SOIL SERIES

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

The 1980 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, Grand Rapids, Lamberton, Morris, Rosemount and Waseca; the "Sand Plain" experimental sites; and Soils and Crop area agents. Associated personnel from the Soil Conservation Service, the Soil and Water Research group of the SEA-USDA, the Tennessee Valley Authority, the Department of Natural Resources and the Departments of Agriculture also contributed information.

Some of the results are from 1979 experiments only and should be regarded on this basis. Since most data are from only 1979 studies, conclusions are not conclusive and are thus not for further publication without the written consent of the individual researchers involved.

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

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

TABLE OF CONTENTS

		Page
1.	Spring 1980 Minnesota Soil Moisture Situation	1
2.	Development of Crop Calendars and Agroclimatic Data for Minnesota Crop Reporting (CRD)	17
	Becker Experiments	
3.	Controlling Soil pH for Potatoes Under Irrigation (Limy Water),1979	24
4.	Micronutrient Tests on Alfalfa	27
5.	Micronutrient Fertilization of Potatoes and Corn Under Irrigation	29
6.	Influence of Nitrogen Form, Nitrification Inhibitors, and Treatment Incorporation on Yields and Nitrogen Utilization of Corn Under Irrigation	33
7.	Influence of Nitrogen Rate, Timing of Nitrogen Application and Use of Nitrification Inhibitors for Irrigated Corn Production	37
	Crookston Experiments	
8.	1979 Weather Summary	41
9.	Effects of Nitrogen Carrier, Rate, and Application Date on Spring Wheat at Crookston - 1979	43
10.	Effects of Nitrogen and Phosphorus Application Methods on Spring Wheat - 1979	46
11.	Spring Wheat Fertilization - 1979	48
12.	Nitrogen Fertilization and Nitrogen Utilization by Fourteen Small Grain Varieties	50
13.	Soil Test Levels as Affected by Different Fertilizer Programs in a Continuous Wheat Cropping System	55
14.	Effects of Anhydrous Ammonia on Germination of Spring Wheat and Barley - 1979	57
15.	Phosphorus and Potassium Fertilizer Rate Studies on Malting Barley - 1979	59
16.	Effects of Micronutrients on Spring Wheat Grown on Organic Soils	61
17.	Residual Effects of Copper Applied on Organic Soils	63
18.	Effects of Nitrogen and Phosphorus Application Methods on Sugar Beets - 1979	64
19.	Comparison of Phosphorus Soil Test Method on a Bearden-Fargo Silty Clay Loam	65
	Lamberton Experiments	
20.	Twenty Years of Field Experimentation with Nitrogen Source, Placement, and Time of Application to a Webster Loam Near Lamberton	66
	Morris Experiments	
21.	Weather Summary -1979	71
22.	Continuous Corn Silage	72
23.	Effect of Fertilization on Corn Grain Yield and N Content of the Ear Leaves	73

Morris Experiments, Cont'd.

Page

24. Foliar Fertilization of Corn..... 78

25. Manure Rate Study..... 79

26. Residual Effect of Heavy Applications of Animal Manures on Corn Growth and Yield and on Soil Properties..... 86

27. Influence of Nitrogen Fertilization on Forage Production and Nitrogen Utilization by Three Small Grain Varieties..... 91

28. Nitrogen Fertilization and Nitrogen Utilization by Seven Small Grain Varieties..... 94

Rosemount Experiments

29. Pesticide Interaction Plots at Rosemount..... 98

Staples Experiments

30. Alfalfa and Red Clover Potassium Trials..... 99

31. Barley Fertilization Trials at Staples..... 104

32. Nitrogen Fertilizer Distribution Between Corn Plants, Soil and Aquifer Under Irrigated Condition..... 110

33. Influence of Nitrogen Rate, Form and Use of Extend on the Yields and Nitrogen Utilization of Corn Under Irrigation..... 112

34. Influence of Nitrogen Rate, Timing of Application and Use of Nitrification Inhibitors on Irrigated Corn..... 117

35. N Rate Studies of Dryland and Irrigated Wheat and Oats, Staples 1979.... 119

36. Phosphate Rate Studies of Irrigated and Dryland Wheat and Oats, Staples, 1979..... 126

37. Water Quality Studies..... 127

Waseca Experiments

38. Weather Data - 1979..... 133

39. Continuous Corn Tillage Study..... 134

40. N Rate, Source, and Incorporation Study - Corn..... 142

41. Rotation Nitrogen Study..... 144

42. Use of Terrazole (Dwell) as a Nitrification Inhibitor in Fall vs. Spring Nitrogen Application Programs for Corn Production in Southern Minnesota..... 147

43. Correcting Chlorosis of Soybeans by Foliar Application of Iron..... 149

44. Soybean Tillage - Herbicide Study..... 151

45. Planterra and Soil Inoculant..... 156

46. Symbex..... 159

Corn

47. Deep Sampling of Soils for Residual Nitrates and Its Potential as a Diagnostic Technique for Corn Production in Southwestern Minnesota..... 165

48. Eco-Gro Studies on Corn..... 170

Page

49. High Phosphorus and Potassium Rates for Continuous Corn..... 173

50. The Influence of Nitrate-Nitrogen in the Soil Profile on the Response of Corn to Nitrogen Fertilization in Southeastern Minnesota - 1979 and 1977-1979 Summary..... 180

51. Use of N-Serve in Fall vs. Spring Nitrogen Application Programs on Fine Textured Soils of Minnesota..... 186

Grass Seed

52. Grass Seed Production as Influenced by Fertilization..... 192

Navy Beans

53. Navy Bean Inoculation Trials - 1979..... 201

Pastures

54. Pasture Fertilization Trials..... 203

Soil Testing

55. Influence of Application of Liquid Cattle Manure on the Nutrient Level of Agriculture Soils in Jackson County, Minnesota - 1979..... 213

56. Yields and Quality of Sunflower and Wheat Crops as Influenced by Fertilizer Recommendations From Several Soil Testing Services..... 220

Soybeans

57. 1979 Soybean Foliar Fertilizer Studies..... 225

Sugarbeets

58. Nitrogen Fertilization on Sugarbeets in West-Central Minnesota-1979..... 226

Sunflowers

59. Fertilizer Trials on Sunflowers - 1979..... 234

60. Nitrogen, Phosphorus and Potassium Fertilizer Rate Studies on Sunflower - 1979..... 237

61. Nitrogen and Potassium Studies on Sunflowers in Pennington County, Minnesota - 1979..... 242

Sweet Corn

62. Nitrogen Fertilization of Irrigated Sweet Corn..... 246

Wheat

63. N Rate, Source, and Incorporation Study Wheat..... 249

64. The Yield and Protein Content of Era Wheat as Influenced by Starter Fertilizer at Several Farm Locations in Red River Basin of Minnesota - 1979..... 251

65. Yields of Winter Wheat on Fine-Textured Soil in Northern Minnesota-1979. 254

Wild Rice

66. Wild Rice Fertilization Research - 1979..... 256

Spring 1980 Minnesota Soil Moisture Situation

by David L. Ruschy, Donald G. Baker, and Earl L. Kuehnast

Soil moisture as of the first of January is above normal to excessive over a great share of the state. Most soils are at 50 percent of capacity or above, except in a few localized dry areas and along the western tier of counties in northwestern Minnesota. This is true of both the topsoil and the subsoil.

There are three areas where the whole 5 foot profile that was sampled is at or above field capacity, which is about twice the average amount of soil moisture for this time of year. These areas include the southwest, a small area in the southeast, and a fairly large area in the central and east-central part of the state.

The fact that the soils in many areas of the state are at or above field capacity can be attributed to the heavy precipitation received last summer. These areas received from 3 to 8 inches above normal precipitation. Fig. 1, "Precipitation for May-September, 1979" shows the great variation in precipitation received this past summer. The range was from less than 8 inches near the Lake of the Woods in the extreme north to over 30 inches in south central and southeast Martin county on the Iowa border where there were reports of 20 inches of rainfall in August alone.

Another big factor that led to the saturated soils was the 2-4 inches of rainfall that fell on October 30 to November 1, 1979. The 2-inch or greater area covered about two thirds of the state, west of a line from Virginia to just west of the Twin Cities to Windom, reaching west into South Dakota and North Dakota, except for Kittson, the western half of Marshall and northwestern Polk counties in Minnesota. This rainfall caused many soils to approach or exceed their field capacities, especially in the southwest. This served to further delay the already late harvest.

Two maps of soil moisture results are included with this report: Fig. 2 shows the plant available water in the total 5-foot profile and Fig. 3 the amount in the top foot of soil. The first, Fig. 2, 'Soil Moisture Adjusted to November 7, 1979' shows results obtained by taking 3 to 4 samples to a depth of 5 feet at each site, gravimetrically calculating the amount of soil moisture, adding the rainfall received between the sample date and Nov. 7 where required (to compensate for the large rainfall of Oct. 30-Nov. 1), then expressing the results as a percent of field capacity. Field capacity represents the optimum content of water in soils and is the maximum plant available water.

Most samples were taken the last week of October except for the southwest where they were taken after the Oct. 30-Nov. 1 rainfall.

The exact water holding capacity of some of the soils is not yet known and have had to be estimated. Therefore, one should not use the soil moisture maps for too detailed an analysis.

Fig. 3 shows the soil moisture in the first foot of soil. This map has also been adjusted to November 7 and expressed as a percent of capacity. For this map no values were allowed to exceed 100% of field capacity when plotted. Though many of the sites may easily have exceeded 100% of field capacity in the top foot, it is difficult to estimate how much of the large rainfall (Oct. 30-Nov. 1) would have remained in the top foot. Since the downward drainage rate is unknown, rather than overestimating some of the sites, it was decided to set maximum of 100% of field capacity.

The map of the moisture conditions for the first foot of soil shows most of the surface soils in southern one third of the state are at field capacity. Somewhat drier areas are present in the west central and northwest areas of the state. There are not enough data available in the north-central and northeast parts of the state for confident estimates on the moisture levels for these areas, but they are probably also near field

capacity, especially the areas that received more than 2 inches of rain from Oct. 30-Nov. 1 storm. Due to this storm, moisture levels in the first foot of almost all soils in Minnesota should be excellent for germination and early season growth this spring.

The amount of water in the top foot of soil at the time it freezes can be of great influence on several factors the next spring. If the surface is saturated little or no water can enter the soil until percolation begins. Thus most of the water from snow melt and early season rains is forced to run off, causing erosion problems and preventing the subsoil from being recharged. If the subsoil is already at or near capacity, percolation is slowed, thus causing a further delay in infiltration of water, increasing the runoff and erosion potential. If the subsoil is dry percolation can occur but infiltration into the soil is still slow due to the moisture blockage in the wet top soil. This can increase the summer drought potential, especially if below normal rains are received.

The amount of water present in the top foot also has great impact on agricultural tillage and planting operations in the spring. If the soil is near field capacity, it does not take much rain to slow the spring work. This problem could be present in parts of the southern third of the state where last fall's harvest operations were greatly slowed by excess water. Much of the corn had to be harvested after the ground froze hard enough to support the heavy machinery. This then prevented farmers from plowing, which means that the plowing will have to be done this coming spring, delaying the regular spring fieldwork.

Conditions for fieldwork this spring depend heavily upon this winter's snowfall and the early spring precipitation. The topsoils in the state cannot absorb much more water. Thus heavy snows or spring rains could make fields in many areas of the state as impassable as they were last fall,

especially in the lower, poorly drained areas of southern Minnesota. Fields with good tile drainage should drain all winter, and thus should fare the best for spring planting.

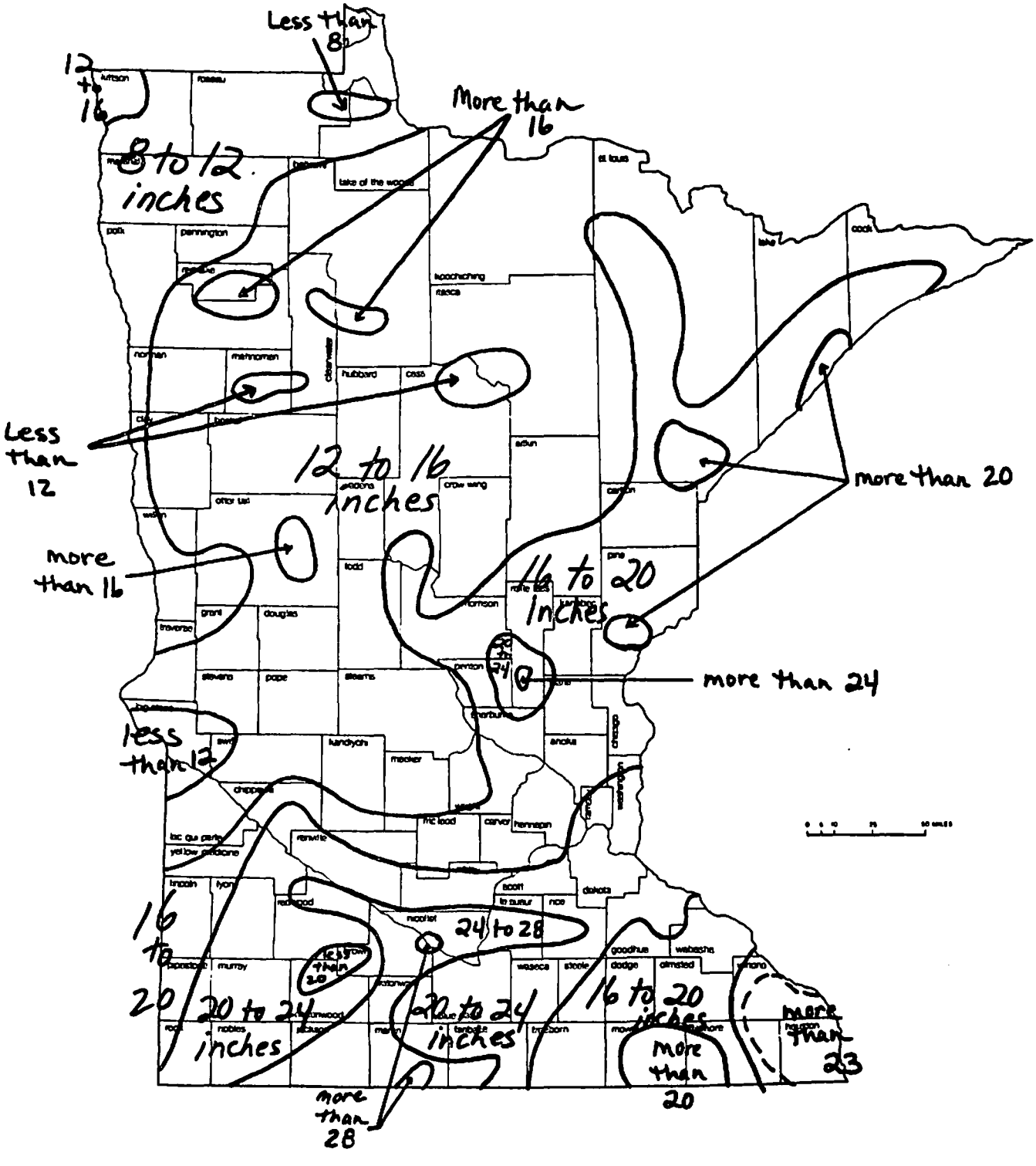
Table 1 shows the available water, field capacity, percent of capacity, and the total season precipitation at each site. The season precipitation is the amount of rainfall received between the spring and fall sample dates. The data were recorded, in most cases, at the site where the samples were taken. Any missing data were substituted with the nearest National Weather Service precipitation observation.

The last three columns show the values where the sampled results were adjusted to include the rainfall between the sample date and November 7. (Dashes indicate that no adjustment was needed.)

Table 2 shows the difference in inches of water between the spring and fall samples. This, when added to the precipitation during that period, gives the total amount of water used by the crop or lost due to evapotranspiration, drainage, and runoff, or used to recharge the soils.

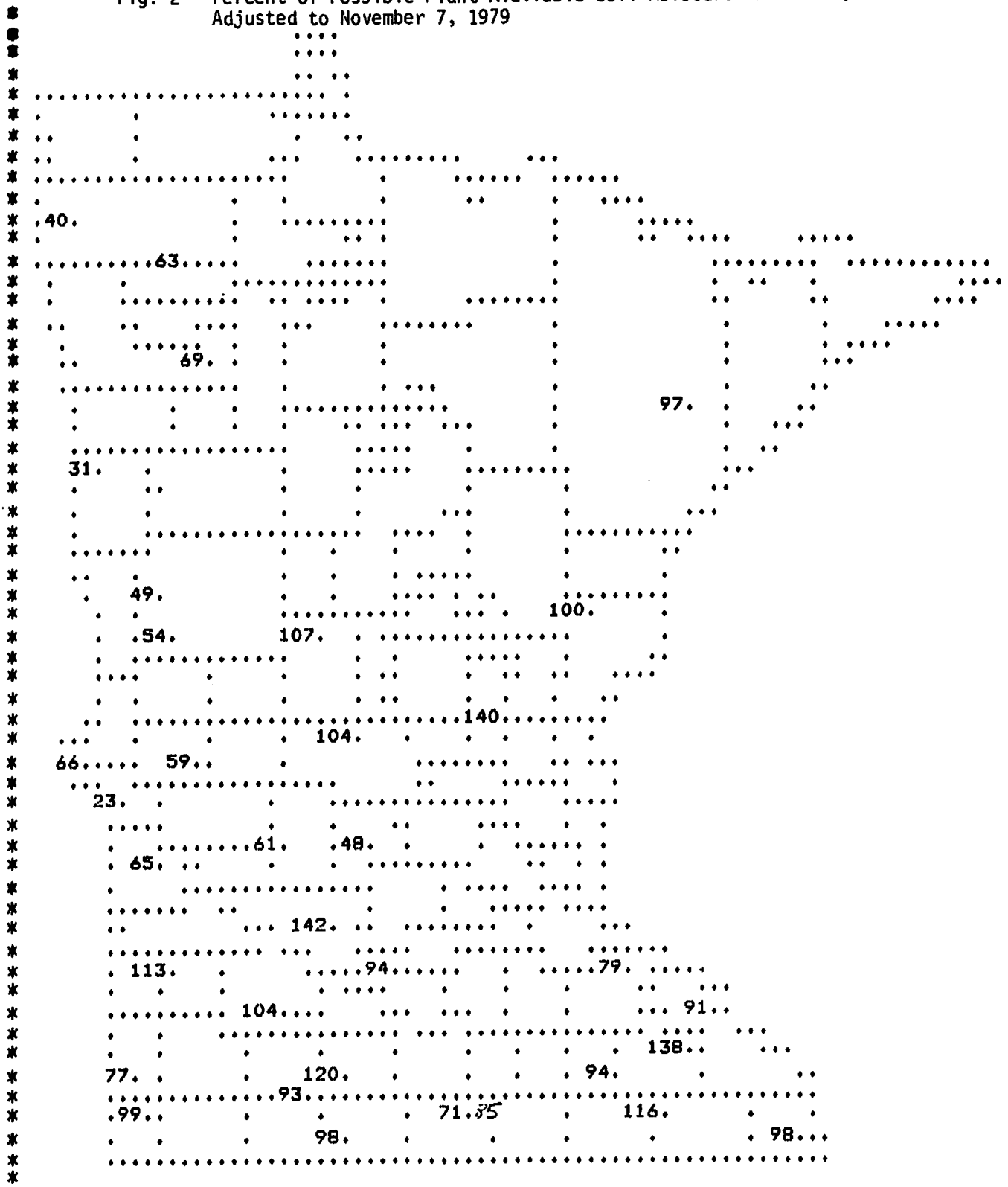
These data show that for the 26 sites sampled that had corn grown on them, an average of 21.3 inches of water was used to satisfy all demands. With most of the sites having 8 to 10 inches or more of available water when sampled last fall, this shows that only 10-22 inches of rainfall which enters the soil during this summer's growing season should be needed for a crop. Twenty-22 inches of water from either soil mositure or rainfall are needed to produce a corn crop.

Fig. 1 PRECIPITATION FOR MAY-SEPTEMBER, 1979



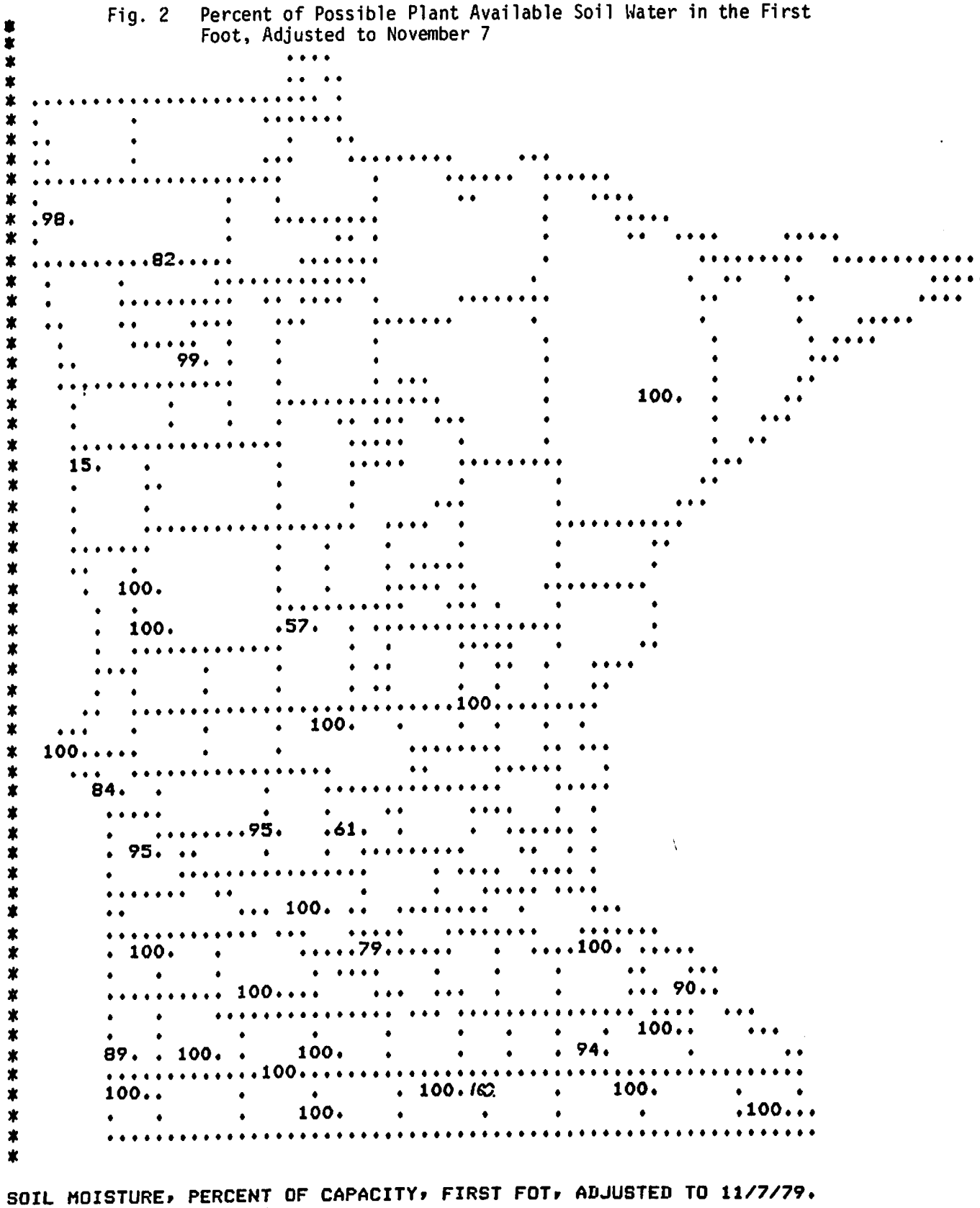
Data prepared from National Weather Service and DNR-Forestry observations.

Fig. 2 Percent of Possible Plant Available Soil Moisture in 5-Feet, Adjusted to November 7, 1979



SOIL MOISTURE ADJUSTED TO NOVEMBER 7, 1979
MEAN..... 84.21
STD DEVIATION... 30.021
MINIMUM..... 23.00
MAXIMUM.....142.00
OBSERVERS..... 35

Fig. 2 Percent of Possible Plant Available Soil Water in the First Foot, Adjusted to November 7



SOIL MOISTURE, PERCENT OF CAPACITY, FIRST FOT, ADJUSTED TO 11/7/79.
MEAN..... 92.06
STD DEVIATION... 17.543
MINIMUM..... 15.00
MAXIMUM.....100.00
OBSERVERS..... 33

Table 1 Fall 1979 Soil Moisture Results, cont'd.

Date Sampled	Cooperator	Address	Soil Type	Crop or Cover	Plant Available Water	Field Capacity	% of Capacity	Season Precip.	Adjusted Plant Available Water	Adjusted % of Capacity	Adjusted Season Precip.
10/29	Ahmann	Eyota	Racine-Ostrander	Corn	9.69	7.98	121	28.12*	11.05	138	29.48
10/26	Evenson	Fergus Falls	Barnes-Aastad	Barley	3.63	12.75	28	11.85*	6.88	54	15.10
10/26	Sethre	Carlisle	Barnes-Aastad	Barley	3.51	12.75	28	9.46*	6.23	49	12.18
10/25	Christenson	Thief River Falls	Viking	Sunflower	4.25	10.30	41	8.56*	6.53	63	10.84
10/23	C.C. Andrews Forest	Willow River	Omega Sand	Red Pine	2.55	3.29	75	10.36	-	-	11.80
11/8	Horton	Pipestone	Kranzburg Silt Loam	Corn	10.82	13.99	77	20.92*	-	-	-
10/25	Buchholtz	McIntosh	McIntosh-Winger S.L.	Wheat	4.68	10.30	45	12.67*	7.06	69	15.05
10/29	S.W. Exp. Sta	Lamberton	Clarion Silt Loam	Corn	7.47	9.81	76	22.81	10.17	104	25.51
11/7	Scheibel	Bird Island	Clarion-Webster	Corn	13.93	9.81	142	21.50*	-	-	-
?	Hamann	Luverne	Moody Silt Loam	Corn	13.12	13.24	99	27.57*	-	-	-
10/24	Viken	Roseau	-Clay	Wheat	-	-	-	7.61*	-	-	8.27
10/23	(Forest)	Aurora	Duluth	Red Pine	8.23	11.02	75	12.57*	10.70	97	15.04
11/9	Woods	Winthrop	Nicollet Clay Loam	Soybeans	11.08	11.78	94	26.99*	-	-	-
11/6	Pfau	Freeport	Webster Clay Loam	Corn	8.38	8.03	104	16.69*	-	-	-
11/14	W.C. Exp. Sta.	Morris	Doland Silt Loam	Corn	6.52	9.81	66	16.98	-	-	-
11/14	W.C. Exp. Sta.	Morris	Hammerly Clay Loam	Corn	6.02	11.6	52	17.95	-	-	-
10/29	Hartung	Bertha	Blowers Silt Loam	Alfalfa	5.45	8.33	65	14.78*	8.91	107	18.24
10/23	Zickrick	Kellog	Fayette Silt Loam	Corn	13.00	15.61	83	23.13*	14.13	91	24.26
10/31	Sandbo	Odin	Nicollet Clay Loam	Soybeans	16.16	13.82	117	26.91	16.61	120	27.36
11/6	Krause	Buffalo	Lester-Clay	Corn	-	-	-	17.79	-	-	-

* Partially or totally estimated from nearest National Weather Service Observation.

Fall 1979 Soil Moisture Results

Date Sampled	Cooperator	Address	Soil Type	Crop or Cover	Plant Available Water	Field Capacity	% of Capacity	Season Precip.	Adjusted Plant Available Water	Adjusted % of Capac.	Adjusted Season Precip.
11/7	Dimberg	Ortonville	Barnes Silt Loam	Corn	2.88	12.75 in.	23	17.23	-	-	-
11/7	Homan	Beardsley	Aastad Silt Loam	Wheat	8.95	13.50	66	15.27*	-	--	-
10/26	Leiseth	Moorhead	Bearden Clay	Wheat	-	-	-	7.93*	-	-	10.24
10/25	Brendamuhl	Georgetown	Bearden Clay	Wheat	2.28	13.34	17	7.55*	4.09	31	9.36
11/8	Turner	Bingham Lake	Nicollet Clay Loam	Corn	12.82	13.82	93	26.95*	-	-	-
12/3	Janes	Hayfield	Kasson Silt Loam	Corn	9.91	10.59	94	21.48*	-	-	-
10/30	Hassing	Wells	Webster Clay Loam	Corn	11.25	14.50	78	18.09*	12.37	85	19.21
10/30	Rauenhorst	Easton	Clarion-Nicollet	Corn	9.20	14.50	63	21.44	10.32	71	22.56
10/29	Olson	Welch	Timula Silt Loam	Corn	11.41	15.61	73	22.37	12.26	79	23.22
10/30	Hoscheit	Caledonia	Fayette Silt Loam	Corn	14.24	15.61	91	29.25	15.24	98	30.25
10/26	Badoura Nursery	Akeley	Menahga Sand	Red Pine	0.72	2.18	33	12.41	-	-	16.13
11/6	Rhoda	Raymond	Barnes Silt Loam	Corn	7.51	12.23	61	17.05	-	-	-
10/24	(Forest)	Littlefork	-clay	Aspen-birch	-	-	-	11.95	-	-	15.61
11/7	Nesvold	Madison	Barnes Silt Loam	Corn	8.23	12.75	65	17.48	-	-	-
11/8	Jeremiason	Minneota	Foreman Clay Loam	Corn	13.79	12.23	113	24.32*	-	-	-
10/25	Riopelle	Argyle	Fargo Clay	Wheat	4.22	13.34	32	7.87	5.40	40	9.05
11/9	Ruschy	Sherburn	Clarion Silt Loam	Corn	9.19	9.34	98	26.06	-	-	-
11/6	Marklowitz	Litchfield	Clarion Silt Loam	Corn	4.52	9.34	48	14.57*	-	-	-
11/9	Nichols	Milaca	Mora Silt Loam	Corn	13.46	9.64	140	23.07	-	-	-
10/30	Goodsell	Spring Valley	Kenyon Silt Loam	Corn	10.35	10.30	100	27.20*	11.91	116	28.76
11/8	Keller	Slayton	Barnes Silt Loam	Corn	13.71	12.23	112	28.77*	-	-	-
11/14	SCS	Nobles Co.	Clarion-Webster	Soybeans	11.80	-	-	30.61*	-	-	-

Table 2: Comparison of spring and fall, 1979 Soil Moisture Results

Cooperator	Address	Soil Type	Crop or Cover	Plant Available Water spring	fall	difference	Precipitation between Samples	Water Use*
Dimberg	Ortonville	Barnes Silt Loam	Corn	4.08 in.	2.88	1.20	17.23	18.43
Homan	Beardsley	Aastad Silt Loam	Corn	9.82	8.95	0.87	15.27	16.14
Leiseth	Moorhead	Bearden Clay	Wheat	5.37	0	5.37	7.93	13.30
Brendamuhl	Georgetown	Bearden Clay	Wheat	10.27	2.28	7.99	7.55	15.54
Turner	Bingham Lake	Nicollet Clay Loam	Corn	8.93	12.82	-3.89	26.95	23.06
Janes	Hayfield	Kasson Silt Loam	Corn	7.74	9.91	-2.17	21.48	19.31
Hassing	Wells	Webster Clay Loam	Corn	10.06	11.25	-1.19	18.09	16.90
Rauenhorst	Easton	Clarion-Nicollet	Corn	11.89	9.20	2.69	21.44	24.13
Olson	Welch	Timula Silt Loam	Corn	11.08	11.41	-0.33	22.37	22.04
Hoscheit	Caledonia	Fayette Silt Loam	Corn	15.32	14.24	1.08	29 25	30.32
Badoura Nursery	Akeley	Menahga Sand	40 Year Trees	2.80	0.72	2.08	12.41	14.49
Rhoda	Raymond	Barnes Silt Loam	Corn	10.22	7.51	2.71	17.05	19.76
Nesvold	Madison	Barnes Silt Loam	Corn	8.70	8.23	0.47	17.48	17.95
Jeremiason	Minneota	Foreman Clay Loam	Corn	8.26	13.79	-5.53	24.32	18.79
Riopelle	Argyle	Fargo Clay	Wheat	13.06	4.22	9.04	7.87	16.91
Ruschy	Sherburn	Clarion Silt Loam	Corn	10.31	9.19	1.12	26.06	24.94
Marklowitz	Litchfield	Clarion Silt Loam	Corn	9.32	4.52	4.80	14.57	19.37
Nichols	Milaca	Mora Silt Loam	Corn	10.48	13.46	-2.98	23.07	20.09
Goodsell	Spring Valley	Kanyon Silt Loam	Corn	9.25	10.35	-1.10	27.20	26.10
Keller	Slayton	Barnes Silt Loam	Corn	10.51	13.71	-3.20	28.77	25.57
SCS	Nobles Co.	Clarion-Webster	Soybeans	8.00	11.80	-3.80	30.61	26.81
Ahmann	Eyota	Racine-Ostrander	Corn	7.85	9.69	-1.84	28.12	26.28
Evenson	Fergus Falls	Barnes-Aastad	Barley	5.95	3.63	2.32	11.85	14.17

Table 2. Comparison of spring and fall, 1979 Soil Moisture Results, Cont'd.

Cooperator	Address	Soil Type	Crop or Cover	Plant Available Water spring	fall	difference	Precipitation between Samples	Water Use*
Sethre	Carlisle	Barnes-Aastad	Barley	9.68	3.51	6.17	9.46	15.63
Christenson	Thief River Falls	Viking	Sunflowers	8.75	4.25	4.50	8.56	13.06
C.C. Andrews Forest	Willow River	Omega Sand	Red Pine	3.23	2.55	0.73	10.36	11.09
Horton	Pipestone	Kranzburg Silt Loam	Corn	10.65	10.82	-0.17	20.92	20.75
Buchholtz	McIntosh	McIntosh-Winger S.L.	Wheat	8.16	4.68	3.48	12.67	16.16
S.W. Exp. Sta.	Lamberton	ClarionSilt Loam	Corn	7.55	7.47	0.08	22.81	22.89
Scheibel	Bird Island	Clarion-Webster	Corn	8.21	13.93	-5.72	21.50	15.78
Hamann	Luverne	Moody Silt Loam	Corn	12.21	13.12	-0.91	27.57	26.66
(Forest)	Aurora	Duluth	Red Pine	6.87	8.23	-1.36	12.57	11.21
Woods	Winthrop	Nicollet Clay Loam	Corn	10.30	11.08	-0.78	26.99	26.21
Pfau	Freeport	Webster Clay Loam	Corn	7.70	8.38	-0.68	16.69	16.01
W.C. Exp. Sta.	Morris	Doland Silt Loam	Corn	7.11	6.52	0.59	16.98	17.57
W.C. Exp. Sta.	Morris	Hammerly Clay Loam	Corn	6.14	6.02	0.12	17.95	18.07
Hartung	Bertha	Blowers Silt Loam	Alfalfa	10.26	5.45	4.81	14.78	19.59
Zickrick	Kellogg	Fayette Silt Loam	Corn	11.67	13.00	-1.33	23.13	21.80
Sandbo	Odin	Nicollet Clay Loam	Soybeans	8.10	16.16	-8.06	26.91	18.85

* Evaporation, Transpiration, Drainage, Runoff, and Recharge.

Soil Moisture Profiles at Lamberton and Morris

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

The detailed soil moisture picture for Lamberton (Redwood Co.) and Morris (Stevens Co.) shown in Fig. 3 indicates that no real shortage existed during the entire season. Instead of the usual severe withdrawal of soil moisture beginning in late June and continuing until late August or early September, the moisture levels were maintained throughout the season at approximately optimum levels. The generally high crop yields experienced in Minnesota in 1979 are in no small part due to the soil moisture levels.

Both at Lamberton and Morris the soil moisture at the end of the season was well above average. This condition may or may not be a disadvantage this spring (in case of above normal spring precipitation it could be), but will be important later in the season when the subsoil reserves are so essential. It is evident that our soils have fully recovered from the drought of 1976.

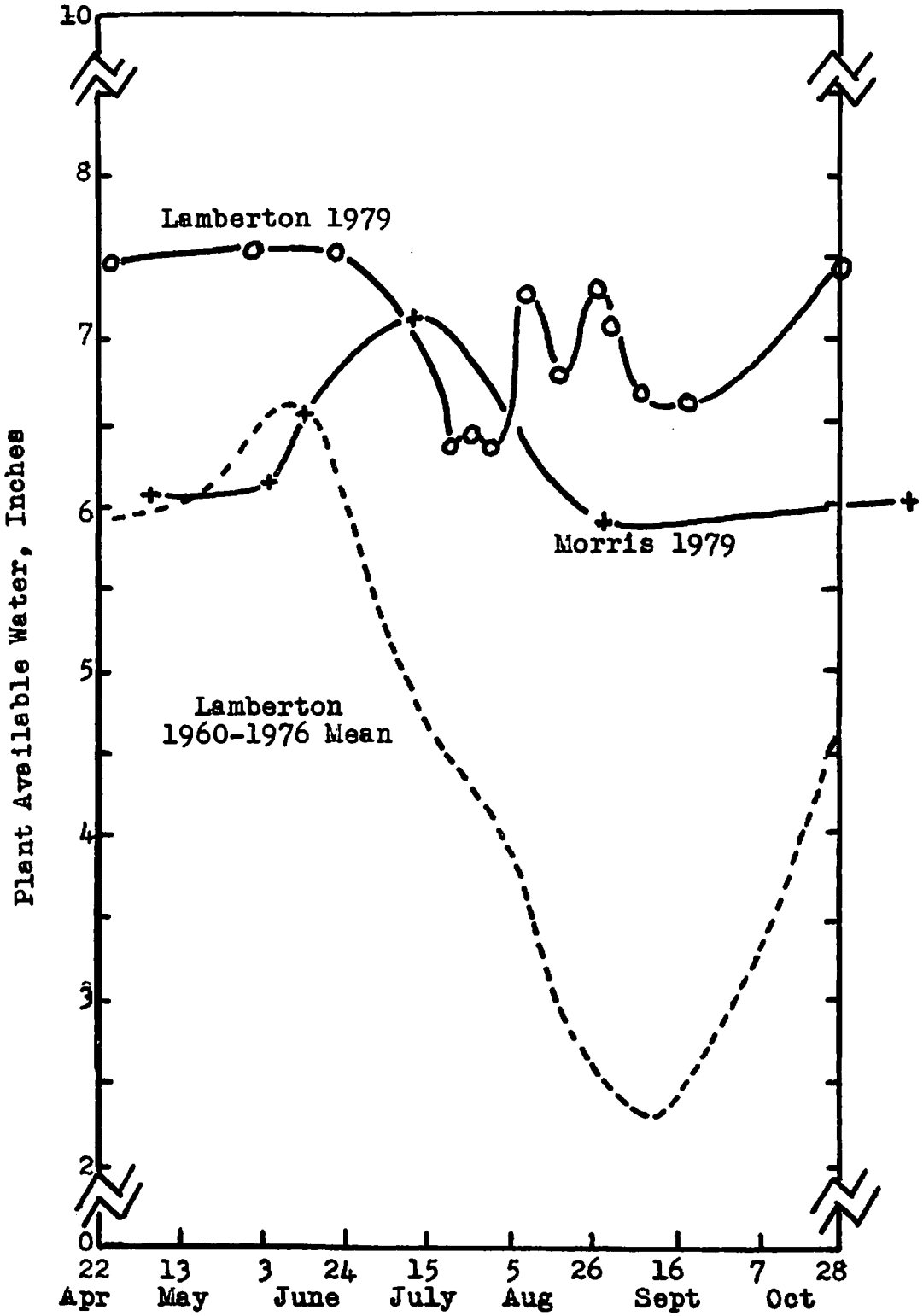


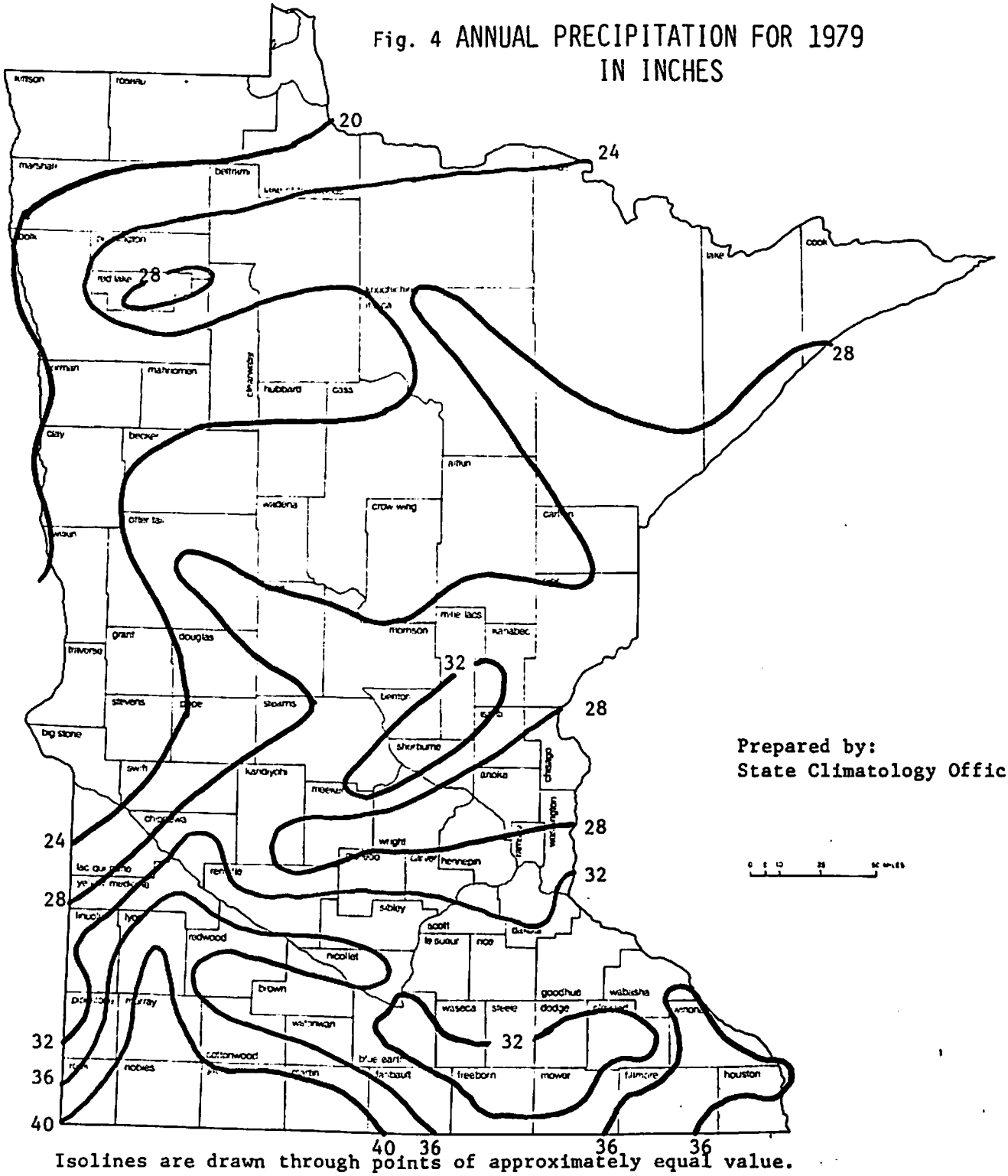
Fig. 3 Soil moisture at Lamberton and Morris in 1979 compared to the long-term Lamberton mean.

The 1979 Precipitation

by Earl L. Kuehnast and Donald G. Baker

The total precipitation for 1979 is shown in Fig. 4 and the departure from normal in Fig. 5. While in the northern half of the state the precipitation was ±3 inches of normal a large departure occurred in most of the southern part of the state. Departures exceeding 9 inches above normal occurred in the southwestern corner of the state and in Waseca County. In Martin County along the Iowa border there were reports of 20 inches of rain in the month of August.

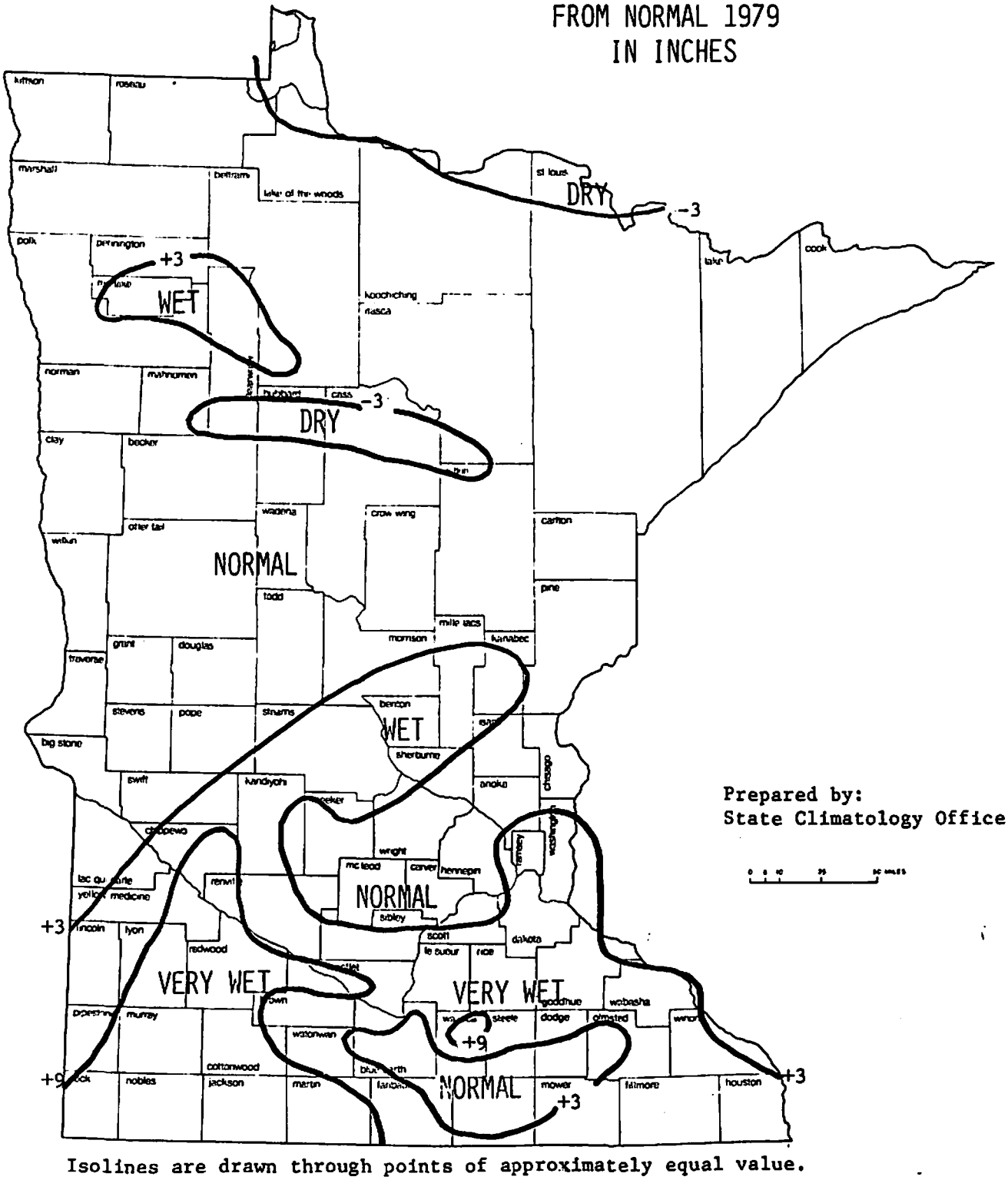
Fig. 4 ANNUAL PRECIPITATION FOR 1979
IN INCHES



Prepared by:
State Climatology Office

Isolines are drawn through points of approximately equal value.
Caution should be used in interpolating on these maps.

Fig. 5 ANNUAL PRECIPITATION DEPARTURE FROM NORMAL 1979 IN INCHES



Isolines are drawn through points of approximately equal value.
Caution shoul be used in interpolating on these maps.

DEVELOPMENT OF CROP CALENDARS AND AGROCLIMATIC DATA FOR MINNESOTA CROP REPORTING DISTRICTS (CRD)

D. Baker, E. Kuehnast, J. Ljungkull, M. Seeley

The developmental rates of crops and insects are governed by environmental conditions. The study of their sequential development is frequently referred to as crop or insect phenology. In the field of agricultural climatology, we are frequently asked to relate seasonal weather conditions to the patterns and rates of crop and insect phenological development. To do such a study is rarely limited by the availability of climatic data from seasons past. Much more commonly, we find that there is a lack of data on crop and insect phenology.

In Minnesota, the Crop and Livestock Reporting Service of the state-federal offices of USDA has been keeping observational records of crop phenology for several years. Such data exist for each crop reporting district (CRD) in the state. These data were made available to us by Carroll Rock, statistician-in-charge, of that department. Combining the crop phenology data with the climatic data summaries available from several sources allows us to derive "normal" crop calendars and the associated climatic characteristics for each crop reporting district. We are now in the process of developing these crop calendars for all major crops, except sunflowers, in each CRD. Sample data from the south-central region, district 8, are shown to illustrate the manner in which these data are being summarized.

Crop Phenological Data

For each season on record, a weekly report of the percentage of acreage at or beyond a given stage of development was available. These data were plotted for each year on record. For example, 14 years of observations on field corn were available in the south-central region. Thus 14 graphs were plotted to show the phenological development rates for each stage. The stages of corn observed were planting, emergence, tasseling, milk, dough, denting, and mature. Once each stage was plotted for each year, data were summed, and mean dates were derived. Samples are shown in Figures 1-3 for field corn in south-central Minnesota.

The rate of development through each stage is shown by plotting the percentage of acreage at or beyond that stage over time. The solid line represents the mean over the 14 year period, while the dashed lines show the earliest and latest seasons for this crop. Another means of expressing these data is shown in Table 1, where specific dates are given.

Agroclimatic Data

A number of climatic parameters relate closely to crop production. Most frequently, we are asked to provide growing degree day (GDD) or heat unit data. This is due primarily to the close relationship between crop development rates and temperature accumulations above the level required for plant growth.

Figure 4 shows the cumulative GDD normals for the south-central region. Both base 40°F, which relate to small grain development, and base 50°F, for corn and soybean development are shown. Examination of Figure 2 and Figure 4 shows that from the mean tasseling date (7/20) to the mean maturity date (9/16) approximately 1200 GDD (B50) normally occur. This agrees with published research on the growing degree day requirement for this phenological period. Corn which normally matures by September 16th also has nearly 300 GDD left in the fall season to enhance dry down of the grain. Variability in maturity date thus leads to greater variability in degree days available in the fall for field drying of the grain. Table 2 shows the degree day normals for selected dates in the growing season.

There are several other important climatic characteristics which can be summarized either tabularly or graphically. Others we intend to include are:

1. Cumulative precipitation.

2. Estimates of consumptive use.

3. Spring and fall frost probabilities.

4. Ratio of potential evapotranspiration to pan evaporation.

5. Estimates of insect phenological stages.

6. Weekly precipitation probabilities.

These data are being compiled and summarized for each CRD in the state and together with the crop calendar data, they are intended to give extension and experiment station staff agroclimatic reference material for different regions of the state. Most frequently when asked to make assessments of current crop or climate conditions, we lack the baseline data for drawing comparisons. Hopefully, this type of information will meet that need.

TABLE 1

The Average and Extreme Dates of Field Corn Development Stages in the South-Central District* (1966-1979)

	Time of Occurrence		
Stage	Earliest	Mean	Latest
Planting	4/29	5/10	5/21
Emerged	5/13	5/23	6/2
Tasseling	7/5	7/20	7/29
Dented	8/13	8/31	9/13
Mature	9/5	9/16	10/1

*Dates represent when 50% of the crop acreage reached the designated stage.

TABLE 2

Cumulative Seasonal Growing Degree Days for the South-Central District Based on Temperature Normals*

	GDD	
Date	Base 40°F	Base 50°F
4/30	230	70
5/31	809	380
6/30	1660	934
7/31	2705	1669
8/31	3680	2334
9/30	4342	2703
10/31	4694	2843

$$*GDD = \frac{TMAX + TMIN}{2} - b \quad \text{for each day}$$

$b = 40^{\circ}F$ or $50^{\circ}F$

FIGURE 1

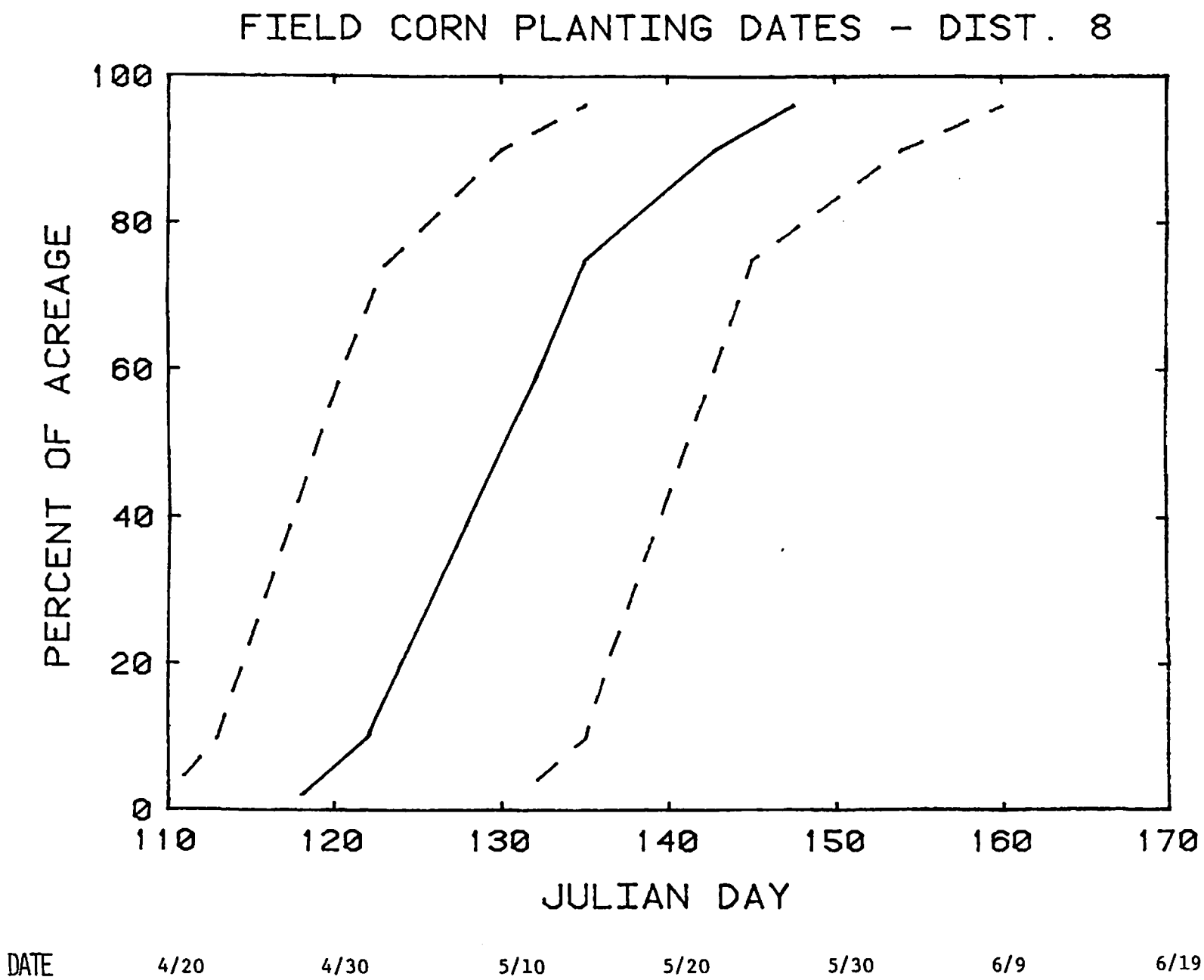

FIELD CORN PLANTING DATES - DIST. 8
PERCENT OF ACREAGE
100
80
60
40
20
0
110
120
130
140
150
160
170
JULIAN DAY
DATE
4/20
4/30
5/10
5/20
5/30
6/9
6/19

FIGURE 2

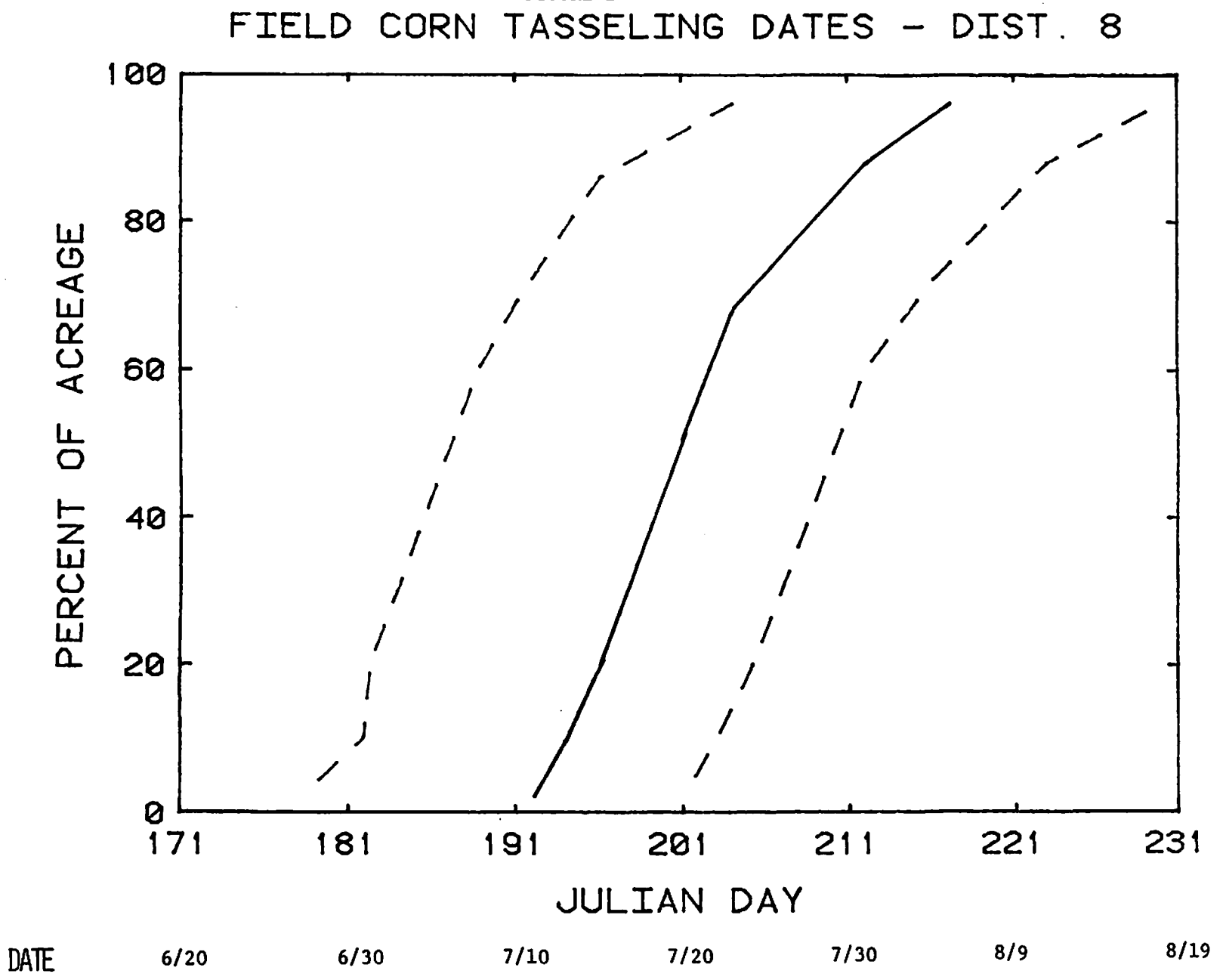

FIELD CORN TASSELING DATES - DIST. 8
PERCENT OF ACREAGE
100
80
60
40
20
0
171
181
191
201
211
221
231
JULIAN DAY
DATE
6/20
6/30
7/10
7/20
7/30
8/9
8/19

FIGURE 3

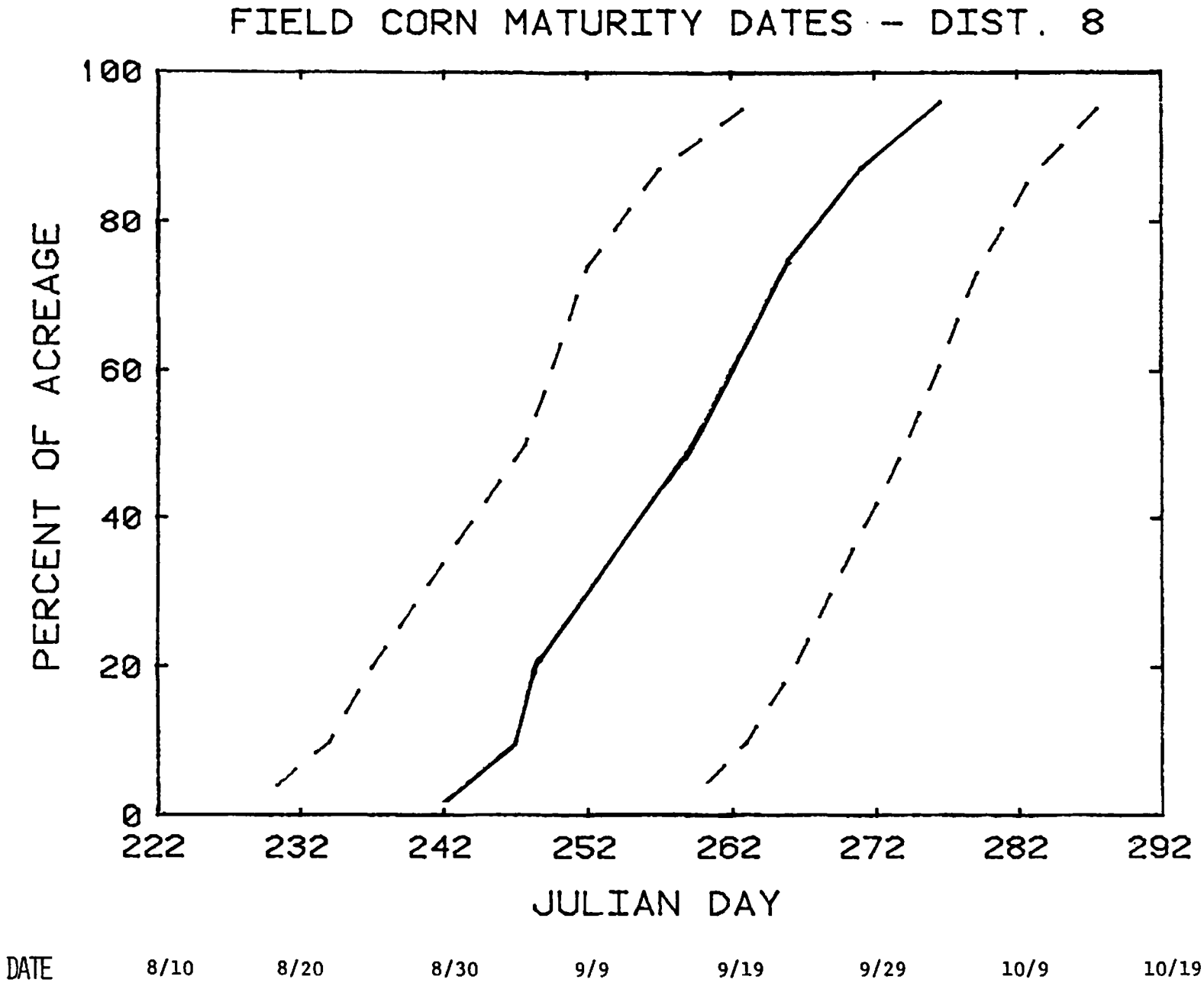
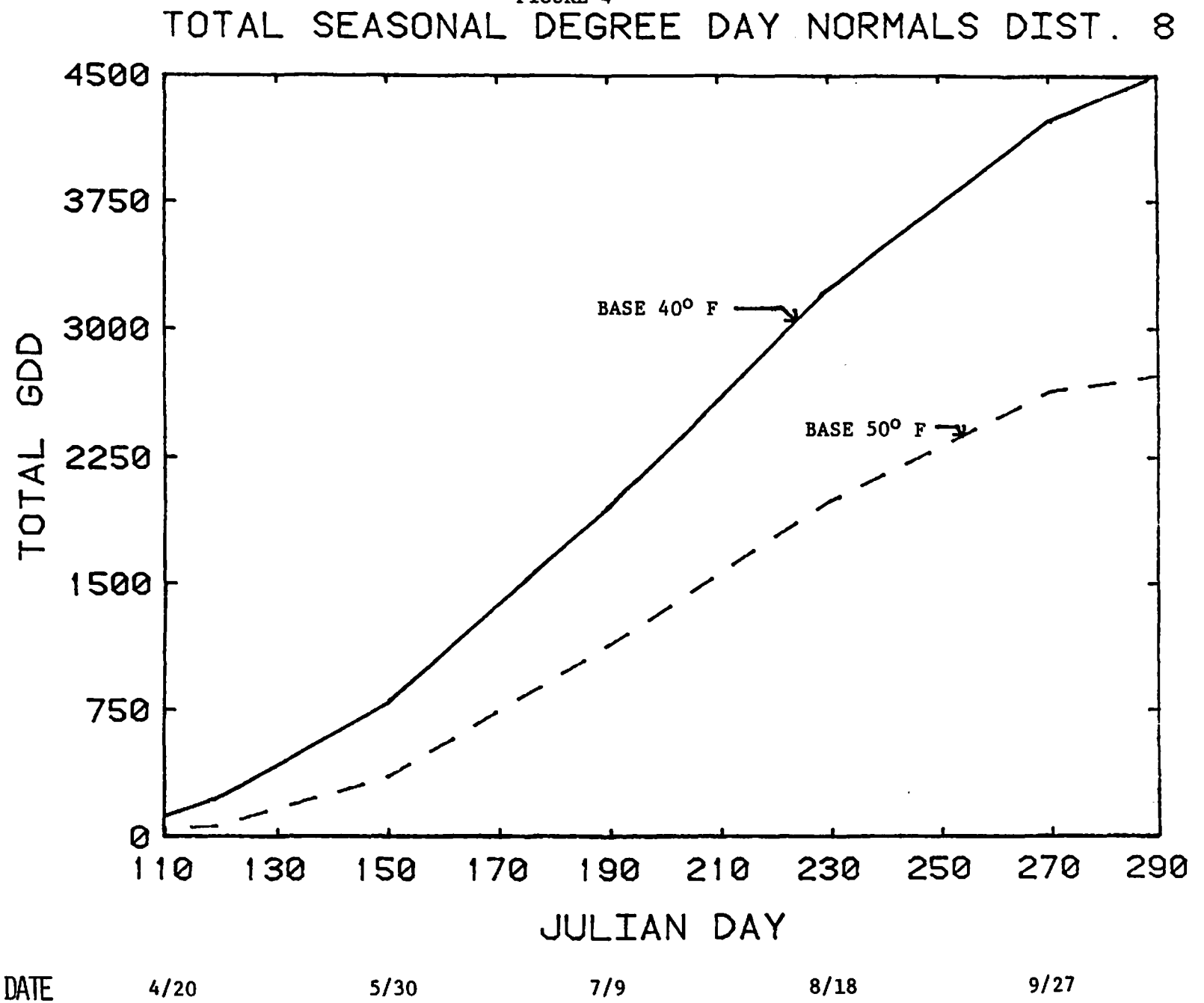

FIELD CORN MATURITY DATES - DIST. 8
PERCENT OF ACREAGE
100
80
60
40
20
0
222
232
242
252
262
272
282
292
JULIAN DAY
DATE
8/10
8/20
8/30
9/9
9/19
9/29
10/9
10/19

FIGURE 4


TOTAL SEASONAL DEGREE DAY NORMALS DIST. 8
TOTAL GDD
4500
3750
3000
2250
1500
750
0
BASE 40° F
BASE 50° F
110
130
150
170
190
210
230
250
270
290
JULIAN DAY
DATE
4/20
5/30
7/9
8/18
9/27

CONTROLLING SOIL pH FOR POTATOES UNDER IRRIGATION (LIMY WATER) 1979

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

Lowering pH with Nitrogen

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

Plot work at the Becker Irrigation Farm 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, are used. The Norland variety received 200 pounds of N per acre since it is relatively early maturing and 300 pounds per acre were used on the Russets.

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, and 252 in 1979.

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 loamy sand.

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

Table 1. The effect of three forms of nitrogen on yield of two varieties of potatoes (Becker Farm, 1976, 1977, 1978, 1979).

Treatment*	Norland				Russets		
	Cwt/A				Cwt/A		
	1976	1977	1978	1979	1976	1977	1978
Check	146 a	109 a	89 a	117 a 115	180 a	138 a	121 a 177
Ammonium nitrate	319 b	300 b	256 b	264 b 285	398 bc	370 b	373 c 380
Urea	372 b	288 b	234 b	248 b 266	408 c	354 b	330 b 364
Ammonium sulfate	389 b	368 c	320 c	280 c 339	385 b	350 b	379 c 371
Trt. Sign.	**	**	**	**	**	**	**
BLSD (5%)	84	51	27	22	16	48	21
Rep.	ns	ns	ns	ns	ns	ns	ns
C.V.	17.7	12.7	8.1	6.6	9.7	10.8	4.7

*Norland received 200# N/A
Russets received 300# N/A

Table 2. The effect of three forms of nitrogen on soil pH of two varieties of irrigated * potatoes (Becker Farm, 1977, 1978 and 1979).

Treatment**	Norland				Russets			
	Spring 1977	Fall 1977	Fall 1978	Fall 1979	Spring 1977	Fall 1977	Fall 1978	Fall 1979
	Soil pH							
Check	6.3	6.4	6.5	6.2	6.3	6.4	6.3	6.4
Ammonium nitrate	6.0	6.2	5.9	5.7	6.0	5.9	5.9	6.0
Urea	6.2	6.4	6.0	5.6	6.3	6.1	6.0	6.1
Ammonium sulfate	6.1	5.8	5.6	5.3	6.1	5.9	5.3	5.5
Significance	ns	**	**	**	ns	**	**	**
BLSD (.01)		.2	.3	.3		.2	.2	.2

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

**Norland received 200# N/A.
Russet Burbank area received 300# N/A until 1979 when rye was grown; no Russets grown in 1979; only 100 pounds of N added in 1979 on the rye plots.

1842

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, or about 100 pounds per acre of S.

No serious scab problem on the tubers in these plots was observed in 1978 or 1979.

MICRONUTRIENT TESTS ON ALFALFA

Becker, MN 1979

C.J. Overdahl and Jerome Lensing

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 to 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.

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 will be added to all plots in 1980.

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

There is evidence that without the gypsum treatments sulfur would be inadequate. There appears to be no micronutrient response. In 1980 all micronutrients and sulfur will be reapplied.

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

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

Micronutrient Treatments per acre	1978	Alfalfa yields tons/acre 1979 1st cut	2nd cut	3rd cut	Total
None	3.68	1.51	1.07	.82	3.40
Mo 4 oz	3.50	1.34	.96	.79	3.09
B 2 lbs	3.57	1.33	.94	.87	3.13
Cu 10 lbs	3.68	1.41	1.08	.81	3.30
Zn 10 lbs	3.56	1.42	1.08	.83	3.33
Fe 0.6 lbs	3.57	1.39	1.06	.80	3.25
Mn 10 lbs	3.56	1.31	.95	.80	3.05
"Shot-gun" all above	3.57	1.28	.93	.88	3.09
no sulfur	3.38	1.58	1.21	.82	3.60
Significance	ns	ns	+	ns	ns
BLSD (.05)	-	-	.18	-	-

Table 2. Alflafa yields from micronutrient treatments in 1978 and 1979. Becker, MN. Irrigated plots.

Micronutrient Treatments per acre	1978	Alfalfa yields tons/acre 1979 1st cut	2nd cut	3rd cut	Total
None	3.95	2.21	2.05	.89	5.15
Mo 4 oz	4.35	2.16	2.19	.98	5.33
B 2 lbs	4.21	2.12	2.09	.97	5.18
Cu 10 lbs	4.16	2.17	2.08	.96	5.21
Zn 10 lbs	3.95	1.96	2.10	.96	5.02
Fe 0.6 lbs	4.54	2.04	1.94	.96	4.94
Mn 10 lbs	4.17	2.14	2.06	1.01	5.21
"Shot-gun" all above	4.25	2.13	2.16	.96	5.25
no sulfur	4.12	1.48	1.93	.88	4.29
Significance	ns	**	ns	ns	**
BLSD (.05)	-	.22	-	-	.36
W/o no-sulfur trt					
Significance		ns	ns	ns	ns
BLSD (.05)		-	-	-	-

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 these 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 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 macro nutrient treatments were established in a randomized complete block design with either four or eight replications. Rates and types of fertilizer applied included: 5 lbs. of copper/A as $Cu(NO_3)_2$, 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 $MnCl_2$. All treatments were applied as preplant broadcast and incorporated treatments. Application of material was made to exactly the same plot area as was applied in 1978. The corn and potato areas were rotated in 1979 so corn was planted into the 1978 potato area (eight 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 3½ lbs./A of Eptam (46 gal./A) incorporated for weed control. Fertilizer treatments were applied, incorporated by discing and the potatoes planted on April 27 and 28th. Norlands were planted in nine inch spacings utilizing 36 inch rows, while Russet Burbanks were planted in 12" spacings with the same row width. At the time of planting, starter was used at the rate of 1200 lbs./A of 8-10-30 and an insecticide, Temik 15G banded at 14 lbs./A. Lorox herbicide was applied on May 17th at 2 lbs./A (46 gal/A spray) for additional weed control. Sidedressing treatments of nitrogen were made on June 4 (230 #/A of 34-0-0) and on June 19th (200 lbs./A of 34-0-0), along with hilling at the last sidedressing. Samples of the youngest mature potato leaves were obtained 79 days after planting for nutrient composition. Several hail storms during the 1979 growing season damaged both varieties. To minimize disease problems, a system of spraying with either Sevin and Bravo or Thiodan and Bravo was started on July 3 and continued through August 3 at approximately 7-11 day intervals. The Norland potatoes were harvested on September 5 and and the Russet Burbanks on October 19th. Irrigation water was applied during the period of June 15 through August 20th with a total addition of 6.55 inches. Precipitation during the period of May-August was 22.02 inches and May-September was 23.01 inches.

Utilizing the 1978 potato experimental area, eight 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 May 7th. 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 a spray application of Lasso (2 lbs. ai/A). Sidedressing applications of nitrogen were made on June 5 (230 lbs./A of 34-0-0) and July 5 (300 lbs./A of 34-0-0) for a total addition of 233 lbs. of N/A for the season. In addition to the 23.0 inches of precipitation received during the growing season an additional 6.55 inches was added through irrigation during the period of June 15th through August 20th.

GENERAL RESULTS

Preliminary soil tests from the experimental area would suggest that large yield response due to the addition of the nutrient elements under investigation would not be anticipated. As expected, no significant yield increases were obtained with either Norland or Russett Burbank potatoes as well as with corn. Yield levels were good considering the hail damage and the poor growing season that was encountered in 1979. In all cases, nutrient composition of the plant tissue appeared to be adequate for good plant growth.

Table 1. Influence of micronutrient fertilization (also Mg and S) on tuber yield and nutrient concentration of the youngest mature leaves 79 days following planting for Norland and Russet Burbank potatoes.

Treatment	Tuber Yield	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
		Norland Potatoes									
		Leaf Concentration									
	cwt/A	%				ppm					
Control	379	.41	6.33	1.46	0.50	45	80	197	12	4	38
Cu	370	.38	6.20	1.52	0.47	36	66	175	9	2	37
B	383	.39	6.60	1.56	0.49	49	94	216	15	6	46
S	374	.41	6.19	1.42	0.45	37	78	181	12	5	38
Mg	379	.42	5.58	1.42	0.71	42	101	132	20	13	35
Zn	374	.42	6.68	1.55	0.58	39	69	201	11	4	37
Mn	361	.43	6.31	1.56	0.59	46	86	160	12	4	38
Signif.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	**
BLSD(.05)	-	-	-	-	-	-	-	-	-	-	3
		Russet Burbank Potatoes									
Control	388	.39	5.88	0.74	0.56	56	89	191	8	3	32
Cu	389	.40	5.50	0.70	0.51	41	76	165	10	4	30
B	426	.41	5.60	0.30	0.57	49	86	187	9	5	34
S	394	.38	5.81	0.49	0.49	47	82	176	9	3	31
Mg	382	.38	5.73	0.32	0.73	49	99	152	16	9	30
Zn	395	.40	5.53	0.32	0.62	40	78	178	10	4	32
Mn	386	.40	5.69	0.52	0.60	113	149	168	12	5	32
Signif.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)	-	-	-	-	-	-	-	-	-	-	-

Table 2. Influence of micronutrient fertilization (also Mg and S) on Leaf N composition, Harvest grain, Total dry matter production, and nitrogen utilization of corn under irrigation.

	Leaf	Harvest Grain			Dry Matter Production							
					Grain			Stover			Total	
Treatments	N	Yield	N Content	N Removal	Yield	N Content	N Removal	Yield	N Content	N Removal	Yield	N Removal
	%	bu/A	%	#/A	T/A	%	#/A	T/A	%	#/A	T/A	#/A
Control	2.95	170.1	1.30	104.7	3.82	1.24	94.6	3.46	0.64	44.2	7.27	138.8
Cu	2.89	168.3	1.27	101.1	3.94	1.25	98.7	3.48	0.61	42.4	7.43	141.1
B	2.93	163.4	1.30	100.7	3.96	1.25	98.8	3.63	0.66	47.9	7.49	146.7
S	2.96	168.0	1.27	101.6	3.98	1.28	101.8	3.63	0.66	47.9	7.61	149.7
Mg	2.83	167.2	1.29	102.3	3.60	1.23	88.7	3.31	0.66	43.6	6.91	132.4
Zn	2.84	173.5	1.32	108.1	3.82	1.24	94.6	3.39	0.66	44.8	7.21	139.5
Mn	2.90	164.1	1.28	99.0	3.91	1.25	97.4	3.57	0.63	44.5	7.47	141.9
Signif.	NS	NS	NS	NS	NS	NS	*	+	NS	NS	+	*
BLSD(.05)	-	-	-	-	-	-	8.7	0.23	-	-	0.47	11.8

INFLUENCE OF NITROGEN FORM, NITRIFICATION INHIBITORS, AND TREATMENT INCORPORATION ON YIELDS AND NITROGEN UTILIZATION OF CORN UNDER IRRIGATION

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

A number of nitrogen management alternatives are available for the corn producer under irrigation. Producers in this situation must be concerned not only with rates of nitrogen application, but also must be prepared to consider timing of nitrogen application, as well as nitrogen form and method of application. 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 application at some point during the growing season to many small applications which may be facilitated through the irrigation water. With such management systems, a variety of fertilizer nitrogen forms may be utilized. Utilization of nitrification inhibitors under such diverse systems creates a number of questions related to the management of nitrification inhibitors. To investigate some of the concerns related to nitrification inhibitor management, a trial was established at the Sand Plains Research Farm near Becker, MN. with the following objectives: 1) to compare the use of urea and 28% nitrogen solutions under irrigation; 2) to evaluate the use of N-Serve (Dow Chemical) and Dwell (Terrazole-Olin Corporation) with different nitrogen forms; 3) to determine the impact of surface applied and incorporated combinations of the previous treatments; and 4) to compare nitrification inhibitors applied with the fertilizer or as separate applications following broadcast fertilizer applications.

Experimental Procedures

A total of 12 main treatments were replicated four times and arranged in a split block design to generate 24 treatment comparisons. Ten of the main treatments consisted of two nitrogen forms (urea and 28% nitrogen solution) with three nitrification inhibitor treatments (none, N-Serve-0.5 #ai/A, and Dwell-Terrazole-0.5 #ai/A). In the above treatments, nitrification inhibitors were applied as coatings or with the fertilizer on four main treatments, or had no nitrification inhibitor applied with the fertilizer on two of the main treatments. Two additional main treatments were added which had each of the nitrification inhibitors applied without the addition of fertilizer nitrogen. Each main plot was split to provide an incorporated (discing immediately after application) and a non-incorporated comparison. All treatments except the latter two main treatments received a total of 150 #N/A as a spring preplant application. The experimental area had been previously fertilized with 325 #/A of K-Mg SO_4(0-0-22) and 300 #/A of 0-0-60 and incorporated by plowing. Treatment applications were made on May 1, and areas requiring incorporation were disced immediately after application. Corn (Pioneer 3901 - 100 day R.M.) was planted into the experimental area on May 7 in 30" rows at a population of 30, 700 seeds/A. Starter fertilizer was applied at the rate of 165 #/A of 8-10-30. A tank mix of Lasso (1½ #ai/A) and Atrazine (1½ #ai/A) was applied on May 7 for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 31, dried and analyzed for Kjeldahl nitrogen. Dry matter production and total grain yield was determined on September 18-19 by harvesting three rows 20' long. Ears were separated from the stalks, field weights obtained and samples removed for moisture and nitrogen determination. Corn grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 15 and continued through August 15 with a total of 5.75 inches of water being applied through irrigation. An additional 22.89 inches of water were obtained during the growing season through rainfall. The corn growing conditions were significantly affected by three hail storms which took place on June 17, 27, and July 10. The storm on June 27 was very severe coming at approximately the 12-13 leaf stage. Damage was estimated at 100% leaf loss and a stand reduction of 15-20%.

General Results

As was mentioned previously to this, hail had a substantial impact on the yields that were obtained in 1979 from this experimental trial. For this reason care should be utilized in interpreting the results which were obtained.

The yield results and nitrogen utilization parameters of the treatments are presented in Tables 1 and 2. In general there was very little difference in yield due to nitrogen form, unlike that which was obtained in 1978. Incorporation of the fertilizer materials without nitrification inhibitors had no influence upon yields and nitrogen utilization. Substantial yield increases were obtained with the use of both nitrification inhibitors (Dwell and N-Serve), but only if incorporation of the treatments was conducted shortly after application. The nitrification inhibitors appeared to be at least equally effective regardless of whether the inhibitor was applied simultaneously (coating onto urea, mixed with 28% N Soln) or was applied in separate applications, (broadcast fertilizer followed by spray-on and disc-in) as long as the treatments were incorporated. Application of nitrification inhibitors without fertilizer nitrogen resulted in very little yield increase and should not be considered as a viable practice. Management of nitrification inhibitor applications appears to be another nitrogen management parameter that the irrigated corn producer must take into consideration.

Table 2. Influence of nitrogen form, nitrification inhibitor, and treatment incorporation on nitrogen content and nitrogen removal by irrigated corn. Becker, 1979.

Treatments			N Content		N Removal		
N Form	Inhibitor	Incorp.	Grain	Stover	Grain	Stover	Total
			%		#/A		
N Form X Inhibitor							
Urea	-	-	1.02	0.51	45.8	15.5	61.3
Urea	N-S(Fert.)	-	1.02	0.47	47.9	14.2	62.1
Urea	Dwell(Fert.)	-	1.04	0.46	52.4	14.7	67.1
Urea	N-S	-	1.02	0.50	47.9	14.1	62.0
Urea	Dwell	-	1.01	0.56	51.1	18.9	70.0
28%	-	-	0.98	0.51	44.0	13.9	57.9
28%	N-S(Fert.)	-	0.98	0.48	44.3	13.1	57.4
28%	Dwell(Fert.)	-	1.02	0.46	49.5	14.2	63.7
28%	N-S	-	1.06	0.48	56.6	15.6	72.2
28%	Dwell	-	1.04	0.46	48.1	13.6	61.7
-	N-S	-	0.96	0.48	24.3	5.6	29.9
-	Dwell	-	0.97	0.48	24.9	6.4	31.3
Significance			+	NS	**	**	**
BLSD(.05)			0.07	-	9.5	5.1	14.2
Incorporation							
-	-	No	0.99	0.48	41.3	12.1	53.4
-	-	Yes	1.02	0.50	48.1	14.6	62.7
Significance			**	+	**	**	**
BLSD(.05)			0.02	0.02	2.0	1.0	2.4
N Form X Inhibitor X Incorp.							
Urea	-	No	0.98	0.46	44.5	14.3	55.8
Urea	-	Yes	1.05	0.55	47.0	16.7	63.7
Urea	N-S(Fert.)	No	0.98	0.45	44.3	11.5	55.8
Urea	N-S(Fert.)	Yes	1.05	0.49	51.4	16.9	68.3
Urea	Dwell(Fert.)	No	1.02	0.43	48.2	12.4	60.0
Urea	Dwell(Fert.)	Yes	1.07	0.50	56.5	17.0	73.5
Urea	N-S	No	0.95	0.49	36.4	11.6	48.0
Urea	N-S	Yes	1.08	0.51	59.4	16.6	76.0
Urea	Dwell	No	1.00	0.56	44.2	17.3	61.5
Urea	Dwell	Yes	1.02	0.54	57.9	20.5	78.4
28%	-	No	1.03	0.54	47.7	15.6	78.3
28%	-	Yes	0.93	0.48	40.4	12.2	52.6
28%	N-S(Fert.)	No	1.00	0.45	41.1	11.1	52.2
28%	N-S(Fert.)	Yes	0.96	0.50	47.6	15.2	62.8
28%	Dwell(Fert.)	No	1.01	0.41	49.2	12.7	61.9
28%	Dwell(Fert.)	Yes	1.04	0.51	49.7	15.7	65.4
28%	N-S	No	1.04	0.48	50.5	14.6	65.1
28%	N-S	Yes	1.08	0.47	62.7	16.5	79.2
28%	Dwell	No	1.02	0.44	44.5	13.0	57.5
28%	Dwell	Yes	1.06	0.48	51.6	14.3	65.9
-	N-S	No	0.93	0.50	21.9	4.4	26.3
-	N-S	Yes	0.98	0.46	26.6	6.9	33.5
-	Dwell	No	0.98	0.48	23.2	6.1	29.3
-	Dwell	Yes	0.96	0.48	26.6	6.8	33.4
Significance			**	NS	**	+	**
BLSD(.05)			0.07	-	6.8	3.7	8.1

Table 1. Influence of nitrogen form, nitrification inhibitor, and treatment incorporation on leaf N content, grain yield, and dry matter production of irrigated corn - Becker, 1979.

Treatments					Dry Matter Production		
N Form	Inhibitor	Incorp.	Leaf N	Grain Yield	Grain	Stover	Total
			%	bu/A	T/A		
N Form X Inhibitor							
Urea	-	-	2.36	93.7	2.22	1.49	3.70
Urea	N-S(Fert.)	-	2.61	99.3	2.35	1.48	3.84
Urea	Dwell(Fert.)	-	2.59	106.0	2.51	1.57	4.08
Urea	N-S	-	2.47	98.5	2.33	1.41	3.74
Urea	Dwell	-	2.64	106.1	2.51	1.71	4.22
28%	-	-	2.66	94.8	2.24	1.36	3.60
28%	N-S(Fert.)	-	2.41	95.6	2.26	1.37	3.63
28%	Dwell(Fert.)	-	2.32	101.8	2.41	1.53	3.94
28%	N-S	-	2.68	112.7	2.67	1.62	4.29
28%	Dwell	-	2.65	97.3	2.30	1.46	3.76
-	N-S	-	1.71	53.5	1.27	0.58	1.84
-	Dwell	-	1.65	54.2	1.28	0.67	1.95
Significance			**	**	**	**	**
BLSD(.05)			0.27	15.8	0.37	0.33	0.68
Incorporation							
-	-	No	2.28	87.1	2.06	1.26	3.32
-	-	Yes	2.51	98.5	2.33	1.45	3.78
Significance			**	**	**	**	**
BLSD(.05)			0.09	3.5	0.08	0.06	0.11
N Form X Inhibitor X Incorp.							
Urea	-	No	2.36	93.5	2.12	1.49	3.70
Urea	-	Yes	2.37	93.9	2.22	1.49	3.71
Urea	N-S(Fert.)	No	2.43	95.1	2.25	1.28	3.53
Urea	N-S(Fert.)	Yes	2.79	103.5	2.45	1.69	4.14
Urea	Dwell(Fert.)	No	2.46	100.3	2.37	1.44	3.81
Urea	Dwell(Fert.)	Yes	2.72	111.8	2.64	1.70	3.35
Urea	N-S	No	2.16	80.7	1.91	1.18	3.10
Urea	N-S	Yes	2.78	116.2	2.75	1.63	4.38
Urea	Dwell	No	2.49	93.0	2.20	1.54	3.74
Urea	Dwell	Yes	2.79	119.2	2.82	1.88	4.70
28%	-	No	2.79	98.2	2.32	1.45	3.77
28%	-	Yes	2.52	91.4	2.16	1.27	3.44
28%	N-S(Fert.)	No	2.21	86.9	2.06	1.23	3.28
28%	N-S(Fert.)	Yes	2.60	104.3	2.47	1.52	3.98
28%	Dwell(Fert.)	No	2.16	103.3	2.44	1.54	3.98
28%	Dwell(Fert.)	Yes	2.47	100.4	2.38	1.52	3.89
28%	N-S	No	2.56	102.6	2.43	1.50	3.93
28%	N-S	Yes	2.80	122.8	2.91	1.74	4.65
28%	Dwell	No	2.37	91.9	2.17	1.45	3.62
28%	Dwell	Yes	2.93	102.6	2.43	1.48	3.91
-	N-S	No	1.70	49.8	1.18	0.43	1.60
-	N-S	Yes	1.73	57.2	1.35	0.72	2.08
-	Dwell	No	1.67	50.1	1.18	0.64	1.82
-	Dwell	Yes	1.62	58.4	1.38	0.71	2.09
Significance			*	**	**	**	**
BLSD(.05)			0.36	12.3	0.29	0.20	0.39

INFLUENCE OF NITROGEN RATE, TIMING OF NITROGEN APPLICATION AND USE OF NITRIFICATION INHIBITORS FOR IRRIGATED CORN PRODUCTION - Becker, 1979

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

Nitrogen management on the coarse textured irrigated soils of Minnesota is a prime 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. 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 applications through the irrigation system or as late sidedressing treatments. These management alternatives often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. Commercial availability of chemical additives known as nitrification inhibitors also offer some potential in minimizing nitrogen losses and may add flexibility into the overall nitrogen management program. A new trial was established in 1979 to evaluate the significance of nitrogen rates, timing of nitrogen application and the use of nitrification inhibitors.

Experimental Procedures

An experiment consisting of 33 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 three times of nitrogen application (preplant, 8 leaf and 12-leaf) were utilized. Also included in the experimental treatments were a control, application of the three nitrogen rates without inhibitors as split applications during the growing season, along with nitrogen application rates of 75 and 150 #N/A applied as single treatments at tasseling. All nitrogen treatments were applied as urea and all nitrification inhibitor treatments were applied at rates of 0.5 #ai/A as coatings onto the urea. All inhibitor treatments were incorporated either by discing in the preplant applications or by utilizing the irrigation water with the later applications. Nitrogen application were made at preplanting (May 1), at the 8-leaf stage of corn growth (June 15), at the 12-leaf growth stage (July 19), and at tasseling (July 31). Split nitrogen application treatments were applied 1/6 at preplant, 1/6 at the 8-leaf stage, 3/6 at the 12-leaf stage, and 1/6 at tasseling. The soil type was a Hubbard coarse sand with approximately 2½% organic matter.

Prior to planting broadcast applications of Potassium-Magnesium Sulfate (325 #/A 0-0-22) and Potassium (300 #/A 0-0-60) were made and incorporated by plowing. Corn (Pioneer 3901-100 day R.M.) was planted on May 7th in 30" rows at a population of 30, 700 seeds/A. Starter fertilizer was applied at the rate of 165 #/A of 8-10-30. A tank mix of Lasso (1½ #ai/A) and Atrazine (1½ #ai/A) was applied on May 7 for weed control.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 31, dried and analyzed for Kjeldahl nitrogen. Dry matter production and total grain yield was determined on September 18-19 by harvesting three rows 20' long. Ears were separated from the stalks, field weights obtained and samples removed for moisture and nitrogen determination. Corn grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 15 and continued through August 15 with a total of 5.75 inches of water being applied through irrigation. An additional 22.89 inches of water was obtained during the growing season through rainfall. The corn growing conditions were significantly affected by three hail storms which took place on June 17, 27 and July 10. The storm on June 27 was very severe coming at approximately the 12-13 leaf stage. Damage was estimated at 100% leaf loss and a stand reduction of 15-20%.

General Results

As was mentioned previous to this, hail had a substantial impact on the yields that were obtained in 1979 from the experimental trial. For this reason care should be utilized in interpreting the results which were obtained. The hail storms set the crop back considerably, so the dates associated with the timing of nitrogen applications with crop growth stage may vary considerably when compared to a similar year which did not have hail.

The yield results and nitrogen utilization parameters of the treatments are presented in tables 1 and 2. The yields obtained ranged from 60 to 127 bu/A. The hail appeared to depress the upper yields rather than the lower yields (compared to previous years). Nitrogen losses associated with the early preplant applications of nitrogen fertilizer were very severe at this location in 1979. Yield increases of less than 20 bu/A obtained with 225#N/A as compared with zero N would suggest that nitrogen fertilizer losses as high as 80-90% probably occurred. The use of nitrification inhibitors with these early nitrogen fertilizer applications resulted in yield increases of 30-40 bu/A at all of the nitrogen application rates utilized. Data would suggest that the nitrification inhibitors both N-Serve and D-Well were effective in minimizing nitrogen losses, but did not stop the losses.

Applications of nitrogen at the 8-leaf stage also minimized nitrogen losses and yield due to the utilization of a nitrification inhibitor were not apparent. It should also be remembered that because of the hail and cold spring these timing treatments were 2-3 weeks later than normal. There was no advantage to the use of a nitrification inhibitor with the late nitrogen application (12-leaf). It would appear that nitrogen applications should have been made prior to the 12-leaf stage and that the nitrification inhibitors reduced yields when used with this late application.

Split nitrogen applications were effective in maximizing yields, although early nitrogen treatments with the inhibitors also gave comparable results. Yield responses were obtained to nitrogen applied as late as tasseling. These responses were, however, severly restricted and nitrogen management programs should be avoided which might result in single nitrogen applications this late into the season.

Table 1. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on Leaf N content, grain yield and dry matter production of irrigated corn. Becker - 1979.

Treatments			Leaf	Grain	Dry Matter Production		
N Rate	Inhibitor	Appl. Time	N	Yield	Grain	Stover	Total
#/A			%	bu/A	T/A		
0	-	-	1.96	67.7	1.60	.69	2.39
75	0	Split	3.04	113.8	2.69	1.29	3.98
75	0	ppl	1.76	60.4	1.43	.78	2.21
75	0	8-leaf	2.85	104.8	2.48	1.31	3.79
75	0	12-leaf	3.06	102.8	2.43	1.25	3.68
75	Dwell	ppl	2.20	94.3	2.23	1.26	3.49
75	Dwell	8-leaf	2.66	94.5	2.23	1.24	3.47
75	Dwell	12-leaf	3.08	103.6	2.45	1.15	3.60
75	N-S	ppl	2.47	93.6	2.22	1.21	3.43
75	N-S	8-leaf	2.95	110.0	2.60	1.39	4.00
75	N-S	12-leaf	3.10	105.4	2.49	1.20	3.69
150	0	Split	3.13	113.3	2.68	1.52	4.20
150	0	ppl	2.01	84.0	1.99	1.15	3.14
150	0	8-leaf	2.93	113.8	2.69	1.45	4.14
150	0	12-leaf	3.20	111.2	2.63	1.27	3.90
150	Dwell	ppl	2.83	119.3	2.82	1.60	4.42
150	Dwell	8-leaf	3.19	119.7	2.83	1.67	4.50
150	Dwell	12-leaf	3.13	108.2	2.56	1.33	3.89
150	N-S	ppl	2.88	114.5	2.71	1.65	4.36
150	N-S	8-leaf	3.34	112.3	2.66	1.55	4.20
150	N-S	12-leaf	3.15	109.3	2.59	1.35	3.94
225	0	Split	3.18	124.8	2.95	1.66	4.61
225	0	ppl	2.40	85.8	2.03	1.36	3.39
225	0	8-leaf	3.20	112.9	2.67	1.49	4.16
225	0	12-leaf	3.19	94.0	2.22	1.16	3.38
225	Dwell	ppl	3.18	120.6	2.85	1.97	4.82
225	Dwell	8-leaf	3.29	115.4	2.73	1.67	4.40
225	Dwell	12-leaf	3.23	102.2	2.42	1.27	3.69
225	N-S	ppl	3.02	127.3	3.01	1.80	4.82
225	N-S	8-leaf	3.38	112.9	2.67	1.68	4.35
225	N-S	12-leaf	3.22	107.9	2.55	1.19	3.74
75	0	Tassel	2.18	83.7	1.98	1.05	3.03
150	0	Tassel	2.41	89.8	2.12	0.97	3.10
Significance			**	**	**	**	**
BLSD(.05)			0.29	10.5	0.25	0.22	0.39
Factorial Arrangement (Excludes control & tassel treatments)							
N Rate - #/A							
75			2.68	96.6	2.29	1.20	3.48
150			2.96	110.3	2.61	1.45	4.06
225			3.13	108.8	2.57	1.51	4.08
Significance			**	**	**	**	**
BLSD(.05)			0.10	3.5	0.02	0.08	0.13
Nitrification Inhibitor							
None			2.73	96.6	2.29	1.25	3.53
Dwell			2.98	108.6	2.57	1.46	4.03
N-Serve			3.06	110.4	2.61	1.45	4.06
Significance			**	**	**	**	**
BLSD(.05)			0.10	3.5	0.08	0.08	0.13
Time of Appl.							
Preplant			2.53	100.0	2.37	1.42	3.79
8-leaf			3.09	110.7	2.62	1.49	4.11
12-leaf			3.15	105.0	2.48	1.24	3.72
Significance			**	**	**	**	**
BLSD(.05)			0.10	3.6	0.02	0.08	0.13
Factorial Arrangement - 75 and 150 #N/A only							
Time of Application							
Split			3.09	113.6	2.68	1.40	4.09
Preplant			1.88	72.2	1.71	0.96	2.67
8-leaf			2.89	109.3	2.59	1.38	3.97
12-leaf			3.13	107.0	2.53	1.26	3.79
Tassel			2.29	86.8	2.05	1.01	3.06
Significance			**	**	**	**	**
BLSD(.05)			0.22	9.3	0.22	0.14	0.32

Table 2. Influence of nitrogen rate, timing of nitrogen application and use of nitrification inhibitors on grain N content and nitrogen removal of irrigated corn. Becker - 1979.

Treatments			N Content		N Removal		
N Rate	Inhibitor	Appl. Time	Grain	Stover	Grain	Stover	Total
#/A			%		#/A		
0	-	-	1.13	0.54	36.0	7.1	43.1
75	0	Split	1.24	0.65	66.6	16.8	83.4
75	0	ppl	1.05	0.47	30.0	7.2	37.2
75	0	8-leaf	1.24	0.53	61.6	14.0	75.6
75	0	12-leaf	1.28	0.66	62.5	16.4	78.9
75	Dwell	ppl	1.01	0.52	45.2	12.9	58.1
75	Dwell	8-leaf	1.12	0.52	50.3	12.8	63.1
75	Dwell	12-leaf	1.30	0.63	63.6	14.6	78.2
75	N-S	ppl	1.05	0.56	46.5	13.5	60.0
75	N-S	8-leaf	1.16	0.54	60.6	15.0	75.6
75	N-S	12-leaf	1.22	0.61	60.8	14.7	75.5
150	0	Split	1.29	0.65	69.5	19.6	89.1
150	0	ppl	1.08	0.46	43.1	10.4	53.5
150	0	8-leaf	1.20	0.54	64.5	15.7	80.2
150	0	12-leaf	1.30	0.79	68.7	20.1	88.8
150	Dwell	ppl	1.16	0.50	65.2	16.1	81.3
150	Dwell	8-leaf	1.28	0.58	72.7	19.5	92.2
150	Dwell	12-leaf	1.26	0.64	64.5	17.3	81.8
150	N-S	ppl	1.16	0.65	62.6	21.6	84.2
150	N-S	8-leaf	1.23	0.72	65.4	22.3	87.7
150	N-S	12-leaf	1.31	0.76	67.8	20.5	88.3
225	0	Split	1.34	0.69	78.9	23.1	102.0
225	0	ppl	1.09	0.46	44.7	13.0	57.7
225	0	8-leaf	1.30	0.64	69.5	18.9	88.4
225	0	12-leaf	1.34	0.72	59.7	16.7	76.4
225	Dwell	ppl	1.28	0.60	73.2	23.6	96.8
225	Dwell	8-leaf	1.35	0.65	73.6	21.7	95.3
225	Dwell	12-leaf	1.29	0.73	62.6	18.5	81.1
225	N-S	ppl	1.18	0.64	71.1	23.2	94.3
225	N-S	8-leaf	1.32	0.62	70.7	20.7	91.4
225	N-S	12-leaf	1.25	0.67	63.8	15.9	79.7
75	0	Tassel	1.26	0.71	50.2	15.0	65.2
150	0	Tassel	1.25	0.68	53.2	13.2	66.4
Significance			**	**	**	**	**
BLSD(.05)			0.07	0.07	7.7	3.7	9.3
Factorial Arrangement (Excludes control & tassel treatments)							
N-Rate - #/A							
75			1.16	0.56	53.4	13.5	66.9
150			1.22	0.63	63.8	18.2	82.0
225			1.27	0.64	65.4	19.1	84.5
Significance			**	**	**	**	**
BLSD(.05)			0.02	0.02	2.6	1.2	3.1
Nitrification Inhibitor							
None			1.21	0.58	56.0	14.7	70.7
Dwell			1.23	0.60	63.4	17.4	80.8
N-Serve			1.21	0.64	63.2	18.6	81.8
Significance			NS	**	**	**	**
BLSD(.05)				0.02	2.6	1.2	3.2
Time of Appl.							
Preplant			1.12	0.54	53.4	15.7	69.2
8-leaf			1.24	0.59	65.4	17.8	83.2
12-leaf			1.28	0.69	63.8	17.2	81.0
Significance			**	**	**	**	**
BLSD(.05)			0.02	0.02	2.6	1.4	3.2
Factorial Arrangement - 75 and 150 #N/A only							
Time of Appl.							
Split			1.26	0.65	68.0	18.2	86.2
Preplant			1.07	0.46	36.5	8.8	45.3
8-leaf			1.22	0.54	63.1	14.8	77.9
12-leaf			1.29	0.72	65.6	18.2	83.8
Tassel			1.26	0.69	51.7	14.1	65.8
Significance			**	**	**	**	**
BLSD(.05)			0.05	0.06	6.5	2.1	7.2

Crookston - 1979 Weather Summary

The 1979 weather will be remembered by many of the Red River Valley residents as an extremely cold winter season followed by a cool spring and nearly normal summer and fall. Three all-time low temperature records were broken, one was equaled, and one all-time high temperature record was set. The annual precipitation for 1979 paralleled the 85-year average for the weather station at Crookston.

January 1 set the trend for the temperatures of the next five months, recording a high of -17°F. and a low of -23°F. During the period of time from January 1 through January 18, the minimum temperatures ranged from -13°F. to -39°F. setting two all-time lows and equaling another all-time low. January 10, 13 and 16 recorded -32, -39 and -31°F. temperatures respectively with January 13 equaling the record set in 1916. The average minimum temperature for January was -19°F., while the average maximum was only 3°F.

February, March, April and May followed the trend set by January with average monthly temperatures 4 to 8°F. below normal. April 6 marked the third all-time low temperature record set in 1979 with a reading of -10°F. The previous low for the date was 8°F. recorded in 1916. Normal temperatures prevailed during the summer and fall of 1979. The winter season so far has been a pleasant surprise with above normal temperatures and below normal precipitation. The average monthly temperature for December was recorded at 21.2°F. which is 10°F. warmer than the long-time average. 1939 is the only year in the history of the weather station with a higher average monthly temperature for the month of December (24.5°F). 1913, 1928 and 1979 all recorded 21.2°F. for December, therefore, 1979 could be considered one of the second warmest Decembers in the history of the weather station.

Reflecting on the precipitation pattern for 1979, six daily precipitation records were surpassed during the year. The precipitation received in February measured three times the amount normally received for this month due partly to a record six inches of snow received on February 23 with a water equivalent of 0.72 inches. April 24th marked the second daily record at Crookston with 1.63 inches of rain recorded in a 24-hour period. The total precipitation for April was nearly 2½ times greater than the 85-year average. The June precipitation was more than one-inch below normal for the month, however, another record daily precipitation amount was recorded June 20 with 1.56 inches of rain amounting to 63% of the June precipitation falling in one 24-hour period.

The total precipitation for July was 1.5 inches above normal due in part to the fifth daily precipitation record recorded in 1979 occurring July 30th with 2.25 inches of rain.

Although November was slightly below normal in regard to precipitation, the final daily precipitation record was set November 1 with .46 inches measured at the Station. Of the 21.02 inches of annual precipitation received in 1979, 62% of the precipitation was received in 8 major rain storms of intensity greater than one-inch.

Precipitation during the 1979 growing season equaled 17.55 inches of moisture which is normal compared to the long-time average of 17.41 inches. The growing season in the Valley initiated May 21, marking the beginning of a 138-day frost-free period culminating October 6 with a minimum temperature of 30°F. The average number of frost-free days for Crookston is 125 days.

The weather during 1979 could be summarized in that old familiar phrase used to describe the weather during March; 1979 roared in like a lion and went out like a lamb.

TABLE 1. Weather summary for 1979 with averages for precipitation and mean temperatures for 1890-1973.

	Precipitation					Mean Temperature	
Month	Snow	Precip.	Rain	Total	1890-1973	1979	1890-1973
	Inches					°F.	
Jan.	7.2	.37	--	.37	.56	-7.8	3.9
Feb.	17.0	1.48	--	1.48	.54	0.0	8.2
Mar.	6.5	.44	.51	.95	.85	19.3	23.0
Apr.	4.5	.22	3.32	3.54	1.53	34.2	41.4
May	2.0	.14	1.90	2.04	2.61	48.7	54.5
June	--	--	2.47	2.47	3.61	64.7	64.5
July	--	--	4.65	4.65	3.13	70.2	69.4
Aug.	--	--	2.31	2.31	2.88	65.1	67.5
Sept.	--	--	.68	.68	2.26	61.2	57.4
Oct.	4.0	.77	1.09	1.86	1.39	44.5	45.4
Nov.	3.5	.16	.46	.62	.76	25.0	26.9
Dec.	1.0	.05	--	.05	.61	21.2	11.5
TOTAL	45.7	3.63	17.39	21.02	20.73	38.5	39.5

EFFECTS OF NITROGEN CARRIER, RATE AND APPLICATION DATE ON SPRING WHEAT AT CROOKSTON - 1979

G.E. Varvel and R.K. Severson

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

Experimental Procedure:

Four nitrogen carriers, 2 rates and 2 application dates were compared. Three of the carriers, urea, UAN solution and ammonium nitrate, were also applied with and without incorporation. To facilitate comparisons, Table 1 includes those treatments where they were incorporated and Table 2 includes those treatments where they were not incorporated, both Tables include the anhydrous ammonia treatments. Application dates were October 19, 1978 and May 14, 1979. Era was planted May 16 and harvested August 27. Whole plant samples taken August 6 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 - 8.1, NO_3-N (0-2') - 50 lb/A, extractable P (Bray P1-10:1) - 41 lb/A and exchangeable K - 200 lb/A.

A randomized complete block design with 4 replications was used.

Results:

Nitrogen carrier rate and application date each had a significant affect on forage N content, N uptake and grain protein (Tables 1 and 2). Significant differences in forage yield were obtained due to carrier, N rate and date of application when the urea, UAN solution and ammonium nitrate were incorporated (Table 1), but only for N rate when they were not incorporated (Table 2). Grain yield was significantly increased by spring application when the treatments were incorporated (Table 1).

Table 2. Effects of nitrogen carrier, rate and application date on yield and nitrogen uptake of spring wheat when the urea, UAN and ammonium nitrate carriers were not incorporated.

Treatment			Forage			Grain	
Carrier	N Rate	Application Time	Yield	Total N	N Uptake	Yield	Protein
	lb/A		lb DM/A	%	lb/A	Bu/A	%
Urea	50	Fall	7273	0.94	68.0	41.4	11.3
(46-0-0)	100	Fall	8298	1.15	95.9	47.8	12.4
	50	Spring	7788	1.19	92.7	47.2	11.8
	100	Spring	8545	1.29	110.2	48.2	13.2
UAN	50	Fall	7036	0.92	64.8	42.5	11.2
Solution	100	Fall	8645	1.23	105.3	46.9	12.1
(28-0-0)	50	Spring	7862	1.03	80.9	46.5	12.2
	100	Spring	8696	1.33	115.7	48.2	13.6
Ammonium	50	Fall	7557	1.22	92.3	44.4	11.7
Nitrate	100	Fall	7760	1.09	84.3	48.4	12.8
(34-0-0)	50	Spring	8785	1.32	115.9	49.7	13.0
	100	Spring	8555	1.29	110.5	47.3	12.9
Anhydrous	50	Fall	8414	1.30	108.9	47.2	12.0
Ammonia	100	Fall	8752	1.30	113.6	43.1	13.3
(82-0-0)	50	Spring	7486	1.28	95.9	45.0	12.4
	100	Spring	8419	1.59	133.6	47.6	13.6
Significance			**	**	**	NS	**
B.L.S.D. (.05)			1000	0.15	18.0		0.9
C.V. (%)			7.9	9.3	13.3	7.6	4.9
Factorial Arrangement							
Carriers							
Urea			7976	1.14	91.7	46.2	12.2
UAN			8060	1.13	91.7	46.0	12.2
Ammonium Nitrate			8164	1.23	100.7	47.5	12.6
Anhydrous Ammonia			8268	1.36	113.0	45.7	12.8
Significance			NS	**	**	NS	**
B.L.S.D. (.05)				0.07	8.9		0.5
N Rate							
50			7775	1.15	89.9	45.5	11.9
100			8459	1.28	108.6	47.2	13.0
Significance			**	**	**	NS	**
B.L.S.D. (.05)			324	0.06	6.7		0.3
Application Date							
Fall			7967	1.14	91.6	45.2	12.1
Spring			8267	1.29	106.9	47.5	12.8
Significance			NS	**	**	**	**
B.L.S.D. (.05)				0.06	6.7	1.8	0.3

Table 1. Effects of nitrogen carrier, rate and application date on yield and nitrogen uptake of spring wheat when the urea, UAN and ammonium nitrate carriers were incorporated.

Treatment			Forage			Grain	
Carrier	N Rate	Application Time	Yield	Total N	N Uptake	Yield	Protein
	lb/A		lb DM/A	%	lb/A	Bu/A	%
Urea (46-0-0)	50	Fall	6555	1.14	74.2	45.9	11.8
	100	Fall	7534	1.15	86.6	44.4	12.5
	50	Spring	7596	1.17	89.0	44.9	12.1
	100	Spring	8356	1.26	105.3	46.1	13.6
UAN Solution (28-0-0)	50	Fall	7375	1.10	81.5	41.0	11.5
	100	Fall	7867	1.24	97.5	47.0	12.9
	50	Spring	7261	1.06	76.7	47.5	11.5
	100	Spring	8611	1.26	109.2	47.5	13.1
Ammonium Nitrate (34-0-0)	50	Fall	7129	1.13	80.5	42.5	12.0
	100	Fall	7435	1.16	85.9	48.0	12.1
	50	Spring	7956	1.32	105.7	45.7	12.9
	100	Spring	7950	1.35	106.8	49.6	13.3
Anhydrous Ammonia (82-0-0)	50	Fall	8414	1.30	108.9	47.2	12.0
	100	Fall	8752	1.30	113.6	43.1	13.3
	50	Spring	7486	1.28	95.9	45.0	12.4
	100	Spring	8419	1.59	133.6	47.6	13.6
Significance			**	**	**	NS	**
B.L.S.D. (.05)			643	0.20	17.5		0.7
C.V. (%)			6.0	10.6	13.0	8.9	4.0
Factorial Arrangement							
Carriers							
Urea			7510	1.18	88.8	45.3	12.5
UAN Solution			7778	1.16	91.2	45.7	12.3
Ammonium Nitrate			7617	1.24	94.7	46.4	12.6
Anhydrous Ammonia			8268	1.36	113.0	45.7	12.8
Significance			**	**	**	NS	*
B.L.S.D. (.05)			318	0.09	8.4		0.4
N Rate							
50			7471	1.19	89.1	44.9	12.0
100			8115	1.29	104.8	46.7	13.0
Significance			**	**	**	NS	**
B.L.S.D. (.05)			237	0.07	6.4		0.3
Application Date							
Fall			7633	1.19	91.1	44.2	12.3
Spring			7954	1.29	102.8	46.7	12.8
Significance			**	**	**	NS	**
B.L.S.D. (.05)			237	0.07	6.4		0.3

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT - 1979

G.E. Varvel and R.K. Severson

The objectives of this study were to determine the effects of application method of nitrogen and phosphorus on forage and grain yield and N and P uptake of spring wheat.

Experimental Procedure:
Treatments used in the study are shown in Table 1. Knifed applications were made at 12" spacings with an anhydrous applicator and broadcast applications were made with a spray rig on May 21. Whole plant samples taken August 7 at soft dough were used to determine forage yield and total nutrient analyses. The trial was harvested on August 27.

Soil test results on samples taken at the start of the study were: pH - 8.2, NO_3-N (0-2') - 66 lb/A, extractable P ($NaHCO_3$) - 7 lb/A and exchangeable K - 251 lb/A.

A randomized complete block design was used.

Results:
Treatments or method did not significantly affect any of the variables (Tables 1 and 2).

Table 1. Effects of nitrogen and phosphorus application methods on grain yield, protein, forage yield and N and P uptake of spring wheat.

Treatment				Grain		Forage		
							Uptake	
Source	N Rate	P_2O_5 Rate	Method	Yield	Protein	Yield	N	P_2O_5
	lb/A	lb/A		Bu/A	%	lb DM/A	- - lb/A - -	
Check	0	0	---	29.0	14.4	6686	101.2	26.6
NH_3	90	0	Knifed	30.4	15.9	6030	80.2	27.9
UAN	90	0	Knifed	34.3	15.1	6268	95.0	25.2
NH_3 + 10-34-0	90	34	Knifed	34.8	15.5	6768	101.5	27.0
NH_3 + 10-34-0	90	102	Knifed	29.8	16.1	6374	91.2	25.4
UAN + 10-34-0	90	102	Knifed	30.6	14.7	5467	74.5	23.7
UAN	90	0	Broadcast	34.0	15.3	6305	94.9	24.6
NH_3 + 10-34-0	90	34	Broadcast	35.8	15.2	6065	91.1	20.4
NH_3 + 10-34-0	90	102	Broadcast	33.4	15.7	5646	82.0	26.5
UAN + 10-34-0	90	102	Broadcast	33.1	15.9	5700	79.6	22.8
Significance				NS	NS	NS	NS	NS
C.V. (%)				18.3	5.5	17.6	23.6	23.9
Method								
Knifed				32.4	15.4	6219	90.6	25.3
Broadcast				34.1	15.5	5929	86.9	23.6
Significance				NS	NS	NS	NS	NS

Table 2. Effect of nitrogen and phosphorus applications on forage analyses at soft dough.

Treatment				Forage Analyses at Soft Dough											
Source	N Rate	P_2O_5 Rate	Method	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	lb/A	lb/A		%					ppm						
Check	0	0	---	1.50	0.17	1.55	0.16	0.20	18	34	50	38	16	2	3
NH_3	90	0	Knifed	1.34	0.20	1.62	0.16	0.21	18	36	33	40	18	2	3
UAN	90	34	Knifed	1.50	0.17	1.66	0.18	0.24	17	37	34	43	20	2	5
NH_3 + 10-34-0	90	34	Knifed	1.51	0.17	1.66	0.21	0.19	21	33	70	41	20	2	5
NH_3 + 10-34-0	90	102	Knifed	1.42	0.17	1.55	0.16	0.21	15	34	30	41	18	2	4
UAN + 10-34-0	90	102	Knifed	1.36	0.20	1.36	0.14	0.21	17	34	58	35	19	2	4
UAN	90	0	Broadcast	1.50	0.17	1.56	0.14	0.19	18	37	129	39	19	2	3
NH_3 + 10-34-0	90	34	Broadcast	1.50	0.15	1.67	0.18	0.23	18	38	23	42	18	2	4
NH_3 + 10-34-0	90	102	Broadcast	1.44	0.20	1.58	0.17	0.23	17	35	131	39	18	2	4
UAN + 10-34-0	90	102	Broadcast	1.39	0.18	1.53	0.16	0.21	17	36	22	44	19	2	4
Significance				NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)				11.2	16.4	20.4	25.3	20.3	26.8	12.6	155.5	16.9	17.9	21.1	40.3

SPRING WHEAT FERTILIZATION - 1979*

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

The objective of these studies was to accumulate additional information about fertilization of spring wheat in northwestern Minnesota.

Experimental Procedure:
Four experiments were conducted. These consisted of 2 phosphorus rate studies, 1 potassium rate study and 1 starter fertilizer study. Three of the experiments were located near Fertile and the other near Blackduck.

Treatments at the Fertile location (Tables 1-3) were applied and the wheat planted on May 23. Whole plant samples taken August 8 were used to determine forage yield and grain was harvested on August 30. Soil test results were: NO_3-N (0-5') - 191 lb/A, extractable P ($NaHCO_3$) - 62 lb/A and exchangeable K - 163 lb/A.

Treatments at the Blackduck location (Table 4) were applied on June 6 and grain was harvested on September 7. Soil test results were: extractable P - 9 lb/A and exchangeable K - 204 lb/A.

A randomized complete block design was used for all studies.

Results:
No significant differences were obtained due to starter fertilizer or phosphorus at the Fertile location (Tables 1 and 2). Potassium concentration in the plant was significantly increased by adding potassium fertilizer (Table 3), but no yield increases were obtained.

A significant increase in yield was obtained due to phosphorus at the Blackduck location (Table 4).

---

*This project was financed through support in part by Minnesota Wheat Council.

Table 1. Effect of starter fertilizer on yield and forage analyses of spring wheat - Fertile location.

Starter Treatment N Rate	Starter Treatment P_2O_5 Rate	Grain Yield	Forage Yield	Forage Analyses N	Forage Analyses P	Forage Analyses K
lb/A	lb/A	Bu/A	lb DM/A	- - - % - - -		
0	0	27.0	5910	1.69	0.31	1.71
10	0	24.0	5490	1.61	0.31	2.04
20	0	30.2	5670	1.86	0.28	1.86
10	34	27.5	5325	1.73	0.33	1.94
20	34	29.4	5400	1.88	0.33	2.02
20	68	27.4	5580	1.80	0.35	1.85
Significance		NS	NS	NS	NS	NS
C.V. (%)		16.0	7.3	10.3	9.5	11.9

Table 2. Effect of phosphorus on yield and forage analyses of spring wheat - Fertile location.

P_2O_5 Rate	Grain Yield	Forage Yield	Forage Analyses P	Forage Analyses K
lb/A	Bu/A	lb DM/A	- - - % - - -	
0	33.6	4890	0.30	1.80
40	33.6	5230	0.31	1.89
80	29.9	5340	0.30	1.84
120	33.5	4995	0.34	2.10
160	33.2	5385	0.32	1.71
200	33.1	5175	0.35	1.81
Significance	NS	NS	NS	NS
C.V. (%)	8.2	8.4	8.0	10.0

Table 3. Effect of potassium on yield and forage analyses of spring wheat - fertile location.

K_2O Rate	Grain Yield	Forage Yield	Forage Analyses P	Forage Analyses K
lb/A	Bu/A	lb DM/A	- - - % - - -	
0	30.2	5475	0.30	1.58
50	31.8	5430	0.31	1.74
100	32.1	5715	0.29	1.71
150	32.8	5640	0.29	1.59
200	35.3	5655	0.29	2.03
250	35.9	5610	0.30	1.86
Significance	NS	NS	NS	*
B.L.S.D.(.05)				0.34
C.V. (%)	12.4	4.9	7.1	11.2

Table 4. Effect of phosphorus on grain yield of spring wheat - Blackduck location.

P_2O_5 Rate	Grain Yield
lb/A	Bu/A
0	25.2
40	26.8
80	29.1
120	28.3
160	27.4
200	31.0
Significance	*
B.L.S.D.(.05)	4.1
C.V. (%)	8.6

Nitrogen Fertilization and Nitrogen Utilization by Fourteen Small Grain Varieties.*

Crookston, MN. - 1979

G.L. Malzer, G. Varvel and R. Busch

The semi-dwarf varieties of hard red spring wheat account for a major portion of the acreage planted to hard red spring wheat in Minnesota. The development of these wheat varieties not only provided improves physical characteristics, but also provided the potential for a plant system which might be capable of responding to higher rates of nitrogen application without lodging. The reasons why some wheat varieties respond more to nitrogen fertilization than others is not well understood but it has been suggested that it may be related to favorable plant characteristics both above and below ground. Trials were established in 1979 to examine some of the difference which exist between wheat varieties, responses to nitrogen fertilization and nitrogen utilization. Existing popular varieties as well as older varieties and experimental varieties were included for comparison in responsiveness to added fertilizer nitrogen as well as to overall nitrogen utilization. Similar trials were conducted at Morris as well as Crookston, MN.

EXPERIMENTAL PROCEDURES

Fourteen varieties of hard red spring wheat were compared at nitrogen application rates of 0, 60, and 120 lbs N/A at the Northwest Experiment Station at Crookston. Nitrogen was applied as a spring application of ammonium nitrate broadcast and incorporated. The treatments were arranged in a split plot design with nitrogen as the main effect and the 14 varieties planted within a uniformly fertilized area. All treatments were replicated four times. Experimental plots were planted into areas 4' x 20' on May 16 utilizing a cone seeder.

Dry matter production was determined at approximately the "soft dough" stage of growth (August 2-3) and samples collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested over a 10 day period from August 14-24 as the grain ripened. The above ground growth (grain plus straw) was removed from the experimental plot and placed in a forced air dryer. After drying, the samples were weighed, thrashed, and the grain re-weighed for yield determination. Straw weight was determined by difference. Samples of both the grain and the straw were collected for determination of nitrogen content and total nitrogen removal. Lodging scores were obtained from the experimental treatments at harvest time. Lodging rankings were made on a 1-5 scale with a rating of one having excellent standing characteristics and a rating of five being flat on the soil surface.

GENERAL RESULTS

In general overall yield responses were obtained up to 60# N/A, (Table 1). Responses of individual varieties to nitrogen application ranged from almost no positive response at all to substantial yield increases up through 120# N/A. Overall yields obtained from the fourteen varities tested ranged from 36-59 bu/A with the top yielding varities being Butte, MN7125, MN70170, Era, and MN7222. Most of the high yielding varieties were also associated with low nitrogen content in the grain (protein).

---

*This project was financed through support in part by Minnesota Wheat Council.

Leaf samples from opposite and below the ear at mid-silking were obtained on July 31, dried and analyzed for Kjeldahl nitrogen. Dry matter production and total grain yield was determined on September 18-19 by harvesting three rows 20' long. Ears were separated from the stalks, field weights obtained and samples removed for moisture and nitrogen determination. Corn grain yields were adjusted to 15.5% moisture.

The irrigation program was started on June 15 and continued through August 15 with a total of 5.75 inches of water being applied through irrigation. An additional 22.89 inches of water was obtained during the growing season through rainfall. The corn growing conditions were significantly affected by three hail storms which took place on June 17, 27, and July 10. The storm on June 27 was very severe coming at approximately the 12-13 leaf stage. Damage was estimated at 100% leaf loss and a stand reduction of 15-20%.

General Results

As was mentioned previously to this, hail had a substantial impact on the yields that were obtained in 1979 from the experimental trial. For this reason, care should be utilized in interpreting the results which were obtained. The hail storms set the crop back considerably, so that dates associated with the timing of nitrogen applications with crop growth stage may vary considerably when compared to a similar year which did not have hail.

The yield results and nitrogen utilization parameters of the treatments are presented in tables 1 and 2. The yields obtained ranged from 60 to 127 bu/A. The hail appeared to depress the upper yields rather than the lower yields (compared to previous years). Nitrogen losses associated with the early preplant applications of nitrogen fertilizer were very severe at this location in 1979. Yield increases of less than 20bu/A obtained with 225 #N/A as compared with zero N would suggest that nitrogen fertilizer losses as high as 80-90 probably occurred. The use of nitrification inhibitors with these early nitrogen fertilizer applications resulted in yield increases of 30-40 bu/A at all of the nitrogen application rates utilized. Data would suggest that the nitrification inhibitors both N-Serve and Dwell were effective in minimizing nitrogen losses, but did not stop the losses.

Applications of nitrogen at the 8-leaf stage also minimized nitrogen losses, but yield increases due to the utilization of a nitrification inhibitor were not apparent. It should also be remembered that because of the hail and cold spring these timing treatments were 2-3 weeks later than normal. There was no advantage to the use of a nitrification inhibitor with the late nitrogen application (12-leaf). It would appear that nitrogen applications should have been made prior to the 12-leaf stage and that the nitrification inhibitors reduced yields when used with this late application.

Split nitrogen applications were effective in maximizing yields, although early nitrogen treatments with the inhibitors also gave comparable results. Yield responses were obtained to nitrogen applied as late as tasseling. These responses were, however, severely restricted and nitrogen management programs should be avoided which might result in single nitrogen applications this late into the season.

Nitrogen content in the grain ranged from 2.26 to 3.01% nitrogen with the lowest nitrogen contents being obtained with MN7222, MN7125, MN70170, and Era. Butte had the highest protein content of the five top yields and ranked intermediate overall. The highest protein contents were obtained with Chris, Coteau, Waldron, Olaf and WS1809.

In addition to generally favorable yield responses to nitrogen application, test weights of the grain were normally depressed with nitrogen fertilization and differences in the lodging scores could be primarily attributed to the variety rather than high nitrogen fertilization.

Nitrogen uptake and utilization was influenced not only by nitrogen treatment but also by the variety planted (Table 2). Certain varieties were capable of utilizing more of the fertilizer nitrogen than others. Likewise there were considerable differences between varieties in nitrogen utilization when no fertilizer nitrogen had been applied. There also appear to be modest differences between varieties in their ability to translocate the nitrogen which is absorbed by the rooting system into the grain. Certain varieties reflected a lower proportion of the total nitrogen taken up still in the straw at harvest. This factor along with the difference in overall nitrogen utilization suggest that improvement in nitrogen utilization can be made with genetic selection.

Table 1. Influence of nitrogen fertilization and variety on yield, N content, test weight, and dodging of 14 hard red spring wheat varieties.

Nitrogen Rate	Variety	Grain Yield	Grain N content	Grain Test wt.	Forage Total Dry Matter	Forage N content	Lodging Score
#/A		bu/A	%	#/bu	T/A		
0	-	44.0	2.70	57.2	2.94	1.30	3.4
60	-	50.2	2.58	56.6	3.53	1.35	3.1
120	-	50.5	2.64	56.4	3.63	1.41	3.3
Significance		**	*	**	**	*	NS
BLSD(.05)		3.6	.08	0.4	0.34	0.06	
-	Coteau	47.2	2.90	56.6	3.81	1.31	3.4
-	WS 1809	41.3	2.75	57.4	2.77	1.41	2.7
-	Era	54.4	2.46	57.5	3.08	1.40	3.4
-	MN 70170	57.4	2.46	56.8	3.41	1.44	2.8
-	Chris	39.5	3.01	56.8	3.19	1.25	4.1
-	James	50.2	2.55	56.8	3.55	1.43	2.8
-	Waldron	45.0	2.86	56.0	3.42	1.30	3.8
-	MN 7125	58.0	2.34	55.7	3.47	1.32	3.1
-	Butte	58.9	2.58	59.6	4.09	1.42	2.3
-	Olaf	43.3	2.86	56.6	3.65	1.40	3.2
-	MN 7222	54.7	2.26	56.5	3.05	1.27	3.8
-	Thatcher	42.0	2.62	56.3	3.47	1.25	3.8
-	Marquis	36.4	2.60	55.9	3.00	1.26	3.5
-	Kitt	47.3	2.72	54.0	3.19	1.49	3.4
Significance		**	**	**	**	**	**
BLSD(.05)		3.6	.08	0.7	0.24	.12	0.7
0	Coteau	45.8	3.01	56.7	3.69	1.22	4.0
0	WS 1809	36.6	2.79	57.9	2.35	1.32	2.2
0	Era	50.7	2.59	57.6	2.93	1.42	4.2
0	MN 70170	56.5	2.40	57.1	3.10	1.34	2.8
0	Chris	36.3	3.27	58.0	2.59	1.38	4.0
0	James	43.9	2.64	56.3	3.09	1.40	3.0
0	Waldron	44.4	2.98	56.4	3.24	1.19	3.5
0	MN 7125	51.6	2.45	57.5	2.63	1.39	3.2
0	Butte	52.0	2.62	59.4	3.43	1.22	2.2
0	Olaf	41.5	2.94	57.0	3.27	1.35	2.8
0	MN 7222	45.6	2.21	58.1	2.42	1.08	4.3
0	Thatcher	39.7	2.61	56.8	2.98	1.32	4.2
0	Marquis	31.5	2.60	56.2	2.75	1.22	3.5
0	Kitt	40.2	2.70	56.0	2.73	1.32	3.5
60	Coteau	50.8	2.86	57.0	4.02	1.44	3.2
60	WS 1809	39.3	2.68	57.5	2.86	1.34	2.5
60	Era	56.1	2.37	58.1	3.38	1.34	3.0
60	MN 70170	56.6	2.52	56.9	3.49	1.53	2.8
60	Chris	40.2	2.96	56.6	3.26	1.20	4.5
60	James	53.0	2.44	57.7	3.72	1.44	2.2
60	Waldron	45.7	2.70	55.8	3.37	1.32	4.0
60	MN 7125	62.0	2.25	55.0	3.61	1.27	3.0
60	Butte	64.7	2.45	59.6	4.60	1.42	2.0
60	Olaf	46.1	2.80	56.4	3.94	1.35	3.3
60	MN 7222	57.0	2.27	55.5	3.04	1.38	3.5
60	Thatcher	43.4	2.60	55.8	3.58	1.14	3.0
60	Marquis	38.5	2.55	56.7	3.24	1.18	3.8
60	Kitt	50.0	2.74	53.3	3.34	1.50	3.0
120	Coteau	45.0	2.84	56.1	3.72	1.27	3.0
120	WS 1809	48.0	2.78	56.9	3.10	1.56	3.2
120	Era	56.4	2.41	56.8	2.92	1.45	3.0
120	MN 70170	59.2	2.45	56.5	3.64	1.44	2.8
120	Chris	42.2	2.81	55.8	3.72	1.17	3.8
120	James	53.6	2.58	56.3	3.84	1.44	3.0
120	Waldron	44.9	2.90	55.6	3.64	1.38	2.8
120	MN 7125	60.4	2.32	54.8	4.17	1.30	3.0
120	Butte	60.0	2.69	59.8	4.24	1.64	2.8
120	Olaf	42.4	2.84	56.4	3.74	1.50	3.5
120	MN 7222	61.4	2.30	55.8	3.69	1.35	3.5
120	Thatcher	42.8	2.64	56.1	3.86	1.28	4.0
120	Marquis	39.1	2.66	54.9	3.02	1.37	3.2
120	Kitt	51.6	2.70	52.8	3.49	1.64	3.8
Significance		NS	**	*	**	**	NS
BLSD(.05)		-	0.19	2.0	0.53	0.24	-

Table 2. Influence of nitrogen fertilization and variety on straw production and nitrogen uptake of forage, straw, and grain of 14 hard red spring wheat varieties.

Nitrogen Rate	Variety	Harvest Straw Dry Matter	Harvest Straw N Content	Nitrogen Removal Forage	Nitrogen Removal Straw	Nitrogen Removal Grain	Nitrogen Removal Grain + Straw
#/A		T/A	%	#/A	#/A	#/A	#/A
0	-	1.84	0.58	76.6	21.5	65.9	87.4
60	-	2.21	0.64	95.3	28.2	71.8	100.0
120	-	2.33	0.72	102.5	33.5	73.6	107.1
Significance		*	*	**	**	*	**
BLSD(.05)		0.31	.09	8.5	5.1	4.5	7.4
-	Coteau	2.43	0.62	100.2	30.0	76.5	106.5
-	WS 1809	1.64	0.64	78.0	21.6	63.5	85.1
-	Era	2.08	0.74	86.7	31.1	74.3	105.4
-	MN 70170	2.22	0.70	98.8	31.7	78.7	110.4
-	Chris	2.35	0.63	78.9	30.0	66.1	96.1
-	James	2.19	0.67	101.6	29.4	71.4	100.8
-	Waldron	2.30	0.62	89.2	28.6	71.8	100.4
-	MN 7125	2.08	0.67	91.3	28.4	75.5	103.9
-	Butte	2.23	0.55	117.8	24.8	84.8	109.6
-	Olaf	2.30	0.62	102.3	28.7	69.0	97.7
-	MN 7222	1.75	0.65	79.1	23.7	69.3	93.0
-	Thatcher	2.15	0.63	86.4	27.3	61.4	88.7
-	Marquis	2.09	0.61	75.0	25.9	52.7	78.6
-	Kitt	2.00	0.67	95.5	26.9	71.3	98.2
Significance		**	**	**	**	**	**
BLSD(.05)		0.16	.06	10.1	4.0	5.6	8.1
0	Coteau	2.30	0.60	90.4	27.5	76.9	104.4
0	WS 1809	1.38	0.51	62.0	14.2	57.1	71.3
0	Era	1.90	0.69	83.3	26.5	73.1	99.6
0	MN 70170	2.01	0.56	84.5	23.0	75.5	98.5
0	Chris	1.95	0.53	71.3	20.9	65.6	86.5
0	James	1.86	0.66	86.5	24.5	64.7	89.2
0	Waldron	2.15	0.62	77.4	26.8	73.7	100.5
0	MN 7125	1.74	0.58	72.9	20.2	70.5	90.7
0	Butte	1.93	0.52	83.5	20.1	76.1	96.2
0	Olaf	2.09	0.60	88.1	25.1	67.8	92.9
0	MN 7222	1.36	0.52	53.9	14.1	56.7	70.8
0	Thatcher	1.81	0.54	78.3	19.5	57.7	77.2
0	Marquis	1.78	0.55	67.3	19.7	45.8	65.5
0	Kitt	1.52	0.60	73.3	18.4	60.7	79.1
60	Coteau	2.51	0.56	116.0	28.0	81.0	109.0
60	WS 1809	1.55	0.65	75.5	20.1	58.6	78.7
60	Era	2.12	0.82	91.2	35.4	74.2	109.6
60	MN 70170	2.27	0.75	106.6	34.2	79.8	114.0
60	Chris	2.40	0.62	78.3	29.8	66.4	96.2
60	James	2.31	0.63	107.4	28.8	72.3	101.1
60	Waldron	2.28	0.56	89.0	25.8	69.0	94.8
60	MN 7125	2.18	0.70	92.1	30.6	78.0	108.6
60	Butte	2.39	0.50	131.0	24.1	88.4	112.5
60	Olaf	2.51	0.58	106.3	29.5	72.0	101.5
60	MN 7222	1.77	0.67	84.1	23.9	72.1	96.0
60	Thatcher	2.27	0.65	82.0	29.7	63.1	92.8
60	Marquis	2.15	0.58	74.9	25.1	54.4	79.5
60	Kitt	2.26	0.66	100.0	29.9	76.3	106.2
120	Coteau	2.47	0.70	94.2	34.3	71.5	105.8
120	WS 1809	1.97	0.76	96.6	30.5	74.8	105.3
120	Era	2.20	0.72	85.5	31.4	75.7	107.1
120	MN 70170	2.40	0.79	105.2	38.1	80.9	119.0
120	Chris	2.71	0.72	87.2	39.3	66.2	105.5
120	James	2.41	0.72	111.0	34.9	77.1	112.0
120	Waldron	2.47	0.68	101.2	33.3	72.6	105.9
120	MN 7125	2.34	0.73	109.1	34.4	78.0	112.4
120	Butte	2.37	0.64	138.9	30.4	89.9	120.3
120	Olaf	2.31	0.69	112.5	31.6	67.3	98.9
120	MN 7222	2.11	0.77	99.4	33.1	79.1	112.2
120	Thatcher	2.37	0.69	98.8	32.8	63.3	96.1
120	Marquis	2.35	0.70	82.7	32.9	57.9	90.8
120	Kitt	2.21	0.74	113.0	32.5	76.8	109.3
Significance		NS	*	*	NS	+	+
BLSD(.05)		-	0.15	25.5	-	13.2	18.7

SOIL TEST LEVELS AS AFFECTED BY DIFFERENT FERTILIZER PROGRAMS 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 affect of different fertilizer programs over a 10-year period on soil test levels in a continuous wheat cropping system. 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 based upon soil test data from the whole plot area were used in 1978. These treatments in subsequent years will be determined by soil test data from those plots on which that treatment was applied the previous year. The treatments used in 1978 are shown in Table 1. All treatments were broadcast and incorporated with a disk on October 31, 1978. Two of the treatments are identical due to an error in application of the P_2O_5. Era wheat was planted May 16 and harvested August 29, 1979. Soil samples were taken October 24, 1979 and analyzed for N, P and K to determine the effects of the 1978 treatments and to determine what the 1979 treatments would be. A randomized complete block design with 4 replications was used. The study is located at the Northwest Experiment Station on a Wheatville loam soil.

Results:

Soil test results from 1978 were: pH - 8.1, NO_3-N (0-5') - 75 lb/A, extractable P - 35 lb/A and exchangeable K - 194 lb/A. These were used as a basis for the 1978 fall treatments.

Forage yield, N content in the forage, N uptake, grain yield, and protein as affected by the treatments are shown in Table 1. Grain yields for all treatments were significantly higher than the check due mainly to the additional N applied. All other variables measured were nonsignificant.

Soil test results from the fall 1979 sampling are shown in Table 2. No differences in NO_3-N or K levels were obtained at any depth. Treatment 5 had a higher P level in the 0-6" depth than the check but no differences were obtained in the 6-12" depth.

---

*This project was financed through support in part by Minnesota Wheat Council

Table 1. Yield and quality of Era wheat as affected by different fertilizer treatments in 1979.

Treatment No.	N	P_2O_5	K_2O	Forage Yield	Total N	N Uptake	Grain Yield	Protein
	------- lb/A --------			lb DM/A	%	lb/A	Bu/A	%
1	0	0	0	6625	1.40	94.1	33.7	13.7
2	70	100	30	6830	1.54	105.2	44.0	14.2
3	70	100	60	7152	1.65	116.3	43.3	15.0
4	100	100	30	6602	1.51	101.5	42.3	14.4
5	70	100	30	7292	1.57	114.2	40.4	14.5
Significance				NS	NS	NS	**	NS
B.L.S.D. (.05)							6.0	
C.V. (%)				11.8	15.6	21.7	9.1	4.4

Table 2. Soil test results from the different treatments after the crop was removed in 1979.

Treatment No.	N	P_2O_5	K_2O	NO_3-N 0-6"	6-12"	12-24"	24-36"	36-48"	P 0-6"	6-12"	K 0-6"	6-12"
	------lb/A----			----------lb/A----------					----lb/A---		---lb/A----	
1	0	0	0	13	13	9	14	15	8	6	173	124
2	70	100	30	11	16	13	19	24	18	7	156	110
3	70	100	60	13	15	14	31	24	22	7	190	115
4	100	100	30	12	16	25	26	13	22	7	164	134
5	70	100	30	14	17	16	21	30	31	5	169	126
Significance				NS	NS	NS	NS	NS	*	NS	NS	NS
B.L.S.D. (.05)									16.2			
C.V. (%)				16.7	24.0	57.2	72.2	41.6	20.2	35.7	11.9	15.1

EFFECTS OF ANHYDROUS AMMONIA ON GERMINATION OF SPRING WHEAT AND BARLEY AT CROOKSTON - 1979

G.E. Varvel and R.K. Severson

The main objective of these studies was to determine the effect of anhydrous ammonia on the germination of spring wheat and barley, and its indirect effect, if any, on yield.

Experimental Procedure:
Treatments in the 2 studies consisted of nitrogen rate and depth of application combinations across which a strip of Era and Morex were seeded at 3 different times. The first seeding was done immediately after all anhydrous treatments were applied on May 25 and the other seedings were done 24 and 48 hours later.

Two stand counts were taken 11 and 18 days after planting. Populations shown in Table 1 are for the latter count. The barley and wheat were harvested August 13 and 29 respectively.

Soil test results from samples taken at the start of the study were: NO_3-N (0-2') - 54 lb/A, extractable P - 42 lb/A and exchangeable K - 191 lb/A.

A split-split block design was used for both studies. They were located on a Wheatville loam soil.

Results:
Results are shown in Table 1 for both studies. The nitrogen rate-depth of application treatment combinations had a significant affect on population in both studies and on plumps and thins in the barley study. The difference in population was probably due to an increased loss of moisture with the deeper application depths. Comparison of means at the different depths of application lends support to this hypothesis. No significant differences in yield or protein were obtained in either study.

Seeding time significantly affected population in both studies, probably due to moisture again, and yield in the wheat study. No other variables were affected by seeding time.

Table 1. Effects of anhydrous ammonia on germination and yield of spring wheat and barley at Crookston.

Treatments		Wheat			Barley				
N Rate	Application Depth	Yield	Protein	Popn.	Yield	Protein	Plumps	Thins	Popn.
lb/A	Inches	Bu/A	%	Plants/A	Bu/A	- - - - -	% - - - -		Plants/A
40	3	41.4	13.6	879,065	60.0	12.0	58.4	6.1	972,840
40	6	40.3	14.1	840,950	61.6	12.5	56.2	6.2	886,627
40	9	39.3	14.0	738,100	54.3	12.0	52.0	7.8	892,072
80	3	39.0	14.0	878,762	60.9	12.4	56.3	5.7	926,104
80	6	38.0	13.9	825,220	56.8	12.2	49.3	7.6	946,976
80	9	37.2	14.6	753,528	58.5	11.9	52.7	7.7	919,751
120	3	37.5	14.0	816,448	60.2	12.2	64.1	6.2	974,655
120	6	32.9	14.7	854,260	58.8	12.5	47.8	8.4	938,809
120	9	33.2	14.3	723,278	56.1	12.3	49.1	8.5	834,900
Significance		NS	NS	**	NS	NS	**	**	**
B.L.S.D.(.05)				14,517			8.4	1.4	23,169
C.V. (%)		19.6	5.5	6.0	11.7	7.4	17.2	22.8	27.6
Seeding Times									
Time 1		41.0		885,720	59.0	12.1	56.2	6.6	999,460
Time 2		37.6		802,432	57.7	12.3	52.8	7.3	905,685
Time 3		34.2		748,385	59.2	12.2	53.0	7.5	859,100
Significance		*	NS	**	NS	NS	NS	NS	**
B.L.S.D.(.05)		3.7		54,189					
C.V. (%)		12.7	4.3	8.6	12.3	13.4	48.4	76.6	5.8
N Rate									
40		40.3	13.9	819,372	58.7	12.2	58.7	6.7	917,180
80		38.1	14.2	819,170	58.8	12.1	52.8	7.0	930,943
120		34.5	14.3	797,995	58.4	12.3	53.6	7.7	916,121
Application Depth									
3	(Inches)	39.3	13.8	858,092	60.4	12.2	59.6	6.0	957,866
6		37.0	14.3	840,143	59.1	12.4	51.1	7.4	924,138
9		36.6	14.3	738,302	56.3	12.1	51.2	8.0	882,241

PHOSPHORUS AND POTASSIUM FERTILIZER RATE STUDIES ON MALTING BARLEY - 1979

G.E. Varvel and R.K. Severson

The objective of this study was to gather data on the phosphorus and potassium fertilizer needs of malting barley in northwestern Minnesota. Results from these studies will be used to aid in improvement of fertilizer recommendations for phosphorus and potassium on malting barley.

Experimental Procedure:

Treatments used in the potassium and phosphorus rate experiments at Fosston are shown in Tables 1 and 2 respectively. The treatments were applied broadcast preplant on May 18, 1979. Blanket applications of 40 lb/A P_2O_5 and 100 lb/A K_2O were broadcast over the potassium and phosphorus experiments respectively. Nitrogen was also applied over both experiments at 100 lb/A. The variety planted was Morex.

Forage yields were taken at soft dough to determine total dry matter production and nutrient content. Grain yield, percent plumps and thins and protein were determined from samples taken at harvest, August 17, 1979.

A randomized complete block design was used for both experiments.

Results:

Soil test results from samples taken on May 18, 1979 were: extractable P ($NaHCO_3$) - 24 lb/A and exchangeable K - 224 lb/A.

No significant differences in grain yield, plumps, thins, protein or forage yield were obtained due to the potassium treatments (Table 1). Significant differences were obtained on some of the nutrient levels in the forage, but no explanation is apparent.

Significant differences in grain and forage yields were obtained due to the phosphorus treatments (Table 2) but no differences were obtained in percent plumps, thins or protein. A significant difference in P levels in the forage was obtained and appears to be consistent with the yields obtained. None of the other nutrient levels in the forage were significantly affected.

Table 1. Effects of different rates of potassium fertilizer on barley at Fosston.

Treatment	Grain				Forage												
						Analyses at Soft Dough											
K_2O Rate	Yield	Plump	Thin	Protein	Yield	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	Bu/A	%	%	%	lbs DM/A	%					ppm						
0	63.1	65.8	6.0	13.8	5214	2.21	0.15	1.81	0.46	0.21	18	28	3350	40	16	3	3
50	72.8	79.0	3.8	14.2	6069	2.26	0.22	1.29	0.29	0.18	10	26	1746	38	24	2	3
100	63.0	59.5	5.2	14.5	5904	2.32	0.17	1.65	0.43	0.23	16	28	2776	46	17	2	4
150	67.5	71.8	5.0	14.3	5904	2.30	0.19	1.91	0.43	0.21	26	40	2026	42	17	2	2
200	60.3	70.8	6.0	14.1	5514	2.26	0.20	1.59	0.33	0.21	12	29	1442	44	21	2	2
250	78.0	75.5	3.2	13.7	6024	2.18	0.16	1.83	0.39	0.20	14	26	2452	38	14	2	2
Significance	NS	NS	NS	NS	NS	NS	*	NS	*	NS	NS	NS	NS	NS	**	NS	NS
B.L.S.D.(.05)							.04		.12						4.0		
C.V. (%)	23.2	15.1	41.0	6.6	15.1	6.6	14.5	21.3	18.5	14.2	59.8	27.8	45.2	17.8	14.3	15.5	33.7

Table 2. Effects of different rates of phosphorus fertilizer on barley at Fosston.

Treatment	Grain				Forage												
						Analyses at Soft Dough											
P_2O_5 Rate	Yield	Plump	Thin	Protein	Yield	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	Bu/A	%	%	%	lbs DM/A	%					ppm						
0	56.1	85.5	2.2	12.8	3985	2.04	0.15	1.45	0.23	0.16	8	24	1676	36	22	2	2
40	71.3	89.8	2.2	13.2	5979	2.11	0.19	1.31	0.24	0.20	10	26	1943	36	20	2	2
80	53.4	86.0	3.0	12.6	4990	2.01	0.21	1.26	0.19	0.16	7	24	1452	33	23	2	1
120	78.6	87.5	2.5	12.8	5394	2.05	0.22	1.25	0.32	0.16	9	26	2094	36	22	2	2
160	73.7	86.0	2.8	13.0	6788	2.08	0.23	1.39	0.25	0.18	8	25	2492	29	18	2	2
200	69.0	81.5	3.5	13.2	5649	2.12	0.21	1.30	0.29	0.18	10	25	1976	36	18	2	3
Significance	+	NS	NS	NS	*	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D.(.05)	24.1				1760		.04										
C.V. (%)	19.8	5.6	22.3	12.9	19.0	3.2	13.3	11.3	24.7	11.5	30.0	14.0	37.2	19.8	17.8	14.5	26.5

+ Denotes significance at the 10% level.

EFFECTS OF MICRONUTRIENTS ON SPRING WHEAT GROWN ON ORGANIC SOILS 1979

G.E. Varvel and R.K. Severson

The major objective of these studies was to determine the effect of micronutrients on spring wheat production. Previous studies had isolated copper as the major limiting nutrient, but combinations of copper with some of the other micronutrients had also showed promise. Based on these findings, two experiments were conducted near Roseau at the same location that had been used for copper experiments in 1977 and 1978.

Experimental Procedure:
One experiment consisted of 3 copper sources, 3 rates and 2 methods of application in a factorial combination. These treatments are shown in Table 1. The other experiment consisted of copper with combinations of boron, molybdenum, iron and zinc. These treatments are shown in Table 2. All treatments were applied and Era wheat was planted with 100 lb/A of 15-30-15 as starter on May 24. Whole plant samples taken August 20 were used to determine forage yields.

A randomized complete block design was used in both studies.

Results:
Copper source, rate and application method significantly affected forage yield (Table 1).

The micronutrient combinations in the second experiment also significantly affected forage yield (Table 2). Copper in combinations with zinc and iron appeared to give the highest yields.

Table 1. Effects of copper source, rate and application method on forage yield of spring wheat at Roseau.

Treatment			
Carrier	Method	Copper Rate	Forage Yield
		lb/A	lb DM/A
Check		0	1422
$CuSO_4$	Brdcst.	1.5	2350
"	"	3.0	3134
"	"	6.0	2741
"	Band	1.5	2194
"	"	3.0	2588
"	"	6.0	3258
Cu Chelate	Brdcst.	1.5	4097
"	"	3.0	5335
"	"	6.0	6190
"	Band	1.5	5169
"	"	3.0	5070
"	"	6.0	5797
Silviplex Cu	Brdcst.	1.5	3354
"	"	3.0	3858
"	"	6.0	4238
"	Band	1.5	2664
"	"	3.0	2479
"	"	6.0	2974
Significance			**
B.L.S.D.(.05)			952
C.V. (%)			20.1
Cu Rate lb/A			
1.5			3305
3.0			3744
6.0			4200
Significance			**
B.L.S.D.(.05)			412
Source			
$CuSO_4$			2711
Cu Chelate			5276
Silviplex Cu			3261
Significance			**
B.L.S.D.(.05)			386
Application Method			
Broadcast			3922
Band			3577
Significance			+
B.L.S.D.(.10)			307

+ Denotes significance at the 10% level.

Table 2. Effect of copper with combinations of boron, molybdenum, iron and zinc on forage yield of spring wheat at Roseau.

Treatments	Forage Yield
	lb DM/A
Cu(6)[1/]	3000
Cu(6)+B(1)	2982
Cu(6)+Mo(.3)	3285
Cu(6)+Zn(5)	4815
Cu(6)+Fe(10)	5564
Cu(6)+Mo(.3)+B(1)	3338
Cu(6)+B(1)+Zn(5)	5289
Cu(6)+B(1)+Fe(10)	5740
Cu(6)+Mo(.3)+Zn(5)	4487
Cu(6)+Mo(.3)+Fe(10)	5706
Cu(6)+Zn(5)+Fe(10)	5595
Cu(6)+Mo(.3)+B(1)+Zn(5)	5022
Cu(6)+Mo(.3)+B(1)+Fe(10)	4836
Cu(6)+B(1)+Zn(5)+Fe(10)	5754
Cu(6)+Mo(.3)+Zn(5)+Fe(10)	5557
Cu(6)+Mo(.3)+B(1)+Zn(5)+Fe(10)	5785
Significance	**
B.L.S.D.(.05)	653
C.V. (%)	10.5

Micronutrient Combinations[2/]	Mean Yield
	lb DM/A
Cu + Mo	4752
Cu + B	4800
Cu + Zn	5287
Cu + Fe	5567

[1/] Rate of application in lb/A.

[2/] Includes all treatments which have the listed micronutrients.

RESIDUAL EFFECTS OF COPPER APPLIED ON ORGANIC SOILS
1979

G.E. Varvel and R.K. Severson

The major objective of this study was to determine the effect of copper applied in 1977 on soil test levels. Wheat yields were also being measured each year to determine how long the residual effect would last.

Experimental Procedure:
Eight broadcast copper treatments were applied in the spring of 1977. Copper sulfate, dissolved in water, was used as the copper source for all treatments. Era wheat was planted and grain yields taken each year of the study, except for 1979 when no grain was harvested due to stand problems.

Soil samples were taken in the spring of 1979 from the 0-6" depth on each plot.

A randomized complete block design was used.

Results:
Soil test copper levels are shown in Table 1. Copper in the soil was significantly increased as the amount that had been applied increased.

Yield response data from the previous 2 years had indicated that the 3 lb/A Cu rate was sufficient. This rate corresponds with a soil test level of 4.3 ppm (Table 1).

Table 1. Effect of copper applied in 1977 on soil test levels in 1979.

Cu Rate	Soil Test Cu
lb/A	ppm
0	1.4
3	4.3
6	9.0
12	12.7
24	32.4
48	74.1
96	254.2
192	371.9
Significance	**
B.L.S.D.(.05)	62.2
C.V. (%)	49.2

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SUGAR BEETS - 1979

G.E. Varvel, L.J. Smith and R.K. Severson

The objectives of this study were to determine the effects of application method of nitrogen and phosphorus on sugar beet yield and quality.

Experimental Procedure:

Treatments used in the study are shown in Table 1. Knifed applications were made at 12" spacings with an anhydrous applicator and broadcast applications were made with a spray rig on May 15. The trial was planted on May 16 and harvested October 12.

Soil test results on samples taken at the start of the study were: NO_3-N (0-2') - 142 lb/A, extractable P ($NaHCO_3$) - 28 lb/A and exchangeable K - 375 lb/A.

A randomized complete block design was used.

Results:

Application method had no significant affect on yield or quality factors (Table 1). Yield was significantly affected by the treatment combinations shown in Table 1, but no explanation was apparent. No differences were obtained in gross sugar, recoverable sugar, percent sugar, Na, K or amino N due to the treatments.

Table 1. Effects of nitrogen and phosphorus application methods on sugar beet yield and quality at Crookston.

Treatment							Impurities			
Source	N Rate	P_2O_5 Rate	Application Method	Yield	Sugar	Gross Sugar	Na	K	Amino N	Recov. Sugar
	lb/A	lb/A		T/A	%	lb/A	- - ppm - -			lb/A
Check	0	0	--	20.4	16.5	6757	508	2663	783	5782
NH_3	90	0	Knifed	21.4	16.1	6873	558	2760	808	5810
UAN	90	0	Knifed	20.1	16.1	6465	495	2648	673	5567
NH_3 + 10-34-0	90	34	Knifed	18.4	16.4	6039	598	2573	765	5163
UAN + 10-34-0	90	34	Knifed	21.2	16.4	6919	610	2383	645	6023
NH_3 + 10-34-0	90	102	Knifed	20.5	15.6	6402	583	2700	775	5397
UAN + 10-34-0	90	102	Knifed	18.4	16.2	5975	483	2585	483	5275
UAN	90	0	Brdcst.	18.3	16.4	6029	485	2318	945	5124
NH_3 + 10-34-0	90	34	Brdcst.	20.8	16.1	6690	593	2725	943	5580
UAN + 10-34-0	90	34	Brdcst.	19.2	16.2	6203	543	2553	933	5220
NH_3 + 10-34-0	90	102	Brdcst.	18.6	16.4	6087	615	2418	715	5258
UAN + 10-34-0	90	102	Brdcst.	19.8	16.0	6325	525	2680	468	5558
Significance				*	NS	NS	NS	NS	NS	NS
B.L.S.D.(.05)				2.9						
C.V. (%)				8.0	2.8	8.3	25.1	12.3	37.4	9.8
Method										
Knifed				19.7	16.1	6360	554	2578	668	5485
Broadcast				19.3	16.2	6266	552	2539	801	5448
Significance				NS	NS	NS	NS	NS	NS	NS

COMPARISON OF PHOSPHORUS SOIL TEST METHOD ON A BEARDEN - FARGO SILTY CLAY LOAM
1979

G.E. Varvel and R.K. Severson

Soil test results from the Bray P1 (1:50) and $NaHCO_3$ methods are shown in Table 1. The soil samples analyzed were taken in the spring of 1979 from a phosphorus rate experiment that had been put out in the spring of 1978.

Table 1. Comparison of phosphorus soil test results obtained by two different extraction methods.

P_2O_5 Rate	Soil Sample Depth	Modified Extraction of Bray-1 (1:50) Rep I	Rep II	Rep III	Rep IV	$\bar{X}$
lb/A		- - - - - - - - - P lb/A - - - - - - - - -				
0	0-6"	2	2	2	1	2
	6-12"	1	1	1	1	
30	0-6"	24	2	18	25	17
	6-12"	2	2	17	6	
60	0-6"	37	43	42	1	31
	6-12"	3	15	10	1	
90	0-6"	45	5	2	1	13
	6-12"	14	2	1	1	
120	0-6"	18	14	37	6	19
	6-12"	54	4	5	2	
150	0-6"	24	6	2	20	13
	6-12"	2	2	1	7	
		$NaHCO_3$ Extraction				$\bar{X}$
0	0-6"	11	12	13	14	13
	6-12"	7	8	7	9	
30	0-6"	20	14	14	18	17
	6-12"	13	7	12	8	
60	0-6"	25	24	20	22	23
	6-12"	14	13	14	14	
90	0-6"	29	21	21	21	23
	6-12"	12	11	16	11	
120	0-6"	19	25	24	32	25
	6-12"	34	12	16	20	
150	0-6"	24	21	55	46	37
	6-12"	16	14	12	18	