SOIL SERIES 109

A REPORT ON FIELD RESEARCH IN SOIL SCIENCE

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

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

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

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

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MINNESOTA SPRING SOIL MOISTURE SITUATION 1981

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

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

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

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

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

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

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

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

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

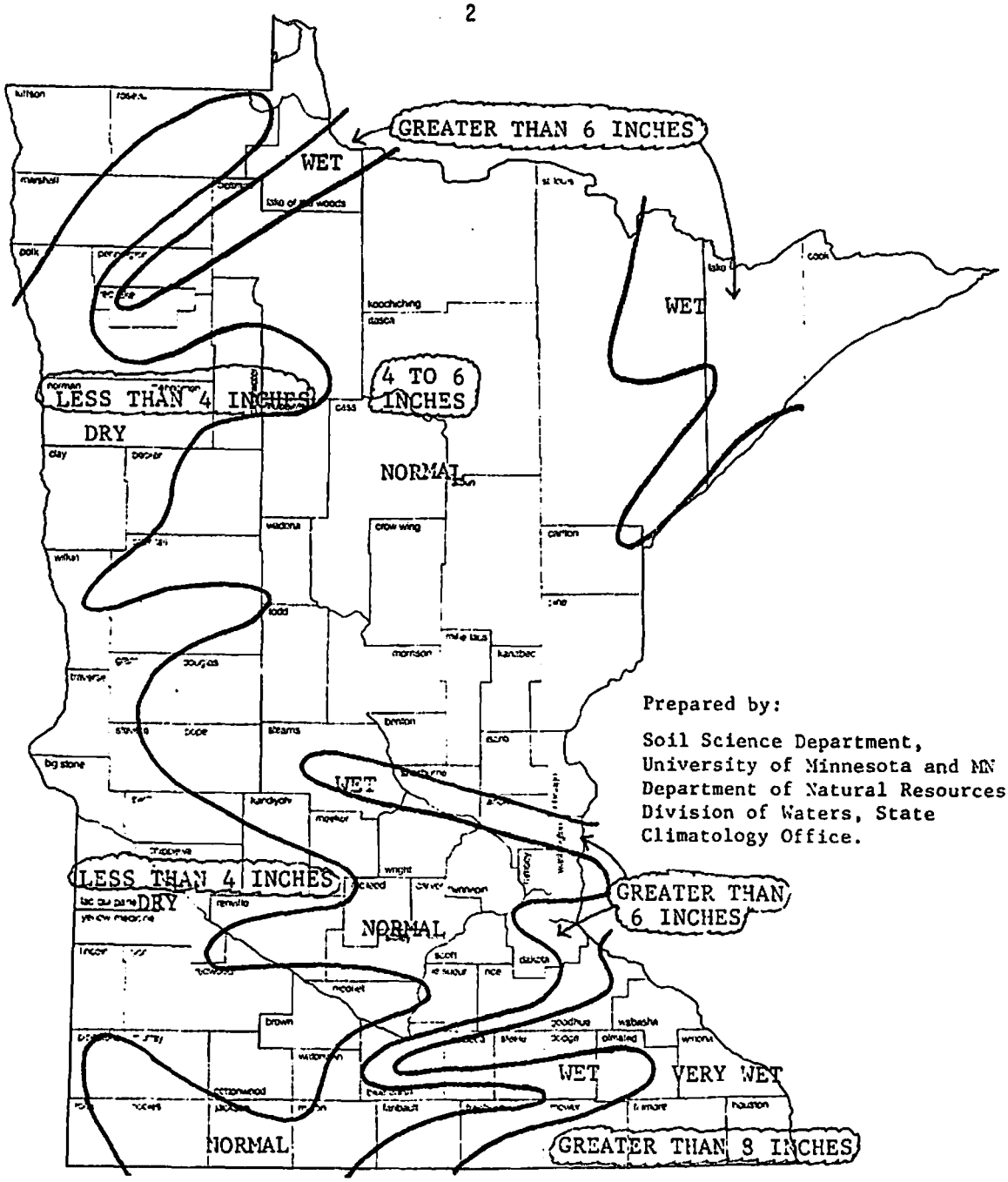

Fig. 1 Plant available soil moisture on December 1, 1980 expressed in inches for the top five feet of medium to fine textured soils. Information is based on actual soil moisture observations; however, precipitation amounts used in conjunction resulted in a more detailed analysis of the soil moisture.

Additional Remarks On Current Soil Moisture and Soil Temperature Conditions

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

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

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

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

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

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

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

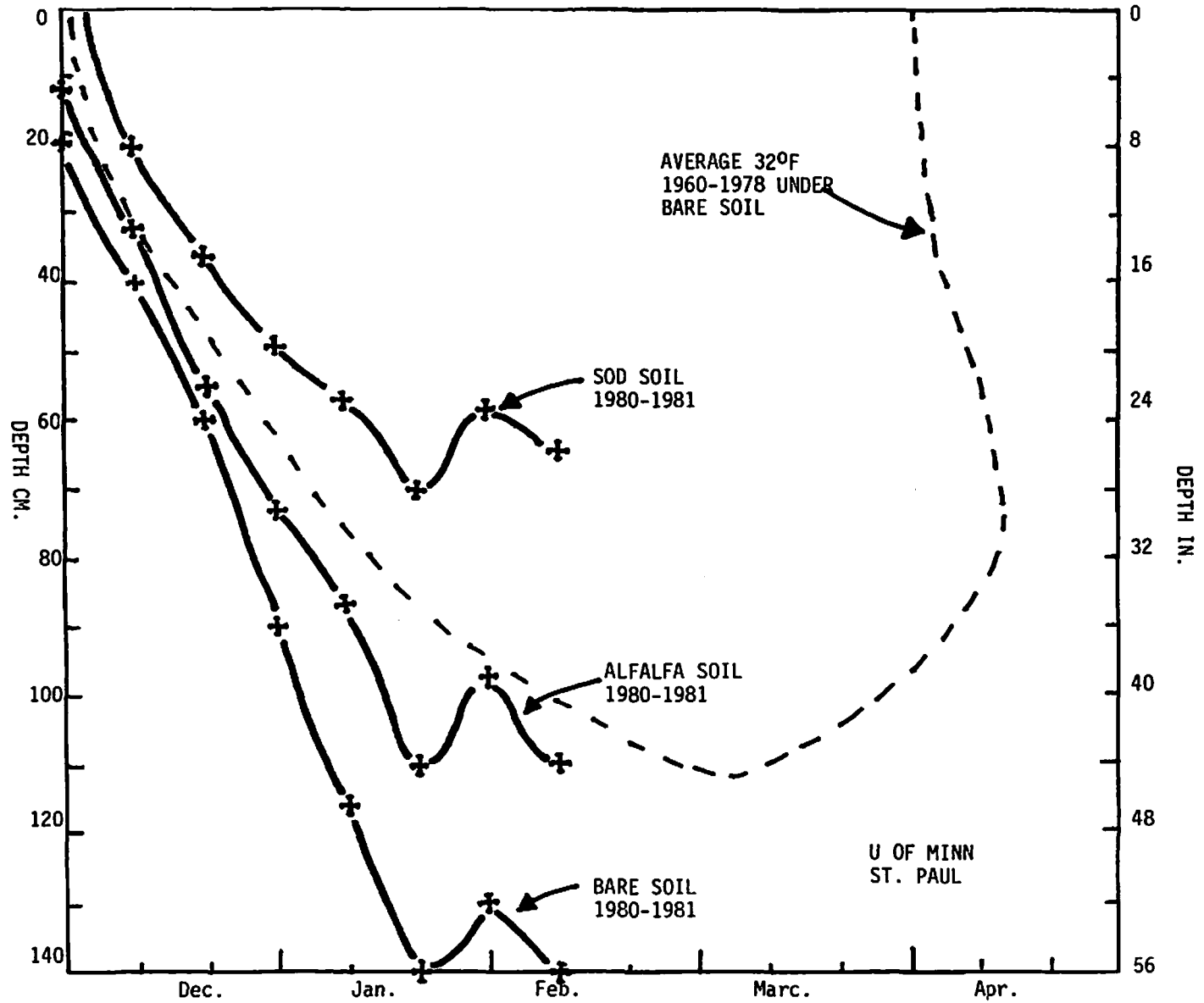

Fig. 2 Soil freezing depths at St. Paul, 1980-81 under 3 different covers compared to the long term mean at St. Paul under a soil bare of vegetation.

Soil Moisture Profiles at Lamberton, Morris and Waseca

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

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

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

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

Hydrologic Year Precipitation, October 1979 - September 1980

E.L. Kuehnast and D.G. Baker

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

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

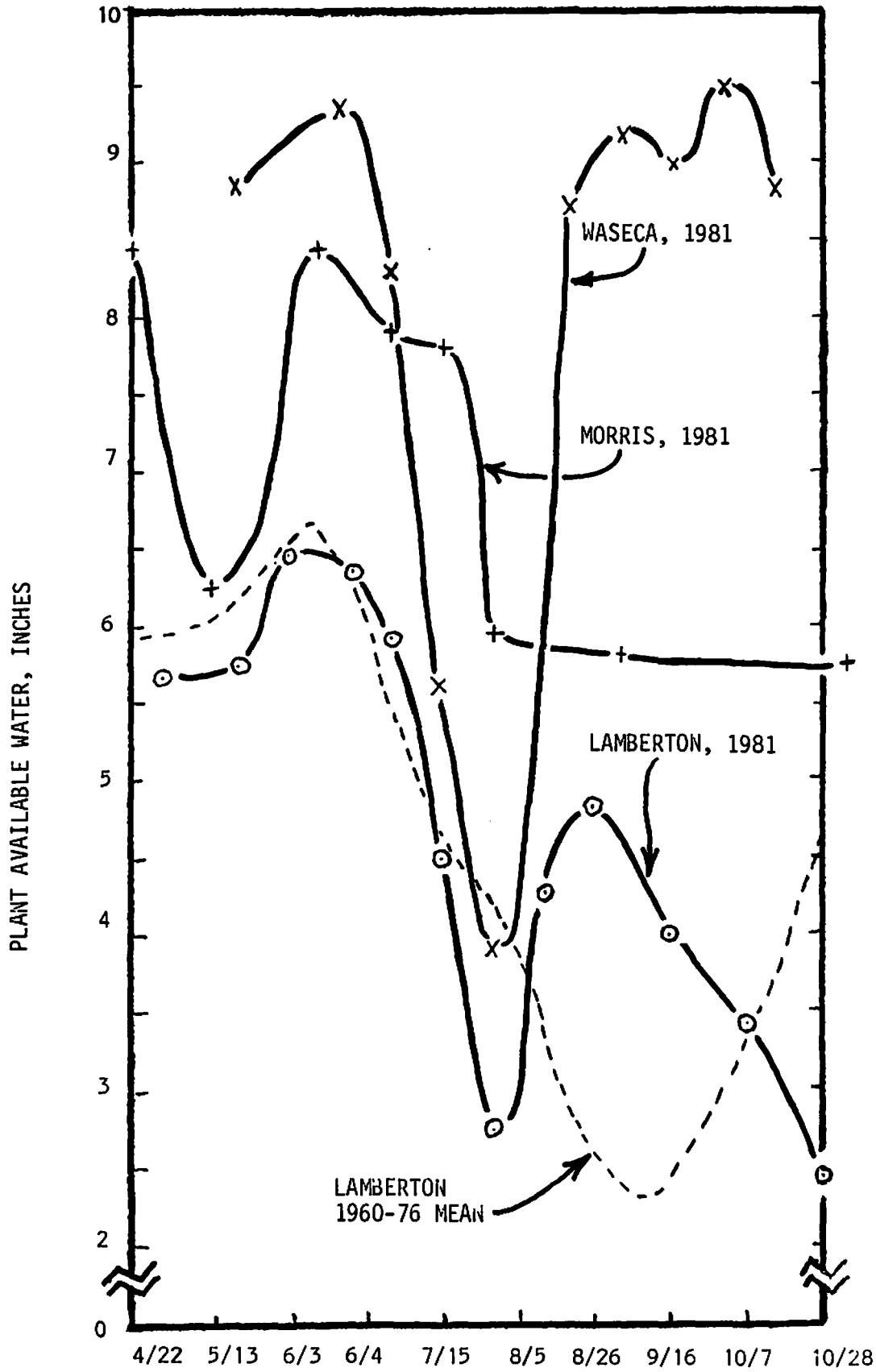

Fig. 3 Soil moisture at Lamberton, Morris, and Waseca in 1980 compared to long term mean at Lamberton.

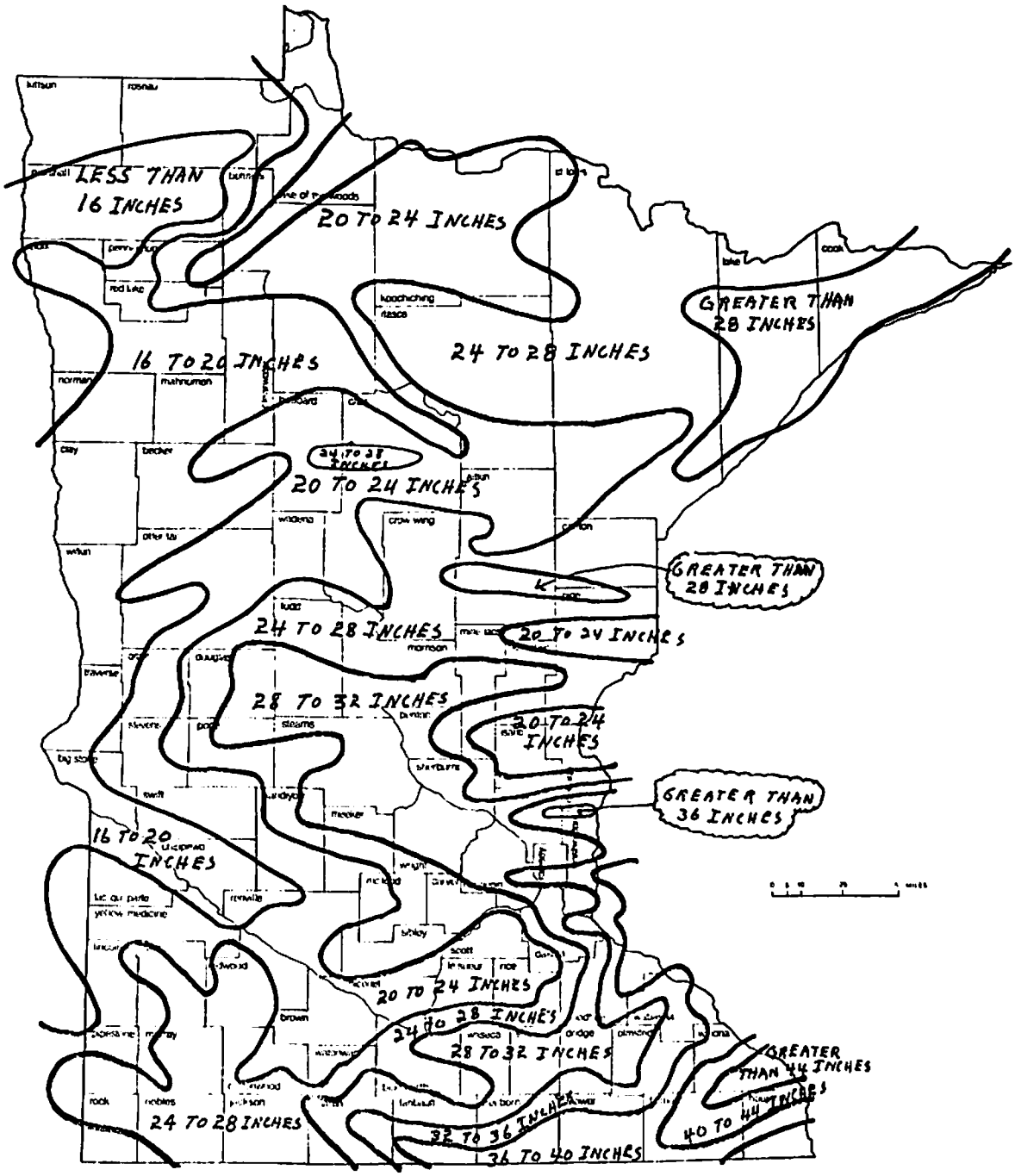

Fig. 4 Hydrologic Year Precipitation October 1979 - September 1980

Prepared by:
State Climatology Office

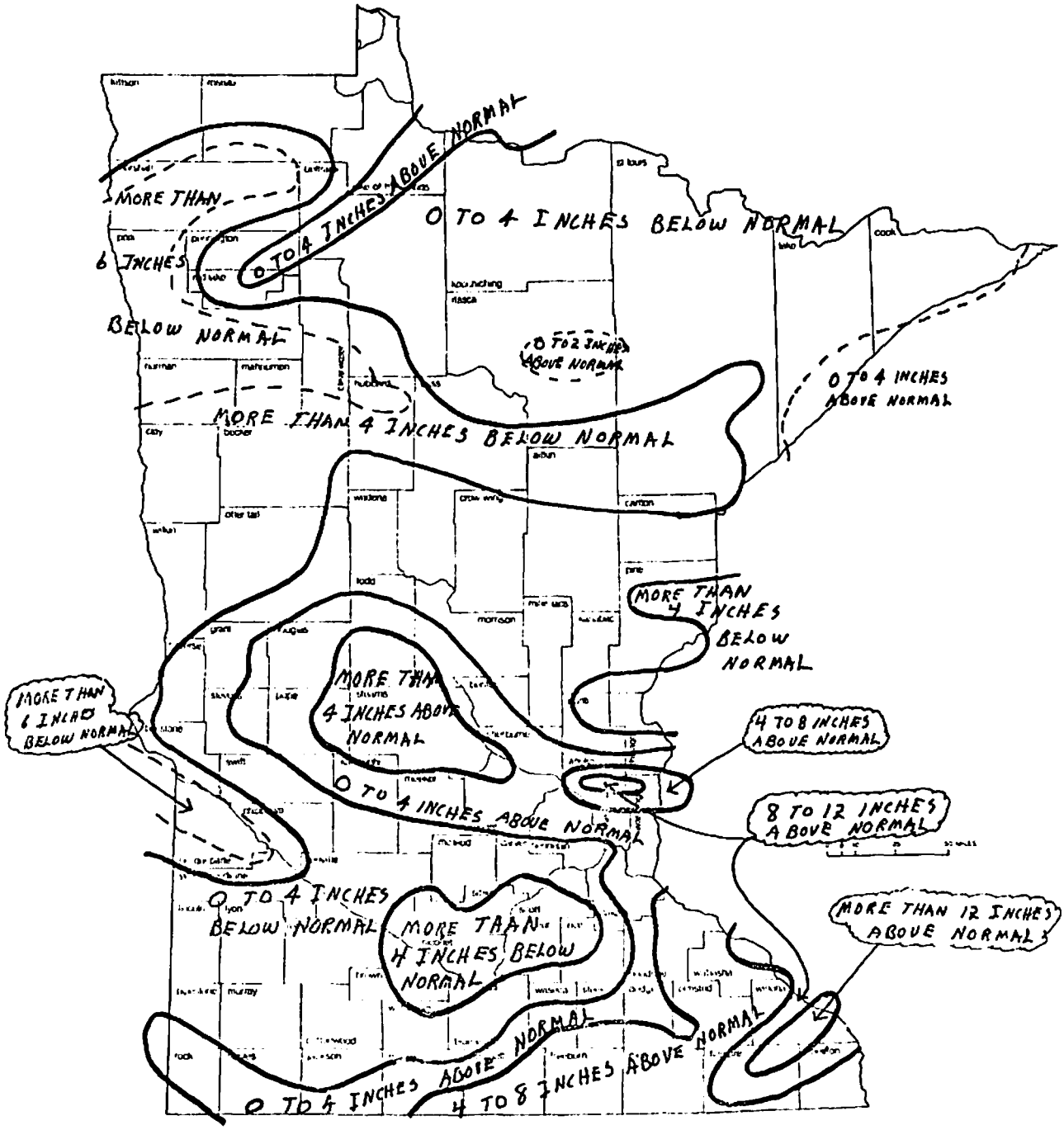

Fig. 5 Hydrologic Year Precipitation Departure from Normal
October 1979 - September 1980

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

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

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

Experimental Procedures

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

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

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

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

General Results

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

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

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

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

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

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

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

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

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

Table 1 and 2 (continued)

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

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

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

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

Experimental Procedures

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

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

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

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

General Results

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

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

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

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

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

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

AA = Anhydrous Ammonia

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

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

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

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

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

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

Experimental Procedures

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

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

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

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

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

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

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

General Results

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

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

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

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

Factorial Statistics (Excludes Control and 15 in row spacings)

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

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

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

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

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

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

FACTORIAL STATISTICS

Fertility

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

Plant Population

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

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

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

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

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

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

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

CORN YIELDS FROM VARYING LEVELS OF POTASH

Becker, MN 1980

C. J. Overdahl and Michael O'Leary

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

Results and Summary

Table 1 and 2 show 1979 and 1980 data.

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

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

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

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

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

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

Micronutrient Fertilization of Potatoes and Corn Under Irrigation

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

Experimental Procedures

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

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

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

General Results

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

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

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

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

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

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

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

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

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

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

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

Lowering pH with Nitrogen

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

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

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

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

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

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

[1]200# N/A

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

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

Table 2. con't.

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

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

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

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

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

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

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

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

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

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

Experimental Procedures

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

Results and Discussion

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

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

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

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

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

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

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

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

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

MICRONUTRIENT TESTS ON ALFALFA

Becker, MN 1980

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

W. E. Jokela and M. O'Leary

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

Experimental Procedures

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

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

Results and Discussion

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

1980 WEATHER SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

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

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

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

Results:

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

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

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

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

RESIDUAL EFFECTS OF COPPER ON ORGANIC SOILS

G. E. Varvel and R. K. Severson

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

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

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

A randomized complete block design with 4 replications was used.

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

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

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

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

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

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

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

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

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

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

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

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

PHOSPHORUS FERTILIZATION OF SUGARBEETS

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

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

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

Results:

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

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

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

Table 2. The effect of P on soil analyses.

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

HIGH PHOSPHORUS AND POTASSIUM RATES ON SPRING WHEAT

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

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

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

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

Results:

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

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

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

EFFECT OF POTASSIUM FERTILIZER ON SPRING WHEAT

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

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

Results:

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

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

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

EFFECTS OF NITROGEN AND PHOSPHORUS APPLICATION METHODS ON SPRING WHEAT

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

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

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

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

Results:

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

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

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

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

G. E. Varvel and R. K. Severson

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

Experimental Procedures

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

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

Results

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

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

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

EFFECTS OF ANHYDROUS AMMONIA ON GERMINATION OF SPRING WHEAT AND BARLEY

G. E. Varvel and R. K. Severson

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

Experimental Procedure:

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

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

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

Results:

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

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

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

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

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

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

Experimental Procedure:

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

Results:

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

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

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

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

Table 2. Soil test results after crop removal in 1980.

Treatment			Depth Increment					
			0-6"	6-12"	1-2'	2-3'	3-4'	4-5'
N	P_2O_5	K_2O	Nitrate Nitrogen					
lb/A			lb/A					
0	0	0	18	11	4	8	10	6
70	45	25	32	29	9	9	14	11
50	45	55	36	26	8	17	16	11
80	45	25	35	40	12	12	12	7
50	75	25	21	32	13	21	13	7
Significance			NS	*	NS	NS	NS	NS
B.L.S.D. (.05)				19.9				
C.V. (%)			46.2	42.2	43.7	58.5	44.3	50.8

Treatment			NDSU				Minnesota		
			$NaHCO_3$-P		K		Bray P-1		
							10:1	50:1	K
N	P_2O_5	K_2O	0-6"	6-12"	0-6"	6-12"	0-6"	0-6"	0-6"
lb/A			lb/A				lb/A		
0	0	0	11	5	292	235	4	24	245
70	45	25	26	12	275	234	6	42	239
50	45	55	26	13	292	228	5	39	260
80	45	25	25	9	285	241	14	50	248
50	75	25	26	8	282	214	13	40	254
Significance			*	NS	NS	NS	NS	**	NS
B.L.S.D. (.05)			11					10	
C.V. (%)			28.8	43.6	6.5	7.3	89.6	16.4	8.8

Nitrogen Fertilization and Nitrogen Utilization by Fourteen Small Grain Varieties - Crookston, MN - 1980*

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 improved 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 reason 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 the ground. Trials were established in 1980 to examine some of the difference which exist between wheat varieties in their ability to provide a yield response to nitrogen fertilization and to ascertain differences in 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 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# 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 April 18th, utilizing a cone seeder.

Dry matter production was determined at approximately the "soft dough" stage of growth (July 9th) and samples collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested July 23rd by harvesting 16 ft^2 of plot area. The above ground growth (grain + 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.

General Results

The yield results obtained in 1980 were considerably lower than what has been experienced in the past, but could also be considered exceptional considering the severe lack of precipitation that was obtained at the NW Experiment Station. Yields across the experiment ranged from 22-35 bu/A with the top yielding varieties including Era, Butte, MN7125, and Kitt. Normally in years where yields are reduced because of some environmental parameter, protein contents will be increased. This was not the case in 1980. Protein contents of the grain were lower in 1980 with low yields than they were in 1979 with relatively good yields. Nitrogen fertilization significantly (.05) increased yields up to the 60# N/A application while protein content of the grain was increased up to the highest rate of nitrogen fertilizer (120# N/A). Significant (.05) differences were also obtained between varieties in every category measured. Although with some similarities, the varieties which ranked the best or worst in 1980 were not necessarily in the same order as was experienced in 1979.

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

Table 1. Influence of nitrogen fertilization and variety on yield, N content and test weight 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
#/A		bu/A	%	#/bu	T/A	%
0	--	25.1	2.06	58.9	1.76	0.80
60	--	29.0	2.36	59.3	2.00	0.86
120	--	30.5	2.43	59.1	2.06	0.95
Significance		**	**	**	**	**
BLSD (.05)		2.7	0.07	--	0.20	0.06
-	Coteau	28.4	2.59	59.0	2.08	0.77
-	WS 1809	24.3	2.30	58.6	1.60	0.88
-	Era	31.1	2.04	60.9	1.98	0.96
-	Mn 70170R	28.4	2.27	59.1	1.88	0.92
-	Chris	25.4	2.28	58.6	1.87	0.81
-	James	28.5	2.30	58.2	1.97	0.82
-	Waldron	28.4	2.45	58.8	1.90	0.87
-	Mn 7125	30.4	2.06	58.1	1.97	0.78
-	Butte	29.3	2.19	60.7	2.01	0.87
-	Olaf	27.5	2.44	60.0	1.98	0.95
-	Mn 7222	28.9	2.02	60.0	2.00	0.87
-	Thatcher	26.8	2.41	58.3	1.87	0.85
-	Marquis	28.0	2.37	58.8	2.07	0.87
-	Kitt	29.5	2.29	58.2	2.01	0.99
Significance		**	**	**	**	**
BLSD (.05)		3.1	0.07	1.2	0.17	0.10
0	Coteau	25.4	2.42	59.0	1.89	0.69
0	WS 1809	21.7	2.11	59.8	1.50	0.84
0	Era	26.7	1.86	60.5	1.86	0.88
0	Mn 70170R	26.4	2.04	59.0	1.64	0.92
0	Chris	24.1	2.02	59.0	1.83	0.68
0	James	24.6	2.00	57.2	1.68	0.68
0	Waldron	25.4	2.18	58.4	1.68	0.80
0	Mn 7125	29.3	1.87	57.5	1.82	0.68
0	Butte	24.5	2.02	60.8	2.00	0.76
0	Olaf	24.8	2.19	60.3	1.79	0.94
0	Mn 7222	25.2	1.83	59.3	1.68	0.85
0	Thatcher	24.8	2.13	58.0	1.76	0.79
0	Marquis	24.2	2.18	58.7	1.94	0.81
0	Kitt	24.3	2.05	57.2	1.62	0.96
60	Coteau	28.8	2.65	59.2	2.11	0.76
60	WS 1809	24.3	2.36	59.0	1.58	0.85
60	Era	31.3	2.06	61.4	2.09	0.92
60	Mn 70170R	27.3	2.32	60.3	1.88	0.87
60	Chris	25.3	2.31	58.7	1.93	0.79
60	James	29.7	2.46	58.8	2.10	0.86
60	Waldron	30.8	2.62	59.7	2.02	0.83
60	Mn 7125	29.2	2.15	57.6	1.89	0.80
60	Butte	29.4	2.24	60.8	1.91	0.92
60	Olaf	29.2	2.57	59.8	2.05	0.89
60	Mn 7222	30.5	2.07	60.2	2.11	0.86
60	Thatcher	28.0	2.53	58.5	1.93	0.80
60	Marquis	30.4	2.43	58.4	2.17	0.91
60	Kitt	31.9	2.28	58.1	2.25	1.01
120	Coteau	30.9	2.70	58.8	2.25	0.86
120	WS 1809	26.8	2.44	57.2	1.71	0.96
120	Era	35.3	2.20	60.8	1.98	1.10
120	Mn 70170R	31.6	2.45	58.1	2.11	0.98
120	Chris	26.7	2.50	58.2	1.84	0.95
120	James	31.2	2.46	58.6	2.13	0.91
120	Waldron	29.0	2.56	58.2	2.01	0.98
120	Mn 7215	32.6	2.16	59.2	2.21	0.88
120	Butte	33.9	2.31	60.5	2.12	0.93
120	Olaf	28.5	2.57	59.8	2.11	1.02
120	Mn 7222	31.0	2.16	60.5	2.21	0.90
120	Thatcher	27.8	2.56	58.5	1.94	0.96
120	Marquis	29.4	2.49	59.3	2.10	0.88
120	Kitt	32.3	2.53	59.2	2.15	1.02
Significance		NS	NS	NS	NS	NS
BLSD (.05)		--	--	--	--	--

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

Nitrogen Rate	Variety	Harvest Straw		Nitrogen Removal			Grain & Straw
		Dry Matter	N Content	Forage	Straw	Grain	
#/A		T/A	%	#/A			
0		0.77	0.29	28.4	4.4	28.9	33.3
60		0.82	0.33	34.7	5.5	38.3	43.7
120		0.85	0.34	39.2	5.6	41.3	47.0
Significance		NS	**	**	**	**	**
BLSD (.05)		--	0.02	4.3	0.7	3.9	4.5
-	Coteau	0.89	0.30	32.3	5.3	41.2	46.5
-	WS 1809	0.60	0.36	28.2	4.3	31.4	35.7
-	Era	0.74	0.36	38.3	5.3	35.7	41.0
-	Mn 70170R	0.71	0.36	35.0	5.1	36.4	41.4
-	Chris	0.88	0.27	30.2	4.7	32.4	37.1
-	James	0.80	0.32	32.8	5.1	37.1	42.2
-	Waldron	0.84	0.31	33.4	5.1	39.2	44.3
-	Mn 7125	0.78	0.33	31.2	5.0	35.0	40.1
-	Butte	0.89	0.30	34.9	5.4	35.8	41.3
-	Olaf	0.82	0.34	38.1	5.6	37.7	43.3
-	Mn 7222	0.66	0.34	34.8	4.6	32.8	37.4
-	Thatcher	0.85	0.29	32.1	4.9	36.3	41.3
-	Marquis	1.04	0.28	35.9	6.0	37.1	43.1
-	Kitt	0.90	0.34	40.1	6.2	38.0	44.2
Significance		**	**	**	**	**	**
BLSD (.05)		0.10	0.03	5.8	0.7	4.3	4.7
0	Coteau	0.81	0.28	26.2	4.4	34.4	38.8
0	WS 1809	0.58	0.31	25.3	3.7	25.7	29.4
0	Era	0.75	0.32	32.8	4.8	27.7	32.5
0	Mn 70170R	0.68	0.34	30.5	4.5	30.4	34.9
0	Chris	0.92	0.24	24.7	4.4	27.3	31.7
0	James	0.71	0.28	22.8	3.9	27.5	31.4
0	Waldron	0.73	0.30	26.7	4.3	30.7	35.1
0	Mn 7125	0.75	0.30	24.5	4.5	30.6	35.1
0	Butte	0.80	0.30	30.2	4.7	27.4	32.0
0	Olaf	0.74	0.30	34.6	4.5	30.3	34.8
0	Mn 7222	0.60	0.32	28.7	3.8	25.9	29.6
0	Thatcher	0.80	0.24	27.7	4.0	29.6	33.6
0	Marquis	1.00	0.27	31.5	5.3	29.3	34.6
0	Kitt	0.90	0.30	30.9	5.5	27.8	33.3
60	Coteau	0.88	0.32	31.8	5.5	42.7	48.3
60	WS 1809	0.55	0.38	27.0	4.1	32.0	36.1
60	Era	0.67	0.38	38.1	5.2	36.2	41.4
60	Mn 70170R	0.67	0.38	32.8	5.0	35.3	40.4
60	Chris	0.83	0.27	30.7	4.4	32.7	37.1
60	James	0.81	0.35	36.3	5.8	40.8	46.6
60	Waldron	0.92	0.31	33.6	5.7	45.2	51.0
60	Mn 7125	0.74	0.35	30.0	5.0	35.2	40.2
60	Butte	0.93	0.30	34.9	5.6	36.7	42.3
60	Olaf	0.86	0.37	36.8	6.3	42.0	48.3
60	Mn 7222	0.68	0.36	36.5	4.9	35.2	40.1
60	Thatcher	0.92	0.31	31.1	5.7	39.7	45.4
60	Marquis	1.08	0.32	39.6	7.0	41.1	48.2
60	Kitt	0.91	0.36	46.3	6.5	40.7	47.2
120	Coteau	0.96	0.30	39.0	5.9	46.6	52.4
120	WS 1809	0.66	0.40	32.4	5.1	36.5	41.6
120	Era	0.81	0.36	43.8	5.8	43.3	49.2
120	Mn 70170R	0.78	0.36	41.7	5.6	43.4	49.0
120	Chris	0.88	0.30	35.3	5.3	37.1	42.4
120	James	0.88	0.33	39.3	5.7	42.8	48.6
120	Waldron	0.87	0.31	40.0	5.4	41.5	46.9
120	Mn 7125	0.85	0.33	39.2	5.6	39.4	45.0
120	Butte	0.95	0.32	39.5	6.0	43.5	49.5
120	Olaf	0.85	0.36	42.7	6.0	40.8	46.8
120	Mn 7222	0.72	0.35	39.3	5.0	37.4	42.4
120	Thatcher	0.82	0.32	37.4	5.1	39.8	44.9
120	Marquis	1.04	0.27	36.7	5.6	40.9	46.5
120	Kitt	0.89	0.37	43.1	6.6	45.5	52.2
Significance		NS	NS	NS	NS	NS	NS
BLSD (.05)		--	--	--	--	--	--

N Incorporation Study on Wheat

Gary Varvel and Harvey Meredith

Objective of Study: Compare yield differences between broadcast forms of nitrogen when incorporated versus surface application without incorporation.

Location: Crookston Experiment Station

N Source: Urea (46-0-0), ammonium nitrate (34-0-0), and urea-ammonium nitrate solution (28-0-0).

N Rate: 0, 40, and 80 pounds N per acre.

Variety: Era

Date of Planting: April 17

Nitrogen application-incorporated: April 17

Nitrogen application - nonincorporated: April 17

Previous crop: Barley

Forage Harvested: July 8

Grain Harvested: July 23

Table 1. Soil Test Data of Nitrogen Source Investigation at Crookston Experiment Station, 1980.

		Nitrate - N	
pH:	8.1	Depth, In.	Lbs/A
P:	22 [1/]		
K:	300	0-12	42
		12-24	18
		24-36	15
		36-48	14

[1/] Sodium bicarbonate extraction

Table 2. Comparison of Three Nitrogen Sources Applied in the Spring at Two Rates With and Without Incorporation on the Yield and Quality of Era Wheat at the Crookston Experiment Station, 1980.

Treatment			Forage			Grain		
Source	N Rate	Incorp.	Yield	Total N	N Uptake	Yield	Protein	Bushel Weight
			lb DM/A	%	lb/A	Bu/A	%	lbs
Check	0		3120	1.17	36.2	24.8	11.6	62.5
AN	40	+	3260	1.32	43.0	25.9	12.8	63.0
	80	+	2810	1.27	35.8	26.3	13.4	62.5
Urea	40	+	3000	1.24	37.4	26.3	13.2	63.0
	80	+	3640	1.42	51.6	29.8	12.6	62.8
UAN	40	+	2850	1.32	36.9	26.0	12.9	62.8
	80	+	3400	1.17	40.4	27.8	13.0	63.0
AN	40	-	2760	1.36	37.6	22.8	12.9	62.8
	80	-	2710	1.40	37.9	24.0	13.3	63.0
Urea	40	-	2870	1.38	39.3	23.0	12.8	62.8
	80	-	2890	1.43	41.2	27.3	13.0	62.3
UAN	40	-	3010	1.37	41.2	25.1	12.7	62.0
	80	-	3110	1.49	46.6	24.9	13.3	63.0
Significance			N.S.	**	*	*	*	N.S.
B.L.S.D. (.05)				0.13	11.9	4.4	1.0	
C.V. (%)			13.3	6.6	15.9	9.8	4.6	0.9
Source								
AN			2880	1.34	38.6	24.7	13.1	62.8
Urea			3100	1.37	42.4	26.6	13.0	62.7
UAN			3100	1.34	41.3	26.0	12.9	62.7
Significance			N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
N Rate lb/A								
40			2690	1.33	39.2	24.9	12.9	62.7
80			3100	1.36	42.3	26.7	13.1	62.8
Significance			N.S.	N.S.	N.S.	**	N.S.	N.S.
B.L.S.D. (.05)						1.5		
Incorporation								
+			3161	1.29	40.9	27.0	13.0	62.8
-			2890	1.40	40.6	24.5	13.0	62.6
Significance			*	**	N.S.	**	N.S.	N.S.
B.L.S.D. (.05)			230	0.05		1.5		

Table 3. Summary of N Source, Rate Incorporation Study, Spring Applied, Era Wheat Yields, Bu/A, Crookston Experiment Station, 1978-80.

	Am. Nitrate						Urea						28% N Soln.					
	Incorporated			Nonincorporated			Incorporated			Nonincorporated			Incorporated			Nonincorporated		
	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80
0	27.9	31.5	24.8	27.9	31.5	24.8	27.9	31.5	24.8	27.9	31.5	31.5	27.9	31.5	24.8	27.9	31.5	24.8
40[1/]	45.5	47.5	25.9	44.0	49.7	22.8	48.2	44.9	26.3	51.0	47.2	23.0	45.4	47.5	26.0	43.5	46.5	25.1
80[2/]	58.5	49.6	26.3	60.9	47.3	24.0	59.3	46.1	29.8	60.6	48.2	27.3	59.1	47.5	27.8	60.3	48.2	24.9

[1/] 50 Lbs N applied in 1979

[2/] 100 Lbs N applied in 1979

Table 4. Temperature and Precipitation Data Ten Days Following Application of N Sources. Crookston Experiment Station, 1980.

Date	Maximum Temperature	Precipitation
4/17	73	None
4/18	80	"
4/19	80	"
4/20	89	"
4/21	96	"
4/22	96	"
4/23	64	"
4/24	61	"
4/25	69	"
4/26	70	"

Discussion: The primary factor evaluated in this study was the comparison of the three broadcast forms of nitrogen and the effect of the performance of these N sources when incorporated with the soil versus surface applied without incorporation.

The months of April and May were the driest on record, only 0.02 inch of precipitation was recorded in April and 0.33 inch was recorded at the end of May. Wheat yields were gravely affected due to the extreme drought. Minimum disturbance of the soil prior to planting and planting to the appropriate depth resulted in excellent stands and surprising yields considering the harsh environment.

Temperatures reached record highs for several days following application of N. Previous research indicated that the greatest losses of N due to ammonia volatilization occur during the first 5 to 10 days following application. Losses are enhanced with elevated temperatures and lack of precipitation. Certainly the temperature-moisture conditions were optimum to field evaluate the hypothesis of ammonia loss from N fertilizer when surface applied without incorporation. The phenomenon is enhanced in the presence of high amounts of carbonates. It will be noted the soil pH was 8.1.

Broadcasting of N fertilizers without incorporation is a common practice. Typically application of N in the spring occurs at a time when the ambient temperature is relatively cool and the probability of precipitation is high. As little as 0.1 inch of precipitation is sufficient to move the ammonium forms of N into the soil such that the ammonium is adsorbed onto clay or organic matter.

Under the extreme conditions of early 1980, the stage was set for optimum N losses due to ammonia volatilization. Although yields were quite low, there was a significant difference in yield at the 5 percent level from the N incorporated plots versus the nonincorporated (27.0 compared to 24.5 bu/A).

Considerable caution must be exercised in the interpretation of this data however. It will be noted that when N sources were compared, urea and UAN resulted in higher yields than ammonium nitrate (26.6 and 26.0 compared to 24.7). Generally, ammonium loss from ammonium nitrate is not considered much of a problem.

Soil Moisture Probabilities

Donald G. Baker and Wallace W. Nelson

There are many occasions where the amount of water within the soil, particularly at seeding time, is of great interest. In addition to the natural concern that farmers have in the condition, there is the interest that researchers have in this subject. A number of projects require information on this topic including those dealing with yield and crop growth models and farm management studies.

The 21-year record of soil moisture measurements at the Southwest Agricultural Experiment Station is now long enough that confidence can be placed in the results. They are shown in Table 1.

Table 1. Probability that plant available soil moisture in a 5-foot column of soil under corn will be within the indicated ranges.

Date	<2.5 in.	2.5-3.9 in	4.0-4.9in.	5.0-7.4in.	>7.5in.
May 3-May 16	0%	4.8%	4.8%	71.4%	19.0%
Oct.11-24	19.0%	42.9%	14.3%	23.8%	0.0%

It is interesting and important for many reasons that at corn plant time, May 3-16, the soil has contained at least 5.0 inches of plant available water in more than 90% of the years. It is also important to realize that both the probabilities and the amount of water increase eastward across the state. These probabilities can be expected to vary with crops to some extent. Although comparable data for crops other than corn are not available , it can be assumed that the probabilities and water content will decrease in the case of more extensively rooted and longer season crops such as alfalfa.

Twentyone Years Of Field Experimentation With Nitrogen Source, Placement, And Time Of Application To A Webster Loam Near Lamberton

G.L. Malzer, W.W. Nelson, and R. Munter

(Annual reports of this experiment have been reported in Soil Series 74 through 107 and some of this information will not be included here).

The fertilizer treatments have now been annually applied to the same plot areas for 21 years. After ear corn removal and stalk cutting, the fall plow down N treatments are broadcast on their respective plots and the entire area is then plowed to an approximate 12 inch depth. The fall surface N treatments are then broadcast, with no further working of the plow area. Each plot is 20' x 77.5' and the 4 treatments replication are arranged in a randomized block.

Spring N treatments are broadcast before seedbed preparation late in April or in early May. The corn is planted in 30 inch rows at a plant population of 20,000 plant/A, using a banded starter fertilizer of 8-24-12 at a rate of 180 lbs/A over the entire experimental area, thus supplying an additional 14 lbs. N/A to all the plots. Nitrogen sidedressing treatments are broadcast in June. Nitrogen concentrations present in the leaf opposite and below the ear at silking were determined and are reported along with plot yields in table 1.

The yields obtained in 1980 were below average when considering the long term previous average for this experiment. Treatment averages in 1980 appeared to follow the trends which had been established with the long term average yields. The extremely dry conditions experienced at the S.W. Experiment Station appeared to have a considerable influence on the results obtained.

Twenty Year Average

The average grain yields for the twenty years of this experiment are shown in table 2. Only modest differences were obtained between nitrogen forms, time of application, and incorporation in the 1980 experiment. The major yield differences that were obtained in 1980 were due to the rate of nitrogen fertilization. The twenty year average would suggest that when only 40 lbs. of N/A was fall applied, urea was slightly better than ammonium nitrate with very littel difference due to incorporation.

Plowing down 80 lbs. of N/A in the fall was much more effective than the lower N rates and approached the yields that were obtained with the highest treatment of fall applied N. At the 40#N/A rate applied in the spring there was no difference between urea and ammonium nitrate. Urea applied in the fall produced similar yield as with spring applications although ammonium nitrate applied in the fall was inferior to spring application at the 40#N/A rate of application.

Side dressing N produced grain yields similar to those of the same rates of spring applied N. The heaviest side dressing treatments were equally effective as the rates plowed down the previous fall.

General Conclusions

1. Urea is as effective as ammonium nitrate for the production of corn on these medium textured non-calcareous soils.
2. Late fall surface applied N is at least equal to that plowed down, but where N fertilization rates are relatively low, spring or sidedressing N treatments appear more effective.
3. Where corn is grown annually on these soils good yields can be maintained with annual applications of 100 lbs. N/A providing adequate amounts of P and K are also supplied. At this rate of application most of the N will be removed in the grain leaving relatively small amounts to be lost to the environment.

Table 1. Average N in sixth corn leaf, grain yield at 15.5% moisture, and 20 year corn average from Webster loam fertilized annually with NH_4 NO_3 or urea.

N applied annually in lbs/A'	% N 6th Leaf	I	II	III	IV	Ave.
Check	1.82	49.8	38.2	55.2	43.4	46.5
40 NH_4 NO_3 - fpd[2]	1.86	102.7	53.7	57.1	57.1	67.5
40 - urea - fpd	2.46	46.7	68.9	74.4	70.6	65.2
40 - NH_4 NO_3 - fps[3]	2.16	81.7	68.6	61.4	67.1	69.7
40 urea - fps	1.98	59.6	57.2	77.0	61.3	63.8
80 - NH_4 NO_3 - fpd	2.60	87.5	105.4	84.6	83.6	90.3
80 - urea - fpd	2.60	76.4	90.2	98.2	82.9	84.7
160 - NH_4 NO_3 - fpd	3.00	98.4	99.5	121.6	117.7	109.3
160 - urea - fpd	2.96	120.4	85.7	105.5	103.2	103.7
40 - NH_4 NO_3 - std[4]	2.20	75.5	85.0	86.4	62.1	77.2
40 - urea - std	2.22	71.4	80.6	52.1	53.2	64.3
80 - NH_4NO_3 -std	2.56	71.9	93.4	82.7	49.8	74.4
80 - urea - std	2.60	76.6	96.0	83.3	81.6	84.4
40 - NH_4NO_3 - sd[5]	1.89	57.0	55.5	97.2	78.0	71.9
40 - urea - sd	1.98	59.5	56.4	109.0	96.9	80.4
80 - NH_4NO_3 - sd	2.21	81.6	53.4	89.2	83.5	76.9
80 - urea - sd	2.19	93.4	100.5	98.1	66.3	89.6
160 -NH_4NO_3 - sd	2.81	99.2	120.4	113.9	105.8	109.8
Significance	**					**
BLSD (.05)	0.24					20.4

[1]The entire area received an additional 14 lbs N/A as starter fertilizer annually (8-24-12 @ 180#/A).

[2]fpd -- fall plow down, [3]fps -- fall plow surface, [4]std -- spring top dress

[5]sd -- sidedress

Table 2. Yields of ear corn during 20 years on a tiled Webster loam near Lamberton with annual applications of NH_4NO_3 or urea nitrogen at different rates, times, and placement. (Average of 4 replications)

N applied annually in lbs/A[1]	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
				Ear corn yield in bushels per acre						
Check	49.5	88.2	26.1	132.6	72.9	33.1	11.1	53.4	102.4	92.8
40 NH_4NO_3-fpd[2]	42.3	87.5	30.9	148.6	88.3	34.9	26.8	75.7	131.6	109.3
40 Urea - fpd[3]	55.1	78.2	29.1	148.8	100.3	38.8	19.8	86.9	132.5	124.5
40 NH_4NO_3-fps[3]	49.0	96.7	29.6	140.1	101.5	45.6	24.3	75.1	135.2	124.6
40 Urea - fps	62.3	101.3	37.0	140.7	84.1	57.4	30.9	87.2	134.0	136.1
80 NH_4NO_3-fpd	67.4	97.9	43.6	149.6	100.8	63.4	47.3	114.3	131.2	146.8
80 Urea - fpd	61.7	76.9	36.7	154.5	104.9	73.0	37.8	117.2	142.6	144.3
160 NH_4NO_3-fpd	69.8	97.9	46.7	147.7	100.9	70.8	38.5	127.4	140.2	158.7
160 Urea - fpd[4]	79.4	112.5	43.5	152.8	112.4	73.5	37.7	121.3	149.9	161.0
40 NH_4NO_3-std	66.2	92.0	45.4	152.2	99.8	63.4	23.7	99.8	128.0	142.0
40 Urea - std	45.4	91.1	31.4	147.6	100.6	59.8	33.8	95.0	140.5	143.4
80 NH_4NO_3-std	59.3	90.0	32.7	149.2	112.5	74.2	49.0	128.3	144.7	159.5
80 Urea - std	57.7	99.1	40.5	149.3	115.7	84.4	41.8	128.6	138.7	155.9
40 NH_4NO_3 -sd[5]	63.6	92.6	39.5	148.6	90.4	54.8	38.6	96.8	133.4	142.3
40 Urea - sd	57.7	95.6	24.9	142.3	94.1	48.4	50.4	86.1	132.2	143.3
80 NH_4NO_3 -sd	50.4	98.4	46.7	140.7	113.0	68.1	43.8	101.6	137.7	140.3
80 Urea - sd	76.9	86.4	48.2	143.8	121.4	64.7	47.3	117.0	146.9	166.2
160 NH_4NO_3-sd	40.7	97.4	77.7	151.7	109.5	77.6	51.4	120.2	141.5	148.3
Ave. annual corn yield in bu/A	58.6	93.3	39.4	147.5	101.3	60.3	37.8	101.8	135.7	140.9

[1]The entire area received and additonal 14 lbs N/A as starter fertilizer annually (8-24-12@ 180#/A).
[2]fpd -- fall plow down [3] fps -- fall plow surface [4] std -- spring topdress [5] sd -- sidedress

Table 2.(con't).

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	20 Year Ave.
Check	85.7	40.8	75.6	69.2	53.4	58.3		141.2	64.6	37.6	46.5	63.0
40 NH_4NO_3-fpd[2]	96.3	88.7	113.6	92.0	80.5	88.6	No	145.1	98.1	63.1	67.6	81.1
40 Urea-fpd	120.4	100.7	113.9	101.5	96.9	96.6		165.2	110.2	76.7	65.2	87.6
40 NH_4NO_3-fps	122.5	81.5	109.9	93.0	88.3	78.2	Yields	149.4	101.3	64.6	69.7	83.5
40 Urea-fpd	121.2	82.4	106.7	97.8	85.0	78.9		156.8	101.4	80.2	63.8	86.8
80 NH_4NO_3-fpd	134.7	108.0	143.1	121.7	103.6	89.2	Taken	156.9	128.4	94.8	90.3	100.6
80 Urea -fpd	141.4	107.8	140.1	117.9	107.2	96.9		146.0	123.6	86.2	84.7	98.7
160 NH_4NO_3-fpd	141.7	120.2	147.6	121.0	113.1	90.4		149.8	129.3	108.7	109.3	105.1
160 Urea-fpd	140.4	110.6	151.7	114.9	105.1	82.4		163.0	124.4	127.3	103.7	107.0
40 NH_4NO_3-std	125.6	84.0	117.0	104.0	82.8	88.0		160.0	97.4	86.6	77.2	91.0
40 Urea-std	118.9	94.6	116.5	97.1	94.5	89.0		165.2	103.9	74.5	64.3	90.0
80 NH_4NO_3-std	140.4	122.7	142.7	118.0	92.9	97.6		162.9	117.1	87.3	74.4	101.4
80 Urea-std	146.2	116.0	142.1	117.6	108.5	93.6		162.2	127.4	100.3	84.4	103.9
40 NH_4NO_3-sd[5]	127.1	104.5	136.0	99.1	82.7	91.8		153.8	106.8	99.2	71.9	92.8
40 Urea-sd	117.1	100.5	133.9	103.9	80.4	92.6		165.4	104.8	94.2	80.4	92.1
80 NH_4NO_3-sd	127.7	97.6	124.7	109.4	87.6	95.3		163.2	110.6	106.3	76.9	96.3
80 Urea-sd	140.5	124.4	149.8	124.0	95.6	90.1		162.8	126.7	118.1	89.6	105.7
160 NH_4NO_3-sd	136.9	104.2	150.0	117.1	105.5	91.3		160.3	126.0	148.0	109.8	107.1
Ave. annual corn yield in bu/A	127.0	99.4	128.6	106.6	92.4	88.3		157.2	111.2	91.9	79.4	94.1
Significance											**	**
C.V. (%)											18.2	10.3
BLSD (.05)											20.4	5.4

* Any letter(s) different from another letter in a column indicates a significant difference between the means at the 5% level.

Nitrate Correlation Study With Corn Following Corn, Soybeans and Wheat - Lamberton, MN - 1980

G.L. Malzer and W.W. Nelson

The rates of fertilizer nitrogen recommended for corn production in Minnesota are currently based upon yield goal and previous cropping history. In many respects depending on the climate conditions, these recommendations have the potential of being too high or too low. Nitrate nitrogen correlation studies were started in 1976 in S.W. MN to determine if residual nitrates could be used as a predictive tool in fertilizer recommendations. Adjustments in fertilizer recommendations are currently made on the basis of previous cropping history. For this reason, three separate experiments were established at the SW Experiment Station to evaluate the importance of previous crop in respect to residual nitrate nitrogen and fertilizer nitrogen response.

Experimental Procedures

Three separate experiments were established utilizing corn with previous cropping histories of corn, soybeans, and wheat. Six different rates of nitrogen fertilizer (none, 40,80,120,160 and 240 #N/A) were applied as spring applications of urea. The six nitrogen rates replicated six times in the corn following corn and corn following soybeans, and four times with corn following wheat. The fertilizer was applied on April 29th and incorporated by field cultivator, Corn (Pioneer 3780) was planted on April 30th at 26,000 seeds/A. A tank mix of Eradicane and Bladex was used for weed control.

Leaf samples from opposite and below the leaf at mid-silking were obtained for Kjeldahl nitrogen. Yields were taken by combine and adjusted to 15.5% moisture.

General Results

Corn grain yields during 1980 were severely restricted due to limited moisture at the S.W. experiment station. In spite of the lowered yields significance yield increase due to nitrogen fertilization were obtained in two out of three of the experiments. No nitrogen response was observed with the corn following soybeans while responses up through approximately 80 # N/A were obtained from corn following corn and corn following wheat. It is highly possible the overall yields as well as nitrogen response may be reflection of soil mositure differences between the previous cropping histories as well as a lack of nitrogen. Similar relationship have been noted with other trials conducted throughout SW Minnesota. Further research in the area of moisture vs. previous crop would be warranted to verify the observations noted.

Table 1. Influence of nitrogen rates on leaf N content and grain yield on corn following corn, soybean and wheat at Lamberton, MN - 1980.

	Corn/Corn		Corn/Soybeans		Corn/Wheat	
Treatments	Leaf N	Yield	Leaf N	Yield	Leaf N	Yield
#N/A	%	Bu/A	%	Bu/A	%	Bu/A
Check	1.57	45.5	2.42	101.7	1.83	84.1
40	2.02	61.8	2.47	101.3	1.95	102.2
80	2.26	86.1	2.51	98.0	2.42	122.5
120	2.34	82.9	2.66	105.5	2.63	124.9
160	2.62	88.0	2.78	106.2	2.68	122.8
240	2.69	93.1	2.70	104.5	2.76	127.7
Significance	**	**	**	NS	**	**
BLSD (.05)	0.21	16.1	0.16	-	0.17	13.5

Table 2. Residual nitrate nitrogen from locations following corn, soybean, wheat

depth	Residual NO_3 -N		
	corn/corn	corn/soybeans	corn/wheat
ft	#/A		
0-1	10	19	46
1-2	4	7	16
2-3	4	8	22
3-4	8	15	39
4-5	10	19	45

WEST CENTRAL EXPERIMENT STATION - MORRIS

WEATHER SUMMARY - 1980

		Precipitation			Air Temperature			Soil (10 cm) Temperature	
Month	Period	1980	94-yr. av.	Dev. from av.	1980	94-yr. av.	Dev. from av.	1980	10-yr. av.
January	1-31	1.17	.68	+ .49	11.1	8.0	+3.1	15.5	20.7
February	1-29	.63	.67	- .04	11.9	12.6	-0.7	17.6	23.9
March	1-31	1.09	1.09	0	21.9	26.7	-4.8	23.7	29.2
April	1-10	.13	.58	- .45	42.0	37.9	+4.1	38.2	
	11-20	.02	.65	- .63	44.6	44.4	+0.2	45.1	
	21-30	0	1.08	-1.08	56.4	48.2	+8.2	57.4	
Total or av.		.15	2.31	-2.16	47.7	43.5	+4.2	46.9	41.4
May	1-10	.05	.78	- .73	56.8	51.9	+4.9	61.2	
	11-20	.34	.95	- .61	52.8	55.8	-3.0	57.2	
	21-31	1.44	1.25	+ .19	70.1	60.1	+10.0	72.5	
Total or av.		1.83	2.98	-1.15	60.3	56.1	+4.2	64.0	57.1
June	1-10	5.03	1.26	+3.77	62.0	63.1	-1.1	61.8	
	11-20	.89	1.27	- .38	64.8	66.5	-1.7	70.4	
	21-30	.77	1.38	- .61	68.2	68.2	0	66.2	
Total or av.		6.69	3.91	+2.78	65.0	66.0	-1.0	68.3	69.3
July	1-10	.16	1.48	-1.32	70.4	70.0	+0.4	77.5	
	11-20	1.87	1.03	+ .84	74.0	71.3	+2.7	80.2	
	21-31	.37	1.03	- .66	67.7	71.5	-3.8	77.4	
Total or av.		2.40	3.54	-1.14	70.6	71.0	-0.4	78.3	76.7
August	1-10	.31	1.05	- .74	69.7	70.3	-0.6	76.7	
	11-20	1.67	.90	+ .77	65.6	69.2	-3.6	70.8	
	21-31	.96	.98	- .02	67.5	66.9	+0.6	71.6	
Total or av.		2.94	2.93	+ .01	67.6	68.7	-1.1	73.0	73.9
September	1-30	2.32	2.19	+ .13	56.9	59.1	-2.2	60.7	61.5
October	1-31	1.23	1.62	- .39	43.5	47.3	-3.8	45.8	47.8
November	1-30	.13	.96	- .83	34.1	29.7	+4.4	34.8	33.6
December	1-31	.18	.68	- .50	15.2	15.5	-0.3	19.7	23.4
April-August Growing Season		14.01	15.67	-1.66	62.3	61.1	+1.2	66.2	63.8
January-December Annual		20.76	23.56	-2.80	42.1	42.0	+0.1	45.8	46.7

CONTINUOUS CORN SILAGE

West Central Experiment Station - Morris

S. D. Evans

I. Experimental Description

In 1965 an experiment was initiated on McIntosh silt loam to determine the effect of removal of continuous corn silage and fertilizer on corn grain and corn silage yields and on soil properties. Rates of fertilizer used were 74 + 48 + 48 ($N + P_2O_5 + K_2O$) and 148 + 96 + 96. All plots received a broadcast application of 10 lbs/acre of zinc as zinc sulfate in the fall of 1965.

II. 1980 Operations

In 1980 the variety was Trojan TXS99. Counter was applied at 1 lb/acre (active ingredient) at planting on May 1. Lasso @ 2.5 lbs/acre plus Bladex @ 2.2 lbs/acre were applied broadcast on May 2. Silage yields were taken on September 22 and grain yields on October 10. Atrazine @ 1.5 lbs/acre plus booster concentrate @ 1 qt/acre were applied on June 9.

III. Silage Yields - Dry matter; tons/acre.

Treatment	1980 yield	1966-80 yield
Silage, low fertility	6.70	5.63
Silage, high fertility	6.92	6.04
Grain, low fertility	6.94	5.60
Grain, high fertility	6.95	5.87

IV. Grain Yields - Bushels/acre @ 15.5% M.

	1980 yield	1966-80 yield
Grain, low fertility	101.44	90.96
Grain, high fertility	106.79	93.68

V. Check Yields

Yields on an additional unfertilized, unreplicated check adjacent to the experimental area:

	1980 yield	1966-80 yield
Grain (0 + 0 + 0)	36.56 Bu/A	50.38 Bu/A
Silage (0 + 0 + 0)	3.44 Tons/A	3.74 Tons/A

VI. Discussion

A. In 1980 there were no significant differences in silage yields but the high fertility plots again yielded slightly more than the low fertility plots.

B. The 15-year average yields show very little difference between silage and grain plots, but there is still a slight advantage for the higher fertility level.

MANURE RATE STUDY

West Central Experiment Station - Morris

S. D. Evans, P. R. Goodrich, R. C. Munter and R. E. Smith

Solid and liquid beef manures were applied at three rates and the effects were compared against check plots. Treatments and results from previous years are given in Soil Series 91, 95, 97, 99, 103, 105, and 107. The last manure application was made in the fall of 1978, but fertilizer has been applied to the fertilized check each year.

I. Planting Information

The plots were planted to Pioneer 3901 on April 29, 1980. Counter @ 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row to the entire area at planting. Starter fertilizer consisting of 154 lbs/acre of 10-26-26 was applied to the fertilized treatment. Nitrogen in the form of urea had been applied on November 5, 1979, prior to plowing to provide 110 lbs/acre of N. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were applied broadcast on April 30, 1980. Atrazine (1.5 lbs/acre) plus booster concentrate (1 qt/acre) were applied on June 9, 1980.

II. Soil Sampling and Analysis

The plots were sampled in the fall of 1980 to a depth of 4 feet for NO_3-N analyses, but the results are not yet available.

III. Plant Tissue Analysis

A. 1979 Grain Samples (Table 1)

In general, higher manure rates increased the N content of the grain. In all cases the N content of the grain from the manured treatments was equal to or higher than that from the fertilized check.

B. 1980 Samples

1. Ear leaf samples at silking (Table 2)

The nutrient concentration of many elements in the ear leaves at silking was significantly affected by the manure treatments. In general, the manure treatments increased the N, P and K levels and decreased the Ca and Mg levels. The effects on Cu and Mn were significant but not related directly to manure application.

2. Grain samples (Table 1)

The effect of the treatments on grain N content was almost identical to that observed in 1979.

IV. Growth and Yield Measurements

A. Early plant height and dry weight - All manure treatments except LB1 were significantly taller and heavier than the fertilized treatment. With both solid and liquid beef manure, there was some trend toward larger plants with increasing manure rates.

B. Grain yield - The only manure treatment significantly higher yielding than FE was LB3. All of the other manure treatments except SB2 were higher yielding than FE.

C. Silage yield - All manure treatments except LB1 and LB2 were significantly higher yielding than the fertilized treatment.

V. Summary

The 1980 cropping season was the second since manure had been applied. It appears that even the lowest rates of each manure were sufficient for yields equal to or higher than the fertilized check.

Table 1. N content of corn grain samples, 1979 and 1980.

Year	Treatment CK	FE	SB1	SB2	SB3	LB1	LB2	LB3	Treatment Significance	5% BLSD
	% N									
1979	1.21	1.68	1.73	1.85	1.77	1.68	1.72	1.75	**	.12
1980	1.14	1.48	1.60	1.70	1.79	1.46	1.52	1.62	**	.18

Table 2. Summary of analysis of corn leaves at silking - 1980.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.45	.26	1.61	.50	.49	94	17.5	4.1	71	5.2
FE	2.84	.27	1.76	.60	.51	99	23.0	5.2	104	5.5
SB1	2.94	.33	2.33	.48	.33	104	15.2	6.0	103	5.3
SB2	2.96	.39	2.35	.52	.30	106	15.7	5.1	114	5.5
SB3	2.97	.47	2.69	.41	.24	109	14.7	3.9	87	4.9
LB1	2.84	.31	1.84	.57	.42	98	18.6	5.5	111	5.5
LB2	2.81	.35	2.18	.49	.34	104	15.2	5.1	108	5.4
LB3	2.86	.34	2.12	.53	.35	109	16.1	5.6	97	5.3
Significance:	*	**	**	**	**	+	+	**	*	NS
BLSD (.05):	.31	.08	.17	.07	.06	-	-	0.5	29	-

Table 3. Summary of plant measurements - 1980.

Treatment	Early plant height	Early plants (10) dry weight	Grain: Grain moisture at harvest	Grain: Yield @ 15.5% M.	Silage: Dry matter at harvest	Silage: Silage yield (D.M.)	Silage: Ear wt. ÷ silage wt.
	inches	grams	%	Bu/A	%	lb/A	%
CK	28.0	71.7	21.2	68.6	54.6	8335	56.8
FE	32.2	107.0	20.0	115.7	48.3	13481	59.8
SB1	39.4	173.0	18.4	121.6	53.0	16189	55.2
SB2	40.2	189.3	19.7	111.5	45.3	15440	57.1
SB3	40.0	181.3	20.1	124.5	43.3	15921	55.3
LB1	34.0	121.7	18.7	123.1	51.3	14477	61.5
LB2	36.6	146.7	18.0	124.7	50.0	14337	59.5
LB3	40.1	183.3	18.0	135.3	45.2	15956	59.0
Significance:	**	**	NS	**	**	**	*
BLSD (.05):	2.0	19.9	-	14.4	5.2	1246	3.7

RESIDUAL EFFECT OF HEAVY APPLICATIONS OF ANIMAL MANURES ON CORN GROWTH AND YIELD AND ON SOIL PROPERTIES

West Central Experiment Station - Morris

S. D. Evans, P. R. Goodrich, R. C. Munter and R. E. Smith

The experiment initiated in 1970 was continued. Treatments and results in previous years are given in Soil Series 88, 89, 91, 95, 97, 99, 103, 105, and 107. Manure was applied in 1970 and 1971 only. Fertilizer has been applied to the fertilized checks each year.

I. Planting Information

Twenty-four rows of corn (var. Pioneer 3901) were planted in each plot on April 29, 1980. Counter @ 8.8 lbs/acre (1 lb/acre active ingredient) was applied in the row at planting to all plots. Starter fertilizer consisting of 154 lbs/acre of 10-26-26 was applied to the fertilized treatment only. Nitrogen in the form of urea was applied to the fertilized plots to provide 110 lbs/acre of N on November 5, 1979. Lasso (2.5 lbs/acre) and Bladex (2.2 lbs/acre) were applied broadcast on April 30, 1980. Atrazine (1.5 lbs/acre) and booster concentrate (1 qt/acre) were applied on June 9, 1980.

II. Soil Sampling and Analysis

The soils were sampled to a depth of 4 feet in the fall of 1980 for NO_3-N analysis but the results are not yet available.

III. Plant Tissue Analysis

A. 1979 Harvest Samples (Table 1)

The N contents of the grain from the fertilized and beef manure plots were not significantly different, but grain from the hog manure treatment was significantly lower than from the liquid beef treatment.

B. 1980 Samples

1. Corn leaves at silking

The nutrient concentrations in the ear leaves at silking in 1980 are given in Table 2. There were significant effects of at least some type of manure as compared to the fertilized treatment in the N, P, K, Ca, Mg, Fe, Zn, and Cu levels. The levels of P, K, and Cu were generally higher in the manured plots and Ca and Mg were generally lower.

2. Grain Samples at Harvest (Table 1)

The results in 1980 were identical to those in 1979 described above.

IV. Growth and Yield Measurements (Table 3)

A. Early plant height and dry matter - The liquid beef manure produced the largest plants followed by solid beef manure. The liquid beef manure plants were almost identical in height to the fertilized plants but were slightly heavier.

B. Grain yield - There were no significant differences between the fertilized and manured treatments but the hog manure treatment was the lowest yielding.

C. Silage yields - As with grain yield, there were no significant differences between fertilized and manured treatments, but the liquid hog manure treatment was again the lowest.

V. Summary

The effects of the manure treatments applied in 1970 and 1971 still show up in most plant measurements. Plant and grain analysis and yield checks show that the liquid hog manure treatment is starting to lose its effect as compared to the other two manure treatments.

Table 1. N content of corn grain, 1979 and 1980.

Year	Treatment* CK	FE	SB	LB	LH	Treatment Significance	BLSD 5%	C.V. %
	% N							
1979	1.10	1.76	1.73	1.82	1.67	**	.10	3.6
1980	1.08	1.45	1.51	1.53	1.42	**	.10	4.1

* CK = CHECK, FE = FERTILIZED, SB = SOLID BEEF MANURE, LB = LIQUID BEEF MANURE, LH = LIQUID HOG MANURE

Table 2. Summary of analysis of corn leaves at silking - 1980.

Treatment	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
CK	2.10	.24	1.56	.54	.47	95	16.7	4.5	83	5.7
FE	2.83	.29	1.74	.59	.50	99	20.2	4.2	86	5.4
SB	2.71	.33	2.21	.48	.28	101	18.3	5.7	101	5.5
LB	2.81	.38	2.32	.51	.29	117	15.4	5.2	89	5.3
LH	2.59	.33	2.11	.50	.41	97	21.4	5.3	79	5.5
Significance	**	**	**	**	*	**	*	*	NS	NS
BLSD (.05)	.27	.04	.28	.03	.18	9	4.0	1.1	-	-

Table 3. Summary of plant measurements - 1980.

Treatment	Early plant height	Early plants(10) dry weight	Grain: Grain moisture at harvest	Grain: Yield @ 15.5% M.	Silage: Dry matter at harvest	Silage: Silage yield (D.M.)	Silage: Ear wt. ÷ silage wt.
	inches	grams	%	Bu/A	%	lbs/A	%
CK	26.6	64.7	22.2	44.6	56.0	6070	53.8
FE	35.1	127.0	21.4	119.8	47.2	15254	57.0
SB	39.1	157.7	16.8	119.9	56.4	15255	58.7
LB	40.3	184.3	19.0	118.8	51.6	14168	59.5
LH	35.6	140.3	17.8	106.0	53.7	12382	63.6
Significance	**	**	**	**	**	**	NS
BLSD (.05)	2.9	34.6	2.0	14.1	4.0	3616	-

Nitrogen Fertilization and Nitrogen Utilization by Eight Small Grain Varieties - Morris, MN. - 1980

G.L. Malzer, S. Evans, and R. Busch

The semi-dwarf varieties of hard red spring wheat accounts for a major portion of the acreage planted to hard red spring wheat in Minnesota. These short statured varieties not only provided improved physical characteristics, but also provided the potential for a system which might be capable of responding to higher rates of nitrogen application without lodging. The difference that exists between wheat varieties in their ability to utilize soil and fertilizer nitrogen is not well understood. A portion of the differences which exists may be due to the genetic ability of the plant because of some favorable plant characteristic either above or below the soil surface. If selection of plant genotypes can be made for more effective nitrogen uptake and utilization, advancements may be made in increasing present yield levels as well as improving the over all protein content of the grain. Trials were established in 1980 to examine some of the differences which exist between wheat varieties in their response to fertilizer nitrogen and their ability to utilize existing soil nitrogen. Existing popular varieties as well as older varieties and experimental varieties were included for comparison. Similar trials were conducted at Crookston as well as Morris, MN.

Experimental Procedures

Eight varieties of hard red spring wheat were compared at nitrogen application rate of 0,60 and 120# N/A at the West Central Experiment Station at Morris. Nitrogen was applied as spring applications of ammonium nitrate broadcast and incorporated. The treatments were arranged in a split plot design with nitrogen as the main effect and the eight varieties planted within a uniformly fertilized area. All treatments were replicated four times. Experimental plots were planted into areas 4' x 20' on April 17th.

Total plant dry matter was measured at approximately the "soft dough" stage of growth (July 3rd) and samples collected for nitrogen content and calculation of nitrogen uptake. Yield grain was harvested on July 31 by harvesting 16 ft.^{2} of the plot area. The above ground growth (straw & grain) was removed from the experimental plot area, allowed to air dry in a forced air dryer. The samples were then weighed, thrased and the grain reweighed for yield determination. Straw weights were determined by difference. Samples of straw and grain were collected and analyzed for nitrogen content and determination of nitrogen removal.

General Results

The 1980 yield results obtained from Morris in 1980 were excellent. This, in spite of the early dry spring which caused considerable problems with emergence and stand uniformity. Grain yields ranged from 30-54 bu/A with positive response to nitrogen fertilization up to the 60# N/A rate of application. Although yield responses were obtained only up to the 60 pound rate of nitrogen application significant increases were obtained in grain protein and many other nitrogen uptake characteristics to the highest rate of nitrogen fertilization (120# N/A). Nitrogen fertilization significantly decreased test wt with each increment of application. Averaged over all nitrogen rates, the highest yielding varieties included MN 70170R, MN 7222, Era and Coteau. Significant differences (.05) between varieties were not only obtained with yield but also with other nitrogen utilization parameters. Of the four highest yielding varieties above, Coteau had the highest overall protein content. Total nitrogen removal by the above ground portion was however the highest with MN 70170R and Coteau while WS 1809 utilized the lowest total quantity of nitrogen. Results would suggest varietal differences not only with total nitrogen removal, but also differences in the ability of the various plant systems to translocate nitrogen into the grain. Both considerations should be evaluated in the attempt to develop plant systems with both high yields and high protein characteristics.

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

Nitrogen Rate	Variety	Grain Yield	Grain N content	Grain Test wt.	Forage Total Dry Matter	Forage N content
#/A		bu/A	%	#/bu	T/A	%
0	-	39.5	2.53	58.0	1.87	1.30
60	-	49.8	2.60	56.4	2.44	1.53
120	-	49.0	2.75	55.4	2.49	1.72
Significance		**	**	**	**	**
BLSD (.05)		3.7	0.07	0.9	0.22	0.08
-	Coteau	48.1	2.85	58.7	2.40	1.49
-	WS 1809	36.0	2.64	53.3	1.86	1.58
-	Era	48.8	2.39	57.0	2.34	1.56
-	Mn 70170R	52.0	2.55	57.6	2.31	1.60
-	Chris	42.2	2.75	57.8	2.29	1.44
-	James	46.8	2.64	56.9	2.35	1.54
-	Waldron	45.8	2.84	56.7	2.42	1.49
-	Mn 7222	49.2	2.33	54.7	2.15	1.43
Significance		**	**	**	**	**
BLSD (.05)		2.6	0.09	0.9	0.12	0.10
0	Coteau	38.4	2.70	58.9	1.98	1.24
0	WS 1809	29.7	2.52	56.5	1.96	1.34
0	Era	40.0	2.27	59.0	1.93	1.30
0	Mn 70170R	47.3	2.37	60.0	1.94	1.36
0	Chris	37.3	2.71	58.0	1.90	1.26
0	James	38.9	2.62	57.5	1.90	1.32
0	Waldron	40.9	2.87	57.0	2.03	1.37
0	Mn 7222	43.7	2.18	56.9	1.80	1.22
60	Coteau	52.4	2.86	58.5	2.60	1.50
60	WS 1809	40.1	2.69	53.6	2.10	1.71
60	Era	51.8	2.52	56.4	2.51	1.50
60	Mn 70170R	56.9	2.42	57.0	2.49	1.62
60	Chris	45.1	2.72	57.9	2.45	1.40
60	James	52.1	2.54	56.6	2.59	1.56
60	Waldron	47.8	2.73	56.3	2.49	1.48
60	Mn 7222	52.5	2.30	54.7	2.27	1.46
120	Coteau	53.6	2.98	58.6	2.61	1.72
120	WS 1809	38.1	2.71	49.9	2.02	1.68
120	Era	54.8	2.38	55.5	2.60	1.87
120	Mn 70170R	51.9	2.87	55.6	2.49	1.83
120	Chris	44.4	2.82	57.4	2.52	1.64
120	James	49.4	2.77	56.7	2.55	1.74
120	Waldron	48.8	2.93	56.6	2.74	1.64
120	Mn 7222	51.4	2.51	52.3	2.38	1.61
Signifiance		NS	**	**	NS	NS
BLSD (.05)		--	0.91	1.8	--	--

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

Nitrogen Rate	Variety	Harvest Straw		Nitrogen Removal			
		Dry Matter	N content	Forage	Straw	Grain	Grain & Straw
#/A		T/A	%	#/A			
0	-	1.46	0.45	48.7	13.1	55.6	68.7
60	-	2.05	0.57	74.5	23.2	72.0	95.2
120	-	2.25	0.75	85.7	33.5	75.1	108.6
Significance		**	**	**	**	**	**
BLSD (.05)		0.22	0.09	8.3	4.2	6.2	8.9
-	Coteau	2.08	0.52	72.5	22.0	77.0	99.0
-	WS 1809	1.62	0.72	59.6	24.3	53.3	77.5
-	Era	1.83	0.59	74.7	22.5	65.4	87.9
-	Mn 70170R	1.93	0.66	75.0	26.8	74.2	101.0
-	Chris	2.03	0.50	66.7	20.8	64.9	85.7
-	James	2.09	0.54	73.2	23.1	69.0	92.1
-	Waldron	2.09	0.54	72.9	23.0	72.8	95.8
-	Mn 7222	1.70	0.66	62.5	23.5	64.1	87.6
Significance		**	**	**	**	**	**
BLSD (.05)		0.11	0.07	7.2	6.1	4.8	6.7
0	Coteau	1.59	0.43	49.2	13.7	58.0	71.6
0	WS 1809	1.18	0.56	39.1	13.1	42.0	55.1
0	Era	1.39	0.46	50.3	13.1	50.4	63.5
0	Mn 70170R	1.48	0.46	53.1	13.9	62.7	76.6
0	Chris	1.66	0.39	47.9	13.0	56.4	69.4
0	James	1.50	0.43	50.1	12.8	56.7	69.5
0	Waldron	1.64	0.44	55.8	14.3	65.6	80.0
0	Mn 7222	1.25	0.45	44.2	11.2	53.1	64.3
60	Coteau	2.27	0.53	78.3	24.2	83.8	108.0
60	WS 1809	1.66	0.66	71.8	21.8	60.2	82.0
60	Era	1.90	0.58	75.6	21.9	72.8	94.7
60	Mn 70170R	2.02	0.66	80.9	26.6	76.8	103.4
60	Chris	2.15	0.46	60.1	19.7	68.4	88.1
60	James	2.40	0.55	80.8	26.3	73.8	100.1
60	Waldron	2.18	0.50	73.3	22.1	73.0	95.1
60	Mn 7222	1.82	0.62	66.2	22.8	67.3	90.0
120	Coteau	2.37	0.59	90.1	28.2	89.1	117.4
120	WS 1809	2.04	0.93	68.0	37.8	57.6	95.4
120	Era	2.20	0.73	98.1	32.5	73.0	105.5
120	Mn 70170R	2.28	0.88	91.0	39.8	83.1	122.9
120	Chris	2.28	0.65	83.1	29.7	69.8	99.6
120	James	2.37	0.64	88.9	30.3	76.4	106.7
120	Waldron	2.46	0.66	89.6	32.7	79.8	112.5
120	Mn 7222	2.02	0.91	77.0	36.6	72.0	108.6
Significance		NS	+	NS	+	NS	NS
BLSD (.05)		--	0.14	--	6.9	--	--

Influence of Nitrogen Fertilization On Forage Production And Nitrogen Utilization By Three Small Grain Varieties

G.L. Malzer and S. Evans

The semi-dwarf varieties of hard red spring wheat account for the major portion of acreage in Minnesota planted to hard red wheat. The advent of these short stemmed wheat varieties not only provided improved physical characteristics and a high yield potential, but also provided a plant system which was capable of responding to higher application rates of nitrogen without lodging. The reasons why some semi-dwarf wheat varieties appear to be more responsive to nitrogen application is not well understood, but it has been suggested that it may be an inter-relationship of a highly efficient rooting system along with it's above ground physical characteristics. An experiment was established to investigate the root growth characteristics of different hard red spring wheat varieties as influenced by nitrogen application and to assess if below ground parameters could be used in the selection of small grain varieties for efficient nitrogen utilization.

Experimental Procedures

Six treatments including three hard red spring wheat varieties were combined with two nitrogen treatments into a randomized complete block design with three replications and the plots established at the West Central Experiment Station at Morris. The three wheat varieties included Chris (medium height), Era (semi-dwarf), and Mn 7125 (Experimental Semi-dwarf). The nitrogen treatments included either zero or 120 #N/A as ammonium nitrate applied as a spring preplant incorporated treatment.

Dry matter production was determined at three different times during plant growth and analyzed for nutrient composition. Grain was harvested on July 31 by hand harvesting 30 ft^2 of plot area. The above ground growth (straw & grain) was removed from the experimental plot area, allowed to air dry in a forced air dryer. The samples were then weighed, thrashed and the grain reweighed for yield determination. Straw weight was determined by difference. Samples of straw and grain were collected and analyzed for nitrogen content and determination of nitrogen removal. Soil samples were obtained at the four sampling above (May 27, June 17, July 3, and July 31) for determination of rooting density, soil moisture and soil nitrate nitrogen. Root samples were obtained utilizing a coring technique. For root analysis, samples were collected over the row and between the row to a depth of four feet. Each core (2 5/8" diameter) was divided into eight 6" increments and each sample consisted of a composite of two cores. The root samples at this time are in the process of being analyzed. Soil samples for moisture and nitrate analysis were taken in a similar manner by obtaining one core in the immediate area from which the root samples were obtained.

General Results

The 1980 growing season was characterized by being extremely warm and dry during the first 4-6 weeks. This created numerous problems including poor germination and uneven stands. At the Morris location rainfall was obtained in early June to recharge the soil moisture in the profile to a substantial depth. The final results obtained from this experiment were excellent even when considering the questionable early environmental conditions. Forage yield, grain yield and nitrogen utilization characteristics of the three varieties tested are included in Table 1. Forage dry matter production at the first sampling was increased when nitrogen was applied with Era but not with the other varieties. Increase in dry matter production due to nitrogen fertilization were observed with the other varieties at subsequent samplings, while the responses obtained with Era deminished with time. Nitrogen concentration of the forage was not influenced by nitrogen fertilization or variety at the first sampling but positive increases were obtained with later samplings. No variety differences in nitrogen concentration in the forage was obtained with the controls, but variety differences were obtained when nitrogen fertilizer was added. Only MN 7125 provided a significant (.05) yield response to applied nitrogen, although the other varieties also reflected a positive trend.

Nitrogen removal in the grain and straw reflected the nitrogen treatments, with relatively little difference between varieties at either the low or high nitrogen fertility.

Table 1. Forage yield, forage N content, total forage nitrogen removal, and yield grain characteristics of three small grain varieties as influenced by nitrogen treatment.

Treatment		Forage Yield Harvest No.			Forage N Content Harvest No.		
Variety	N Rate	1	2	3	1	2	3
	#/A	------T/A-------			----------	----------	
Chris	0	0.25	1.32	2.21	3.32	1.64	0.99
Chris	120	0.27	1.56	3.56	3.35	2.56	1.52
MN7125	0	0.25	1.11	2.46	3.28	1.51	1.02
MN7125	120	0.29	1.81	3.51	3.36	2.52	1.67
Era	0	0.25	1.17	2.36	3.12	1.70	1.12
Era	120	0.40	1.51	2.80	2.84	2.88	1.80
Significance		*	**	*	NS	**	**
BLSD (.05)		0.11	0.33	1.04	--	0.28	0.21

		Forage N Removal			Grain Yield	Straw Yield	Harvest N Content		Harvest N Removal		Test wt
		1	2	3			Grain	Straw	Grain	Straw	
		------#/A-------			bu/A	T/A	------	-----	-----#/A----		#/bu
Chris	0	16.6	43.3	43.5	37.9	1.78	2.51	0.34	57.1	12.1	54.9
Chris	120	18.0	80.0	108.3	47.7	2.77	2.85	0.81	81.9	44.8	55.3
MN7125	0	16.3	33.4	50.0	43.9	1.40	2.09	0.46	55.3	12.9	56.4
MN7125	120	19.7	91.3	117.1	57.0	2.33	2.56	0.87	87.7	40.5	52.8
Era	0	15.4	38.4	52.8	49.2	1.46	2.15	0.45	64.2	13.3	57.8
Era	120	22.2	87.2	104.4	57.8	2.44	2.63	0.81	91.6	39.8	52.4
Significance		**	**	**	**	**	**	**	*	**	NS
BLSD (.05)		3.12	11.5	38.0	10.0	0.32	0.39	0.11	26.7	7.8	--

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Use Of N-Serve As A Nitrification Inhibitor In Fall Vs. Spring Nitrogen Application Programs For Corn Production in West Central Minnesota

G.L. Malzer and S. Evans

A considerable interest has developed over the last several years concerning the use of N-Serve as a nitrification inhibitor with ammonium forming fertilizers on fine textured soils of Minnesota. On many of these fine textured soils, depending on the climatic conditions encountered and internal soil drainage, losses of nitrate nitrogen may occur through denitrification. If this loss occurs a portion of the plant available nitrogen is lost, and yield reductions may develop. With the normally cool wet spring conditions which are encounted on most of these soils, there may also be a considerable advantage in time management, associated with earlier nitrogen fertilization. This condition exists provided that nitrogen losses are not severe in the interm period. If nitrification inhibitors are capable of minimizing the production of nitrate nitrogen with fall nitrogen applications, they may have the advantage of minimizing potential nitrate nitrogen losses as well as increasing the length of time that would be available in the fall to apply nitrogen (prior to 50-55° soil temperatures).

Experimental Procedures

An experiment consisting of four replications of fourteen treatments was established at the West Central Experiment Station at Morris MN for the 1980 growing season. The treatments consisted of a control, three times of nitrogen application (1-Sept 20, 1979, 2-Oct 29, 1979, and 3-May 2, 1980), and two rates of nitrogen fertilization (40 or 80 # N/A) with all N combinations with and without N-Serve at 0.5 # a.i./A. An additional spring treatment of 120 # N/A without N-Serve was also included in the experiment. Corn (Dekalb XL12) was planted on May 6th at a seeding rate of 22,000 seeds/A. Weed control was accomplished with a tank mix of Lasso (2½ # a.i./A) plus Bladex (2#a.i./A).

Leaf samples were collected from opposite and below the ear at silking and Kjeldahl nitrogen determined. Total dry matter production was determined on September 17th by hand harvesting 50 ft^2. Ears were separated from the stalks, field weights obtained, and samples removed for moisture determination and Kjeldahl nitrogen analysis for calculation of nitrogen removal. Corn grain yields were collected by machine harvesting two rows 55 ft. long from each plot on October 9th, subsamples were taken for moisture determination.

General Results

Corn grain yields at the West Central Experiment Station were quite good in 1980. Yield responses to nitrogen fertilization were obtained up through the 80 pound/acre rate of application. Time of nitrogen application, as well as, use of a nitrification inhibitor (N-Serve) provided relatively few differences in the parameters measured. This would suggest that net nitrogen losses to the extent of reducing yields were not great during the fall of 1979 or spring of 1980. This information follows the responses that have been obtained in the past three years with timing of N application and use of nitrification inhibitors at the West Central Experiment Station. The results would therefore suggest that nitrogen losses in this area on similar soils are relatively small. It would also suggest (within the constraints of the experiment) that there is considerable flexibility with fall nitrogen management programs and that perhaps the 50-55° F temperature recommendations currently being utilized may not be as critical as what might be observed in South Central Minnesota.

Table 1. Influence of nitrogen rate of application, time of application and the use of N-Serve as a nitrification inhibitor on leaf N content, grain yield, yield grain N content, dry matter production and nitrogen removal on corn from Morris, MN - 1980

Treatments						Dry Matter Production			Dry Matter N-Content		Dry Matter N-Removal		
N Rate	Time	Inh.	Leaf N	Grain Yield	Yield Grain N	Grain	Stover	Total	Grain	Stover	Grain	Stover	Total
#/A		0.5#ai/A	%	Bu/A	%	T/A			%		lbs/A		
Check		No	2.14	89.9	1.15	2.61	3.22	5.83	1.12	0.59	58.7	38.1	96.8
40	1	No	2.66	119.2	1.37	3.54	3.62	7.17	1.37	0.72	97.4	51.7	149.1
40	1	Yes	2.69	125.8	1.36	3.63	3.91	7.54	1.32	0.64	96.3	50.7	147.1
80	1	No	2.90	135.3	1.53	3.83	3.93	7.76	1.53	0.78	117.5	61.6	179.1
80	1	Yes	2.92	122.4	1.44	3.78	3.81	7.58	1.51	0.73	114.2	55.3	169.5
40	2	No	2.84	122.6	12.8	3.36	3.68	7.05	1.33	0.65	89.7	48.2	138.0
40	2	Yes	2.75	123.3	1.41	3.42	3.63	7.04	1.30	0.75	89.3	54.8	144.1
80	2	No	2.85	125.5	1.42	3.52	3.90	7.42	1.44	0.72	101.6	56.4	158.0
80	2	Yes	2.87	131.3	1.47	3.63	3.83	7.46	1.47	0.72	106.9	55.9	162.8
40	3	No	2.78	122.0	1.36	3.37	3.69	7.07	1.34	0.67	90.8	49.5	140.3
40	3	Yes	2.75	126.0	1.49	3.63	3.72	7.35	1.44	0.71	104.4	52.7	157.1
80	3	No	2.93	128.9	1.52	3.84	4.04	7.88	1.57	0.79	120.4	63.5	183.8
80	3	Yes	2.85	130.5	1.51	3.75	3.92	7.67	1.51	0.82	113.3	64.8	178.1
120	3	No	3.14	133.3	1.57	3.88	4.10	7.98	1.51	0.89	117.1	72.7	189.8
Significance			**	**	**	**	*	**	**	*	**	**	**
BLSD(.05)			0.16	12.7	0.11	0.42	0.48	0.78	0.11	0.17	13.1	13.7	23.1
N-Rate													
40			2.75	123.1	1.38	3.49	3.71	7.20	1.35	0.69	94.7	51.3	145.9
80			2.89	129.0	1.48	3.73	3.90	7.63	1.51	0.76	112.3	59.6	171.9
Significance			**	*	**	*	*	**	**	*	**	**	**
BLSD(.05)			0.09	5.6	0.07	0.18	0.16	0.41	0.05	0.06	8.0	7.1	13.6
Inhibitor													
No			2.83	125.6	1.42	3.58	3.81	7.39	1.43	0.72	102.9	55.2	158.1
Yes			2.80	126.5	1.45	3.64	3.80	7.44	1.43	0.73	104.1	55.7	159.8
Significance			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
BLSD(.05)			-	-	-	-	-	-	-	-	-	-	-
Time													
1			2.79	125.7	1.43	3.70	3.82	7.52	1.44	0.72	106.4	54.8	161.2
2			2.83	125.7	1.40	3.48	3.76	7.25	1.39	0.71	96.9	53.8	150.7
3			2.83	126.8	1.47	3.65	3.84	7.49	1.46	0.75	107.2	57.6	164.8
Significance			NS	NS	+	NS	NS	NS	*	NS	*	NS	+
BLSD (.05)			-	-	0.06	-	-	-	0.05	-	7.5	-	11.6

SOIL TEST LAB COMPARISON

West Central Experiment Station - Morris

S. D. Evans and W. E. Jokela

In the past few years the number of commercial laboratories testing soils in west central Minnesota has increased. In many cases the commercial laboratory fertilizer recommendations differ greatly from those of the University of Minnesota Soil Testing Laboratory. In order to develop educational material for use by the extension soils specialists, trials were started at the West Central Experiment Station in 1980 on a corn-wheat rotation.

In the fall of 1979 a large composite soil sample was taken. This sample was dried thoroughly, mixed and sub-divided and sent to five different laboratories for a complete analysis. Recommendations were requested for corn at a yield goal of 110 Bu/A and spring wheat at a yield goal of 55 Bu/A. In the spring of 1980 samples were taken to a depth of 2 feet in the 1980 wheat area and again sent to the five laboratories for NO_3-N analysis and N recommendations. After receiving the soil tests and recommendations (Tables 1 and 2), the fertilizer treatments were calculated with (1) an adjustment for soil buildup over a period of years (LAB C) and (2) an adjustment for wheat only to convert drill recommendations to broadcast recommendations (LABS A and E).

General

The experiment was set up as a randomized complete block with 4 replications on each crop. Two blocks, each with 24 plots, are adjacent to one another and will alternate between wheat and corn. The plot size is 15 feet by 40 feet. Row spacing on the corn is 30 inches.

Wheat

The P, K and S treatments for wheat were applied broadcast by hand in a dry form on April 23. The micronutrients were dissolved in water and sprayed onto the plots the same day. Since NO_3-N analyses were not available, N was applied as urea to supply 30 lb/A of N. All plots were then worked with a field cultivator and Era wheat was seeded @ 1 3/4 Bu/A. After receiving the NO_3-N readings, the remainder of the recommended N was applied as ammonium nitrate on May 13. On May 16 bromoxynil (.25 lb/A) and MCPA ester (.25 lb/A) were applied for weed control. The upper 4-5 leaves from 20-25 plants were collected on June 16 prior to flowering for nutrient analysis. The plots were harvested with a plot combine on July 31 (Rep I) and August 4 (Reps II, III and IV). Samples of grain were saved for protein analysis.

Corn

The N, P, K and S treatments for corn were applied broadcast by hand in a dry form on May 8. The micronutrients were dissolved in water and sprayed onto the plots the same day. All plots were then worked with a field cultivator and planted to corn on May 9. The variety was Trojan TXS 99 and was planted at 22,000-23,000 seeds per acre. There was no starter fertilizer used. An insecticide, Counter, was applied in the row at 8.8 lb/A (1 lb/A active ingredient). Herbicides used were Lasso @ 2.5 lb/A and Bladex @ 2.2 lb/A on May 12 and 2,4-D LV ester @ .33 lb/A on June 9. Early plant heights were taken on June 19 and ear leaf samples were collected from 10 plants on July 18. The plots were harvested with a plot combine on October 10. Samples of grain were saved for protein analysis.

Results and Discussion of Wheat Trial

As shown in Table 1, the soil test and fertilizer recommendations varied greatly with laboratory. All of the commercial labs recommended sulfur and three recommended at least one micronutrient. There were also wide variations in N, P and K recommendations.

The leaf analysis of the wheat (Table 3) showed significant effects on N, Ca and Mn. LAB D consistently shows up with low concentrations of these elements and in some cases is not significantly different from the check. LABS A, B, C and E are not significantly different.

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Table 1. Soil test results and the suggested fertilizer program for wheat in 1980.

Test	Soil Test Results[1]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
pH	8.1	7.4	7.7	7.7	7.5
Phosphorus (Bray 1)	7-L	10-L	-	12-M	9
($NaHCO_3$)	-	34-M	6-L	-	-
Potassium	126-H	142-M	140-L	135	110
Organic matter (%)	3.8	3.6-H	3.6-H	M	H
Calcium	8000	3260-H	4900-VH	3600-M	-
Magnesium	1040	570-VH	670-VH	620-H	-
Sodium	118	-	21-M	-	-
Sulfur	5-L	8-M	9-L	1-VL	8
Iron	27.3-H	17-H	23.3-H	4-H	-
Manganese	12.3-VH	8-L	6.2-ADQ	10-H	-
Zinc	1.93-H	1.8-M	0.7-L	4.8-ADQ	1.6
Copper	0.85-H	0.6-L	0.7-ADQ	2.6-L	-
Boron	-	0.9-M	0.6-L	-	-
ENR (lb/A)	60	72	-	-	-
Nitrate nitrogen (lb/A)	60(0-2 ft)	11-M	5-VL	72	61(0-2 ft)
C.E.C. (meq/100 g)	24.9	21.4	30.5	-	-
Soluble salts (mmhos/cm)	0.3	-	0.15	-	0.6

Nutrient	Suggested Fertilizer Program[2]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
Nitrogen	75	80	90	28	60
Phosphorus (P_2O_5)	48[3]	60	78[4]	34	45[3]
Potassium (K_2O)	25[3]	85	130[4]	80	23[3]
Sulfur	2	10	24	40	-
Zinc	-	2	3	-	-
Manganese	-	2	-	-	-
Copper	-	0.5	-	2	-
Boron	-	-	1.0	-	-

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

[2] All values indicate pounds of nutrient suggested per acre for a yield goal of 55 bushels of wheat per acre.

[3] Values specified for drill application so were increased by 50% and applied broadcast.

[4] Values include maintenance plus 1/3 of suggested buildup, both applied in 1980, with remaining 2/3 of buildup to be applied in 1981 and 1982.

Table 2. Soil test results and the suggested fertilizer program for corn in 1980.

Test	Soil Test Results[1]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
pH	8.1	7.6	7.7	7.7	7.5
Phosphorus (Bray 1)	7-L	8-L	-	12	9
($NaHCO_3$)	-	30-M	6-L	-	-
Potassium	126-H	131-M	140-L	135	110
Organic matter (%)	3.8	2.9-M	3.6-H	M	H
Calcium	8000	2900-H	4900-VH	3600-M	-
Magnesium	1040	554-VH	670-VH	620-H	-
Sodium	118	-	21-M	-	-
Sulfur	5-L	6-L	9-L	1-VL	8
Iron	27.3-VH	15-L	23.3-H	4-H	-
Manganese	12.3-VH	7-L	6.2-ADQ	10-H	-
Zinc	1.93-H	1.7-M	0.7-L	4.8-ADQ	1.6
Copper	0.85-H	0.5-L	0.7-ADQ	2.6-H	-
Boron	-	1.2-M	0.6-L	-	-
ENR (lb/A)	60	74	-	-	-
Nitrate-Nitrogen (lb/A)	144	19-M	2-VL	152	147
C.E.C. (meq/100 g)	24.9	19.5	30.5	-	-
Soluble salts (mmhos/cm)	0.3	-	0.15	-	0.6

Nutrient	Suggested Fertilizer Program[2]				
	LAB A	LAB B	LAB C	LAB D	LAB E (UM)
Nitrogen	75	125	105	150	90
Phosphorus (P_2O_5)	100	75	92[3]	85	100
Potassium (K_2O)	50	115	158[3]	140	30
Sulfur	20	14	16	40	-
Zinc	-	1.5	7.5	-	-
Manganese	-	2	-	-	-
Copper	-	0.5	-	2	-
Boron	-	-	1.0	-	-

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

[2] All values indicate pounds of nutrient suggested per acre for a yield goal of 110 bushels of corn per acre.

[3] Values include maintenance plus 1/3 of suggested buildup, both applied in 1980, with remaining 2/3 of buildup to be applied in 1981 and 1982.

There were no significant differences in wheat yield, but LAB D again showed up with a low protein percentage.

The fertilizer cost and return over fertilizer are given in Table 6.

Results and Discussion of Corn Trial

As with wheat, the soil test values and fertilizer recommendations for corn (Table 2) varied greatly. All of the commercial labs again recommended sulfar and three recommended at least one micronutrient.

The ear leaf nutrient concentrations (Table 4) showed significant treatment effects on P, Ca, Fe and Zn. The only significant difference in P is between the check and LAB A. With Ca and Fe the effect was significant only at the 10% level, with the check being lowest in both cases. With Ca there was a significant difference between LAB B and E, but with Fe the five labs were not significantly different. The Zn concentration with LAB B and check were almost identical. The only significant difference at the 5% level was between LAB D and check.

There were no significant differences in corn grain yield. However, the check treatment was considerably lower in yield than all other treatments.

The fertilizer cost and return over fertilizer are given in Table 6.

General

Fertilizer recommendations from the five labs varied greatly, but application of these rates did not result in significantly different yields. With both corn and wheat, the only element where there appeared to be a relation between application and tissue concentration was nitrogen. In almost all cases micronutrient applications did not increase tissue concentrations. The only element where application resulted in a higher level (but still non-significant) was boron in the wheat leaves on LAB C plots (1 lb/A of B applied). Fertilizer costs for both wheat and corn were lowest with LAB E (UM).

Table 3. Effect of suggested fertilizer applications on the leaf nutrient concentration of wheat.

	Nutrient Concentration of Upper 4 Leaves Prior to Flowering									
LAB	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
A	4.02	.268	2.38	.779	.336	92	35.3	2.7	62	24.2
B	4.23	.280	2.10	.758	.319	86	29.6	2.8	58	23.2
C	4.28	.301	2.54	.789	.346	99	37.2	3.0	68	32.3
D	3.42	.287	2.65	.637	.290	90	31.0	2.7	54	23.7
E (UM)	4.18	.286	2.42	.743	.359	96	36.4	3.1	62	26.6
Check	3.42	.274	2.65	.561	.259	81	28.6	2.3	50	25.0
Significance:	**	NS	NS	*	NS	NS	NS	NS	+	NS
BLSD (.10):	.13	-	-	.149	-	-	-	-	11	-
BLSD (.05):	.21	-	-	.179	-	-	-	-	-	-
CV (%):	3.7	15.3	12.8	14.8	16.5	11.9	15.4	13.4	13.3	18.3

Table 4. Effect of suggested fertilizer applications on the leaf nutrient concentration of corn.

LAB	Ear Leaf Nutrient Concentrations									
	N	P	K	Ca	Mg	Fe	Zn	Cu	Mn	B
	%					ppm				
A	3.14	.328	1.92	.651	.558	114	18.6	5.1	82	5.3
B	3.02	.309	1.79	.662	.520	111	16.7	4.1	80	5.4
C	3.14	.320	2.02	.592	.496	108	19.8	5.0	81	5.6
D	3.22	.309	1.97	.635	.446	107	20.4	5.1	84	5.4
E (UM)	3.10	.322	2.06	.575	.487	110	19.6	5.4	82	5.6
Check	2.86	.290	1.87	.562	.448	100	16.6	4.6	66	5.0
Significance:	NS	*	NS	+	NS	+	**	NS	NS	NS
BLSD (.10):	-	.022	-	.076	-	8	2.0	-	-	-
BLSD (.05):	-	.037	-	-	-	-	3.3	-	-	-
CV (%):	1.8	5.0	8.5	8.6	13.9	5.4	8.0	16.4	13.4	6.6

Table 5. Effect of suggested fertilizer applications on corn and wheat growth and yield.

LAB	Corn					Wheat	
	Early Plant Height	Broken Stalks	Final Population	Corn Grain Yield	Corn Grain Moisture	Wheat Grain Yield	Wheat Grain Protein
	in	%	ppAx10^{-3}	Bu/A	%	Bu/A	%
A	22.8	1.6	19.9	118.9	22.9	48.7	16.0
B	24.2	2.7	18.4	116.8	21.5	48.1	15.2
C	24.1	2.9	19.4	120.4	22.5	48.5	16.0
D	24.2	1.9	19.2	118.7	22.4	49.0	13.7
E (UM)	23.9	1.8	17.7	115.7	22.2	50.7	15.4
Check	23.1	2.8	19.9	107.9	23.4	50.2	13.9
Significance:	NS	NS	**	NS	NS	NS	**
BLSD (.05):	-	-	0.9	-	-	-	1.5
CV (%):	6.5	61.0	3.3	6.4	5.0	7.7	6.2

Table 6. Economic return over fertilizer costs.

LAB	Wheat			Corn		
	Value of Crop @ $4/Bu	Fertilizer Cost*	Return over Fertilizer	Value of Crop @ $3/Bu	Fertilizer Cost*	Return over Fertilizer
	$/A			$/A		
A	194.80	30.45	164.35	356.70	46.45	310.25
B	192.40	43.70	148.70	350.40	58.20	292.30
C	194.00	62.36	131.64	361.20	67.75	293.45
D	196.00	35.80	160.20	356.10	75.27	280.83
E (UM)	202.80	23.01	179.79	347.10	42.10	305.00
Check	200.80	0	200.80	323.70	0	323.70

* Values used ($/lb) were as follows: N = $0.15, P_2O_5 = $0.25, K_2O = $0.12, S= $0.21, Cu = $2.40, Zn = $0.90, Mn = $0.71, B = $1.52

ALFALFA AND RED CLOVER POTASSIUM TRIALS

Staples, Minnesota 1980

C. J. Overdahl, Melvin Wiens and J. Lensing

Alfalfa and red clover trials at Staples were first established in July, 1970. At that time experiments were established using varying amounts of phosphorus, sulfur, lime and potassium. Soil tests were high for sulfur and phosphorus, and after 1974 these trials were discontinued; no responses had been obtained. The lime trial was also discontinued at the time because lime in the irrigation water had raised the pH of all plots above 7. In the last 4 years, pH in the trial area is 7.5 or higher.

After 1974 only the potassium trials on alfalfa and red clover were continued. The red clover had to be reseeded in 1974 and no red clover yields were obtained that year. In 1977 both alfalfa and red clover areas were plowed and reseeded. The main purpose was to have the higher yielding Anchor alfalfa and Arlington red clover in the comparisons. Red clover stand failed in 1979, since then only the alfalfa trial was continued. The experiment will not continue after 1980.

Yield and soil test results

The objective of the alfalfa-red clover comparisons is to measure the approximate economic differences of these crops after several years on soils where considerable potash is needed.

Potassium soil test were below expectations through 1976, even with annual treatments of 240 pounds of K_2O per acre. Table 1 shows a K test as low as 128 pounds of exchangeable K in 1976 where 2 treatments of 120 pounds of K_2O had been added annually since 1970. The 120 pounds treatment was increased to 180, and the 240 pound treatment was increased to 360 for 1978. This increase in potassium rates has been reflected in increases of K test up to 287 pounds of K from one of the 360 pound treatments. The upward trend does not appear to continue from the 360 pounds of K_2O treatments in 1979. Table 1b shows 0 to 3 inch tests over the 300 level only from one 360 pound treatment, and averages for the 0 to 6 inch depth do not go above 300 pounds of K_2O treatment yield about .3 ton of alfalfa more than the 180 pounds annual treatment, with a soil test ranging between 100 and 138 pounds of K.

Alfalfa responded significantly to potash with the 360 pound treatment resulting in yields only slightly higher than the 180 pound treatment, in spite of the much greater difference in soil test K.

Red clover did not significantly respond to potash, even with a K soil test as low as 58. Red clover yielded nearly as well as alfalfa in 1978 and produced approximately a ton more per acre on the no-potash plot than did the alfalfa.

There has been no real difference in yield between October or June application, nor has there been an advantage to split applications.

Yield of over 5 tons of alfalfa have been measured on the no-potash treated plots (1974 & 1975), while the 0 to 6 inch soil sample is very low, i.e., between 40 and 60 pounds of exchangeable K. Subsoil samples taken in 1974 show K tests of 50 at 1 to 2 feet and 20 at 2 to 3 feet deep, indicating that subsoil K source cannot explain the good alfalfa yields on the check plots. In 1978, however, the no-potash plots yeilded approximately 2 tons per acre and show K deficiency symptons. Low K tests after high K treatments occur at the Becker farm also. The high K treatments and low K tests would be a good thesis problem especially since yield increases from soil test above 120 pounds of K are not very large.

Plant analysis

Generally, October treated plots show more K in leaves at the first cut since the June application goes on just after the first cutting. On the other hand, K levels are higher for the third cut from June application than from the October treatment (Table 2).

The critical level of 2.5% K described in some research reports would indicate that many of the samples before 1978 were below this level. In 1978 and 1979, only a few of the 180 pound treated plots were below this level and none from the plots receiving 360 pounds of K_2O. The check plots for both alfalfa and red clover were considerably below this level in most samples for all the years of the trial. The third cutting in 1979 was taken late in September.

Table 1a. Potassium treatments effect on red clover and alfalfa yields, 1972 through 1976.

	Annual treatments of K_2O in lbs/A and time of application						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	significance
	Yields Tons/Acre at 15% Moisture						
Alfalfa							
1972	3.4	3.6	3.8	3.5	3.4	3.6	ns
1973	4.0a	4.8bc	4.6bc	4.6bc	4.3ab	4.8c	5%
1974	5.1a	6.5b	6.4b	6.4b	6.3b	6.5b	5%
1975	5.1a	6.4bc	6.6c	6.1b	6.2b	6.4bc	1%
1976	4.5a	6.2c	6.1c	5.8b	5.6b	5.7b	1%
Red Clover							
1972	4.2	5.0	4.5	4.7	4.7	4.7	ns
1973	3.3	3.6	3.3	3.4	3.6	3.7	ns
1974*	-	-	-	-	-	-	
1975	5.0a	6.0b	5.8b	5.8b	5.6b	6.0b	5%
1976	2.8a	3.2b	3.3b	3.2b	3.1b	3.2b	5%

Table 1b. Potassium treatment effect on red clover and alfalfa yield in 1978, 1979, and 1980 after K_2O increase.

	K_2O in lb/A annual and time of application							
1978 Cutting	None	June 360	Oct. 360	June 180	Oct. 180	June 180+ Oct. 180	significance	
	tons/acre 15% moisture							
Alfalfa								BLSD (.05)
1	.38	1.31	1.22	1.05	1.05	1.22	**	.20
2	.71	1.19	1.20	1.08	1.12	1.14	**	.14
3	.88	1.31	1.39	1.28	1.25	1.37	**	.12
total	1.97	3.81	3.81	3.41	3.42	3.73	**	.32
Red Clover								
1	.96	1.40	.95	.87	1.12	1.06	ns	-
2	.97	1.19	1.21	1.20	1.20	1.19	**	-
3	1.02	1.27	1.20	1.26	1.17	1.21	ns	-
total	2.95	2.86	3.36	3.33	3.49	3.46	ns	-

*Red clover stand failed

Table 1b. con't.

1979 Cutting	None	June 360	Oct. 360	June 180	Oct. 180	June 180+ Oct. 180	significance	
				tons/acre 15% moisture				
Alfalfa								
1	.58	1.58	1.64	1.41	1.45	1.50	**	.20
2	1.17	1.62	1.59	1.56	1.53	1.70	**	.41
3	.51	.93	.95	.88	.88	.84	**	.21
total	2.26	4.13	4.18	3.85	3.86	4.04	**	.32
Red Clover Discontinued								
1980								
Alfalfa								
1	.99	2.48	2.48	1.86	2.18	2.46	**	.29
2	.37	1.02	1.06	.91	.96	1.10	**	.23
3	.74	1.27	1.20	1.22	1.14	1.26	**	.21
total	2.10	4.77	4.37	3.99	4.28	4.82		

Table 2a. Exchangeable potassium soil tests according to potash treatment, 1972 through 1976. Soil sampled in September each year.

	Soil Test K lbs/A						
	None	June 240	Oct. 240	June 120	Oct. 120	June 120+ Oct. 120	
Alfalfa							
1972	92	258	322	160	165	185	Avg. pH-7.6 (1978)
1973	85	290	210	150	140	195	Avg. P Alf=47 R.C.=72 (1978)
1974	60	175	240	95	75	200	
1975	48	178	160	75	63	135	
1976	40	210	145	68	68	128	
1977**							
Red Clover							
1972	107	262	230	182	167	162	
1973	90	290	240	160	190	310	
1974*	135	180	200	150	155	180	
1975	60	180	83	108	60	115	
1977**							

*Red clover failed in 1974, was reseeded August 1, 1974

**Crops reseeded in 1977 to Anchor alfalfa and Arlington Red Clover. No yields or soil samples taken in 1977. Treatment of K_2O in 1978 were increased from 120 to 180 pounds of K_2O per acre and the 240 pound treatment was increased to 360 (data in Table 1b).

Table 2b. Soil test K from 1978, 1979, and 1980.

	Soil test K lbs/A							
	None	June 360	Oct. 360	June 180	Oct. 180	June 180+ Oct. 180		
Alfalfa								
1978	54	287	216	123	91	212		
1979								
0-3"	55	317	249	180	116	261	**	38
3-6"	44	275	303	96	84	206	**	40
Avg(0-6")	50	296	276	138	100	233		
1980	34	375	309	108	88	268		

Table 2b. con't.

	Soil test K lbs/A					
	None	June 360	Oct. 360	June 180	Oct. 180	June 180+ Oct. 180
Red clover						
1978	58	300	170	138	86	210
1979	No crop after 1978					

Phosphorus & pH averages for all plots

1978 P Alf = 47
R. C. = 72
pH Alf = 7.6
R.C. = 7.6

1979 P 0-3" = 37
3-6" = 33
pH = 7.5

1980 P 0-6" = 31
pH = 7.5

Table 2c. Potassium (%) in alfalfa and red clover tops, 1972 through 1976.

Plant Analysis

K_2O treatments

	None	June 240	Oct. 240	June 120	Oct. 120	June 120 Oct. 120	significance
Alfalfa							
1972-1st cut	2.05	2.76	2.98	2.20	2.74	2.65	
2nd cut	2.00	2.50	2.46	2.27	1.92	2.34	
3rd cut	2.52	3.44	3.08	2.94	2.85	3.18	
1973-1st cut	1.74a	2.74b	2.88b	2.40b	2.45b	2.47b	5%
2nd cut	1.58	1.76b	2.76b	2.48b	2.39b	2.65b	1%
3rd cut	1.64a	2.60b	2.57b	2.45b	2.17b	2.56b	5%
1974-1st cut	1.37	3.08	3.59	2.17	2.32	3.21	
2nd cut	1.29	2.40	2.85	2.25	1.89	2.60	
3rd cut	1.11	2.18	2.48	2.08	1.62	2.46	
1975-1st cut	1.24a	2.19c	2.67d	1.67b	2.15c	2.31c	1%
2nd cut	1.39a	2.74c	2.49bc	2.27b	1.93a	2.67c	1%
3rd cut	1.23a	2.60c	2.85c	2.15b	1.72a	2.56bc	1%
1976-1st cut	1.24a	3.66f	3.26de	1.55b	2.38c	2.99d	5%
2nd cut	1.45a	2.98d	2.83d	2.68c	2.02b	2.90d	5%
3rd cut	1.49a	2.78cd	2.86d	2.26b	2.03b	2.68c	5%
1977-None							
Red Clover							
1972-1st cut	2.14	3.05	2.83	3.02	2.61	3.04	
2nd cut	2.20	2.86	2.60	2.51	2.21	2.44	
3rd cut	2.65	3.54	2.98	3.32	2.87	2.98	
1973-1st cut	1.76a	2.63b	2.65b	2.56b	2.42b	2.66b	5%
2nd cut	2.03a	2.84c	2.97c	2.65bc	2.48b	2.92c	1%
3rd cut	1.81a	3.00d	2.53c	2.40c	2.10b	2.66c	1%
1974-None							
1975-1st cut	1.55a	2.59d	2.33cd	2.01bc	1.87ab	2.45d	1%
2nd cut	1.69a	3.00c	2.18b	2.80c	2.05b	2.89c	1%
3rd cut	1.78a	3.12d	2.37b	2.68c	2.25b	2.87c	1%
1976-1st cut	1.43	2.96	3.18	2.08	2.47	2.80	5%
2nd cut	1.70a	3.09c	2.67b	2.66	2.47b	3.05c	5%
1977-None							

Where letters differ, the values are significantly different. (5%)

Table 2c. con't.

	K_2O treatment and dates of application							
	None	June 360	Oct. 360	June 180	Oct. 180	June 180 Oct. 180	significance	BLSD 5%
Alfalfa								
1978-1st cut	1.51	2.66	2.83	2.33	2.48	2.71	**	.15
2nd cut	1.52	2.74	2.77	2.37	2.30	2.81	**	.14
3rd cut	1.58	2.96	2.86	2.56	2.33	2.81	**	.12
1979-1st cut	1.34	3.14	3.04	2.42	2.54	3.08	**	.19
2nd cut	1.49	3.17	3.20	2.68	2.51	3.24	**	.21
3rd cut	0.86	2.09	2.03	1.87	1.60	2.06	**	.12
1980-1st cut	0.98	2.48	2.47	2.11	2.13	2.48	**	.30
2nd cut	1.59	3.35	3.26	2.86	3.01	3.39	**	.22
3rd cut	1.18	2.33	2.32	2.09	1.98	2.39	**	.14
	Sufficiency levels for alfalfa 2.5%							
Red Clover								
1978-1st cut	1.64	3.11	2.74	2.40	2.49	2.86	**	.44
2nd cut	1.63	3.12	2.72	2.77	2.50	3.02	**	.15
3rd cut	1.60	3.21	2.74	2.82	2.39	2.94	**	.26
1979-None								
1980-None								

Table 3. Plasma emission spectrograph analysis of alfalfa, Staples 1980.

1st cut		%				ppm					
lbs, K_2O/A	Time	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
0	--	.37	.98	2.53	.44	32	128	48	24	4	50
360	June	.38	2.48	1.64	.29	38	149	46	26	3	46
360	Oct.	.38	2.47	1.60	.29	37	140	47	27	3	51
180	June	.36	2.11	1.85	.33	45	136	45	24	4	51
180	Oct.	.37	2.13	1.93	.34	35	129	49	26	3	47
360	½ June ½ Oct.	.38	2.48	1.66	.30	37	127	47	26	4	53
signif.		ns	**	**	**	ns	ns	ns	ns	ns	ns
BLSD (.05)		-				-	-	-	-	-	-
C.V.		5.8	4.6	8.4	7.8	22.3	16.9	10.3	9.3	20.1	10.0
2nd cut											
lbs, K_2O/A	Time										
0	--	.48	1.59	2.25	.46	26	165	49	30	9	55
360	June	.49	3.35	1.67	.35	27	166	44	38	8	52
360	Oct.	.48	3.26	1.68	.34	32	180	48	36	8	52
180	June	.48	2.86	1.82	.39	28	162	52	35	8	54
180	Oct.	.50	3.01	1.78	.41	27	169	46	36	7	51
360	½ June ½ June	.49	3.39	1.57	.35	29	171	44	37	8	48
signif.		ns	**	**	**	ns	ns	ns	**	ns	ns
BLSD (.05)		--				--	--	--		--	--
C.V.		4.9	7.8	5.3	5.6	12.4	7.9	13.4	5.8	9.6	8.9

Table 3. con't.

3rd cut		%				ppm					
lbs, K_2O/A	Time	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
0	--	.39	1.18	3.21	.59	34	188	53	21	5	69
360	June	.33	2.33	2.36	.27	39	219	42	20	5	67
360	Oct.	.33	2.32	2.43	.26	39	217	44	20	5	68
180	June	.34	2.09	2.61	.32	41	211	48	21	5	74
360	Oct.	.34	1.98	2.78	.27	40	226	46	21	5	75
	½ June ½ Oct.	.33	2.39	2.33	.27	42	213	45	21	5	67
signif.		**	**	**	**	**	*	*	ns	ns	ns
BLSD (.05)		.02	.14	.15	.05	4	25	7	-	-	-
C.V.		4.9	5.0	4.2	9.7	6.5	6.9	8.5	5.6	9.2	7.3

BARLEY FERTILIZATION TRIALS UNDER IRRIGATION*

M.J. O'Leary, J.N. Lensing and M. Wiens

Studies to evaluate nitrogen fertilization of irrigated malting barley were continued in 1980. These studies were initially started because conditions that usually exist when soils are irrigated in Minnesota indicate a potential of malting barley production with high yields and acceptable malting characteristics. The irrigated soils of Minnesota are predominantly coarse testured types, low in organic matter and consequently low in a supply of native soil nitrogen. Because of this fact there is the possibility of optimum nitrogen fertilizer management to produce acceptable yields of grain with desirable malting characteristics. Experiments in 1980 were located at Staples, and Westport, Minnesota, on Estherville sandy loam soils. Varietal response to various nitrogen rates and timing of nitrogen application were the main objectives of these studies.

Experimental Procedures

Two experiments were conducted at Staples. In order to evaluate the performance of malting barley varieties at various nitrogen rates a split plot design replicated four times was used. Varieties were treated as main plots and nitrogen rates as subplots. Six varieties, three presently grown commercially and three experimental, were used at nitrogen rates of 0, 45, 90, and 135, pounds per acre. Nitrogen was applied as ammonium nitrate with 2/3 applied preplant and 1/3 at tillering stage.

The time of nitrogen application experiment was conducted using two varieties, each receiving treatments of nitrogen at various times. Each variety was tested in a randomized complete block replicated four times. One treatment received no nitrogen, all other treatments 90 lbs N/A as ammonium nitrate.

Experimental areas at Staples received 60 lbs. K_2O/A applied broadcast and plowed down. Preplant nitrogen treatments were broadcast and incorporated. Plot areas were packed and then planted at 96 lbs./A of seed on April 18. 20 lbs. P_2O_5/A was applied with the seed. Weeds were controlled with an application of Brominal + (¼ lbs. ai/A) at the four leaf stage. A total of 9.75 inches of water was applied by irrigation with an additional 6.2 inches received as rainfall. The crop in 1979 was barley.

A variety by nitrogen rate trial was also conducted at Westport utilizing a split plot design with varieties as main plots and nitrogen rates as subplots. Four varieties, Manker, Larker, Morex and M-32 (experimental), were compared at nitrogen rates of 0, 40, 80, and 120 lbs. N/A. Nitrogen was applied as urea. Plot area was then disced twice and planted at 96 lbs./A of seed on April 21. Brominal + (¼ lb. ai/A) was applied at four leaf stage for weed control. Eight inches of water was applied by irrigation with an additional 13.5 inches received as rainfall. 1979 crop was adzuki beans.

*This project was supported in part by funds from the Malting Barley Improvement Association.

Results

Variety by Nitrogen Rate - Staples

Very good yields were obtained in 1980 as a result of good growing conditions and the absence of barley leaf diseases. Differences in yield, test weight and % plump due to variety were highly significant (Table 1). Yield and % plump did not show the same response for all varieties. Yield response to nitrogen rates showed all varieties responding quite well to 45 and 90 lbs. N/A. Not all varieties showed a yield increase with 135 lbs. N/A. Percent plump showed a tendency to be lowest at the high nitrogen rate.

Time of Application Trial - Staples

This trial was designed to evaluate the effects various application schemes of nitrogen had on irrigated malting barley. The addition of nitrogen significantly increased yields for the variety Manker but there was no difference in application scheme (Table 2a). There were significant differences in % protein and % plump due to application scheme. Nitrogen applied 2/3 preplant and 1/3 early boot resulted in significantly higher values for % protein and % plump compared to other treatments.

Yields for M-32 were increased significantly with the application of nitrogen (Table 2b). Application split into 3 increments (trt. E) produced a significant increase in yield compared to 2/3 preplant and 1/3 early boot. Treatment D resulted in significantly higher % plump than any of the other treatments. Neither addition of nitrogen or scheme of application had significant effects on % protein.

Variety by Nitrogen Rate - Westport

There was a significant varietal difference in test weight and % plump (Table 3). Significant differences in % protein, test weight and % plump were shown between nitrogen rates. A bacterial leaf blight infection was quite severe and no doubt had considerable impact on grain yield and quality. Larker showed the most resistance to this disease.

Table 1. Effect of variety and nitrogen rate on yield, test weight, percent plumpness and percent protein of Barley grain, Staples, 1980.

Treatment		Yield	Test wt.	Plump	Protein
		bu/A	lbs./bu	%	%
Variety					
M - 32		62.2	47.5	69.1	10.2
M - 34		75.9	49.5	85.2	10.2
M - 36		74.1	50.8	81.6	9.9
Larker		69.8	49.5	71.9	9.6
Manker		73.0	50.2	72.2	10.2
Morex		69.5	47.5	75.1	10.2
signficance		**	**	**	ns
BLSD (.05)		5.7	1.5	2.2	-
lbs. N/A					
0		33.4	48.9	76.5	9.4
45		65.8	49.5	79.1	9.1
90		89.3	48.9	74.9	10.5
135		94.5	49.4	72.9	11.2
significance		**	ns	**	**
BLSD (.05)		3.5	-	1.8	.4
Variety	lbs. N/A				
M - 32	0	30.6	47.7	73.2	9.4
M - 32	45	54.0	49.4	74.8	9.3
M - 32	90	83.0	46.8	66.5	10.4
M - 32	135	81.2	46.2	61.8	11.8
M - 34	0	36.1	48.8	79.5	9.5
M - 34	45	66.7	49.3	88.8	8.9
M - 34	90	95.6	49.7	87.0	10.7
M - 34	135	105.0	50.1	85.8	11.5
M - 36	0	34.6	50.8	81.0	9.4
M - 36	45	72.8	51.0	86.2	9.3
M - 36	90	90.2	50.5	78.5	9.9
M - 36	135	98.8	50.9	80.8	11.0
Larker	0	34.2	49.9	74.0	9.1
Larker	45	58.9	49.9	72.8	8.3
Larker	90	89.4	48.4	72.5	10.1
Larker	135	96.6	49.9	68.2	10.9
Manker	0	32.4	49.0	73.5	9.2
Manker	45	70.8	49.9	71.5	9.2
Manker	90	92.2	50.3	73.2	11.1
Manker	135	96.7	51.5	70.8	11.2
Morex	0	32.1	47.2	78.0	9.6
Morex	45	71.9	47.4	80.8	9.3
Morex	90	85.4	47.8	71.5	11.0
Morex	135	88.5	47.7	70.2	11.1
significance		+	ns	**	ns
BLSD (.05)		11.2	-	4.9	-
C.V.		9.6	2.7	4.4	8.6

Table 2a. Effect of time of nitrogen application on Manker barley yield, test weight, percent plumpness and percent protein, Staples, 1980.

Treatment*	Yield bu/A	Test wt. lbs./bu	Plump %	Protein %
A 0 - N	25.5	49.4	64.0	8.6
B 90 ppl	82.3	50.5	70.2	8.4
C 60 ppl + 30 T	84.6	50.4	65.8	9.2
D 60 ppl + 30 EB	82.1	52.2	84.2	12.2
E 40 ppl + 30 T + 20 EB	88.3	51.2	71.2	10.4
significance	**	*	**	**
BLSD (.05)	9.4	1.9	6.3	1.3
C.V.	9.2	2.2	6.0	9.1

Table 2b. Effect of time of nitrogen application on M - 32 barley yield, test weight, percent plumpness and percent, Staples, 1980.

Treatment*	Yield bu/A	Test wt. lbs./bu	Plump %	Protein %
A 0 - N	24.3	49.2	68.0	9.6
B 90 ppl	71.8	47.6	72.8	9.6
C 60 ppl + 30 T	69.9	45.7	69.5	10.2
D 60 ppl + 30 T	65.4	49.5	85.0	11.2
E 40 ppl + 30 T + 20 EB	73.0	48.9	69.3	10.6
significance	**	+	**	ns
BLSD (.05)	6.7	2.9	3.8	-
C.V.	7.8	4.1	3.7	10.6

*Treatment Code

A 0 Nitrogen
B 90 #N/A - preplant
C 60 #N/A - preplant; 30 #N/A - tillering stage
D 60 #N/A - preplant; 30 #N/A - early boot stage
E 40 #N/A - preplant; 30 #N/A - tillering stage
20 #N/A - early boot stage

Table 3. Effect of variety and nitrogen rate on yield, test weight, percent plumpness and percent protein of barley grain, Westport, 1980.

Treatment		Yield bu/A	Test wt. lbs./bu	Plump %	Protein %
Variety					
Manker		70.8	44.6	49.1	12.0
Larker		78.3	44.4	75.1	11.4
Morex		74.1	42.9	65.7	11.6
M - 32		76.6	41.2	54.4	11.7
significance		ns	*	**	ns
BLSD (.05)		-	1.8	9.5	-
lbs. N/A					
0		70.5	44.2	72.0	10.4
40		77.4	43.3	60.1	11.5
80		76.4	42.6	57.8	12.1
120		75.5	42.9	54.3	12.7
significance		ns	*	*	**
BLSD (.05)		-	1.2	11.1	.6
Variety	lbs. N/A				
Manker	0	64.3	46.0	59.7	10.6
Manker	40	77.6	45.0	53.3	11.3
Manker	80	70.2	44.4	48.7	12.2
Manker	120	71.3	42.9	34.7	13.7
Larker	0	79.6	44.7	81.7	10.0
Larker	40	78.1	45.1	73.0	11.1
Larker	80	78.6	44.0	79.0	11.8
Larker	120	77.1	43.6	66.7	12.7
Morex	0	68.9	44.1	77.0	10.1
Morex	40	72.1	42.5	64.3	11.5
Morex	80	80.3	42.4	58.3	11.9
Morex	120	75.1	42.6	63.0	12.7
M - 32	0	69.4	42.0	69.7	11.1
M - 32	40	81.7	40.6	49.7	11.9
M - 32	80	76.4	39.7	45.3	12.4
M - 32	120	78.7	42.7	53.0	11.5
significance		ns	ns	ns	ns
C.V.		10.2	3.1	20.8	7.1

Fertilizer Nitrogen Uptake by Irrigated Potatoes

A.C. Caldwell, G.C. Buzicky, Mel Wiens

Irrigated potatoes require substantial amounts of N to obtain good yields. However, most irrigated potatoes are grown on sandy soils and any N not taken up by the plant or immobilized in the soil will likely find its way into the aquifer. There is little information locally on the efficiency of fertilizer N use by potatoes, but this deficiency in knowledge can be lessened if the amount of N absorbed by potatoes is measured using 15-N labelled fertilizer. There have been some reports that potatoes have responded more to ammonium rather than nitrate forms of N. If there is this perference a greater uptake of ammonium by the potato might be shown by labelling the fertilizer with 15-N.

Objectives

1. To determine N derived from fertilizer and amount recovered by the plant by labelling the fertilizer with 15-N.
2. To determine if there is any difference in utilization of the labelled ammonium or nitrate-N fertilizer source by the potato.

Procedure

A one year trial was conducted at the Staples Irrigation Center in 1980 to investigate the previously stated objectives. Burbank Russet potatoes were planted on April 30 in 36" rows with 10" spacings. On April 28, phosphorus, potassium and sulfur were applied at rates of 44,352 and 73 lbs/A respectively. Nitrogen treatments consisted of zero, 300 lbsN/A as ammonium chloride and 300 lbsN/A as calcium nitrate. The nitrogen was applied in three 100 lbN/A splits. The first split was applied at planting, the second on June 9 and the final split was put on with the hilling operation on June 23. A completely randomized design with four replications was used.

Within each nitrogen treated plot, small subplots (10' x 3') recieved fertilizer nitrogen that was tagged with 5% atom enriched 15-N. Tuber and vines were harvested from these subplots to determine the fertilizer nitrogen recovered by the plant. The 15-N subplots were also sampled in the fall to determine the amount of fertilizer nitrogen immobilized in the upper 12 inches of soil.

Weed control consisted of 4 lbs a.i./A Eptam applied preplant and incorporated. Insectide and fungicide applications were made after irrigation, on a weekly basis, from late June through late July. A total of 11.4 acre - inches of water was applied by irrigation in addition to the 15.0 acre-inches of rainfall recieved during the growing season.

The above ground portion of the plant was harvested for maximum vegtative growth on August 1. Vines were chopped on September 9 and tubers were harvested for yield on Sept 23.

Results

The data in Table 1 indicates a significant difference between the two fertilizer nitrogen forms with ammonium chloride appearing most beneficial. The overall appearance of the NH_4 treated plots was better after the third nitrogen application was made. Possible explantions for the response to the ammonium source are:1) the persistance of ammonium in the rooting zone as opposed to the leaching of the nitrates or, 2) a true preference of potatoes for the ammonium ion. As expected, there was also a significant difference between the check and the nitrogen treated plots. Data concerning fertilizer nitrogen distribution and efficiency is not available at this time since 15-N analysis has not been completed.

Table 1. Effect of nitrogen source and application on Russet Burbank plant yield, N content and N removal at Staples, 1980.

Trmt	'New' Yield	Tuber Yield	Max Veg. Yield	Tuber D.M.	Tuber N	Max. Veg. N	Tuber	Max Veg.
	----cwt./A----		------lbs/A--		-----%----		--lbsN/A	Rem'd--
Check	175	238	696	5486	1.00	2.22	55.3	15.4
$Ca(NO_3)_2$	277	467	2209	11117	1.31	3.04	145.3	67.7
NH_4Cl	286	568	2680	12300	1.44	3.49	176.7	93.5
Signifiance	**	**	**	**	*	**	**	**
BLSD (.05)	33	37	219	1038	.25	44	28.8	13.9
C.V.	8.1	5.2	7.1	6.5	11.4	8.8	13.7	14.3

Table 2. Effect of nitrogen source and application on analysis of the maxium vegetative growth of Russet Burbank potatoes at Staples, 1980.

Trmt	P	K	Ca	Mg	Nutrient Al	Fe	Na	Mn	Zn	B
	----------%---------				----------ppm----------					
check	.19	5.06	2.74	.72	553	1898	87	64	23	30
$Ca(NO_3)_2$	.16	4.80	2.20	1.12	450	1232	64	58	15	23
NH_4Cl	.23	5.44	1.77	0.91	477	1062	66	183	24	25
Significance	**	NS	**	**	NS	**	+	**	**	**
BLSD (.05)	.02	-	.24	.16	-	321	23	45	5	1.7
C.V.	7.2	7.0	6.3	9.9	18.8	13.5	17.4	26.4	12.2	3.9

Influence Of Nitrogen Rate, Timing Of Application And Use of Nitrification Inhibitors On Irrigated Corn - Staples - 1980

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

Nitrogen management on the coarse textured irrigated soils of Minnesota is a major decision that corn producers must consider. Nitrogen fertilizer application is essential for top yield on these soils. Likewise, large amounts of fertilizer nitrogen may be lost due to leaching if the nitrogen fertilizer is applied too early. To minimize these losses, nitrogen application are often made in split applications through the irrigation system or as a late sidedressing treatments. These often add to the cost of production and require a reasonable amount of timeliness to avoid yield reductions. Commerical availability of chemical additives know as nitrification inhibitors also offer some potential in minimizing nitrogen losses and may add flexibility into the overall nitrogen management program. A trial was established in 1978 to evaluate the significance of nitrogen rates, timing of nitrogen applications and use of nitrification inhibitors.

Experimental Procedures

Nine treatments were replicated four times and arranged in a randomized complete block design. The treatments were established on a Sverdrup sandy loam at the CMDIR station at Staples, MN. Potassium (225 # k_2O/A) and Phosphorus (30 # P_2O_5) were broadcast and incorporated prior to planting. The treatments included a check, two nitrogen rates, (80 and 160 # N/A as urea), two methods of application (single vs split) and two nitrification inhibitors (N-Serve-Dow Chemical Co.) and Dwell (Terrazole - Olin Corporation). Nitrogen treatments were applied in either one single preplant application or in multiple applications during the growing season. Split applications of nitrogen were applied on May 2 (preplant), June 16 (8 leaf stage), July 15 (12-leaf stage) and on July 22 (tasseling) in a ratio of 1/6,1/6,3/6,1/6 respectively.

Nitrification inhibitors treatments were applied with the single nitrogen application treatments as coatings on to area (0.5 # ai/A) for both N-Serve and Dwell. The preplant nitrogen applications were broadcast over the plot area and immediately incorporated by discing. Corn (Pioneer 3978) was planted on May 2 in 30 inch rows at a population of 28,000 seeds/A. Weed control was obtained using a combination of chemicals (Atrazine - 2 # ai/A and Lasso 3#ai/A). Irrigation of the plot area was started on May 6 and concluded on September 8 with a total of 12.75 inches of water being applied through irrigation. An additional 15.05 inches were obtained through precipitation during the growing season.

Leaf samples from opposite and below the ear at silking were collected on July 22, dried and analyzed for Kjeldahl nitrogen. Total dry matter production was not taken because of head smut infestation at the station. Yields were obtained on November 3 by harvesting 2 rows 20 feet long and yields were adjusted to 15.5% moisture.

General Results

As was mentioned above only limited information was obtained from this location in 1980 because of the detection of head smut at the experimental farm. This research trial was at one time during the growing season guaranteened and scheduled to be destroyed. Yield samples were allowed and the results obtained were similar to those that have been found in the past. Grain yields ranged from 74 to 140 bu/A due to nitrogen treatment Loss of fertilizer nitrogen due to leaching of nitrate nitrogen from early (preplant) nitrogen application appeared to reduce yields at both nitrogen rates by approximately 12 bu/A. No nitrification inhibitor response was obtained at the lower rate of nitrogen application. The use of nitrification inhibitors with preplant applications of the higher rate of nitrogen approximated the yields that were obtained with the split nitrogen combination.

Table 1. Influence of nitrogen rate, timing of nitrogen application, and nitrification inhibitors on leaf nitrogen concentration, and grain yield of corn under irrigation. - Staples, MN - 1980.

Treatments				
N-Rate	No. of Appl.	Inhibitor	leaf N	Grain Yield
#/A			%	bu/A
0	-	-	2.19	74.0
80	1	-	2.54	121.9
80	1	N-Serve	2.70	122.2
80	1	Dwell	2.67	124.2
80	4	-	3.11	133.6
160	1	-	2.81	127.3
160	1	N-Serve	2.93	136.5
160	1	Dwell	3.02	139.8
160	4	-	3.06	136.0
Significance			**	**
BLSD(.05)			0.13	15.4

SOUTHERN EXPERIMENT STATION - WASECA
WEATHER DATA - 1980

Month	Period	Precipitation 1980	Precipitation Normal	Avg. Air Temp. 1980	Avg. Air Temp. Normal	Growing Degree Days 1980	Growing Degree Days Normal
		---inches----		------°F-----			
January	1-31	1.71	.73	14.2	12.9		
February	1-28	1.26	.96	13.9	17.5		
March	1-31	0.97	1.94	24.1	28.5		
April	1-30	2.37	2.48	45.4	45.6		
May	1-10	0.01		56.6		113.5	
	11-20	0.79		51.4		65.5	
	21-31	1.74		70.3		216.0	
	Total	2.54	3.86	59.8	57.7	395.0	319
June	1-10	1.77		63.2		124.0	
	11-20	0.70		65.1		172.0	
	21-30	0.87		70.2		197.0	
	Total	3.34	4.75	66.2	67.1	493.0	519
July	1-10	0.07		71.3		208.0	
	11-20	0.17		76.7		244.0	
	21-31	0.27		67.4		196.5	
	Total	0.51	4.02	71.8	71.4	648.5	646
August	1-10	4.22		70.1		180.5	
	11-20	3.42		66.0		178.0	
	21-31	2.05		67.0		186.5	
	Total	9.69	3.60	67.6	69.7	545.0	604
September	1-30	5.14	3.45	58.0	60.3	220.5	337
October	1-31	1.63	1.89	43.3	50.3	0.0	35
November	1-30	0.12	1.25	35.2	32.9		
December	1-31	0.83	1.02	18.4	19.0		
Year	Jan-Dec	30.11	29.95	43.2	44.4	2302.0	2460
Growing Season	May-Sep	21.22	19.68	64.7	65.3	2302.0	2425

Notes:

1) Highest temp. on July 12 -- 96°
2) Highest 24-hour precipitation on September 21 -- 3.00"
3) Only 2.08" rain between June 8 and August 2, greatest rainfall event = 0.85" on June 28
4) Second lowest June and July rainfall on record (1934 had 2.51")
5) 49% of 1980 precipitation occurred in 55-day period between August 2 and September 25
6) Frost on September 17

HIGH PHOSPHORUS AND POTASSIUM RATES FOR CONTINUOUS CORN

1980

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

EXPERIMENTAL PROCEDURES

Ten P and K treatments (Table 1) were applied at three branch experiment stations (Southern Experiment Station, Waseca; Southwest Experiment Station, Lamberton; and West Central Experiment Station, Morris) in Minnesota. A randomized, complete-block design with four replications was used. The 50-pound rates were estimated to be "maintenance" rates, and the 0, 100 and 150-pound rates provide the response curves for each element. Treatment 5 and 8 receive P and K, respectively, every third year for the duration of the experiment. Treatments 9 and 10, applied in the fall of 1973, did not receive P and K again until the fall of 1978 when the treatments were resumed at Waseca because P appeared to be limiting. These two treatments were resumed at Morris in 1979 for the same reason. All other treatments have been applied annually.

Table 1. Phosphorus and potassium treatments applied in the high P and K rate study in Minnesota.

Trt No.	Application Year (Fall) 1973,'76,'79	1974,'75,'77,'78
	----------lb P_2O_5 + K_2O/A----------	
1	0 + 0	0 + 0
2	0 + 100	0 + 100
3	50 + 100	50 + 100
4	100 + 100	100 + 100
5	150 + 100	0 + 100
6	100 + 0	100 + 0
7	100 + 50	100 + 50
8	100 + 150	100 + 0
9[1/]	150[2/] + 100	0 + 0[3/]
10[1/]	100 + 150[2/]	0 + 0[4/]

[1/] Neither P nor K was applied in 1976.

[2/] The 150-lb rate was not applied at Lamberton or Waseca in 1979 but was applied at Morris.

[3/] 150 + 100 applied at Waseca in 1978.

[4/] 100 + 150 applied at Waseca in 1978.

The P and K materials were broadcast on cornstalks and plowed down at all locations in the fall of 1979. Phosphorus was applied as CSP (0-46-0) and K as muriate of potash (0-0-60). Zinc was applied at a rate of 18 lb Zn/A as $ZnSO_4$ prior to field cultivation on April 30 at Waseca. Starter fertilizer was not used.

Specific experimental procedures used at each of the stations are presented in Table 2. Management practices providing for optimum yields were employed at each location. Nitrogen rates were slightly higher than optimum. Planting rate was increased at Waseca in 1980.

RESULTS AND DISCUSSION

Soil samples were taken at the end of the 1980 growing season. Responses to the treatments were quite similar to those obtained in 1979. Soil test P was affected significantly at all three locations (Table 3). There appeared to be an almost linear response to P application rates. Soil test P was always lowest with treatments 1 and 2, which received no P. Intermediate P levels were found with treatment 3 (50 lb P_2O_5 annually) and treatment 5 (150 lb P_2O_5 every third year). Highest soil test P values were associated with the annual 100 lb P_2O_5 treatments at all locations. Use of the 1:50 soil to Bray P_1 solution ratio on the calcareous Aastad soil at Morris indicates high amounts of extractable P in this soil; over twice that indicated by the 1:10 ratio. Soil test P levels with all treatments at Lamberton were substantially lower than in 1979 and 1978.

Soil test K was influenced (P=.01) by the K treatments at all locations (Table 3). The response to the annual K applications was not as pronounced as with P. Similar to P all soil test K values for Lamberton were substantially lower than in 1979. Soil pH was not related to the P and K treatments.

Table 2. Experimental procedures for the high P and K rate study on continuous corn at the three branch stations in 1980.

Variable	Lamberton	Morris	Waseca
Planting date	4/29	4/29	4/30
Row spacing	30"	30"	30"
Planting rate	25,000	25,000	32,000
Hybrid	Pioneer 3780	Pioneer 3901	Pioneer 3732
Nitrogen rate	180#	110#	200#
Herbicide	2½# Eradicane + 1½# Bladex/A (Bdct)	2½# Lasso + 2 1/5# Bladex/A (Bdct)	3½# Lasso + 3# Atrazine/A (Bdct)
Insecticide	1# Furadan/A	1.3# Counter/A	1# Dyfonate/A
Harvest date	10/9	10/10	10/10

Table 3. Soil test values as influenced by seven year's application of P and K treatments.[1/]

Treatment No.	Description[2/]	pH La	pH Mo	pH Wa	P La	P M_{10}	P M_{50}	P Wa	K La	K Mo	K Wa
	lb P_2O_5+K_2O/A				lb/A						
1	0 + 0	6.0	7.7	5.8	26	10	32	24	154	384	204
2	0 + 100	6.1	7.7	5.9	21	9	30	22	214	471	239
3	50 + 100	6.6	7.6	5.6	30	32	90	40	204	460	233
4	100 + 100	6.1	7.7	5.9	48	59	154	59	210	471	264
5	150 + 100	6.3	7.7	5.8	46	40	118	42	218	451	236
6	100 + 0	6.0	7.6	5.9	50	59	147	59	157	388	218
7	100 + 50	6.1	7.7	5.9	48	47	131	52	190	395	203
8	100 + 150	6.2	7.5	5.7	48	63	158	48	191	413	212
9	150 + 100	6.4	7.6	5.8	24	30	80	31	165	393	229
10	100 + 150	6.1	7.7	6.0	32	19	60	34	158	389	225
Significance:[3/]		NS	NS	NS	**	**	**	**	**	**	**
BLSD(.05) :					8	8	18	10	36	49	32
CV(%) :		4.9	22.	4.2	16.	16.	14.	18.	13.	7.9	8.9

1/ Samples were taken in October before the 1980 treatments were applied.

2/ Rates applied in fall of 1979 for 1980 crop. The 150-lb rates in treatments 9 and 10 were not applied at Lamberton or Waseca.

3/ **, *, and + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level.

Approximately 5-6 weeks after planting, ten plants randomly selected from each plot were measured, harvested, dried and weighed to determine early plant growth. Early plant weight and height were increased significantly (P=.01) by the treatments at Lamberton and Waseca (Table 4). Although definite trends toward increased plant weight and height appeared with P additions at Morris, significant (P=.05) effects were not noted due to the variability. Both plant weight and height were generally lowest with the check treatment (no. 1) and the 0 P_2O_5 treatment (no. 2) indicating that the growth response was due primarily to P. Early weight was increased by the 50 and 100 lb P_2O_5 rates over the 0 P_2O_5 rate (no. 2) by 10 and 22% at Lamberton, 8 and 25% at Morris, and 9 and 34% at Waseca, respectively. No effect of K was noticed on either early plant weight or height.

Table 4. Early plant growth as influenced by high P and K rates at the three experimental sites in 1980.

Treatment		Weight			Height		
No.	Description	La	Mo	Wa	La	Mo	Wa
	lb P_2O_5+K_2O/A	g/dry plant			-------inches-------		
1	0 + 0	5.1	6.2	5.2	30.4	25.2	26.8
2	0 + 100	6.2	6.8	6.4	29.5	25.9	26.7
3	50 + 100	6.8	7.4	7.0	32.1	27.6	28.8
4	100 + 100	7.6	8.5	8.6	32.4	28.8	29.7
5	150 + 100	7.4	8.2	8.0	32.9	28.3	30.0
6	100 + 0	8.2	7.7	8.3	32.1	27.5	30.3
7	100 + 50	8.0	7.6	8.8	32.4	27.4	30.6
8	100 + 150	7.9	8.2	9.0	32.4	28.8	31.5
9	150[1/] + 100	6.0	7.4	7.4	30.6	27.3	28.6
10	100 + 150[1/]	7.4	7.4	7.9	32.0	26.9	28.6
	Significance:	**	NS	**	**	+	**
	BLSD(.05) :	1.2		1.1	1.4		1.5
	CV(%) :	12.	14.	10.	3.0	5.9	3.7

[1/] The 150-lb rate was not applied at Lamberton or Waseca.

The small plants were chemically analyzed with the results from all locations shown in Table 5. Concentrations of P, K, Ca and Mg were affected significantly (P=.10) by the treatments at all locations. Whole plant P and K were consistently increased by the P and K treatments while Ca and Mg were generally decreased by the K additions. The response to K rate was more linear than was the P response except at Lamberton. Zinc and Cu concentrations were depressed by increasing P rates at Morris and Waseca.

Analysis of the leaf opposite and below the ear at silking indicated significant effects of the P and K treatments at all locations (Table 6). At Morris and Waseca, both leaf P and K were increased linearly (P=.01) with increasing rates of P and K while leaf Mg was reduced by the K treatments. None of the nutrients were affected by the P treatments at Lamberton. However, applied K did increase leaf K while reducing Ca and Mg. Leaf Zn concentrations were reduced by the P treatments at Morris and Waseca.

Planting populations were thinned to uniform stands at all locations in 1980. Significant differences in final plant population were not found at any of the three sites (Table 7). Barren stalks resulting from the moisture stress at pollination were high at Lamberton but were not influenced by the P and K treatments. Grain moisture an indication of maturity at harvest was affected inconsistently by the treatments at Waseca (Table 7) but was not at Lamberton and Morris.

The influence of the seven years of P and K application on silage and grain yields for all three locations is given in Table 8. Silage yields were not increased significantly (P=.10) by the P and K treatments at Lamberton or Waseca. At Morris silage yields were improved significantly; primarily by the P treatments. Grain yields were not affected significantly at the 90% level at any of the locations due to experimental variability. However, a strong trend toward a response to P was shown with 13 to 19 bu/A yield increases at Morris and 7 to 21 bu/A increases at Waseca with the 50 and 100 lb P_2O_5/A treatments. A weak trend toward a yield response to K was observed at Waseca. The 50 lb K_2O/A treatment showed approximately a 9 bu/A advantage over the 0 lb K_2O/A treatments. These results again demonstrate the difficulty of assessing treatment benefits when yield differences are highly economical but not statistical.

Table 5. Effect of high P and K rates on the nutrient concentrations in the small whole plants at the three experimental sites in 1980.

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	%				ppm				
						Lamberton				
1	0 + 0	.39	4.34	.58	.48	306	75	49	7.8	9.0
2	0 + 100	.40	5.22	.50	.39	347	70	49	8.0	9.0
3	50 + 100	.41	4.86	.49	.37	304	66	36	8.2	9.6
4	100 + 100	.42	5.06	.51	.36	337	76	43	6.9	9.5
5	150 + 100	.44	5.51	.55	.42	322	72	44	6.6	8.3
6	100 + 0	.44	4.60	.65	.51	326	84	51	6.4	8.8
7	100 + 50	.43	5.50	.59	.44	295	79	49	6.3	8.1
8	100 + 150	.43	5.11	.59	.41	350	77	43	6.5	9.0
9	0 + 100	.42	5.12	.56	.44	300	70	48	7.7	8.9
10	100 + 0	.42	5.04	.61	.45	310	76	45	6.9	8.6
	Significance:	+	+	**	**	NS	NS	NS	**	NS
	BLSD(.05) :			.07	.07				.8	
	CV(%) :	6.2	10.	8.3	10.	12.	13.	16.	7.5	10.
						Morris				
1	0 + 0	.32	3.52	.50	.46	565	77	46	8.2	7.0
2	0 + 100	.31	4.14	.45	.37	690	78	41	7.6	6.8
3	50 + 100	.37	4.18	.52	.36	750	85	36	7.8	7.5
4	100 + 100	.39	4.22	.51	.38	679	79	35	7.4	7.3
5	150 + 100	.36	4.10	.49	.39	620	80	37	7.6	7.2
6	100 + 0	.40	3.28	.61	.51	678	84	34	7.7	7.2
7	100 + 50	.39	3.92	.54	.42	591	79	35	7.6	7.3
8	100 + 150	.40	3.90	.54	.42	786	82	32	7.2	7.3
9	150 + 100	.36	3.65	.52	.45	644	80	36	7.6	7.6
10	100 + 150	.35	3.68	.53	.42	778	86	38	8.2	7.2
	Significance:	**	**	**	**	*	NS	**	NS	NS
	BLSD(.05) :	.02	.43	.04	.03	171		6		
	CV(%) :	4.0	7.4	5.9	5.8	14.	5.8	10.	6.0	5.6
						Waseca				
1	0 + 0	.34	3.64	.50	.42	390	71	47	9.1	7.7
2	0 + 100	.34	4.77	.41	.31	326	60	46	9.3	7.6
3	50 + 100	.38	4.54	.43	.31	348	66	45	8.8	7.6
4	100 + 100	.39	4.53	.48	.33	361	68	39	7.4	7.3
5	150 + 100	.38	4.42	.47	.32	344	69	39	8.1	7.5
6	100 + 0	.44	3.27	.60	.48	370	76	38	7.6	7.7
7	100 + 50	.40	4.09	.53	.40	326	67	39	7.7	7.5
8	100 + 150	.39	4.16	.52	.38	354	71	42	7.8	7.5
9	0 + 100	.37	4.06	.48	.38	376	69	46	9.3	7.8
10	100 + 0	.39	4.07	.50	.37	363	68	43	8.8	7.6
	Significance:	**	**	**	**	NS	NS	**	**	NS
	BLSD(.05) :	.03	.40	.03	.03			6	.7	
	CV(%) :	4.9	7.0	4.5	6.9	15	9.8	8.8	6.0	4.6

Table 6. Effect of high P and K rates on the nutrient concentrations in the corn leaf at the three experimental sites in 1980.

Treatment No.	Description	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	lb P_2O_5+K_2O/A	----------%----------				----------ppm----------				
						Lamberton				
1	0 + 0	.22	2.02	.84	.64	128	82	27	7.6	22.7
2	0 + 100	.23	2.63	.75	.46	130	62	26	6.9	22.2
3	50 + 100	.24	2.60	.76	.47	126	68	23	6.7	20.9
4	100 + 100	.24	2.44	.75	.46	123	74	22	6.1	22.1
5	150 + 100	.24	2.65	.77	.49	128	66	21	6.1	20.4
6	100 + 0	.24	1.98	.89	.65	124	79	21	5.8	21.4
7	100 + 50	.23	2.42	.79	.50	126	80	25	6.1	22.7
8	100 + 150	.24	2.34	.80	.52	116	80	23	4.8	21.7
9	0 + 100	.22	2.27	.80	.53	122	66	25	5.8	22.9
10	100 + 0	.23	2.12	.87	.60	128	65	20	5.6	21.9
	Significance:	NS	**	**	**	NS	NS	NS	**	NS
	BLSD(.05) :		.16	.07	.06				.9	
	CV(%) :	5.4	5.0	5.8	7.6	4.9	21.	17.	9.8	8.6
						Morris				
1	0 + 0	.26	1.57	.60	.50	151	100	30	5.3	6.1
2	0 + 100	.26	1.95	.50	.38	147	83	31	4.6	6.8
3	50 + 100	.29	1.83	.67	.47	158	92	24	4.5	6.0
4	100 + 100	.30	1.95	.62	.49	149	94	21	4.8	6.3
5	150 + 100	.30	1.88	.63	.48	148	100	22	4.3	6.3
6	100 + 0	.30	1.61	.70	.62	146	101	20	5.0	6.0
7	100 + 50	.29	1.76	.62	.53	146	90	20	4.3	5.7
8	100 + 150	.29	1.79	.62	.49	148	90	22	3.8	5.6
9	150 + 100	.29	1.55	.68	.59	151	94	24	4.0	6.1
10	100 + 150	.28	1.77	.59	.49	146	86	24	4.1	6.0
	Significance:	**	**	**	**	NS	NS	**	**	NS
	BLSD(.05) :	.03	.20	.09	.08			4	0.3	
	CV(%) :	7.1	8.2	10.	11.	6.3	11.	11.	10.	13.
						Waseca				
1	0 + 0	.24	1.44	.60	.54	139	75	34	4.6	10.8
2	0 + 100	.24	1.92	.51	.42	142	56	32	5.9	9.6
3	50 + 100	.25	1.90	.54	.42	135	65	27	4.6	10.0
4	100 + 100	.27	1.86	.57	.44	141	64	25	4.4	9.4
5	150 + 100	.26	1.78	.57	.46	140	69	25	4.6	9.6
6	100 + 0	.28	1.36	.60	.56	146	73	24	4.2	8.9
7	100 + 50	.27	1.65	.57	.48	143	67	25	4.4	8.9
8	100 + 150	.28	1.72	.60	.48	144	70	26	4.0	9.8
9	0 + 100	.26	1.68	.56	.49	136	62	27	4.7	9.1
10	100 + 0	.25	1.72	.57	.48	140	63	25	5.5	9.7
	Significance:	**	**	*	**	NS	NS	**	**	NS
	BLSD(.05) :	.02	.13	.07	.03			5	.8	
	CV(%) :	5.9	5.6	6.8	5.2	6.4	14.	12.	12.	11.

Table 7. Population and grain moisture at harvest as influenced by high P and K rates in 1980.

Treatment No.	Treatment Description	Final Population La	Final Population Mo	Final Population Wa	Barren stalks La	Grain Moisture La	Grain Moisture Mo	Grain Moisture Wa
	lb P_2O_5+K_2O/A	plants/A x 10^{-3}			%	----------%----------		
1	0 + 0	24.3	18.4	26.8	28	25.8	18.6	25.0
2	0 + 100	23.8	19.1	27.5	32	24.8	19.8	25.4
3	50 + 100	23.9	18.8	28.2	30	25.2	18.3	24.4
4	100 + 100	23.9	19.9	27.1	27	23.4	17.9	24.6
5	150 + 100	23.7	19.2	27.2	26	23.5	19.1	24.4
6	100 + 0	23.3	19.6	27.8	29	23.7	16.5	23.7
7	100 + 50	23.6	19.5	28.0	33	23.5	17.8	24.1
8	100 + 150	24.0	18.6	26.6	29	22.8	16.9	24.6
9	150[1/] + 100	24.1	20.1	27.3	30	24.2	17.9	25.1
10	100 + 150[1/]	22.7	19.2	27.0	21	23.7	17.0	25.1
	Significance:	NS	NS	NS	NS	NS	NS	+
	CV(%) :	3.4	4.5	3.2	24.	6.1	10.	3.0

[1/] The 150-lb rate was not applied at Lamberton or Waseca.

Table 8. Corn, silage and grain yields as influenced by high P and K rates in Minnesota in 1980.

Treatment No.	Treatment Description	Silage Yield La	Silage Yield Mo	Silage Yield Wa	Grain Yield La	Grain Yield Mo	Grain Yield Wa
	lb P_2O_5+K_2O/A	-------T DM/A-------			---------bu/A---------		
1	0 + 0	5.32	6.70	7.39	80.8	107.1	136.8
2	0 + 100	5.13	6.56	7.08	87.6	108.5	129.9
3	50 + 100	5.40	7.52	7.46	85.7	123.8	146.4
4	100 + 100	5.91	7.66	6.93	87.0	127.0	143.8
5	150 + 100	5.74	7.30	7.32	86.6	120.8	150.8
6	100 + 0	5.71	7.37	7.64	88.1	127.3	137.4
7	100 + 50	5.60	7.24	7.30	81.7	126.7	145.7
8	100 + 150	5.68	7.62	7.19	89.4	121.5	143.0
9	150[1/] + 100	5.38	7.36	6.76	81.0	120.1	143.1
10	100 + 150[1/]	5.95	7.27	7.23	94.2	126.1	146.9
	Significance:	NS	+	NS	NS	NS	NS
	CV(%) :	8.3	6.8	11.	10.	9.0	9.3

[1/] The 150-lb rate was not applied at Lamberton or Waseca.

LIQUID AND DRY STARTER FERTILIZERS FOR CORN IN SOUTH-CENTRAL MINNESOTA

Waseca, 1980

G. W. Randall

Row-applied starter fertilizers have been used for over 30 years in corn production. As greater amounts of P and K fertilizers have been broadcast-applied and soil tests have increased over the last decade, row applications have declined in popularity because of less direct yield response and greater time and labor required for this method of application. Within the last five years liquid starter fertilizers have become extremely competitive with dry materials and in some cases have replaced dry fertilizers; largely because of ease and speed of handling. The purpose of this study was to determine (1) the influence of starter fertilizer on early corn growth, nutrient uptake and corn yield and (2) the relative effectiveness of dry vs liquid starter fertilizer methods.

EXPERIMENTAL PROCEDURES

Five starter fertilizer treatments and a check with no starter fertilizer (Table 1) were applied in a randomized, complete-block design with six replications on a Nicollet clay loam soil (Aquic Hapludoll). Soil test of this site averaged: pH = 5.7, Bray 1 extractable P = 71 lb/A and exchangeable K = 325 lb/A. Corn that had been moldboard plowed was the previous crop. Nitrogen as urea was broadcast-applied at a rate of 170 lb N/A and incorporated with a field cultivator prior to planting.

Corn (Pioneer 3780) was planted on May 7 at a rate of 27700 plants/A with a 4-row John Deere 7000 Max-Emerge planter. This planter was used to apply the dry material in a 2 x 2 band and the liquid in the row with the seed. The 9-23-30 and 7-25-5 were obtained from local fertilizer dealers while the 9-18-9 was supplied by Na-Churs. Based on Na-Churs recommendation liquid Zn chelate (6% Zn) was added to the 9-18-9 treatments at a rate of 3/4 pint/A. Cytozyme a cytokinen containing material was added to the 7-25-5 because of claims by the distributor that this material aided liquid starter fertilizers. Furadan at a rate of 1 lb/A (active) was band-applied to control root worms. Lasso (3 qts/A) and atrazine (2½ lb/A) were applied to control weeds.

Ten randomly selected plants from the outside 2 rows of these 4-row plots were sampled on June 18 for early plant growth measurements and for nutrient analysis. Leaf samples opposite and below the ear were taken at silking (July 28) for analysis. Silage yields were obtained at physiological maturity (Sep 24) by harvesting 15' of one of the outside rows. Grain yields were determined by combine harvesting the center two rows of each plot with a JD 3300 modified plot combine. Moisture and protein analyses were determined on those samples.

RESULTS

Although temperatures in the six-week period after planting were slightly warmer and drier than normal, significant differences in early plant weight were noticed (Table 1). The liquid materials resulted in larger plants compared to no addition of starter fertilizer. The dry material did not influence plant weight but did result in slightly higher P and Mn concentrations. None of the liquid treatments increased the nutrient levels above those of the control. The addition of Zn did not influence the small plant Zn concentration.

Nutrient uptake, the product of nutrient concentration times small plant weight (dry matter), was influenced by the treatments (Table 2). The higher levels of K, Ca, Mg, Fe, Mn and B were associated with the larger dry matter accumulations found with the liquid materials. Uptake of P, Zn and Cu were not affected by the starter fertilizers.

Rainfall was extremely limited and temperatures very hot in the six-week period prior to silking. As a result the plants were under severe stress at pollination. This stress may have influenced the leaf nutrient concentration (Table 3). Leaf N and P were noticeably low considering the N and P treatments and the P soil test. Nutrient concentrations in the earleaf were not influenced by the starter fertilizer treatments under these conditions.

Table 1. Influence of starter fertilizer on the nutrient concentration in the small whole corn plants at Waseca in 1980.

Treatment Material	Rate	Small plant weight	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		g DM/plt.	----------%----------				----------ppm----------				
No Starter		5.1	.35	4.51	.56	.30	251	67	54	6.7	7.9
9-23-30(dry)	140 lb/A	5.2	.38	4.72	.56	.29	248	80	57	6.3	7.8
9-18-9 (liq)	3.5 gal/A[1]	6.0	.35	4.58	.56	.29	271	67	50	6.0	8.3
9-18-9 (liq)	5 gal/A[1]	5.9	.34	4.62	.55	.29	260	66	50	6.0	7.9
7-25-5 (liq)	5 gal/A	6.4	.34	4.56	.54	.29	262	68	57	6.3	8.1
7-25-5 (liq)	5 gal/A	6.7	.34	4.58	.54	.29	258	64	51	5.6	8.0
+ 4 oz. cytozyme											
Significance:[2]		**	+	NS	NS	NS	NS	**	NS	NS	NS
BLSD(.05) :		.9						7			
CV(%) :		12.	7.8	5.6	4.2	3.7	9.7	8.9	20.	14.	5.5

[1] Also contained 3/4 pt. Zn chelate/A.

[2] **, *, and + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level.

Table 2. Influence of starter fertilizer on the nutrient uptake in the small whole corn plants at Waseca in 1980.

Treatment Material	Rate	Uptake P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------mg/plant----------								
No Starter		17.9	229	28	15.2	1.3	.33	.28	.034	.040
9-23-30(dry)	140 lb/A	20.1	246	29	15.0	1.3	.41	.31	.032	.041
9-18-9 (liq)	3.5 gal/A[1]	21.1	273	34	17.2	1.6	.40	.29	.036	.050
9-18-9 (liq)	5 gal/A[1]	20.2	275	33	17.1	1.5	.39	.30	.036	.047
7-25-5 (liq)	5 gal/A	22.1	290	34	18.4	1.6	.43	.37	.040	.052
7-25-5 (liq)	5 gal/A	22.2	306	36	19.4	1.7	.43	.34	.037	.053
+ 4 oz. cytozyme										
Significance:		NS	*	**	**	*	*	NS	NS	**
BLSD(.05) :			48	5	2.5	.3	.07			.008
CV(%) :		15.	14.	12.	12.	16.	13.	27.	14.	13.

[1] Also contained 3/4 pt. Zn chelate/A.

Table 3. Influence of starter fertilizer on the nutrient concentrations in the corn ear leaf at Waseca in 1980.

Treatment Material	Rate	Nutrient N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		----------%----------					----------ppm----------				
No Starter		2.0	.20	2.65	.68	.34	125	49	28	4.0	10.3
9-23-30(dry)	140 lb/A	2.0	.20	2.68	.71	.34	123	54	33	4.7	10.4
9-18-9 (liq)	3.5 gal/A[1]	2.0	.20	2.61	.73	.36	126	46	29	4.4	10.5
9-18-9 (liq)	5 gal/A[1]	2.0	.20	2.73	.71	.35	134	50	30	4.9	9.6
7-25-5 (liq)	5 gal/A	2.0	.20	2.58	.72	.34	128	52	33	4.0	11.5
7-25-5 (liq)	5 gal/A	2.0	.20	2.70	.71	.35	124	49	29	4.6	10.6
+ 4 oz. cytozyme											
Significance:		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%) :		10.	5.7	7.0	9.6	6.2	9.3	13.	18.	18.	11.

[1] Also contained 3/4 pt. Zn chelate/A.

There have been reports of reduced plant stand when applying these liquid fertilizer materials with the seed. The data shown in Table 4 indicate no effect of any treatment on plant population. Silage and grain yields were extremely variable and were not large primarily because of the very dry conditions. As a result neither silage nor grain yield was affected by the starter fertilizer treatments. No explanation can be given for the apparent yield reduction with the 7-25-5 material. Grain moisture was highest when no starter was used and was decreased significantly by the liquid materials. Grain protein was not affected by the starter treatments.

Table 4. Influence of starter fertilizer on corn population, silage yield, grain yield, grain moisture and grain protein at Waseca in 1980.

Treatment		Final	Silage	Grain		
Material	Rate	population	yield	Yield	Moist.	Protein
		x 10^{-3}	T DM/A	bu/A	--------%	--------
No Starter		24.1	6.04	97.9	26.2	10.6
9-23-30(dry)	140 lb/A	23.8	6.33	96.2	25.9	10.8
9-18-9 (liq)	3.5 gal/A[1/]	24.0	5.97	96.6	25.3	10.9
9-18-9 (liq)	5 gal/A[1/]	23.9	5.71	92.5	25.2	10.7
7-25-5 (liq)	5 gal/A	24.4	5.47	82.6	25.4	11.1
7-25-5 (liq)	5 gal/A + 4 oz. cytozyme	24.7	6.10	83.5	25.3	11.1
Significance:		NS	NS	NS	*	NS
BLSD(.05) :					.7	
CV(%) :		4.6	13.	17.	2.1	5.0

1/ Also contained 3/4 pt. Zn chelate/A.

SUMMARY

Under these high soil test P and K conditions early plant growth was enhanced by the liquid fertilizer materials. However, nutrient concentrations in the small plants were generally not affected by the starter fertilizers or by the addition of zinc or cytozyme to the liquid materials. Nutrient concentrations in the earleaf at silking were not influenced by the starter fertilizer treatments. Plant population, silage yield, grain yield and grain protein were not affected by the starter treatments. Grain moisture was lower with the liquid materials.

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ROTATION NITROGEN STUDY

Waseca, 1980

Gyles W. Randall

Increasing the efficiency of fertilizer N along with reducing fertilizer N recommendations by improved diagnostic techniques, symbiotic N fixation, crop rotation, etc. are goals which are gaining widespread research support throughout the United States. The adoption of crop rotations or sequences may play a vital role in the conservation of N. The purpose of this study is to determine the N needs of corn following corn, soybeans, wheat and wheat interseeded with alfalfa in a crop sequence study.

EXPERIMENTAL PROCEDURES

The crop sequences (continuous corn, corn-soybean, corn-wheat and corn-wheat + alfalfa) were begun in 1974 on a Webster clay loam. Each N plot within each crop sequence is 15' wide (6 rows) by 50' long. Rates of N (0, 40, 80, 120, 160 and 200 lb N/A) were applied as anhydrous ammonia on April 24. Wheat received 50 lb N/A as urea before planting. Broadcast P and K of 120 + 200 lb P_2O_5 and K_2O/A was applied in the fall of 1979 before moldboard plowing all plots. Row P and K (0 + 30 + 45 lb N + P_2O_5 + K_2O/A) was applied to the corn at planting.

Corn (Pioneer 3780) was planted in 30" rows at 27,700 ppA on April 28. Furadan was applied to all corn plots at 1 lb/A to control rootworms. Era wheat and Hodgson soybeans were planted on April 25 and May 15, respectively.

Weeds were chemically controlled along with one cultivation of the corn. A combination of 4 qt Lasso plus 3½ lb Bladex/A was applied preemergence to corn. Soybeans received 3½ qt Lasso plus 5 qt Amiben/A applied preemergence.

Corn leaf samples were taken at silking from rows 2 and 5 of each six-row plot while rows 3 and 4 were mechanically harvested for yield. Grain moisture and protein data were obtained on the harvested samples.

RESULTS

Grain yield, leaf N and grain N (protein) all showed significant response to fertilizer N regardless of the previous crop (Table 1). Grain yield response to N ranged from 40 bu/A following wheat interseeded with alfalfa to 55 bu/A following wheat. When no N was added yields were lowest following corn, intermediate following wheat and highest following soybeans or wheat + alfalfa. Yields were maximized at 160, 120-160, 120 and 80 lb N/A when corn, soybeans, wheat, or wheat + alfalfa were the preceding crops, respectively. At the 200 lb/A rate corn yields were

37, 28 and 37 bu/A higher following soybeans, wheat or wheat + alfalfa as compared to continuous corn.

When no N was added, leaf and grain N were highest following wheat + alfalfa and lowest following corn or wheat. At the 200 lb/A rate differences in leaf and grain N were not found among the previous crops. Leaf N was maximized at the 200, 120, 160 and 120 lb/A rates following corn, soybeans, wheat or wheat + alfalfa, respectively. Grain N was maximized at approximately the 160, 120, 120 and 120 lb/A rates for the same previous crops.

Table 1. Leaf N, corn yield and grain N in 1980 following various crops at Waseca.

N rate	Previous Crop			
	Corn	Soybeans	Wheat	Wheat + Alfalfa
lb N/A				
		Yield (bu/A)		
0	60.9	100.6	80.4	104.2
40	77.4	118.8	110.6	123.2
80	91.1	129.7	127.7	145.5
120	99.0	134.2	131.2	146.6
160	105.2	134.0	133.6	134.8
200	107.4	144.6	135.9	144.8
		Leaf N (%)		
0	1.29	1.42	1.24	1.86
40	1.55	2.04	1.70	2.02
80	1.86	2.16	2.04	2.32
120	2.18	2.39	2.41	2.59
160	2.35	2.48	2.38	2.46
200	2.51	2.42	2.56	2.58
		Grain N (%)		
0	1.18	1.21	1.10	1.36
40	1.35	1.33	1.22	1.37
80	1.37	1.52	1.36	1.54
120	1.64	1.66	1.67	1.61
160	1.69	1.70	1.77	1.68
200	1.70	1.67	1.66	1.65

N Rate, Source-Incorporation Study

Gyles Randall and Harvey Meredith

Objective of Study: Determine yield differences between soil incorporated broadcast nitrogen versus surface application without incorporation.

Location: Waseca Experiment Station

N Source: Urea (46-0-0), ammonium nitrate (34-0-0), and urea-ammonium nitrate solution (28-0-0).

N Rate: 0, 75, and 150 pounds N per acre.

Hybrid: Pioneer 3780, 105-day relative maturity

Starter Fertilizer: 140 pounds/A of 0-23-30

Date of Planting: May 7

Nitrogen application - incorporated: May 5

Nitrogen application - nonincorporated: May 20.

Herbicide: Lasso-Bladex

Previous crop: corn

Table 1. Temperature and Precipitation Data, Waseca Experiment Station May 20-31, 1980.

	Maximum Ambient Temperature, °F	Precipitation, In.
20	76	20
21	78	21
22	84	22
23	86	23
24	87	24
25	85	25
26	89	26
27	89	27
28	90	28
29	93	29 .29
30	77	30 1.14
31	68	31 .48

Table 2. Yield of Corn Grain, Waseca Experiment Station, 1980.

Lbs N/A	Yield - Bu/A					
	Am. Nitrate		Urea		28% Soln.	
	I	N	I	N	I	N
0	- - - - - - - - - - - -		-55.6	- - - - - - - - - - - -		
75	94.0	84.4	93.9	97.0	77.8	86.9
150	98.8	99.3	99.4	100.4	87.0	93.0

BLSD (.05) = 15.4
CV (%) = 15

Table 3. Nitrogen Content of the 6th Leaf of Corn at Silking, Waseca Experiment Station, 1980.

Lbs N/A	Percent N					
	Am. Nitrate		Urea		28% Soln.	
	I	N	I	N	I	N
0	- - - - - - - - - - - 1.39 - - - - - - - - - - - -					
75	1.77	1.74	1.81	1.86	1.69	1.63
150	2.13	2.13	2.00	2.13	1.90	1.95

BLSD (.05) = .16
CV (%) = 8.3

Soil pH: The pH of the surface soil varied between 5.4 to 5.6

Final Population: Final stand count varied between 25,500 to 27,200, statistically nonsignificant.

Table 4. Individual Factors Considered for Significance.

N Rate Lb/A	% Leaf N	Bu/A Yield	Grain Moisture %
75	1.75	89.0	25.9
150	2.04	96.3	26.1
Sig.	**	*	NS
N Source			
Am. Nitrate	1.94	94.1	26.0
Urea	1.95	97.7	25.9
28% N Soln.	1.79	86.2	26.2
Sig.	**	**	NS
BLSD (.05)	.08	7.3	
Incorporation			
No	1.91	93.5	26.2
Yes	1.88	91.8	25.9
	NS	NS	NS

Discussion: Because of the high temperature and dry surface conditions following application of the broadcast forms of nitrogen, one would expect a severe test case for volatilization of ammonia both from urea and urea-ammonium nitrate solution.

The driest June and July since 1934 coupled with excessively high temperatures resulted in extensive moisture stress and lower yields than expected.

Nitrogen was applied on the incorporation plots just prior to planting and incorporated. N was broadcast on the unincorporated plots following planting so as not to disturb the soil or incorporate in any way.

At the higher rate the N solution plots yielded lower than either urea or ammonium nitrate. Tissue N at silking followed the same trend.

There were no significant differences between the incorporated and non-incorporated treatments.

It will be noted from Table 1 that hot dry conditions prevailed from May 20 forward following application of the N on the soil surface without incorporation. The first five to ten days are likely the most critical. The average high temperature over this period was 85.7 ^{o} F. For the first eight days following N application, May 20-28, there was no precipitation recorded. Surely a valid test. Yet the data show that there was no difference in yield between the incorporated N treatments and the treatments which were left on the surface without incorporation.

Table 5. NO_3-N of N Rate, Source, Incorporation Study, Waseca Experiment Station, Soil Sampled Spring 1980.

Depth, feet	Replication No.						Mean
	1	2	3	4	5	6	
0-1	32	34	24	22	42	42	33
1-2	10	12	10	9	15	11	11
2-3	10	10	9	11	11	10	10
3-4	12	13	10	16	14	16	14
4-5	24	19	16	26	16	24	21
	88	88	69	84	98	103	89

Use of Dwell (Terrazole) And N-Serve As Nitrification Inhibitors with Spring Nitrogen Application For Corn Production In Southern Minnesota

G.L. Malzer, T. Graff and G.W. Randall

The use of nitrification inhibitors on fine textured soils of southern Minnesota has gained considerable attention over the last several years. There are several chemicals known which are capable of delaying the rate of nitrification,but there is only one currently on the market (N-Serve-Dow Chemical, U.S.A.). An experimental chemical Dwell (Terrazole - Olin Corporation) has shown nitrification inhibition characterstics and was evaluated under field condition along with N-Serve at the Southern Experiment Station at Waseca, MN in 1980. The objectives of the trial were to evaluate the use of nitrogen rates, nitrogen forms and the use of inhibitors with spring application of nitrogen fertilizer.

Experimental Procedures

An experiment consisting of nineteen treatment, with six replication was arranged in a randomized complete block design and established at the Southern Experiment Station. A factorial arrangement consisting of a control, two nitrogen rates (75 and 150 # N/A), three nitrogen forms (urea, anhydrous ammonia and 28%), and three nitrification inhibitor treatments (none, N-Serve, and Dwell), were applied as a spring application May 8th. Urea was broadcast and the respective nitrification inhibitor treatments made as a separate spray application over the soil surface followed by immediate incorporation. The anhydrous ammonia treatments were injected at a depth of 6-8 inches utilizing 30" knife spacings. N-Serve applications were made by addition of the product directly into the anhydrous tank so that both products were applied simultaneously. Dwell applications were made simultaneously with the use of a dual-tube anhydrous shank and a separate pressurized system for the application of the Dwell. Applications of 28% N Solution were sprayed onto the plots followed by separate spray applications for the nitrification inhibitor treatments and then immediate incorporation. All nitrification inhibitors were applied at 0.5 # a.i./A. Corn (Pioneer 3732) was planted into the experimental area in 30" rows at a seeding rate of approximately 27,000 seeds/A.

Leaf samples were collected from opposite and below the ear at silking, dried, and Kjeldahl nitrogen determined. Dry matter production was determined by harvesting 15' of row from each plot at physiological maturity separating the sample into ears and stover and subsamples collected for moisture determination and Kjeldahl nitrogen analysis. Corn grain yields were determined by machine harvesting the center two rows from each plot (55') and expressing the yields at 15.5% moisture.

General Results

A good corn production year was experienced at Waseca in 1980. Yield responses to the application of fertilizer nitrogen were obtained up through the highest rate of fertilization (150 # N/A.) Nitrogen losses large enough to reduce yields appeared to occur with the 1980 spring nitrogen application, although yield reductions were highly related to nitrogen form. At the low rates of nitrogen application both urea and 28% nitrogen solution were inferior to anhydrous ammonia. Urea was very similar to anhydrous ammonia at the higher rate of nitrogen while the use of 28% nitrogen solution was substantially lower. The use of nitrification inhibitors provided yield increases in 1980, but only with certain treatment comparisons. Within these comparisons Dwell appeared to have a slight advantage over N-Serve, but the difference between the inhibitors were not statistically significant. Substantial yield increases were obtained with Dwell at the 75 # N/A rate of application when urea was applied and with both N-Serve and Dwell at the 150 # N/A rate of application when 28% nitrogen solution was utilized. No nitrification inhibitor response was obtained in 1980 when utilized with anhydrous ammonia.

Table 1. Influence of nitrogen form nitrogen rates, and nitrification inhibitors (N-Serve and Dwell) on leaf N content, grain yield, dry matter production and nitrogen removal of corn. - Waseca 1980.

Treatments					Dry Matter Production			N-Concentration		N-Removal		
N Rate	N Form	Inhib.	Leaf N	Grain yield	Grain	Stover	Total	Grain	Stover	Grain	Stover	Total
#/A			%	Bu/A	---------T/A--------			--------%-----		-------lbs/A----------		
Check	-	-	1.52	92.6	2.19	3.32	5.51	1.16	0.46	50.5	30.5	81.0
75	Urea	-	1.89	126.5	2.81	3.82	6.63	1.36	0.62	75.9	46.8	122.7
75	Urea	N-S	1.86	130.8	3.18	3.94	7.12	1.34	0.59	84.7	46.8	131.5
75	Urea	Dwell	1.91	138.7	3.49	4.12	7.61	1.31	0.64	90.8	52.9	143.7
75	AA	-	2.30	144.2	3.41	4.31	7.72	1.37	0.62	93.4	53.8	147.2
75	AA	N-S	2.26	140.8	3.34	4.46	7.81	1.43	0.71	95.6	63.7	159.3
75	AA	Dwell	2.28	146.7	3.60	4.26	7.86	1.32	0.65	95.1	55.8	150.9
75	28%	-	2.00	130.9	3.37	4.20	7.56	1.30	0.59	86.8	49.2	136.0
75	28%	N-S	2.03	134.0	3.30	3.99	7.30	1.36	0.57	89.5	45.6	135.1
75	28%	Dwell	1.99	138.0	3.38	4.08	7.46	1.29	0.63	86.9	51.6	138.5
150	Urea	-	2.20	152.7	3.65	4.63	8.28	1.37	0.72	99.9	66.2	166.1
150	Urea	N-S	2.15	151.1	3.50	4.34	7.85	1.52	0.78	106.4	67.0	173.4
150	Urea	Dwell	2.05	151.4	3.54	4.32	7.86	1.37	0.64	96.2	55.2	151.4
150	AA	-	2.63	153.5	3.59	4.68	8.26	1.60	0.93	114.4	87.1	201.5
150	AA	N-S	2.51	153.0	3.85	4.80	8.65	1.48	0.96	114.2	91.1	205.3
150	AA	Dwell	2.54	152.7	3.29	4.64	7.93	1.60	1.02	104.6	95.1	199.7
150	28%	-	2.34	142.4	4.11	4.63	8.75	1.48	0.74	121.8	68.1	189.9
150	28%	N-S	2.23	155.1	3.60	4.62	8.22	1.47	0.80	105.3	74.0	179.5
150	28%	Dwell	2.30	160.8	4.26	4.79	9.05	1.44	0.81	122.2	77.3	199.5
Significance			**	**	**	**	**	**	**	**	**	**
BLSD (.05)			0.12	13.2	0.39	0.35	0.67	0.09	0.12	10.2	11.2	17.0
Factorial Arrangement												
N-Rate												
75			2.06	136.7	3.32	4.13	7.45	1.34	0.62	88.8	51.8	140.6
150			2.33	152.5	3.71	4.61	8.32	1.48	0.82	109.4	75.7	185.1
Significance			**	**	**	**	**	**	**	**	**	**
BLSD (.05)			0.05	4.8	0.14	0.12	0.24	0.03	0.04	3.8	4.2	6.4
N-Form												
Urea			2.01	141.9	3.36	4.20	7.56	1.38	0.66	92.3	55.8	148.1
AA			2.42	148.5	3.51	4.52	8.04	1.47	0.82	102.9	74.5	177.4
28%			2.15	143.5	3.67	4.38	8.06	1.39	0.69	102.1	61.0	163.1
Significance			**	+	**	**	**	**	**	**	**	**
BLSD (.05)			0.05	5.4	0.17	0.14	0.28	0.04	0.05	4.3	4.6	7.0
Inhibitor												
None			2.22	141.7	3.49	4.38	7.87	1.41	0.70	98.7	61.9	160.6
N-Serve			2.17	144.1	3.46	4.36	7.82	1.44	0.74	99.3	64.7	164.0
Dwell			2.18	148.0	3.59	4.37	7.96	1.39	0.73	99.3	64.7	164.0
Significance			NS	NS	NS	NS	NS	+	NS	NS	NS	NS
BLSD (.05)			-	-	-	-	-	0.04	-	-	-	-

MAXIMUM YIELD DEMONSTRATION
University of Minnesota
Southern Experiment Station
Waseca, MN
1980

Gyles W. Randall

Numerous studies have been initiated over the last few years to "pull out the stops" in an effort to maximize corn and soybean yields. The purpose of our effort was to establish a "non-limiting" environment in which corn and soybean yields could be maximized in a demonstration approach without replication.

EXPERIMENTAL PROCEDURES

The site that we selected was formerly a garden demonstration area which had a long history of high fertilization rates. The soil was a moderately well drained Nicollet clay loam with a 2-4% south-facing slope. Each crop system was planted in an area measuring 20' x 65'. Trickle irrigation using Chapin Watermatic Twin Wall 4 mil, 12" outlet tubing was installed at 45" spacings. Flow meters measured application rates. Water was applied from May 23 thru July 31. The corn was hand planted while a Tye drill was used to plant the soybeans. The corn plots were harvested and measurements taken on the center 40' of each row including the border rows. However, the data reported in Table 4 represent only the center 4 rows and, thus, eliminate the border effects. Soybean yields were taken from combine harvested areas measuring 10' x 50' from each plot. Additional experimental procedures are outlined in Table 1.

The effect of a high fertilization history is shown in Table 2. Soil test P and K levels down to 24 inches were extremely high. Soil test Zn and S were judged to be very high and high, respectively. Soil pH was slightly acid with medium to high levels of organic matter.

RESULTS

Nutrient concentrations in the diagnostic tissues shown in Table 3 indicate sufficient amounts of all nutrients with the possible exception of Mg. The Mg levels were somewhat lower than normal probably due to the extremely high soil K levels. However, high soil K did not result in extremely high tissue K levels. Soybean leaf N levels also are somewhat lower than sometimes recommended in the literature.

Yields from this demonstration fell far below our goals of 250 and 80 bu/A for corn and soybeans, respectively (Table 4). The highest corn yield was 195.0 bu/A with one variety following corn and 192.0 bu/A with the other variety following soybeans. One variety did not stand out as being better than the other. When averaging the yields of both varieties, there was only a 5 bushel advantage for corn following soybeans (183.6 vs 178.8 bu/A).

Because of severe lodging (44 to 100%) yields were taken shortly after physiological maturity. Barren stalks ranged from 12 to 24% of the plants and accounted for a grain yield loss. Final population ranged from 37700 to 39000 and was quite close to our planted population of 40000 plants/acre.

The soybean yield following corn was 17.4 bu/A better than the continuous soybean yield (Table 4). The late season wet weather apparently resulted in increased disease pressure with the continuous soybeans. As a result they matured 9 days earlier than the soybeans in rotation. Seed size of the continuous soybeans was 146 mg/seed while the soybeans in rotation averaged 183 mg/seed.

DISCUSSION

A number of frustrations and hazards were encountered in the 1980 season. Some of these occurrences were either directly or indirectly responsible for our failure to meet the high yield goals.

Total precipitation during June and July was the lowest since 1934. This necessitated heavy dependence on the trickle irrigation which, in general, worked quite well. However, birds in their quest for water pecked holes in the 4-mil plastic tubing. As a result we were continuously patching and/or replacing the tubing. In the future we will use either 8-mil or 12-mil tubing to resolve this problem.

Table 1. Experimental procedures used in "non-limiting" environment demonstration at Waseca in 1980.

Parameter	Crop System: Cont. Corn	Corn after Soybeans	Soybeans after Corn	Cont. Soybeans
Tillage:	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)	F. Chisel Spr. f. cult. (2x)
Manure:	20,000 gal/A liq. dairy (ca 375#N)	20,000 gal/A liq. dairy (ca 375#N)	None	None
Fertilizer:	200 lb N/A as urea(PPI) No P or K	200 lb N/A as urea(PPI) No P or K	None	None
Hybrid-Variety:	Cargill 921 Pioneer 3732	Cargill 921 Pioneer 3732	Vickery	Vickery
Planting date:	4/21	4/21	5/1	5/1
Planting rate:	40000 ppA	40000 ppA	160000 ppA	160000 ppA
Row width:	15"	15"	6 2/3"	6 2/3"
Herbicide:	Lasso + Bladex	Lasso + Bladex	Treflan + Amiben	Treflan + Amiben
Insecticide:	Counter(2#/A)	Counter(2#/A)	None	None
Rainfall:		May	2.54"	
		June	3.34"	
		July	0.51"	
		August	9.69"	
Irrigation: May	1.23"	0.85"	0	0
Jun	1.18"	1.14"	0.99"	1.31"
Jul	7.82"	9.30"	6.51"	3.70"
Harvest date:	9/15	9/15	10/2	10/2
Harvest method:	Hand	Hand	Combine	Combine

High winds with 0.85 inches of rain occurred on June 27. The Cargill 921 variety lodged badly as a result but goose-necked back up before tasseling. This was our first indication that the plant population was too high.

Because of the early planting this was the most mature corn in the area. As a result birds and squirrels began to attack the corn as soon as it reached the blister to early milk stages. We had to cover the corn plots with bird netting and run the netting down and under a 3-foot high wire fence which was installed completely around the plots. Between the fence and the netting most of the birds and squirrels were excluded from the plots. However, some of the ear tips on the outside rows still received considerable damage.

Heavy rains and high winds during August and early September blew off the netting and lodged much of the corn. The netting was quickly replaced. With the high population, low sunlight and lodged conditions stalk diseases entered and premature death occurred quickly.

The humid conditions in this jungle of vegetation resulted in germination of the kernels in the ear while still 6 feet off the ground. This occurred in about 1% of all ears.

Based on our observations in 1980, we will reduce our population somewhat in 1981. We feel that this should give us greater stalk strength and less chance of disease without reducing yield. It will also allow more sunlight to the plants which we think was a major limiting factor this year. In support of that argument, we averaged 270.2 bu/A corn on the outside rows and 250.6 bu/A on the second row from the outside. In this second row where plant competition occurred on each side,

greater amounts of sunlight were apparently available. This resulted in less barren plants and improved standability of the corn.

Table 2. Soil tests from "non-limiting" environment demonstration at Waseca.

Depth	Cont. Corn	Corn after Soybeans	Soybeans after Corn	Cont. Soybeans
	Crop System			
inches	pH			
0-6	6.6	6.4	6.1	6.4
6-12	6.4	6.3	6.0	6.2
12-18	5.9	5.9	5.6	5.8
18-24	5.9	5.7	5.4	5.7
	OM (%)			
0-6	4.5	5.0	4.4	4.4
	Bray P_1 (lb/A)			
0-6	317	262	255	235
6-12	285	260	200	195
12-18	101	148	95	112
18-24	42	60	28	30
	Exch. K (lb/A)			
0-6	930	960	880	990
6-12	820	890	520	920
12-18	420	880	490	920
18-24	380	940	440	900
	Zn (ppm)			
0-6	6.3 (VH)	5.2 (VH)	4.5 (VH)	4.4 (VH)
	S (ppm)			
0-6	15 (H)	15 (H)	13 (H)	14 (H)

Table 3. Nutrient concentrations in the leaf[1/] from the "non-limiting" environment demonstration at Waseca in 1980.

Crop System	Hybrid	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
Cont. Corn	C921	2.84	.34	2.42	.67	.21	162	81	60	5.3	13
	P3732	2.64	.38	2.92	.56	.24	212	53	21	5.6	11
Corn - Sb	C921	2.56	.32	2.67	.56	.15	170	50	36	4.2	10
	P3732	2.64	.38	2.82	.56	.23	207	62	32	5.8	10
Soybeans - C		4.47	.43	2.64	1.10	.35	157	74	47	4.5	60
Cont. Sb		4.29	.38	2.54	1.22	.36	146	56	43	3.3	62

[1/] Corn: leaf opposite and below the ear at silking.
Soybeans: uppermost, fully mature trifoliate at mid-bloom.

Table 4. Corn and soybean production in a "non-limiting" environment at Waseca in 1980.

Crop System	Hybrid-Variety	Grain Yield	Grain Moisture	Grain Prot.	Total Dry Matter	Barren Stalks	Root + Stalk Lodging	Final Popl'n.
		bu/A	%	%	T/A	%	%	x 10^{-3}
Cont. Corn	C921	162.5	32.8	10.0	9.19	20	100	37.7
" "	P3732	195.0	33.9	9.1	11.11	12	44	39.0
Corn - Sb	C921	192.0	36.6	8.8	10.47	24	100	38.8
" "	P3732	175.2	32.9	9.6	9.69	ND[1/]	100	39.0
Soybeans - C	Vickery	54.8	13.7					
Cont. Sb	Vickery	37.4	13.0					

[1/] ND = Not Determined

SUMMARY

Under the growing conditions and experimental conditions used in this demonstration plot in 1980, corn yields reached 195.0 and soybeans 54.8 bu/A. The high corn population which resulted in less sunlight per plant coupled with the climatic conditions were thought to be the main factors limiting yields.

CONSERVATION TILLAGE STUDY

Waseca, 1980

G. W. Randall, J. W. Bauder and J. B. Swan

With increasing emphasis on controlling erosion and minimizing energy requirements (time, labor and fuel), tillage practices of the future will undoubtedly change markedly within the next decade. As a result these practices may be commonly referred to as "conservation tillage" systems.

Experimental Procedures

To evaluate some of these conservation tillage practices on continuous corn an experiment was established in 1975 on a Webster clay loam at the Southern Experiment Station. Five tillage treatments (Table 1) were replicated four times. Each plot was 20' wide by 125' long. Beginning in 1979 all plots were split into two, 4-row plots -- one with 140 lb 9-23-30/A as starter fertilizer and the other without starter fertilizer. Tile lines spaced 75' apart lie perpendicular to the rows within all plots.

Ridges are built along the corn rows for the till-plant (Ridge) treatment by cultivation in June each year. After harvest the stalks are chopped and the moldboard and chisel plow operations are performed in early November. On May 5 the moldboard and chisel plow plots were field cultivated once with the chisel plots receiving a prior disking.

Corn (Pioneer 3732) was planted in 30-inch rows at a rate of 26,100 ppA on May 5. The no-tillage, fall plow and fall chisel treatments were planted with a John Deere Max-Emerge planter equipped with 2" fluted coulters. A Buffalo till planter was used for the till-plant treatments.

Broadcast P and K were applied at a rate of 20+50+150 (lb $N+P_2O_5+K_2O$/A) in November, 1979. Nitrogen (170 lb N/A as ammonium nitrate) was broadcast on May 2. Furadan (1 lb/A) was applied to all plots at planting. Chemical weed control consisted of 3½ lb Lasso and 3 lb atrazine/A applied preemergence. A postemergence treatment of atrazine and oil (2 lb + 1½ qt. oil conc./A) was applied to the no-tillage treatment on June 9 to control weeds that had escaped the preemergence application. Treatments 2, 3, 4, and 5 were cultivated on June 20. Weed control was excellent in all cultivated treatments.

Planting depth was determined by cutting off the coleoptile at the soil surface from all the plants in a 3-meter length of row in each plot 30 days after planting. The seeds were then excavated and the length of the coleoptile to the seed was measured. Early plant growth was determined by harvesting the above ground portion of 10 random plants per plot 43 days after planting. Yields were taken by combine harvesting two rows from each plot.

Results

Significant differences in final population, grain moisture, N removal in the grain and grain yield were found among the tillage treatments (Table 1). Grain protein was not affected.

Grain yield of the moldboard plow treatment (MP) was significantly higher than any of the other treatments (Table 1). Differences among the other systems were not significant, but the chisel plow (CP), till plant (ridge) (TP-R) and till plant (flat) (TP-F) yielded 10 to 15 bushels/A more than the no tillage (NT) system. This was the first year in six years of the study that the MP treatment had excelled to this degree over the other tillage systems. A probable cause could have been the extremely dry and hot conditions during late June and July. Rainfall for the June plus July period was the lowest since 1934. Shortly after cultivation all treatments except the MP showed drought signs. Leaves were rolled and the plants became stunted compared to the MP plants (Table 5). Even though substantial rain fell in August, the stunted plants from the CP, TP-R, TP-F and NT treatments never did equal the MP plants. Perhaps the higher residue/mulch levels of the CP, TP-R, TP-F and NT systems resulted in shallower root growth early in the season. Roots in the MP plots may have been growing deeper. As the hot, dry conditions prevailed, plants from the MP system may have been in a better position to acquire subsoil moisture to meet the high ET demands of the crop. In addition, the cultivation operation on June 20 may have pruned some of the shallow roots and caused

greater evaporation losses. This operation would then have been more critical to the tillage systems with higher surface residue accumulation. Visual stress notes taken on July 18 showed plant stress to increase in the order MP < CP < TP-R < TP-F < NT.

Table 1. Influence of tillage methods and starter fertilizer on continuous corn production at Waseca in 1980.

Treatment			Grain			
Tillage	Starter[2] fertilizer	Final popl'n x 10^{-3}	Moist.	Protein	N Removal	Yield
			--------%--------		lb/A	bu/A
No tillage[1]	S		26.3	9.50	94.2	131.6
No tillage	NS		26.7	9.06	87.8	128.2
Fall plow, f.cult.[1]	S		23.8	9.00	108.6	159.6
Fall plow, f.cult.	NS		24.0	9.06	115.8	168.5
Fall chisel, d., f.cult.[1]	S		25.6	9.12	100.1	146.6
Fall chisel, d., f.cult.	NS		26.5	8.81	88.1	133.0
Till plant (Ridge)	S		24.7	9.62	102.7	142.8
Till plant (Ridge)	NS		25.7	9.50	99.8	139.8
Till plant (Flat)	S		26.0	8.75	94.1	143.2
Till plant (Flat)	NS		26.2	8.38	92.4	145.5
Individual Factors						
Tillage						
No tillage		22.8	26.5	9.31	91.0	129.9
Fall plow		24.1	23.9	9.06	112.2	164.0
Fall chisel		24.1	26.0	8.94	94.1	139.8
Till plant (Ridge)		24.2	25.2	9.56	101.2	141.4
Till plant (Flat)		21.7	26.1	8.56	93.3	144.3
Significance:[3]		**	**	NS	**	**
BLSD(.05) :		1.2	.8	--	7.5	15.8
Starter fertilizer						
Starter			25.3	9.19	99.9	144.8
No starter			25.8	8.94	96.8	143.0
Significance:			*	NS	+	NS
Till x SF IA						
Significance:			NS	NS	*	NS
BLSD(.05) :			--	--	8.9	--
CV(%) :		3.4	2.7	6.6	5.5	5.4

[1] Planted with J.D. Max-Emerge planter with fluted coulters.

[2] S = starter fertilizer used; NS = no starter fertilizer.

[3] **, *, + are significant at the 99, 95 and 90% levels, respectively; NS = not significant at the 90% level.

Starter fertilizer did not improve grain yield when averaging over all treatments (Table 1). However, the 13.6 bu/A increase with starter on the CP treatment was an economical response even though the tillage x starter fertilizer interaction was not significant (P=.10 level). An F value of 2.27 was obtained when a value of 2.36 was needed to be significant.

Final population for the MP, CP and TP-F systems were equal and were significantly higher than the population of the TP-F or NT systems (Table 1).

Grain moisture, an indication of maturity, was significantly lower with the MP treatment (Table 1). The TP-R treatment was intermediate and showed significantly less moisture than the CP, TP-F and NT treatments. Slightly less moisture was associated with the addition of starter fertilizer.

Nitrogen removal in the grain (product of grain N times yield) was closely related to yield because grain protein (N) levels were not affected by the tillage or starter fertilizer treatments (Table 1). Highest N removal occurred with the MP system, intermediate removal with the TP-R system and lowest removal with the CP, TP-F and NT systems. Slightly higher removal was associated with the starter fertilizer. The tillage x starter fertilizer interaction shows significantly more N removal with the CP system when starter fertilizer is used.

Surface residue measured just prior to secondary tillage on the CP system and planting of the TP-R system showed 2.8 and 4.4 T residue/A, respectively (Table 2). Eight days after planting these residue levels were reduced to 1.9 T/A by secondary tillage of the CP system and to 2.5 T/A by till planting on the ridges. Significantly higher residue amounts were found on the TP-F and NT systems after planting. Because of the large corn yields in 1979, some residue was found on the surface of the MP treatment in 1980.

Table 2. Influence of tillage methods for continuous corn on surface residue and seedling depth at Waseca in 1980.

Treatment	Surface Residue: Before Planting	Surface Residue: After Planting	Planting Depth: Average	Planting Depth: S	Planting Depth: Range
	-------T DM/A--------		----------mm----------		
No tillage		4.39	56.7	7.3	36-70
Fall plow		0.64	64.4	5.4	53-78
Fall chisel	2.81	1.88	58.3	8.0	37-72
Till plant (Ridge)	4.43	2.54	47.0	6.7	25-70
Till plant (Flat)		3.85	49.6	10.2	30-69
Significance:	*	**	**		
BLSD(.05) :		.68	8.1		
CV(%) :	15.	18.	9.4		

Planting depth generally averaged significantly deeper when the John Deere planter was used (NT, MP and CP systems) as compared to the Buffalo till-planter (Table 2). Greatest average depth was found with the MP system. The variability in the seeding depth as measured by standard deviation (S) and shown by the range in depths indicates least variability with the MP system and greatest with the TP-F system. Seed placement ranged between 2.1" and 3.1" for the MP system and between 1.2" and 2.7" for the TP-F system. Although the range was greater for the TP-R system (1.0" to 2.7") the standard deviation ranked second to the MP system. Careful adjustment of the till-planter must be practiced, otherwise stand losses will be encountered with shallow seed placement. The shallow and variable seed placement with the TP-F system probably was responsible for the reduced final plant population in 1980.

Soil temperature at the 4-inch depth measured by thermocouples placed directly beneath the seed was affected by the surface residues in the five-week period following planting (Table 3). Average temperatures were warmest with the FP treatment (65.6°) and coolest with the NT treatment (60.5°). The TP-R treatment (63.5°) was slightly warmer than the CP system (63.3°) and the TP-F system (60.9°).

Table 3. Soil temperature (4" average) after planting as influenced by tillage practices at Waseca in 1980.

Treatment	Period: 5/12 -17	5/19 -24	5/26 -31	6/2 -7	6/9 -14	6/16 -19
	----------°F----------					
No tillage	49.4	57.2	64.1	63.0	64.0	65.3
Fall plow	53.5	64.2	69.6	66.5	69.3	70.4
Fall chisel	51.4	61.0	67.4	64.7	67.0	68.1
Till plant (Ridge)	51.6	60.9	67.5	65.1	67.2	68.7
Till plant (Flat)	49.9	57.8	64.7	63.2	64.5	65.5

The rate of seedling emergence was determined by counting the number of plants that had spiked thru in 50-feet of row/plot each day from the 17th to the 28th day following planting (emergence was much slower in 1980 than 1979). Emergence, as a percent of final stand, shown in Table 4 indicates the most rapid germination and growth with the TP-R and FP treatments. The CP treatment was somewhat slower. Slowest emergence occurred with the NT system. The TP-F system was somewhat faster than the NT system but lagged behind the others.

Table 4. Influence of tillage methods on the emergence progress of continuous corn at Waseca in 1980.

Treatment	Days Post Planting									
	17	18	19	20	21	22	23	24	25	28
	% emerged									
No tillage	0	0	3	16	41	70	87	96	98	100
Fall plow	18	59	84	93	97	98	98	98	99	100
Fall chisel	0	10	36	68	89	95	98	98	99	100
Till plant (Ridge)	20	63	89	95	98	100	100	100	100	100
Till plant (Flat)	0	3	22	39	67	82	92	96	97	100

Table 5. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant growth, plant height, tassel and silking date at Waseca in 1980.

Treatment		Early plant growth	Plant[1/] height	Tassel date	Silking date
Tillage	Starter fertilizer	g/10 plants	inches		
No tillage	S	41.0	47.1	7/22	7/26
No tillage	NS	29.0	43.6		
Fall plow	S	75.5	58.0	7/18	7/22
Fall plow	NS	57.2	58.4		
Fall chisel	S	61.2	51.4	7/18	7/23
Fall chisel	NS	45.2	51.7		
Till plant (Ridge)	S	68.5	52.9	7/18	7/22
Till plant (Ridge)	NS	62.2	52.3		
Till plant (Flat)	S	40.2	47.9	7/20	7/24
Till plant (Flat)	NS	32.5	45.4		
Individual Factors					
Tillage					
No tillage		35.0	43.4		
Fall plow		66.4	58.2		
Fall chisel		53.2	51.6		
Till plant (Ridge)		65.4	52.6		
Till plant (Flat)		36.4	46.7		
Significance:		**	**		
BLSD(.05) :		9.8	1.8		
Starter fertilizer					
Starter		57.3	51.5		
No starter		45.2	50.3		
Significance:		**	**		
Till x SF IA					
Significance:		NS	*		
BLSD(.05) :			1.8		
CV(%) :		19.	2.2		

1/ Taken on July 2.

Early plant growth (EPG) measurements shown in Table 5 indicate substantial differences among the tillage treatments. Plant growth by mid-June showed significantly larger plants with the MP and TP-R systems, intermediate growth (80% of the MP and TP-R) with the CP system and smallest plants (55% of the MP and TP-R) with the TP-F and NT systems. Starter fertilizer significantly improved

early growth with all tillage systems. The correlation between EPG and grain yield was not significant with starter fertilizer (+.255^{NS}) and no starter treatments (+.248^{NS}).

Because of the stress symptoms and apparent stunting, plant height of 10 plants/plot were taken on July 2 and are shown in Table 5. Plants grown on MP tillage were significantly taller than all others. Intermediate height was shown with the CP and TP-R systems. Plants were somewhat taller with the TP-F system as compared to NT. A height response to starter fertilizer was also shown.

Tasseling and silking dates were 2 to 4 days later with the TP-F and NT treatments (Table 5). The effect of the dry conditions can be seen by the silking dates which were 4 to 5 days later than the tassel date.

The small whole plants taken for early plant growth (EPG) measurements were chemically analyzed (Table 6). Nutrient analyses indicated significant effects (P=.10) of the tillage treatments on small plant P, K, Ca, Mg, Fe and B. Highest P levels were obtained with the TP-R system. Significantly higher K and B concentrations were found with the MP system. The TP-F system had significantly less plant K. Plant Fe was higher for all systems which received some tillage, indicating that soil had probably splashed onto the plants and contamination resulted. The addition of starter fertilizer reduced plant Ca, Mg, Mn, Zn, Cu and B, but the reason is not known. A tillage x starter fertilizer interaction was evident with only Mg and Cu (P=.05). All plant concentrations appeared to be sufficient for optimum yields.

Table 6. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient concentrations at Waseca in 1980.

Treatment		Nutrient								
Tillage	Starter fertilizer	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	S	.41	4.59	.35	.23	177	40	32	7.7	5.6
No tillage	NS	.40	4.65	.40	.27	161	44	37	9.8	6.4
Fall plow	S	.41	5.53	.41	.26	427	44	40	7.0	6.6
Fall plow	NS	.40	5.02	.50	.30	368	59	43	10.0	7.6
Fall chisel	S	.38	4.59	.42	.28	361	54	36	8.7	6.4
Fall chisel	NS	.39	4.94	.43	.26	312	53	36	9.2	6.8
Till plant (Ridge)	S	.44	4.90	.38	.27	323	43	37	7.6	6.4
Till plant (Ridge)	NS	.42	4.57	.49	.38	318	48	46	10.5	6.8
Till plant (Flat)	S	.39	4.04	.43	.30	364	46	36	9.6	6.1
Till plant (Flat)	NS	.40	4.23	.50	.36	299	47	43	11.2	6.5
Individual Factors										
Tillage										
No tillage		.40	4.62	.38	.25	169	42	35	8.7	6.0
Fall plow		.40	5.28	.45	.28	398	51	42	8.5	7.1
Fall chisel		.39	4.77	.42	.27	336	54	36	9.0	6.6
Till plant (Ridge)		.43	4.74	.44	.32	320	45	41	9.0	6.6
Till plant (Flat)		.39	4.14	.47	.33	331	46	39	10.4	6.3
Significance:		+	**	+	+	**	NS	NS	NS	**
BLSD(.05) :			.38			56				.4
Starter fertilizer										
Starter		.40	4.73	.40	.26	330	45	36	8.1	6.2
No starter		.40	4.68	.46	.31	292	50	41	10.1	6.8
Significance:		NS	NS	**	**	+	**	**	**	**
Till x SF IA										
Significance:		NS	NS	+	*	NS	+	+	*	NS
BLSD(.05) :					.06				1.4	
CV(%) :		7.9	7.9	7.7	12.	21.	11.	8.6	8.9	6.7

Nutrient uptake by the small plants was calculated by multiplying the nutrient concentrations (Table 6) by the EPG found in Table 5. The differences in uptake values among the tillage treatments are closely associated with the respective EPG values (Table 7).

Uptake of all elements was significantly affected by the tillage treatments. Generally, uptake was greatest with MP and TP-R systems, intermediate with the CP system and least with the TP-F and NT systems. Starter fertilizer resulted in significantly higher uptake of P, K, Fe, Zn and B.

Table 7. Influence of tillage methods and starter fertilizer for continuous corn on small whole plant nutrient uptake at Waseca in 1980.

Treatment		Nutrient								
Tillage	Starter fertilizer	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		-----g/10 plants------				---------mg/10 plants---------				
No tillage	S	.17	1.88	.14	.09	7.2	1.64	1.32	.317	.229
No tillage	NS	.12	1.35	.12	.08	4.6	1.29	1.08	.285	.188
Fall plow	S	.30	4.16	.31	.19	31.7	3.24	3.07	.530	.497
Fall plow	NS	.22	2.86	.28	.18	20.3	3.46	2.41	.573	.432
Fall chisel	S	.24	2.81	.26	.17	21.8	3.28	2.23	.529	.396
Fall chisel	NS	.18	2.24	.19	.12	14.0	2.39	1.64	.412	.312
Till plant (Ridge)	S	.30	3.35	.26	.18	21.7	2.92	2.51	.521	.438
Till plant (Ridge)	NS	.26	2.90	.30	.23	19.6	2.93	2.85	.641	.422
Till plant (Flat)	S	.16	1.65	.17	.12	14.7	1.72	1.45	.366	.243
Till plant (Flat)	NS	.13	1.38	.16	.12	9.8	1.48	1.40	.354	.209
Individual Factors										
Tillage										
No tillage		.14	1.62	.13	.09	5.9	1.46	1.20	.301	.208
Fall plow		.26	3.51	.30	.18	26.0	3.35	2.74	.552	.464
Fall chisel		.21	2.52	.22	.14	17.9	2.83	1.94	.470	.354
Till plant (Ridge)		.28	3.12	.28	.21	20.6	2.93	2.68	.581	.430
Till plant (Flat)		.14	1.52	.17	.12	12.2	1.60	1.42	.360	.226
Significance:		**	**	**	**	**	**	**	**	**
BLSD(.05) :		.04	.52	.04	.05	3.1	.78	.57	.105	.072
Starter fertilizer										
Starter		.23	2.77	.23	.15	19.4	2.56	2.12	.453	.360
No starter		.18	2.15	.21	.14	13.7	2.31	1.88	.453	.312
Significance:		**	**	NS	NS	**	NS	+	NS	*
Till x SF IA										
Significance:		NS	NS	NS	NS	*	NS	NS	NS	NS
BLSD(.05) :						4.0				
CV(%) :		20.	21.	24.	24.	15.	26.	20.	24.	20.

Leaf samples were taken from the leaf opposite and below the ear at silking. With the exception of Mg and B, nutrient concentrations were not affected significantly (P=.05) by the tillage systems (Table 8). Significantly lower Mg and B concentrations were found with the MP system. Although a definite trend toward lower leaf K in the TP systems was evident, concentrations were not statistically different (P=.10). Starter fertilizer did not affect leaf nutrient concentrations with the exception of lower K and Cu with the row-applied fertilizer.

Table 8. Influence of tillage methods and starter fertilizer for continuous corn on the nutrient concentration in the earleaf at Waseca in 1980.

Treatment		Nutrient									
Tillage	Starter fertilizer	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%					ppm				
No tillage	S	2.5	.26	1.93	.61	.38	154	40	25	5.0	12.2
No tillage	NS	2.5	.24	2.02	.57	.40	132	39	24	6.3	10.6
Fall plow	S	2.6	.24	1.98	.53	.32	137	44	24	5.0	7.9
Fall plow	NS	2.6	.25	2.15	.54	.30	150	42	28	5.4	8.6
Fall chisel	S	2.6	.25	1.91	.59	.41	144	46	25	5.1	10.2
Fall chisel	NS	2.4	.24	1.98	.59	.40	146	44	25	5.3	10.4
Till plant (Ridge)	S	2.5	.24	1.77	.59	.46	152	39	25	4.5	9.8
Till plant (Ridge)	NS	2.4	.24	1.77	.61	.45	148	41	26	4.7	9.6
Till plant (Flat)	S	2.6	.24	1.75	.61	.43	135	44	25	5.1	10.6
Till plant (Flat)	NS	2.5	.23	1.84	.60	.42	128	42	24	5.2	9.6
Individual Factors											
Tillage											
No tillage		2.5	.25	1.98	.59	.39	143	39	24	5.7	11.4
Fall plow		2.6	.25	2.06	.54	.31	144	42	26	5.2	8.3
Fall chisel		2.5	.25	1.94	.59	.40	145	45	25	5.2	10.3
Till plant (Ridge)		2.4	.24	1.77	.60	.46	150	40	25	4.6	9.7
Till plant (Flat)		2.5	.23	1.80	.60	.42	131	43	24	5.2	10.2
Significance:		NS	NS	NS	NS	*	NS	NS	NS	NS	**
BLSD(.05) :						.09					1.4
Starter fertilizer											
Starter		2.5	.25	1.87	.58	.40	144	43	25	5.0	10.2
No starter		2.5	.24	1.95	.58	.39	141	42	25	5.4	9.8
Significance:		NS	NS	*	NS	NS	NS	NS	NS	*	NS
Till x SF IA											
Significance:		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV(%) :		6.7	6.2	5.8	8.6	8.9	8.8	11.	8.8	9.5	12.

SUMMARY

A field experiment was established in 1975 to evaluate five tillage systems (no tillage, moldboard plow, chisel plow, till-plant (ridge) and till-plant (flat)) on continuous corn on a Webster clay loam. Beginning in 1979 all plots were split to evaluate the effect of starter fertilizer with these tillage treatments. Grain yields with the moldboard plow were significantly higher than with any of the other systems. This was probably due to greater root penetration into the subsoil to supply the plants with water during the hot, dry June and July. Lowest yields were obtained with no tillage. Starter fertilizer did not improve yields when averaged over all treatments. Even though the interaction between tillage and starter fertilizer was not significant a 13 bu increase was obtained when the chisel plow system received starter fertilizer.

SIX-YEAR YIELD SUMMARY

Grain yields have been obtained from the five tillage systems where starter fertilizer was used from 1975-1980 (Table 9). The 6-year average yield shows a 4.5 bu/A yield advantage for the moldboard plow over the till-plant (ridge) system. Most of this difference could be attributed to the 17 bushel advantage in 1980 for moldboard plowing. The chisel plow and till-plant (flat) systems showed intermediate yields while lowest yields were obtained with no tillage. Weed control has been excellent in all treatments except no tillage. In the last two years, however, postemergence herbicides have also provided good weed control with no tillage.

Two-year data indicate some advantage for the use of starter fertilizer with the chisel plow, till-plant (ridge) and no tillage systems. No reason can be given for the obvious difference in response to starter fertilizer between the no tillage and till-plant (flat) systems when both treatments represent the most severely reduced tillage systems.

Table 9. Influence of tillage methods and starter fertilizer on continuous corn yields at Waseca.

Treatment		Grain	
Tillage	Starter fertilizer	1979-80 Avg. Yield	1975-80 Avg. Yield
		bu/A	
No tillage	S	144.2	126.7
No tillage	NS	138.9	
Fall plow	S	165.4	147.2
Fall plow	NS	170.4	
Fall chisel	S	157.8	137.3
Fall chisel	NS	147.8	
Till plant (Ridge)	S	154.0	142.7
Till plant (Ridge	NS	148.6	
Till plant (Flat)	S	149.8	140.0
Till plant (Flat)	NS	152.2	

SOYBEAN TILLAGE-HERBICIDE STUDY

Waseca, 1980

G. W. Randall, E. L. Carter and G. E. Ham

Concern for soil erosion has increased interest in tillage methods that leave residue on the soil surface. In addition, tillage methods which require lesser amounts of energy yet result in an acceptable seed bed are being considered. In south central Minnesota soybeans are generally grown in a corn-soybean sequence; hence, large amounts of corn residue are present. The objective of the study is to determine the effect of various tillage-herbicide systems (residue management) on soil parameters, weed control, nitrogen fixation and soybean production.

EXPERIMENTAL PROCEDURES

To evaluate various tillage-herbicide systems on soybean production following corn, an experiment consisting of 8 tillage-herbicide treatments was established in the fall of 1979 on a Webster-Nicollet clay loam soil complex at the Southern Experiment Station. Primary tillage treatments included no tillage, fall moldboard plow, fall chisel plow, combined fall and spring disking and a double spring disking. The latter three treatments were split to also evaluate methods of herbicide application with minimum tillage. A preplant incorporate herbicide (Treflan) was compared to a preemergence herbicide (Lasso). All plots were 125' long and 20' wide (8-30" rows).

In the fall of 1979, fertilizer was broadcast at a rate of 0+120+200 ($N+P_2O_5+K_2O$/A) before any tillage was started. Row-placed fertilizer at planting was not used.

The no tillage, moldboard and chisel plow treatments were stalk chopped on November 14 and were immediately followed by the fall moldboard, chisel and disk tillage operations. Corn stalks on the spring disk treatments were allowed to stand throughout the winter. Secondary tillage was conducted on May 14. All chisel and disk treatments were disked with Treflan being applied at 1 qt/A to the PPI treatments. The fall plow and chisel treatments were field cultivated the same day.

Soybeans (Corsoy) were planted in 7 of the 8 rows at 8.4 beans/foot on May 15. A non-nodulating isoline was planted in the remaining row to determine the effect of the tillage treatments on dinitrogen fixation and yield only. A John Deere Max-Emerge planter with 2" fluted coulters was used on all plots. On May 16 the preemergence herbicide treatment (Lasso, 3 qt/A) was applied. Amiben at a rate of 5 qt/A was superimposed over all plots on the same date. All plots were cultivated once on July 7. In addition, one-half of all plots were handweeded to evaluate the sole effect of tillage on soybean yield without confounding with weed pressure. A tillage-herbicide x weed interaction could then be investigated.

Thermocouples and soil moisture blocks (gypsum) were installed at the 4-inch depth on April 22 to determine soil temperature and moisture prior to planting. They were removed for planting and then reinstalled directly below a soybean row on May 16. Plant emergence rates were measured in four 10-foot sections from May 25 thru June 11. Final population was taken at that time. Surface residue amounts were determined by removing, weighing, washing and drying corn residue from 27 ft^2/plot on May 27. Early plant growth was determined on July 3 by harvesting and drying the above ground portion of 16 randomly selected plants from the center 4 rows of each plot. Nutrient composition of these samples was determined by ICP analysis. Uppermost, mature trifoliate samples were taken on July 30 for chemical analysis. Volunteer corn population counts were taken on June 30 by counting the total number of single plants or clumps (if a large number of plants emerged from a single ear) in the plot area which was not handweeded. Seed yields were determined by harvesting the center 4 rows with a modified JD 3300 combine and the non-nodulating row with an ALAMCO plot combine on October 6.

RESULTS

Significant differences in small soybean plant K, Ca, Mg, Fe and Ca concentrations were found among the tillage treatments (Table 1). Moldboard plowing resulted in higher K and Fe levels and lower Ca and Mg levels than most of the reduced tillage treatments. Iron differences may have resulted largely from soil splash as influenced by the surface residue, however. No tillage and the fall plus spring disk treatment showed the lowest K concentrations.

Table 1. Influence of primary tillage-herbicide combinations for soybeans following corn on the nutrient concentration of small whole soybean plants in 1980.

Treatment		Nutrient								
Tillage	Herbicide[1]	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage[2]	Pre	.28	1.96	1.90	.68	196	49	30	7.5	34
Fall plow[2]	Pre	.29	2.33	1.77	.60	265	53	30	7.0	34
Fall chisel[2]	Pre	.29	2.22	1.89	.64	235	51	30	7.4	35
Fall chisel[2]	PPI	.28	2.07	1.88	.66	250	49	30	8.2	35
Spr. disk (2x)	Pre	.28	2.15	1.76	.70	220	43	27	6.3	32
Spr. disk (2x)	PPI	.29	2.16	1.80	.71	213	44	29	6.9	34
Fall & Spr. disk	Pre	.28	2.05	1.90	.67	223	47	31	7.4	35
Fall & Spr. disk	PPI	.28	2.00	1.91	.70	213	47	31	7.6	36
Significance:[3]		NS	**	**	**	**	+	NS	**	NS
BLSD(.05) :			.14	.09	.06	31			.7	
CV(%) :		5.5	5.6	4.1	6.7	11.	11.	9.3	7.8	6.6

[1] Pre = Lasso (3½ lb/A), PPI = Treflan (1 lb/A).

[2] These treatments were stalk chopped.

[3] **, *, + are significant at the 99, 95, and 90% levels, respectively. NS = not significant at the 90% level.

Dry matter per acre (product of DM/plant times plants/A) was affected significantly by the tillage treatments (Table 2). Dry matter accumulation five weeks after emergence was significantly higher with moldboard plow tillage than with most reduced tillage treatments. This was probably due to more rapid emergence as shown in Table 5. Even though no tillage resulted in the least DM accumulation, DM was not significantly less than with any of the reduced tillage treatments.

These dry matter differences coupled with the associated nutrient concentration resulted in large tillage treatment differences in uptake of most nutrients (Table 2). Moldboard plow tillage showed the highest uptake levels and significantly higher levels of K, Fe, and Mn than all other treatments. In general, nutrient uptake ranked in order of increasing degree of tillage (plow > chisel = disk > no tillage).

Table 2. Influence of primary tillage-herbicide combinations for soybeans following corn on small plant dry matter accumulation and nutrient uptake in 1980.

Treatment			Nutrient								
Tillage	Herb.	DM	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		lb/A									
No tillage	Pre	481	1.34	9.5	9.1	3.3	.093	.023	.014	.0036	.016
Fall plow	Pre	718	2.09	16.8	12.7	4.3	.192	.038	.021	.0050	.024
Fall chisel	Pre	610	1.74	13.6	11.6	3.9	.140	.031	.018	.0044	.021
Fall chisel	PPI	561	1.59	11.7	10.6	3.7	.141	.028	.017	.0046	.019
Spr. disk (2x)	Pre	558	1.57	12.0	9.9	3.9	.122	.024	.015	.0035	.018
Spr. disk (2x)	PPI	562	1.67	12.1	10.2	4.0	.118	.024	.016	.0038	.019
Fall & Spr. disk	Pre	619	1.73	12.8	11.7	4.1	.134	.029	.019	.0045	.021
Fall & Spr. disk	PPI	588	1.66	11.8	11.2	4.1	.124	.027	.018	.0045	.021
Significance:		*	*	**	+	NS	**	**	*	+	*
BLSD(.05) :		143	.38	2.8			.029	.006	.005		.005
CV(%) :		18.	17.	19.	19.	21.	19.	19.	21.	21.	19.

At the mid-to late bloom stage (four weeks after the whole plants were sampled), leaf K was highest for the moldboard plow treatment, intermediate with chisel plowing and lowest with the disk and no tillage treatments (Table 3). Opposite effects were noticed on leaf Ca and Mg. Leaf Mn was also highest with the plow treatment.

Soil temperatures at the 4-inch depth in the two week period before planting ranged from about 53°F with the no tillage and fall chisel treatments to over 56°F with moldboard plowing (Table 4). Temperatures were intermediate with the disk treatments. In the week immediately following planting soil temperatures averaged about 5°F warmer with the plow treatment and about 1°F warmer with the chisel and disk treatments as compared to no tillage. During the six-week period following planting soil temperatures with the chisel and disk treatments averaged about 1°F and the plow about 3°F warmer than no tillage. These temperature differences were governed largely by the surface residue accumulations shown in Table 6.

Table 3. Influence of primary tillage-herbicide combinations for soybeans following corn on the leaf nutrient concentration of soybeans in 1980.

Treatment		Nutrient[1/]								
Tillage	Herb.	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
		%				ppm				
No tillage	Pre	.30	1.53	1.47	.50	106	51.8	35.1	8.8	58
Fall plow	Pre	.31	1.88	1.37	.41	110	55.7	34.0	8.6	57
Fall chisel	Pre	.30	1.67	1.42	.46	105	48.8	37.0	8.8	58
Fall chisel	PPI	.31	1.68	1.37	.46	107	50.0	35.5	9.3	57
Spr. disk (2x)	Pre	.30	1.54	1.45	.49	105	46.8	34.2	8.7	57
Spr. disk (2x)	PPI	.31	1.54	1.44	.50	104	45.8	35.2	8.9	58
Fall & Spr. disk	Pre	.30	1.58	1.48	.49	105	46.3	35.9	8.7	58
Fall & Spr. disk	PPI	.30	1.56	1.48	.48	107	51.0	37.0	8.9	60
Significance:		NS	**	**	**	NS	**	NS	NS	NS
BLSD(.05) :			.11	.06	.04		4.5			
CV(%) :		4.5	6.2	3.6	6.6	5.0	7.6	5.7	7.0	6.3

1/ Uppermost, mature, trifoliate leaf at mid-to late bloom.

Table 4. Weekly 4-inch soil temperature averages as influenced by tillage method for soybeans following corn in 1980.

Treatment		Soil temperature[1/]							
		Before planting		After planting					
Tillage	Herb.	4/28 -5/2	5/5 -10	5/19 -24	5/26 -31	6/2 -7	6/9 -14	6/16 -21	6/23 -28
		°F							
No tillage	Pre	52.0	53.3	60.6	68.5	64.1	67.1	68.7	74.1
Fall plow	Pre	56.7	56.2	65.6	71.6	66.0	70.6	73.0	77.7
Fall chisel	Pre	52.3	53.5	61.6	69.2	64.3	67.9	70.0	75.0
Spr. disk (2x)	Pre	53.6	54.9	61.2	69.0	64.4	68.0	69.9	75.3
Fall & Spr. disk	Pre	53.6	54.3	61.3	69.2	64.1	67.3	69.5	74.7

1/ Average of maximum and minimum daily T.

Table 5. Influence of primary tillage-herbicide combinations for soybeans following corn on the emergence progress of the soybeans in 1980.

Treatment		Emergence Date										
Tillage	Herb.	5/ 25	5/ 26	5/ 27	5/ 28	5/ 29	5/ 30	5/ 31	6/1	6/2	6/4	6/11
		% emerged										
No tillage	Pre	18	46	66	78	82	84	85	86	92	95	100
Fall plow	Pre	58	82	94	97	97	97	97	97	97	97	100
Fall chisel	Pre	13	53	77	88	92	94	96	96	98	98	100
Fall chisel	PPI	10	33	58	71	82	89	89	93	97	97	100
Spr. disk (2x)	Pre	11	44	67	78	84	84	91	94	96	98	100
Spr. disk (2x)	PPI	9	41	57	68	76	83	88	91	93	96	100
Fall & Spr. disk	Pre	14	50	70	83	86	88	90	91	93	95	100
Fall & Spr. disk	PPI	13	40	62	73	80	87	88	93	94	96	100

Emergence rate of the soybeans was greatly affected by the tillage treatments (Table 5). On the first day of measurement, 58% of the plants had emerged with moldboard plow tillage while no more than 18% had emerged with the reduced tillage treatments. Over 90% were emerged on the plowed treatment 12 days after planting (May 27) while it took 17 days with the chisel and disk systems and 18 days with no tillage to reach 90% emergence.

Fairly high corn residue levels were found after the 1979 crop (Table 6). The proportion of the residue incorporated cannot be estimated in 1980 because some of the residue blew off the no tillage plots during the winter. Fall chisel plowing did incorporate a significantly greater amount than the disk treatments with no difference between the fall plus spring disking and the double spring disk treatments.

Because of the high variability significant differences in early plant weight were not shown in 1980 (Table 6). However, a trend showing largest plants with moldboard plow tillage, intermediate with chisel and disk tillage and smallest with no tillage was evident. This may have been due possibly to the cooler soil temps and slower emergence rates.

Table 6. Influence of primary tillage-herbicide combinations for soybeans following corn on early growth, volunteer corn, population and soybean yield in 1980.

Treatment		Surface residue accuml'n	Early plant weight	Vol.[1] corn	Final popl'n	Seed Yield		
							1980	1977-80
Tillage	Herb.					HW[2]	Std.[3]	Std. Avg.[3]
		T DM/A	g/plant	ppA	beans/ft.	bu/A		
No tillage	Pre	2.6	1.8	6	6.8	48.5	37.7	40.2
Fall plow	Pre	.2	2.5	6	7.5	49.8	49.8	51.0
Fall chisel	Pre	1.2	2.1	6	7.6	46.4	49.7	49.9
Fall chisel	PPI		2.0	6	7.2	51.6	50.8	51.1
Spr. disk (2x)	Pre	2.4	2.1	30	7.1	49.7	50.1	49.4
Spr. disk (2x)	PPI		2.1	24	6.9	50.4	51.2	50.2
Fall & Spr. disk	Pre	2.6	2.2	6	7.4	49.4	48.0	49.0
Fall & Spr. disk	PPI		2.3	30	6.8	49.8	48.3	49.5
Significance:		**	NS	NS	*	**		
BLSD(.05) :		.4			.7	4.4		
CV(%) :		22.	16.	235.	6.9	5.5		
Individual Factors								
HW vs Std.						49.4	48.2	
Significance:						*		
Till x Weed IA								
Significance:						**		
BLSD(.05) :						3.0		

1/ Each clump of corn was counted as one plant.

2/ HW = handweeded.

3/ Std. = standard non-handweeded plots.

Volunteer corn was not a problem in any of the tillage treatments in 1980. A trend toward improved control with Treflan was not observed because of the high degree of variability and the few corn plants available (Table 6).

Slight differences in the final bean population were again found in 1980 (Table 6). Highest populations occurred with the plow, chisel-Pre and fall plus spring disk-Pre treatments. Lowest populations were associated with no tillage and the disk-PPI treatments. A trend toward reduced stand with the PPI (Treflan) treatments was noted in 1980. However, all stands were considered adequate for maximum yields.

Soybean yields were again depressed significantly by no tillage (Table 6). Yield differences among the other standard tillage-herbicide treatments did not exist. Highest yields were obtained, however, with the chisel and the double spring disk treatments with Treflan. When yields from the "standard" and handweeded areas were averaged over all tillage treatments, a significant advantage existed for handweeding. The highly significant tillage x weed interaction indicates that only the no tillage treatment benefited from handweeding and that this extra degree of weed control did not affect yields from the other tillage treatments. These results indicate that soybean yields can be optimized over a wide range of tillage systems provided that adequate weed control is maintained.

Four-year averages for the "standard" (non-handweeded) treatments indicate that excellent soybean yields can be obtained with reduced tillage systems following corn and with both PPI or preemergence grass herbicide programs (Table 6). Sizable yield reductions occurred with no tillage primarily because weed control was insufficient.

Nitrogen fixation, nodulation, root length, N uptake, seed oil and protein content are being evaluated by Mr. Ed Carter as partial fulfillment of his Master's Degree. A non-nodulating line planted in each treatment helps him assess the effect of the tillage treatments on the N status of the soybeans.

SUMMARY

Optimum soybean yields were obtained in 1980 with reduced tillage systems. Surface residue accumulations of up to 2.6 T/A did influence soybean development somewhat. No tillage resulted in slightly cooler soils, smaller plants and very poor weed control (primarily broadleaves and some grasses). Nutrient uptake was affected by the tillage treatments but was adequate for optimum soybean yields. Volunteer corn populations were too small to evaluate the treatments thoroughly. These results indicate that soybean production following corn can be excellent with tillage systems that manage surface residue, thus, limiting soil erosion.

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CORRECTING CHLOROSIS OF SOYBEANS BY FOLIAR APPLICATION OF IRON

Gyles W. Randall
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Waseca, MN
1980

It has been estimated that about 400,000 acres in Minnesota have a sufficiently high pH to exhibit iron chlorosis symptoms. The major agronomic crop that is currently adversely affected by chlorosis induced Fe-deficiency is soybeans. Chlorotic soybeans are a common occurrence and in many instances major seed losses result.

The purpose of this study was to determine if the foliar application of some new iron compounds to the leaves of iron-chlorotic soybeans would correct the deficiency and result in significant yield improvement.

Experimental Procedures

An experimental site was selected on the Orville Collins farm near Waldorf in Waseca County. Peterson 3800 soybeans had been planted in 30" rows. Weeds were controlled by 1 qt Treflan/A. The soybeans were severely chlorotic and were in the 2nd trifoliate stage with the 3rd trifoliate just beginning to emerge.

All foliar iron materials were applied between 0930 and 1100 hours on June 18. Temperatures were warm with partly cloudy skies. Treatments were replicated 8 times in single-row plots measuring 20' long. All materials were applied with a stainless steel hand sprayer at a gallonage rate of 50 gpa with X-77 at 0.25% v/v. The iron application rates (lb Fe/A) are shown in Table 1.

Nine days after iron application a hail storm passed thru the plot site and did result in some additional leaf loss of the already weakened plants. Visual observations were taken on June 23 and on July 8. Yields were obtained on September 30 by hand harvesting 16' of row per plot and threshing with a stationary soybean thresher.

Results

Visual color response five days after iron application indicated some improvement in the green color of some of the leaves. Instead of a general color improvement, however, the darker green responses appeared as mottled splotches throughout the leaf tissue. The response also seemed to be more consistent with the sequestrene 138-Fe material than the other materials. Phytotoxic symptoms were not evident.

Three weeks after application and about 10 days after the hail storm, the visual responses were still mottled and were not consistent throughout the experiment. The hail may have lead to this mottled condition and did prevent any evidence of phytotoxicity symptoms because of the shredding of the leaf tissue.

Yield results shown in Table 1 were extremely variable (CV=68) and were not affected significantly (P=.10 level) by the iron treatments. The highest average yield resulted from the sequestrene 138-Fe treatment. All other treatments had at least two plots (reps) per treatment in which no yield was obtained. The standard error of the mean ($S_{\bar{x}}$) for each of the averages indicates greatest variability for the check, Hamp-Iron, NFE (.22 lb) and Perma Green treatments when expressed in relation to the mean.

Table 1. Influence of various iron products applied to the foliage of chlorotic soybeans in Waseca County in 1980.

Iron Treatment Material	Rate	Seed Yield Avg.	Range	$S_{\bar{x}}$ [1]
	lb Fe/A	-------bu/A---------		
Check	0	9.0	0.0-38.8	4.7
Sequestrene 138-Fe	0.15	16.0	0.5-42.4	5.0
Hamp-Iron	0.20	10.1	0.0-34.3	5.2
Eagle Iron	1.20	13.1	0.0-32.4	4.4
NFE	0.22	10.5	0.0-31.6	4.3
NFE	0.43	8.0	0.0-16.6	2.4
Perma Green F21	0.20	11.0	0.0-33.0	4.5
Significance:		NS		
CV(%)	:	68.		

[1] Standard error of the mean.

Summary

Soybean yield variability was extremely high and may have been magnified by the hail damage shortly after the materials were applied. Yields were not improved statistically by the foliar application of these materials at the 2nd trifoliate stage. An economical response, however, was obtained with the sequestrene 138-Fe.

Soil Inoculant

1980

Waseca, Minnesota

D.K. Langer, G.W. Randall and G.E. Ham

World Agrisearch Corporation markets the product "Soil Inoculant" which contains non-symbiotic forms of N fixing bacteria and blue-green algae. The product can be combined with pesticides or liquid fertilizers at application. World Agrisearch claims that their product "decomposes crop residues, builds soil humus, and accelerates the nitrogen cycle". They state that this totally natural and safe product makes available the nitrogen, phosphorus, potassium and secondary and trace elements needed for crop production. Another claim is that a more stable form of "nitrogen is slowly released all through the growing season for even feeding of the growing crop". The purpose of this study was to evaluate "Soil Inoculant" on corn and soybean production in south-central Minnesota.

Experimental Procedures

Corn

The study was established on a Nicollet clay loam soil which had corn removed as grain the previous year. Prior to establishment of the study, P and K fertilizer was applied to the area at a 120 + 200 lb/A rate, respectively, (oxide basis). Treatments were randomized in a six-replicate, 3 x 2 factorial design. Treatments included 0, 75, and 150 lb N/A with and without "Soil Inoculant". The "Soil Inoculant" was applied and incorporated with a field cultivator on May 9, 1980 at the recommended rate of 0.1 gal "Soil Inoculant" + 30 gal H_2O/A. Corn (Pioneer 3732) was planted at a rate of 29,900 ppA in 30-inch rows on May 14 with 1 lb Furadan/A and 140 lb 0-23-30/A as starter fertilizer. Chemical weed control consisted of 3½ lb Lasso and 3 lb atrazine/A applied preemergence.

The leaf opposite and below the ear was sampled from 10 plants at silking and submitted for N analysis. Final populations were determined from 35 feet of row in each plot. Silage samples taken from 15 feet of row at physiological maturity (black layer stage) were weighed for yield and submitted for N analysis. Grain yield, moisture and protein were determined on combine-harvested corn from the center two rows of each 6-row plot. Grain yields were converted to 15.5% moisture.

Soybeans

Two different soybean lines (Hodgson 78 and 129-nonnod) were planted May 16 on a Webster clay loam soil at a rate of 5 beans/foot in 14-inch rows. This area received 120 + 200 lb P and K/A (oxide basis) the previous fall. Treatments were arranged in a six-replicate, randomized, complete-block design. The "Soil Inoculant" was soil-applied May 19 at the recommended rate of 0.1 gal "Soil Inoculant" + 30 gal H_2O/A. Chemical weed control consisted of 1 qt Treflan + 6 qts Amiben/A (PPI). Seed yield was determined on soybeans combine harvested from the center four rows of each 6-row plot.

Results

Corn

The data for each N rate shown in Table 1 are an average of each respective N rate over both "Soil Inoculant" treatments. Likewise the "Soil Inoculant" values are an average over all N rates. Nitrogen concentration in corn leaf and fodder continually increased with additional nitrogen. Neither leaf nor fodder nitrogen concentration showed a significant "Soil Inoculant" effect, or an interaction between N rate and "Soil Inoculant".

Silage and grain yields were optimized at the 75 lb N rate. Grain yield was not influenced by "Soil Inoculant" while silage yield showed a decrease with the addition of "Soil Inoculant" (P=.10). The nitrogen x "Soil Inoculant" interaction was not significant for either yield. Hot dry weather during late June and July created stress during pollination which added to the variability (high CV's) of this study. Grain moisture was not affected by "Soil Inoculant".

Grain protein content was increased with increasing N rate and by the "Soil Inoculant". The grain protein increase occurred with "Soil Inoculant" at the 0 and 150 lb N rates but not at the 75 lb N rate. These results indicate no positive, consistent effect of "Soil Inoculant" on corn production in south-central Minnesota and, thus, we could not recommend its use even though there was a slight grain protein advantage.

Table 1. Influence of "Soil Inoculant" on the nitrogen concentrations in the corn leaf and fodder, population, silage yield, grain yield, moisture and protein content at Waseca in 1980.

Treatment	Nitrogen		Final	Yield		Grain	
	Leaf	Fodder	Popln.	Silage	Grain	Moist.	Protein
	------%-------		x 10^{-3}	T DM/A	bu/A	--------%--------	
0 lb N	1.43	.53	27.2	5.23	82.2	26.5	7.38
0 lb N + Soil Inoc.	1.47	.56	27.2	4.79	82.8	26.4	8.88
75 lb N	2.06	.62	26.8	7.08	108.6	26.4	8.75
75 lb N + Soil Inoc.	2.12	.64	27.8	7.11	111.0	26.4	8.75
150 lb N	2.32	.76	27.3	7.66	110.9	26.9	9.44
150 lb N + Soil Inoc.	2.29	.84	27.9	6.80	107.4	27.6	10.50
Individual Factors							
N Rate (lb/A)							
0	1.45	.54	27.2	5.01	82.5	26.4	8.14
75	2.09	.62	27.3	7.10	109.8	26.4	8.74
150	2.30	.80	27.6	7.23	109.2	27.2	9.98
Significance:[1/]	**	*	NS	**	**	**	**
BLSD(.05) :	.09	.16	--	.47	11.1	.4	.75
Soil Inoc.							
No	1.94	.64	27.1	6.66	100.5	26.6	8.52
Yes	1.96	.68	27.6	6.23	100.4	26.8	9.39
Significance:	NS	NS	NS	+	NS	NS	**
N x SI IA	NS	NS	NS	NS	NS	NS	NS
CV(%):	6.3	30.	7.6	9.8	14.	2.0	10.

[1/] **, * and + are significant at the 99, 95 and 90% levels, respectively.
NS = not significant at the 90% level.

Soybeans

The "Soil Inoculant" was applied on two different soybean lines. Hodgson 78 is a well adapted, widely grown variety that symbiotically fixes nitrogen. The 129-nonnod line is not capable of nodulation and thus does not fix nitrogen. One would expect that if "Soil Inoculant" non-symbiotically fixes N that it would be demonstrated by higher yields with the nonnod line receiving "Soil Inoculant". Yields shown in Table 2 indicate no advantage for the use of "Soil Inoculant" with either line of soybeans. Thus, "Soil Inoculant" was not fixing or releasing sufficient N for improved soybean production. This is similar to our 1979 results as shown in the 2-year average.

Table 2. Influence of "Soil Inoculant" on two lines of soybeans for yield at Waseca in 1980.

Line - Treatment	Yield 1980	Yield 2-yr. avg.
129 Nonnod - Check	22.3	18.2
129 Nonnod - Soil Inoc.	23.4	18.7
Hodgson 78 - Check	49.6	42.8
Hodgson 78 - Soil Inoc.	48.3	42.2
Individual Factors		
Line		
Nonnod	22.8	
Hodgson 78	49.0	
Significance:	**	
Soil Inoc.		
No	36.0	
Yes	35.8	
Significance:	NS	
Line x Soil Inoc. IA:	NS	
CV(%):	6.1	

Summary

In 1980 corn leaf nitrogen, fodder nitrogen, silage yield, grain yield and grain moisture were not affected positively by "Soil Inoculant". Grain protein, however, was positively affected by the addition of "Soil Inoculant". "Soil Inoculant" showed no effect on soybean yield at Waseca in 1979 or 1980. These results indicate no support for the use of "Soil Inoculant" for corn and soybean production in south-central Minnesota.

Soil Test Comparison Study

Waseca, 1980

D. K. Langer, G. W. Randall and W. E. Jokela

Soil testing is one of the best and most economical methods of ascertaining the nutrient status of the soil. The test then serves as the basis for fertilizer recommendations for crops. Many private and public laboratories provide that service to Corn Belt farmers. The purpose of this study is to compare the soil analyses and fertilizer recommendations given by five regional laboratories for corn production in Southern Minnesota. Working with the laboratories in this comparison study we should be able to improve and standardize fertilizer recommendations for corn production.

Procedures

Two experimental sites measuring 150' by approximately 300' were selected for sampling in October 1979. One of the sites had a history of high P and K fertilization while the other had not received P or K since 1974. The soil type in the former is a Nicollet clay loam while that in the latter is primarily Webster clay loam with some Nicollet clay loam. Both sites have been cropped to continuous corn. Tile lines spaced at 75' intervals provide excellent drainage at both sites. Neither site can be irrigated.

Four samples consisting of approximately 35 cores each were taken from each site. The sampling depth was 7 inches. All samples were oven-dried at 95°F, crushed and mixed thoroughly. The samples were then subdivided and sent out to the five laboratories. Soil analyses requested consisted of pH, OM, extractable P_1, exchangeable K, extractable S and the micronutrients generally tested by each laboratory. For the 1980 growing season the fertilizer recommendations were based on a yield goal of 180 bu/A corn. It was stipulated that all fertilizer would be broadcast-applied.

The six treatments consisted of the specific fertilizer recommendations from the five laboratories and a check (no fertilizer) treatment. These treatments were arranged in a six-replicate, randomized, complete-block design. Each plot measured 15' wide by 55' long. The appropriate fertilizer treatments were applied April 24 and 25. Corn (Pioneer 3732) was planted at the rate of 29,900 ppA in 30-inch rows on April 26 (medium testing site) and April 28 (very high testing site) with 1 lb Furadan/A and no starter fertilizer. Chemical weed control consisted of 3½ lb Lasso and 3 lb atrazine/A applied preemergence.

Ten random, small, whole plants were sampled from the four center rows of each plot, weighed and submitted for analyses. The leaf opposite and below the ear was sampled from ten plants at silking and submitted for analyses. Final populations were determined from 70' of row. Grain yield, moisture and protein were determined on corn harvested with a modified JD 3300 plot combine from the center two rows of each plot. Grain yields were converted to 15.5% moisture.

In September 1980 0-7" soil samples were taken from each treatment at each of the two sites and were sent to the laboratory of the respective treatment. The results obtained from these samples will be used for the 1981 growing season.

Results

Very high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 1 for the very high testing site. This was designated as the very high testing site because the University of Minnesota Soil Testing Laboratory results indicate the soil test P and K levels to be very high. Nitrogen recommendations among the laboratories were quite similar while the P and K recommendations were substantially higher with the private labs. Various micronutrients were recommended by three of the four private labs.

Table 1. Soil test results and the recommended fertilizer programs for the very high testing site at Waseca in 1980.

Test	Soil Test Results[1] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	5.6	5.5	6.5	6.3	5.4
pH (buffer)	6.6	6.5	---	6.6	6.0
Phosphorus	34 VH	36 H	29	38 VH	28 VH
Potassium	163 M	195 M	181	151 H	159 VH
Organic matter (%)	4.1 H	3.2 H	L	2.7	M
Calcium	2012 M	2850 H	---	2750 M	---
Magnesium	372 VH	428 H	---	450 L	---
Sulfur	5 L	18 L	28 A	10 M	5 L
Iron	46 VH	87 H	8+ A	6 VH	---
Manganese	26 H	37 H	2+ A	2.1 VH	---
Zinc	1.1 M	1.0 L	1.4 A	1.2 M	1.1 H
Copper	1.0 M	1.0 A	0.4+ A	---	---
Boron	0.7 L	1.1 A	2.9 S	---	---
ENR (lb/A)	112	---	---	55 M	---
C.E.C. (meq/100g)	17.5	24.4	---	18.4	---

[1] All soil test results are stated in ppm unless noted otherwise. Each value is an average of 4 samples.

Nutrient	Recommended Fertilizer Program[2] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	225	220	220	255	200
Phosphorus (P_2O_5)	45	60	65	60	30
Potassium (K_2O)	115	95[3]	60	55	20
Sulfur	22	12	---	---	---
Iron	---	---	---	.15[4]	---
Manganese	---	---	---	.15[4]	---
Zinc	6.0	8.0	---	.75[4]	---
Copper	0.5	---	---	---	---
Boron	1.0	---	---	---	---
Lime (T/A)	2.0	3.0	---	2.0	7.0

[2] All values indicate pounds of nutrient recommended per acre for a yield goal of 180 bushels of corn per acre.

[3] Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

[4] As 6 qt/A of a material weighing 10 lb/gal and containing 5% Zn, 1% Fe and 1% Mn.

Grain yields were not affected by any of the fertilizer treatments (Table 2). Late June and July hot, dry weather created extreme stress during pollination which resulted in yields being much lower than normally expected. This also added to the lodging problem. Lodging was due primarily to the absence of N in the check treatment. Slight grain moisture differences were evident among the treatments.

Small whole plant micronutrient concentrations were higher with the treatments receiving fertilizer (Table 3). This is primarily due to the imbalance created by nitrogen deficiency in the plants of the check treatment. The boron application recommended by lab A shows up as a significant increase in concentration at this early growth stage.

Earleaf nutrient concentration differences among the five laboratory recommendation treatments were not found (Table 4). However, marked N deficiency and lower P levels of the plants in the check were shown. Some of the micronutrient concentrations in the earleaf show the effect of the N deficient plants in the check. There appears to be a trend toward higher Zn concentrations in those treatments that received a Zn application.

Table 2. Effect of fertilizer recommendations on corn lodging, final population, grain yield and moisture on the very high testing site.

Lab	Fertilizer Recommendations	Lodging	Final Population	Grain Yield	Grain H_2O
	lb/A[1]	%	ppA x 10^{-3}	bu/A	%
A	225N +45P +115K +S+Zn+Cu+B	6.2	26.0	97.8	27.2
B	220N +60P +95K +S+Zn	5.2	25.7	100.1	27.7
C	220N +65P +60K	5.4	25.6	106.5	26.9
D	225N +60P +55K +Fe+Mn+Zn	2.4	26.4	102.1	27.4
E(UM)	200N +30P +20K	3.5	24.9	107.1	26.8
Check		72.8	24.9	95.6	26.7
	Significance:[2]	**	NS	NS	*
	BLSD(.05) :	6.0			0.8
	CV(%) :	36.	4.7	11.	2.2

[1] P and K expressed on oxide basis.

[2] **, * and + are significant at the 99, 95 and 90% levels, respectively. NS = not significant at the 90% level.

Table 3. Effect of fertilizer recommendations on small plant growth and nutrient concentrations on the very high testing site.

Lab	Small plant dry weight	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plt.	%				ppm				
A	6.7	.321	5.14	.37	.27	320	71	47	6.9	8.5
B	6.8	.324	5.02	.37	.27	305	71	49	6.8	7.2
C	6.7	.325	5.01	.38	.27	321	70	45	6.8	7.2
D	6.9	.317	5.24	.36	.27	304	72	46	6.3	6.7
E(UM)	7.0	.311	4.98	.37	.27	350	67	44	6.6	7.0
Check	6.0	.302	4.82	.38	.26	324	54	33	6.0	6.5
Signif. :	NS	NS	NS	NS	NS	NS	**	**	*	**
BLSD(.05):							5	5	.6	.8
CV(%) :	13.	6.0	6.4	4.5	5.3	11.	6.9	9.3	6.8	9.0

Table 4. Effect of fertilizer recommendations on corn earleaf nutrient concentrations on the very high testing site.

Lab	Nutrient N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A	2.21	.303	2.12	.52	.36	164	96	42	4.2	10.6
B	2.29	.289	2.06	.52	.36	149	85	40	4.1	9.5
C	2.29	.296	2.07	.53	.37	164	86	36	4.5	9.6
D	2.28	.301	2.12	.54	.36	160	96	36	4.8	9.9
E(UM)	2.31	.284	2.08	.53	.38	172	82	36	5.2	10.2
Check	1.70	.203	1.94	.55	.37	137	49	21	3.0	8.8
Signif. :	**	**	NS	NS	NS	**	**	**	**	NS
BLSD(.05):	.22	.016				10	12	5	.5	
CV(%) :	8.7	5.5	6.4	7.0	6.3	5.8	13.	12.	11.	11.

Soil analyses conducted after the 1980 growing season again show similar N recommendations among the labs (Table 5). However, P and K recommendations from the private labs are still higher than the UM lab, but the differences are not as great as the previous year. All four private labs recommend either S or at least one micronutrient.

Table 5. Soil test results and the recommended fertilizer programs on the very high testing site at Waseca in 1981.

Test	Soil Test Results[1] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	5.7	5.6	5.8	5.5	5.3
pH (buffer)	6.6	6.2	6.5	6.4	6.4
Phosphorus	29 H	36 L	29	37 VH	20 H
Potassium	141 M	180 L	120	158 H	108 MH
Organic matter (%)	3.8 H	4.9	M	3.8	H
Calcium	2390 M	2900 M	---	2405 VH	---
Magnesium	326 VH	450 M	---	356 M	---
Sulfur	6 L	15 M	25 A	7 L	6 LM
Iron	65 VH	75.2 VH	8+ A	5.6 VH	---
Manganese	33 VH	38.5 H	2+ A	2.1 VH	---
Zinc	2.1 M	2.9 H	1.0 M	1.1 M	1.3 H
Copper	0.8 L	1.0 M	0.4+ A	---	---
Boron	1.6 H	1.2 H	3.4 S	---	---
ENR (lb/A)	106	---	---	95 M	---
C.E.C. (meq/100g)	19.0	27.8	---	24.0	---

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

Nutrient	Recommended Fertilizer Program[2] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	190	185	182	215	170
Phosphorus (P_2O_5)	35	60	56	75	50
Potassium (K_2O)	130	160[3]	128	110	105
Sulfur	18	14	---	13	---
Iron	---	---	---	.12[4]	---
Manganese	---	---	---	.12[4]	---
Zinc	---	---	8	.6 [4]	---
Copper	1	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	2.0	4.5	5.5	3.5	5.0

[2] All values indicate pounds of nutrient recommended per acre for a yield goal of 160 bushels of corn per acre.

[3] Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

[4] As 5 qt/A of a material weighing 10 lb/gal and containing 5% Zn, 1% Fe and 1% Mn.

Medium-high testing site

The soil test results and the accompanying recommended fertilizer program of each laboratory are shown in Table 6 for the medium-high testing site. This site was designated as the medium-high testing site because the UM laboratory results indicate the soil test P level to be medium and the soil test K level to be high. Nitrogen recommendations among the laboratories were quite similar while the P and especially K recommendations were substantially higher with the private labs. Sulfur and various micronutrients were recommended by three of the four private labs.

Table 6. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1980.

Test	Soil Test Results[1/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.4	6.4	6.7	6.8	6.4
pH (buffer)	6.7	6.8	---	7.0	---
Phosphorus	18 M	16 L	9	10 L	9 M
Potassium	144 M	165 M	145	100 L	147 H
Organic matter (%)	5.5 H	3.6 H	M	3.0	M
Calcium	2975 M	4525 VH	---	4205 M	---
Magnesium	540 VH	695 VH	---	795 M	---
Sulfur	6 L	13 L	20 A	7 L	14 H
Iron	37 VH	55 H	8+ A	6 VH	---
Manganese	13 M	21 H	2+ A	2.1 VH	---
Zinc	1.1 M	1.1 L	1.4 A	1.4 M	1.1 H
Copper	1.1 M	1.1 A	.4+ A	---	---
Boron	1.1 M	1.4 A	3.2 S	---	---
ENR (lb/A)	140	---	---	67 M	---
C.E.C.(meq/100g)	21.8	31.0	---	27.9	---

1/ All soil test results are stated in ppm unless noted otherwise.

Nutrient	Recommended Fertilizer Program[2/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	210	220	195	215	200
Phosphorus (P_2O_5)	95	120[3/]	135	105	80
Potassium (K_2O)	150	215[3/]	120	140	25
Sulfur	22	21	---	13	---
Iron	---	---	---	.12[4/]	---
Manganese	0.5	---	---	.12[4/]	---
Zinc	4.5	7.0	---	.6 [4/]	---
Copper	0.25	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.5	1.0	---	---	---

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 180 bushels of corn per acre.

3/ Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

4/ As 5 qt/A of a material weighing 10 lb/gal and containing 5% Zn, 1% Fe and 1% Mn.

At this medium-high testing site the treatments that received fertilizer yielded significantly more than the check (Table 7). However, there were no significant yield differences among the fertilizer treatments (recommendations). Stress during pollination was also a problem at this site but because of greater soil water holding capacity was not as severe as at the previous site. Stalk lodging was greatly reduced by the addition of fertilizer.

Small plant growth was increased over the check by all treatments which received fertilizer (Table 8). The P concentration in the small plants showed almost a linear relationship to the amount of P fertilizer added. The K concentration was not as closely related to the amount of K applied. Magnesium showed an inverse relationship to K which would be expected from the K-Mg interaction. Increases in Mn and Zn concentration with the fertilizer treatments suggest a general N deficiency in the check plants.

Table 7. Effect of fertilizer recommendations on corn lodging, final population, grain yield and moisture on the medium-high testing site.

Lab	Fertilizer Recommendations	Lodging	Final Population	Grain Yield	Grain H_2O
	lb/A[1/]	%	ppA x 10^{-3}	bu/A	%
A	210N +95P +150K +S+Mn+Zn+Cu	10.1	27.1	135.5	25.9
B	220N +120P +215K +S+Zn	7.0	27.0	127.5	26.2
C	195N +135P +120K	6.2	27.2	136.5	25.6
D	215N +105P +140K +S+Fe+Mn+Zn	8.9	27.0	128.7	26.1
E(UM)	200N +80P +25K	10.8	27.5	133.2	25.4
Check		48.8	27.2	115.1	25.3
	Significance:	**	NS	*	+
	BLSD(.05) :	10.3		14.1	
	CV(%) :	61.	4.5	8.3	2.3

1/ P and K expressed on oxide basis.

Table 8. Effect of fertilizer recommendations on small plant growth and nutrient concentrations on the medium-high testing site.

Lab	Small plant dry weight	Nutrient P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	g/plt.	%				ppm				
A	6.2	.343	3.11	.58	.56	242	56	44	9.4	7.9
B	6.7	.349	2.95	.57	.54	231	60	42	9.1	8.0
C	6.8	.371	3.17	.58	.56	246	60	42	8.9	7.7
D	6.8	.351	3.09	.59	.57	265	57	44	9.0	7.6
E(UM)	6.4	.343	2.47	.61	.65	246	58	42	9.2	7.3
Check	4.4	.315	1.87	.57	.58	277	49	36	9.1	7.2
Signif. :	**	**	**	NS	*	+	**	+	NS	NS
BLSD(.05):	1.1	.024	.46		.06		6			
CV(%) :	16.	5.8	14.	5.2	8.1	11.	8.2	11.	7.0	7.2

The N deficiency is clear in the earleaf N concentration (Table 9). The P concentration in the earleaf still showed a linear relationship to the amount of P added but the leaf P levels among the recommended P rates were not significantly different. Leaf K concentrations were significantly influenced by the laboratory recommendations. The U. of Minnesota (Lab E) recommendation did not increase leaf K over that of the check plot. The K-Mg interaction was again obvious. Magnesium, Mn and Zn nutrient concentrations in the check were all low due to the less vigorous N deficient plants. Although small plant and earleaf nutrient concentration differences were evident, the differences failed to be expressed in the final yield.

Table 9. Effect of fertilizer recommendations on corn earleaf nutrient concentrations on the medium-high testing site.

Lab	Nutrient N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
	%					ppm				
A	2.44	.250	1.28	.62	.59	115	62	30	4.4	11.4
B	2.46	.265	1.37	.63	.60	117	70	29	4.5	10.9
C	2.41	.262	1.27	.61	.59	115	62	26	4.4	10.4
D	2.45	.257	1.24	.63	.59	117	65	29	4.4	11.3
E(UM)	2.38	.244	1.03	.62	.68	117	61	26	4.6	10.8
Check	1.94	.204	1.04	.63	.57	114	39	21	3.9	10.2
Signif. :	**	**	**	NS	**	NS	**	**	NS	NS
BLSD(.05):	.23	.022	.13		.06		8	4		
CV(%) :	8.5	7.9	9.7	7.0	8.2	7.3	13.	12.	10.	12.

Soil analyses conducted for the medium-high testing site after the 1980 growing season for the 1981 season show somewhat similar N and P recommendations from the labs (Table 10). The K recommendations are higher with the private labs but the range is not as large as the previous year. Three of the four private labs recommend either S or a micronutrient.

Table 10. Soil test results and the recommended fertilizer programs on the medium-high testing site at Waseca in 1981.

Test	Soil Test Results[1/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
pH	6.5	6.9	6.8	6.5	6.5
pH (buffer)	6.7	---	---	7.0	---
Phosphorus	14 M	24 L	22	24 M	12 MH
Potassium	163 L	180 L	120	228 H	100 MH
Organic matter (%)	4.2 H	7.4	M	4.2	H
Calcium	4300 H	5600 H	---	6090 VH	---
Magnesium	577 VH	770 M	---	1038 H	---
Sulfur	6 L	14 L	25 A	8 M	7 MH
Iron	37 VH	39.4 H	8+ A	5.6 VH	---
Manganese	21 H	16.1 H	2+ A	2.1 VH	---
Zinc	1.3 M	1.9 H	1.1 A	1.7 M	1.2 H
Copper	1.0 M	0.9 M	0.4+ A	---	---
Boron	1.7 H	1.5 H	3.4 A	---	---
ENR (lb/A)	114	---	---	110 H	---
C.E.C.(meq/100g)		35.0	---		---

1/ All soil test results are stated in ppm unless noted otherwise.

Nutrient	Recommended Fertilizer Program[2/] Lab A	Lab B	Lab C	Lab D	Lab E (UM)
Nitrogen	185	185	182	200	170
Phosphorus (P_2O_5)	80	90[3/]	56	90	80
Potassium (K_2O)	125	195[3/]	128	110	105
Sulfur	18	16	---	---	---
Iron	---	---	---	.12[4/]	---
Manganese	---	---	---	.12[4/]	---
Zinc	3	---	---	.6 [4/]	---
Copper	---	---	---	---	---
Boron	---	---	---	---	---
Lime (T/A)	1.5	---	---	0.5	---

2/ All values indicate pounds of nutrient recommended per acre for a yield goal of 160 bushels of corn per acre.

3/ Value includes maintenance recommendation, plus 50% of the buildup recommendation which was to be applied over a two-year period.

4/ As 5 qt/A of a material weighing 10 lb/gal and containing 5% Zn, 1% Fe and 1% Mn.

SUMMARY

There were substantial differences among the laboratories fertilizer recommendations at both sites. Nitrogen recommendation among laboratories were generally similar, but P and K recommendations for the 1980 crop were substantially higher for the private laboratories. Sulfur and various micronutrient recommendations were also provided by the private labs.

Small growing plants showed some uptake response to the micronutrients and K recommended. Earleaf nutrient concentrations among the lab recommendations were not significantly different except for K on the medium-high testing site. Grain yield differences were not observed among the 5 lab recommendations at either site.

Extreme plant stress due to hot, dry conditions during pollination resulted in yields well below our goal. These low yields coupled with the lack of large yield response over the check resulted in the cost of the fertilizer not being offset by the yield response to that fertilizer addition (Table 11).

Table 11. Effect of fertilizer recommendations on yield value, fertilizer cost and the resulting economic difference on both the very high testing site and medium-high testing site at Waseca in 1980.

	Very High Testing Site				Medium-High Testing Site			
Lab	Yield	Value @$3/bu	Fert.[1/] cost	Diff.[2/]	Yield	Value @$3/bu	Fert.[1/] cost	Diff.[2/]
	bu/A	----------$/A----------			bu/A	----------$/A----------		
A	98	294	71	223	136	408	83	325
B	100	300	69	231	128	384	99	285
C	106	318	56	262	136	408	77	331
D	102	306	71	235	129	387	87	300
E(UM)	107	321	40	281	133	399	53	346
Check	96	288	0	288	115	345	0	345

[1/] Using May 1, 1980 prices for each nutrient expressed as dollars/lb as follows: N, .15; P_2O_5, .25; K_2O, .12; S, .21; Mn, .71; Zn, .89; Cu, 2.40; B, 1.52.

[2/] Yield value @$3/bu - fertilizer cost = difference.

Conclusions from the 1980 study can be summarized as follows:

1. Fertilizing to meet very high yield goals under limited moisture conditions is not practical.

2. Application of high rates of P and K to soils already testing very high is not practical.

3. No benefit or response was obtained with the addition of S or the micronutrients even though they were recommended by some laboratories.

NITRATE NITROGEN IN THE SOIL PROFILE AND THE RESPONSE OF CORN TO NITROGEN FERTILIZATION IN SOUTHEASTERN MINNESOTA - 1980

W. E. Jokela, M. O'Leary, and J. Lensing

Studies conducted from 1977 to 1979 showed a relationship between the amount of nitrate nitrogen in the soil profile and the corn yield increase from the application of a standard rate of nitrogen fertilizer.

In 1980 the experiment was changed to include variable nitrogen rates. The objectives of the 1980 study are: 1) to determine the influence of nitrate nitrogen in the soil profile on the yield response of corn to nitrogen fertilization, 2) to determine the optimum nitrogen rate for corn grown on southeastern Minnesota soils, and 3) to monitor nitrate nitrogen in the soil profile with different rates of nitrogen.

Experimental Procedures

In each of seven southeastern Minnesota counties a site was selected in a field to be planted to corn, avoiding fields where alfalfa was the preceding crop or where manure had been applied in the past year. All the plot areas had been in corn the previous year except the Goodhue County one which was in soybeans. The seven farmer cooperators are list in table one along with the county location, soil type, and soil organic matter content of each plot area. The Webster and Floyd-Clyde soils in Steele and Dodge Counties are poorly drained. All the other soils are well drained silt loam soils. Soil fertility levels were generally high with the following range of test values: pH 6.1-7.5, P 30-93 lbs/A, K 167-329 lbs/A. Fertilizer other than nitrogen was applied by the farmer according to his own program.

Each site was sampled in late April to a depth of 5 feet and samples were divided into one-foot increments for nitrate testing. Three 1½ inch cores were taken from each rep. Six rates of nitrogen (0, 50, 100, 150, 200, 250 lbs/A) in four replications were broadcast as urea and incorporated with tillage. In addition a small amount of nitrogen (10 to 20 lbs/acre) was applied to all plots in the starter. Planting was done by the farmer-cooperator. Earleaf samples were taken at early silking from the 0, 50, 100, and 150, lbs/acre N treatments. Grain was harvested from 2-20 foot rows per plot at maturity and yields were determined. Five foot soil samples were taken after harvest from the 0, 100, and 200 lbs/acre N treatment plots (2 cores per plot) and analyzed for nitrate nitrogen.

Results and Discussion

Grain yields and earleaf nitrogen content are shown in Table 2. Yields with nitrogen ranged from 135 to 160 bu/acre except in Dodge County where midsummer drought severely reduced yields. Three locations - Goodhue, Olmsted, and Steele - showed a statistically significant yield response to nitrogen at the 50 to 100 lb/acre rate. These yield responses were reflected in the earleaf nitrogen content. The Houston County site also showed a substantial yield increase with nitrogen, though it was not statistically significant. Earleaf nitrogen and visual observation also indicated a response. At the Wabasha County location severe nitrogen deficiency symptoms were observed in some of the check and low nitrogen plots, but the high variability resulted in no significant response.

Spring and fall soil profile nitrates are shown in Table 3. The 0 to 2 foot spring nitrates range from 39 to 88 lbs/acre with none extremely high or low. The four sites that showed a yield and/or earleaf N response were below 60 lbs/acre nitrate-N in the 0 to 2 foot depth, which is the range in which yield responses were observed in previous years. All responsive sites had less than 150 lbs/acre of nitrate-N in the 5 foot depth. The Winona County location was below 60 lbs/acre in the 0 to 2 foot depth and below 150 in the 0 to 5 foot depth but did not show N response.

Most sites showed little or no increase in nitrate in the soil profile from spring to fall with the addition of 100 lbs/acre nitrogen, which was equal to or greater than the optimum N rate. The 200 lb/acre nitrogen rate, which was excessive in all cases, resulted in an increase of nitrate in the soil profile in 4 of the 7 locations.

Summary

Yield and/or earleaf nitrogen content response to nitrogen occurred in four our of seven locations in 1980, with visual indications of a repsonse in a fifth one. The amount of nitrate nitrogen in the soil profile showed some general relationship to nitrogen response, but it was not consistent at all sites. There was little or no accumulation of nitrate in the soil profile at the end of the season with the application of 100 lbs/acre of nitrogen, a rate that was adequate for maximum yields in this study. A build up of nitrate did result from the application of an excessive rate (200 lbs/acre) at four locations.

Table 1

Cooperator	County	Soil Type	Soil Organic Matter (%, 0 - 6")
A. Moenning	Dodge	Floyd-Clyde silty clay loam	6.7
V. Jokela	Goodhue	Seaton silt loam	3.4
M. Hoschiet	Houston	Mt. Carroll silt loam	2.9
R. Randall	Olmsted	Port Byron silt loam	3.9
A. Abbe	Steele	Webster clay loam	5.9
E. Graner	Wabasha	Seaton silt loam	2.1
A. Redig	Winona	Seaton silt loam	2.4

Table 2 - Influence of nitrogen rate on grain yield and nitrogen content of earleaf at seven locations in southeastern Minnesota - 1980.

N Rate* (lb/A)	Location (county)						
	Dodge	Goodhue	Houston	Olmsted	Steele	Wabasha	Winona
	Yield (bu/A)						
0	97.7	140.5	110.2	130.6	106.9	133.4	121.2
50	109.6	157.0	135.8	144.1	112.2	147.2	128.1
100	89.4	160.7	127.3	146.8	130.1	136.7	135.4
150	96.8	163.0	134.9	148.2	139.7	151.6	138.1
200	98.9	161.0	137.9	151.7	134.5	146.5	133.6
250	108.5	161.1	137.0	150.7	128.0	144.1	127.8
Signif.	ns	+	ns	**	**	ns	ns
BLSD (.05)	-	16.3	-	11.4	15.8	-	-
	Earleaf N (%)						
0	2.60	1.83	2.49	2.68	2.16	2.39	2.64
50	2.62	2.40	2.84	2.80	2.30	2.44	2.50
100	2.64	2.66	2.93	2.90	2.40	2.53	2.62
150	2.72	2.69	2.78	3.05	2.66	2.80	2.73
Signig.	ns	**	+	*	*	ns	ns
BLSD (.05)	-	.26	.33	.24	.29	-	-

*All plots received an additional 10 to 20 lbs/acre nitrogen as a starter.

Table 3 - Residual nitrate nitrogen in the soil profile in the spring and the influence of nitrogen rate on nitrate nitrogen in the soil profile in the fall after harvest. 7 locations in southeastern Minnesota - 1980.

----------Nitrate - Nitrogen (lb/A)----------

Depth (ft.)	Dodge County Spring	Dodge County Fall N Rate (lb/A) 0	100	200	Goodhue County Spring	Goodhue County Fall N Rate (lb/A) 0	100	200	Houston County Spring	Houston County Fall N Rate (lb/A) 0	100	200
0-1	33	29	43	58	28	16	34	40	17	20	22	21
1-2	48	12	36	56	14	8	22	42	22	18	10	12
2-3	33	11	34	56	12	8	8	13	22	14	8	14
3-4	29	21	26	44	13	8	8	9	15	10	9	16
4-5	29	30	25	41	16	8	10	13	11	10	14	14
0-2	81	41	79	114	42	24	56	82	39	38	32	33
0-5	172	103	164	255	83	48	82	117	87	72	63	77

	Olmsted County Spring	Olmsted County Fall N Rate (lb/A) 0	100	200	Steele County Spring	Steele County Fall N Rate (lb/A) 0	100	200	Wabasha County Spring	Wabasha County Fall N Rate (lb/A) 0	100	200
0-1	30	28	39	40	33	32	48	66	32	20	41	38
1-2	26	12	36	52	20	11	26	52	56	12	42	38
2-3	38	10	33	67	19	10	25	44	76	15	24	55
3-4	29	18	52	48	20	11	23	32	98	34	66	84
4-5	18	22	32	38	18	14	16	25	86	59	98	90
0-2	56	40	75	92	53	53	74	118	88	32	83	66
0-5	141	90	192	245	110	78	138	219	348	140	271	295

	Winona County Spring	Winona County Fall N Rate (lb/A) 0	100	200
0-1	34	18	24	24
1-2	18	9	14	16
2-3	14	8	10	14
3-4	14	8	10	19
4-5	15	9	13	15
0-2	52	27	38	40
0-5	92	52	71	88

Deep Sampling Of Soils For Residual Nitrates And Its Potential As A Diagnostic Technique For Corn Production In Southwestern Minnesota

G.L. Malzer, G. Holcomb, W.W. Nelson, and S. Evans

The rate of fertilizer nitrogen recommended for corn production in Minnesota are currently based upon yield goal and previous cropping history. In many respects depending on the climatic conditions, these recommendations have the potential of being either too high or too low. Research experiments were therefore, established with the following objectives: 1) To determine if the residual nitrates within the top five feet of soil or to a lesser depth could be used in predicting nitrogen fertilizer requirements for corn; 2) To evaluate fall vs spring soil sampling; 3) to ascertain the importance of nitrate accumlation and movement within the soil profile.

Experimental Procedures

Eight locations were established in the fall of 1979 on farmer cooperator fields (Table 1) in Southwestern MN. At each location, four nitrogen treatments (with four replications) were applied as ammonium nitrate at rates of 0,40,60 and 100 #N/A. Due to the wet fall of 1979 no deep (0-5') soil samples were obtained. Soil samples were, however, collected from the control plots (zero N/A) in the spring. Samples were collected to a depth of five feet in increments of one foot, analyzed for nitrate nitrogen and soil moisture (Table 3). All cooperators were asked to follow normal management practices for the areas except for nitrogen fertilization or manure application. Treatments were evaluated by obtaining leaf samples from opposite and below the ear at silking for nitrogen analysis, grain yields and nitrogen utilization by grain (Table 2).

General Results

Of the eight locations established for 1980, one location was lost to early harvest (location 2); three locations showed significant positive yield increases due to nitrogen application, and four locations revealed no significant yield response to applied nitrogen. Yields and nitrogen utilization appeared to be highly correlated with soil nitrate nitrogen. Yield potential as well as soil nitrate nitrogen must be considered when determining when a location will respond to additional fertilizer nitrogen.

Observations over four years - The development of a soil test for predicting nitrogen availability to corn appears to be a promising technique. The quantity of nitrate nitrogen contained within the soil profile is highly correlated with grain yield. It also appears that the availability of the nitrogen is also highly correlated with soil moisture. For these reasons the positioning of the nitrates within the soil profile have a considerable impact on the availability of nitrate nitrogen deeper in the profile. Adjustments in soil nitrates based upon soil moisture have provided much higher correlations with yeild than total soil nitrates going down through the profile. In addition to adjusted soil nitrates, an estimate of mineralizable nitrogen has assisted a great deal in making better predictions of corn grain yields. More information will be forthcomming concerning an operational model for predicting fertilizer nitrogen needs.

Table 1. Location number, cooperator and county of the experimental site.

Location No.	Cooperator	County
1 (2)	Cornelius Boerboom	Lyon
2 (3)	Clarence Feste	Murry
3 (13T)	Werner Fisher	Redwood
4 (13S)	Werner Fisher	Redwood
5 (4)	Donald Lensing	Redwood
6 (6)	Carsten Madsen	Lincoln
7 (9)	Lawrence Quade	Cottenwood
8 (12)	Don Werner	Pipestone

Table 2. Influence of nitrogen treatments on grain yield, leaf N at silking, grain N and grain nitrogen removal at seven locations in S.W. Minnesota.

Nitrogen Rate	Location No. 1	3(T)	4(5)	5	6	7	8
#/A	Yield - bu/A						
0	160.6	153.6	158.6	86.1	124.4	134.8	63.2
40	153.9	148.6	162.2	114.1	140.3	139.2	68.0
60	173.5	157.0	163.8	141.1	141.8	129.3	81.8
100	169.2	155.5	167.6	152.3	135.9	129.0	85.5
Significance	+	NS	NS	*	+	NS	NS
BLSD (.05)	15.2	-	-	39.5	12.6	-	-
	Leaf N %						
0	2.30	2.56	2.41	1.32	2.66	1.73	2.32
40	2.43	2.62	2.40	1.76	2.65	2.08	2.47
60	2.48	2.45	2.35	1.78	2.64	2.15	2.51
100	2.50	2.69	2.43	2.15	2.80	2.23	2.52
Significance	NS	NS	NS	**	NS	*	*
BLSD (.05)	-	-	-	0.38	-	0.33	0.16
	Grain % N						
0	1.30	1.61	1.68	1.16	1.34	1.37	1.88
40	1.41	1.52	1.64	1.11	1.42	1.52	1.94
60	1.39	1.57	1.78	1.31	1.50	1.61	1.90
100	1.44	1.71	1.78	1.28	1.50	1.69	1.85
Significance	NS	NS	+	NS	NS	NS	NS
BLSD (.05)	-	-	0.12	-	-	-	-
	N- Removal with Grain - #/A						
0	99.1	117.5	126.7	46.4	79.1	88.5	55.8
40	102.6	107.2	125.6	61.7	94.4	100.0	63.0
60	114.1	117.3	138.0	87.5	100.3	98.0	73.2
100	115.1	125.7	141.2	93.4	96.4	102.3	74.8
Significance	+	NS	NS	*	*	NS	NS
BLSD(.05)	13.1	-	-	31.7	15.8	-	-

Table 3. Residual nitrate nitrogen content by depth at seven experimental locations in S.W. Minnesota measured in the spring prior to planting.

Depth -Ft-	Nitrate Nitrogen - #/A depth increments Locations 1(Soybeans)	2(Soybeans)	3&4(Soybeans)	5(Corn)	6(Soybeans)	7(Soybeans)	8(Flat)
0-1	48	41	54	9	61	60	78
1-2	19	29	18	5	31	26	44
2-3	28	49	103	10	32	18	36
3-4	45	71	15	32	32	22	24
4-5	57	80	13	60	27	18	22
Total	197	270	203	116	183	144	204

( ) = previous crop

SULFUR AND MAGNESIUM TRIALS ON IRRIGATED CORN IN CENTRAL MINNESOTA - 1980*

W. E. Jokela and M. O'Leary

In the last few years a large acreage of cropland in central Minnesota has been put under irrigation. This has increased the yield potential of these coarse-textured soils from a marginal corn yield of 70 or 80 bu/acre to as much as 150 bu/acre.

However, in the past two years there have been numerous reports of good farm operators experiencing serious production problems on substantial parts of their irrigated continous corn acreage. Preliminary soil and plant analysis suggested that deficiencies of sulfur and possibly magnesium may be responsible.

The objective of this study is to evaluate nutrient needs that have been limiting irrigated corn production in central Minnesota, specifically, to determine the effect of different rates and sources of sulfur and/or magnesium on increasing irrigated corn yields.

Experimental Procedures

Two farm sites were selected in Wadena and Morrison Counties where irrigated corn production problems have occurred in the past. They are representative of a large area of sand and loamy sand soils under irrigation in central Minnesota. Both fields were in corn for at least four years. A sulfur trial was conducted at the Wadena County site and a sulfur and a magnesium trial at the Morrison County location. A randomized complete block design with four replications was used in all three trials.

Wadena County

This trial was located on a low organic matter, sand texture soil on the farm of Norm Baker. Broadcast sulfur treatments were 0, 25, and 50 lbs/acre of actual sulfur from three sources - gypsum, elemental sulfur ("Agri-Sul" - 90% S), and a mixture of gypsum and elemental sulfur. The high rates and different sources were used because of concern that under these irrigated conditions leaching of the sulfate form of sulfur might be causing deficiency conditions later in the season. Sulfur was applied in the spring and incorporated with two diskings. Nitrogen management on the whole plot area consisted of 80 lbs/acre N pre-plant as urea and 90 lbs/acre sidedressed as anhydrous ammonia on June 17. Adequate potash (150 lbs/acre K_2O) was also applied. Corn was planted on May 8 at a population of approximately 18,000 by the farmer-cooperator. Starter was applied at rate of 100 lbs/acre of 10-20-40. Soil test results, shown in Table 1, indicate low sulfur in the 0-6 and 6-12 inch depth.

Morrison County

A sulfur and a magnesium trial were located on adjacent areas on a low pH, low organic matter, sand textured soil on the farm of Joe Kroll. The sulfur treatments were broadcast rates of 0, 25, and 50 lbs/acre from two sources - gypsum and elemental sulfur ("Agri-Sul, 90% S). Starter fertilizer was applied to all plots, with half of each plot receiving 200 lbs/acre of 8-10-30 and half receiving 200 lbs/acre of 8-10-30 - 6.5 S (13 lbs/acre actual sulfur). (Due to impurities the "no sulfur" starter actually contained 2.5% sulfur, enough to supply 5 lbs/acre). The magnesium trial consisted of four broadcast treatments 0, 50, and 100 lbs/acre of magnesium as magnesium chloride, and four tons/acre of dolomitic limestone (CCE 85%, 36% passing 60 mesh screen). All treatments were applied preplant and incorporated with two passes of a field cultivator.

*This project supported in part by funds from CENEX.

Both areas received adequate rates of potash and either magnesium or sulfur (150 K_2O, 75 Mg on S plots, 50 S on Mg plots). Nitrogen application consisted of 160 lbs/acre N an anhydrous ammonia (80 on 6/11 and 80 on 6/20) plus 16 lbs/acre in the starter.

Pioneer 3906 variety was planted by the farmer cooperator on April 29 at a population of 22,000 plants/acre. Sulfur and magnesium soil tests, shown in Table 1, were in the low range on both trials. Soil test levels for all nutrients except potassium showed very little change with depth.

Wadena and Morrison County

In all three trials earleaf samples were taken at early silking on selected treatments. Grain was harvested by hand (2-20 ft. rows/plot) at maturity and yields calculated.

Results and Discussion

Wadena County

Plant analysis results and grain yields are shown in Table 2. Yields were low and variable and there were no significant differences due to treatment. Major causes of the low yields were low and uneven plant population and large amounts of volunteer corn.

Some yellowing was observed in late June, nine days after anhydrous ammonia had been sidedressed. This was a temporary condition that improved later, apparantly as the sidedressed N took effect. Nutrient concentration in the earleaf at silking showed adequate levels of sulfur and nitrogen and no differences between the check and the 50 lbs/acre treatment from gypsum.

Morrison County

Grain yields and earleaf nutrient concentrations are shown in Tables 3 and 4. Yields averaged over 120 bu/acre in both the sulfur and the magnesium trials but there was no significant response to any treatment. Some irregular areas showed drought stress in mid summer, apparantly due to soil differences, but yields were still maintained quite well. Earleaf nutrient concentrations were all adequate and not affected by treatment.

The magnesium plots were sampled at harvest to determine what effect the various treatments had on the magnesium level in the surface layer. Results are shown in Table 4. Variability was quite high, but the plots receiving dolomitic lime tested higher in magnesium than the other treatments. Based on an average magnesium content of dolomitic limestone of 11.5% and assuming that the material of 60 mesh or finer is available the first year (36% for this lime), 4 tons of this dolomitic limestone would provide over 300 lbs of actual magnesium. This may explain why magnesium soil test level was increased compared to the other treatment. It also gives some evidence that dolomitic limestone may give some benefit in correcting a magnesium deficiency within a year of application. The pH on the limed plots was also increased to 6.0 compared to an average of 5.5 on the unlimed plots.

Summary

The results of the three trials in 1980 showed no yield increase from the application of sulfur or magnesium. Concentration of both nutrients in the earleaf at silking was adequate and not affected by treatment. At the Wadena County location the low and variable yields were limited by other production problems, specifically plant population and volunteer corn. At the Morrison County site yields were much better. The cooperator indicated that his entire farm averaged 125 bu/acre in 1980, about the same as those in the trial, compared to yields of 70 to 90 bu/acre in the two previous seasons. Improved weather, fewer pest problems, and possibly some management factors contributed to the increased production. Temperature and moisture conditions may have created optimum conditions for release of sulfur by mineralization during the season.

Table 1. Soil test results from sulfur and magnesium trials. Wadena and Morrison County. Spring, 1980.*

Wadena Co.

Depth inches	Texture	pH	O.M. %	P	K	Mg	Zn	S
				---lbs/A----			- ppm -	
0 - 6	S	6.4	1.5	70	246	188	.6	6
6 - 12	S	5.8	L	59	231	195	-	5

Morrison Co.

Sulfur Trial

0 - 6	S	5.6	.8	94	190	64	.7	5
6 - 12	S	5.4	L	94	91	58	-	5
12 - 24	S	6.2	L	73	84	66	-	5

Magnesium Trial

0 - 6	S	5.4	1.0	102	230	72	.7	4
6 - 12	S	5.7	L	84	128	103	-	4

*Average of two samples.

Table 2. Grain yield and earleaf nutrient concentration of irrigated corn as affected by rate and source of sulfur. Wadena County (Baker). 1980.

Sulfur (S) Applied* lbs/A	Earleaf Nutrient Concentration % S	% N	Yield bu/A
0	.21	3.1	81.4
25 E			90.6
50 E			77.5
25 G			82.9
50 G	.24	3.4	95.4
25 M			87.0
50 M			75.1
Significance	ns	ns	ns
C.V.			13.4

*E = elemental S ("Agri-Sul"), G = gypsum, M = mixture (½ from elemental S, ½ from gysum)

Table 3. Grain yield and earleaf sulfur concentration of irrigated corn as affected by rate and source of sulfur. Morrison County (Kroll). 1980.

Sulfur (S) Applied* lbs/A	Earleaf Sulfur Concentration %	Yield bu/A
Broadcast		
0	.23	122.5
25 E		123.5
50 E		122.5
25 G		118.6
50 G	.24	128.0
Significance	ns	ns
Starter		
No sulfur	.24	123.0
With sulfur	.23	123.0
Significance		ns
C.V.		7.0

*E = elemental S ("Agri-Sul"), G = gypsum

Table 4. Grain yield, earleaf nutrient concentration, and magnesium soil test as affected by rate and source of magnesium. Morrison County (Knoll). 1980.

Magnesium (Mg) Treatment	Earleaf Nutrient Concentration							Yield bu/A	Mg Soil Test 10/80 lbs/A
	---------%----------				------ppm-----				
	P	K	Ca	Mg	Zn	Cu	B		
0	.29	2.02	.48	.23	30	8	8	128.4	86
50 lbs/A*	.28	1.99	.47	.22	33	9	7	122.8	72
100 lbs/A*	.29	1.95	.49	.25	33	7	7	125.6	90
Dolomitic Lime** (4 tons/A)	.28	1.99	.50	.26	27	8	9	133.5	124
Significance	ns	ns	ns	ns	ns	ns	ns	ns	*
BLSD (.05)	-	-	-	-	-	-	-	-	35
C.V.	4.8	6.7	14.3	22.2	14.0	26.0	20.8	6.0	22.1

*Applied as MgCl.
**Lime analysis: CCE = 85%, 36% passing 60 mesh screen.

TILLAGE STUDY SUMMARY
1979-1980 Lancaster, Wisconsin

W. Paulson, Supt., A.E. Peterson, J.B. Swan, R. Higgs

Location: Northwest corner of Lancaster Experimental Farm on north side of County Rd.
Soil: Rosetta silt loam, 9 percent north slope
Moderately eroded
Experimental Design: RCB, 3 reps
Previous crop: Corn
Plot size: 90 ft. wide by 100 ft. long

Year	Date Planted	Average Population: Buffalo Till	Chisel Plow	Slot Plant	Conv	Starter Fertilizer
1979	May 16	22940	20650	21452	20612	120 lbs/ac of 7-23-5
1980	May 9	22204	21261	21402	21285	

1979 ADDITIONAL DATA

Weed control:
a) Atrazine 2 lbs/acre, Prowl 2 qts/acre — broadcast as preemergence
b) Banvel ¼ pt/acre for velvet leaf control — broadcast at 4-inch ht, postemergence
c) Atrazine 1 lb + oil 1 qt - postemergence - 1 ft. high
d) on slot plant only
2 qts Lorox directed spray at 2½ ft. corn height

Residue Prior to Tillage: Cornstalks from 1978 + 20 T/acre manure
entire area received light disking on April 20.

N: Anhydrous ammonia (injected) 100 lbs/ acre N applied preplant

Hybrid: Pioneer 3780 (100 day R.M.) Harvest 10/29/79.

1980 ADDITIONAL DATA

Weed control:
a) Aatrex Nine-O 2 lbs/ acre
Lasso 2 qts/acre

Residue Prior to Tillage: Cornstalks

Conv. plots plowed and disked on 5/2/80
Chisel plowed plots on 5/8/80

N: Urea - Dry 5/2/80 @ 200 lbs/acre

Hybrid: Pioneer 3747.

Tillage Trials, Lancaster, Experiment Station,
Lancaster, Wisconsin.
J.B. Swan, A.E. Peterson, W.H. Paulson, R. Higgs

1979 CORN YIELDS Bu/Ac.

Tillage	Rep				
TMT	I	II	III	Σ	Avg.
Buffalo-till	145.2	166.9	174.7	468.8	162.3
Chisel plow	161.2	165.8	154.0	481.0	160.3
Slot plant (Disked)	154.4	160.3	174.3	489.0	163.0
Conventional (Plow Disk)	163.4	165.2	177.4	506.0	168.7
Rep Σ	624.2	658.2	680.4	1962.8	
Rep Avg.	156.0	164.6	170.1	163.5	

ANOVA - RCB

Source	DF	SS	MS	F	
Block (B-1)	2	400.6067	200.3033	2.60	NS F.10=3.46
TMT (t-1)	3	115.427	38.476	0.50	NS F.10=3.29
Error (B-1) (t-1)	6	462.433	77.072		
Total	11	978.4667			

Tillage Trials, Lancaster Experiment Station, Lancaster, Wisconsin

1980 CORN YIELD Bu/Ac.

Tillage TMT	Rep I	Rep II	Rep III	TMT Total	Avg. Bu/Ac
Buffalo till	157.8	166.9	145.1	469.8	156.6
Chisel plow	156.8	142.4	151.6	450.8	150.3
Slot plant	149.7	145.8	142.1	437.6	145.9
Conventional (Plow-Disk)	163.6	164.2	145.9	473.7	157.9
Rep Total	627.9	619.3	584.7	1831.9	
Rep Avg.	157.0	154.8	146.2	152.7	

ANOVA - RCB

Source	DF	SS	MS	F	
Block	2	261.45	130.7233	2.37	NS F.10=3.46
TMT	3	284.58	94.86	1.72	MS F.10=3.29
Error	6	329.7467	54.96		
Total	11	875.7692			

CF=279,654.8008

1979-1980 Totals Bu/Ac

Tillage	1	2	3	Σ	Avg. Bu/ac
Buffalo till	303.0	333.8	319.8	956.6	159.4
Chisel Plow	318.0	308.2	305.6	931.8	156.3
Slot plant	304.1	306.1	316.4	926.6	154.4
Conventional	327.0	329.4	323.3	979.7	163.3
Rep Σ	1252.1	1277.5	1265.1	3794.7	
Rep Avg.	156.5	159.7	158.1	158.1	

ANOVA For Yrs 1979 & 1980
(From Torrie Steel p. 248)

	Source	df	SS	MS	F
	Blocks (R)	2	40.33	20.17	0.41
I	Tillage (T)	3	299.5713	99.857	2.04 N.S.
	Error	6	293.25	48.875	
	Subtotal I	11	633.1512		
	Years (C)	1	713.9504	713.95	8.59*
II					F.05=5.99
	RC	2	621.72	310.86	3.74 Sig at 10% F.10=3.46 F.05=5.14
	TC	3	100.43	33.48	0.40
	Error b	6	498.94	83.16	

Conclusions: No significant interaction between tillage TMT and years (TC). Interaction of Reps and years (RC) was significant at 10% level

THE EFFECT OF THREE NITROGEN PRODUCTS ON SOIL pH IN THE GREENHOUSE

Curtis J. Overdahl, Todd King, Micheal O'Leary

A sulfur containing nitrogenous waste product from 3M was compared to urea and ammonium sulfate. Corn was grown in the greenhouse with a loamy sand soil from the Becker irrigation farm. Two separate trials were conducted during January and through March 1980.

The project was funded by the 3M Company to determine beneficial or possible undersirable effects of the waste product.

A complete report has been made to the 3M Company a copy of which is available in the soils Extension Office. This is an abridged report that only presents the effect of the nitrogen materials on plant content of various elements and the effect on soil pH and soil sulfur. Major emphasis is placed on the effect of lime and nitrogen on the availability of phosphorus under extremes of too high and too low a soil pH of the two different trials. Both trials were replicated six times, watered daily and carefully randomized on the greenhouse bench.

Trial 1

The original soil test for trial one was as follows: pH = 5.0, P = 21, K = 70, S = 5. Fifty pounds per acre of P_2O, and 365 pounds of K_2O were mixed in for all pots. Calcium oxide at 3300 pounds per acre was also added to the soil for all pots.

After the first trial growing corn was completed the P test was 61 and K test 161. The pH and sulfur tests varied with the nitrogen treatments as follows:

Product	N		S
	ppm	pH	ppm
none	0	7.8	5
3M	30	7.7	18
	60	7.5	33
	90	7.3	40+
	180	7.0	40+
A.S.	30	7.6	21
	60	7.5	34
	90	7.4	40+
	180	7.1	40+
urea	30	7.9	4
	60	7.8	5
	90	7.7	4
	180	7.8	4

The 3M product was basically a liquid ammonium-sulfate at 7.1% N. The pH values decrease from the increasing rate of nitrogen for the 3M and A.S. products but for the brief time of the greenhouse trial (3 weeks) the urea had no effect on pH. Since urea contained no sulfur it had no effect on soil sulfur, but the sulfur containing nitrogen product sharply increased soil sulfur content.

The second greenhouse trial was conducted the same as the first, except no lime was added to the soil. In the first trial the corn turned a purple color and it was believed that the lime raised the pH too high.

Approximately the same soil was used as in the first trial except surprisingly the starting

pH was 5.1. After the completion of the second trial the P test was 34 and the K test 244, the pH and S test varied with nitrogen treatment as follows:

Product	N ppm	pH	S ppm	soluble salts m-mhos
none	0	5.1	3	1.6
3M	30	5.0	15	1.2
	60	4.8	33	1.6
	90	4.7	40+	1.5
	180	4.6	40+	2.6
A.S.	30	4.9	18	0.9
	60	4.7	35	1.1
	90	4.6	40+	1.8
	180	4.5	40+	2.7
urea	30	5.0	5	1.1
	60	5.1	3	1.2
	90	5.1	3	1.0
	180	5.5	4	1.0

It can be seen that the pH again decreased with increasing nitrogen levels but at a considerably lower level than in the first trial where lime had been added. There is again a great increase in soil sulfur from the two sulfur containing products and apparently a moderate rise in soluble salts, except for urea.

Plant analysis.

Product	N ppm	1st trial % N	P	K	S	2nd trial % N	P	K	S
3M	180	2.14	.19	3.57	.37	1.96	.10	4.65	.29
A.S.	180	1.95	.19	3.24	.20	1.77	.11	4.45	.21
urea	180	1.70	.21	3.75	.16	2.13	.11	4.18	.13
adequate		2.70	.40	3.00	.20	2.70	.40	3.00	.20

When the second trial was harvested the corn again was turning purple. Plant analysis would indicate that low phosphorus was the problem. The very high pH had P averaging at .20% while at the low pH the P averaged about .10%.

A third trial will be conducted with the same soil source. The pH will be held at close to neutral as possible.

It was difficult to draw final conclusions as to comparitive values of the three nitrogen products, although there appeared to no harmful effects from the waste product. Growth results were the same for all three products.

THE EFFECT OF THREE NITROGEN PRODUCTS ON LAWN GRASS GROWTH AND NUTRIENT CONTENT

Curtis J. Overdahl, Todd King, Michael O'Leary

A sulfur containing nitrogenous waste product from 3M was compared to urea and ammonium sulfate on a grass lawn at the Becker irrigation farm. The project was funded by the 3M Company to further study beneficial or possible undesirable effects of the waste product following two corn trials in the greenhouse using Becker soil. It is anticipated that the 3M product might find greater use as a lawn fertilizer rather than for farm fields.

Lawn grass dry weights were determined June 6, June 19, July 24, and August 20. The nitrogen was applied May 20.

A complete report has been made to the 3M Company and a copy is available in the Soils Extension Office. Only specific points will be presented here.

Dry weight yields according to cuttings were as follows:

Product	N lbs/acre	cuttings 1	2	3	4*
		lbs/acre			
none	0	266	147	306	729
3M	120	541	435	515	743
A.S.	120	608	503	692	836
urea	120	526	313	711	737

*the higher yield apparently due to larger interval in time since last clipping

Only the high nitrogen rate is shown for each product. The nitrogen had dissipated by August since it had no effect on the 4th cutting.

The growth appearances were the same for the three products.

Plant analysis.

The comparison of nitrogen and sulfur contents, at the highest nitrogen rate and with none, for four different cuttings.

Product	N lbs/A	cuttings 1	2	3	4	cuttings 1	2	3	4
		% N				% S			
none	0	2.2	2.1	2.4	1.8	.24	.21	.31	.22
3M	120	4.1	3.6	3.0	2.0	.37	.30	.33	.21
A.S.	120	4.0	3.8	3.2	2.1	.35	.27	.33	.21
urea	120	4.0	3.2	2.8	2.0	.30	.20	.34	.22

The nitrogen and sulfur contents for the 120 pound rate are about the same as the untreated plots at the time of the fourth cutting.

Plots were replicated four times and complete statistical analysis was run. There were no apparent differences from the three products in growth or in plant analysis, except lower sulfur from urea.

FERTILIZATION OF GRASSES GROWN FOR SEED PRODUCTION

A PROGRESS REPORT
December 19, 1980

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Research with cool season grasses during 1980 included: 1) a nitrogen source comparison study on mineral soils, 2) a nitrogen rate study on peat, and 3) a copper study on peat. Six trials with Kentucky bluegrass and timothy were conducted on growers' fields in Roseau and Lake of the Woods counties. Effects of fertilization were determined by measuring the yield and by chemical analysis of grass tissue.

A. WEATHER CONDITIONS DURING THE 1979/80 GROWING SEASON

Extreme drought that hit much of northwestern Minnesota had a most damaging effect on the production of grass seed. The seedset of Kentucky bluegrass was so poor that most growers did not even harvest their fields. Timothy also was hit hard and only a few fields yielded more than 100 pounds of seed per acre.

Generally, during the period from August 1979 to July 1980, only 12 inches of total precipitation, or 9 inches below normal, was recorded at Roseau (Table 1). Actually there was a precipitation deficit of nearly 11 inches because, as indicated by previous records, top seed yields are produced during those growing seasons when the weather in the area is on the cool side and the precipitation is about 2 inches above normal. The growing season was characterized by dry weather conditions in the fall, below normal snowfall during winter and extremely low rainfall during April, May and June. According to Earl Kuehnast, State Climatologist (personal communications), the precipitation of 2.4 inches, recorded during April, May, June was the second lowest in the 78 year long history of weather recording at Roseau.

Table 1. Precipitation and temperature data for the 1979/80 growing season as measured at Roseau Weather Station (KRWB Radio)*.

Period	Precipitation (inches) Total	Departure from Normal	Air Temperature (°F) Average	Departure from Normal	GDD T_b=40°F
1979 Aug.	1.59	-1.63	57.9	-7.0	555
Sept.	0.45	-2.16	54.2M‡	-0.4	426
Oct.	1.40	0.18	35.5	-9.0	28
1979 Nov. to 1980 Apr.	3.24	-1.75	16.6	-0.2	111
1980 May	0.24	-2.21	58.0	6.1	558
June	1.75	-1.49	61.5	-0.8	645
July	3.35	0.16	68.0	-0.1	868
Total	12.02	-8.97			3191
Average			36.2	-1.0	
Normal (1941-1970)	20.99		37.2		

*Calculated from Climatological Data, Minnesota, Vol. 85 and 86, 1979 and 1980, U.S. Dept. of Commerce.

‡ M = less than 10 days record missing

Note: Data for the period from November to March represent averages for the Northwest Division.

Table 2. Amount of nitrate-N in the soil collected from 0-3, 3-6, and 6-24 inch depths.+

Location	Soil Texture	Sampling depth, inches 0-3	3-6	6-24	Total Nitrate-N in 0-24"
		--- Nitrate-N, pp2m---			lb/A
Helmstetter Bros. Park K. bluegrass	SL	1.8	1.8	10.1	13.7
Kveen Heidemij timothy	CL	2.0	1.9	9.8	13.7
Erickson Climax timothy	SIL	2.1	5.1	12.0	19.2
Kveen Park K. bluegrass	P	2.9	1.0	3.8	7.7

+ samples collected on October 8-10, 1979.

B. NITROGEN SOURCE COMPARISON

Three field experiments were conducted with Heidemij and Climax timothy, and Park Kentucky bluegrass to evaluate the effectiveness of anhydrous ammonia, urea and ammonium nitrate as sources of nitrogen. The soils contained 14 to 19 lbs/acre of nitrate in the top two feet (Table 2). This amount of nitrate is relatively low when compared to the levels commonly found after some cultivated crops or fallow. The main root zone of grasses (0-3 inches) contained less than 3 pp2m nitrate-N. The soils were calcareous with pH values near 8 (Table 3).

The objectives of this investigation were: 1) to determine effectiveness of the nitrogen source, 2) to determine sod injury from anhydrous ammonia injection.

All dry fertilizer materials were applied on October 8-10, 1979. Urea (46-0-0) and ammonium nitrate (34-0-0) were applied to 10 x 40 ft. plot areas with a 5-foot Gandy spreader. A 0+40+40 fertilizer treatment was made across all plots. Anhydrous ammonia (82-0-0) was applied with commercial applicators with the knives set 15-inches apart to 24 x 40 ft. plot areas. Anhydrous ammonia was applied to the Park Kentucky bluegrass trial during the first half of October, while the application to both timothy fields was delayed until May 2, 1980. All nitrogen treatments were replicated six times.

Heidemij Timothy produced a relatively low yield (Table 4). The application of 90 lbs/acre of nitrogen increased the N concentration of grass tissue and the yield of seed. Although ammonium nitrate treatments tended to have the highest yield and N content, statistically, all sources were equally effective.

Climax Timothy produced less than 100 pounds of seed per acre (Table 5). While fertilization with nitrogen increased the N% in tissue, it had no effect on the yield.

Park Kentucky Bluegrass on the Helmstetter Bros. farm was not harvested because of extremely poor growth and seedset. It was estimated that most plots would yield only 20 to 40 lbs/acre of seed. Nitrogen concentration of grass tissue collected from N treatments was relatively high. Tissue from the urea plots had the lowest N levels among the nitrogen fertilizers.

Table 3. Soil test results of samples collected from 0-3, 3-6 and 6-24 inch depths.+

Location	Sampling Depth (inches)	Texture	pH	Extractable P pp2m	Exchangeable K pp2m	DTPA Extractable Cu ppm
Helmstetter Bros.	0-3	SL	7.6	45	132	
Park K. bluegrass	3-6	SL	7.9	11	58	
	6-24	SL	8.0	9#	49	
Kveen	0-3	CL	8.0	21	200	
Heidemij timothy	3-6	L	8.3	7#	152	
	6-24	CL	8.3	3#	154	
Erickson	0-3	SIL	8.0	23#	211	
Climax timothy	3-6	SIL	8.1	17#	168	
	6-24	SIL	8.2	7#	61	
Kveen	0-3	P	7.3	43	190	
Park K. bluegrass	3-6	P	7.4	9	44	
(N-Rate trial)	6-24	P	6.9	9	43	
Kveen	0-3	P	7.7	55	236	1.3
Park K. bluegrass	3-6	P	7.5	10#	27	0.7
(copper trial)						
Kveen	0-3	P	6.4	51	488	1.3
Newport K.	3-6	P	6.4	50	181	1.3
bluegrass						
(copper trial-check plots)						

+ samples collected on October 8-10, 1979.

1:50 soil/solution ratio.

Table 4. Effect of nitrogen treatments on seed yield and N concentration in tissue of Heidemij timothy, Gus Kveen farm, Roseau County, 1980.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	60	2.15
Ammonium Nitrate + Knife	154	3.29
Ammonium Nitrate	198	3.33
Anhydrous Ammonia	154	3.11
Urea	161	3.03
Significance	**	**
BLSD (0.05)	64	0.36
C.V., %	36	11

Nitrogen materials were applied at a rate of 90 lb. N/acre, dry materials were applied on October 9, 1979, anhydrous ammonia was applied on May 2, 1980; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Table 5. Effect of nitrogen treatments on seed yield and N concentration in tissue of Climax timothy, Douglas Erickson farm, Roseau County, 1980.

Treatment	Seed Yield lb/acre	N Percent in Dry Matter
Check	88	2.28
Ammonium Nitrate + Knife	99	3.20
Ammonium Nitrate	71	3.25
Anhydrous Ammonia	91	2.91
Urea	87	3.00
Significance	ns	**
BLSD (0.05)	--	0.33
C.V. %	38	8

Nitrogen materials were applied at a rate of 90 lb. N/acre, dry materials were applied on October 9, 1979, anhydrous ammonia was applied on May 2, 1980; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

Table 6. Effect of nitrogen treatments on N concentration in tissue of Park Kentucky bluegrass, Helmstetter Bros. farm, Lake of the Woods County, 1980.

Treatment	N Percent in Dry Matter
Check	1.38
Ammonium Nitrate + Knife	2.82
Ammonium Nitrate	2.83
Anhydrous Ammonia	2.68
Urea	2.05
Significance	**
BLSD (0.05)	0.22
C.V. %	9

Nitrogen materials were applied at a rate of 120 lb. N/acre on October 9, 1979; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

C. NITROGEN RATE STUDY ON PEAT

A field experiment with Park Kentucky bluegrass on peat was established in the fall of 1975 to investigate the effectiveness of different N rates. Nitrogen rates included 0, 20, 40, 60 and 80 lb/acre, and the treatments were replicated four times. All plots received uniform 0+40+40 lb/acre phosphate and potash treatment. Fertilizer materials were applied with a Gandy spreader on October 10.

The seedset was extremely poor and no yield measurements were taken. The grass tissue, at heading time, contained a relatively high concentration of N. Nitrogen content of tissue was increased significantly by the application of 40 or more pounds of N per acre (Table 7).

Table 7. Effect of fertilization on N concentration in tissue of Park Kentucky bluegrass on peat, Gus Kveen farm, Roseau County, 1980.

Nitrogen Rate lb/acre	N Percent in Dry Matter
0	2.49
20	2.65
40	2.75
60	2.90
80	2.93
Significance	**
BLSD (0.05)	0.24
C.V. %	6

Ammonium nitrate (34-0-0) was applied on October 10, 1979; all plots received 0+40+40 lb/acre of P_2O_5 and K_2O.

D. COPPER STUDY ON PEAT

A field experiment with Newport Kentucky bluegrass on peat was established in the fall of 1978. The soil contained 1.3 ppm DTPA extractable copper in the top 3 inches (Table 3), indicating a relatively low availability of this micronutrient. Copper treatments included two sources (copper sulfate and copper chelate), single application made in the fall of 1978 (residual) and an annual application (made either in fall or spring). The treatments were arranged in a split-plot design with the time of application as main plots, and the subplots consisting of residual and annual treatments. All treatments were replicated four times. Copper sulfate and copper chelate were dissolved in water and sprayed on 10 x 20 ft. plot areas. Because of extremely heavy regrowth of the grass in the fall of 1979, the application of copper materials was delayed until May 13, 1980 after the field had been burned.

Although there was considerable amount of vegetative growth, the Newport Kentucky bluegrass on peat did not develop any panicles and produced no seed. While the residual treatments, made during the fall of 1978, tended to have higher Cu concentrations of grass tissue than the control, the copper content was increased significantly only by the annual applications (Table 8).

Another copper trial with Park Kentucky bluegrass was established in the spring of 1980. Because of drought, growth was poor and the grass was not harvested for seed. Copper spray treatments on May 13 resulted in exceptionally high Cu concentrations in the tissue: 161 ppm from Cu-sulfate, 30 ppm from Cu-chelate, compared to 2 ppm Cu from control plots. Since the area had received very little rain and the vegetative growth was very poor, it is likely that most of the copper from spring application was still on the plant at sampling time.

Table 8. Copper concentration of Newport Kentucky bluegrass tissue as affected by fertilization with Cu, Gus Kveen farm, Roseau County, 1980.

Copper Treatment	Copper, ppm in Dry Matter
None	1.52
50 lb/acre Copper Sulfate - Residual[1)]	5.32
" " " - Annual[2)]	30.13
6 lb/acre Copper Chelate - Residual[1)]	3.51
" " " - Annual[2)]	8.35
Significance	**
BLSD (0.05)	7.50
C.V. %	53

1) Residual treatments were made once either in fall 1978 or spring 1979.

2) Annual treatments were made either in fall 1978 or spring 1979, and on May 13, 1980.

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PASTURE FERTILIZATION TRIALS

Washington Co., 1978, 1979, & 1980

Morris Station, 1979, & 1980

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

A pasture trial was initiated at the Kelly farms in Washington County, managed by Morris Grogan. The objective of one trial was to document magnesium levels which might be related to grass tetany in cattle. Magnesium content and relationship to potash treatments, to added dolomitic lime and to magnesium sulfate applications were studied. A nitrogen trial was also conducted at this site and was adjacent to the magnesium plot. This plot had varying nitrogen treatments to 120 pounds and is a continuation of the nitrogen trials in Goodhue County. Plots were fenced to prevent grazing.

A bromegrass plot was established at the Morris Station in 1979 in cooperation with Dr. Sam Evans to observe urea benefits topdressed on a high pH soil. Urea and ammonium were applied to split plots. This was continued in 1980.

This project was financed through support by Cenex Foundation funds.

Table 1 The effect of potash, magnesium (Epson salts), and dolomotic limestone on dry matter yield of grass pasture. Kelly Farms 1980.

	dry matter yields			
	Cuttings			
	1	2	3	total
Lime 4 T/A*	4679	903	373	5955
No lime	4354	1013	274	5641
Significance	ns	ns	ns	ns
BLSD (05)	-	-	-	-
*lime added spring 1978.				
lbs K_2O/A				
0	4468	1083	290	5841
160	4670	810	308	5788
320	4542	1028	352	5921
640	4364	854	375	5594
1000	4507	1068	334	5909
1000 + 100# Mg/A	4546	904	286	5736
Significance	ns	ns	ns	ns
BLSD (.05)	-	-	-	-

*potash added spring 1978 and 1980.

4 Emission spectrograph analysis 1st cutting, Kelly farms, Washington Co. 1980.

Trt.	%				ppm					
	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
Lime										
No lime	.26	3.06	.25	.14	38	73	171	31	7	9
Lime 4 T/A	.25	2.98	.25	.17	38	72	73	26	5	9
Significance	ns	ns	ns	ns	ns	*	*	*	ns	ns
BLSD (.05)	-	-	-	-	-	.6	24	2	-	-
Lbs. K_2O/A*										
0	.25	1.92	.33	.21	42	73	97	29	7	11
160	.24	2.59	.27	.16	39	69	104	27	5	9
320	.24	2.97	.27	.16	41	76	131	28	6	8
640	.27	3.65	.23	.13	37	73	126	30	7	8
1000	.27	3.54	.22	.12	39	75	138	28	7	9
1000 + 100 # Mg/A	.25	3.43	.18	.15	31	67	137	28	6	9
Significance	ns	**	**	**	ns	ns	**	ns	ns	ns
BLSD (.05)	-	.32	.05	.03	-	-	21	-	-	-

*Lime added 1979, potash added 1978 and 1980.

4 . Emission analysis 2nd cutting, 1980.

Trt	%				ppm					
	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
No lime	.29	3.08	.33	.19	40	72	185	24	7	12
Lime 4 T/A	.30	3.06	.31	.22	39	73	87	21	6	9
Significance	ns	ns	ns	+	ns	ns	+	ns	ns	ns
BLSD (.05)	-	-	-	.02	-	-	89	-	-	-
Lbs. K_2O/A										
0	.30	1.77	.44	.28	44	75	117	25	6	18
160	.31	2.80	.36	.22	42	73	113	23	6	9
320	.29	3.08	.36	.22	39	72	132	23	6	9
640	.30	3.58	.27	.16	37	71	132	22	7	9
1000	.29	3.53	.25	.13	38	73	144	22	7	11
1000 + 100 # Mg/A	.31	3.65	.24	.20	36	71	179	23	7	9
Significance	ns	**	**	**	*	ns	**	ns	ns	ns
BLSD (.05)	-	.50	.05	.05	4	-	25	-	-	-

4c. Emission, spectrograph analysis of pasture grass, Kelly Farms, Washington County 1980. 3rd cutting.

Trt										
No lime	.31	2.19	.47	.21	55	80	242	22	4	7
Lime 4 T/A	.33	2.19	.45	.27	62	86	121	21	3	6
Significance	ns	ns	ns	*	ns	ns	*	ns	ns	ns
BLSD (.05)	-	-	-	.04	-	-	43	-	-	-
Lbs. K_2O/A										
0	.31	1.61	.62	.32	65	88	142	23	3	7
160	.32	2.08	.51	.26	54	76	152	22	3	7
320	.31	2.34	.55	.27	56	77	180	23	3	7
640	.32	2.35	.36	.18	66	88	195	19	3	5
1000	.33	2.34	.36	.17	52	82	198	20	4	5
1000 + 100 # Mg/A	.32	2.43	.36	.24	57	87	223	22	4	5
Significance	ns	**	**	**	ns	ns	*	ns	ns	ns
BLSD (.05)	-			.05	-	-	47	-	-	-

Table 5. Soil test average of two samples per plot at 0 to 3 and 3 to 6 inch depths, according to lime and potash treatments. Kelly Farms, Washington County, 1980.

	Potash Treatment Per Acre																	
	0			160			320			640			1000			1000 + Mg		
	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K
	0 to 3 inches depth 1980																	
No lime	5.3	12	73	5.2	12	114	5.3	9	196	5.4	18	502	5.4	13	600+	5.5	15	544
Lime	6.8	17	94	6.8	8	162	6.8	12	255	6.7	10	414	6.8	19	588	6.8	15	489
	3 to 6 inches depth 1980																	
No lime	5.5	7	55	5.6	11	62	5.6	6	104	5.6	10	360	5.6	9	504	5.6	9	386
Lime	5.9	10	84	6.2	8	91	6.1	8	181	6.1	7	324	6.2	10	489	6.2	10	460

Avg. pH	1980	
	0-3"	3-6"
No lime	5.4	5.6
4 T/A	6.8	6.1

Table 6. Soil tests average of 2 samples per plot at 0 to 3 and 3 to 6 inch depths, according to lime and potash treatments. Kelly farms, Washington Co., 1978 & 1979.

	Potash treatment per acre																	
	0			160			320			640			1000			1000 + Mg		
	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K	pH	P	K
0 to 3 inch depth 1978																		
No lime	5.2	24	192	5.2	39	270	5.2	21	314	5.4	42	548	5.4	26	580	5.4	31	600†
Lime	6.2	28	263	6.3	28	207	6.1	28	340	6.2	23	490	6.0	27	555	6.2	23	600
3 to 6 inch depth 1978																		
No lime	5.4	16	155	5.4	26	195	5.4	13	160	5.4	28	314	5.4	18	426	5.3	16	360
Lime	5.6	22	201	5.6	15	129	5.4	16	236	5.5	15	264	5.5	21	375	5.5	16	479
Avg. P & K 0-6"		23	203		27	200		20	263		27	404		23	484		22	510
0 to 3 inch depth 1979																		
No lime	5.2	11	65	5.1	16	212	5.2	9	135	5.2	19	308	5.2	16	371	5.3	16	294
4 T/A	6.4	17	139	6.5	17	122	6.5	19	205	6.4	24	328	6.4	24	420	6.5	16	328
3 to 6 inch depth 1979																		
No lime	5.6	9	44	5.3	15	152	5.5	8	96	5.3	17	252	5.5	14	271	5.4	13	323
4 T/A	5.6	15	110	5.7	12	75	5.7	15	137	5.6	14	267	5.6	19	308	5.6	13	297
Avg. P & K 0-6"		13	89		15	140		13	143		19	289		18	343		15	311

Avg. pH	1978		1979	
	0-3"	3-6"	0-3"	3-6"
No lime	5.2	5.4	5.2	5.4
4 T/A	6.2	5.6	6.4	5.6

Table 7 . The effect of varying nitrogen treatments on grass yields (dry matter) and percent nitrogen, Kelly farms 1980.

Trt			lbs, D.M./A				%N		
			cuttings				cuttings		
N	P_2O_5	K_2O	1	2	3	Total	1	2	3
0	0	0	1816	645	313	2774	1.32	1.99	2.52
0	40	40	2013	614	267	2894	1.44	1.75	2.37
30	40	40	2836	735	228	3798	1.40	1.88	2.35
60	40	40	4163	911	316	5390	1.61	1.92	2.47
120 (60+60)	40	40	4361	1182	308	5852	2.20	2.34	2.64
Significance			**	**	+	**	**	*	+
BLSD (.05)			565	300	61	660	.81	.31	.19
C.V.			13.1	23.3	15.0	11.2	8.0	9.7	5.3

Table 8. Pounds of nitrogen removed per acre and yield of protein. Kelly Farm 1980.

Trt							yield, protein/acre			
			cuttings				cuttings			
N	P_2O_5	K_2O	1	2	3	Total	1	2	3	Total
0	0	0	24.0	13.2	7.9	45	8	12	16	281
0	40	40	28.6	10.9	6.3	46	9	10	15	286
30	40	40	39.7	13.7	5.4	59	9	12	15	367
60	40	40	66.8	17.5	7.8	92	10	12	15	575
120	40	40	95.6	27.5	8.1	131	14	15	17	820
Significance			**	**	*	**	**	*	+	**
BLSD (.05)			9.0	5.7	1.7	12	1	2	1	74
C.V.			12.5	23.2	14.6	11.2	8.	9.7	5.3	11.2

Table 9. Brome grass yield and percent nitrogen (1980) comparing effects of urea vs. ammonium nitrate topdressing on high pH soils, Morris, MN 1979, & 1980.

	Total Yield of 2 Cuttings			
N, lbs/A	1979	1980	% N 1980 1st cut	% N 1980 2nd cut
none	10636	3947	2.03	1.51
50 urea	10465	4615	2.79	1.73
50 A.N.	9068	5107	2.67	1.62
100 urea	9966	5588	2.71	1.82
100 A.N.	9644	6039	2.64	1.88
Significance	ns	**	+	**
BLSD (.05)	-	761	.54	.28

Table 10. Comparison of two nitrogen farms urea vs. ammonium nitrate on high pH soils by cutting by year. Morris, MN 1979, & 1980.

	1st cut		2nd cut		% N 1980	
	1979	1980	1979	1980	1st cut	2nd cut
urea	6480	2742	3728	10349	2.75	1.86
A.N.	5806	3230	3627	9784	2.65	1.79
Significance	+	*	ns	+	ns	ns

Discussion and Summary

Kelly farms

1. Applications of dolomitic lime in the spring of 1978 did not increase magnesium content of grass that year, but in 1979 magnesium significantly increased from the topdressed application in 2 of the 4 cuttings. Epsom salts also increased magnesium. In 1980 magnesium was increased slightly by lime and epsom salts.

2. Potassium, at very high rates, decreased magnesium content but at recommmended rates no serious reduction occurred.

3. There were no grass yield benefits from liming, only the magnesium quality benefits that could offset potential problems of grass tetany in cattle.

4. Soil pH, on the surface 3 inches, has increased from 5.2 to 6.4 in 1979 and to 6.8 in 1980 from 4 tons of lime.

Morris, MN

Comparisons of ammonium nitrate and urea topdressed on high pH soil (7.8) 1979 and 1980.

1. There was no significant nitrogen response in 1979 hence comparison differences are difficult to evaluate. Urea plots yielded significantly higher at the 10 percent level of significance at first cut and ammonium nitrate was significantly higher than urea in 1980 at this cutting time.

2. Yields from the second cutting from the two forms of nitrogen were different but urea was higher only at the 10 percent level of significance.

3. There was no difference in percent nitrogen in the plot from the two forms at the first or second cutting in 1980. No nitrogen content measurements were made in 1979.

4. The limited information from the two cuttings each of the two years would not indicate inferiority of urea to perform on high pH soils.

THE EFFECTS OF 3 NITROGEN LEVELS ON SUGARBEET VARIETY PERFORMANCE

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The objective of this trial is to investigate the responses of currently grown sugarbeet varieties to different soil nitrogen regimes. Specific items being investigated are, 1) nitrogen effects on yield and quality factors, b) nitrogen x variety interactions, and c) varietal responses to nitrogen from the northern end of the sugarbeet growing area of Minnesota to the southern end.

Excess nitrogen has been recognized as a major contributor to reduced sugar content and to increased levels of impurities in the sugarbeet crop. With payments to producers based on recoverable sugar per acre, rather than on tons produced, management of nitrogen becomes increasingly important. If excess nitrogen exists due to uncontrollable environmental conditions or past mismanagement, selection of a sugarbeet variety that would minimize these consequences would be of great value.

Procedure:
Trials were planted at Crookston, MN on June 10 and at Bird Island, MN on April 22. The June 10 planting at Crookston represents a replanting situation. At each location, 4 randomized blocks with nitrogen levels as whole plots and varieties as sub-plots were established. Nitrogen treatments (soil NO_3-nitrogen, 0-2', plus added ammonium nitrate) were 150, 250 and 350 total pounds of nitrogen per acre. At Crookston a check plot was included in 1980. These nitrogen levels represent the recommended level (150 lb/A) and two excess levels. Phosphorus and potassium levels were high. Seven varieties were planted at Crookston and 6 at Bird Is. These varieties were Beta 1443, Beta 1345, Hilleshog Mono-309, Mono-Hy R1, Bush Monofort, ACS-ACH-17 and ACH-30. ACH-17 was not planted at Bird Island. These varieties represent over 90 percent of the sugarbeet varieties grown in Minnesota.

Eptam was fall applied at a rate of 4.25 lb/a at Crookston and spring applied at 3.0 lb/A at the southern Minnesota locations. Insecticide was used at planting.

The beets were planted in 22-inch rows, thinned to a uniform population of 125/100 ft. of 22-inch row in late June, and harvested the first week in October. Quality factors were determined at the American Crystal Tare Lab in Grand Forks, North Dakota.

A split plot design with N levels as main plots and varieties as sub-plots was used at each location.

Results:
The results of the Crookston trial for yield, percent sugar, gross and recoverable sugar and sugarbeet impurities are summarized in Table 1 as variety means over nitrogen levels and nitrogen means over varieties. Varieties were significant for all variables measured except percent recoverable sugar, Na content and the impurity index. Nitrogen effects were significant for percent sugar, recoverable sugar, percent recoverable, recoverable per ton, amino nitrogen and impurity index. The effect of nitrogen on overall yield was nonsignificant. No nitrogen by variety interaction was present in 1980.

Table 1. Means for varieties and N fertilizer rates (Crookston, MN).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1345	10.8	14.0	3037	2494	81	229	518	3028	779	1204
Beta 1443	11.0	14.0	3088	2561	82	232	483	3136	670	1139
Hilleshog 309	11.8	13.4	3193	2597	81	219	575	3294	677	1246
ACS-ACH-17	9.8	13.3	2608	2114	81	215	578	2934	773	1265
Mono-Hy R1	10.7	13.6	2908	2386	82	223	437	3069	741	1198
ACS-ACH-30	10.5	13.9	2956	2446	82	231	559	2722	766	1156
Bush Monofort	10.6	14.2	3019	2514	83	238	518	2794	714	1116
Significance	**	**	**	**	NS	**	NS	*	**	NS
LSD (05)	.64	.61	226	216		15.4		431	68	
N-Rate lb/A										
Check	10.8	14.2	3104	2604	83	239	615	2839	640	1086
150	10.8	13.8	3013	2499	82	230	509	2870	715	1137
250	10.8	13.5	2941	2398	81	220	488	3012	772	1231
350	10.5	13.5	2833	2277	80	218	486	3266	800	1303
Significance	NS	*	NS	*	**	**	NS	NS	**	**
LSD (05)		.59		264	1.6	13.3			55	108

Mean varietal responses to the 3 nitrogen levels at Crookston are shown in Table 2. At the recommended nitrogen rate (150 lb/A) Hilleshog 309 had significantly higher yield than all varieties except Beta 1345. As the nitrogen level increased to 350 lb/A, Hilleshog-309 showed the greatest decrease in percent sugar. Hilleshog 309 and Beta 1345 showed the largest decline in recoverable sugar per acre between the 150 and 350 lb/A nitrogen rates. At the recommended nitrogen level, Beta 1345 had excellent yield and sugar percentage.

Because of the late planting and extremely droughty conditions of 1980, the varieties in this trial failed to reach their full potential. While the yields were relatively low, the percent sugar for all varieties was surprisingly good.

Results of the Bird Island trial are summarized as variety means over nitrogen levels and nitrogen means over varieties in Table 3. The main effects of varieties were significant for percent sugar, gross and recoverable sugar, recoverable per ton, percent recoverable and impurity index. Mono-Hy R1, Bush Monofort and ACH-30 had significnatly higher sugar percentages than Hilleshog 309 and Beta 1443. Bush Monofort, Mono-Hy R1 and ACH-30 produced significantly more recoverable sugar per acre than the other 3 varieties.

The main nitrogen effects were significant for all variables except yield, gross sugar, Na and K content (Table 3). The recommended rate of nitrogen produced significantly more recoverable sugar per acre than did the other nitrogen levels.

Table 2. Varietal response at varying N levels (Crookston, 1980).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities ppm Na	Impurities ppm K	Impurities ppm Amino N	Impurity Index
Beta 1345	Check	11.0	14.1	3143	2578	81	232	701	3060	730	1210
	150	11.4	14.6	3334	2801	84	245	414	2741	761	1064
	250	11.3	13.6	3098	2543	82	224	474	2674	830	1191
	350	9.4	13.6	2574	2053	79	217	485	3638	797	1353
Beta 1443	Check	10.9	14.8	3247	2755	84	251	605	3111	526	1006
	150	10.9	13.8	3027	2515	82	229	506	3031	669	1136
	250	10.8	13.9	2998	2453	81	227	440	3305	723	1205
	350	11.4	13.5	3081	2518	81	221	383	3100	764	1211
Hilleshog 309	Check	11.2	14.4	3242	2734	84	243	521	2969	611	1047
	150	12.2	13.8	3375	2767	81	226	518	3229	705	1202
	250	12.0	12.9	3120	2491	79	206	635	3484	676	1340
	350	11.9	12.7	3032	2397	79	201	629	3495	718	1395
ACS-ACH-17	Check	9.5	13.2	2537	2068	81	215	683	2717	748	1233
	150	10.2	13.4	2744	2262	82	221	552	2710	734	1170
	250	9.8	13.2	2624	2116	80	214	540	3061	797	1294
	350	9.6	13.2	2526	2008	79	212	539	3250	814	1364
Mono-Hy R1	Check	11.2	14.0	3167	2681	84	237	478	2325	718	1022
	150	10.0	13.5	2698	2235	82	223	431	2980	685	1144
	250	10.6	13.2	2833	2284	80	213	441	3611	693	1297
	350	10.8	13.6	2934	2346	80	218	400	3360	869	1329
ACS-ACH-30	Check	10.6	14.5	3092	2600	83	245	686	2888	604	1068
	150	10.4	14.1	2960	2466	83	234	528	2627	769	1116
	250	10.5	13.5	2854	2341	81	222	499	2619	826	1204
	350	10.6	13.7	2917	2378	81	223	523	2756	864	1235
Bush Monofort	Check	11.2	14.7	3298	2812	84	250	630	2802	542	1019
	150	10.6	13.9	2953	2449	83	231	611	2775	684	1125
	250	10.7	14.2	3058	2561	83	237	389	2333	858	1088
	350	10.0	14.1	2768	2236	81	231	441	3264	771	1232
Significance		*	*	**	**	**	*	NS	*	**	**
LSD (05)		1.2	1.6	554	450	1.4	38.2		1113	136	297

Table 3. Means for varieties and N fertilizer rates (Bird Island, 1980).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	18.7	13.5	5044	4211	83	225	420	2310	800	1101
Beta 1345	18.3	14.2	5206	4414	84	241	338	2185	810	1013
Hilleshog 309	19.3	12.5	5830	4014	83	208	466	2224	716	1127
Mono-Hy R1	19.7	14.6	5768	4882	84	248	338	2229	851	1015
Bush Monofort	19.2	14.5	5611	4783	85	248	422	2165	791	996
ACS-ACH-30	18.8	14.8	5608	4791	85	254	446	2176	771	973
Significance	NS	**	**	**	**	**	NS	NS	NS	**
LSD (05)		.47	366	299	1.5	10.6				103
N-Rate lb/A										
150	18.4	14.7	5444	4727	86	257	356	2146	670	886
250	19.2	13.8	5326	4474	84	231	382	2225	826	1072
350	19.3	13.6	5262	4347	82	224	478	2273	873	1154
Significance	NS	**	NS	*	**	**	NS	NS	**	**
LSD (05)		.39		250	1.4	7.2			80	94

Mean varietal response to the 3 nitrogen levels is shown in Table 4. Hilleshog 309 showed a significant increase in yield as the nitrogen level increased to 250 lb/A. At the 150 lb/A nitrogen rate this variety had the lowest yield and recoverable sugar in the trial. This was due mainly to Cercospora leaf spot which affected this nitrogen level to a greater extent than at the other levels. This variety had significantly lower percent sugar at all nitrogen levels than the other varieties. Bush Monofort produced the highest recoverable sugar at the 150 lb/A nitrogen rate, but showed the largest decrease as the nitrogen rate was increased to the 350 lb/A rate.

Tables 5 and 6 show trial results at Crookston for 1978-80. All variables measured showed significant differences except amino nitrogen and percent recoverable sugar for varieties (Table 5). Hilleshog 309 had the highest yield and recoverable sugar over the 3 years but the lowest sugar content, percent recoverable sugar and sugar per ton of beets. Bush Monofort, Mono-Hy R1 and ACH-30 had the highest percent recoverable sugar.

The effects of nitrogen were nonsignificant for yield and Na content (Table 5). All other variables were highly significant, indicating deleterious effects from fertilizing above the recommended rate of nitrogen.

Table 4. Varietal response at varying N levels (Bird Island, 1980).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities ppm Na	Impurities ppm K	Impurities ppm Amino N	Impurity Index
Beta 1443	150	18.9	14.1	5308	4490	84	238	476	2467	697	1025
	250	18.2	13.5	4930	4072	82	222	410	2220	915	1164
	350	19.0	13.0	4920	4050	83	214	391	2263	886	1186
Beta 1345	150	17.5	14.8	5180	4524	87	259	285	1978	687	846
	250	18.2	14.1	5124	4297	83	236	313	2195	902	1074
	350	19.3	13.7	5314	4420	83	228	417	2381	840	1120
Hilleshog 309	150	16.7	13.5	4516	3841	85	229	368	2101	737	1004
	250	21.5	12.2	5282	4370	82	202	462	2195	740	1161
	350	19.9	11.8	4691	3829	81	192	569	2376	671	1216
Mono-Hy R1	150	19.3	15.0	5782	5006	87	259	240	2103	766	892
	250	20.3	14.5	5894	5019	85	247	314	2325	779	987
	350	19.4	14.6	5671	4748	84	244	460	2258	1008	1074
Bush Monofort	150	20.0	15.4	6161	5446	88	271	402	2217	517	777
	250	18.4	14.4	5294	4458	84	242	374	2212	874	1054
	350	19.2	14.0	5378	4446	82	231	489	2067	982	1157
ACS-ACH-30	150	18.0	15.9	5722	5067	88	285	362	2010	621	773
	250	19.1	14.6	5601	4731	84	247	437	2241	842	1037
	350	19.4	14.2	5501	4586	83	236	540	2278	852	1109
Significance		*	**	**	**	**	**	*	NS	**	**
LSD (05)		2.47	.91	717	552	2.4	20.2	184		227	164

Table 5. Means for varieties and N fertilizer rates (Crookston, 1978-80).

Variety	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	16.9	14.4	4891	3967	81.0	233	747	2439	1012	1264
Beta 1345	16.2	14.8	4889	3960	81.0	239	680	2336	1110	1266
Hilleshog 309	18.1	14.2	5181	4164	80.4	228	826	2483	1001	1307
Bush Monofort	16.1	14.8	4780	3928	82.2	243	740	2291	981	1189
Mono-Hy R1	16.9	14.6	4955	4091	82.3	240	594	2442	961	1183
ACS-ACH-30	15.7	14.8	4667	3843	82.2	243	762	2228	981	1189
ACS-ACH-17	15.6	14.2	4455	3653	81.6	233	751	2226	967	1225
LSD (05)	.37	.23	122	142		7.1	68	184		152
N-Rate lb/A										
150	16.5	14.8	4918	4111	83.4	247	692	2247	881	1105
250	16.6	14.5	4853	3927	81.0	235	727	2350	1063	1270
350	16.5	14.3	4723	3793	81.2	228	768	2450	1062	1321
LSD (05)		.18	130	104	.6	3.9		134	79	42

Table 6. Varietal response at varying N levels (Crookston, 1978-80).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities ppm Na	Impurities ppm K	Impurities ppm Amino N	Impurity Index
Beta 1443	150	16.9	14.5	4920	4070	82.5	239	747	2316	905	1166
	250	17.3	14.6	5070	4105	80.8	235	696	2496	1056	1279
	350	16.5	14.2	4680	3726	79.8	225	795	2502	1074	1345
Beta 1345	150	16.4	15.3	5050	4255	84.1	257	611	2130	924	1056
	250	16.8	14.6	4949	3844	78.3	227	706	2283	1420	1448
	350	16.1	14.3	4667	3781	80.5	231	724	2592	1006	1293
Hilleshog 309	150	17.9	14.6	5237	4311	82.2	240	772	2423	907	1185
	250	18.4	14.0	5221	4172	80.0	224	900	2522	982	1332
	350	18.1	13.9	5085	4008	78.9	218	804	2501	1114	1403
Bush Monofort	150	16.1	15.0	4885	4079	83.4	251	742	2309	875	1105
	250	16.0	15.0	4819	3973	82.5	247	709	2121	1028	1164
	305	16.1	14.3	4635	3729	80.5	230	768	2441	1038	1297
Mono-Hy R1	150	16.4	14.7	4854	4080	83.8	246	578	2289	867	1082
	250	17.1	14.5	4992	4095	81.8	237	619	2523	976	1213
	350	17.1	14.5	5018	4098	81.2	235	584	2512	1040	1252
ACS-ACH-30	150	16.1	14.9	4825	4078	84.3	251	729	2107	817	1047
	250	15.3	14.8	4540	3742	82.3	243	690	2263	983	1179
	350	15.9	14.6	4636	3707	79.9	232	866	2314	1142	1338
LSD (05)		.88	.41	232	261	2.8	12.2	124	290	285	191

Within varieites Mono-Hy R1 showed the lowest decline in gross and recoverable sugar per acre as the nitrogen levels increased (Table 6, Figure 1). Beta 1345 showed the largest decrease in recoverable sugar as the nitrogen level was increased from the recommended level to the 350 lb/A level. Hilleshog 309 showed the largest drop in percent sugar between nitrogen levels, while Mono-Hy R1 and ACH-30 showed the least (Figure 3).

Tables 7 and 8 show results of the southern Minnesota trials for 1978-80. Varieties were significant for all variables measured (Table 7). As with the Crookston trial, Hilleshog 309 produced the highest tonnage, but had the lowest percent sugar. This variety along with Mono-Hy R1 and Beta 1443 produced the largest amounts of gross and recoverable sugar per acre. Hilleshog 309 and Beta 1443 had significantly lower percent recoverable sugar than the other varieties.

The effects of nitrogen were significant for all variables except yield and K content. As with the Crookston trial, this indicates that only deleterious effects were realized from the addition of nitrogen over the recommended rates.

Within varieties Beta 1443 had the largest drop in gross and recoverable sugar per acre as the nitrogen rates increased (Table 8, Figure 2). Mono-Hy R1 showed the least decline. ACH-30 had the largest drop in percent sugar over nitrogen levels (Figure 3).

Table 7. Means for varieties and N fertilizer rates (Southern Minnesota (1978-80).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	23.6	14.6	6912	5755	83.0	242	650	2177	929	1131
Beta 1345	22.2	15.1	6604	5639	84.1	253	572	2071	933	1063
Hilleshog 309	24.5	14.3	7061	5878	83.2	237	673	2159	863	1120
Bush Monofort	22.2	14.8	6568	5529	84.1	250	646	2027	884	1058
Mono-Hy R1	23.2	15.0	6934	5844	84.3	253	511	1971	950	1046
ACS-ACH-30	22.3	15.1	6734	5688	84.4	256	660	2066	867	1042
LSD (05)	.70	.19	225	224	.7	4.6	42	138	71	48
N-Rate lb/A										
150	22.9	15.3	7012	5995	85.5	262	574	2059	804	966
250	23.0	14.8	6799	5695	83.6	247	634	2052	926	1091
350	23.1	14.4	6645	5477	82.4	237	648	2124	982	1172
LSD (05)		.16	179	149	.7	4.1	66		49	49

Table 8. Varietal response at varying N levels (Southern Minnesota (1978-80).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	150	24.2	15.0	7322	6216	84.7	255	639	2210	799	1017
	250	23.2	14.5	6771	5557	81.8	237	700	2133	1041	1210
	350	23.3	14.2	6640	5490	82.5	234	609	2187	944	1164
Beta 1345	150	22.6	15.3	6938	5940	85.6	262	533	1965	829	954
	250	21.8	15.2	6688	5650	84.2	257	549	2072	938	1049
	350	22.1	14.6	6483	5327	82.2	241	635	2176	1030	1185
Hilleshog 309	150	24.0	14.8	7215	6113	84.7	251	622	2095	814	1019
	250	25.1	14.2	7217	5999	83.0	236	683	2151	878	1133
	350	24.4	13.7	6751	5521	81.8	223	712	2229	894	1208
Bush Monofort	150	21.9	15.4	6733	5787	86.0	264	625	2084	731	931
	250	22.0	14.7	6447	5400	83.6	246	625	2071	926	1091
	350	22.7	14.4	6523	5399	82.7	238	686	1923	994	1150
Mono-Hy R1	150	22.6	15.3	6891	5875	85.3	260	444	1980	896	980
	250	23.2	15.0	6926	5874	84.8	253	509	1814	929	1010
	350	23.8	14.8	6983	5781	82.8	244	578	2117	1023	1146
ACH-ACH-30	150	21.9	15.9	6972	6033	86.6	276	578	2015	754	892
	250	22.5	15.0	6740	5689	84.2	252	737	2071	838	1051
	350	22.4	14.5	6488	5341	82.3	239	663	2111	1006	1180
LSD (05)		1.3	.36	389	354	1.2	8.6	80	215	108	84

The analysis of variance table for N levels, varieties and N x variety interactions for the northern and southern Minnesota locations for 1978-80 is shown in Table 8A.

Table 8A. Analysis of variance.

	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurity Index
			Northern Minnesota 1978-80				
N-Level	NS	**	**	**	**	**	NS
Variety	**	**	**	**	NS	**	**
N x Var.	*	NS	**	+	NS	NS	NS
			Southern Minnesota 1978-80				
N-Level	NS	**	**	**	**	**	**
Variety	**	**	**	**	**	**	**
N x Var.	NS	**	**	*	*	**	*

*, ** Significant at 5 and 1% levels, respectively.

Results of the combined trials (3 years-2 locations) are shown in Tables 9, 10 and Figures 3, 4. The variety and nitrogen effects for this combined data is similar to that reported in the above text for individual locations.

Table 11 shows the loss (-) or gain (+) in recoverable sugar per acre for the varieties in this trial over years and locations. Mono-Hy R1 shows the smallest decline over nitrogen levels of the varieties tested. At the recommended nitrogen rate, this variety produces significantly less recoverable sugar than several of the other varieties. This is reversed at the higher nitrogen levels.

Table 11. Recoverable sugar loss or gain per acre between the 150, 250 and the 350 lb/A nitrogen rate (average 3 yr-2 location).

	Varieties					
Nitrogen Levels	Beta 1443	Beta 1345	Hilleshog 309	Bush Monofort	Mono-Hy R1	ACS-ACH-30
150 N → 250 N	-312	-350	-127	-246	+7	-341
150 N → 350 N	-535	-543	-447	-369	-39	-532

Summary:

In six trials conducted in both northern and southern Minnesota from 1978-80, no benefit has been realized from the addition of nitrogen fertilizer in excess of the recommended rate of 150 lb/A. These trials have represented large variations in weather patterns as well as times of planting.

Of the varieties tested all perform well at the recommended rates of nitrogen fertilization. Mono-Hy R1 has shown the least decline in recoverable sugar at the excess nitrogen rates, however. How varieties not included in these trials will react is not known.

Table 9. Means for varieties and N fertilizer rates (3 yr.-2 loc. average).

Variety	Yield (T/A)	Sugar (%)	Gross Sugar (lb/A)	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	20.2	14.5	5901	4861	82.0	238	698	2307	970	1197
Beta 1345	19.3	14.9	5796	4799	82.5	246	626	2203	1021	1164
Hilleshog 309	21.3	14.2	6121	5021	81.8	232	749	2320	932	1213
Bush Monofort	19.1	14.8	5674	4728	83.1	246	692	2158	932	1123
Mono-Hy R1	20.0	14.8	5944	4967	83.2	246	552	2206	955	1114
ACS-ACH-30	19.0	14.9	5700	4765	83.2	249	711	2147	923	1115
LSD (05)	.32	.12	106	112	1.0	3.8	43	102		68
N-Rate lb/A										
150	19.7	15.1	5987	5070	84.4	254	635	2160	843	1036
250	19.9	14.7	5865	4842	82.2	241	677	2210	998	1180
350	19.9	14.3	5716	4659	81.3	232	702	2300	1025	1247
LSD (05)		.11	106	90	.5	2.7	48	90	52	34

Table 10. Varietal response at varying N levels (3 yr.-2 loc. average).

Variety	N Rate lb/A	Yield T/A	Sugar %	Gross Sugar lb/A	Recoverable Sugar lb/A	Recoverable Sugar %	Recoverable Sugar lb/T	Impurities, ppm Na	Impurities, ppm K	Impurities, ppm Amino N	Impurity Index
Beta 1443	150	20.6	14.8	6121	5143	83.6	247	693	2263	852	1092
	250	20.3	14.5	5920	4831	81.3	236	698	2315	1049	1245
	350	19.9	14.2	5660	4608	81.1	230	702	2344	1009	1254
Beta 1345	150	19.5	15.3	5994	5097	84.9	259	572	2047	877	1005
	250	19.3	14.9	5818	4747	81.3	242	627	2178	1169	1248
	350	19.1	14.5	5575	4554	81.4	236	679	2384	1018	1239
Hilleshog 309	150	20.9	14.7	6226	5212	83.4	246	697	2259	860	1102
	250	21.7	14.1	6219	5085	81.5	230	791	2336	930	1232
	350	21.2	13.8	5918	4765	80.4	221	758	2365	1004	1305
Bush Monofort	150	19.0	15.2	5809	4933	84.7	257	683	2197	803	1018
	250	19.0	14.9	5633	4687	83.0	246	667	2096	977	1127
	350	19.4	14.3	5579	4564	81.6	234	727	2182	1016	1223
Mono-Hy R1	150	19.5	15.0	5873	4977	84.5	253	511	2134	881	1031
	250	20.1	14.8	5959	4984	83.3	245	564	2169	952	1112
	350	20.4	14.6	6000	4938	82.0	239	581	2314	1031	1199
ACS-ACH-30	150	19.0	15.4	5898	5056	85.4	264	654	2061	786	969
	250	18.9	14.9	5640	4715	83.2	247	714	2167	911	1115
	350	19.1	14.5	5562	4524	81.1	235	765	2212	1074	1259
LSD (05)		.81	.27	239	231	1.5	7.5	74	193	156	107

FIGURE 1: GROSS & RECOVERABLE SUGAR (NORTHERN MN 1978-80)

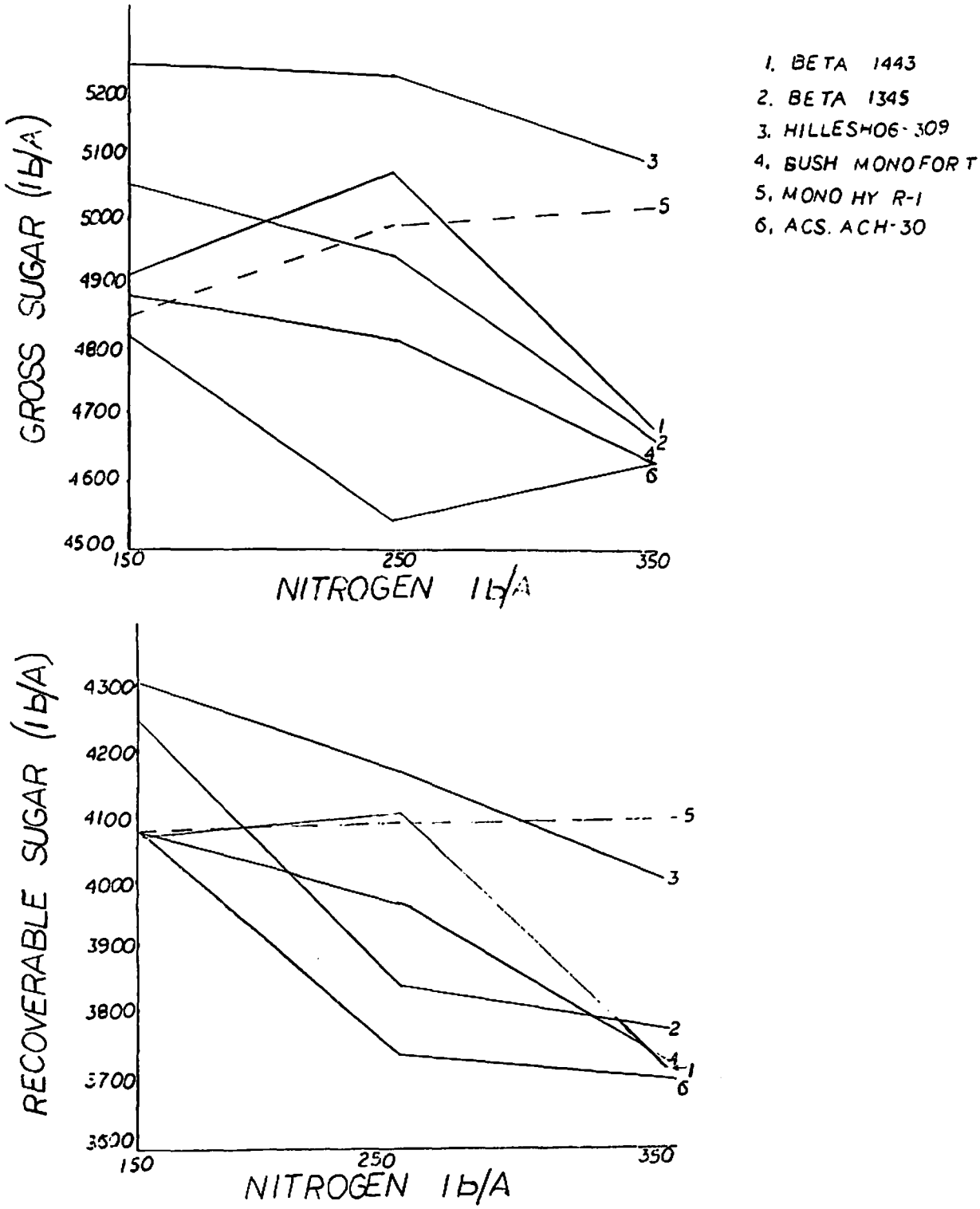


FIGURE 2: GROSS & RECOVERABLE SUGAR (SOUTHERN MN 1978-80)

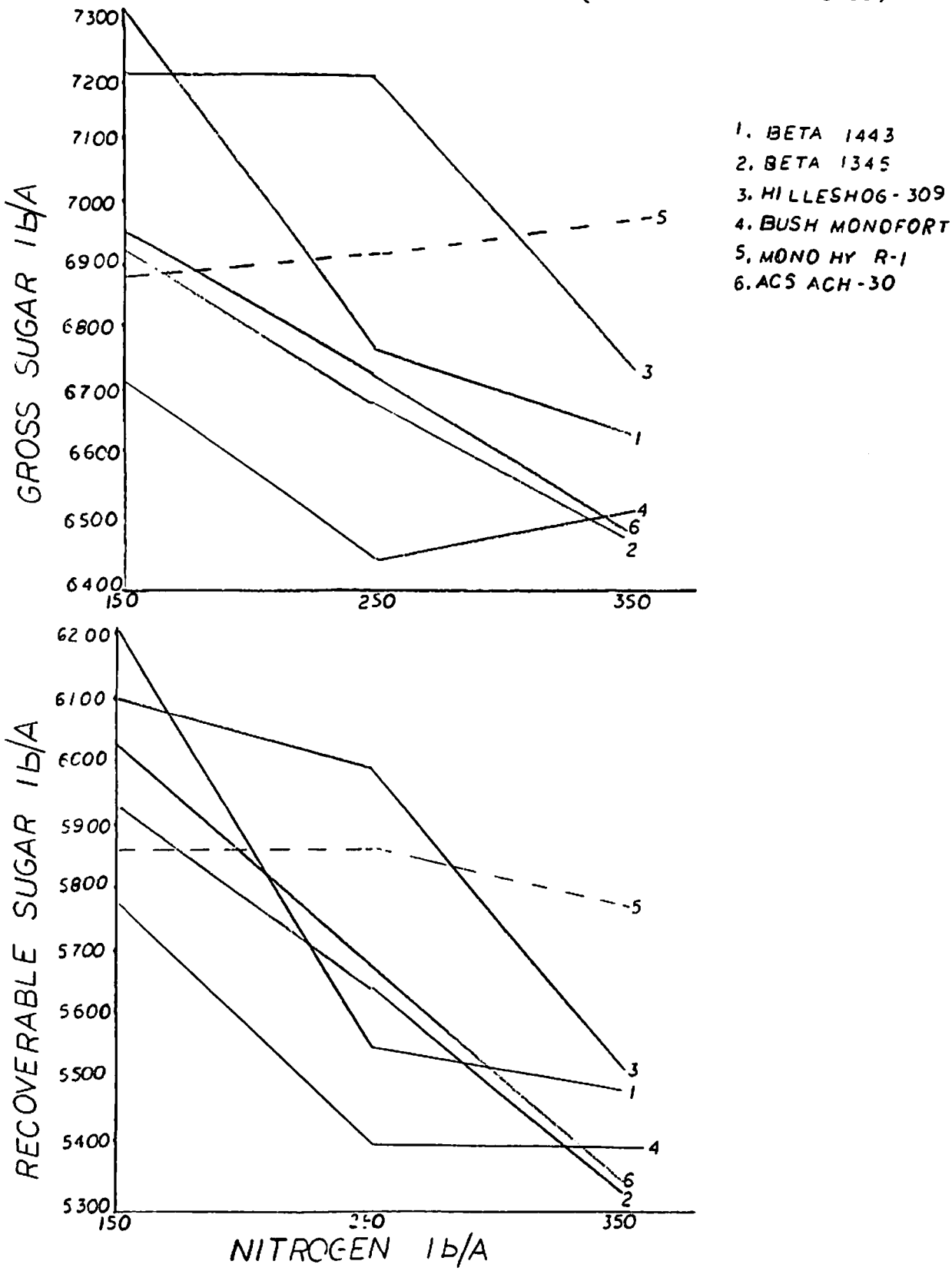


FIGURE 3: PERCENT SUGAR (SOUTHERN MN., NORTHERN MN (COMBINATION) 1978-80

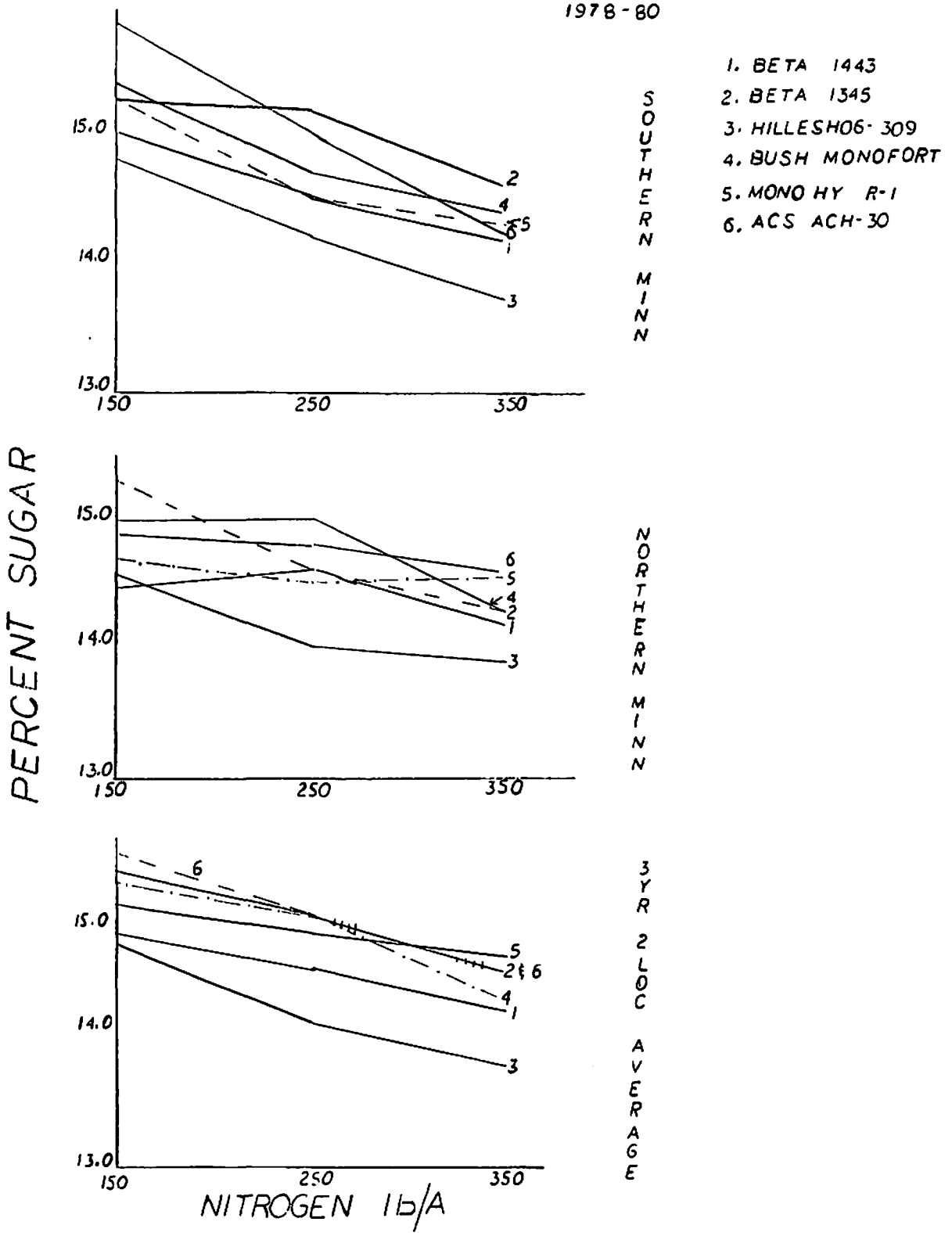
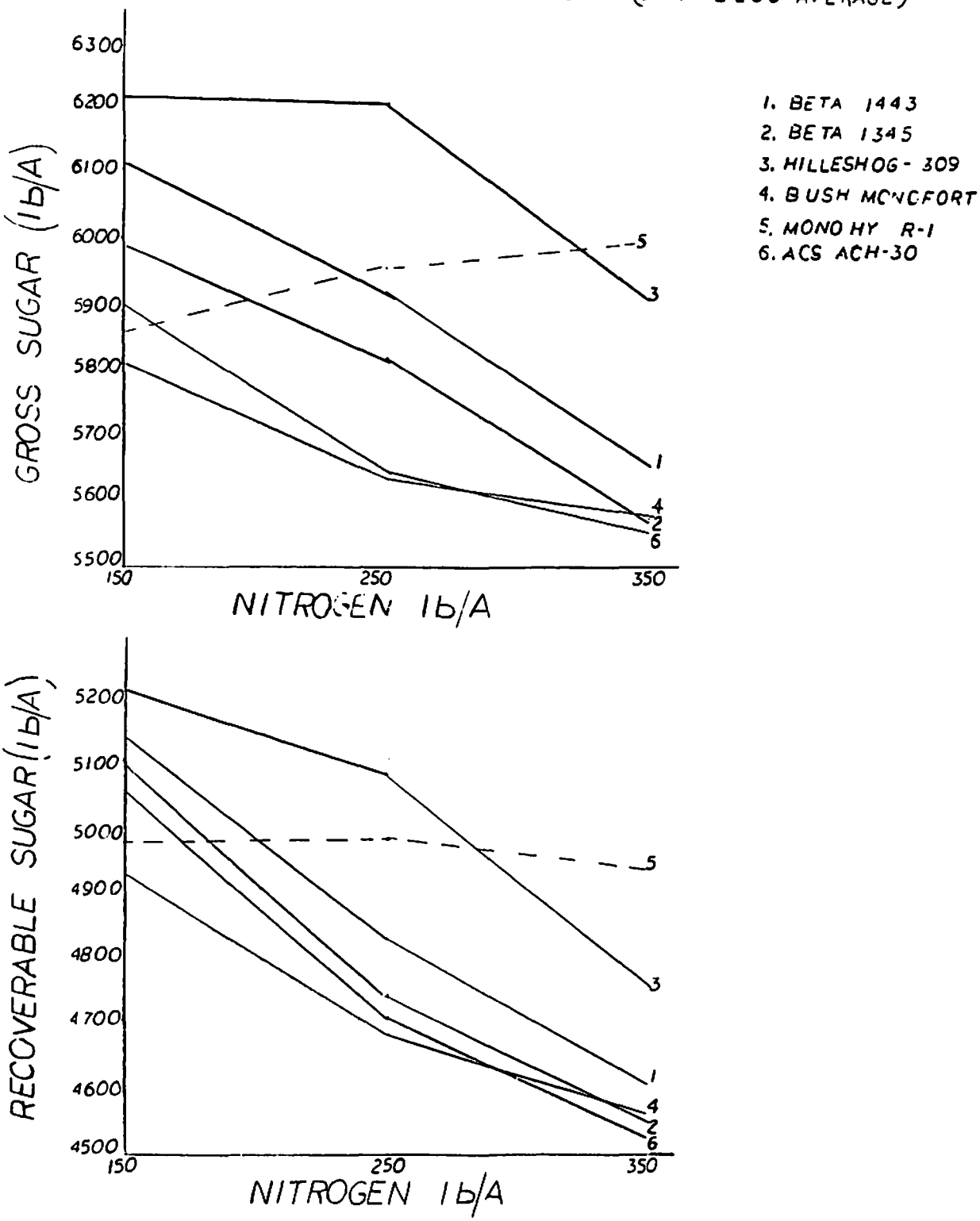


FIGURE 4: GROSS & RECOVERABLE SUGAR (3 YR - 2 LOC AVERAGE)



NITROGEN FERTILIZATION OF SUGARBEETS IN WEST-CENTRAL MINNESOTA - 1980

G.L. Malzer, J.N. Lensing, and O.M. Gunderson

Nitrogen management continues to be a prime consideration that sugarbeet growers not only in West-Central Minnesota, but also in other sugarbeet production areas should be concerned with if they are to attain maximum sugar production per acre. The need for nitrogen in sugarbeet production is well documented, but it has also been demonstrated that excess nitrogen fertilizer may decrease the sugar percentage and purity thereby lowering the recoverable sugar per acre. An accurate prediction of nitrogen needs is therefore essential in the overall nitrogen management system. The measurement of residual nitrates in the soil to a depth of two feet has aided a great deal in estimating the nitrogen needs for sugarbeets, but depending on the year (weather), soil type, soil organic matter, soil drainage and previous cropping history, the nitrogen fertilizer requirement may vary from one location to another. The sugarbeet variety planted and the plant population utilized could also influence the yield, quality and the nitrogen needs of the crop.

Research was initiated in 1976 to study the problem of predicting fertilizer nitrogen requirements for sugarbeets in West-Central Minnesota. One of the major concerns of the research in 1976 was to determine the adequacy of the two foot nitrate-nitrogen test in making fertilizer recommendations. Since many soils outside of the Red River Valley have better drainage characteristics, large accumulations of nitrate-nitrogen below a depth of two feet may be encountered. If sugarbeets are capable of utilizing large quantites of nitrate-nitrogen below a depth of two feet, then fertilizer recommendations and associated soil testing techniques should be modified to more accurately predict fertilizer nitrogen needs. The objectives of the studies in 1980 were to look at various aspects of nitrogen management and to evaluate the following: 1) the importance of deep subsoil nitrates, and to determine the optimum soil sampling depth; 2) the correlation and calibration of soil nitrate-nitrogen levels to fertilizer nitrogen rates; 3) the evaluation and importance of nitrogen rates and plant populations and 4) the varietal response of sugarbeets to increasing rates of nitrogen application.

Materials and Methods: Seven location were selected in West-Central Minnesota for nitrogen management studies in 1980. Of the seven locations, five of the locations were selected for fertilizer nitrogen correlation-calibration research, one location for plant population and nitrogen rate investigation and one location for studying the nitrogen response to different sugarbeet varieties.

The correlation-calibration experiments consisted of four locations with nitrogen rates of 0,40,80 and 120 pounds of nitrogen per acre applied in the fall as urea. These trials were established with four replications and arranged in a randomized

complete block design. One location consisted of four paired comparisons of nitrogen fertilizer versus a no nitrogen control. These 200-400 foot strips were established by the farmers utilizing the nitrogen fertilizer rate and form which was used on the remainder of the field. A trial was established at Wayne Schwitter's to evaluate the effect of nitrogen and plant populations on yield and sugarbeet quality. The trial was conducted with three plant populations, three nitrogen rates and four replications in a split plot arrangement. Nitrogen rates were 0, 60, 120 lbs N/A applied as urea in the fall of 1979. Beets were thinned to plant populations of 75, 125 and 175 plants/100 foot row. A trial to investigate the importance of nitrogen rates and sugarbeets varieties was established at the LeRoy Stamer farm in Renville County. This trial was conducted in cooperation with Dr. Larry Smith at the Crookston station. The trial was conducted with six varieties, three nitrogen levels and four replications in a split block arrangement. Nitrogen treatments included rates of 150, 250 and 350 lbs of N/A as total fertilizer N plus soil NO_3 -N within the surface two feet. The six varieties utilized were: Beta 1443, G.W. R-1, ACH-30, Beta 1345, Bush Monofort, and Hilleshog 309.

Soil cores were taken to a depth of five feet prior to fertilization in all experiments. The soil cores were separated into increments of 0-½', ½-1', 1-2', 2-3', 3-4' and 4-5' and analyzed for nitrate-nitrogen. In addition, a composite sample of the 0-½' depth was analyzed for pH, organic matter, available phosphorus, exchangeable potassium and zinc. Petiole samples were obtained for nitrate-nitrogen determination from the Stamer and Schwitter locations three times during the season. The first samples were taken on August 18th with subsequent samplings taken over a three week period.

Plots were harvested in late September and early October utilizing either a four row farmhand lifter or a modified one row plot harvester supplied by Dr. Smith at the Crookston Experiment Station. Subsamples were collected and processed through the tare lab at the American Crystal lab at East Grand Forks.

Results and Discussion: In 1980, three out of five nitrate calibration-correlation sites had low nitrate levels throughout the profile (less than 100#N/A in the top 4 feet). These sites showed a significant response to the addition of fertilizer nitrogen. One site with a nitrate test of 92 #N/A showed a trend toward a nitrogen response with the addition of 40 #N/A. The remaining trial showed no response to fertilizer nitrogen. The high soil nitrate test on this site (148 #N/A) would predict minimal response.

The nitrogen by population trial showed no significant response to nitrogen or plant population. There was, however, a high accumulation of nitrate-nitrogen in the subsoil (142 #N/A in the 2-4 foot depth). The high subsoil nitrate-nitrogen plus the limited moisture during portions of the growing season may have contributed to a lack of response.

The information from the trial conducted at the Stamer location is included in an overall summary compiled by Dr. Larry Smith in the 1980 Sugarbeet Research and Extension Report.

General Comments: The present two foot soil sample for nitrate-nitrogen is a very valuable tool in predicting the nitrogen needs for sugarbeets. When the nitrate test is high (greater than 150# N/A) response to fertilizer nitrogen is minimal. When the nitrate test (2') is less than 150 lbs. N/A responses and calibration are less clear cut. In several situations an estimate of the nitrate-nitrogen below a depth of two feet was useful in predicting the type of response which would be expected. The positioning of the nitrates in the soil profile may also be important and a 0-3' or 0-4' may not be as good as a 0-2' and 2-4' sample.

Minnesota soils have a tremendous ability to release nitrogen from organic matter when the moisture and growing season are adequate. The sugarbeet grower should, therefore, not be misled into believing he needs to apply large amounts of nitrogen to obtain high tonnage. These excessive rates of nitrogen fertilization can decrease sugar and purity and not necessarily increase tonnage.

Acknowledgements: Sincere appreciation is extended to the Sugarbeet Research and Education Board and to the University of Minnesota Experiment Station for financing and supporting this research project. Recognition should be given to our farmer-copperators for their interest and assistance and to Wayne Schwitter for his special assistance during harvest. Special appreciation is also extended to the Department of Soil Science field crew for their attention to the field phases of the project and to Dr. Larry Smith for his assistance with the experiments.

Table 1. Soil nitrate-nitrogen levels at the experimental locations in 1980

Soil Depth	Pete Frieborg Renville Co. Site 1	Site 2	Harold Peterson Chippewa Co. Site 1	Site 2	Wayne Schwitters Chippewa Co.	Leroy Stamer Renville Co.	Norman Bosch Chippewa Co.
inches	lbs NO_3-N/A						
0-12	71	14	18	19	13	32	98
12-24	21	16	32	33	21	10	50
24-36	14	6	5	11	48	6	17
36-48	14	6	2	33	144	6	9
48-60	12	4	4	14	164	8	10

Table 2. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Pete Frieborg, Site 1 Renville Co. 1980.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	19.1	14.2	5404	83.8	4531	237
40	22.5	15.4	6982	84.9	5925	263
80	23.0	14.1	6487	83.1	5390	234
120	20.3	14.8	6069	84.8	5150	254
Significance	NS	NS	NS	NS	NS	NS
BLSD (.05)	--	--	--	--	--	--

Table 3. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, recoverable sugar. Pete Frieborg, Site 2, Renville Co. 1980.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	14.0	16.7	4692	87.2	4093	292
40	16.1	16.5	5329	88.0	4691	291
80	17.6	17.0	6003	88.7	5323	302
120	19.5	17.0	6648	88.3	5868	301
Significance	*	NS	*	NS	*	NS
BLSD	4.0	--	1325	--	1160	--
C.V.	13.5	4.8	13.5	1.9	13.5	6.4

Table 4. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson, Site 1, Chippewa Co. - 1980

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	14.2b	17.0	4802	89.5	4296	303
40	15.9b	17.3	5494	88.4	4859	306
80	16.3ab	16.6	5420	86.5	4687	288
120	19.4a	16.2	6278	87.6	5501	283
Signifance	*	NS	NS	NS	NS	NS
BLSD	3.1	--	--	--	--	--
C.V.	11.0	7.4	12.7	3.0	13.0	9.5

Table 5. Effect of various rates of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Harold Peterson, Site 2, Chippewa Co. - 1980

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	19.2	16.4	6297	86.6	5454	284
40	21.5	17.0	7302	87.2	6365	296
80	23.3	16.0	7327	87.1	6380	274
120	20.2	16.4	6780	84.4	5720	283
Signifance	*	NS	NS	NS	NS	NS
BLSD (.05)	3.2	--	--	--	--	--
C.V.	8.5	7.3	10.5	3.4	12.3	10.6

Table 6. Effect of nitrogen on sugarbeet yield, percentage sugar, gross sugar, purity, and recoverable sugar. Norman Bosch Chippewa Co. - 1980.

Nitrogen Rate	Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A	T/A	%	lbs/A	%	lbs/A	lbs/T
0	21.1	16.3	6907	85.0	5871	277
100	21.5	15.9	6840	85.1	5837	271
Significance	NS	NS	NS	NS	NS	NS
C.V.	6.3	6.0	11.2	2.8	13.2	8.6

Table 7. Effect of various nitrogen rates and plant populations on sugarbeet yield, percentage sugar, gorss sugar, purity, and recoverable sugar. Wayne Schwitters, Chippewa Co. - 1980.

Nitrogen Rate		Roots	Sugar	Gross Sugar	Purity	Recoverable Sugar	
lbs/A		T/A	%	lbs/A	%	lbs/A	lbs/T
0		19.7	15.0	5898	84.2	4973	252
60		21.4	14.9	6346	83.0	5284	248
120		21.3	15.2	6476	84.0	5468	255
Significance		NS	NS	NS	NS	NS	NS
Population plants /100' row							
75		20.9	14.8	6173	83.3	5148	246
125		21.3	14.9	6350	83.8	5334	251
175		20.2	15.3	6198	84.2	5242	259
Significance		NS	NS	NS	NS	NS	NS
Interaction N Rate X Pop.							
0	75	20.1	14.7	5911	83.7	4949	247
0	125	19.1	15.1	5989	84.3	5062	254
0	175	19.2	15.1	5795	84.6	4908	255
60	75	21.0	14.6	6108	82.4	5032	240
60	125	22.3	14.5	6427	82.8	5318	240
60	175	20.8	15.6	6504	84.0	5503	264
120	75	21.7	15.0	6499	83.8	5465	251
120	125	21.7	15.2	6632	84.4	5623	257
120	175	20.5	15.3	6297	83.9	5315	258
Signif.		NS	NS	NS	NS	NS	NS
C.V.		6.3	7.8	11.6	3.5	14.4	11.1

STARTER AND BROADCAST FERTILIZER TRIAL ON SUNFLOWERS

Pennington County, 1980

W. E. Jokela and M. O'Leary

Experimental Procedure

This trial was established to examine the effect of starter and broadcast fertilizer, especially potassium, on sunflower yield and oil content on a soil testing medium in potassium. It was located on a Clearwater/Thief River fine sandy loam soil on the farm of Ken Mehrkens, Pennington County. Soil test levels in the plow layer are as follows (lbs/A): pH 7.6, P 24 (Bray 1, 1:50), K 133. Organic matter level is high.

Broadcast fertilizer was applied in the spring and incorporated with secondary tillage. A randomized complete block design was used with four replications. Starter fertilizer at the rate of 95 lbs/acre of 10-20-20 was applied to half of each broadcast treatment plot. Adequate nitrogen was applied to the whole plot area. Interstate 894 variety was planted on May 10. Plant population at harvest was 21,000 plants/acre. Leaf samples were taken at early bloom and heads were harvested at maturity.

Results and Discussion

Nutrient content of the 5th leaf at early bloom is shown in Table 1. Potassium content of leaves increased and magnesium content decreased significantly with increasing rates of potash. Magnesium content was also reduced by use of the starter. When phosphorus was applied the concentration of zinc in the leaves decreased significantly. Yields were quite high (over 2000 lbs/A), especially considering the drought conditions in 1980, but there was no significant yield response to either starter or broadcast fertilizer (Table 2). Oil percentage increased slightly with the use of the starter.

Table 1. Nutrient content of sunflower leaves (5th leaf) at early bloom as affected by fertilizer treatment. Pennington County (Mehrkens), 1980.

Fertilizer Rate lbs/A		%				ppm					
P_2O_5	K_2O	P	K	Ca	Mg	Fe	Na	Mn	Zn	Cu	B
0	0	.31	3.86	1.51	1.16	70	7	51	40	13	72
0	60	.32	3.86	1.56	1.09	74	15	55	41	13	66
0	120	.32	4.12	1.45	.99	67	7	50	39	12	71
0	240	.29	4.30	1.53	.89	68	9	53	41	13	72
60	0	.35	3.63	1.62	1.32	70	8	55	35	11	61
60	120	.34	4.08	1.52	1.01	71	6	52	35	11	69
significance		ns	*	ns	**	ns	ns	ns	**	ns	ns
BLSD (.05)		-	.25	-	.18	-	-	-	3	-	-
No starter		.31	3.94	1.56	1.13	71	8	53	39	13	71
Starter		.33	4.01	1.50	1.02	69	9	52	38	12	66
Significance		ns	ns	ns	**	ns	ns	ns	ns	ns	ns
BLSD (.05)		-	-	-	.06	-	-	-	-	-	-
C.V.		13.5	5.8	12.3	9.6	9.9	38.1	14.6	15.7	17.0	18.1

Table 2. Yield, oil content, and test weight of sunflowers as affected by fertilizer treatment. Pennington County (Mehrkens), 1980.

Fertilizer Rate lbs/A		Yield (D.M.) lbs/A	Oil %	Oil lbs/A	Test weight lb/bu
P_2O_5	K_2O				
0	0	2057	49.0	1006	29.2
0	60	2051	49.5	1015	29.4
0	120	2110	50.4	1063	30.1
0	240	2094	49.6	1037	28.8
60	0	2064	49.2	1015	29.9
60	120	2165	49.1	1061	29.6
Significance		ns	ns	ns	+
BLSD (.05)		-	-	-	.8
Starter					
-		2119	49.1	1040	29.1
+		2062	49.8	1026	29.9
Significance		ns	**	ns	**
BLSD (.05)		-	.3	-	.5
C.V.		10.7	1.1	10.2	2.7

SUNFLOWER FERTILIZATION

G. E. Varvel and R. K. Severson

The objective of these studies was to determine the effect of N, P and K fertilizer on sunflower yield and oil content.

Experimental Procedure:

The experiment was conducted at 2 locations, Fosston and McIntosh. Three factors (N, P, K) each at 2 levels were combined in a factorial arrangement. A randomized complete block design with 4 replications was used. All treatments were broadcast on April 24 and 25 at Fosston and McIntosh respectively. Sunflower was planted April 28 at McIntosh and May 1 at Fosston and harvested at both locations on September 28. Leaf samples were taken at 40-50% pollination on July 29 at the Fosston location.

Soil test results from samples taken at the start of the study at Fosston were: NO_3-N (0-2') - 140 lb/A, $NaHCO_3$ P (0-6") - 23 lb/A, and exchangeable K (0-6") - 360 lb/A. Those from McIntosh were: NO_3-N (0-2') - 100 lb/A, $NaHCO_3$ P (0-6") - 14 lb/A and exchangeable K (0-6") - 295 lb/A.

Results:

Elemental analyses of the leaf samples taken at the Fosston location are shown for the main effects (N, P, K) only (Table 1). No significant interactions were obtained. Nitrogen had no significant effect on the leaf analyses, P significantly increased N, P and Mn content in the leaf and K significantly increased K content in the leaf. All nutrient levels in the leaf appeared to be above those required for optimum growth. Also, in support of this statement, no yield response was obtained at Fosston (Table 2).

Results shown for the McIntosh location are quite different (Table 2). Nitrogen, P and K each significantly increased seed and oil yield with the highest yields being obtained with the treatment which included all three. In addition, as N was added, oil content was significantly reduced. No significant interactions were obtained.

Table 1. The main effects of N, P and K on the elemental analyses of sunflower leaf samples taken at approximately 40-50% pollination at Fosston.

N Rate (lb/A)	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
	%					ppm						
0	3.44	.31	3.48	2.61	1.36	27	78	8	55	42	22	91
100	3.57	.30	3.53	2.55	1.39	19	71	8	53	47	22	84
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	5.5	10.7	7.4	8.6	12.0	88.9	22.5	16.3	12.0	15.2	18.4	14.4
P_2O_5 Rate (lb/A)												
0	3.41	.29	3.56	2.52	1.33	24	74	8	50	46	23	86
80	3.60	.33	3.45	2.64	1.42	22	75	8	57	43	21	89
Significance	*	**	NS	NS	NS	NS	NS	NS	**	NS	NS	NS
B.L.S.D. (.05)	.14	.02							5			
K_2O Rate (lb/A)												
0	3.54	.31	3.40	2.62	1.40	23	75	8	53	44	21	85
100	3.48	.31	3.61	2.54	1.34	23	74	8	54	45	23	89
Significance	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)			.18									

Table 2. The effect of N, P and K fertilizer on sunflower seed yield, oil content and oil yield.

Treatment			Location					
			McIntosh			Fosston		
			Seed			Seed		
N	P_2O_5	K_2O	Yield	Oil	Oil Yield	Yield	Oil	Oil Yield
- - - lbs/A - - -			lbs/A	%	lbs/A	lbs/A	%	lbs/A
0	0	0	1550	49.3	764	1913	46.6	890
100	0	0	1914	48.6	930	1905	45.3	862
0	80	0	1929	50.4	973	1961	45.2	884
100	80	0	2145	48.5	1040	1980	46.4	918
0	0	100	1801	50.2	903	1876	46.0	863
100	0	100	2178	48.4	1050	1976	45.6	900
0	80	100	2012	50.0	1007	1999	45.4	906
100	80	100	2305	48.5	1117	1813	45.0	815
Significance			**	**	**	NS	NS	NS
B.L.S.D. (.05)			252	1.4	111			
C.V. (%)			8.8	1.8	8.0	12.4	2.6	12.0
Main Effects								
N-Rate lb/A								
0			1823	50.0	912	1937	45.8	886
100			2135	48.5	1034	1918	45.6	874
Significance			**	**	**	NS	NS	NS
B.L.S.D. (.05)			129	.7	57			
P_2O_5 Rate lb/A								
0			1861	49.1	912	1918	45.9	879
80			2098	49.4	1034	1938	45.5	881
Significance			**	NS	**	NS	NS	NS
B.L.S.D. (.05)			129		57			
K_2O Rate lb/A								
0			1884	49.2	927	1940	45.8	889
100			2074	49.3	1019	1916	45.5	871
Significance			**	NS	**	NS	NS	NS
B.L.S.D. (.05)			129		57			

PHOSPHORUS AND POTASSIUM FERTILITY STUDIES ON SUNFLOWER*

G. E. Varvel and R. K. Severson

The objective of these studies were to measure total above ground plant growth, nutrient uptake, seed yield and oil content of sunflower as affected by P and K fertilizer.

Experimental Procedures:
Two locations were used with a P and K experiment at both. A randomized complete block design with 6 treatments was used for all experiments.

Location:	McIntosh	Fosston
Variety:	USDA 894	USDA 894
Population:	19,500 Plants/A	23,000 Plants/A
Herbicides:	Fargo-Treflan	Treflan
Planting Date:	April 28, 1980	May 1, 1980
Harvest Date:	Sept. 23, 1980	Sept. 23, 1980
Soil Test Levels:		
NO_3-N (0-2')	100 lb/A	140 lb/A
$NaHCO_3$ P (0-6")	14 lb/A	23 lb/A
K (0-6")	310 lb/A	365 lb/A
pH (0-6")	8.0	8.1

At Fosston and McIntosh, the P studies had 100 lb/A K_2O and 80 lb/A N broadcast over the entire experimental areas while the K studies had 120 lb/A P_2O_5 and 80 lb/A N broadcast over the entire experimental area.

Results:
Results for each location are shown in the following tables. A significant yield response to P was obtained at the McIntosh location (Table 1). No significant yield response was obtained for K at either location or for P at the Fosston location (Tables 1 and 2). Oil content was not affected by the treatments at any of the locations (Tables 1 and 2).

Fosston P Study: Above ground dry matter yields and elemental analyses are shown in Tables 3, 4 and 5 for the June 23, July 29 and September 4 sampling dates respectively. Differences in some of the nutrient contents at the various dates are not well explained by the treatments. No significant difference in dry matter yield, P content of the plant or P uptake was obtained.

Leaf samples were also taken on July 29 and the elemental analyses are shown in Table 6. Phosphorus, Mg and Zn content of the leaf were affected, but somewhat erratically. In general, P and Mg content increased and Zn levels decreased with additions of P fertilizer.

Fosston K Study: Above ground dry matter yields and elemental analyses are shown in Tables 7, 8 and 9 for the June 23, July 29 and September 4 sampling dates respectively. Potassium content of the plant was significantly increased by the addition of potassium at the August 4 sampling. No significant differences in elemental analyses, total dry matter or K_2O uptake were obtained.

Leaf samples were taken on July 29 and the elemental analyses are shown in Table 10. Potassium content increased and Mg content decreased with the addition of K fertilizer. Zinc differences seem to have no relationship to the fertilizer treatments.

* Project financed in part by Potash and Phosphate Institute of America.

McIntosh P Study: Above ground dry matter yields and elemental analyses are shown in Tables 11, 12 and 13 for the June 24, July 29 and September 4 sampling dates respectively. Phosphorus content of the plant and P_2O_5 uptake were significantly increased by the addition of phosphorus fertilizer at all three sampling dates. Total dry matter at the June 24 sampling and Zn and Cu analyses at the July 29 sampling dates were also significantly affected by the fertilizer treatments.

Leaf samples taken on July 29 and the elemental analyses are shown in Table 14. Phosphorus content increased and Zn and Cu content decreased signficantly with the addition of P fertilizer.

McIntosh K Study: Above ground dry matter yield and elemental analyses are shown in Tables 15, 16 and 17 for the June 24, July 29 and September 4 sampling dates respectively. Magnesium content of the plant was significantly reduced at the first and second sampling date. No other significant differences were obtained.

Leaf samples were taken on July 29 and the elemental analyses are shown in Table 18. Potassium content increased and Mg content decreased as the rate of applied K increased.

Conclusions:
Results from the four experiments reported here correlate very well with responses predicted by the soil test levels. A significant response to P was obtained at the McIntosh location which had a medium P soil test. Soil test results at the other three locations were all high and no responses were obtained.

Table 1. The effect of P on sunflower seed yield and oil content in 1980.

P_2O_5	Seed			
	Yield		Oil Content	
Rate	McIntosh	Fosston	McIntosh	Fosston
lb/A	-lb/A-		-%-	
0	1940	1990	48.8	46.0
40	2400	2100	48.1	45.1
80	2310	2100	48.2	45.8
120	2380	2300	47.5	44.8
160	2340	2170	47.4	45.6
200	2470	2310	47.4	44.8
Significance	*	NS	NS	NS
B.L.S.D. (.05)	320			
C.V. (%)	8.4	11.1	1.8	1.6

Table 2. The effect of K on sunflower seed yield and oil content in 1980.

K_2O	Seed			
	Yield		Oil Content	
Rate	McIntosh	Fosston	McIntosh	Fosston
lb/A	-lb/A-		-%-	
0	2500	1920	47.9	46.6
50	2400	1930	47.6	47.6
100	2260	1860	48.0	47.1
150	2180	2090	47.9	47.2
200	2360	2080	48.1	46.1
250	2270	2070	48.1	47.0
Significance	NS	NS	NS	NS
C.V. (%)	7.7	12.1	1.7	2.2

Table 3. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately the 18 leaf stage at Fosston.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	3.58	0.29	6.14	2.00	1.06	134	157	129	50	24	8	47	668	4.4
40	3.53	0.28	5.83	2.13	1.02	172	191	122	54	23	8	48	650	4.1
80	3.58	0.29	5.05	2.23	1.22	140	167	173	63	24	8	48	472	3.0
120	3.61	0.30	6.37	1.86	0.99	93	120	105	47	26	10	48	557	3.8
160	3.47	0.29	5.66	2.18	1.11	123	148	190	59	25	8	49	723	4.8
200	3.55	0.30	5.08	1.95	1.35	92	118	271	49	25	9	49	497	3.3
Significance	NS	NS	NS	NS	NS	*	*	NS	**	NS	NS	NS	NS	NS
B.L.S.D. (.05)						52	52		9					
C.V. (%)	6.4	9.5	12.2	11.6	18.7	25.0	20.3	51.5	10.7	6.7	16.6	7.6	27.8	24.3

Table 4. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at Fosston.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	2.11	0.24	3.47	1.43	1.00	69	79	58	36	27	10	50	6949	36.7
40	1.82	0.23	2.95	1.39	1.08	72	79	85	36	27	9	48	7031	37.3
80	1.83	0.22	3.56	1.45	1.02	72	88	40	33	25	9	51	7804	40.2
120	1.83	0.26	3.17	1.50	1.03	84	91	56	38	26	9	51	8652	51.9
160	1.97	0.24	3.34	1.50	1.10	118	125	59	34	24	10	53	6108	34.3
200	1.93	0.24	3.48	1.52	1.04	64	74	52	37	23	9	49	6238	34.0
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	12.5	15.3	11.7	5.9	9.1	41.8	35.4	46.5	10.4	9.7	13.0	7.4	21.0	27.7

Table 5. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at Fosston.

P_2O_5 Rate	Elemental Analyses											Total Dry Matter	Uptake P_2O_5
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%				ppm							lb/A	
0	0.22	2.88	1.11	0.75	63	73	78	23	29	11	36	9121	46.1
40	0.21	2.58	0.93	0.75	62	65	101	20	26	9	31	8232	39.3
80	0.23	2.91	1.11	0.73	104	109	63	22	27	10	38	8724	46.7
120	0.24	2.55	1.13	0.78	97	104	146	24	27	10	35	8221	45.2
160	0.24	2.69	1.09	0.74	73	83	80	21	24	10	35	8846	48.9
200	0.24	2.68	1.16	0.77	105	110	108	26	26	10	34	8238	45.8
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	13.5	12.5	11.6	11.1	30.5	24.8	48.3	20.5	12.3	9.3	8.9	18.6	25.5

Table 6. The effect of P on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at Fosston.

P_2O_5 Rate	Elemental Analyses										
	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
lb/A	%					ppm					
0	3.52	0.35	3.77	2.80	1.22	98	75	64	48	24	96
40	3.49	0.38	3.36	2.96	1.40	100	79	75	50	21	97
80	3.62	0.35	3.84	2.91	1.35	99	78	61	42	21	93
120	3.60	0.44	3.46	3.15	1.33	103	79	72	44	21	97
160	3.63	0.36	3.35	2.87	1.47	98	77	58	37	21	89
200	3.53	0.42	3.68	3.07	1.32	102	78	62	42	20	92
Significance	NS	*	NS	NS	*	NS	NS	NS	*	NS	NS
B.L.S.D. (.05)		0.06			0.16				7		
C.V. (%)	6.3	10.4	9.1	7.9	6.9	7.5	10.0	13.8	10.3	11.4	11.2

Table 7. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately the 18 leaf stage at Fosston.

K_2O Rate	Elemental Analyses												Total Dry Matter	Uptake K_2O
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	3.62	0.34	6.08	2.37	1.13	214	232	116	64	26	9	52	636	46.3
50	3.36	0.31	6.05	2.08	1.15	208	210	133	58	26	9	49	888	64.6
100	3.50	0.32	5.55	2.21	1.13	213	271	148	64	26	8	50	767	51.4
150	3.59	0.32	5.74	2.22	1.12	241	254	136	74	27	8	50	807	56.6
200	3.69	0.33	5.89	2.24	1.01	253	265	116	63	25	8	51	612	43.0
250	3.53	0.33	6.35	1.99	1.03	177	189	107	51	24	8	47	746	57.9
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	5.1	11.6	8.6	13.3	9.7	43.0	44.2	30.3	15.0	10.2	13.5	7.8	28.9	32.7

Table 8. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at Fosston.

K_2O Rate	Elemental Analyses												Total Dry Matter	Uptake K_2O
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	1.66	0.17	2.44	1.32	1.00	65	70	54	30	21	8	47	6578	193.5
50	1.75	0.19	2.31	1.34	1.14	69	80	49	37	22	8	48	6304	178.6
100	1.73	0.19	2.94	1.28	0.90	65	71	38	31	23	9	49	5494	192.4
150	1.89	0.19	3.17	1.35	0.75	84	96	38	32	24	9	50	6156	240.2
200	1.74	0.18	3.18	1.28	0.95	73	77	51	28	22	9	47	6672	256.6
250	1.82	0.19	3.50	1.39	0.84	69	74	34	38	26	8	49	5905	247.2
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	10.5	15.0	19.4	12.1	24.4	15.6	16.7	56.4	16.2	13.7	18.6	13.5	18.0	29.4

Table 9. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at Fosston.

K_2O Rate	Elemental Analyses											Total Dry Matter	Uptake K_2O
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%				ppm							lb/A	
0	0.20	2.09	1.19	0.80	108	115	79	25	26	9	38	7131	181.4
50	0.20	2.06	1.05	0.75	93	105	64	28	23	8	38	6498	160.9
100	0.19	2.47	1.17	0.69	125	132	80	25	24	10	40	7490	222.5
150	0.20	2.46	1.08	0.73	99	101	57	24	24	10	36	7156	213.8
200	0.21	2.55	1.14	0.74	92	100	95	24	26	10	39	6613	209.6
250	0.20	2.87	1.19	0.66	89	102	54	27	26	9	38	7495	268.3
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)		0.58											
C.V. (%)	8.6	14.0	7.0	14.8	25.2	20.7	49.2	13.6	8.1	15.4	5.9	18.1	26.3

Table 10. The effect of K on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at Fosston.

K_2O Rate	Elemental Analyses										
	N	P	K	Ca	Mg	Al	Fe	Mn	Zn	Cu	B
lb/A	%					ppm					
0	3.31	0.30	3.26	2.73	1.38	90	70	52	37	18	85
50	3.31	0.29	3.16	2.66	1.48	91	70	62	35	17	85
100	3.36	0.31	3.55	2.55	1.23	86	71	52	31	16	85
150	3.29	0.33	3.85	2.62	1.18	91	76	53	38	21	96
200	3.31	0.31	3.85	2.67	1.26	90	71	53	39	20	90
250	3.47	0.32	3.90	2.67	1.09	92	74	60	37	19	84
Significance	NS	NS	**	NS	*	NS	NS	NS	**	NS	NS
B.L.S.D. (.05)			0.47		0.24				4		
C.V. (%)	6.9	10.7	8.2	10.8	11.3	7.3	6.0	15.6	6.8	19.7	11.3

Table 11. The effect of P on the elemental analyses, dry matter yield and uptake of the sunflower whole plants at approximately the 18 leaf stage at McIntosh.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	3.24	0.29	4.89	1.51	1.31	154	161	157	52	25	10	46	701	4.7
40	3.15	0.31	5.31	1.72	1.34	272	269	168	64	25	11	50	1017	7.2
80	3.05	0.28	5.15	1.61	1.41	151	157	180	50	25	11	48	1003	6.6
120	3.14	0.32	5.01	1.75	1.39	221	221	186	54	23	10	48	919	6.6
160	3.14	0.35	5.57	1.52	1.26	142	149	126	49	20	10	46	898	7.1
200	3.18	0.38	5.07	1.60	1.40	142	152	211	52	24	9	49	1146	9.5
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	**
B.L.S.D. (.05)		0.05											279	
C.V. (%)	6.1	10.5	9.8	12.1	9.8	68.7	60.8	21.8	19.6	14.9	7.8	7.6	17.3	20.6

Table 12. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at McIntosh.

P_2O_5 Rate	Elemental Analyses												Total Dry Matter	Uptake P_2O_5
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%					ppm							lb/A	
0	1.60	0.15	2.70	1.13	1.03	89	97	41	34	21	10	39	6265	21.6
40	1.66	0.20	3.24	1.17	1.03	71	78	41	33	19	10	38	8129	36.7
80	1.73	0.19	2.09	1.15	1.03	85	90	44	33	18	8	33	6031	25.6
120	1.55	0.20	2.66	1.27	1.08	79	86	47	33	20	10	39	7060	33.0
160	1.47	0.20	2.93	1.17	1.06	73	78	60	30	15	8	35	6100	28.2
200	1.77	0.25	2.70	1.19	1.13	71	81	47	34	17	8	38	7142	40.1
Significance	NS	**	NS	NS	NS	NS	NS	NS	NS	**	*	NS	NS	**
B.L.S.D. (.05)		0.05								2	1			10.7
C.V. (%)	11.1	15.2	18.3	8.1	9.8	18.4	15.5	26.9	11.6	8.3	8.7	9.0	14.9	21.6

Table 13. The effect of P on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at McIntosh.

P_2O_5 Rate	Elemental Analyses											Total Dry Matter	Uptake P_2O_5
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B		
lb/A	%				ppm							lb/A	
0	0.15	2.41	1.11	0.86	155	151	76	28	23	11	33	7469	26.3
40	0.21	2.70	1.05	0.78	133	133	65	25	21	11	32	8384	40.3
80	0.22	2.44	1.17	0.83	174	183	100	28	22	10	33	8349	41.8
120	0.22	2.52	1.19	0.89	158	161	62	27	20	10	33	8597	44.1
160	0.24	2.84	1.22	0.84	140	148	82	26	19	10	33	7847	43.6
200	0.25	2.55	1.23	0.92	177	176	86	30	19	10	33	9073	54.1
Significance	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
B.L.S.D. (.05)	0.04												16.4
C.V. (%)	11.7	14.7	8.2	6.8	14.6	13.8	60.0	7.5	11.0	10.8	6.6	13.8	23.3

Table 14. The effect of P on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at McIntosh.

P_2O_5 Rate	Elemental Analyses											
	N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	%					ppm						
0	3.20	0.25	3.69	2.09	1.29	60	86	11	54	30	22	57
40	3.20	0.27	3.61	2.30	1.33	46	77	8	56	26	19	45
80	3.39	0.28	3.47	2.09	1.39	43	75	6	51	26	18	47
120	3.27	0.32	3.58	2.26	1.41	47	80	7	55	25	20	51
160	3.07	0.36	3.61	2.25	1.36	45	76	6	52	23	18	49
200	3.27	0.38	3.42	2.33	1.54	46	78	8	62	23	17	53
Significance	NS	*	NS	NS	NS	NS	NS	NS	NS	*	*	NS
B.L.S.D. (.05)		0.08								5	3	
C.V. (%)	6.0	16.5	7.6	11.8	8.2	24.6	12.7	31.2	14.5	12.3	9.5	19.3

Table 15. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately the 18 leaf stage at McIntosh.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Total Dry Matter	Uptake K_2O
lb/A	%					ppm							lb/A	
0	3.22	0.31	5.10	1.62	1.46	215	213	235	49	21	11	45	837	51.1
50	3.15	0.32	5.69	1.65	1.13	131	142	130	44	25	10	47	828	56.3
100	3.14	0.34	6.24	1.47	1.10	130	134	127	41	23	9	45	994	76.3
150	3.36	0.31	5.65	1.62	1.04	132	142	161	52	21	10	44	791	52.8
200	3.43	0.34	6.50	1.65	1.13	158	161	136	51	22	10	47	764	58.8
250	3.00	0.28	6.13	1.46	1.07	124	105	149	46	25	10	41	855	61.7
Significance	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)					0.25									
C.V. (%)	8.1	10.8	9.1	16.2	10.9	40.7	32.2	34.3	26.5	15.4	16.9	8.0	26.1	29.6

Table 16. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at approximately 40-50% pollination at McIntosh.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Total Dry Matter	Uptake K_2O
lb/A	%					ppm							lb/A	
0	1.60	0.19	2.63	1.26	1.18	83	89	77	32	17	10	28	6504	206.9
50	1.60	0.27	3.46	1.28	0.85	64	70	41	24	22	9	34	5823	241.5
100	1.46	0.25	3.26	1.21	0.82	106	109	36	23	19	9	34	5365	202.2
150	1.78	0.23	3.60	1.35	0.89	85	90	39	33	19	10	39	6332	273.8
200	1.73	0.22	3.38	1.23	0.90	87	98	41	30	21	9	34	6138	246.6
250	1.52	0.19	3.44	1.21	0.83	72	76	29	28	19	9	34	6844	287.3
Significance	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)					0.20									
C.V. (%)	12.0	22.7	18.9	9.2	11.6	34.3	29.1	43.6	16.4	23.4	18.7	6.7	27.1	36.0

Table 17. The effect of K on the elemental analyses, dry matter yield and uptake of sunflower whole plants at maturity at McIntosh.

K_2O Rate	Elemental Analyses P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B	Total Dry Matter	Uptake K_2O
lb/A	%				ppm							lb/A	
0	0.20	2.44	1.12	0.81	148	140	67	24	19	11	34	6407	188.3
50	0.25	2.86	1.11	0.63	127	120	46	17	22	10	30	7970	280.7
100	0.26	2.82	1.20	0.64	159	146	39	19	22	11	30	8855	318.6
150	0.21	2.35	1.25	0.72	219	200	60	25	18	10	29	8973	258.4
200	0.22	2.87	1.18	0.72	149	138	48	23	21	10	31	7819	267.2
250	0.19	3.02	1.15	0.69	174	155	48	22	19	10	30	7788	295.3
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	12.9	13.9	16.5	15.5	47.3	44.3	29.1	22.6	18.8	13.1	9.0	21.8	35.6

Table 18. The effect of K on the elemental analyses of leaf samples of sunflower taken at approximately 40-50% pollination at McIntosh.

K_2O Rate	Elemental Analyses N	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
lb/A	%					ppm						
0	3.29	0.37	3.66	2.41	1.42	46	74	11	49	21	18	34
50	3.19	0.40	3.67	2.69	1.14	43	74	13	50	28	19	58
100	3.20	0.39	3.61	2.46	1.20	48	82	12	48	24	17	37
150	3.19	0.33	3.93	2.39	1.03	50	76	11	46	25	20	58
200	3.34	0.36	4.01	2.46	1.06	48	77	13	48	30	20	54
250	3.32	0.37	4.32	2.35	0.87	50	77	14	42	29	20	53
Significance	NS	NS	*	NS	*	NS	NS	NS	NS	NS	NS	NS
B.L.S.D. (.05)			0.49		0.32							
C.V. (%)	5.9	12.9	7.5	9.3	17.3	18.5	11.8	50.5	22.3	29.2	16.2	32.3

FERTILIZER TRIALS ON SUNFLOWERS - 1980

C. J. Overdahl, S. D. Evans, G. W. Randall

Field trials on sunflowers were started in 1978 and continued in 1979 and 1980.

Plots were located at Waseca, Morris, and Becker, Minnesota. Additional trials were conducted by Dr. Varvel in the Crookston area his data and that by William Jokela are reported elsewhere in the annual report. Tables 1 through 7 show results from nitrogen and potash treatments.

Summary of results

Significant responses from nitrogen were observed at Becker and Waseca and a significant response to potash was measured at Becker.

Where nitrogen responses were measured the nitrate-nitrogen tests were quite low such as at Becker and Waseca but at Morris where the nitrate test was quite high, 119 lbs to 5 feet, no response was obtained.

Potassium tests at Becker were very low and were increased with K treatments but best yields were obtained where K tests were still low.

Table 1. Sunflower yields, percent oil, pounds of oil per acre and test weight of sunflowers according to potash treatments on sunflowers. Becker 1980.

lbs. K_2O/A	D.M. #seed/A	% oil (D.M.)	lbs. Oil/A	test wt.
0	1292	45.4	586	26.8
60	1588	47.5	754	27.7
120	1765	48.5	855	27.8
180	1866	48.6	906	27.8
240	1725	47.4	821	28.0
480	1906	48.6	927	28.0
significance	*	*	**	*
BLSD (.05)	345	1.9	173	1.3
C.V.	12.6	2.5	13.6	2.7

120 + 40 + 0 added to all plots in split applications.
160 lbs/acre 18-46-0
60 lbs N preplant
60 lbs N July 1

Table 2. Soil tests and percent K in sunflowers due to potash treatments. Becker 1980.

K_2O lbs/A	Soil test K	% K 5th leaf
0	42	2.76
60	54	2.94
120	60	3.19
180	72	3.43
240	67	3.74
480	104	4.28
significance		**
BLSD (.05)		.37
C.V.		7.7

Table 3. Emission spectrograph analysis of sunflowers from potash treatments, 5th leaf at pollination, Becker 1980.

	%				ppm						
lbs, K_2O/A	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.52	2.75	3.04	1.35	11	58	11	104	44	16	46
60	.50	2.94	3.23	1.11	14	62	10	113	37	17	47
120	.45	3.19	2.91	1.04	14	56	8	100	35	16	45
180	.49	3.43	2.74	.90	22	64	12	100	36	16	43
240	.47	3.74	2.75	.78	22	64	14	103	33	18	43
480	.42	4.28	2.54	.61	25	65	14	90	30	18	40
significant	ns	**	*	**	*	+	ns	ns	**	ns	ns
BLSD (.05)	-	.37	.37	.18	9	6	-	-	4	-	-
C.V.	13.0	7.7	8.0	12.8	29.6	7.3	22.7	16.9	7.9	16.4	13.6

Table 4. Sunflower yields, percent oil, pounds of oil per acre, percent N in leaf and test weight from N treatments, Becker, 1980.

lbs. N/A	D.M. #seed/A	% oil (D.M.)	lbs. oil/A	% N 5th leaf	test wt.
0	1736	48.8	848	3.49	30.2
60	2194	48.6	1065	3.69	29.5
90	2412	47.2	1141	4.09	29.0
120	2318	46.8	1085	4.10	29.4
150	2313	47.4	1099	3.98	29.8
180	2258	46.5	1052	4.04	29.4
significance	*	ns	+	ns	ns
BLSD (.05)	451	-	200	-	-
C.V.	12.0	3.1	12.9	12.9	3.9

Added across all plots:
300 lbs/acre of sul-po-mag plowed down
0 + 17 + 85 as starter

Table 5. Sunflower yields, percent oil, oil in pounds per acre, percent N and test weights, Morris, 1980.

lbs. N/A	D.M. #seed/A	% oil (D.M.)	lbs. oil/A	% N 5th leaf	test wt.
0	1696	42.9	726	3.51	35.4
30	1630	42.7	698	3.51	34.9
60	1881	43.6	819	3.72	35.3
90	1840	42.4	784	3.99	34.9
120	1926	42.2	814	4.15	36.1
150	1908	42.4	810	3.97	35.0
Significance	ns	ns	ns	ns	ns
BLSD (.05)	-	-	-	-	-
C.V.	9.3	2.2	9.7	13.3	2.9

Table 6. Sunflower yields, percent oil, oil pounds per acre, leaf N test weight, population and head diameter. Waseca, 1980.

lbs. N/A	D.M. #seed/A	% oil (D.M.)	lbs. oil/A	% N 5th leaf	test wt.	population x 1000	Head Diam. (CM)
0	2332	48.6	1131	2.80	34.0	21.8	15.1
30	2482	49.3	1223	2.86	33.7	21.6	15.1
60	2776	48.3	1341	2.90	33.7	20.6	16.2
90	2721	48.5	1319	3.00	34.1	21.9	15.6
120	2721	47.9	1305	3.27	34.0	22.4	15.8
150	2894	47.8	1385	3.25	33.8	20.4	17.1
Significance	**	ns	*	ns	ns	**	**
BLSD (.05)	303	-	148	-	-	1.1	1.0
C.V.	9.2	2.1	9.0	14.2	1.8	4.1	5.2

0 + 120 + 200 per acre added to all plots

Table 7. Profile nitrate-nitrogen soil test pounds per acre. Morris and Waseca, 1980.

depth feet	Morris	Waseca
0 - 1	11	29
1 - 2	9	14
2 - 3	17	9
3 - 4	36	12
4 - 5	46	24
Total		
0 - 5	119	88

FERTILIZER TRIALS ON WHEAT ON HIGH FERTILITY SOILS IN NORTHWESTERN MINNESOTA - 1980*

W. E. Jokela, M. O'Leary and T. Courneya

Several trials were established in 1980 to evaluate the effect of starter and/or broadcast fertilizer on the yield and protein content of wheat on high fertility soils in northwestern Minnesota. Due to a serious drought 8 of the 10 trials were abandoned. Yields were reduced substantially in the remaining 2 trails, which are reported here.

I. Starter and broadcast fertilization of wheat in Pennington County.

This experiment was located on a Clearwater loam soil on the farm of Ken Mehrkens near Thief River Falls. Soil pH was 6.7 and phosphorus and potassium tests were 46 and 451 lbs/acre, both very high. Solar variety of wheat was planted on April 23. Adequate nitrogen was applied to all plots.

Four broadcast treatments - 0, 40 P_2O_5 only, 60 K_2O only, and 40 P_2O_5 + 60 K_2O - were applied in four replications in the spring and incorporated with secondary tillage. Half of each broadcast treatment area received drill applied starter at the rate of 170 lbs/acre of 10-20-20. Experimental design was randomized complete block with starter as a split plot treatment.

Table 1. Yield, test weight, and protein content of wheat as affected by fertilizer treatment. Pennington County - (Mehrkens) 1980.

Fertilizer Treatment			Yield	Test wt.	Protein Content
P_2O_5/A	K_2O/A		bu/A	lbs/bu	%
0	0		26.3	61.6	11.5
40	0		28.5	61.8	12.5
0	60		28.4	61.8	11.7
40	60		28.3	61.7	12.5
Significance			ns	ns	ns
No starter			27.4	61.8	12.2
Starter			28.4	61.7	12.0
Significance			+	ns	ns
P	K	Start			
0	0	-	25.4	61.6	11.4
0	0	+	27.2	61.6	11.6
40	0	-	27.6	61.8	12.7
40	0	+	29.3	61.8	12.2
0	60	-	28.3	61.8	11.7
0	60	+	28.6	61.6	11.8
40	60	-	28.1	61.8	12.8
40	60	+	28.6	61.6	12.2
Significance			ns	ns	ns
C.V.			5.5	.5	6.5

*This project was supported in part by funds from the Minnesota Wheat Council.

The effect of fertilizer treatment is shown in Table 1. Broadcast phosphorus and/or potassium had no effect on yield, test weight, or protein content of grain. Starter had no effect except for a 1.0 bushel increase in yield, which was significant at the 10% level.

II. Starter fertilizer on wheat in Marshall County.

This trial was located on the farm of Medard Yutrzenka near Argyle, MN on a site that had been summer fallowed the previous season. When the wheat was seeded, strips the width of the grain drill were left without starter fertilizer and were compared to wheat seeded with drill applied starter. Starter rate was 15 gallons/acre of a 20-10-0 liquid, which supplies approximately 34 lbs of N and 17 lbs of P_2O_5 per acre. Four paired comparisons were made at one site. Soil test results on this high organic matter, loam soil were a pH of 7.6, P test of 49 lbs/acre, (Bray 1, 1:10), and a K test of 372 lbs/acre.

Grain, test weight and protein content are shown in Table 2. There was no significant response to drill applied fertilizer on this high fertility soil under the weather conditions of 1980.

Table 2. Yield, test weight, and protein content of wheat as affected by starter fertilizer. Marshall County (Yutrzenka). 1980.

	Yield bu/A	Test Wt. lbs/bu	Protein Content %
Starter	40.9	63.3	16.2
No starter	42.0	63.9	16.0
Significance	ns	ns	ns

POTASSIUM ON WHEAT - PENNINGTON COUNTY, 1980*

William Jokela and Micheal O'Leary

This trial was established to determine the effect of broadcast applications of potassium on wheat yield, potassium uptake, and soil test level on a soil testing medium in potassium.

Experimental Procedures

The experimental site is located on a Borup loam soil on the Evert Flesche farm in Pennington County. Six rates of potassium were broadcast and incorporated with secondary tillage. Plot design was randomized complete block with four replications. Solar variety of wheat was planted and 100 lbs/acre of 18-46-0 fertilizer was applied as a starter with the drill to all plots. Soil test results are shown in Table 1. Potassium level is medium (158 lbs/A) in the surface layer and low in the subsurface layers.

Results and Discussion

Yield, test weight, and protein percentage of grain and yield and potassium uptake of forage at soft dough stage are shown in Table 2. There were no significant differences in grain yield or percent protein or in forage yield or potassium uptake. Test weight was significant at the 10% level, increasing slightly with increase in potash applications. Both forage and grain yield were low and highly variable due to drought conditions.

Nutrient content of whole plants at soft dough stage are shown in Table 3. Potassium in the forage increased and magnesium decreased consistently with increasing potash application rate.

Some other elements showed a significant difference but the generally decreasing trend was variable, perhaps due to dilution effects with the variable forage yield.

Drought conditions in 1980 reduced yields substantially, probably contributing to the lack of yield response.

Table 1. Soil test results. Pennington County (E. Flesche). Spring 1980.

Depth (inches)	pH	P* (lbs/A)	K (lbs/A)
0 - 6	7.8	28	158
6 - 12	8.0	7	92
12 - 18	8.1	2	48

*Bray 1 (1:50)

*This project was supported in part by funds from the Minnesota Wheat Council.

Table 2. Effect of potassium rate on yield, test weight, and % protein of wheat grain and yield and potassium uptake of forage. Pennington County (E. Flesche). 1980.

K_2O Rate (lbs/A)	Grain			Forage (soft dough)	
	Yield (bu/A)	Test Wt. (lb/bu)	Protein %	Dry Matter (lbs/A)	K uptake (lbs/A)
0	21.1	58.0	17.7	3544	40
40	25.3	58.3	16.8	3886	50
80	28.4	59.2	17.0	4954	67
120	28.2	58.8	18.1	4505	66
160	30.2	59.4	16.5	4506	68
320	24.3	59.0	17.1	4228	58
Significance	ns	+	ns	ns	ns
BLSD (.05)	-	1.0	-	-	-
C.V. (%)	23.8	1.1	7.4	25.3	31.3

Table 3. Effect of potassium rate on nutrient content of whole wheat plants at soft dough stage. Pennington County (E. Flesche). 1980.

K_2O Rate (lbs/A)	%				ppm						
	P	K	Ca	Mg	Al	Fe	Na	Mn	Zn	Cu	B
0	.177	1.15	.403	.277	160	185	19	57	29	2	13
40	.183	1.28	.340	.262	93	120	25	54	29	2	11
80	.156	1.31	.346	.263	94	117	13	49	24	2	12
120	.167	1.45	.276	.250	58	81	18	44	28	2	13
160	.158	1.46	.326	.256	69	92	16	50	29	2	12
320	.146	1.37	.308	.241	76	101	10	50	25	2	10
Significance	+	*	*	ns	**	**	ns	*	ns	ns	ns
BLSD (.05)	.025	.211	.068	-	47	46	-	8	-	-	-
C.V.	10.6	9.3	12.5	9.3	33.0	25.8	46.3	9.7	11.2	11.4	22.5

COPPER AND MANGANESE FERTILIZATION OF WHEAT ON AN ORGANIC SOIL

Roseau County - 1980*

C. A. Simkins, W. E. Jokela, and M. O'Leary

Attempts to raise wheat on organic soils in the Roseau County area in recent years have been largely unsuccessful. In addition to limitations due to the short growing season there have been production problems that appear to be caused by nutrient deficiencies. Some fields were diagnosed as showing copper deficiency, but applications of copper on wheat in the following year did not correct the problem. This trial was conducted on the Roger Welin farm near Roseau, MN on a field where copper had been applied unsuccessfully three years earlier.

Experimental Procedures

The experiment was located on a high pH organic soil consisting of 1½ to 2 feet of peat over clay mineral soil. Soil test results are shown in Table 1. Plot design was a randomized complete block with four replications and five treatments. The fertilizer treatments consisted of a no fertilizer check and four NPK treatments with or without copper and/or manganese, applied as indicated in Table 2. Fertilizer was applied at the time of seeding on May 13.

Results and Discussion

Yield, test weight, and protein percentage of grain are shown in Table 2. Yields were low due to a late spring frost and an extremely dry growing season, but the manganese treatments resulted in large and significant yield increases over the other treatments. Yield from the NPK application was not significantly greater than the absolute check, and the application of copper did not increase yields significantly over the NPK treatment.

These limited results from one year indicate that the application of manganese may be beneficial in increasing wheat yields on high pH organic soils where nutrient related production problems have occurred. There is not adequate information available to know if a soil test can be used to determine the need for manganese on these soils.

Table 1. Soil test results on organic soil. Roseau County (Welin farm), 1980.

pH	P*	K	S	Zn*	Cu*	Mn*
	lbs/A		ppm			
7.7	26	64	40+	7.1	4.7	50.9

*Extractant is Bray 1 (1:10) for P and DTPA for Zn, Cu, and Mn.

*This project was supported in part by funds form the Minnesota Wheat Council.

Table 2. Yield, test weight, and protein percentage of wheat grain as affected by fertilizer treatment. Roseau County (Welin). 1980.

Fertilizer Treatment	Grain Yield (bu/A)	Test Weight (lb/bu)	% protein
Check	13.5	51.5	14.8
NPK[1]	16.0	50.7	15.6
NPK + Cu[2]	17.8	51.8	15.2
NPK + Mn[3]	25.6	53.2	15.8
NPK + Cu + Mn	24.5	52.7	16.0
Significance	**	+	*
BLSD (.05)	3.4	1.6	0.8
C.V. (%)	12.1	2.1	3.2

[1]40 N, 40 P_2O_5, and 120 K_2O (lbs/A) applied broadcast and disked in prior to seeding.
[2]24 lb/A copper sulfate (6 lbs/A Cu) applied broadcast and disked in prior to seeding.
[3]64 lb/A manganese sulfate (16 lbs/A Mn) drill applied with the seed.

N Rate, Source, and Incorporation Study - Wheat

W. Nelson, S. Evans, J. Lensing, M. O'Leary and H. Meredith

Objective of Study: Delineate effect of N fertilization on wheat yields when broadcast N forms are incorporated into the soil surface or left on the surface unincorporated.

Locations: Morris and Lamberton Experiment Stations.

N Sources: Urea, ammonium nitrate and 28% urea ammonium nitrate solution.

N Rate: 0, 40, and 80 pounds N per acre.

	Morris	Lamberton
Date of Planting:		
	April 18	April 22
Nitrogen application:		
Incorporation	April 18	April 22
Nonincorporation	April 18	April 23
Previous Crop:	Corn	Wheat
Grain harvested:	July 29	July 31
Seeding rate:	1-3/4 bu/A	
Starter Fertilizer:	115#/A of 0-26-26	
Herbicide:	¼#/A Bromoxynil + ¼#/A MCPA ester	
Soil Test Data:		
	pH - 7.5 P - 19 K - 270	

Depth In	NO_3-N Lb/A
0-1	10.5
1-2	10.5
2-3	8.0
3-4	8.5
4-5	6.9

Table 1. Maximum Temperatures °F at Lamberton and Morris Experiment Stations Ten Days Following Application of N Sources, 1980.

Date	Morris	Date	Lamberton
4/18	73	4/23	81
4/19	76	4/24	64
4/20	77	4/25	58
4/21	93	4/26	62
4/22	98	4/27	56
4/23	72	4/28	72
4/24	64	4/29	71
4/25	60	4/30	71
4/26	65	5/1	78
4/27	58	5/2	81

Note: There was no recorded moisture over the 10 day period following application of nitrogen.

Table 2. Available Water From Nonfertilized Plots From the N Source x Incorporation Study at Lamberton Experiment Station, 1980 (Sampled 5/2/80).

Depth, Ft.	Available Water, In.
0-1	1.24
1-2	.90
2-3	1.02
3-4	1.38
4-5	1.50
Total	6.04

Ave. of 4 reps.

Table 3. Summary of N Rate, Source, Incorporation Study, Lamberton and Morris Experiment Stations, 1978-80.

	Am. Nitrate						Urea						28% N Soln.					
	Incorporated			Nonincorporated			Incorporated			Incorporated			Nonincorporated			Incorporated		
Morris	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80
0	44	13	38	44	13	38	44	13	38	44	13	38	44	13	38	44	13	38
40	46	24	55	51	25	56	53	28	58	51	22	57	50	25	54	44	24	47
80	52	24	70	44	25	70	52	26	60	42	28	66	43	27	50	49	25	58
Sig.	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**
BLSD			8.0			8.0			8.0			8.0			8.0			8.0
CV	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4	18.1	14	10.4
Rate x Source x Inc.																		
Sig.			NS			NS			NS			NS			NS			NS
CV			10.4			10.4			10.4			10.4			10.4			10.4
Lamberton																		
0	28	15	36	28	15	36	28	15	36	28	15	36	28	15	36	28	15	36
40	33	20	43	29	19	43	31	19	42	32	20	44	28	20	47	29	18	46
80	33	22	50	28	22	49	30	20	46	30	21	48	30	22	52	31	22	48
Sig.	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**	NS	NS	**
BLSD (.05)			4.8			4.8			4.8			4.8			4.8			4.8
CV	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4	9.8	8.8	7.4
Rate x Source x Inc.																		
Sig.	NS		NS			NS			NS			NS			NS			NS
CV			6.3			6.3			6.3			6.3			6.3			6.3

Table 4. Summary of Era Wheat Grain Yields When Fertilized With Three Sources of Nitrogen, Lamberton and Morris Experiment Stations, 1980.

			Morris				Lamberton			
N-Rate	Source	Inc.	Bu/A	Grain %N	Grain % Prot.	Test Wt.	Bu/A	Test Wt.	Grain %N	Grain % Prot.
	Check		38.0	1.94	11.1	60.7	36.1	59.6	2.35	13.4
40	AN	+	55.3	1.98	11.3	60.4	43.3	58.9	2.44	13.9
80	AN	+	70.3	2.30	13.1	60.0	49.6	58.5	2.54	14.5
40	Urea	+	58.0	2.00	11.4	60.7	42.1	59.2	2.41	13.7
80	Urea	+	60.0	2.24	12.8	60.3	45.9	58.6	2.40	13.7
40	28%	+	53.6	1.88	10.7	60.5	47.0	59.8	2.39	13.6
80	28%	+	49.8	1.90	10.8	60.2	52.0	59.0	2.51	14.3
40	AN	-	55.6	1.98	11.3	60.8	43.4	59.5	2.44	13.9
80	AN	-	70.4	2.22	12.7	60.6	48.6	56.7	2.68	15.3
40	Urea	-	56.6	1.98	11.3	59.6	44.0	59.3	2.44	13.9
80	Urea	-	65.8	2.23	12.7	59.6	48.3	57.8	2.53	14.4
40	28%	-	47.0	1.99	11.3	60.2	46.4	59.8	2.47	14.1
80	-		58.0	1.97	11.2	60.5	48.0	57.5	2.61	14.9
Signif.			**	**	NS	**	*	**	**	**
BLSD (.05)			8.0	.12	.7	--	4.8	2.0	.18	1.1
C.V.			10.4	4.3	4.3	1.3	7.4	2.0	4.5	4.5
Rate x Source x Inc.										
Signif.			NS	NS	NS	NS	NS	NS	NS	NS
BLSD (.05)			--	--	--	--	--	--	--	--
C.V.			10.4	3.4	3.4	1.1	6.3	2.1	4.6	4.6

Table 5. Summary of Era Wheat Yields Comparing N Sources, Rates and Incorporation, Morris and Lamberton Experiment Stations, 1980.

	Morris				Lamberton			
							Grain	
Rate	Bu/A	Grain %N	Grain % Prot.	Test Wt.	Bu/A	Test Wt.	%N	% Prot.
40	54.4	1.97	11.2	60.4	44.4	59.4	2.43	13.9
80	62.3	2.14	12.2	60.2	48.7	58.0	2.55	14.5
Signif.	**	**	**	NS	**	**	**	**
BLSD (.05)	3.6	.04	.2	--	1.7	.7	.07	.4
Source								
AN	62.9	2.12	12.1	60.4	46.2	58.4	2.53	14.4
Urea	60.0	2.11	12.0	60.0	45.1	58.7	2.44	13.9
28%	52.1	1.93	11.0	60.4	48.3	59.0	2.50	14.2
Signif.	**	**	**	NS	*	NS	NS	NS
BLSD (.05)	4.1	.05	.3	--	2.1	--	--	--
Incorporation								
Yes	57.8	2.05	11.7	60.3	46.6	59.0	2.45	14.0
No	58.9	2.06	11.7	60.2	46.4	58.4	2.53	14.4
Signif.	NS	NS	NS	NS	NS	NS	*	*
BLSD (.05)	--	--	--	--	--	--	.07	.4
C.V.	10.4	3.4	3.4	1.1	6.3	2.1	4.6	4.6

Table 6. Statistical Analyses of N Sources x Incorporation Study, Morris and Lamberton Experiment Stations, 1980.

		Morris				Lamberton		Grain	
Rate x	Source	Bu/A	Grain %N	Grain % Prot.	Test Wt.	Bu/A	Test Wt.	%N	% Prot.
40	AN	55.5	1.98	11.3	60.6	43.3	59.2	2.44	13.9
40	Urea	57.3	1.99	11.4	60.2	43.1	59.2	2.42	13.8
40	28%	50.3	1.94	11.0	60.4	46.7	59.8	2.43	13.8
80	AN	70.3	2.26	12.9	60.3	49.1	57.6	2.61	14.9
80	Urea	62.8	2.24	12.7	59.9	47.1	58.2	2.46	14.0
80	28%	54.0	1.93	11.0	60.4	50.0	58.3	2.56	14.6
Signif.		*	**	**	NS	NS	NS	NS	NS
BLSD (.05)		6.4	.07	.4	--	--	--	--	--
Rate x	Inc.								
40	+	55.7	1.95	11.1	60.5	44.1	59.3	2.41	13.8
40	-	53.1	1.98	11.3	60.2	44.6	59.4	2.45	14.0
80	+	59.9	2.14	12.2	60.2	49.2	58.7	2.48	14.2
80	-	64.7	2.14	12.2	60.3	48.3	57.3	2.61	14.9
Signif.		*	NS	NS	NS	NS	**	NS	NS
BLSD (.05)		4.4	--	--	--	--	1.0	--	--
Source x	Inc.								
AN	+	62.8	2.14	12.2	60.2	46.4	58.7	2.49	14.2
AN	-	63.0	2.10	12.0	60.7	46.0	58.1	2.56	14.6
Urea	+	59.9	2.12	12.1	60.5	44.0	58.9	2.40	13.7
Urea	-	61.2	2.11	12.0	59.6	46.1	58.5	2.48	14.2
28%	+	51.7	1.89	10.8	60.4	49.4	59.4	2.45	14.0
28%	-	52.5	1.98	11.3	60.4	47.2	58.7	2.54	14.5
Signif.		NS	*	*	*	NS	NS	NS	NS
BLSD (.05)		--	.07	.4	.7	--	--	--	--
C.V.		10.4	3.4	3.4	1.1	6.3	2.1	4.6	4.6

Table 7. Statistical Analyses of Corn Grain From N Source x Incorporation Study, Waseca Experiment Station, 1980.

N-Lbs/A	Source	Inc.	% N
0	-	-	1.40
75	AN	+	1.56
150	AN	+	1.72
75	U	+	1.54
150	U	+	1.74
75	UAN	+	1.54
150	UAN	+	1.66
75	AN	-	1.62
150	AN	-	1.61
75	U	-	1.57
150	U	-	1.69
75	UAN	-	1.55
150	UAN	-	1.65
Significance			**
BLSD (.05)			.09
C.V.			5.3

N Rate

75	1.56	
150	1.68	
Significance	**	
BLSD (.05)	.03	Rate x Source
		NS

N Rate x Incorporation

				Form
75	+	1.55		NS
75	-	1.58		
150	+	1.71		
150	-	1.65		Incorporation
				NS
Significance		*		
BLSD (.05)		.06		

Rate x Form x Incorporation

NS

Form x Incorporation

NS

WILD RICE FERTILIZATION RESEARCH - 1980

A PROGRESS REPORT
December 18, 1980

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Research was continued during 1980 on fertilization, nutrient requirement and water quality. Soil, water and air temperatures, and quality of paddy water were monitored during the growing season to obtain information on the environment in which wild rice grows. Two nitrogen experiments were conducted with the Netum variety on a mineral soil at Grand Rapids. A fertilization trial was conducted with K2 wild rice on peat in Aitkin County. Tissue samples were collected for plant analysis to learn more about nutrient uptake by the plant.

A. WEATHER CONDITIONS AND PLANT DEVELOPMENT

The growing season of 1980 started exceptionally early and higher than normal temperature during April and May advanced plant development ahead of the usual pattern. At Grand Rapids, for example, the average air temperature (Table 1) was 6.2° and 7.2°F above normal during April and May, respectively.

Soil, water and air temperatures were measured at three locations by automatic sensing and recording thermographs (see Fig. 1, 2, 3). Water temperature was not recorded at Gully because of an instrument malfunction.

The air and water temperatures, as expected, fluctuated more than the soil temperature. The mineral soil at Grand Rapids also showed greater temperature fluctuations than the two organic soils. The temperature of both organic soils measured about 45°F during plant emergence on May 2, increased to about 55° by mid-May and remained somewhat constant within the range of 55-65° for the rest of the season.

Plants emerged on May 2 at Grand Rapids and in Aitkin County (Fig. 4, 5). The jointing stage was reached by Netum (2nd year stand) at Grand Rapids on June 12, 41 days after emergence, and by K2 in Aitkin County on June 25, 54 days after emergence. Netum was harvested on July 30, 89 days after emergence. The K2 in Aitkin County was harvested on August 18, 108 days after emergence. During 1979, for comparison, Netum at Grand Rapids emerged on May 11, reached the jointing stage on July 6 and was harvested on August 2, 108 days after emergence. The K2 variety in Aitkin County emerged on May 8, 1979, reached the jointing stage on July 9 and was harvested on August 28, 112 days after emergence.

Table 1. Average air temperature as measured at three U.S. weather stations.[1/]

Station Year	Month April	May	June	July	August	5 Month Average	GDD T_b=40
	----------average air temperature, °F----------						
Fosston, Polk Co.							
Normal[2/]	41.0	54.6	63.6	69.4	67.5	59.2	2955
1974	41.0	50.5	63.4	71.6	62.8	57.9	2744
1975	34.8	55.7	61.9	70.5	64.6	57.5	2852
1976	46.6	54.9	66.8	68.8	70.9	61.6	3315
1977	49.1	66.4	64.6	70.3	60.6	62.2	3446
1978	41.7	59.2	63.4	67.8	67.7	60.0	3060
1979	36.0	48.7	63.6	69.6	63.6	56.3	2627
1980	48.9	61.3M	68.5	71.0	64.6	62.9	3466
Grand Rapids, N.C. School							
Normal	39.9	52.7	62.0	67.4	65.1	57.4	2681
1974	41.6	49.4	62.7	70.7	62.8	57.4	2670
1975	34.7	57.0	62.2	71.5	65.2	58.1	2951
1976	47.1	54.4	66.1	68.2	67.4	60.6	3166
1977	48.2	63.8	64.0	69.2	60.2	61.1	3284
1978	41.3	57.9	62.8	66.5	66.0	58.9	2892
1979	37.1	49.5	61.5	68.1	62.6	55.8	2511
1980	46.1	59.9	64.0	69.0	66.4	61.1	3237
Aitkin							
1974	42.9	49.8	63.1	71.1	63.3	58.0	2770
1975	39.0M[3/]	59.4M	64.4M	72.1	66.2M	60.2	3141
1976	47.5	54.8	66.8	69.3M	68.1	61.3	3267
1977	48.3M	64.4M	65.4M	70.3M	61.0	61.9	3446
1978	40.7M	57.5M	64.1M	67.0M	66.9	59.2	2938
1979	37.7	50.6M	62.0	68.1M	63.4	56.4	2585
1980	53.9	58.3	64.0	68.5	66.0	62.1	3394

1/ Source: Climatological Data, Minnesota, Vol. 80-86 (1974-80), U.S. Dept. of Commerce.

2/ Normals for the period 1931-60.

3/ M = less than 10 days record missing.

Figure 1.

MEAN AIR, WATER AND SOIL TEMPERATURES
GRAND RAPIDS-1980

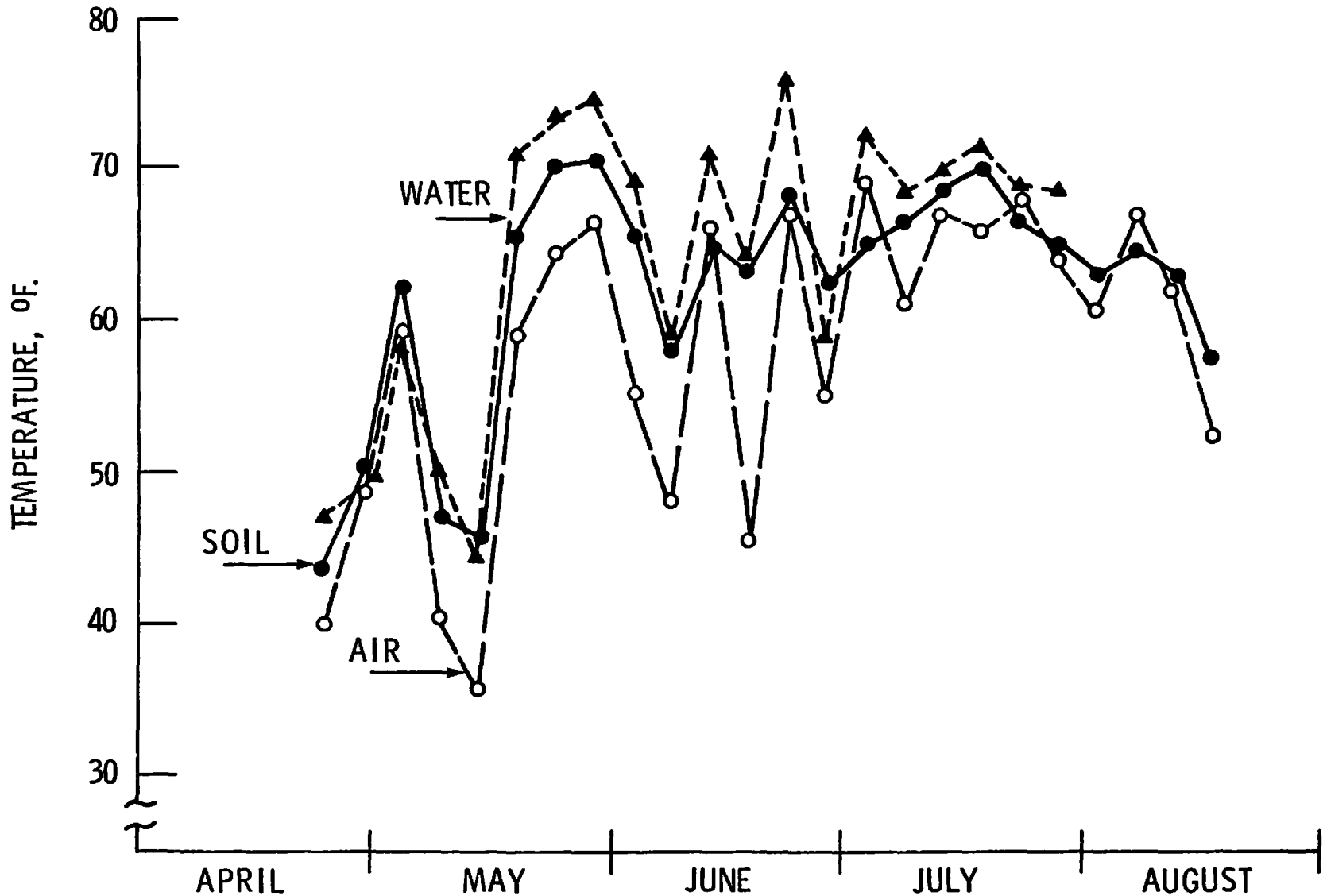


Figure 2.

MEAN AIR, WATER AND SOIL TEMPERATURES
KOSBAU BROS., AITKIN CO.-1980

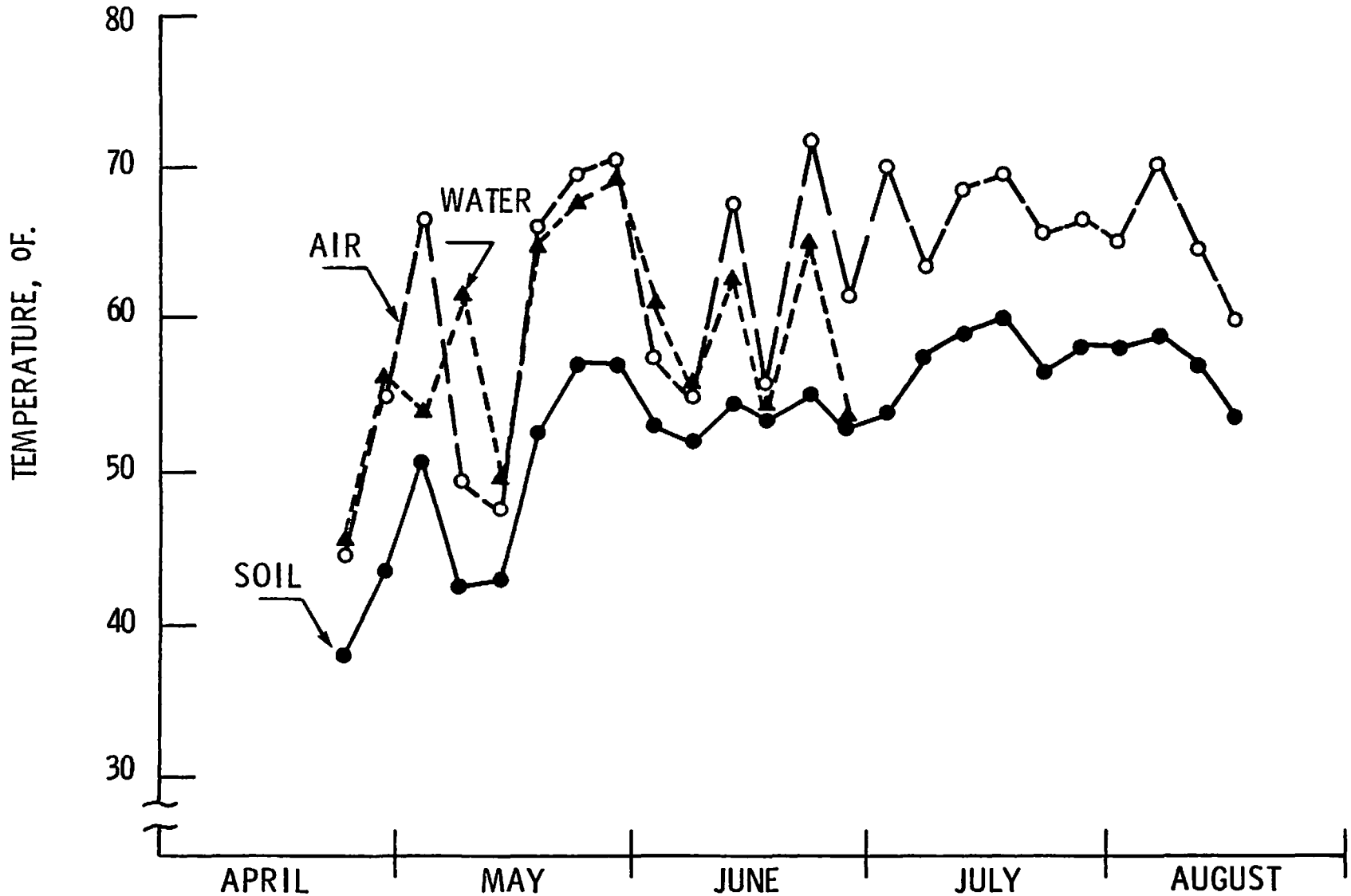


Figure 3.

MEAN AIR AND SOIL TEMPERATURES
GULLY-1980

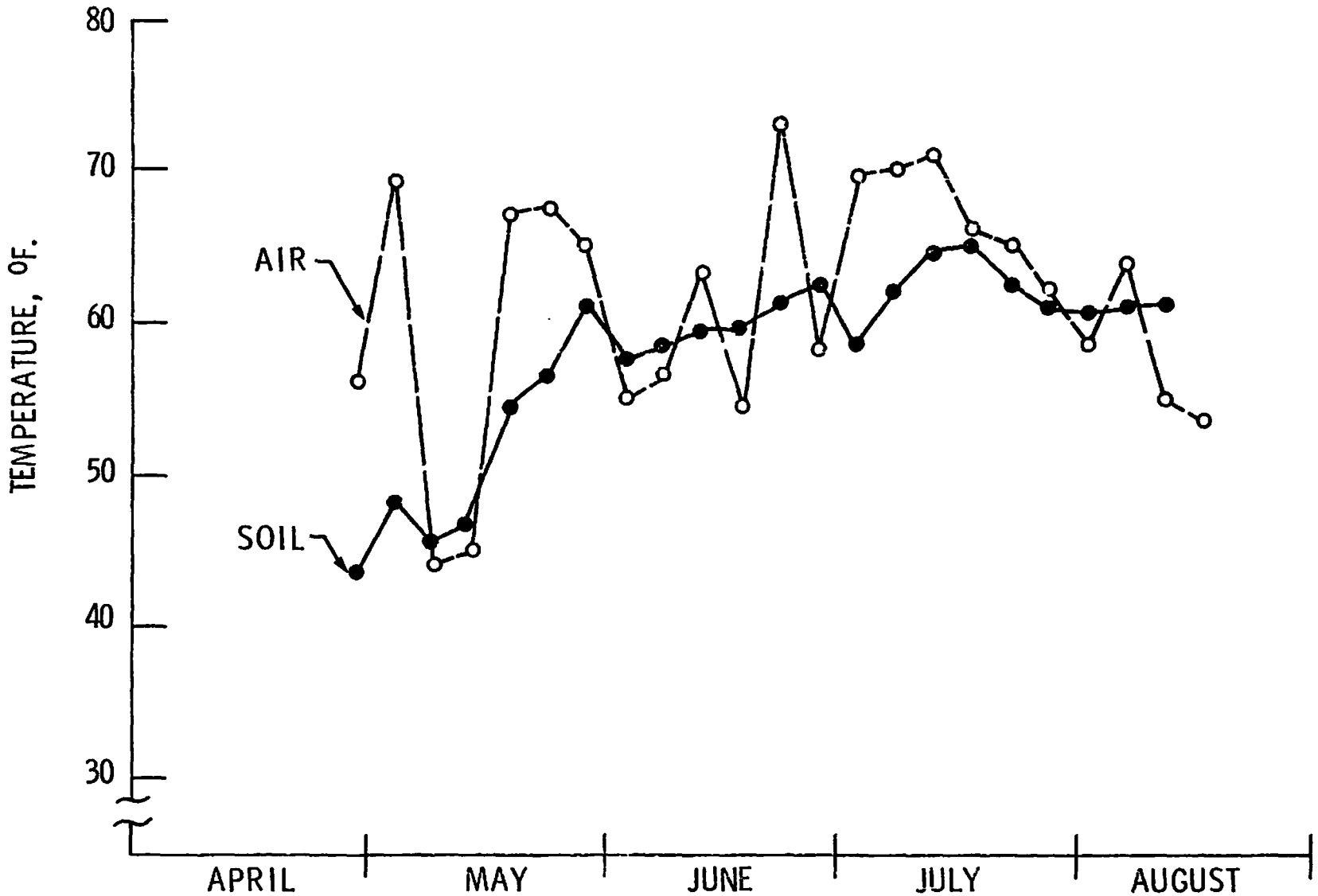
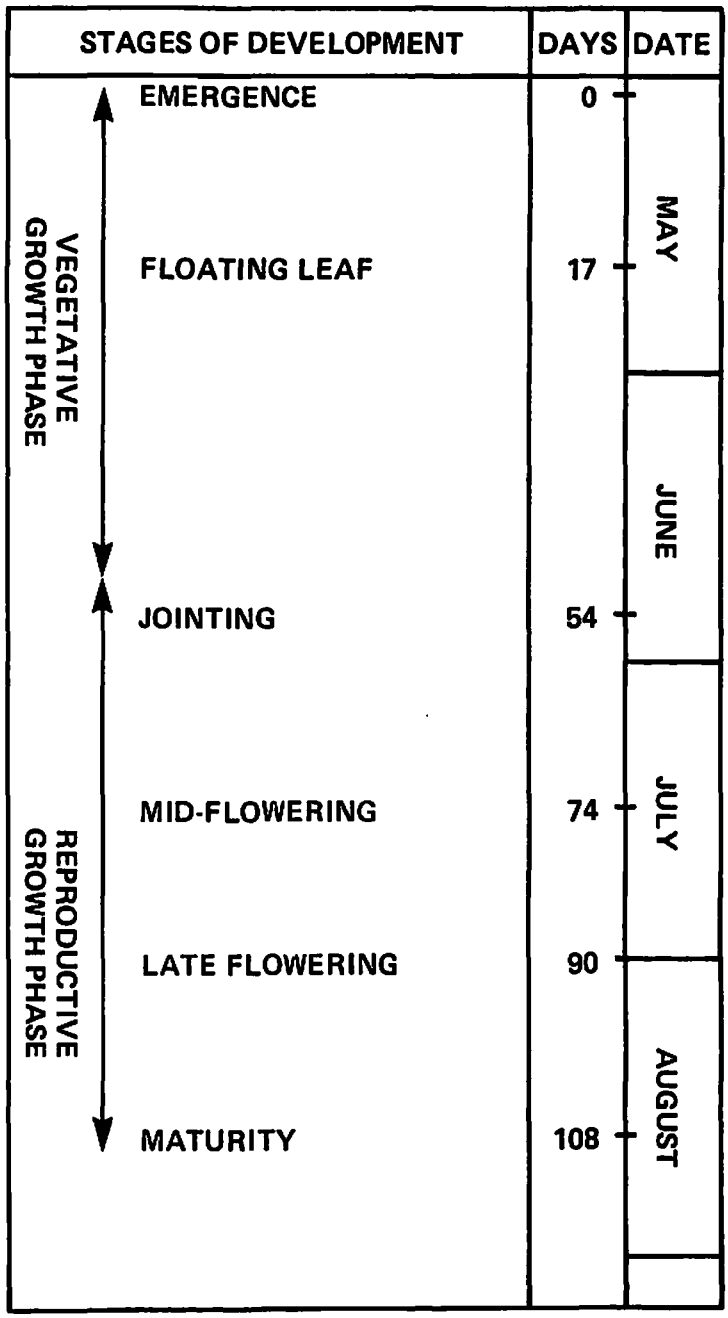


Figure 4. WILD RICE DEVELOPMENT
NETUM VARIETY, 2ND YEAR STAND
GRAND RAPIDS, 1980

	STAGES OF DEVELOPMENT	DAYS	DATE
VEGETATIVE GROWTH PHASE	EMERGENCE	0	MAY
	FLOATING LEAF	11	
	AERIAL LEAF	21	
	TILLERING	34	JUNE
REPRODUCTIVE GROWTH PHASE	JOINTING	41	
	BOOT	46	
	HEADING	51	
	MID-FLOWERING	62	JULY
	LATE FLOWERING	74	
	MATURITY	89	

Figure 5. WILD RICE DEVELOPMENT
K2 VARIETY, KOSBAU BROS., AITKIN CO., 1980



B. CHEMICAL CHARACTERISTICS OF PADDY WATER

Water samples were collected from several sites at three different paddy locations during the 1980 growing season. At Grand Rapids, samples were collected from two experimental paddies used for nitrogen studies on mineral soil, and from the Prairie River which was the source of water. Water was also sampled within an experimental paddy in Aitkin County. Paddies at this site derived water from the Little Willow River via a diversion ditch. The third sampling site was in the Imle and Gunvalson paddies near Gully. These paddies derived water from the Clearwater River.

Water samples were collected and stored in 250 ml polyethylene bottles, with a preservative added (2 ml mercuric chloride solution, made by dissolving 40 mg $HgCl_2$/L, to 250 ml of sample). Chemical analyses were made by the Research Analytical Laboratory, University of Minnesota. Information on location, sampling dates, and chemical composition data of water is given in Table 2.

The electrical conductivity measurement gives an indication of total concentration of salts in the water. The conductivity of samples from Grand Rapids and Aitkin County locations was relatively low ranging from 0.14 to 0.30 mmhos/cm, while that of the water at Gully ranged from 0.58 to 0.78 mmhos/cm. The hardness of water is a measure of dissolved calcium and magnesium, and is expressed as mg $CaCO_3$/ liter. The water from the Clearwater River was very hard (251 mg/L) while water from the Prairie River and Little Willow River was moderately hard (76 and 63 mg/L).

At Grand Rapids, total N, P and K concentrations of paddy water were slightly higher than those of the river water, and increased as the growing season progressed. Total concentrations in the water ranged from 0.6 to 2.4 ppm N, 0.02 to 0.19 ppm P, and 1.5 to 6.3 ppm K.

At Gully, nutrient concentrations of the water ranged from 1.0 to 4.3 ppm N, 0.07 to 0.25 ppm P, and 3.2 to 9.6 ppm K.

Paddy water at the Aitkin County location had considerably higher concentration of total N, P and K than that found in the river water. Total N concentration of paddy water ranged from 3.2 to 10.0 ppm compared to 0.9 to 2.4 ppm found in samples collected from the diversion ditch. Total P concentration in paddy water ranged from 0.81 to 1.84 ppm compared to 0.05 to 0.23 ppm in the water from the diversion ditch. Potassium levels of paddy water ranged from 3 to 10 ppm while the water from the diversion ditch had a concentration of 1 to 4 ppm K.

The sulfate concentration of water is reported in terms of parts per million of sulfate-sulfur. To convert results to the sulfate form, they must be multiplied by 3. For example, 14 ppm sulfate-S x 3 = 42 ppm sulfate (SO_4) in the water.

The water at Grand Rapids and in Aitkin County, generally, contained about 15 ppm of sulfate. The sulfate concentration of the water at Gully, however, was relatively high (131-157 ppm SO_4).

Table 2. Chemical composition of water collected from wild rice paddies during 1980 growing season.

Sample No.	Sampling Date	Location	Conductivity milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm	Na ppm
Location: Grand Rapids															
3.	4/23	EP-E	.19	59.0	62.9	1.5		<0.1	0.07	<0.01	5.0	16.4	4.7	1.7	2.1
4.	4/23	EP-W	.18	60.5	66.9	1.1		0.1	0.07	<0.01	5.1	17.3	5.0	1.5	2.2
5.	4/23	PR	.20	76.0	75.8	1.0		0.1	0.02	<0.01	5.0	20.4	5.5	1.5	2.2
12.	5/22	EP-E	.19			1.6			0.06			19.4	5.3	1.2	2.4
13.	5/22	EP-W	.19			1.0			0.06			19.7	5.2	1.2	2.4
14.	5/22	PR	.22			0.6			0.03			21.4	6.0	1.5	2.4
18.	6/17	EP-E	.17			2.2			0.11			25.1	7.7	3.6	3.6
19.	6/17	EP-W	.18			1.4			0.08			24.9	7.5	2.3	2.8
17.	6/17	PR	.20			0.6			0.04			27.7	7.7	3.3	3.0
26.	7/3	EP-E	.18			0.8			0.10			19.8	6.3	3.7	3.6
27.	7/3	EP-W	.15			0.3			0.05			19.6	6.6	1.6	2.5
28.	7/3	PR	.19			0.8			0.04			26.3	7.1	2.0	2.9
33.	7/23	EP-E	.22			2.4			0.19			25.1	8.2	6.3	4.6
32.	7/23	EP-W	.20			2.1			2.15			27.3	7.8	2.9	3.5
31.	7/23	PR	.20			0.9			0.13			28.2	7.7	4.4	3.3

Abbreviations and description of sampling sites at Grand Rapids: EP-E = Experimental Paddy #1 East; EP-W = Experimental Paddy #1 West; PR = Prairie River.

Table 2 continued.

Sample No.	Sampling Date	Location	Conductivity milli-mhos/cm	Alkalinity as $CaCO_3$ mg/L	Hardness $CaCO_3$ mg/L	Total Kjeldahl N ppm	Ammonium N ppm	Nitrate & nitrite N ppm	Total P ppm	Soluble P ppm	Sulfate S ppm	Ca ppm	Mg ppm	K ppm	Na ppm
Location: Kosbau Bros., Aitkin Co.															
1.	4/23	EP	.14	9.5	33.2	10.0		<0.1	0.94	0.08	14.0	7.7	2.5	9.0	3.4
2.	4/23	DD	.18	62.0	62.6	1.7		<0.1	0.06	0.01	5.1	15.8	5.1	1.3	2.6
8.	5/13	EP	.23			4.4			0.42			18.1	5.9	7.7	4.2
9.	5/13	DD	.22			0.9			0.05			20.9	6.6	1.8	3.2
10.	5/22	EP	.26			3.2			0.65			20.7	6.5	1.6	4.5
11.	5/22	DD	.24			2.4			0.09			24.3	7.7	1.9	3.4
16.	6/12	EP	.24			3.3			1.26			30.7	9.8	10.3	5.6
15.	6/12	DD	.24			1.3			0.07			34.0	10.5	3.7	4.3
22.	6/25	EP	.19			8.2			1.84			31.0	10.2	3.1	4.7
23.	6/25	DD	.26			2.1			0.23			41.6	11.9	0.9	4.3
30.	7/7	EP	.26			3.9			0.81			38.7	12.2	6.1	7.3
29.	7/7	DD	.27			2.1			0.13			39.0	12.2	1.9	5.5
34.	7/31	DD	.30			2.4			0.25			45.0	14.1	1.9	5.9

Abbreviations and description of sampling sites at Kosbau Bros.: EP = Experimental Paddy; DD = Diversion Ditch at bridge near the Little Willow River.

Location: Imle and Gunvalson, Gully															
6.	4/28	PP	.60	169.5	247.6	4.3		<0.1	0.21	0.02	52.2	63.1	21.3	9.6	5.2
7.	4/28	CR	.60	210.5	251.4	1.1		<0.1	0.07	0.01	43.6	64.6	21.3	4.0	4.7
20.	6/18	PP	.78			2.9			0.25			121.2	44.6	3.2	9.2
21.	6/18	CR	.61			1.1			0.19			88.5	32.9	5.7	8.0
25.	7/1	PP	.58			1.4			0.11			85.1	32.6	3.9	7.8
24.	7/1	CR	.65			1.0			0.13			94.9	34.5	5.2	8.3

Abbreviations and description of sampling sites at Gully: PP = Production Paddy; CR = Clearwater River.

C. NITROGEN STUDIES ON MINERAL SOIL

Two field experiments were conducted with Netum wild rice on a mineral soil at the North Central Experiment Station, Grand Rapids. Soil tests (Table 3) indicated a very high level of extractable phosphorus (60 and 80 pp2m) and medium to high level of exchangeable potassium (164 and 230 pp2m).

N Rate Trial

The nitrogen rate study, initiated in 1979, was continued on paddy No. 1 East with 2nd year stand of Netum. Four rates of nitrogen were used in this experiment: 0, 20, 40, 80 pounds per acre. Urea (46-0-0) was applied by hand and incorporated into the soil by rototilling. A randomized block design was used in this experiment. Each nitrogen treatment was replicated five times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. To ensure a sufficient stand, 27 pounds per acre of seed was broadcast - applied by hand on October 17 and rototilled into the soil. Plant density, at harvest, was about 8 plants per square foot. Water level was maintained at about 6 to 10 inches. Ten plants were collected at random from each plot at jointing, and five plants at late flowering for weight measurement and plant analysis. The jointing stage was reached on June 12 (Fig. 4). A 32 sq. ft. area from each plot was hand-harvested on July 30 for yield determination.

Netum wild rice produced 543 to 684 pounds of grain per acre (Table 4). The yield, however, was not affected by the application of nitrogen.

The second leaf at jointing contained 2.63 to 3.37% N, considered to be low to medium concentration (Table 5). The total amount of nitrogen accumulated by the plant at jointing and late flowering stages was relatively low and was not affected by the N treatments (Table 6).

Generally, individual Netum plants in this experiment were somewhat shorter and had fewer tillers than observed in previous seasons. Individual plants had accumulated about 3 and 6.5 grams of dry matter at jointing and late flowering, respectively. This may have been partially due to the exceptionally early and warm growing season which hastened plant development, and to the relatively thick stand (8 plants/sq. ft.). Also the grain yield could have been higher if the harvest had been delayed by about one week.

Table 3. Soil test values of experimental paddies, Grand Rapids.[1)]

Location	pH	Extractable P pp2m	Exchangeable K pp2m	NO_3-N lb/A
Paddy No. 1 East	5.8	88	164	18
Paddy No. 1 West	5.7	60	230	18

1) Samples collected from 0-6 inch depth on 10/17/79.

Table 4. Effect of nitrogen application on the yield of Netum wild rice, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	Grain Yield lbs/acre
0	565[1)]
20	543
40	604
80	684
Significance	ns

1) 7% moisture, average of 5 replications

Table 5. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	N % in Dry Matter
0	2.89
20	2.69
40	2.63
80	3.37
Significance	ns

Table 6. Effect of nitrogen application on total uptake of N by the wild rice plant at jointing and late flowering, Netum variety, 2nd year stand, Grand Rapids, 1980.

N Rate lbs/acre	Stage of Development	
	Jointing	Late Flowering
	---N in milligrams per plant---	
0	55	77
20	57	80
40	47	80
80	59	78
Significance	ns	ns

N Rate and Time of Application Trial

This experiment was established in paddy No. 1 West in fall of 1979. The paddy had been in fallow during 1979 and had been fumigated with methyl bromide. Nitrogen treatments consisted of four rates (0, 20, 40, 80 lb N/acre) applied in single (fall) or split-applications (½ fall + ½ jointing, or ½ fall + ½ early flowering). Urea (46-0-0) was the source of nitrogen. Fall-application of urea was made on October 17 and the fertilizer was incorporated into the soil by rototilling. Additional N was topdressed by hand at jointing or early flowering. A randomized block design was used in this experiment. Each treatment was replicated four times. Individual plots occupied a 14 x 16 ft. area and were separated from adjoining plots by 5 ft. wide alleys. Seed of Netum variety was broadcast-applied by hand on October 17 and rototilled into the soil. Plant density, at harvest, ranged from 1 to 2 plants per square foot.

It was extremely difficult to maintain the water level in this paddy at the desired level, particularly during the early stages of plant development. Frequently the surface soil in some areas was not covered with water. This appeared to delay the emergence and development of plants. Generally, the plants of this 1st year stand (Paddy No. 1 West) was from 7 to 10 days behind in development to the 2nd year stand of Netum in Paddy No. 1 East. Jointing stage was reached on June 19. A 16 sq. ft. area from each plot was harvested on August 19 for yield measurement. Harvesting was delayed on purpose to allow the grain to ripen, shatter and thus ensure a sufficient stand of wild rice next season.

Grain yields (7% moisture) ranged from 833 to 1144 lb/acre (Table 7). The yield of wild rice was not affected by any of the nitrogen treatments.

The second leaf at jointing contained 4.33 to 5.05% N, considered to be a relatively high concentration (Table 8). Total nitrogen uptake by the plant at jointing or late flowering was not affected by the N treatments (Table 9).

Generally, the stand in areas that appeared to be most affected by the low water level was sparse, and the plants were shorter and behind in development to normal plants in other areas. The affected plants were light green in color with yellow lower leaves. While these symptoms are generally associated with nitrogen deficiency, they were observed also in plants that had received 40 or 80 lb/acre of nitrogen in the fall. Poor growth of wild rice appeared to be more related to the location within the paddy than to nitrogen treatments.

Table 7. Effect of nitrogen application on the yield of Netum wild rice, 1st year stand, Grand Rapids, 1980.

Treatment No.	N Rate lbs/acre	Time of Application			Grain Yield lbs/acre
		Fall	Jointing	Early Flowering	
		---------N lbs/acre----------			
1	0	-	-	-	1144
2	20	20	-	-	833
3	40	40	-	-	1063
4	40	20	20	-	909
5	40	20	-	20	937
6	80	80	-	-	1141
7	80	40	40	-	960
8	80	40	-	40	1105
Significance					ns

Table 8. Effect of nitrogen application on N concentration in 2nd leaf of Netum wild rice at jointing, 1st year stand, Grand Rapids, 1980.

N Rate lbs/acre	N % in Dry Matter
0	4.56
20[1)]	4.88
40[1)]	5.05
80[1)]	4.33

1) Fall applied treatments

Table 9. Effect of nitrogen application on total uptake of N by Netum wild rice, 1st year stand, Grand Rapids, 1980.

Treatment No.	N Rate[1)] lbs/acre	Stage of Development	
		Jointing	Late Flowering
		---N in milligrams per plant---	
1	0	37	165
2	20	29	106
3	40	47	118
4	40	-	127
5	40	-	131
6	80	48	125
7	80	-	124
8	80	-	143

1) See Table 7 for time of application

D. FERTILIZATION STUDIES ON PEAT

A fertilizer experiment was conducted with the K2 variety of wild rice on organic soil in a Kosbau Bros. paddy in Aitkin County. Relatively high extractable phosphorus (23 pp2m), and medium/low exchangeable potassium (103 pp2m) levels were indicated by soil tests. The soil pH was 5.6. This was an incomplete factorial experiment with six NPK treatments, replicated six times, arranged in randomized blocks. Individual plots occupied a 14 x 16 ft. area. Fertilizer materials (46-0-0, 0-46-0, 0-0-60) were applied by hand on October 18, 1979 and incorporated into the soil by disking. The stand was thinned once by airboat on May 20. Average plant density, at harvest, was 5 plants per square foot.

Plants reached the jointing stage on June 25. The paddy was drained on June 28. A 16 sq. ft. area from each plot was harvested on August 18 for yield determination. Some grain from the primary panicles had been lost through shattering and some grain in the panicles of tillers had not filled. This may explain why the wild rice in this experiment produced only moderate yield (Table 10). Fertilizer treatments had no effect on the yield.

The concentration of nutrient elements in the 2nd leaf at jointing (see Table 10) was relatively high: 3.85-4.29% N, 0.59-0.65% P, 3.67-4.02% K.

Table 10. Effect of fertilization on grain yield and N concentration in 2nd leaf of K2 wild rice at jointing, Kosbau Bros., 1980.

Treatment					Grain Yield	N%	P%	K%
N		P_2O_5		K_2O				
lbs/acre					lbs/acre	in Dry Matter		
None					528	4.10	0.59	3.74
0	+	40	+	60	584	3.86	0.59	3.78
30	+	40	+	0	535	4.04	0.60	3.67
30	+	0	+	60	505	3.85	0.61	3.82
30	+	40	+	60	452	4.29	0.65	4.02
60	+	40	+	60	467	3.95	0.64	3.86
Significance					ns	ns	ns	ns

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