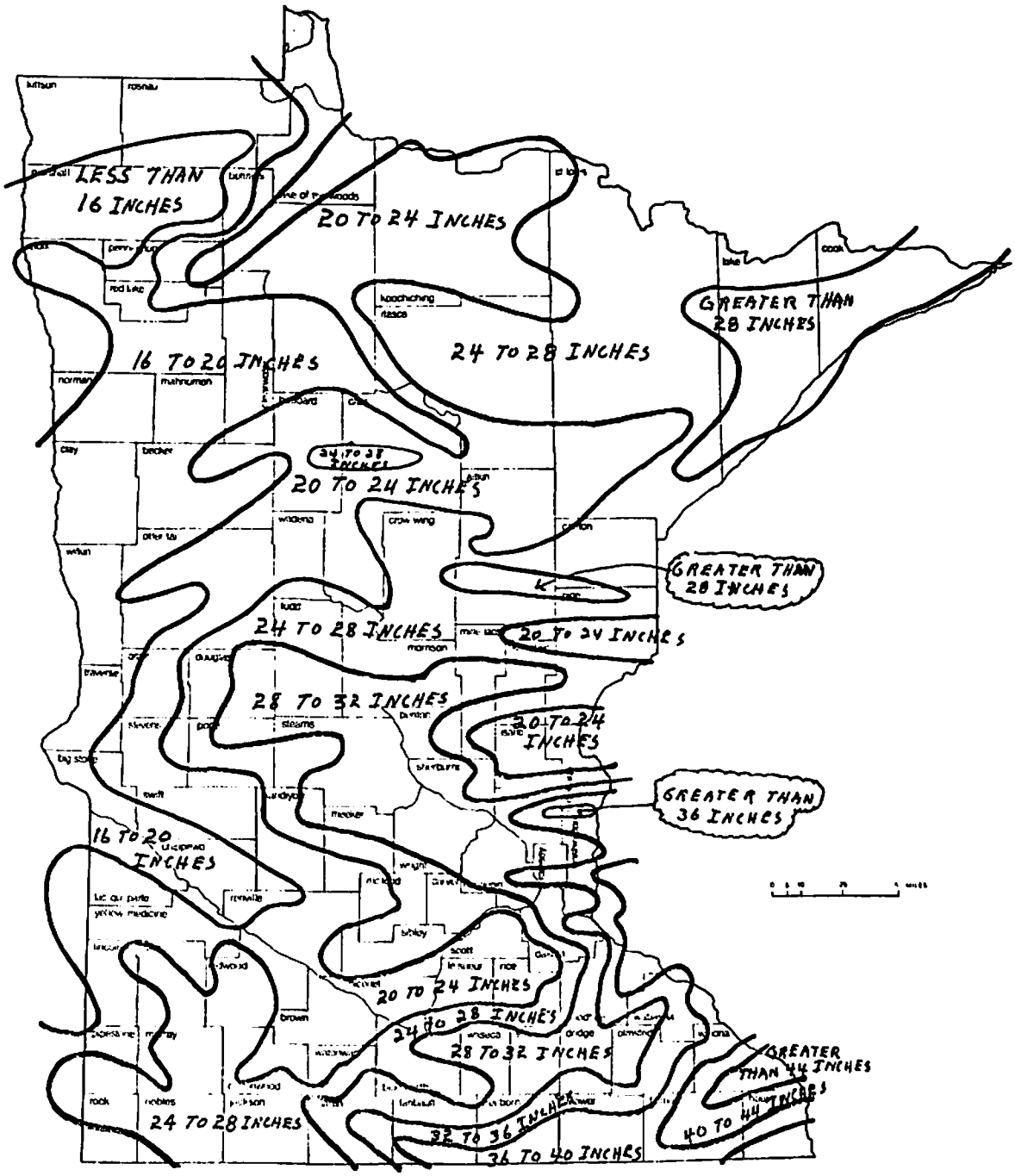

Fig. 4 Hydrologic Year Precipitation October 1979 - September 1980

Prepared by:
State Climatology Office

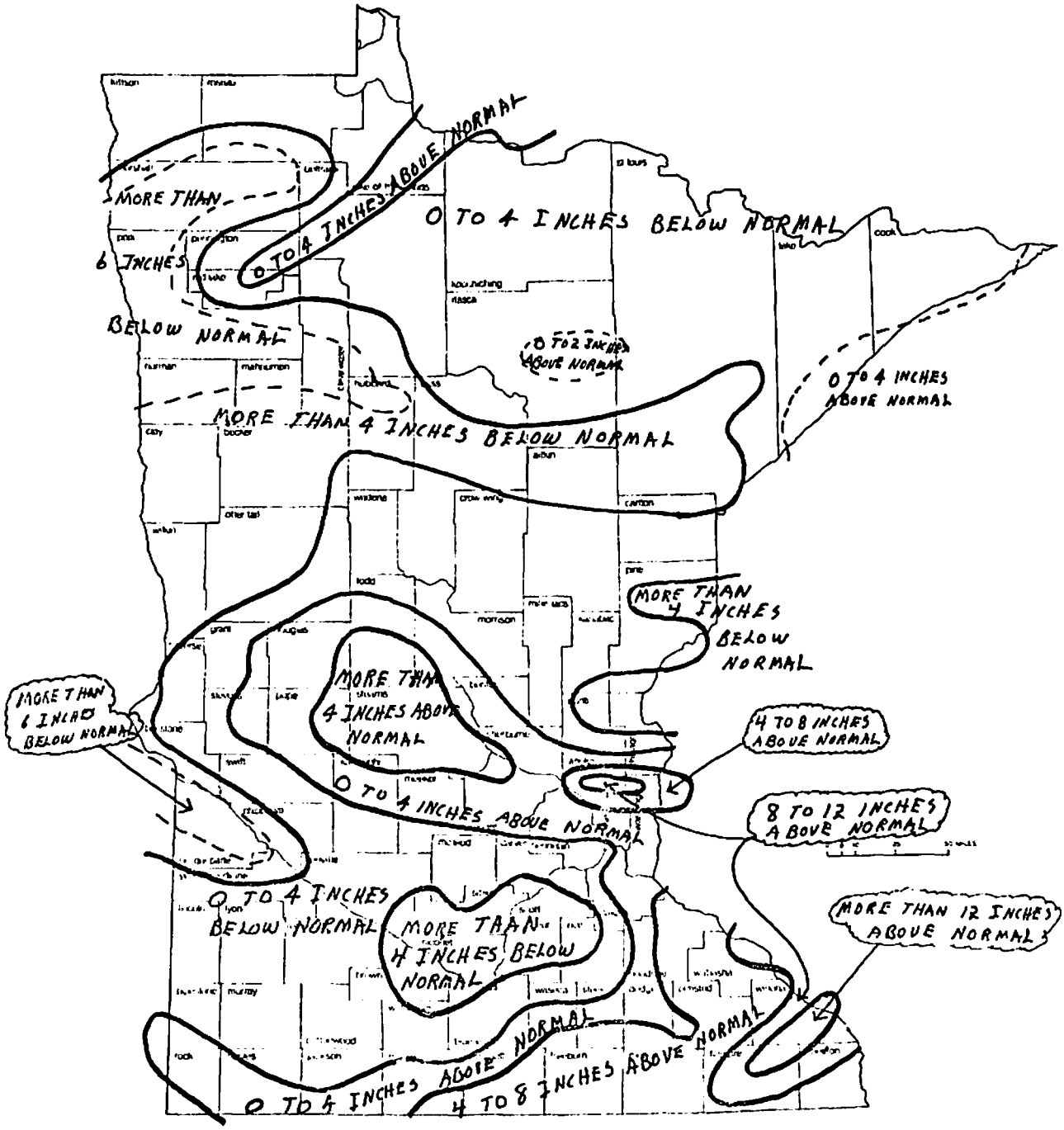

Fig. 5 Hydrologic Year Precipitation Departure from Normal
October 1979 - September 1980

Influence Of Nitrogen Rate, Timing Of Nitrogen Application And Use Of Nitrification Inhibitors For Irrigated Corn Production - Becker, 1980

G.L. Malzer, T. Graff and J. Lensing

Nitrogen management on the coarse textured irrigated soils of Minnesota is a major decision that all corn growers must make in their production system. Nitrogen management includes many aspects of nitrogen fertilization such as rates, forms, methods, times, equipment, and additives. Nitrogen fertilizer application is an essential component for top yields on these coarse textured soils, and many times the produce does not have the flexibility in nitrogen management that a producer on a finer textured soil might have. A large portion of the flexibility in nitrogen management is lost due to the potential loss of nitrate nitrogen by leaching prior to plant demand. To minimize these losses, nitrogen applications are often made in split application through the irrigation system or as late side dressing treatments. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. Commerical availability of chemical additives know as nitrification inhibitors also offer some potential in minimizing nitrogen losses and may add flexability into the overall nitrogen management program. A new trial was established in 1980 to evaluate the significance of nitrogen rates, timing of nitrogen application and the use of nitrification inhibitors.

Experimental Procedures

An experiment consisting of 52 treatments with four replications was arranged in a randomized complete block design and established at the Sand Plains Research Farm near Becker, MN. A Factorial treatment arrangement consisting of three rates of nitrogen (75,150, and 225 # N/A), three nitrification inhibitor treatments (none, N-Serve-Dow Chemical Co. and Dwell-Terrazole-Olin Corporation) and five nitrogen application programs (all preplant, all 8-leaf, all 12 leaf, 1/3 preplant, 2/3 12-leaf, and 2/3 preplant 1/3 12-leaf) were utilized. The experimental design also included a control, the three nitrogen rates applied at tasseling, and the three N rates applied in split combinations (1/6 preplant, 1/6 8-leaf, 3/6 12-leaf, and 1/6 at tasseling). When a nitrification inhibitor was applied with the two times of N application treatments (1/3 - 2/3 or 2/3 - 1/3) the inhibitor was applied only with with the preplant application of nitrogen. All nitrogen treatments were applied as urea and all nitrification inhibitor treatments were applied at rates of 0.5 # a.i./A as coating on to the urea. All inhibitor treatments were incorporated either by discing in the prelant applications or by utilizing the irrigation water with the later applications. Nitrogen applications were made at preplanting (April 28), at the 8-leaf stage of corn growth (June 6), at the 12-leaf growth stage (June 16) and at tasseling (July 11).

Prior to planting broadcast applications of Potassium-Magnesium Sulfate (300 #/A 0-0-22) and Potassium (275 #/A 0-0-60) were made and incorporated by plowing. Corn (Pioneer 3901-100 day R.M.) was planted on April 39th in 30" rows at a population of 30,700 seed/A. Starter fertilizer was applied at the rate of 165 #/A of 8-10-30 banded at planting. A tank mix of Lasso (1½ # ai/A) and Atrazine (1½ # ai/A) was applied on April 30th for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 16th dried and analyzed for Kjeldahl nitrogen. Dry matter production was determined on September 18 by hand harvesting 50 ft^2 of plot. Ears were separated from the stalks, field weights obtained and samples removed from moisture and nitrogen determination. Corn yield were determined on October 2nd by hand harvesting 100 ft^2 of plot area and samples taken and adjusted to 15.5 moisture.

The irrigation program was started on May 1st and continued through August 14th with a total of 11.40 inches of water being applied through irrigation. An additional 21.97 inches of water was obtained during the growing season through rainfall.

General Results

The growing season was excellent at the Sand Plains Research Farm in 1980. This was reflected in the fact that a number of treatment averages were in excess of 200 bu/A. The growing season was characterized by being warm and dry. The numerous early spring rains which have been experienced over the last several years were minimal in 1980. Nitrogen losses due to leaching would be expected to be minimal compared to previous years.

The yield results and nitrogen utilization parameters of the treatments are presented in tables 1 and 2. An excellent nitrogen response ranging from 83 to 209 bu/A were obtained in this experiment. Yield responses up to the highest rate of nitrogen fertilization (225 #N/A) were obtained, but different management alternatives would suggest that this level of a fertilization could decreased with proper or better nitrogen management. Timing of nitrogen applications had a considerable impact final

grain yield and nitrogen utilization. Reduced yields were encountered with early nitrogen applications (especially preplant) and with late nitrogen applications (Tasseling). These yield reductions appear to be reflecting two different concerns: 1) nitrogen loss due to leaching with early nitrogen applications, and 2) applications of nitrogen too late into the season to enable the crop to utilize all of the nitrogen which is being applied. Both of these should be of concern to the corn producer operating under irrigation. In general, improve yields were obtained with sidedress or split applications during the growing season.

The use of nitrification inhibitors (N-Serve and Dwell) provided sizeable yield increases when utilized with the early nitrogen applications (especially with the preplant applications where nitrogen losses were the biggest problem). Relatively few responses to nitrification inhibitors were obtained with applications of nitrogen later into the growing season. Yield increases due to nitrification inhibitors application were not obtained past the 8-leaf stage of application during th 1980 growing season. These general comments may however be altered from year to year depending upon the precipitation and other climatic factors which are encountered during the growing season.

The 1980 results provide some very interesting information concerning nitrogen management for the irrigated corn producers. The information points out not only the importance of nitrogen management but provides some insight into nitrogen management flexibility, and the advantages and roles that nitrification inhibitors may have to play in the overall nitrogen management program.

Table 1. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on leaf N content, grain yield, yield grain N content and dry matter production on irrigated corn. Becker - 1980.

Treatments						Dry Matter Production		
N-Rate	Inh.	Appl. Time	Leaf N	Grain Yield	Yield Grain N	Grain	Stover	Total
#/A			%	bu/A	%	---------T/A----------		
Check	-	-	1.28	82.9	1.02	2.11	2.17	4.28
75	-	ppl	1.93	141.5	1.13	2.88	3.06	5.94
75	-	sp(4)	2.44	172.8	1.22	3.89	3.50	7.39
75	-	sp(2)1/3,2/3	2.26	165.9	1.18	3.58	3.93	7.52
75	-	sp(2)2/3,1/3	1.93	132.6	1.04	2.72	2.87	5.59
75	-	8-leaf	2.14	150.2	1.17	3.51	3.24	6.75
75	-	12-leaf	2.56	164.5	1.16	3.72	3.21	6.94
75	-	Tassel	1.83	143.0	1.32	3.27	2.51	5.78
75	Dwell	ppl	1.83	138.3	1.07	3.26	3.62	6.89
75	Dwell	sp(2) 1/3,2/3	2.49	180.1	1.32	3.82	3.60	7.42
75	Dwell	sp(2) 2/3,1/3	2.26	174.6	1.10	3.65	3.59	7.24
75	Dwell	8-leaf	2.28	158.6	1.21	3.72	3.58	7.30
75	Dwell	12-leaf	2.60	187.0	1.29	3.92	3.44	7.36
75	N-S	ppl	1.97	149.2	1.15	3.26	3.32	6.58
75	N-S	sp(2)1/3,2/3	2.45	160.5	1.12	3.43	3.32	6.74
75	N-S	sp(2)2/3,1/3	2.16	155.9	1.11	3.44	3.53	6.98
75	N-S	8-leaf	2.33	169.7	1.14	3.77	3.73	7.50
75	N-S	12-leaf	2.62	167.4	1.12	3.56	3.47	7.04
150	-	ppl	1.88	153.4	1.10	3.33	3.84	7.18
150	-	sp(4)	2.48	190.3	1.40	4.35	3.84	8.18
150	-	sp(2)1/3,2/3	2.60	171.8	1.31	4.05	3.77	7.82
150	-	sp(2)2/3,1/3	2.44	157.4	1.21	3.64	3.60	7.24
150	-	8-leaf	2.54	188.1	1.36	4.00	4.44	8.44
150	-	12-leaf	2.86	193.1	1.33	4.25	4.25	8.50
150	-	Tassel	1.84	148.2	1.37	3.22	2.37	5.59
150	Dwell	ppl	2.68	206.3	1.34	4.38	3.71	8.09
150	Dwell	sp(2)1/3,2/3	2.72	202.2	1.37	4.10	4.00	8.12
150	Dwell	sp(2) 2/3,1/3	2.59	194.1	1.36	4.21	3.89	8.10
150	Dwell	8-leaf	2.68	193.0	1.35	4.41	4.02	8.43
150	Dwell	12-leaf	2.78	181.7	1.38	4.15	3.35	7.50
150	N-S	ppl	2.45	198.9	1.40	4.33	3.90	8.23
150	N-S	sp(2)1/3,2/3	2.56	181.4	1.42	4.22	3.72	7.94
150	NS	sp(2)2/3,1/3	2.77	189.8	1.26	4.56	4.30	8.86
150	NS	8-leaf	2.63	192.6	1.40	4.19	3.81	8.00
150	NS	12-leaf	2.75	179.7	1.43	4.05	4.01	8.06
225	-	ppl	2.45	188.6	1.36	4.47	3.94	8.41
225	-	sp(4)	2.65	191.1	1.48	4.14	3.82	7.97
225	-	sp(2)1/3,2/3	2.66	195.9	1.34	4.15	3.64	7.80
225	-	sp(2)2/3,1/3	2.68	209.0	1.43	4.56	3.98	8.54
225	-	8-leaf	2.72	201.4	1.42	4.16	4.52	8.68
225	-	12-leaf	2.74	184.0	1.37	3.84	3.71	7.55
225	-	Tassel	1.84	151.9	1.31	3.59	2.76	6.36
225	Dwell	ppl	2.77	196.2	1.44	4.82	4.86	9.68
225	Dwell	sp(2)1/3,2/3	2.71	192.7	1.42	4.08	3.74	7.82
225	Dwell	sp(2)2/3,1/3	2.72	202.1	1.44	4.44	4.24	8.68
225	Dwell	8-leaf	2.71	196.5	1.46	3.91	4.12	8.03
225	Dwell	12-leaf	2.75	195.5	1.38	4.29	3.79	8.08
225	N-S	ppl	2.87	204.1	1.46	3.92	4.04	7.96
225	N-S	sp(2)1/3,2/3	2.70	198.9	1.44	4.31	4.04	8.34
225	N-S	sp(2)2/3,1/3	2.78	203.9	1.47	4.39	4.32	8.71
225	N-S	8-leaf	2.84	201.5	1.44	4.17	4.11	8.28
225	N-S	12-leaf	2.94	181.7	1.44	3.98	3.40	7.38
Significance			**	**	**	**	**	**
BLSD (.05)			0.17	15.9	0.10	0.50	0.53	7.97

Table 2. Influence of nitrogen rate, timing of nitrogen application use of nitrification inhibitors on grain N content and nitrogen removal of irrigation corn. Becker 1980.

Treatments		Appl.	N Content		N Removal		
N-Rate	Inhibitor	Time	Grain	Stover	Grain	Stover	Total
#/A			%		lbs/A		
Check	-	-	1.10	0.38	46.9	16.8	63.7
75	-	ppl	1.17	0.43	67.6	26.0	93.5
75	-	sp(4)	1.29	0.52	100.4	36.6	137.0
75	-	sp(2) 1/3,2/3	1.25	0.41	89.7	32.2	122.0
75	-	sp(2),2/3,1/3	1.11	0.40	59.5	23.2	82.7
75	-	8-leaf	1.16	0.45	81.3	29.7	111.1
75	-	12-leaf	1.23	0.45	91.7	29.2	120.9
75	-	Tassel	1.32	0.59	85.9	29.4	115.4
75	Dwell	ppl	1.12	0.41	74.1	29.9	104.0
75	Dwell	sp(2)1/3,2/3	1.22	0.53	94.0	37.5	131.5
75	Dwell	sp(2)2/3,1/3	1.19	0.40	88.0	28.5	116.6
75	Dwell	8-leaf	1.12	0.46	83.6	33.2	116.8
75	Dwell	12-leaf	1.22	0.48	95.9	23.9	128.8
75	N-S	ppl	1.18	0.42	78.5	28.5	107.0
75	N-S	sp(2)1/3,2/3	1.11	0.44	76.8	29.1	105.9
75	N-S	sp(2)2/3,1/3	1.20	0.51	83.0	36.3	119.3
75	N-S	8-leaf	1.16	0.52	88.2	39.0	127.2
75	N-S	12-leaf	1.13	0.51	81.1	35.7	116.8
150	-	ppl	1.12	0.50	74.8	38.6	113.5
150	-	sp(4)	1.35	0.57	117.5	44.3	161.8
150	-	sp(2)1/3,2/3	1.33	0.60	107.7	45.1	152.8
150	-	sp(2)2/3,1/3	1.14	0.47	84.0	33.8	117.8
150	-	8-leaf	1.41	0.55	112.8	49.2	162.0
150	-	12-leaf	1.36	0.65	115.9	55.1	171.0
150	-	Tassel	1.30	0.60	84.1	28.3	112.4
150	Dwell	ppl	1.36	0.56	118.9	42.2	161.1
150	Dwell	sp(2)1/3,2/3	1.34	0.47	110.1	37.7	147.8
150	Dwell	sp(2)2/3,1/3	1.36	0.52	115.0	40.1	155.2
150	Dwell	8-leaf	1.42	0.61	125.2	49.4	174.7
150	Dwell	12-leaf	1.35	0.64	112.2	43.3	155.6
150	N-S	ppl	1.39	0.56	120.4	43.5	163.8
150	N-S	sp(2)1/3,2/3	1.37	0.54	115.5	40.3	155.8
150	N-S	sp(2)2/3,1/3	1.36	0.49	124.2	42.5	166.7
150	N-S	8-leaf	1.42	0.59	119.4	45.2	164.7
150	-	12-leaf	1.29	0.61	104.8	48.6	154.3
225	-	ppl	1.35	0.50	120.4	39.4	159.8
225	-	sp(4)	1.41	0.65	116.8	49.5	166.4
225	-	sp(2)1/3,2/3	1.36	0.63	113.2	46.3	159.6
225	-	sp(2)2/3,1/3	1.42	0.60	129.9	47.8	177.7
225	-	8-leaf	1.42	0.78	118.6	71.4	189.9
225	-	12-leaf	1.37	0.66	105.6	49.5	155.0
225	-	Tassel	1.36	0.67	97.6	37.2	134.8
225	Dwell	ppl	1.47	0.60	141.6	58.0	199.6
225	Dwell	sp(2)1/3,2/3	1.39	0.64	113.6	48.2	161.9
225	Dwell	sp(2)2/3,1/3	1.45	0.57	128.7	48.1	176.8
225	Dwell	8-leaf	1.42	0.65	111.2	53.1	164.3
225	Dwell	12-leaf	1.38	0.60	119.2	45.5	164.7
225	N-S	ppl	1.38	0.66	108.2	53.4	161.6
225	N-S	sp(2)1/3,2/3	1.48	0.62	127.2	50.6	177.8
225	N-S	sp(2)2/3,1/3	1.42	0.56	125.2	50.4	175.7
225	N-S	8-leaf	1.39	0.66	116.4	54.1	170.5
225	N-S	12-leaf	1.36	0.59	108.3	40.3	148.5
Significance			**	**	**	**	**
BLSD (.05)			0.10	0.09	16.6	9.3	22.6

Table 1 and 2 (continued)

Treatments	Leaf N	Grain Yield	Yield Grain N	Dry Matter Production Grain	Stover	Total	N-Content Grain	Stover	N-Removal Grain	Stover	Total
	%	bu/A	%	-------- T/A -------			------%------		--------lbs/A--------		
Factorial Arrangement (Nitrogen Rate X Time of application)											
N Rate #/A											
75	2.16	152.9	1.18	3.37	3.19	6.56	1.22	0.46	82.3	29.5	111.8
150	2.38	171.7	1.30	3.82	3.73	7.56	1.29	0.56	99.5	42.1	141.6
225	2.53	188.8	1.39	4.13	3.77	7.90	1.38	0.64	114.6	48.7	163.3
Significance	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)	0.06	5.1	0.04	0.17	0.17	0.29	0.03	0.03	5.4	3.7	7.8
Time											
preplant	2.09	161.1	1.20	3.56	3.61	7.17	1.21	0.48	87.6	34.7	122.3
8-leaf	2.46	179.8	1.32	3.89	4.08	7.96	1.33	0.60	104.2	50.1	154.3
12-leaf	2.72	180.6	1.29	3.94	3.72	7.66	1.32	0.59	104.4	44.6	148.9
Tassel	1.84	147.7	1.33	3.36	2.55	5.91	1.33	0.62	89.2	31.6	120.8
sp(2)1/3,2/3	2.51	177.9	1.28	3.93	3.78	7.71	1.31	0.55	103.6	41.2	144.8
sp(2)2/3,1/3	2.35	166.3	1.23	3.64	3.48	7.12	1.22	0.49	91.1	34.9	126.1
sp(4)1/6,1/6 3/6,1/6	2.52	184.7	1.37	4.13	3.71	7.85	1.35	0.58	111.6	43.5	155.0
Significance	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)	0.10	8.0	0.06	0.28	0.26	0.45	0.05	0.06	8.8	6.0	12.6
Factorial Arrangement (Nitrogen Rate X Inhibitor X Time)											
N-Rate #/A											
75	2.25	159.7	1.15	3.48	3.43	6.92	1.17	0.46	82.2	31.4	113.6
150	2.60	185.6	1.33	4.12	3.91	8.03	1.33	0.56	110.7	43.6	154.4
225	2.74	196.8	1.42	4.23	4.03	8.26	1.40	0.62	119.7	50.4	169.6
Significance	**	**	**	**	**	**	**	**	**	**	**
BLSD(.05)	0.05	4.3	0.03	0.13	0.14	0.23	0.02	0.02	4.6	2.4	6.1
Nitrification Inhibitor											
None	2.43	173.2	1.26	3.79	3.73	7.53	1.28	0.54	98.2	41.1	139.3
Dwell	2.57	186.6	1.33	4.08	3.84	7.92	1.32	0.54	108.8	41.8	150.6
N-Serve	2.59	182.3	1.32	3.97	3.80	7.77	1.31	0.55	105.1	42.5	147.6
Significance	**	**	**	**	NS	*	**	NS	**	NS	**
BLSD(.05)	0.05	4.8	0.03	0.14	-	0.26	0.03	-	4.8	-	6.7
Time											
preplant	2.31	175.1	1.27	3.85	3.81	7.66	1.28	0.52	100.5	39.9	140.4
8-leaf	2.54	183.5	1.33	3.98	3.95	7.93	1.33	0.59	106.3	47.1	153.5
12-leaf	2.73	181.6	1.32	3.98	3.63	7.60	1.30	0.58	103.8	42.2	146.1
sp(2)1/3,2/3	2.57	183.3	1.32	3.97	3.75	7.72	1.32	0.54	105.3	40.8	146.1
sp(2)2/3,1/3	2.48	179.9	1.27	3.96	3.82	7.77	1.29	0.50	104.2	39.0	143.1
Significance	**	**	**	NS	*	NS	NS	**	NS	**	+
BLSD (.05)	0.06	7.4	0.04	-	0.23	-	-	0.03	-	3.4	8.7

Influence Of Nitrogen Form, Nitrogen Rate, Timing of Nitrogen Application and Nitrification Inhibitors For Irrigated Corn - Becker, 1980.

G.L. Malzer, T. Graff and J. Lensing

Nitrogen management on the coarse textured irrigated soils of Minnesota is a major decision that all corn growers must make in their production system. Nitrogen management includes many aspects of nitrogen fertilization such as rates, forms, methods, times, equipment, and additives. Nitrogen fertilizer application is an essential component for top yields on these coarse textured soils, and many times the producer does not have the flexibility in nitrogen management that a producer on a finer textured soil might have. The use of nitrification inhibitors under irrigation also presents some new nitrogen management techniques that should be considered. The most common method for application of nitrification inhibitors is with simultaneous application of anhydrous ammonia. Under irrigation, nitrogen application may take place in several manners, ranging from one single applications which may be facilitated through the irrigation water. With such management systems, a variety of fertilizer nitrogen forms may be utilized. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. A new trial was established in 1980 to evaluate the significance of nitrogen rates, nitrogen form, timing of nitrogen application and the use of nitrification inhibitors for irrigated corn production.

Experimental Procedures

An experiment consisting of 24 treatments, with four replication was arranged in a randomized complete block design and established at the Sand Plan Research Farm near Becker, Mn. A factorial arrangement consisting of two fertilizer rates, two nitrogen forms and three times of nitrogen application were combined with a second factorial arrangement of two nitrogen rates two nitrogen forms and two nitrification inhibitor treatments. Four additional treatments including a control, and three urea treatments (150 # N/A applied with three nitrification inhibitor treatments) were also included. Nitrogen fertilizer was applied at rates of 75 and 150 # N/A at one of three time periods including preplant, 8-leaf and 12-leaf growth stages. The nitrogen form used included 28% nitrogen solution and anhydrous ammonia at all times and rates of application and also included urea at the 150 # N/A as a preplant application. Nitrification inhibitors (N-Serve-Dow Chemical or Dwell - Olin Corporation) were applied at 0.5 #ai/A with the various preplant combinations but was not included with the later sidedress treatments of 28% N solution or anhydrous ammonia.

In the fall of 1979 lime was applied at the rate of four ton/A over the entire experimental area. Broadcast application of Potassium-Magnesium Sulfate (200 #/A 0-0-22) and Potassium (300 #/A 0-0-60) were also made prior to plant and incorporated by plowing. Nitrogen application were made prior to planting (May 12th) at the 8-leaf stage (June 16th) and at the 12-leaf stage (June 27th). Corn (Pioneer 3901-100 day R.M.) was planted on May 14th in 30" rows at a population of 30,700 seeds/A. Starter fertilizer was applied at the rate of 160 #/A of 8-10-30 banded at planting. A tank mix of Lasso (1½ #ai/A) and Atrazine (2#ai/A) was applied on May 15th for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 6th, dried and analyzed for Kjeldahl nitrogen. Total dry matter production was determined on September 19th by hand harvesting 50 ft^2 of plot area. Ears were separated from the stalks, field weights obtained, and samples removed for moisture and nitrogen determination. Corn grain yield were obtained on October 9th by hand harvesting 100 ft^2. Grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 25 and continued through August 14th with a total of 8 inches of water being applied through irrigation. An additional 21.80 inches of water obtained during the growing season through rainfall.

General Results

Corn grain yields in this experiment ranged from 94 to 186 bu/A depending upon nitrogen treatment. Most of the yield increases obtained from this experiment were due to increasing rates of nitrogen application. The use of anhydrous ammonia at the lowest nitrogen rate (75 # N/A) provided a yield increase with applications of nitrogen during the season (up to the 12-leaf stage). This response was reversed at the higher nitrogen rate with anhydrous ammonia suggesting that high rates of anhydrous ammonia applied late in the season should be avoided. This dramatic yield increase and yield decreases due to timing of application was not observed with 28% nitrogen solution. Urea for some unknown reason appeared to be inferior to either AA or 28% N Solution.

In general, results would suggest that nitrogen losses due to leaching were minimal during 1980. This may be result of the later planting associated with the dry spring. Under such climatic conditions a yield response due to the application of a nitrification inhibitor would be minimal. Only one

treatment comparison (75 # N/A as A.A. with N-Serve) provided significant yield increase with the use of a nitrification inhibitor. The general lack of yield responses with the nitrification inhibitors would again suggest that nitrogen losses were minimal.

This research experiment will be continued in 1981 to more clearly define the importance of nitrogen form, nitrogen rates and use of nitrification inhibitors for irrigated corn production.

Table 1. Influence of nitrogen form nitrogen rates, nitrification inhibitors, timing of nitrogen application on yield grain, yield grain N content, and dry matter production on irrigated corn, Becker, 1980.

Treatments				Grain Yield	Yield Grain N	Dry Matter Production			
N-Rate	N-Form	Inh.	Time			Grain	Cob	Stover	Total
#/A				bu/A	%	----------T/A----------			
Check	-	-	-	94.1	1.03	2.63	0.27	2.27	5.16
75	AA	-	ppl	158.9	1.15	3.91	0.43	2.72	7.06
75	AA	-	8-leaf	167.5	1.24	4.47	0.44	2.67	7.58
75	AA	-	12-leaf	174.6	1.30	4.20	0.41	2.50	7.12
75	28%	-	ppl	166.1	1.19	4.36	0.42	2.97	7.95
75	28%	-	8-leaf	165.8	1.22	4.15	0.47	2.77	7.39
75	28%	-	12-leaf	152.4	1.24	3.84	0.40	2.42	6.66
75	AA	Dwell	ppl	152.6	1.18	4.04	0.44	2.78	7.26
75	28%	Dwell	ppl	153.9	1.19	4.13	0.44	2.97	7.54
75	AA	N-S	ppl	174.9	1.28	4.37	0.51	2.95	7.85
75	28%	N-S	ppl	164.1	1.18	4.17	0.39	2.75	7.30
150	AA	-	ppl	185.7	1.44	4.62	0.50	2.92	8.04
150	AA	-	8-leaf	180.6	1.41	4.39	0.49	2.77	7.65
150	AA	-	12-leaf	168.2	1.35	4.44	0.54	2.70	7.68
150	Urea	-	ppl	150.6	1.18	3.15	0.35	2.69	6.19
150	28%	-	ppl	174.5	1.36	4.54	0.51	3.07	8.13
150	28%	-	8-leaf	182.4	1.38	4.53	0.51	3.19	8.23
150	28%	-	12-leaf	171.9	1.28	4.26	0.49	2.63	7.38
150	AA	Dwell	ppl	183.7	1.41	4.45	0.52	2.77	7.74
150	Urea	Dwell	ppl	151.3	1.16	4.21	0.46	2.95	7.61
150	28%	Dwell	ppl	183.5	1.32	4.86	0.56	3.30	8.72
150	AA	N-S	ppl	183.9	1.46	4.63	0.56	2.79	7.98
150	Urea	N-S	ppl	155.2	1.16	3.68	0.42	2.68	6.77
150	28%	N-S	ppl	179.1	1.28	4.30	0.50	2.82	7.63
Significance				**	**	**	**	+	**
BLSD(.05)				14.1	0.08	0.66	0.10	0.61	1.22
Factorial Arrangement (Excludes check, and urea, treatments)									
N-Rate #/A									
75				161.8	1.20	4.16	0.44	2.86	7.49
150				181.8	1.38	4.57	0.52	2.95	8.04
Significance				**	**	**	**	NS	*
BLSD(.05)				8.2	0.04	0.35	0.04	-	0.44
N-Form									
AA				173.3	1.32	4.34	0.49	2.82	7.65
28%				170.2	1.25	4.40	0.47	2.98	7.88
Significance				NS	**	NS	NS	+	NS
BLSD(.05)				-	0.04	-	-	0.16	-
Inhibitor									
None				171.3	1.28	4.36	0.47	2.92	7.80
Dwell				168.4	1.28	4.37	0.49	2.95	7.82
N-Serve				175.5	1.30	4.37	0.49	2.83	7.69
Significance				NS	NS	NS	NS	NS	NS
BLSD(.05)				-	-	-	-	-	-
Factorial Arrangement (Excludes check, urea, and inhibitor treatments)									
N-Rate #/A									
75				164.2	1.22	4.16	0.43	2.68	7.29
150				177.2	1.37	4.46	0.51	2.88	7.85
Significance				**	**	*	**	*	*
BLSD(.05)				7.1	0.05	0.25	0.06	0.19	0.42
N-Form									
AA				172.6	1.31	4.34	0.47	2.71	7.52
28%				168.9	1.28	4.28	0.47	2.84	7.62
Significance				NS	+	NS	NS	NS	NS
BLSD(.05)				-	0.03	-	-	-	-
Time									
ppl				171.3	1.28	4.36	0.47	2.92	7.80
8-leaf				174.1	1.31	4.38	0.48	2.85	7.71
12-leaf				166.8	1.29	4.19	0.46	2.56	7.21
Significance				+	NS	NS	NS	**	+
BLSD (.05)				6.0	-	-	-	0.23	0.46

AA = Anhydrous Ammonia

Table 2. Influence of nitrogen form, nitrogen rates, nitrification inhibitors, timing of nitrogen application on leaf N content, grain N content and nitrogen removal by irrigated corn. Becker, 1980.

Treatments				N-Content			N-Removal		
					Silage				
N-Rate	N-Form	Inh.	Time	Leaf	Grain	Stover	Grain	*Stover	Total
#/A				--------%----------			--------lbs/A----------		
Check	-	-	-	1.71	0.96	0.43	50.8	21.8	72.5
75	AA	-	ppl	2.31	1.13	0.42	89.8	26.9	116.7
75	AA	-	8-leaf	2.65	1.17	0.61	105.5	38.0	143.5
75	AA	-	12-leaf	2.72	1.27	0.76	107.4	43.1	150.5
75	28%	-	ppl	2.30	1.22	0.36	106.7	24.6	131.2
75	28%	-	8-leaf	2.58	1.18	0.45	98.7	29.1	127.7
75	28%	-	12-leaf	2.54	1.15	0.43	88.1	23.9	112.1
75	AA	Dwell	ppl	2.39	1.21	0.46	98.1	29.7	127.9
75	28%	Dwell	ppl	2.38	1.15	0.50	96.2	33.2	129.4
75	AA	N-S	ppl	2.69	1.28	0.45	111.7	31.1	142.9
75	28%	N-S	ppl	2.52	1.18	0.48	99.0	29.9	123.9
150	AA	-	ppl	2.87	1.38	0.62	128.0	41.8	169.7
150	AA	-	8-leaf	2.88	1.40	0.70	123.0	45.9	168.9
150	AA	-	12-leaf	2.43	1.30	0.72	115.2	45.8	161.0
150	Urea	-	ppl	2.23	1.13	0.46	71.6	28.8	100.4
150	28%	-	ppl	2.70	1.26	0.58	115.0	41.5	156.5
150	28%	-	8-leaf	2.80	1.31	0.70	119.1	52.1	171.2
150	28%	-	12-leaf	2.73	1.32	0.66	112.7	40.9	153.6
150	AA	Dwell	ppl	2.69	1.40	0.65	124.1	42.4	166.5
150	Urea	Dwell	ppl	2.30	1.24	0.55	103.8	37.8	141.6
150	28%	Dwell	ppl	2.73	1.28	0.64	124.5	49.5	174.0
150	AA	N-S	ppl	2.60	1.43	0.68	132.1	45.5	177.6
150	Urea	N-S	ppl	2.29	1.16	0.38	85.4	23.2	108.7
150	28%	N-S	ppl	2.76	1.28	0.56	110.4	37.3	147.6
Significance				**	**	**	**	**	**
BLSD(.05)				0.24	0.11	0.24	19.9	10.1	24.3
Factorial Arrangement (Excludes check, and urea treatments)									
N-Rate #/A									
75				2.43	1.20	0.44	100.3	29.2	129.5
150				2.73	1.34	0.62	122.3	43.0	165.4
Significance				**	**	**	**	**	**
BLSD(.05)				0.15	0.07	0.05	11.8	4.0	14.0
N-Form									
AA				2.59	1.31	0.55	114.0	36.2	150.2
28%				2.57	1.23	0.52	108.6	36.0	144.6
Significance				NS	**	NS	NS	NS	NS
BLSD(.05)				-	0.07	-	-	-	-
Inhibitor									
None				2.55	1.25	0.50	109.8	33.7	143.6
Dwell				2.55	1.26	0.56	110.7	38.7	149.5
N-Serve				2.64	1.29	0.54	113.3	35.9	149.2
Significance				NS	NS	*	NS	*	NS
BLSD(.05)				-	-	0.05	-	4.1	-
Factorial Arrangement (Excludes check, urea, and inhibitor treatments)									
N-Rate #/A									
75				2.52	1.19	0.50	99.4	30.9	130.3
150				2.74	1.33	0.66	118.4	44.7	163.5
Significance				**	**	**	**	**	**
BLSD(.05)				0.11	0.06	0.08	10.8	6.0	13
N-Form									
AA				2.64	1.28	0.63	111.5	40.3	151.7
28%				2.61	1.24	0.53	106.7	35.4	142.1
Significance				NS	NS	**	NS	*	+
BLSD(.05)				-	-	0.08	-	4.6	8.6
Time									
ppl				2.55	1.25	0.50	109.8	33.7	143.6
8-leaf				2.73	1.27	0.61	111.6	41.3	152.8
12-leaf				2.61	1.26	0.64	105.9	38.4	144.3
Significance				**	NS	**	NS	*	NS
BLSD(.05)				0.10	-	0.07	-	5.8	-

AA = Anhydrous Ammonia
*Stover includes cob + stover N-Removal

High Corn and Soybean Yield Trials on the Coarse Textured, Irrigated Soils of Minnesota

G.L. Malzer, G. Ham, and F. Bergsrud

The agricultural producer is becoming increasingly aware of the importance of management for maximum economic return. With the severe economic pressures producers are currently encountering, the tendency is to cut back on some of the variable inputs used in crop production. The lowering of production costs is a viable consideration in increasing economic return, as long as decreased production does not offset the benefit from decreasing the production costs. An alternative to the above approach is improved management. If a producer can obtain higher yields with relatively little change in inputs, higher economic returns would result. Management for high production and at the same time highest economic return is very complicated and it takes a top manager to evaluate all of the alternatives which are available. A trial was established at the Sand Plain Research Farm near Becker, Minnesota to evaluate the impact of three management variables (soil fertility, plant population, and row spacing) that may be important for high corn and soybean production. These are only three variables of many that the producer may have to make decisions upon. The producer should have a knowledge of or be aware of what impact these management factors, as well as others might have upon overall production if he is to assess and make wise decisions in improving his management system.

Experimental Procedures

Corn Trial - An experiment consisting of four replications of nine treatments, was arranged in a randomized complete block design. A factorial arrangement consisting of two fertilizer application rates and three plant populations, were combined with a control receiving only nitrogen and two additional treatments for evaluation of row spacing at high plant populations. The fertilizer variables included treatments of 220 + 60 + 220 which might be considered adequate for this site along with a rate of application 50% higher, 330 + 90 + 330. Plant population included a base level of 28,000 plants/acre (a reasonable level to utilize under irrigation) a population 25% higher 35,000 plants/acre and a population 50% higher, 42,000 plant/acre. Row spacings were established at a base distance of 30 inches with two additional treatments planted at 15-inch spacings at the 42,000 ppa population. The control treatments which received only 220 lbs N/A as a treatment was planted at 28,000 ppa in 30-inch rows. Soybean trial - This experiment was located directly north of the corn trial, and was the same site of the previous years corn trial. The soybean experiment consisted of nine treatments, with four replications, and was arranged in a randomized complete block design. A factorial arrangement consisting of two fertilizer application rates, and four plant populations were combined with a control plot receiving no fertilizer treatments. The fertilizer variables included treatments of 0 + 60 + 220 and an application 50% higher 0-90-330.

Plant populations included rates of 2.5, 5, 7.5 and 10 seeds/foot of row planted in 14-inch rows. The control treatment was planted at a population of 5 seeds/ft of row.

The soil type is a Hubbard coarse sand containing approximately 2 1/2% organic matter. Soil test indicated a soil pH of 5.5, Bray P-1 test of 72, an ammonium acetate extractable K test of 170 and DTPA extractable An at 1.4 ppm.

Prior to planting, broadcast applications of Potassium magnesium sulfate (325 #/A 0-0-22) were made over the entire experimental area. The additional phosphorus and potassium treatments were applied and incorporated into the appropriate plots. Nitrogen was applied to the corn as broadcast applications of urea (were made) throughout the season, with 25% of the nitrogen applied at planting, 25% at the 8-leaf stage (June 6) and 50% of the nitrogen at the 12-leaf stage (June 16). Corn (Pioneer 3901 - 100 day relative maturity) was hand planted into the experimental area on April 28th. Weed control was accomplished utilizing Lasso (2 # ai/A).

Leaf samples from opposite and below the ear at mid-silking were taken on July 17, dried, ground, and analyzed for elemental content. Total dry matter production was determined on September 19th by hand harvesting 50 ft^2. Ears were separated from the stalks, field weights obtained, and samples removed for moisture determination and elemental content. Corn grain yield were taken on October 3rd by hand harvesting 100 ft^2. Grain yields were adjusted to 15.5% moisture. The irrigation program was started on April 29th and continued through August 8th with a total of 8.95 inches of water being applied through irrigation. An additional 21.96 inches of water was obtained during the growing season through rainfall.

The soybean (Hodgson - 78 medium to late maturing) were planted on May 13th. Leaf samples from the first mature soybean trifoliate were taken on August 12th, dried, ground, and analyzed for elemental content. Soybean grain yield were obtained in late September.

The irrigation program for the soybeans was started on June 26th and continued through August 6th with a total of 7.75 inches of water being applied through irrigation. An additional 21.75 inches of water was obtained during the growing season through rainfall. Weed control was accomplished with Treflan (1/2 # ai/A).

General Results

The results obtained from the corn and soybean research trials conducted in 1980 in tables 1 - 6. The overall results from the Sand Plains Research Farm in 1980 were excellent. Results from this experiment as well as other experiments recorded many replicated treatment averages in excess of 200 bu/A. Record yields were established in this area for research plots conducted for production purposes. Of the three parameters studied in 1980; fertility,

plant population and row spacing; plant population appeared to have the largest impact on yield and other growth parameters. A significant (.05) yield increase was obtained within the corn experiment by increasing the plant population from 28,000 to 42,000 plant/acre. Likewise with soybeans, a substantial positive yield response was obtained to soybean seeding rates much higher than are currently recommended. A 6 bu/A increase was obtained with soybeans when the seeding rate was increased from 186,000 (5 seeds/ft of row) to 373,000 (10 seeds/ft of row) seeds/A. Increasing rates of fertilizer application had only modest influences on nutrient concentrations and total quantities of nutrients removed by the corn crop. Corn row spacing likewise had relatively little influence on the yields which were obtained. There is some concern that perhaps we are approaching the yield potential of this variety within this growing region.

Table 1. Influence of fertilizer treatment, and plant population on corn forage production, grain yield and grain nitrogen. - Becker, MN 1980

Treatment					Corn Forage Production			Harvest Grain	
N	P_2O_5	K_2O	Plant pop.	Row width	Grain	Stover	Total	Yield	N content
------#/A-------			X1000/A	in	----------T/A----------			bu/A	%
220	0	0	28	30	4.86	3.53	8.39	194.6	1.43
220	60	220	35	30	4.78	3.52	8.30	199.1	1.35
220	60	220	28	30	4.72	3.39	8.11	190.3	1.37
220	60	220	42	15	4.83	3.55	8.38	199.7	1.39
220	60	220	42	30	4.85	3.70	8.55	202.8	1.32
330	90	330	35	30	4.87	3.73	8.60	197.0	1.47
330	90	330	28	30	4.77	3.67	8.44	194.7	1.45
330	90	330	42	15	4.75	3.82	8.57	198.2	1.42
330	90	330	42	30	4.80	3.84	8.64	197.9	1.39
		Significance			N.S.	N.S.	N.S.	N.S.	N.S.
		BLSD (.05)			--	--	--	--	--

Factorial Statistics (Excludes Control and 15 in row spacings)

Fertility					
220-60-220	4.79	3.54	8.33	197.4	1.35
330-90-330	4.81	3.75	8.56	196.5	1.44
Significance	N.S.	N.S.	N.S.	N.S.	*
BLSD (.05)	--	--	--	--	.06

Plant Population					
28	4.75	3.53	8.28	192.5	1.41
35	4.82	3.62	8.44	198.0	1.41
42	4.83	3.77	8.60	200.4	1.36
Significane	N.S.	N.S.	N.S.	*	N.S.
BLSD (0.5)	--	--	--	6.4	--

Table 2. Influence of fertilizer treatment and plant population on the elemental concentration of the leaf opposite and below the ear at silking. Becker MN - 1980

Treatment					Leaf Elemental Concentration											
N	P_2O_5	K_2O	Plant pop.	Row width	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A-------			X1000/A	Inches	----------%----------					----------ppm----------						
220	0	0	28	30	3.06	0.33	2.96	0.56	0.26	110	188	72	133	22	18	11
220	60	220	35	30	2.93	0.32	2.85	0.56	0.27	95	187	86	152	22	17	12
220	60	220	28	30	2.95	0.31	2.98	0.52	0.24	104	176	64	130	21	15	9
220	60	220	42	15	2.81	0.32	3.00	0.53	0.25	93	175	67	132	29	15	11
220	60	220	42	30	2.86	0.32	2.92	0.57	0.26	88	161	65	147	26	17	12
330	90	330	28	30	3.00	0.32	2.94	0.54	0.25	91	178	70	134	22	15	12
330	90	330	35	30	3.04	0.33	2.87	0.58	0.27	92	185	96	143	24	17	11
330	90	330	42	15	2.84	0.32	2.96	0.54	0.25	87	150	94	136	22	16	10
330	90	330	42	30	2.96	0.33	3.09	0.56	0.26	97	184	101	138	24	16	13
Significance					*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (.05)					.18	--	--	--	--	--	--	--	--	--	--	--
FACTORIAL STATISTICS																
Fertility																
220	60	220			2.91	0.32	2.92	0.55	0.56	94	178	76	130	22	16	11
330	90	330			3.00	0.33	2.97	0.55	0.56	95	174	75	147	26	16	11
Significance					+	*	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
BLSD (.05)					.01	.01	--	--	--	--	--	--	11	--	--	--
Plant Population																
			28		3.00	0.32	2.93	0.56	0.26	100	192	76	146	23	16	11
			35		2.96	0.32	2.90	0.54	0.25	90	160	65	138	26	16	10
			42		2.91	0.33	3.01	0.54	0.25	93	176	86	132	23	15	12
Significance					NS	NS	NS	NS	NS	NS	+	NS	+	NS	NS	NS
BLSD (.05)					--	--	--	--	--	--	23	--	10	--	--	--

Table 3. Influence of fertilizer treatment and plant population on the elemental concentration of forage grain at physiological maturity. Becker MN - 1980

Treatments					Forage Grain Elemental Concentration											
N	P_2O_5	K_2O	Plant pop.	Row width	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
----#/A-------			X1000/A	Inches	----------%----------					----------ppm----------						
220	0	0	28	30	1.38	0.29	0.41	.004	0.14	.2	22	4	7	19	5	2
220	60	220	35	30	1.36	0.26	0.37	.003	0.12	.2	20	5	7	18	5	2
220	60	220	28	30	1.29	0.28	0.39	.003	0.13	.2	20	6	7	20	5	2
220	60	220	42	15	1.43	0.26	0.35	.003	0.12	.2	20	8	6	19	5	2
220	60	220	42	30	1.25	0.27	0.37	.003	0.12	.1	20	2	6	18	4	2
330	90	330	28	30	1.34	0.26	0.36	.003	0.12	.1	18	1	6	19	4	2
330	90	330	35	30	1.47	0.26	0.37	.003	0.12	.1	18	1	6	21	4	2
330	90	330	42	15	1.42	0.26	0.36	.003	0.12	.2	20	2	7	19	4	2
330	90	330	42	30	1.36	0.27	0.37	.003	0.12	.1	19	3	6	19	4	2
		Significance			**	NS	+	*	NS	NS	NS	**	NS	+	**	NS
		BLSD (.05)			0.11	--	.034	.001	--	--	--	3	--	2	1	--

FACTORIAL STATISTICS

Fertility

220	60	220			1.30	.27	.38	.003	0.13	.2	19	4	6	19	5	2
330	90	330			1.39	.26	.36	.003	0.12	.1	20	2	7	20	4	2
		Significance			**	NS	NS	NS	NS	NS	NS	**	NS	*	**	NS
		BLSD (.05)			.08	--	--	--	--	--	--	2	--	1	1	--

Plant Population

			28		1.38	0.27	0.38	.003	0.13	.2	21	4	7	20	4	2
			35		1.35	0.26	0.36	.003	0.12	.1	19	3	6	18	4	2
			42		1.31	0.27	0.37	.003	0.12	.1	20	3	6	18	4	2
		Significance			NS	NS	NS	NS	*	+	*	NS	*	**	NS	NS
		BLSD (.05)			--	--	--	--	0.01	.1	1	--	1	1	--	--

Table 4. Influence of fertilizer treatment and plant population on the elmental concentration of forage stover at physiological maturity. Becker MN - 1980

Treatments					Forage Stover Elemental Concentration											
N	P_2O_5	K_2O	Plant pop.	row width	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
------#/A------			X1000/A	inches	----------%----------					----------ppm----------						
220	60	220	28	30	0.54	0.04	2.47	0.34	0.15	292	273	66	94	8	11	14
220	60	220	35	30	0.63	0.04	2.58	0.28	0.13	196	189	55	96	9	12	14
220	60	220	28	30	0.60	0.05	2.07	0.32	0.16	220	199	60	97	9	12	13
220	60	220	42	15	0.62	0.04	2.44	0.27	0.13	252	215	54	85	8	10	10
220	60	220	42	30	0.61	0.04	2.46	0.33	0.12	248	221	49	101	8	11	12
330	90	330	35	30	0.71	0.04	2.17	0.31	0.14	293	241	48	102	8	11	12
330	90	330	28	30	0.72	0.03	2.51	0.22	0.11	172	157	37	65	7	9	10
330	90	330	42	15	0.77	0.06	2.55	0.26	0.13	200	190	44	85	10	9	9
330	90	330	42	30	0.77	0.05	2.36	0.30	0.13	225	206	48	92	10	11	11
Significance					+	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS
BLSD (.05)					.17	--	--	--	--	--	--	14	--	--	--	--
FACTORIAL STATISTICS																
Fertility																
220	60	220			0.61	0.04	2.37	0.28	0.13	229	201	55	83	8	11	10
330	90	330			0.73	0.04	2.35	0.30	0.14	240	218	44	102	9	11	12
Significance					**	NS	NS	NS	NS	NS	NS	*	+	NS	NS	**
BLSD (.05)					0.10	--	--	--	--	--	--	7	15	--	--	2
Plant Population																
			28		0.65	0.04	2.29	0.30	0.14	255	223	48	89	9	12	11
			35		0.67	0.04	2.38	0.30	0.13	190	180	52	98	8	11	11
			42		0.69	0.05	2.41	0.28	0.13	260	225	48	94	8	10	11
Significance					NS	*	NS	NS	NS	+	NS	NS	NS	NS	NS	NS
BLSD (.05)					--	0.01	--	--	--	64	--	--	--	--	--	--

Table 5. Influence of fertilizer treatment and plant population on the total elemental removal of corn at physiological maturity.

Treatments					Total Elemental Uptake										
N	P_2O_5	K_2O	Plant pop.	Row width	N	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
-----#/A------			X1000/A	inches	----------#/A----------										
220	0	0	28	30	172.2	31.5	201.0	21.6	24.0	2.2	0.5	0.7	.24	0.12	0.12
220	60	220	35	30	174.8	28.1	207.6	21.3	20.5	1.5	0.4	0.7	.23	0.13	0.12
220	60	220	28	30	162.2	29.5	166.5	21.4	23.4	1.5	0.5	0.7	.24	0.13	0.11
220	60	220	42	15	182.6	27.2	197.9	21.3	20.8	1.7	0.4	0.7	.24	0.11	0.09
220	60	220	42	30	166.7	20.1	211.6	21.5	21.0	1.9	0.4	0.8	.23	0.12	0.11
330	90	330	35	30	183.2	27.6	186.0	21.4	22.0	1.9	0.4	0.8	.25	0.12	0.11
330	90	330	28	30	192.8	27.2	208.7	21.1	19.1	1.3	0.3	0.5	.26	0.10	0.09
330	90	330	42	15	194.1	30.1	219.4	21.3	21.7	1.6	0.3	0.7	.26	0.11	0.09
330	90	330	42	30	190.6	29.7	206.3	21.4	21.9	1.8	0.4	0.8	.25	0.13	0.10
Significance					NS	NS	NS	NS	NS	NS	**	NS	NS	NS	NS
BLSD (.05)					--	--	--	--	--	--	0.1	--	--	--	--
FACTORIAL STATISTICS															
Fertility															
220	60	220			167.9	28.9	195.2	21.3	21.0	1.6	0.4	0.6	.23	.12	.09
330	90	330			188.8	29.1	200.3	21.4	22.2	1.8	0.3	0.8	.25	.12	.11
Signficance					**	NS	NS	NS	NS	NS	*	*	+	NS	*
BLSD (.05)					17.6	--	--	--	--	--	0.1	0.1	.02	--	.01
Plant Population															
				28	177.5	28.3	187.6	21.4	22.4	1.8	0.4	0.7	.25	.12	.10
				35	179.0	28.8	196.8	21.4	21.1	1.5	0.4	0.8	.24	.12	.10
				42	178.7	29.4	209.0	21.4	21.4	1.9	0.4	0.8	.24	.12	.10
Significance					NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD (.05)					--	--	--	--	--	--	--	--	--	--	--

Table 6. Influence of fertilizer treatment, plant population, yield and the elemental concentration of the first mature soybean trifoliate on Aug. 12- Becker, MN - 1980

Treatments				Yield	Leaf Elemental Concentration										
N	P_2O_5	K_2O	Plant pop.	Bu/A	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
	#/A		plant/foot		----------%----------					----------ppm----------					
0	0	0	5.0	47.0	4.73	0.41	1.78	1.31	0.37	47	144	141	31	15	42
0	60	220	10.0	56.3	4.86	0.48	2.13	1.40	0.39	52	162	183	34	15	45
0	60	220	7.5	54.2	4.78	0.40	1.84	1.24	0.32	46	150	156	29	14	38
0	60	220	5.0	50.6	4.64	0.42	1.88	1.22	0.34	42	142	161	31	14	38
0	60	220	2.5	46.0	4.77	0.46	1.99	1.25	0.35	46	143	136	31	16	44
0	90	330	10.0	58.2	4.50	0.41	1.99	1.32	0.34	50	158	199	31	13	38
0	90	330	7.5	55.1	4.85	0.43	1.93	1.27	0.33	45	145	169	30	14	42
0	90	330	5.0	51.9	4.86	0.43	1.93	1.24	0.32	41	144	163	30	14	40
0	90	330	2.5	47.4	4.78	0.49	2.08	1.36	0.35	53	165	178	35	17	44
	Significance			*	NS	NS	NS	NS	+	NS	NS	**	NS	NS	NS
	BLSD (.05)			9.6	--	--	--	--	0.04	--	--	35	--	--	--
	Fertility														
0	60	220		51.8	4.76	0.44	1.96	1.28	0.35	46	149	159	31	15	41
0	90	330		53.1	4.75	0.44	1.96	1.30	0.34	47	153	177	32	14	41
	Significance			NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS
	BLSD (.05)			--	--	--	--	--	--	--	--	17	--	--	--
	Spacing		Plants/foot												
			10.0	57.3	4.68	0.44	2.00	1.36	0.36	51	160	191	33	14	42
			7.5	54.7	4.82	0.42	1.89	1.25	0.32	46	148	162	30	14	40
			5.0	51.2	4.75	0.43	1.90	1.23	0.33	42	143	162	31	14	39
			2.5	46.7	4.78	0.47	2.04	1.30	0.35	49	154	157	33	16	44
	Significance			**	NS	NS	NS	NS	+	*	NS	*	NS	+	NS
	BLSD (.05)			6.2	--	--	--	--	0.03	6.3	--	26	--	2	--

CORN YIELDS FROM VARYING LEVELS OF POTASH

Becker, MN 1980

C. J. Overdahl and Michael O'Leary

Corn was grown in 1980 on the sunflower plot site of 1979. This was an experiment where potash treatments of 0, 60, 120, 180, 240 and 300 pounds per acre were used in 1979. Since soil tests increased from 63 pounds on the no treatment plot to only 91 pounds per acre K from the 300 pounds treat, the 300 pound treatment was increased to 480 pounds per acre of potash in 1980.

Results and Summary

Table 1 and 2 show 1979 and 1980 data.

The 480 pounds per acre of potash raised the K soil test to 142 but yields most profitable yields were at the 120 pound treatment. It appears that very high corn yields can be obtained when K tests are still low. The soil test is not indicating the K level adequately since the 36 pounds K test produced a corn yield of 161 bushels per acre.

Table 1. Corn yields, soil tests and percent K due to potash treatments. Becker 1980.

K_2O[1] lbs/acre		Corn Yield	Soil Test K		% K Plants
1979	1980		1979	1980	
0	0	161	63	36	1.05
60	60	190	69	44	1.54
120	120	198	76	58	1.93
180	180	195	86	80	2.28
240	240	193	87	109	2.98
300	480	197	91	142	2.41
Significance		**			**
BLSD (.05)		18			.27
C.V.		6.4			99

[1]0 + 50 + 0 broadcast (plow down)
18 - 46 - 0 at 160 lbs/acre as starter
75 + 0 + 0 sidedressed at 8 leaf stage
100 + 0 + 0 sidedressed at 12 leaf stage

Table 2. Emission spectrograph analysis of 6th corn leaf at tasselling, potash trial on corn. Becker, 1980.

	%				ppm						
lbs K_2O/A	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.33	1.05	.82	.83	46	104	61	97	21	6	11
60	.30	1.54	.80	.64	48	109	80	90	22	8	11
120	.29	1.93	.69	.51	56	112	81	82	20	8	11
180	.29	2.28	.62	.44	51	108	71	83	20	8	10
240	.28	2.98	.65	.38	48	107	75	91	21	8	12
480	.28	2.41	.69	.40	55	113	85	77	21	8	10
Significance	**	**	*	**	ns	ns	ns	ns	ns	*	ns
BLSD (.05)	.03	.27	.16	.09	-	-	-	-	-	1	-
C.V.	6.1	9.9	12.9	12.6	13.2	5.8	15.9	16.1	8.8	9.8	26.8

Micronutrient Fertilization of Potatoes and Corn Under Irrigation

G.L. Malzer, T. Graff, J. Lensing and G. Titrud

The need for micronutrient fertilization and application of fertilizers other than those which supply N,P, and K continue to be of concern to the producers of potatoes and corn as well as other crops on the coarse textured soils under irrigation. Because of the intensive management operations, high yield potentials, and often low nutrient supplying capacities of those soils, conditions may develop where yield reductions due to the lack of an essential nutrient other than N,P, or K may occur. Three separate experiments were established in 1978 and continued in 1979 and 1980 at the Sand Plains Research Farm at Becker, MN. to assess the significance of certain plant nutrients other than N,P, and K on yield and nutrient composition of the plant tissue for potatoes and corn.

Experimental Procedures

Seven treatments, including a control, four micronutrient treatments, and two macronutrient treatments were established in a randomized complete block design with four replications. Rates and types of fertilizer applied included: 5 lbs. of Copper/A as $CuSO_4 \cdot 5H_2O$, 2 lbs. of Boron/A as Solubor, 25 lbs. of Sulfur/A as $CaSO_4$, 75 lbs. of Magnesium/A as $MgCl_2$, 10 lbs. of Zinc/A as $ZnCl_2$ and 3 lbs. of Manganese/A as $MnCl_2$. Application of material was made to exactly the same plot as was applied in 1978 and 1979. The corn and potatoes areas were rotated in 1980 so corn was planted into the 1979 potato area (four replications) and potatoes were planted into the corn areas, (four replications of each variety).

The entire experimental area was spring plowed and the experimental potato area sprayed with 4 lbs./A Eptam (40 gal./A) and incorporated for weed control. Fertilizer treatments were applied, incorporated by discing on April 21 and the potatoes planted on April 23rd. Norlands were planted in 9 inch spacings utilizing 36 inch rows, while Russet Burbanks were planted in 12 inch spacings with the same row width. At the time of planting, starter was used at the rate of 1050 lbs./A at 8-10-30 and a insecticide, Temik 15G banded at planting time. Lorox herbicide was applied May 9th at 2 lbs./A (in 56 gal/A spray) for additional weed control. Sidedressing treatments of nitrogen were made on May 27 (230 lbs./A 34-0-0) and on June 12 (230 lbs./A 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 84 days after planting for nutrient composition. To minimize disease problems a system of spraying with either Bravo and Thiodan or Lannate and Bravo was started on June 13th and continued through July 19th at approximately 5-12 day intervals. The Norland potatoes were harvested on August 22nd and the Russet Burbanks on September 22nd. Irrigation water was applied during the period of May 28th through August 13th with a total addition of 11.50 inches. Precipitation during the period of May-August was 15.60 inches and May-September was 21.24 inches.

Utilizing the 1979 potato experimental area, four replications of the aforementioned treatments were planted to corn. The experimental area had been fertilized with 500 lbs./A of 8-10-30 prior to planting on April 8th. A commercial corn variety (Pioneer 3901) was planted in 30" rows at a population of 30,700 seeds/A. Starter fertilizer at the rate of 165 lbs./A of 8-10-30 was utilized at planting time followed by spray application of Lasso (2 lbs. ai/A). Sidedressing applications of nitrogen were made on May 29th (210 lbs./A 34-0-0) and June 18th (275 lbs./A 34-0-0) for the season. On June 23rd 120 lbs. K_2O/A was sidedressed on the corn. In addition to the 21.96 inches of precipitation received during the growing season an additional 12.20 inches was added through irrigation during the period of May 1st through August 13th.

General Results

During the first two years of this experiment relatively few differences were obtained with the fertilizer treatments applied. After three years of intensive cropping, certain trends appear to be developing which would suggest some concern. Significant (.05) yield increases were obtained with Norland potatoes when Mg and S were applied, with substantial yield increases also observed with application of many of the other elements. Although not statistically significant relatively large yield increases were obtained when some of the treatments were utilized on Russet Burbanks. These trials will be continued to hopefully more clearly define those nutrients which might be of concern to the potato grower. Corn yields were not significantly increased by any of the treatments, although zinc and boron provided small yield increase. In three years, this was the first hint of a boron response, although Zn has shown a 5-7 bu/A advantage over the control in every year of the experiment. Soil test for zinc in this area were marginal, therefore a yield response due to zinc application, especially at the high level of production would not be surprising.

Table 1. Influence of micronutrient fertilization (also Mg and S) on tuber yield and nutrient concentration of the youngest mature leaves 84 days following planting for Norland and Russet Burbank potatoes.

Treatment	Tuber Yield	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
		Leaf Concentration											
	cwt/A	%					ppm						
Norland Potatoes													
Control	394	3.88	0.31	5.55	2.99	0.98	98	138	69	375	18	11	41
Cu	421	3.95	0.31	5.57	2.91	0.95	94	135	73	365	18	17	40
B	426	3.99	0.34	5.75	3.12	0.98	114	154	165	439	18	14	52
S	443	3.91	0.28	5.43	3.02	1.06	131	160	76	346	17	9	41
Mg	444	3.90	0.31	5.42	2.98	1.24	118	170	162	353	18	11	38
Zn	422	3.93	0.31	5.35	3.04	1.00	92	137	68	379	25	11	39
Mn	426	3.96	0.34	5.86	3.08	1.05	111	145	182	392	19	13	45
Significance	*	NS	+	NS	NS	NS	NS	*	NS	NS	**	**	NS
BLSD (.05)	33	--	0.04	--	--	--	--	25	--	--	.3	3	--
Russet Burbank Potatoes													
Control	469	5.08	0.35	4.11	1.29	0.72	55	110	29	207	18	15	36
Cu	487	4.85	0.34	4.18	1.27	0.71	59	111	39	208	18	18	39
B	493	4.79	0.36	4.13	1.25	0.70	59	107	36	196	19	15	43
S	479	4.77	0.33	4.12	1.29	0.73	55	106	35	208	18	13	34
Mg	520	4.89	0.33	3.94	1.22	0.74	56	112	30	210	18	14	32
Zn	509	4.74	0.34	4.22	1.36	0.75	56	107	35	218	21	14	34
Mn	474	4.79	0.35	4.17	1.21	0.68	53	103	32	212	18	15	33
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	**	NS
BLSD (.05)	--	--	--	--	--	--	--	--	--	--	2	3	--

Table 2. Influence of micronutrient fertilization (also Mg and S) on corn grain yield and dry matter production.

Treatment	Harvest Grain Yield 15.5%M	Harvest Grain Dry Matter	Harvest Grain N Removal	Dry Matter (Physiological Maturity) Stover	Grain	Total
	bu/A	%	#/A	T/A		
Check	194.2	66.7	138.6	3.74	4.68	8.32
Cu	196.7	66.2	135.8	3.87	4.93	8.80
B	205.9	68.8	133.8	3.71	4.79	8.50
S	196.1	66.9	133.1	3.80	4.83	8.63
Mg	194.8	67.3	129.8	3.82	4.64	8.46
Zn	200.8	67.6	128.7	3.89	4.70	8.59
Mn	197.4	66.6	126.7	3.63	4.61	8.24
Significance	NS	NS	NS	NS	NS	NS
BLSD (.05)	--	--	--	--	--	--

Table 3. Influence of micronutrient fertilization (also Mg and S) on the elemental concentration of silage stover, silage, grain and the leaf opposite and below the ear at silking

Treatment	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Silage Stover Elemental Concentration											
	%					ppm						
Check	0.55	0.05	2.29	0.31	0.12	203	175	43	73	10	12	11
Cu	0.56	0.05	2.78	0.28	0.11	257	212	36	69	10	11	11
B	0.56	0.04	2.70	0.27	0.32	330	266	37	71	8	11	13
S	0.43	0.04	2.50	0.24	0.08	185	166	33	63	8	11	10
Mg	0.50	0.04	2.48	0.24	0.15	236	201	38	60	10	10	10
Zn	0.50	0.04	2.41	0.25	0.12	163	142	28	51	17	9	10
Mn	0.54	0.05	2.78	0.31	0.12	277	240	42	75	12	11	9
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	+
BLSD (.05)	--	--	--	--	--	--	--	--	--	4	--	3
	Silage Grain Elemental Concentration											
Check	1.33	0.33	0.45	0.003	0.14	1	23	4	7	24	7	4
Cu	1.34	0.34	0.47	0.004	0.15	1	24	6	7	24	8	4
B	1.32	0.29	0.42	0.005	0.13	2	23	9	7	22	8	4
S	1.32	0.33	0.46	0.004	0.14	2	24	8	7	24	8	4
Mg	1.31	0.32	0.44	0.003	0.14	1	24	2	7	24	7	3
Zn	1.33	0.30	0.42	0.005	0.14	2	24	42	6	27	9	4
Mn	1.34	0.31	0.42	0.003	0.13	1	22	6	6	23	7	3
Significance	NS	NS	NS	NS	NS	**	NS	NS	NS	+	NS	NS
BLSD (.05)	--	0.05	--	--	--	1	--	--	--	3	--	--
	Leaf Elemental Concentration											
Check	2.64	0.32	2.89	0.62	0.23	56	127	69	102	22	14	8
Cu	2.66	0.33	3.06	0.56	0.21	55	127	62	106	22	14	9
B	2.63	0.33	2.92	0.60	0.22	57	130	65	111	22	14	10
S	2.71	0.33	2.97	0.56	0.19	56	130	57	117	23	13	10
Mg	2.62	0.34	2.88	0.61	0.30	60	130	79	93	23	13	9
Zn	2.62	0.32	2.92	0.64	0.24	60	132	79	91	34	13	8
Mn	2.67	0.33	2.91	0.58	0.22	53	127	63	98	23	13	10
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD (.05)	--	--	--	--	--	--	--	--	--	3	--	--

Table 4. Influence of micronutrient fertilization (also Mg and S) of the total elemental removal of silage stover, and silage grain at physiological maturity.

Treatment	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	Silage Stover Total Elemental Removal											
	lbs/A											
Check	40.8	4.0	172	23.4	9.2	1.5	1.3	0.32	0.54	0.08	0.09	0.08
Cu	43.8	4.1	215	21.1	8.6	2.0	1.6	0.28	0.53	0.08	0.08	0.09
B	41.2	3.0	198	20.3	25.6	2.6	2.0	0.26	0.53	0.06	0.08	0.10
S	32.6	2.7	190	18.1	6.4	1.4	1.2	0.25	0.48	0.06	0.08	0.08
Mg	38.6	3.2	188	19.6	11.5	1.8	1.5	0.29	0.46	0.08	0.08	0.08
Zn	39.0	2.7	188	19.1	9.2	1.2	1.1	0.22	0.40	0.13	0.07	0.08
MN	38.6	3.4	199	22.4	8.5	2.0	1.7	0.29	0.54	0.08	0.08	0.06
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS
BLSD (.05)	-	-	-	-	-	-	-	-	-	0.03	-	-
	Silage Grain Total Elemental Removal											
Check	124.1	30.4	42	0.3	13.2	0.01	0.22	0.04	0.06	0.23	0.07	0.03
Cu	132.2	34.0	46	0.4	14.3	0.01	0.24	0.05	0.07	0.24	0.08	0.04
B	126.4	28.0	41	0.4	12.2	0.02	0.22	0.08	0.06	0.21	0.07	0.04
S	127.7	32.2	44	0.4	13.8	0.02	0.23	0.07	0.07	0.23	0.07	0.03
Mg	121.9	29.6	41	0.3	13.5	0.01	0.22	0.02	0.06	0.22	0.06	0.03
Zn	125.3	28.4	40	0.4	12.8	0.02	0.22	0.38	0.06	0.26	0.08	0.04
Mn	123.1	28.3	39	0.3	12.2	0.01	0.20	0.56	0.06	0.21	0.06	0.32
Significance	NS	+	+	NS	NS	*	NS	NS	NS	NS	NS	NS
BLSD (.05)	-	3.8	5	-	-	0.01	-	-	-	-	-	-
	Total Elemental Removal											
Check	164.9	34.4	214	23.7	22.4	1.52	1.52	0.36	0.60	0.31	0.16	0.11
Cu	175.6	38.1	262	21.5	22.9	2.00	1.87	0.33	0.60	0.32	0.16	0.12
B	167.6	31.0	239	20.7	37.8	2.58	2.27	0.34	0.59	0.27	0.16	0.13
S	160.3	34.8	234	18.5	20.2	1.42	1.49	0.33	0.55	0.29	0.15	0.11
Mg	160.5	32.9	229	19.9	25.0	1.81	1.75	0.31	0.52	0.30	0.14	0.11
Zn	164.2	31.1	228	19.5	22.0	1.27	1.32	0.60	0.46	0.39	0.15	0.11
Mn	161.6	31.7	239	22.7	20.7	1.98	1.90	0.35	0.60	0.29	0.14	0.10
Significance	NS	+	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
BLSD (.05)	-	4.8	-	-	-	-	-	-	-	0.05	-	-

CONTROLLING SOIL pH FOR POTATOES UNDER IRRIGATION (LIMY WATER) 1980

C. J. Overdahl and Jerome Lensing[1*]

Lowering pH with Nitrogen

Lime in irrigation water causes a rapid rise in soil pH, especially when legumes are grown. On potatoes, the problem may be less serious because of the acidifying effect of added nitrogen.

Plot work at the Becker Irrigation Farm studying pH and nitrogen was initiated in 1976 with three forms of nitrogen; ammonium nitrate, urea, and ammonium sulfate. The latter is expected to reduce pH faster than the other two. Soil pH readings are determined in the fall annually. Two varieties, Norland and Russet Burbank, were used until 1978, since then Norland variety has been rotated with rye. The Norland variety receives 200 pounds of N per acre annually.

The calcium carbonate equivalent of the irrigation water averages 42 pounds per acre inch. The irrigation water supplied 721 pounds per acre of very fine lime in 1976, 483 pounds in 1977, 386 pounds in 1978, 252 in 1979. With about 11 acre inches of irrigation water in 1980, 462 pounds of lime were added.

Initial soil tests were made in April 1976 before fertilizer application. The range of these test results were: pH 6.0 to 6.4; P 30 to 42; K 60 to 120; soil texture was loamy sand.

Table 1. The effect of three forms of nitrogen on yield of Norland potatoes (Becker Farm, 1976 to 1980).

	Cwt/A					
treatment[1]	1976	1977	1978	1979	1980	1980 rye bu/acre
none	146	109	89	117	120	19
Ammonium nitrate	319	300	256	264	384	30
Urea	372	288	234	248	414	32
Ammonium sulfate	389	368	320	280	442	29
Trt. Sign.	**	**	**	**	**	**
BLSD (5%)	84	51	27	22	43	4
C.V.	17.7	12.7	8.1	6.6	8.5	9.1

[1]200# N/A

Table 2. The effect of three forms of nitrogen on soil pH on irrigated* potatoes (Becker Farm, 1977 to 1980).

	Spring 1977	Fall 1977	Fall 1978	Fall 1979	Fall 1979 rye	Fall 1980 rye	Fall 1980 Norlands
treatment				Soil pH			
none	6.3	6.4	6.5	6.2	6.4	6.5	6.5
Ammonium nitrate	6.0	6.2	5.9	5.7	6.0	6.0	5.8
Urea	6.2	6.4	6.0	5.6	6.1	6.0	6.0
Ammonium sulfate	6.1	5.8	5.6	5.3	5.5	5.3	5.3

Table 2. con't.

	Spring 1977	Fall 1977	Fall 1978	Fall 1979	Fall 1979 rye	Fall 1980 rye	Fall 1980 Norlands
				Soil pH			
Significance	ns	**	**	**	**	-	-
BLSD (.01)		.2	.3	.3	.2	-	-

Calcium carbonate in irrigation water 1976, 721 lbs/acre; 1977, 483 lbs/acre; 1978, 386 lbs/acre; 1979, 252 lbs/acre; 1980, 462 lbs/acre.

Norlands received 200# N/A. One-hundred pounds of N added in 1979 and 1980 on the rye plots which are alternated with the potatoes.

Because ammonium sulfate has double the acidifying effect of the other 2 forms of nitrogen, it is not surprising to see this form of nitrogen causing a greater lowering of pH. Table 2 shows that ammonium sulfate has reduced pH significantly more than urea or ammonium nitrate.

Tuber yield in Table 1 shows that ammonium sulfate plots produced significantly higher yield with Norlands in 1977 and 1978. Gypsum at 300 pounds per acre has been added to all plots to prevent compounding of sulfur as a nutrient in ammonium sulfate. Gypsum was added to all plots in 1979 at 600 pounds per acre, which is 100 pounds per acre of S. The ammonium sulfate plot yields still appear slightly higher.

On the plots, no serious scab problems on the tubers was observed prior to 1980. In 1980 using an index of 1 to 10 where 10 has greatest amount of scab the Norlands were observed as follows:

N	scab 0-10
none	7
A.N.	4
urea	6
A.S.	1
significance	+
BLSD (.05)	3.8
C.V.	59.6

[1*] The efforts of Mike O'Leary and Glenn Titrud in arranging the field work is gratefully acknowledged.

FERTILIZER TRIAL ON STRAWBERRIES ON AN IRRIGATED SAND - BECKER, 1980

W. E. Jokela, L. B. Hertz, and M. O'Leary

This experiment was established in 1978 to determine the fertility needs of strawberries grown on a coarse textured soil under irrigation.

Experimental Procedures

The trial is located on a Hubbard loamy sand with 3.0% organic matter under irrigation at the Sand Plains Farm at Becker, MN. Plot design is a randomized complete block with four replications and 10 treatments. Each plot consists of one 25 foot row. Row spacing is four feet. Fertilizer treatments are shown in table 1. They consist of two rates of nitrogen with different timing schedules, as well as treatments with and without phosphorus and/or potassium. Times of nitrogen application were at transplanting, June 20, and August 1 in the establishment year and early spring, renovation, and early September (fruit set) in succeeding years. The phosphorus and potassium treatments were applied in the sping of the establishment year (1978) and prior to renovation in 1979 and 1980. Trumpeter variety of strawberries was used. Soil samples were taken at the beginning of the experiment and again in spring, 1980.

Results and Discussion

Plots from selected treatments were sampled in the spring of 1980 prior to fertilizer application. Results are shown in Table 2 and 3. Fertilizer applied during two seasons was reflected in the soil test levels of both phosphorus and potassium. pH ranged from 5.1 to 5.5. Nitrate nitrogen in the top two feet was relatively high for an irrigated sand, and there was no relationship with rate of nitrogen applied. Apparantly, mineralization of nitrogen in this 3% organic matter sand is quite good, and any differences due to the previous year's nitrogen rates was lost due to leaching.

Severe hail in June of 1979 destroyed most of the crop, so no results are reported. The berry weights and yields from four pickings in late June of 1980 are shown in Table 1. Phosphorus and potassium application did not effect yields, since two of the higher yields were with no phosphorus (4) and with no potassium (5). There were significant differences between treatments, but none of the treatments showed a significantly higher yield than the treatment with no nitrogen, phosphorus, or potash.

Table 1. Berry weight and yield of irrigated strawberries as affected by fertilizer treatment. Becker, 1980.

Treatment No.	Fertilizer Applied Nitrogen Total/Yr.	1978* 1 2 3	1979-80** 1 2 3	P_2O_5 1978	K_2O 1980	Berry Weight gms/berry	Yield lbs/A
	(lbs./A/yr)						
1	0	0 0 0	0 0 0	0	0	9.53	11918
2	0	0 0 0	0 0 0	50	160	9.28	11059
3	80	20-20-20	0-40-40	50	160	10.72	14060
4	80	20-20-40	0-40-40	0	160	9.99	13334
5	80	20-20-40	0-40-40	50	0	10.43	13467
6	80	80- 0- 0	0-80- 0	50	160	10.94	11118
7	80	40- 0-40	20-60- 0	50	160	10.69	11892
8	80	0-40-40	20-40-20	50	160	10.56	13917
9	120	20-20-80	0-80-40	50	160	11.52	10709
10	120	40-40-40	20-60-40	50	160	11.29	13321
Significance						*	*
BLSD (.05)						1.93	2355
C.V.						8.0	11.6

*In 1978 times of N application were: 1-at transplanting, 2-June 20, 3-August 1.
**In 1979-80 times of N application were: 1-early spring, 2-at renovation, 3-early September

Table 2. Phosphorus and potassium soil test results from treatments 1, 4, and 5. 0 to 6 inch depth. Spring, 1980.

Treatment No.	Annual Fertilizer Rate (lbs/A) P_2O_5	K_2O	Soil Test (lbs/A) p	K
1	0	0	39	143
4	0	160	46	286
5	50	0	54	144

Table 3. Nitrate nitrogen soil test results from treatments 2, 3, 6, and 9. 0 to 24 inch depth. Spring, 1980.

Treatment No.	Annual Fertilizer Rate (lbs/A)	Nitrate - N (lbs/A, 0-2')
2	0	38
3	80	32
6	80	24
9	120	36

MICRONUTRIENT TESTS ON ALFALFA

Becker, MN 1980

C. J. Overdahl, Jerome Lensing and Michael O'Leary

Micronutrient trials on both irrigated and unirrigated alfalfa were established at Becker in the spring of 1977. Dairy farmers are seeking information on the micronutrient needs of sandy textured soils, generally with neutral of slightly acid pH. The plot was located on a Hubbard loamy coarse sand.

One rate of each nutrient was compared tc none or to a complete mixture of all micronutrients. The nutrients and rates were applied in April 1977 for unirrigated plots and April 1978 for irrigated plots since the first plot had stand problems. All treatments were repeated in April 1980.

Material	Nutrient	Content %	Rate/acre
sodium molybdate	molybdenum (Mo)	39.6	4 oz
solubor	boron (B)	20.5	2 lbs
copper sulfate	copper (Cu)	25.2	10 lbs
zinc sulfate	zinc (Zn)	36	10 lbs
iron chelate 138	iron (Fe)	6	.6 lbs
manganese sulfate	manganese (Mn)	32.5	10 lbs

Sulfur at 100 pounds per acre was applied across all plots, except the "no-sulfur" plots, as fortified gypsum (2/3 gypsum, 1/3 elemental S), in spring 1977 and 1978 for unirrigated and irrigated plots respectively. Sulfur was omitted on a special plot in each replicate to get an idea about sulfur needs. In the spring of 1977, 340 pounds per acre of K_2O was applied to all plots. Phosphorus tests were very high (30 to 45 range), no phosphorus was added. The pH ranged from 6.1 to 6.3, but 500 to 1000 pounds of lime each year would be added in the irrigation water, depending on the amount of irrigation. No lime was added. After the second cutting in 1978, 240 pounds of K_2O was added to maintain potassium levels. The initial K test was less than 100 pounds of exchangeable K per acre. The irrigated and unirrigated plots were each replicated 4 times. In spite of liberal application of potassium, soil tests are still in only the medium range. A rate of 300 pounds per acre of K_2O was added to all plots in 1980.

Alfalfa yields at 15 percent moisture from the 3 cuttings are shown in Table 1 and 2.

There is evidence that without the gypsum treatments sulfur would be inadequate. There appears to be no micronutrient response.

The efforts of Glenn Titrud and Mike O'Leary are gratefully acknowledged.

Table 1. Alfalfa yields from micronutrient treatments. Non-irrigated plots. Becker 1978, 1979, and 1980.

Micronutrient treatments per acre	1978	1979	Alfalfa yields tons/acre 1980 cuttings			
			1st	2nd	3rd	total
none	3.68	3.40	.60	1.09	.59	2.28
Mo 4 oz	3.50	3.09	.52	1.14	.64	2.30
B 2 lbs	3.57	3.13	.60	1.06	.62	2.28
Cu 10 lbs	3.68	3.30	.56	1.08	.67	2.31
Zn 10 lbs	3.56	3.33	.58	1.10	.58	2.26
Fe .6 lbs	3.57	3.25	.51	1.03	.66	2.19
Mn 10 lbs	3.56	3.05	.52	.98	.60	2.09
all above	3.57	3.09	.60	.97	.60	2.18
no sulfur[1]	3.38	3.60	.73	1.10	.55	2.37
significance	ns	ns	*	ns	ns	ns
BLSD (.05)	-	-	.13	-	-	-

Table 2. Alfalfa yields from micronutrient treatments. Irrigated plots. Becker 1979, 1979, and 1980.

Micronutrient treatments per acre	1978	1979	Alfalfa yields tons/acre 1980 cuttings				
			1st	2nd	3rd	4th	total
none	3.95	5.15	.72	1.23	1.66	.84	4.46
Mo 4 oz	4.35	5.33	.68	1.28	1.73	.83	5.52
B 2 lbs	4.21	5.18	1.14	1.27	1.73	.96	5.10
Cu 10 lbs	4.16	5.21	.65	1.18	1.75	.83	4.41
Zn 10 lbs	3.95	5.02	.58	1.22	1.81	.90	4.51
Fe .6 lbs	4.45	4.94	.65	1.22	1.59	.85	4.30
Mn 10 lbs	4.17	5.21	.84	1.22	1.66	.90	4.62
"Shot-gun" all above	4.25	5.25	1.08	1.37	1.82	.90	5.16
no sulfur	4.12	4.29	.40	.98	1.57	.81	3.76
significance	ns	**	**	*	+	ns	**
BLSD (.05)	-	.36	.26	.24	.19	-	.55
w/o no sulfur trt							
signficance	ns	**	ns	ns	ns	ns	*
BLSD (.05)	-	-	.29	-	-	-	.66

[1]When no sulfur plots were deleted in non-irrigated plots there was no significant difference due to treatments in 1980.

Table 3. Plasma emission spectrometer readings from alfalfa micronutrient study non-irrigated plots. Becker, MN, 1980. 1st cuttings.

Micronutrient treatments per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check	-	.22	1.86	1.98	.42	67	88	113	34	9	30
Mo	4 oz	.22	1.95	1.94	.41	85	98	116	40	9	24
B	2 lbs	.22	1.89	1.91	.40	65	86	117	33	8	59
Cu	10 lbs	.22	1.94	1.94	.40	72	92	112	33	15	14
Zn	10 lbs	.21	1.82	2.07	.42	78	92	125	66	8	17
Fe	6 lbs	.23	1.92	1.88	.40	82	95	109	33	9	16
Mn	10 lbs	.22	2.09	1.85	.40	70	86	122	46	9	17
all above		.21	1.70	2.09	.43	78	92	143	60	16	60
No - S		.25	2.17	1.70	.38	79	97	101	33	9	17
significance		**	**	**	*	ns	ns	*	*	**	**
BLSD (.05)		.02	.24	.15	.03	-	-	27	22	5	29
C.V.		5.1	7.8	5.2	4.8	21.7	11.8	13.0	32.8	31.4	66.2
No - S - trt selected											
significance		ns	+	*	ns	ns	ns	ns	*	*	**
BLSD (.05)		-	.22	.15	-	-	-	-	24	5	32
C.V.		5.4	7.7	4.7	4.7	20.9	11.5	13.2	34.0	32.8	67.2

Table 4. Emission spectrometer readings, micronutrient study non-irrigated plots. Becker, MN, 1980. 2nd cuttings.

Micronutrient treatment per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check		.36	3.32	1.43	.37	28	97	101	49	14	19
Mo	4 oz	.35	3.25	1.50	.37	28	96	102	48	14	18
B	2 lbs	.35	3.33	1.39	.36	29	95	103	47	14	52
Cu	10 lbs	.36	3.39	1.43	.37	27	96	101	50	15	21
Zn	10 lbs	.36	3.41	1.43	.37	26	95	96	64	14	18
Fe	6 lbs	.37	3.47	1.44	.37	27	94	96	49	14	21
Mn	10 lbs	.34	3.63	1.46	.37	29	93	100	48	14	21
shot gun		.34	3.36	1.44	.36	28	94	106	67	15	51
No - S		.40	3.46	1.32	.39	29	92	102	47	14	25
significance		*	ns	ns	ns	ns	ns	ns	**	ns	**
BLSD (.05)		.03	-	-	-	-	-	-	6	-	4
C.V.		5.4	6.8	6.1	3.8	5.	3.7	6.6	7.9	6.2	10.8
No - S - selected											
significance		ns	ns	ns	ns	ns	ns	ns	**	ns	**
BLSD (.05)		-	-	-	-	-	-	-	6	-	4
C.V.		5.4	7.2	6.0	3.7	4.9	3.5	6.8	8.1	6.5	10.6

Table 5. Emission spectrometer readings from micronutrient study. Becker, MN, 1980. Non-irrigated. 3rd cutting.

Micronutrient treatment per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check	-	.15	2.28	2.21	.30	80	116	123	22	6	28
Mo	4 oz	.15	2.31	2.26	.30	78	116	128	21	7	28
B	2 lbs	.15	2.26	2.17	.29	78	113	123	21	6	92
Cu	10 lbs	.16	2.32	2.13	.28	79	113	113	22	7	28
Zn	10 lbs	.16	2.36	2.18	.29	83	118	115	34	7	28
Fe	6 lbs	.16	2.21	2.24	.29	77	114	127	21	6	28
Mn	10 lbs	.15	2.32	2.17	.28	76	114	122	21	7	32
all above		.15	2.30	2.25	.29	74	110	131	38	6	96
No - S		.20	2.24	2.31	.35	87	128	131	21	9	34
significance		**	ns	ns	**	*	**	+	**	**	**
BLSD		.01	-	-	.02	8	6	13	3	1	9
C.V.		4.6	4.4	5.9	5.4	5.8	3.7	6.8	10	8.4	15.6
No - S - selected											
significance		ns	ns	ns	ns	ns	ns	+	**	ns	**
BLSD (.05)		-	-	-	-	-	-	13	4	-	9
C.V.		5.0	3.9	5.8	4.9	6.1	3.7	6.8	10.8	8.5	15.9

Table 6. Emission spectrometer readings from micronutrient study. Becker, MN, 1980. Irrigated. 1st cutting.

Micronutrient treatment per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check		.25	1.69	2.06	.55	255	187	82	28	11	19
Mo	4 oz	.25	1.77	1.96	.51	239	173	77	28	57	21
B	2 lbs	.24	1.82	1.92	.52	160	134	77	26	20	60
Cu	10 lbs	.25	1.70	2.04	.54	205	158	75	25	46	17
Zn	10 lbs	.25	1.68	2.06	.53	310	204	118	175	12	20
Fe	6 lbs	.27	1.86	1.95	.50	285	213	80	29	9	20
Mn	10 lbs	.25	1.83	1.90	.50	186	147	113	60	8	22
all above		.23	1.82	1.86	.50	200	163	124	135	128	60
No - S		.25	1.56	2.08	.59	415	256	93	30	12	20
significance		**	ns	ns	*	**	**	+	**	**	**
BLSD (.05)		.02	-	-	.07	108	55	43	87	56	5
C.V.		4.7	10.	7.3	7.4	28.7	19.8	29.9	94.3	110.4	14.2
No - S - selected											
significance		**	ns	ns	ns	*	*	ns	**	**	**
BLSD (.05)		.02	-	-	-	109	54	-	95	61	6
C.V.		5.0	10.5	7.7	7.9	27.3	18.7	95.5	94.5	108.3	14.5

Table 7. Emission spectrometer readings from micronutrient study. Becker, MN, 1980. Irrigated. 2nd cutting.

Micronutrient treatment per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check	-	.41	3.15	1.61	.40	24	97	75	39	12	17
Mo	4 oz	.43	3.11	1.66	.42	26	102	81	41	12	21
B	2 lbs	.42	3.12	1.63	.39	23	97	80	41	13	50
Cu	10 lbs	.42	3.08	1.60	.42	24	94	72	38	14	18
Zn	10 lbs	.40	2.94	1.60	.40	25	95	77	49	12	17
Fe	6 lbs	.41	2.91	1.62	.40	25	95	72	40	11	18
Mn	10 lbs	.43	3.24	1.60	.41	26	99	74	39	11	22
all above		.42	3.00	1.64	.41	23	98	82	49	15	52
No - S		.40	2.99	1.49	.43	26	91	73	39	11	16
significance		ns	ns	*	ns	ns	+	*	**	**	**
BLSD (.05)		-	-	.10	-	-	6	9	4	1	5
C.V.		4.6	5.6	3.7	5.8	8.9	4.5	6.6	6.7	6.0	15.1
No - S - selected											
significance		ns	ns	ns	ns	ns	ns	ns	+	**	**
BLSD (.05)		-	-	-	-	-	-	8	4	1	5
C.V.		4.7	5.7	3.9	4.7	8.6	4.7	6.7	7.0	6.1	15.2

Table 8. Emission spectrometer readings from micronutrient study. Becker, MN, 1980. Irrigated. 3rd cutting.

Micronutrient treatment per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check	-	.30	2.67	1.72	.32	21	82	56	27	8	19
Mo	4 oz	.30	2.60	1.68	.31	20	79	52	26	8	20
B	2 lbs	.30	2.57	1.72	.32	22	82	56	26	8	54
Cu	10 lbs	.31	2.59	1.76	.33	19	84	55	26	10	18
Zn	10 lbs	.31	2.72	1.72	.32	22	85	57	34	8	17
Fe	6 lbs	.30	2.46	1.62	.30	23	79	50	25	7	18
Mn	10 lbs	.32	2.66	1.81	.33	21	84	57	27	8	23
all above		.30	2.75	1.74	.32	22	85	61	33	10	54
No - S		.30	2.68	1.63	.34	31	88	57	27	8	16
significance		ns	ns	ns	ns	**	ns	+	**	**	**
BLSD (.05)		-	-	-	-	5	-	7	2	1	5
C.V.		7.0	6.0	7.9	7.2	14.5	7.4	8.2	6.3	9.2	13.5
No - S - selected											
significance		ns	ns	ns	ns	ns	ns	+	**	**	**
BLSD (.05)		-	-	-	-	-	-	7	3	1	5
C.V.		7.1	6.4	8.3	7.5	14.8	7.9	8.5	6.7	9.6	13.4

Table 9. Plasma emission spectrometer readings form micronutrient study. Becker, MN, 1980. Irrigated. 4th cutting.

Micronutrient treatment per acre	rate/A	%				ppm					
		P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
check	-	.16	1.70	2.76	.35	81	121	82	14	5	23
Mo	4 oz	.16	1.77	2.49	.32	85	117	73	14	5	24
B	2 lbs	.16	1.84	2.63	.31	84	121	85	14	5	92
Cu	10 lbs	.16	1.76	2.61	.33	78	116	76	14	6	20
Zn	10 lbs	.16	1.95	2.54	.31	79	116	80	19	5	22
Fe	6 lbs	.17	1.89	2.43	.31	84	119	72	14	5	21
Mn	10 lbs	.17	1.83	2.54	.33	86	119	80	15	5	25
all above		.16	1.76	2.63	.32	79	120	96	20	5	94
No - S		.16	1.88	2.42	.35	82	116	80	15	6	20
signficance		ns	ns	*	ns	ns	ns	**	**	+	**
BLSD (.05)		-	-	.24	-	-	-	9	1	.9	8
C.V.		5.8	7.6	5.4	7.5	7.4	5.	7.6	7.	11.3	15.3
No- S - selected											
significance		ns	ns	ns	ns	ns	ns	**	**	ns	**
BLSD (.05)		-	-	-	-	-	-	9	1	-	8
C.V.		5.7	7.3	5.6	7.2	7.4	4.8	7.5	6.9	12.2	15.0

SOIL TEST LAB COMPARISON ON IRRIGATED CORN - BECKER, 1980.

W. E. Jokela and M. O'Leary

Several commercial laboratories test soils and make fertilizer recommendations in Minnesota. Substantial differences have sometimes been observed in the recommendations from different labs. This experiment was established to compare soil test results, recommended fertilizer rates and costs, and yields of irrigated corn fertilized according to the recommendations of five soil testing labs. Similar experiments are being conducted on corn at Waseca and on corn and wheat in rotation at Morris.

Experimental Procedures

The experiment was established on a Hubbard loamy sand at the Sand Plains Irrigation Farm at Becker, MN, on an area that had been in unfertilized rye the previous season. A composite sample was taken in the fall on 1979. The samples were dried, thoroughly mixed, and divided into five subsamples which were sent to five soil testing labs, including the University of Minnesota. A fertilizer recommendation was requested for a 200 bu/acre yield of corn under irrigation.

Experimental design is randomized complete block with four replications. Plot size is 10 feet by 30 feet. Fertilizer as recommended by each of the five labs was applied in the spring before plowing. A sixth treatment was a no-fertilizer check. Pioneer 3901 variety was planted in 30 inch rows at a population of 30,700 on May 12. Earleaf samples were taken at early silking. Two 20 foot rows per plot were harvested by hand on October 14 and grain yield and moisture content were determined.

Results and Discussion

Soil test results and fertilizer recommendations are shown in Tables 1 and 2. There was considerable variation between labs in the amounts of all nutrients recommended. A portion of the NPK fertilizer was applied as a starter and the nitrogen was split into three applications as indicated in Table 2.

Plant analysis results of earleaf at silk are given in Table 3. The check was significantly lower than all labs in nitrogen, phosphorus, and calcium, but there were no significant differences between labs in these elements. There was also significant variation between treatments in several micronutrients.

Grain yield, grain moisture, and an economic comparison are shown in Table 4. There were significant differences in both grain yield and moisture at harvest, primarily due to the check treatment.

Grain yields varied from 181 to 196 bu/acre with the different fertilizer programs, compared to 86 bu/acre on the check. Grain moisture at harvest was approximately 30% on the fertilized treatments and 36% on the unfertilized check.

Cost of fertilizer recommended by the various labs ranged from $81 to $144 per acre. The return over fertilizer cost for the five recommended fertilizer programs varied by less than $30, and all were substantially higher than the no fertilizer check.

Table 1. Soil test results from 5 soil testing labs. Becker, MN 1980.

	Soil Test Results[1]				
Test	Lab A	Lab B	Lab C	Lab D	Lab E (U.M.)
pH	6.7	7.6	6.5	7.0	6.6
Buffer index	---	---	---	6.9	---
Phosphorus (Bray 1)	14 L	18 M	16 M	16	12
Potassium	40 VL	57 L	48 L	55 L	39
Calcium	1000 L	980 H	800 L	1250	---
Magnesium	210 M	211 VH	250 M	275	---
Sulfur	8 L	6 L	7 L	14.1	5
Iron	17.9 H	18 H	16 H	8+	---
Manganese	4.8 L	5 L	6 M	2+	---
Zinc	.3 L	.5 VL	1.6 L	.5 L	.4
Copper	.4 L	.4 L	1.3 L	.4+	---
Boron	.4 VL	1.0 M	---	.3 L	---
Nitrate-N (0-6")	2 VL	---	1.8	---	
Organic matter (%)	1.1 L	1.8 M	L	2.0	L
C.E.C. (meg/100g)	6.9	6.8	---	9.7	---

[1]All soil test results are in ppm unless noted otherwise.

Table 2. Fertilizer recommendations from 5 soil testing labs for 200 bu/acre irrigated corn following rye. Becker, MN 1980.

	Fertilizer Recommended[1]				
Nutrient	Lab A	Lab B	Lab C	Lab D	Lab E (U.M.)
Nitrogen[2]	270	280	244	240	180
Phosphorus (P_2O_5)	122[3]	115	147	124	60
Potassium (K_2O)	222[3]	275	404	388	240
Sulfur	36	20	30	0	20
Zinc	15	8	10	8	8
Manganese	2.5	5	2	0	0
Copper	1	2	3	0	0
Boron	1.5	0	0	0.5	0

[1]Amounts are pounds of nutrient per acre.
A portion of the recommended rate (12-15-45) was applied as a starter.

[2]Nitrogen was split into 3 applications - ¼ pre-plant + starter, ¼ at 8 leaf, ½ at 12 leaf.

[3]Includes maintenance plus 1/3 of suggested build rate.

Table 3. Nutrient concentration in earleaf at early silking as influenced by fertilizer programs from different labs.

	Nutrient Concentration in Earleaf											
	----------%----------					----------ppm----------						
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
A	3.13	.298	2.09	.603	.418	49.1	109.0	69.6	56.8	24.5	9.6	10.3
B	3.13	.290	2.20	.561	.368	55.9	112.8	68.1	61.4	25.8	10.1	9.0
C	3.04	.298	2.26	.598	.376	52.7	109.3	74.7	59.2	22.5	10.1	11.6
D	3.06	.300	2.32	.562	.378	48.9	107.2	73.8	53.7	20.9	7.8	11.1
E (U of M)	3.11	.278	1.95	.638	.402	51.4	115.0	68.1	60.7	25.6	9.4	8.7
check	1.58	.255	2.05	.446	.332	49.9	69.2	73.8	24.4	13.8	5.0	10.8
significance	**	**	ns	*	ns	ns	**	ns	**	**	**	ns
BLSD (.05)	.28	.025	-	.111	-	-	7.5	-	7.5	3.4	1.6	-
C.V.	7.0	5.5	9.0	11.8	11.2	7.6	5.2	14.0	10.1	10.7	12.8	20.0

Table 4. Corn grain yield, grain moisture at harvest, and economic return over fertilizer costs for six fertilizer programs. Becker, MN 1980.

Lab	Grain Yield	Grain Moisture at Harvest	Crop Value @ $3/bu	Fertilizer Cost*	Return Over Fertilizer Cost
	bu/A	%	----------$/A----------		
A	185.7	30.1	557.10	123.12	433.98
B	193.1	29.2	579.30	121.95	457.35
C	196.0	29.8	588.00	144.18	443.82
D	188.9	30.6	566.70	121.44	445.26
E (U of M)	180.9	31.1	542.70	81.28	461.42
check	86.4	36.2	259.20	0	259.20
significance	**	**			
BLSD (.05)	14.8	2.6			
C.V.	6.3	2.5			

*Fertilizer prices used ($/lb): N = .15, P_2O_5 = .25, K_2O = .12, S = .21, Zn = .89, Mn = .71, Cu = 2.40, B = 1.52

1980 WEATHER SUMMARY

The weather for 1980 will go down in history as the 5th driest year in the past 91-year history of climatological data for Crookston, MN. Well above normal temperatures coupled with the lack of adequate precipitation created severe drought conditions for the Crookston area of the Red River Valley. The small grain crops suffered the most damage from the drought with the early unseasonably high temperatures and only 1.44 inches of precipitation during the small grain growing season.

The 1980 snow pack in the Valley began melting in mid-March and was completely gone by April 4. Seven all-time high temperature records were broken in 1980 and an additional five second place all-time high daily temperatures were recorded.

New Record High Temp.		Previous Record High Temp.	
4-18-80	80°	4-18-73	77°
4-19-80	80°	4-19-52	80°
4-20-80	89°	4-20-26	85°
4-21-80	96°	4-21-76	83°
4-22-80	96°	4-22-42	78°
5-22-80	95°	5-22-55	92°
10-8-80	84°	10-8-43	81°

2nd Highest Temp.		Record High Temp.	
7-10-80	100°	7-10-36	105°
7-11-80	100°	7-11-36	105°
9-7-80	92°	9-7-31	98°
9-30-80	83°	9-30-31	84°
10-7-80	84°	10-7-75	86°

April 22 also set an all-time record high minimum temperature with a reading of 57°F. Two all-time low records were also set in 1980 on February 29th and March 1st.

New Record Low Temp.		Previous Record Low Temp.	
2-29-80	-28°	2-29-16	-24°
3-1-80	-31°	3-1-62	-30°

August and October were the only two months in 1980 where the mean monthly temperature were below normal. April and May marked the most extreme deviations from normal monthly temperatures with April 8.2° and May 7.5° above normal. For the total year, 1980 was 2.5° above the long-time average temperature of 38.9°. The last spring frost occurred on May 15 with a reading of 27° and the first fall frost of 31° on September 22 marked a frost-free period of 131 days for 1980. The long-time average last frost occurs on May 19 and the first fall frost on September 20 with an average 124-day frost-free period.

The precipitation for 1980 was well below normal at Crookston. The total precipitation for 1980 was 14.07 inches which is 6.12 inches less than the 91-year average of 20.20 inches. Of the 14.07 inches of precipitation, 11.97 inches were received as rain and the remaining 2.10 inches fell as 43.4 inches of snow with a water equivalent of .05 inch precipitation per 1 inch snow. The normal snowfall is 40 inches containing 3.09 inches of water or .08 inch water per inch of snow. There was no measureable precipitation recorded in April of 1980. April of 1893 is the only other month in the 91-year history when no precipitation was received. January and August were the only two months in 1980 when above normal precipitation was received. For the growing season April 1 through July 31, we received 3.43 inches of precipitation which is 7.06 inches less than normal or only one-third the normal precipitation for this period. Only 1.55 inches of the 3.43 inches of precipitation for this period were received in rain showers of intensity greater than one-half inch. For the growing season April 1 through September 30, we received 10.14 inches of precipitation which is only two-thirds the normal precipiation for this period. 6.97 inches of the precipitation for this period were received in showers greater than one-half inch. For the month of August 4.63 inches of the 5.24 inches fell in storms of greater than one-half inch intensity. Over 50 percent of the growing season precipitation fell after August 20th which was too late for most crops in the area.

The fall months were also well below normal in regard to precipitation. Consequently, fall soil moisture recharge for 1980 and the 1981 growing season was very minimal.

Table . Weather summary for 1980 with averages for precipitation and mean temperatures for 1890-1973.

Month	Precipitation					Mean Temperature	
	Snow	Precip.	Rain	Total	1890-1973	1980	1890-1973
	inches					°F	
January	16.0	0.93	0.03	0.96	0.56	6.1	4.9
February	10.4	0.45	--	0.45	0.59	8.0	8.1
March	9.8	0.34	--	0.34	0.78	19.2	16.3
April	Tr.	Tr.	--	Tr.	1.54	49.6	41.4
May	--	--	0.30	0.30	2.61	62.0	54.5
June	--	--	1.14	1.14	3.36	66.1	64.0
July	--	--	1.99	1.99	2.98	71.7	69.7
August	--	--	5.24	5.24	2.60	66.3	67.5
September	--	--	1.47	1.47	2.11	61.2	57.2
October	Tr.	0.03	1.36	1.39	1.34	43.2	45.0
November	2.0	0.21	0.44	0.65	0.86	31.6	27.2
December	5.2	0.14	--	0.14	0.86	12.2	11.5
TOTALS	43.4	2.10	11.97	14.07	20.19	41.4	38.9

USE OF N-SERVE IN A SPRING NITROGEN APPLICATION PROGRAM ON CORN

G. E. Varvel and R. K. Severson

The objective of this study was to determine if spring applications of N with N-Serve would improve yield or other quality factors on corn. Previous work in the area had shown no benefit on spring wheat, but no information was available on a full season crop such as corn.

Experimental Procedure:

A factorial arrangement of 3 rates of N (30, 60 and 90 lb/A) as anhydrous with and without N-Serve in a randomized complete block design with 4 replications was used. The rate of N-Serve used was 0.5 pounds ai/A. The anhydrous treatments were applied with knives spaced 14 inches apart on April 28. The variety Agsco 4XA was planted April 30.

Silage and grain yields were taken September 18. Subsamples were taken for moisture and total N analyses.

Initial soil test levels were: pH (0-6") - 8.0, NO_3-N (0-2') - 30 lb/A, $NaHCO_3$ extractable P (0-6") - 20 lb/A and exchangeable K (0-6") - 120 lb/A. A broadcast application of 120 lb/A K_2O was made over the entire area and plowed down on October 28, 1979.

Results:

The effects of the treatments are shown in Table 1 for N rate and N-Serve with each factor averaged over the other. Nitrogen significantly increased yield, protein and total N in the silage. Yield increased up to the 60 lb/A rate and then decreased which was probably due to the dryness of the growing season. The high N rate had more vigorous growth early and used up the soil moisture much quicker which resulted in lower yields in the end.

N-serve had no effect on any of the measured variables.

Table 1. The effect of spring applied nitrogen with and without N-Serve on corn.

Treatments	Grain				Silage			
N-Rate	Yield	Moisture	Protein	Lodging	Yield	Moisture	Total N	N Uptake
lb/A	Bu/A	%	%	%	lb DM/A	%	%	lb/A
30	58.6	36.4	9.6	5.6	7675	62.0	1.09	84.0
60	71.9	38.9	10.3	7.8	8579	63.1	1.22	104.8
90	63.4	37.3	10.9	4.0	7724	63.9	1.26	97.3
Significance	*	NS	**	NS	NS	NS	**	NS
B.L.S.D. (.05)	10.1		0.7				0.10	
N-Serve								
lb ai/A								
0	64.3	38.1	10.3	6.2	8205	62.9	1.20	98
0.5	65.0	37.0	10.3	5.4	7780	63.1	1.18	92
Significance	NS	NS	NS	NS	NS	NS	NS	NS

RESIDUAL EFFECTS OF COPPER ON ORGANIC SOILS

G. E. Varvel and R. K. Severson

The objective of this study was to determine the residual effects of copper applied in 1977 by measuring soil test copper levels and spring wheat yields each succeeding year.

Experimental Procedure:
The treatments were broadcast in the spring of 1977. Era wheat was planted that year and each succeeding year over the entire area. Early whole plant, forage at soft dough and grain samples at maturity were taken.

Soil samples were taken to a depth of 6 inches each spring to determine copper levels.

A randomized complete block design with 4 replications was used.

Results:
Soil test copper levels increased significantly as the rate of applied copper increased (Table 1).

Elemental analyses of early plant samples are shown in Table 2. All significant differences occur between the check and the other treatments. Elemental analyses tended to decrease for all those elements affected except for copper which increased as the amount of copper applied increased.

Forage yield and its elemental analyses as affected by copper are shown in Table 3. No forage or grain yields have been obtained from the check plots because all the plants die about 6 weeks after emergence so they are not included. No differences in forage yield were obtained, but copper levels were significantly increased.

The effects of copper on grain yield and its elemental analyses are shown in Table 4. No differences in yield between the copper rates were obtained, but copper level in the grain was increased significantly.

Table 1. The effect of copper applied in 1977 on soil test levels in 1980.

Cu Rate	Soil Test Cu
lb/A	- ppm -
0	1.0
3	5.6
6	10.4
12	17.0
24	40.4
48	151.5
96	260.0
192	644.2
Significance	**
B.L.S.D. (.05)	75.1
C.V. (%)	40.0

Table 2. The effect of residual copper on early whole plant sample analyses.

Cu Rate	Elemental Analyses										
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	%				ppm						
0	.65	3.69	.51	.46	32	100	155	102	62	.6	7
3	.34	1.99	.46	.43	18	61	296	61	48	2.5	4
6	.32	2.14	.41	.38	19	56	185	56	42	3.4	4
12	.37	2.37	.42	.39	17	53	208	54	42	5.0	4
24	.36	2.26	.43	.40	16	53	239	48	45	5.4	4
48	.33	1.83	.45	.41	26	64	254	56	44	7.1	4
96	.33	2.19	.45	.40	20	54	188	51	48	6.7	4
192	.35	2.30	.58	.48	25	58	196	63	48	7.3	4
Significance	**	**	NS	+	NS	**	*	**	**	**	**
B.L.S.D. (.05)	.04	.58		.08		18	93	18	6	1.4	1
C.V. (%)	8.8	17.3	18.6	10.7	44.7	19.7	25.3	19.9	9.1	22.5	16.4

Table 3. The effects of residual copper on forage yield and elemental analyses.

Cu Rate	Forage											
		Elemental Analyses										
	Yield	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	lbs DM/A	%				ppm						
3	5344	.28	1.26	.25	.24	24	60	98	57	40	1.4	6
6	5645	.28	1.28	.22	.23	24	55	75	62	35	2.5	8
12	5757	.31	1.40	.23	.23	25	54	102	66	33	3.1	6
24	5963	.34	1.21	.22	.24	18	49	71	64	43	3.4	7
48	5241	.27	1.13	.20	.22	20	49	113	52	36	3.9	5
96	5834	.28	1.27	.20	.22	22	55	98	56	36	4.4	6
192	5241	.30	1.04	.19	.23	17	49	80	59	39	4.1	4
Significance	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	**	NS
B.L.S.D. (.05)							9				.5	
C.V. (%)	10.8	13.4	16.0	16.4	9.8	21.2	10.0	27.0	26.4	12.4	11.6	45.1

Table 4. The effects of copper on grain yield and elemental analyses.

Cu Rate	Grain											
		Bushel	Elemental Analyses									
	Yield	Weight	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu
lb/A	Bu/A	lb	%				ppm					
3	34.0	54.8	.47	.51	.07	.23	2	58	13	51	54	1.3
6	39.9	55.5	.50	.55	.06	.24	2	54	13	50	56	2.2
12	39.0	54.5	.51	.56	.07	.25	2	56	12	48	54	2.8
24	34.4	55.8	.49	.55	.06	.24	2	54	15	48	55	3.6
48	29.2	54.2	.50	.53	.07	.25	3	54	14	52	55	4.8
96	33.0	53.0	.48	.54	.07	.24	3	50	19	50	55	5.7
192	31.7	55.0	.49	.53	.07	.24	2	51	12	54	56	4.9
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
B.L.S.D. (.05)												1.4
C.V. (%)	19.4	2.8	6.8	7.6	5.5	7.3	18.1	7.9	13.7	12.0	6.6	27.0

PHOSPHORUS FERTILIZATION OF SUGARBEETS

G. E. Varvel and R. K. Severson

The objectives of this study were to determine the effect of added P on sugarbeet yield and quality and on the Bray P-1 and $NaHCO_3$ soil test P results from the fertilized plots.

Experimental Procedure:

Six rates of P in a randomized complete block design with 4 replications were used. The P fertilizer treatments were broadcast on Sept. 12, 1979. Sugarbeets were planted in the spring of 1980, but emergence and stand were very erratic because of extreme heat and drought during the growing season. Due to these problems, yields were not taken. However, petiole samples were taken on Aug. 27 to evaluate the effect of the applied P on their nutrient content. Soil samples were also taken at this time to evaluate the effects of the added P on soil test P results.

Soil test results from samples taken prior to the initiation of the study on Sept. 12, 1979 were: pH (0-6") - 8.1, $NaHCO_3$ extractable P (0-6") - 13 lb/A and exchangeable K (0-6") - 225 lb/A.

Results:

Total P, Zn and Cu levels in the petiole were significantly affected by the treatments (Table 1). Phosphorus levels increased while Zn and Cu levels decreased with added P fertilizer. The $NaHCO_3$ and Bray P-1 (50:1) soil test levels also increased significantly with added P (Table 2).

Table 1. The effect of P on sugarbeet petiole analyses.

P_2O_5	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	%							ppm			
0	.21	4.07	5.29	1.00	.03	.02	2.61	43	19	10	32
40	.22	3.84	5.06	.94	.03	.03	2.54	37	17	8	33
80	.25	3.68	5.53	.97	.04	.02	2.38	38	18	8	34
120	.26	3.64	4.83	.99	.03	.02	2.53	43	16	8	33
160	.26	3.18	4.93	.96	.03	.02	2.90	42	16	8	36
200	.26	3.04	4.25	.97	.03	.02	3.30	38	14	7	31
Significance	*	NS	NS	NS	NS	NS	NS	NS	*	*	NS
B.L.S.D. (.05)	.04								4	2	
C.V. (%)	10.0	16.2	14.8	19.1	20.4	19.3	17.0	15.1	12.7	11.3	8.4

Table 2. The effect of P on soil analyses.

	NDSU			Minnesota			
	$NaHCO_3$			Bray P-1			
P_2O_5	pH	P	K	pH	10:1	50:1	K
lb/A	lb/A			lb/A			
0	8.1	13	282	7.9	14	29	242
40	8.0	12	281	7.9	18	32	244
80	8.0	19	289	7.8	28	41	246
120	8.0	21	284	7.9	28	46	254
160	8.1	26	284	7.9	20	42	249
200	8.1	30	278	7.9	25	49	236
Significance	NS	**	NS	NS	NS	**	NS
B.L.S.D. (.05)		7				11	
C.V. (%)	1.2	22.2	6.8	0.8	43.8	18.0	9.9

HIGH PHOSPHORUS AND POTASSIUM RATES ON SPRING WHEAT

G. E. Varvel and R. K. Severson

The objective of this study was to determine the effect of high rates of P and K on wheat yield, nutrient uptake and soil test P and K levels. This is the first year of a long term study which is designed to look at the effect of different combinations of P and K at "maintenance" and "build" levels. Three years will be needed to complete the first cycle of treatments.

Experimental Procedure:

The treatment combinations shown in Table 1 were broadcast and incorporated on a Wheatville loam soil with a field cultivator on May 2, 1980. A broadcast application on 60 lb/A N was applied over the entire experiment and Era wheat was planted that same day. Due to the extreme heat and drought, emergence and stand were very poor so grain yields were not taken.

Soil samples were taken on August 4 to determine the effect of the treatments on soil test P and K levels. All soil samples were split and sent to both the North Dakota State University and University of Minnesota soil testing labs.

Initial soil test levels were: pH (0-6") - 8.0, NO_3-N (0-2') - 40 lb/A, $NaHCO_3$ extractable P (0-6") - 11 lb/A and exchangeable K (0-6") - 250 lb/A.

Results:

The effects of the treatments are shown in Table 1. Both soil testing labs obtained significant increases in P and K in the 0-6 inch samples. No differences in the 6-12 inch samples were obtained.

Table 1. The effect of high P and K rates on soil test results.

Treatment		Minnesota						N.D.S.U.			
		Bray P-1				Exchangeable K		$NaHCO_3$ P		Exchangeable K	
		10:1	50:1	10:1	50:1						
		Depth (Inches)									
P_2O_5	K_2O	0-6	0-6	6-12	6-12	0-6	6-12	0-6	6-12	0-6	6-12
lbs/A		lb/A									
0	0	19	36	7	21	251	231	12	8	264	251
0	100	30	36	25	26	257	238	12	7	271	231
50	100	39	46	20	23	261	232	22	8	270	238
100	100	29	49	13	32	274	214	30	10	282	238
150	100	56	64	24	30	293	233	37	14	284	255
100	0	17	37	8	20	256	223	19	8	260	236
100	50	43	52	18	20	256	200	31	8	265	232
100	150	52	56	21	27	315	248	31	9	301	255
150	100	50	62	13	24	278	215	32	11	278	240
100	150	48	68	16	24	304	222	34	12	289	244
Significance		*	**	NS	NS	*	NS	**	NS	**	NS
B.L.S.D.(.05)		33	17			49		13		24	
C.V. (%)		48.0	22.6	60.2	29.0	10.2	14.7	33.0	36.2	54	8.2

EFFECT OF POTASSIUM FERTILIZER ON SPRING WHEAT

G. E. Varvel and R. K. Severson

The objective of this study was to determine the effect of potassium fertilizer on grain yield and quality and on forage yield, nutrient content and uptake of spring wheat on a Wheatville loam soil.

Experimental Procedure:

Six rates of potassium fertilizer in a randomized complete block design with 4 replications were used. The treatments were broadcast and incorporated on April 21, 1980. Era wheat was planted on April 24 and harvested July 23, 1980. Whole plant samples taken July 18 at soft dough were used to determine forage yield and nutrient uptake. Soil test results from samples taken from the area of the study were: pH (0-6") - 8.0, NO_3-N (0-2') - 30 lb/A, and $NaHCO_3$ extractable P (0-6") - 20 lb/A and exchangeable K (0-6") - 110 lb/A.

Results:

Grain yield and bushel weight were increased significantly with the addition of K fertilizer (Table 1). No other differences were obtained.

Table 1. The effect of potassium on grain yield and quality and on forage yield, nutrient content and uptake of spring wheat.

K_2O	Grain			Forage		
Rate	Yield	Bushel Weight	Protein	Yield	K	K Uptake
lb/A	Bu/A	lb	%	lb DM/A	%	lb/A
0	22.9	56.5	15.0	3279	0.97	32.8
50	30.5	57.8	14.1	4057	1.05	43.9
100	22.2	58.8	15.3	3119	0.93	29.2
150	29.6	59.0	14.4	3406	0.98	33.7
200	25.8	58.2	14.9	3549	1.13	40.0
250	32.2	59.5	13.8	3494	1.04	37.0
Significance	*	*	N.S.	N.S.	N.S.	N.S.
B.L.S.D. (.05)	8.3	1.8				
C.V. (%)	17.6	1.9	6.0	14.0	8.8	21.2

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT

G. E. Varvel and R. K. Severson

The objective of this study was to compare nitrogen and phosphorus fertilizer application methods on spring wheat. The study was initiated to determine if P is more effective when injected with anhydrous ammonia by the dual injection method than when broadcasted or drill applied on spring wheat.

Experimental Procedure:

Treatments used in the study are shown in Table 1. Both N and P were applied by each method at equal rates and N alone was applied by each method at the same rate as was in the N and P combination treatments. All treatments had 90 lb/A total N applied. A broadcast application of 200 lb/A K_2O was made over the entire study on April 21 and plowed down on April 22. All broadcast treatments were also plowed down. The knife and drill applied treatments were made immediately after the area had been plowed.

Era wheat was seeded April 22 and harvested July 23. Whole plant samples taken July 18 were used to determine forage yield and nutrient uptake.

Soil test results for the area were: pH (0-6") - 8.0, NO_3-N (0-2') - 30 lb/A, $NaHCO_3$ extractable P (0-6") - 20 lb/A and exchangeable K (0-6") - 110 lb/A.

Results:

The results are shown in Table 1. No interpretation will be given due to the variability caused by the extreme heat and drought during the early part of the growing season of 1980. No significant differences between application methods were obtained.

Table 1. The effect of N and P application methods on spring wheat.

Source			N	P_2O_5	Grain			Forage		
							Bushel		Uptake	
NH_3	UAN	10-34-0	Rate	Rate	Yield	Protein	Weight	Yield	N	P
- Application Method -			lb/A	lb/A	Bu/A	%	lb	lb DM/A	- - lb/A - -	
--	--	--	0	0	21.6	12.9	61.2	2115	31.2	5.1
Knife	--	--	90	0	27.7	13.9	59.2	3349	53.8	6.3
--	Knife	--	90	0	26.1	13.9	59.2	3576	58.8	7.7
--	Brdcst	--	90	0	23.6	14.2	59.2	2491	43.2	5.4
Knife	--	Knife	90	45	22.3	14.5	59.2	2707	48.1	5.9
--	Knife	Knife	90	45	25.3	13.7	59.8	2791	50.6	6.2
Knife	--	Brdcst	90	45	28.8	14.1	59.5	2989	51.0	6.7
--	Brdcst	Brdcst	90	45	27.9	14.3	59.2	3096	55.6	6.4
Knife	--	Drill	90	45	25.0	14.3	58.8	3168	60.4	7.8
--	Brdcst	Drill	90	45	28.5	14.2	60.0	3328	59.7	7.4
Knife	Drill	--	90	0	26.5	14.2	60.2	3408	58.7	7.5
- Brdcst & Drill -			90	0	24.7	14.2	60.2	2926	46.6	5.9
Significance					NS	NS	*	NS	*	NS
B.L.S.D. (.05)							1.5		18.2	
C.V. (%)					24.7	4.2	1.5	22.6	20.7	28.5

EFFECTS OF NITROGEN CARRIER, RATE AND APPLICATION DATE ON SPRING WHEAT - 1980

G. E. Varvel and R. K. Severson

The objectives of this study were to determine the effect of nitrogen carrier, rate and application date on forage yield and N uptake and grain yield and protein of spring wheat.

Experimental Procedures

Four nitrogen carriers, 2 rates and 2 application dates were combined in a factorial arrangement in a randomized complete block design. The treatment combinations are shown in Table 1. The application dates were October 29, 1979 and April 15, 1980. Era was planted on April 16 and harvested July 23. Whole plant samples taken July 8 at soft dough were used to determine forage yield and nitrogen uptake.

Soil test results from samples taken prior to initiation of the study were: pH (0-6") - 8.1, NO_3-N (0-2') - 80 lb/A, $NaHCO_3$ extractable P (0-6") - 32 lb/A and exchangeable K (0-6") - 360 lb/A.

Results

No significant differences due to carrier, N rate or date of application were obtained. The lack of response was mainly due to a lack of precipitation and extreme heat during the early part of the growing season.

Table 1. The effects of nitrogen carrier, rate and application date on yield and N uptake of spring wheat.

	Forage			Grain		
Treatment	Yield	Total N	N Uptake	Yield	Protein	Bushel Weight
	lb DM/A	%	lb/A	Bu/A	%	lb
Carriers						
Urea	3070	1.34	41.3	25.7	12.9	62.1
UAN	3369	1.41	47.0	27.1	13.5	61.8
Ammonium Nitrate	3407	1.45	49.4	26.6	13.1	62.1
Anhydrous Ammonia	3370	1.46	48.7	28.0	13.1	62.1
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	21.9	10.8	23.2	18.4	7.2	1.3
N Rate (lb/A)						
30	3153	1.42	44.6	26.3	13.1	62.1
60	3454	1.41	48.5	27.4	13.3	62.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	21.9	10.8	23.2	18.4	7.2	1.3
Date of Application						
Fall	3302	1.40	46.0	27.1	13.0	62.0
Spring	3305	1.43	47.1	26.7	13.3	62.0
Significance	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)	21.9	10.8	23.2	18.4	7.2	1.3

EFFECTS OF ANHYDROUS AMMONIA ON GERMINATION OF SPRING WHEAT AND BARLEY

G. E. Varvel and R. K. Severson

The objectives of this study were to determine the effect of anhydrous ammonia on the germination of spring wheat and barley and its indirect effect on yield.

Experimental Procedure:

The experiment was conducted using a split-plot design with time of seeding as the main plot with combinations of 4 rates of N (0, 40, 80 and 120 lb/A) as anhydrous ammonia at 3 application depths (3, 6 and 9 inches) in a factorial arrangement as the subplots within each main plot. Four replications were used. The times of seeding were done 0, 24 and 48 hours after the anhydrous application on April 30.

Stand counts were taken 30 days after planting. Emergence was slow due to the extremely dry weather. Yield samples were taken on July 24 and August 6 for the barley and wheat respectively with subsamples taken for protein analyses.

Soil test results from samples taken at the start of the study were: NO_3-N (0-2')-30 lb/A, $NaHCO_3$ P (0-6")-32 lb/A and exchangeable K (0-6")-360 lb/A.

Results:

Results are shown in Table 1 for the effects of each of the factors separately since no significant interactions were obtained. Significant increases in yield were obtained with the N treatments on both wheat and barley. Protein content of wheat and barley were significantly increased as N was added and as the depth of application was increased. Barley protein also increased with delay in time of seeding. Plant population was significantly reduced by application depth in both wheat and barley and by the 80 and 120 lb/A N treatments on barley.

Table 1. Effects of anhydrous ammonia on plant population, yield and protein of spring wheat and barley.

	Wheat			Barley		
Seeding Times	Yield	Protein	Population	Yield	Protein	Population
	Bu/A	%	Plants/A	Bu/A	%	Plants/A
0	24.0	14.4	908,500	32.6	11.8	715,000
24	28.1	14.0	886,900	36.4	11.7	701,500
48	29.0	14.2	853,800	37.4	12.1	678,000
Significance	NS	NS	NS	NS	*	NS
B.L.S.D. (.05)					0.4	
N Rate (lb/A)						
0	22.2	13.4	899,400	28.9	11.2	710,600
40	28.3	14.2	893,000	37.0	11.9	716,300
80	29.0	14.6	874,600	38.0	12.1	679,100
120	28.5	14.6	863,400	37.8	12.3	686,600
Significance	**	**	NS	**	**	**
B.L.S.D. (.05)	2.0	0.3		2.7	0.2	29,600
Depth (Inches)						
3	27.6	14.0	904,700	37.6	11.7	723,700
6	26.9	14.1	902,800	35.9	11.8	704,800
9	26.6	14.5	840,300	33.7	12.1	666,000
Significance	NS	**	**	NS	**	**
B.L.S.D. (.05)		0.3	29,500		0.2	22,100

EFFECTS OF DIFFERENT FERTILIZER PROGRAMS ON SOIL TEST LEVELS IN A CONTINUOUS WHEAT CROPPING SYSTEM

G. E. Varvel, C. A. Simkins and R. K. Severson

The objective of this study was to measure the effect of different fertilizer programs over a 10-year period on soil test levels in a continuous wheat cropping system on a Wheatville loam soil. Measurements on a yearly basis will provide information for evaluation and determination of the most efficient fertilizer program in this system. The use of continuous wheat on which yield and quality factors are measured will enable nutrient uptake and removal to be calculated under the various fertility programs.

Experimental Procedure:

Five fall applied treatments with 4 replications in a randomized complete block design were used. Each treatment is based upon soil test data from those plots on which that treatment was applied in the previous year. The 1980 treatments are shown in Table 1. All treatments were applied and incorporated October 29, 1979. Era wheat was planted April 16 and harvested July 23, 1980. Whole plant samples taken July 8 at soft dough were used to determine forage yield and uptake values. Soil samples taken August 4 were analyzed for N, P and K to determine the effects of the 1980 treatments and to establish the 1981 treatments.

Results:

The effect of the treatments on grain and forage yield and uptake values is shown in Table 1. No significant differences were obtained.

Soil test results from the fall 1980 sampling are shown in Table 2. Nitrate levels at the 6-12", 1-2' and the combined 0-2' and 0-5' depths were significantly affected by the treatments. Phosphorus levels in the 0-6" depth showed significant differences according to both the Bray-1 and $NaHCO_3$ tests of the University of Minnesota and North Dakota State University labs respectively.

Table 1. Yield and uptake by Era wheat as effected by the different fertilizer programs.

Treatment			Grain			Forage			
				Bushel			Uptake		
N	P_2O_5	K_2O	Yield	Weight	Protein	Yield	N	P	K
- - - - lb/A - - - -			Bu/A	-lb-	-%-	lb DM/A	- - - lb/A - - -		
0	0	0	24.9	61.8	13.2	2840	40.0	4.9	23.2
70	45	25	23.0	60.2	14.2	3102	43.6	5.0	24.2
50	45	55	23.7	60.5	14.3	3146	44.3	5.0	26.5
80	45	25	25.3	61.2	13.4	2744	39.4	4.0	20.7
50	75	25	23.5	61.0	14.6	3290	50.8	6.0	28.0
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
C.V. (%)			22.9	1.9	6.3	21.3	19.3	32.8	26.0